Evaluation of the Strategic Areas at NTNU – 2007

By

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1. Strategic Areas: The International Context

In 1999 NTNU launched a forward-looking initiative to foster four Strategic Areas which were organised around larger themes in common fora of interdisciplinary cooperation. To understand and evaluate NTNU's initiative, it may be helpful to look abroad in order to compare NTNU's endeavours with the motivation and challenges of other institutions which have also undertaken overarching initiatives of thematic organisation. Indeed, a recent study of research strategy development at European universities showed that there is a growing trend among those institutions that make an effort to develop research strategies to also select some thematic areas for which some investments and support is prioritised.[1] Of course, the extent of such prioritisation differs greatly from one institution to the next, dependent on the extent of central institutional resources and its degree of centralisation in terms of institutional governance.

To understand such institutional initiatives one should distinguish two types of thematic areas:

1. on the one hand, there are those that function mainly as **strategic priority areas**, aiming at the "profiling" or positioning of the institution in an increasingly competitive national and international arena;
2. on the other hand, there are thematic initiatives which primarily seek to foster **interdisciplinary** (and often also inter-institutional) **cooperation**.

The motivation for the **strategic priority areas** relates largely to an institutional will to be as proactive as possible with respect to institutional development, first and foremost, by setting some priorities, not just symbolically and in terms of institutional communication but also with respect to resource allocation. The prioritised areas are usually selected on the basis of their strong performance and potential with respect to future scientific development. Some areas may to be more risky choices than others with the explicit aim of inciting new research in emerging areas and prioritising particularly promising young research groups/ areas. Even though priority setting is not necessarily linked to a requirement for interdisciplinarity, the chosen areas are often interdisciplinary in nature, partly because of the observation that the most exciting scientific developments often occur at the interfaces between disciplines.

In order to justify prioritised resource allocation, internal and sometimes even external evaluation usually precede the selection. The transparency and prior agreement on the criteria of quality assessment and selection is seen to be vital for building an institutional culture of sustainable priority setting and performance mobilisation.

Associated with the selection and further development of the selected areas, is the hope to identify or even foresee scientific and societal developments and to overtake the average speed of developments. Thereby institutions hope to be in a position to contribute to setting the agenda in particular areas of scientific development, as well as in research and technological and related social policy. Thus the institution's market or competitive position would be enhanced.

It should be noted in this context that the idea of rewarding the most promising areas, and

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[1] Sybille Reichert, *Research Strategy Development and Management at European Universities*. Brussels: EUA Publications 2006.

placing limited resources on areas with the biggest (academic and social) return on investment is usually not just related to academic criteria and values, even though outstanding academic performance is a condition sine qua non for selection, but also to the areas' perceived contribution to addressing major societal challenges. In order to enable the traditionally disciplinary science cultures to respond to these challenges, interdisciplinary approaches are strongly emphasised in areas which are seen to be of more direct relevance to society.

Finally, strategic priority areas are selected and promoted as being the most attractive research environments in which the institution stands the best chances of attracting the most competitive and best qualified researchers from abroad. Often strategic reserves are even put aside for strategic hires in this context.

Some institutions also initiate **thematic areas to specifically foster interdisciplinary cooperation**. Such interdisciplinary areas or platforms are fostered because it is argued that they increase the ability to identify and pursue new scientific questions which often emerge at the interface of disciplines or that some scientific problems may require several disciplines to be addressed at all (e.g. systems biology). Thus they are also associated with the hope to be as early as possible in the identification of new emerging fields and to create particularly innovative and thus attractive research environments which mobilise creative potential.

As mentioned above, interdisciplinary approaches are also seen to be necessary to increase the relevance of scientific research for society and to bring the dialogue with external stakeholders onto a more proactive engaged and mutually reinforcing dialogue. In this context, institutional leaders often emphasise that the identification and solution of societal problems in close dialogue with stakeholders requires new forms of interchange at several institutional levels of attention: between researchers in academia and industry or government, as well as at the level of institutional leadership.

Interdisciplinary areas are fostered at institutional level not just because they are perceived to offer added value in scientific and communicational terms, but also because they are known to need additional support to withstand the many obstacles which interdisciplinary research usually encounters. Such obstacles comprise:

- Faculty/ departmental organisational structures reflecting disciplinary constituencies in decision-making procedures. These become particularly strong obstacles during periods of budgetary retraction, where one finds the natural tendency to serve the primary constituency (i.e., students majoring in the discipline) so that resources become scarce for teaching and research which is comparatively far from the center of the discipline as traditionally understood.
- Resource allocation mechanisms which prevent money flow between separate budgetary units;
- Double structures leading to disproportionate time in meetings;
- Discipline-based career promotion patterns and tenure decisions;
- Journals with predominantly disciplinary focus;
- External stakeholders traditionalism.

Hence one may observe, in the context of the larger science community, a tendency for some interdisciplinary areas to become new disciplines, with their own institutional forms as they consolidate (as was the case for neuroscience, biochemistry, bioengineering). At the level of the academic institution, one finds more and more efforts to develop measures to protect and prioritise the interests of interdisciplinary areas. At proactive institutions, means are thus set aside to foster such research or to create structures which help scientists regroup around interdisciplinary themes. Some institutions also feel it is necessary to formulate guidelines

which alleviate some of the formal administrative difficulties, defining, for example, procedures for joint appointments or common funds. (See examples in the Annex)

Both of the above-described types of thematic areas -- strategic priority areas or interdisciplinary cooperative platforms -- aim to increase the visibility of university research by clustering it into larger themes which create or reveal critical mass to the scientific or political community and which are more meaningful windows onto research for citizens and tax payers whose identification with science is needed to sustain R&D expenditures.

Interestingly, one should take note of the fact that many national research funding authorities are beginning to require evidence of such critical mass, larger interdisciplinary horizons and institutional strategic support as conditions for grant selection (as is the case, for example, in the Netherlands, Germany, and the UK). Many institutions report that the funding authorities' demand for institutional sustainability and co-funding between external and internal sources is becoming an increasingly difficult challenge for some institutions, sometimes forcing them to set priorities through matching funds, which they did not have the intention of setting when initially supporting the area. Thematic areas may thus at first be justified as attempts to create critical mass, or form consortia which would enable researchers to apply for bigger projects, to then develop into genuine institutional priorities, expressed in terms of additional resources or positions.

While they are characterised by very different degrees of resource support and access to strategic reserves and actions on the part of the institutional leadership, strategic priority areas and interdisciplinary cooperation areas usually involve a **similar range of activities**, namely:

- Forming consortia to increase the ability to address larger scientific questions and to obtain funding;
- Building and developing Centres of Excellence;
- Organising academic or university/industry exchange (conferences, workshops, summer schools);
- Planning and using common scientific equipment and larger infrastructure;
- Developing and running common graduate or research schools;
- Developing and running Master & PhD programmes in the thematic area;
- Developing and running specialisation tracks at advanced Bachelor level;
- Developing foresight ideas and strategies;
- Project and Team Work;
- Cooperating with external stakeholders in projects and through common (strategy or other) fora;
- Networking, friend- and fund-raising in systematic fashion around more easily graspable scientific and economic/ societal interests;
- Increasing visibility through printed and electronic media.

Since their aims and activities of strategic priority areas and interdisciplinary cooperation areas either coincide or can be regarded as complementary, some institutions have thematic areas which perform both the function of an interdisciplinary cooperation platform as well as that of a strategic priority area, as is the intention of NTNU (see also examples from Stanford University in the Annex). All institutions that proactively select areas as strategic priorities will at least have some that also build on and foster interdisciplinary cooperation.

Interestingly, one may distinguish a certain phasing effect with areas moving from a state of loose coupling via increasingly dense bonding to more sustained institutional forms or "marriages" as expressed in competence centres, new departments or simply prioritised

clustered hiring practices. Such phasing does not necessarily apply simultaneously to all areas but is usually a response to the achievements of a given area. Indeed, often the interdisciplinary areas' activities and achievements lead to a clearer identification of sub-areas with highest potential, or to identification of emerging areas where further competence should be built at the institution, in light of its existing strengths. Thus strategic choices on a long term expansion of these areas are made on this basis, as expressed through:

- hiring professors or even groups of professors (adding competence or as new engine to create additional pull);
- building research training structures and research positions around the key focus areas, which link the research strengths with graduate training;
- the acquisition of strategic scientific facilities as attractors for future researchers;
- re-allocated lab/ office spaces or new buildings to create new proximities.

Of course, all of these decisions imply strongly prioritised resource allocation.

2. Strategic Areas at NTNU: Rationale, Aims and Achievements

2.1 The Aims of the Strategic Interdisciplinary Areas at NTNU

In 1999 the Norwegian University of Science and Technology launched thematic Strategic Areas which were designed to support its ambitious goal of being "rated among the international academic leaders in our main areas of concentration" (1998 strategic plan "Creative, Constructive, Critical"). The then rector Emil Spjøtvold invited the research community to suggest wider areas of activity in which NTNU was already holding a leadership position or in which such potential could be seen. From the faculties' proposals, which were selected on the basis of a number of previously communicated criteria, 4 areas were chosen, a 5th and 6th being added later (2000 and 2005 respectively). If we look at the aims associated with the Strategic Areas, we will find the 2 sets of aims which we associated with the two types of thematic areas distinguished in section1, the strategic priority areas and interdisciplinary cooperation platforms. There are both:

1. profiling aims which were associated with the above-mentioned strategic positioning of NTNU, aiming at increased competitiveness and visibility of NTNU in an international university context;
2. aims associated with internal and external communication, including the responsiveness and proactiveness of NTNU with respect to societal and industrial concerns.

The full list of aims of the Strategic Areas, derived from different strategic documents, reports or plans, can just be grouped as follows, with some aims supporting both types of aims:

Profiling aims	Aims associated with internal and inter-institutional or stakeholder dialogue
Instrument to reach goal of being among international academic leaders in main areas of concentration	Achieve objectives and identify challenges or opportunities of strategic national importance
Drive scientific development Implement dynamic selection of focus areas and show ability to evolve	Generate synergy and interaction between basic research and applied research and innovation
File applications to Centres of Excellence,	Promote collaboration with SINTEF, other

strategic university programmes and other project applications to the Norwegian Research Council and EC	research institutes and industry
Attract best qualified researchers and students	Develop a good strategic collaboration with industry
Be a driving force toward the Research Council, EC and other international programmes	Play a clear role in relation to the needs of society
Make visible and profile NTNU's activities within strategic area,	Strengthen collaboration across NTNU's activities, in particular between natural and technical sciences, on the one hand, and social sciences and humanities, on the other (i.e. across the still existing borders of the formerly separate institutions)
Promote interdisciplinary cooperation	
Promote international cooperation and networks	

Hence, NTNU's strategic thematic areas can be regarded as both strategic profiling areas as well as platforms of interdisciplinary exchange and institutional outreach. Especially the second set of aims resonates strongly with NTNU's clearly formulated vision and long term strategy: to be "an academic leader that safeguards and expands Norway's technological expertise" and contributes "to greater understanding of the interaction between culture, society, nature and technology."

Not only in the justification of the existence of the Strategic Areas but also in their enactment in the various focus areas' activities, NTNU strongly reflects its realisation that the ability to identify and address technological and societal challenges presupposes larger and more cooperative structures of scientific process, from research design to everyday practice. In the decision to launch Strategic Areas as well as in their realisation, NTNU shows a deep **willingness to take the challenge of conducting academic science in open dialogue with societal, industrial and economic concerns very seriously**. Researchers involved in the various Strategic Areas have not shied away from considerable effort and openness in their interaction with external stakeholders, setting up early-warning and foresight activities, connecting with and contributing to their strategic thinking as well as responding to their research and innovation needs. Both at the level of the institution as well as at the level of the strategic area, university-industry or –government relations seem to be taken to a new level of mutual recognition, with NTNU as a university analysing current developments and identifying future challenge so as to enable industry and government to enhance its own adaptability and competitiveness. Hence, we can conclude that, with its Strategic Areas, NTNU can really be said to be a truly engaged university, taking its own vision seriously.

External partnership has also been pursued very vigorously in NTNU's relation with SINTEF. As pointed out in the evaluations of the individual areas, such as Materials, Marine and Maritime Technology, as well as Energy and Petroleum, NTNU researchers have not only pursued cooperation through research projects but also share lab facilities, research groups and even develop strategic directions together, as is the case in the Materials, Marine and Medical Technology Areas.

Considerable attention was also paid to the encouragement of **internal cooperation** across disciplinary boundaries. In the Energy and Resources Area such interdisciplinary cooperation

even stretched across the cultural divide between the social and technical sciences, thus offering the side effect of reaching across the institutional divide between the two campuses (which were two separate institutions a little more than ten years ago). Indeed, in two areas it was emphasised that such cross-institutional cooperation was an important aim of the Strategic Areas since the rift between the different parts of the institution could still be felt strongly. Moreover, the geographic separation of the faculties across remote parts of the campus reinforces the cultural divide and hinders cooperation. Therefore, targeted attention is indeed necessary to facilitate interdisciplinary cooperation between the social and natural or technical sciences. Indeed, NTNU could also have explicitly justified the existence of overarching thematic structures by pointing to value of an integrative approach to a hitherto fragmented university structure, which still reflects the relatively recent merger of several institutions out of which NTNU derives.

While the aims regarding cooperative structures and responsiveness to external stakeholders were pursued with considerable investment of time and attention, other aims which would relate to the competitive positioning of the institution seem to have receded to the background in comparison. As mentioned above, NTNU formulated ambitious aims with respect to the future positioning of the institution, both in the 1998 strategy and even more forcefully in 2007, aspiring to

- To international leadership in selected Strategic Areas and

- to be among the 10 leading technological and scientific universities in Europe, and among 1% of universities in the world with broad scope. (Strategy of Dec. 2006, "NTNU 2020 – Internationally Outstanding")

Whether these aims are realistic or not, will presumably be judged differently in the different areas. In any case it is clear that, to realise such aims, bold steps are needed (see section 3) reflecting scientific priorities in resource allocation and hiring policy. Until now, the Strategic Areas do not seem to have been regarded as much as priorities in terms of major resource allocation or long term investments. The limited realisation of cross-institutional prioritisation is also owed to the fact that strategic decisions are traditionally taken through the department-faculty lines with no procedural attention to cross-faculty priorities. Thus the assertiveness of ideas and strategic input from the Strategic Areas on decisions depends on the interest of opinion- and decision-makers in the faculties, as discussed in the next chapter.

Whatever the reasons, at this point it should simply be noted that the profiling aims have, as yet, only led to **significant efforts in seeking support for centres of excellence and centres of research-based innovation and other major research consortia**. In this respect, major achievements could be noted, though more strongly on expanding excellence on the side of research-based innovation than in expanding the claim on leadership in basic research. 3 of 13 centres of excellence were granted to NTNU in the first round in 2003: Centre for Ships and Ocean Structures, the Centre for the Biology of Memory, the Centre for Quantifiable Quality of Service in Communication Systems. (However, none of the 8 grants went to NTNU in the second round in 2006. 6 of 14 centres of research-based innovation were granted to NTNU and SINTEF in 2006: 3 based at NTNU the Medical Imaging Laboratory for Innovative Future Healthcare, Structural IMpact Laboratory, Center for e-Field and Integrated Operations for Upstream Petroleum Activities, another 3 based at SINTEF with NTNU researchers closely involved: Aquaculture Technology, Concrete Innovation Centre, Norwegian Manufacturing Future. In addition numerous larger EU grants as well as Research Council grants were obtained.

Also, the influence with respect to setting the agenda and defining strategy of the Research Council seems to have been enlarged significantly. The opinion of NTNU researchers for defining research areas is sought and reflected in the decisions of the Council.

In contrast, the expression of profiling aims in terms of prioritising internal resource allocation and, most importantly, in terms of defining academic fields for vacant professorships seems to have been the exception rather than the rule. Only in those areas where the directors of the areas were also deans of a faculty in which these areas were highly present or even dominant playing fields, was such priority setting even mentioned as an aim. Explicitly, only the ICT area has pointed to its strategic prioritisation as a core function "to achieve scientific changes and influence research priorities within the basic formally stable organisation". Indeed the latter have also shown more attention to influencing hiring decisions, within the bounds of faculty budgets. But even here, the evaluators report weak prioritisation of areas with greater scientific performance and potential over others. At institutional level, the rector is reported to have repeatedly asked the faculties to relate their hiring and infrastructural investment proposals to the Strategic Areas, but has abstained, as yet, from stronger steering interventions such as special funds or budget reallocations reserved for hiring professors in the Strategic Areas.

Overall, it can be concluded that **NTNU's interdisciplinary Strategic Areas have not been realised as strong strategic instruments in terms of prioritisation but rather as strategic communication areas**. The important aims associated with this dimension were pursued with energy and application, resulting in a remarkable range of achievements. While the project of expanding NTNU's research strengths through overarching thematic areas may not have been pursued with the same resolution, all evaluators agree that the idea is worth such an effort: "The overall *vision* of the NTNU in setting up and supporting areas of strength is both exciting and appropriate to producing a university of global standing", one evaluation report comments rightly. Hence some suggestions will be made in the next chapter as to how this strategic function of the thematic areas could be reinforced.

In summary, we may give our own estimation of the weight which was *de facto* attributed to the most important aims associated with NTNU's Strategic Areas, on a scale from 1 to 3 (least to most weight):

Contribution to international competitiveness and leadership of NTNU	1
Fostering interdisciplinary cooperation	2 or 3 (depending on the area)
Fostering cooperation with SINTEF	2 or 3 (depending on the area)
Fostering dialogue and partnership with external stakeholders in industry and society	3
Influencing policy making and increasing visibility and success with Research Council	3
Influencing policy making and increasing visibility with European Commission Programmes	3
Increasing international networking	3
Attract researchers	1
Attract students	2

A last comment should be made with respect to the aims of the Strategic Areas, namely on their adaptability to changing conditions. The self-evaluation reports and interviews showed

that several areas have adapted some of the key focuses and aims of the Strategic Areas within the first few years. A very striking example of such adaptability can be found in the ICT area: The ICT area, which joined the group of interdisciplinary areas in 2000, was at first designed to be an instrument to co-ordinate basic ICT research at NTNU across the faculty boundaries. According to ICT representatives, in 2000, basic ICT was fragmented and organised at different faculties, and the different "subcultures" were fighting between each other. The first and most important operational objective was to create a sense of togetherness among the scientists working in core ICT research, for which purpose a research programme on basic ICT (WEBTECH) was established. Further cooperation, identification of common interests and increased visibility led to the formation of the Faculty of Information Technology, Mathematics and Electrical Engineering (IME) in 2002. Thereupon, co-ordination of basic ICT research was "handed over" to the new faculty and WEBTECH was closed. The cooperation focus moved to the background. The formerly secondary focus of the strategic area moved to the foreground, namely to forge links to the ICT appliers.

While the other areas have not shifted the weight of their aims as strongly as the ICT area, they also showed considerable adaptability in redefining their internal focus areas, in response to perceived strengths or cooperation potential (Globalisation). Several SFAs report of different phases of managerial history in which more informal groups have given rise to more formalised ones, larger groups have been converted to smaller more operationally efficient ones. In the Energy area, adaptability is also highlighted as a strength, namely with respect to the ability to adjust to new circumstances as the societal priorities change.

2.2 Key Achievements of the Strategic Areas in Relation to Prioritised Aims

Not surprisingly, the achievements of the strategic focus areas reflect the above-described weights that have been attributed to the different aims. While details will be described in the individual areas' evaluation reports, some highlights may serve to give a sense of the enormous energy, targeted attention and consequent successes which these areas have mobilised.

First and foremost, all evaluation reports highlight the **value and** commend the **substantial efforts which have been invested into fostering interdisciplinary approaches to scientific problems**: Thus the evaluators of the Energy area comment that "the activity within the area is in all respects impressive and especially in the cross-cutting between actors, topics, disciplines etc. This cross-cutting in itself has certainly added value without diluting quality." The SFAs have clearly enhanced the efficiency of interdisciplinary cooperation -- even though there is still room for improvement as the evaluation reports of the areas point out and in spite of the fact that the latter is still somewhat hindered by faculty decision-making and administrative structures (see below).

It seems that all areas have been very **successful at networking** not only in individual projects but as an area of larger thematic interest vis-à-vis national and international partners and stakeholders. Forming larger consortia has not only increased visibility but has enabled the areas
  ▪ to develop, launch and obtain support for larger projects of major national and international proportion, such as the North Hammerfest Campus in Energy and Petroleum or the European Technology Platform in Marine Technology.

- to achieve a considerable increase of national and European grants.
- to successfully influence national (for example: e-government, energy and petroleum policy, materials policy, marine technology) and European policy in the relevant areas.
- to approach industry representatives not only at the level of cooperating researchers but also at the level of strategy development and institutional decision-making. Here, the cooperation between the initiatives of the Strategic Areas and the institutional attention through the rectorate have also contributed to gaining major significance as a key interlocutor for relevant industry sectors.

The **close cooperation between NTNU and industry** is indeed a **particularly impressive feature of the Strategic Areas**. Only Globalisation mentions having problems in mobilising committed industry support for the area (but shows great engagement with other societal concerns and cooperation projects). While it is difficult to ascertain how many of these contacts are really new, the additional strategic component is an important added value that cannot be emphasised enough. Three areas have undertaken major technology foresight initiatives, thereby influencing industrial sector strategies but also government policies. The link between more long term perspectives being advanced through NTNU and industrial application in the medium term should be an important contributing factor to Norwegian competitiveness, especially with respect to the enrichment of resource dependent economies with innovative potential and sustainable perspectives.

Another important aspect of industry cooperation which NTNU's Strategic Areas have offered relates to the **marriage of industrial interests and societal concerns**. From sustainable approaches to resource production and management in energy and marine technology to health and globalisation concerns, the NTNU Strategic Areas have truly realised the vision of the university to be "an academic leader that safeguards and expands Norway's technological expertise" and contributes "to greater understanding of the interaction between culture, society, nature and technology." The systematic search for the interface between industrial advantage and competitiveness on the one hand, and sustainability and societal needs, on the other, would seem to me to be a major contribution of a technological university vs. a technological research department of a large corporation. NTNU has gained a clear institutional profile in this area.

While cooperation with companies is frequent and deeply embedded, the **innovation management** in the more narrow sense of the term (commercialisation, business development) was not described in much detail in terms of output (apart from some patents and start-ups mentioned in ICT and Materials, and Energy). Innovation policy definition in terms of Intellectual Property Protection, which is highlighted as a challenge by some, and guidelines on conflicts of interest etc. is still in its early stages (as in many other places in Europe) Only ICT mentioned seems to have already formulated an IPR policy in dialogue with their industrial partners. Thus, the internal process of formulating guidelines which NTNU has started recently on the same issue is indeed of great importance to realise innovation opportunities without undermining the core values of the institution.

Abundant experience has been accumulated with respect to industry research contracts, however, as ICT, Materials and Energy areas show well, as observed in the evaluation reports. A remarkable achievement in terms of "industry" collaboration has also been reached in the MedTech area with respect to its inclusion of research activities in clinical hospitals so that end users of medical technology, namely the clinicians at hospital, would be enabled to adopt and feed back user perspectives to the medical technology researchers at

university. Such approach could become a unique feature of NTNU and serve as an international model of good practice.

Institutional **cooperation with SINTEF** has also been taken to a new level of intensity which allows common use of facilities, joined positions and is beginning to enable the formulation of common strategic directions, as becomes evident in the areas of Materials (with respect to Nanomat), Energy, Medical Technology and Marine Technology. As NTNU has already emphasised when launching the Strategic Areas, the closer union of NTNU and SINTEF is of major strategic importance to NTNU and greatly enhanced the critical mass and impact of both institutions. A healthy cooperative spirit, common interests and compatible institutional cultures seem to underpin the increasingly close alliance between both institutions.

As mentioned above, the Strategic Areas have also invested considerable energy in **application for Centers of Excellence and Centers of Research-based Innovation**. Clearly, they were quite successful with the Centers of Research-based Innovation and somewhat less so with respect to the Centers of Excellence, a fact which may deserve closer analysis. There is no analysis of the reasons in the self-evaluation reports and only experts are in a position to offer meaningful analyses. The Energy Area shows particular success, having had 3 of their 4 applications for Research-based Innovation Centers granted (together with SINTEF). Clearly the attention to closer and more strategic relation to industry has been rewarded already while building scientific excellence has not been as successful or been made as visible in comparison. Beyond the CoE and CRI grants, most areas have also been very successful in raising other major grants, with external grant income amounting to half of more of the available resources n some areas. This is clearly a sign of commitment and success, but should also raise some questions with respect to the balance between scientific drivers for development versus industrial ones. International leadership in technological research tends to be built on a healthy balance of both.

All of these achievements were strong motivating factors for the launching phase and first build up of the Strategic Areas: **NTNU should thus be commended for having realised these aims so successfully within these five or less years and with relatively moderate additional resources.**

New opportunities and added value have also been created with respect to **researcher training**: Many **new PhD positions** have been created, either through NTNU's internal pool of positions of which 10% were reserved for the Strategic Areas, but even more significantly through external funding. The international attractiveness of NTNU for graduate students seems to vary between the fields. However, recruitment strategies regarding the kinds of qualification requirements which are expected of Norwegian and international PhD candidates were not explicit and would perhaps benefit from some institutional discussion of common excellence standards and requirements.

In the framework of the Strategic Areas, n**ew graduate programmes** were created at Master and PhD level, e.g. International Masters, creating new opportunities for interdisciplinary exploration and problem-solving, producing graduates who are more likely to face complex technological and innovation challenges than those who are educated in traditional disciplinary boundaries. Examples are
- the PhD programme Information and Communications Technology,
- the PhD programme Medical Technology,
- an Erasmus Mundus programme in Security and Mobile Computing,

- international master programme in Gas Technology,
- an international master programmes in globalisation.

Clearly these programmes have created added value to students in terms of possibilities of interdisciplinary exchange. It has not become quite clear, whether or not these opportunities actually relate to a wider range of skills development opportunities for graduates or PhD candidates, including transferable skills which would help prepare candidates for research-based careers inside and outside of Academia (including project and time management, team skills, presentation skills etc.) – an approach which would be in tune with NTNU's wider profile. Of course to some extent such skills development may be impliedin the above-mentioned programmes, but the full use of this potential is not described in the reports and did not become evident during the interviews. Subject-specific transferable skills development is being developed in several countries (UK, NL, Germany) and is welcomed greatly by PhD candidates interested in multiversal career opportunities.

Graduate schools which would provide an overarching institutional, scientific and social context for professors and young researchers have not been established at NTNU yet. This is mainly due to the absence of national incentives (however, some such initiatives may be launched soon). But even without national incentives, the increasing international competition in this respect could have been reason enough to launch some institutional initiatives, especially since the NTNU Strategic Areas provide excellent contexts for scientific exchange and aim to enhance institutional attractiveness to the best qualified graduate students abroad (see further discussion in 3.) Even for national attractiveness, international graduate schools with very visible opportunities for exchange and career development may help to make academic research training an attractive alternative to industry which, the evaluators heard, is offering very competitive positions in terms of payment and career perspectives.

With respect to **student recruitment**, all areas have managed to increase their attractiveness to students considerably, thanks to the thematic organisation and programme focus, both at undergraduate as well as at graduate level. This is emphasised strongly recorded in the Energy, Marine technology, Medical technology, Globalisation areas. The evaluators of the different areas have attested that the momentum of the Strategic Area helps to attract "the best and brightest of students to this area" (Energy). The latter evaluators suggest putting more emphasis on student design projects and student prize competitions to increase student involvement as well as to strengthen student entrepreneurial activities and the spinning off of new ideas to start ups – a recommendation which applies to most other areas as well.

With respect to enhancing national and international attractiveness to potential professors or other researchers, few details were provided in the reports or interviews. A few examples of enhanced attractiveness of NTNU to highly sought-after researchers were mentioned in the areas of Medical Technology (see also section 3.1).

3. Implementation of the Strategic Areas

Having described the range of achievements for which NTNU's Strategic Areas are responsible and which, for the most part, relate to the aims of fostering internal and external thematic cooperation across disciplinary boundaries, one should now look more closely at

some aspects of the implementation of the Strategic Areas. In this context we will ask more specifically, what would be done, in the implementation, to take the label "Strategic" more at heart value so as to identify areas in which there may be room for more ambitious future development of the Strategic Areas.

Before discussing individual aspects of implementation of the Strategic Areas, however, one should note that these areas are the only ones with the label "Strategic" but they are not the only areas which *de facto* function as strategic areas and are supported through strategic institutional resources: In addition to the Strategic Areas, so the evaluators learnt, NTNU has **other instruments and methods and indeed additional areas or centres through which strategic development is reflected or realised**. If the "Strategic Areas" were to deserve their name and the prioritised visibility and communicative attention from which they have benefited in recent years, it would be advisable to embed all areas, institutes, centres, initiatives or areas which have been selected as deserving prioritised institutional attention into a common portfolio and to streamline the instruments with which such prioritisation is realised. This would make leadership decisions and strategic process within the institution more transparent for opinion- and decision-makers. In the following remarks, NTNU's Strategic Areas are looked at from the point of view of the most important methods of implementation.

3.1 Hiring policy

Faculty hiring policy and practice can be regarded as the only way to change an academic institution in a major way, in the long-term. This is particularly true at NTNU where positions tend to be permanent and where tenure is automatic or immediate upon hiring. In all strategic interdisciplinary areas, the evaluators observed that the identification of Strategic Areas has not translated into hiring priorities or practice yet. While some areas reported that the deans of the host faculty considered the relation to Strategic Areas in hiring decisions and it was also mentioned that the rector asked for reference to the Strategic Areas when responding to hiring proposals of the faculties, the Strategic Areas do not yet fully deserve the label "strategic" with respect to faculty hiring practice which, after all, constitute the most important investment decisions at institutional or faculty levels. If NTNU wants to regard its interdisciplinary areas as selected areas of strategic development because of their strengths, potential and relevance, then it would have to draw the consequence to allow decision-making processes to reflect these strategic choices (see section 3.2 and 3.3). Especially in times of expansion, such as the recent years (2002 to 2006) in which the number of faculty members at NTNU increased from 863 to 956, such strategic prioritisation will not be as difficult to implement as in stagnant budget years in which a decrease in budget or positions to any other units would to be the precondition for strategic hiring practice. It appears that in some areas, such as Materials, even the contrary was the case until now, i.e. that the available faculty members to carry out the new responsibilities have decreased during a time of growth of NTNU (and during a time during which the Materials Area was supposed to be a priority): As Figure 1 and 2 show, the FTE positions of the faculties that contribute most to the Strategic Areas have actually stagnated or grown less than other faculties with little Strategic Area involvement.
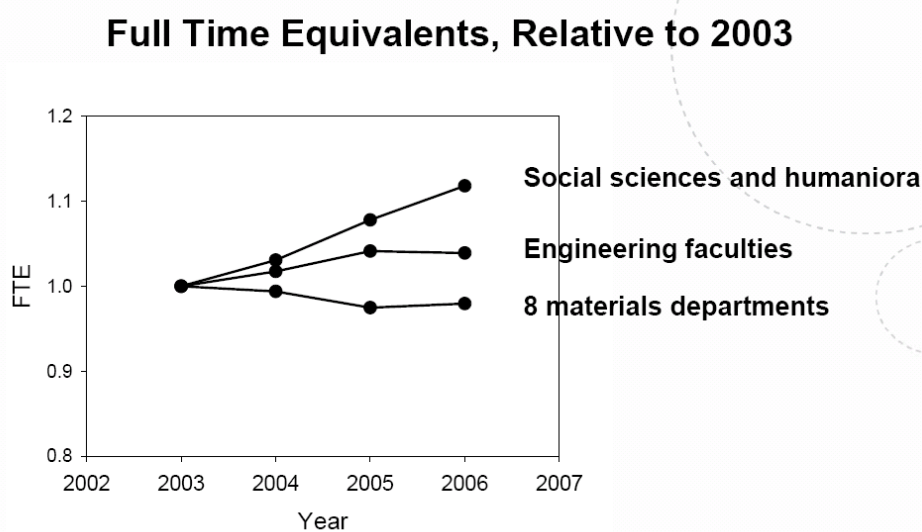
Figure 1: Development of FTE Faculty in Comparison

Full Time Equivalents, Relative to 2003

Source: DBH. Filter: Førstest=ja. Category: Undervisnings- og forskerstillinger

Figure 2: Development of Faculty Positions from 2002 to 2007

Faculty	2002	2003	2004	2005	2006	2007	Change 02-07 in %
Natural science and Technology	145	146	144	146	142	146	0,1 %
Engineering Science and Technology	165	168	173	173	173	170	2,6 %
Information Technology, Mathematics and electrical engineering	136	141	149	156	161	151	10,5 %
Arcitecture and Fine Art	40	41	43	41	40	41	1,5 %
Department of Industrial Economics and Technology Management at Social science and Technology	28	29	28	28	35	30	6,7 %
Sum	**515**	**526**	**537**	**544**	**550**	**537**	**4,1 %**
Medicine	74	85	94	101	106	106	43,5 %
Faculty of Arts	123	125	131	134	135	134	8,7 %
Museum of Natural History and Archaeology	21	14	13	13	15	14	-31,8 %
Social science and Technology without Department of Industrial Economics and Technology Management	130	135	137	149	151	165	27,2 %
Sum	**274**	**274**	**282**	**295**	**301**	**313**	**14,4 %**
Total	**863**	**884**	**913**	**940**	**957**	**956**	**10,8 %**

To help interlacing of faculty line structures and interdisciplinary approaches, NTNU may also consider developing its interdisciplinary approach through **joint appointments** between faculties or, most advantageously, between a given faculty and the strategic area, provided the latter were given a more substantial budget and governance position. Such joint appointments are frequent practice in many institutions which have promoted interdisciplinary structures.

Finally, in addition to faculty hiring, post-doctoral and doctoral researchers are clearly important recruitment decisions. While NTNU has invested a significant percentage of its institutional PhD positions to its Strategic Areas (10%), the evaluators were wondering whether the selection of the areas could not have been reflected in even more emphatic support in this respect. Especially with respect to internationally advertised post-doc positions, additional institutional support could have helped raise attractiveness further in some areas. In several areas it was reported that the heavy reliance on external funds and the one year duration of internal funds made competitive hiring difficult.

3.2 Strategic development process

The Strategic Areas have truly been strategic from the point of view of their willingness to approach the thematic range of scientific fields with **strategic foresight and imagination**. Moreover, they have used their intensified contacts with external partners to develop a wider transinstitutional perspectives for strategic vision. The foresight exercises which the areas of Marine Technology, Energy and Medical Technology have undertaken for key issues in their areas attest to such strategic awareness. At the level of institutional development, strategic thinking was equally developed, as shown in the Energy, Marine and Materials Area, for example. The strategic area plan for 2007 –2012 developed in the Materials strategic area was described by the evaluators as "an excellent example of responding to both current opportunities and future developments." In the ICT area, an initiative to create an agreed research strategy will be taken in the autumn of 2007, bringing together core ICT, cross-discipline interests, Norwegian ICT industry and different ICT user perspectives.

With respect to instruments of implementation, however, the strategic plans which have already been formulated remain rather vague in so far as they give implementation resource detail at all. While there is a clear analysis of institutional strenghts and opportunities in relation to the area there are **neither business plans nor hiring plans attached to this strategic analysis**.

This latter shortcoming is probably a consequence of the **weak position which the Strategic Areas still hold in relation to the faculty line decision-making**. Strategic decisions are made at faculty level, after in depth consultation with the departments where future perspectives are first formulated. The only way in which the Strategic Areas can realise their own strategic development ideas is by appealing to the deans, first and foremost of the faculty which hosts the areas but also to the other faculties concerned, most often through individual representatives of the area who belong to that faculty. In most areas it was particularly in the non-host faculties that the Strategic Areas had a weak standing. Sometimes they were even disadvantaged since they were viewed as already having received some extra funds through the institutional support. As already emphasised with respect to hiring policy, this weakness will have to be redressed if the Strategic Areas are really meant to function as areas of scientific and institutional development in areas of major potential for future competitiveness. Especially, if NTNU is sincere about its most recently formulated institutional goals with respect to international standing, its selected areas of highest potential should receive all the support they can get in terms of faculty positions for hiring, including funds for competitive international hires, infrastructural investment, and reallocation of funds, in addition to the excellent communicational support they already receive.

With all due belief in the benefits of forward looking strategic perspectives, some cautionary remarks should also be made with respect to a desirable **balance** between academic initiative and **academic freedom**, on the one hand, **and steering through focus areas and priorities**, on the other. While the latter approach is highly beneficial for institutions which cannot develop all areas into positions of international competitiveness or leadership, some flexibility and room has to be maintained for all those unforeseeable developments and new uprising areas. Hence, mechanisms and resources should remain in the system, at institutional and faculty level, to identify and support such new kernels of excellence. Such balance is rightly sought also within the Strategic Areas, as is well expressed in the ICT Area, for example: "The programmes naturally are supposed to expand research through projects according to the predefined scientific strategy developed by the programme. On the other hand, in order to maintain scientific freedom, programmes are not to enforce negative control over project initiatives in the scientific community."

3.3 Governance and Leadership

The governance of the Strategic Areas should be commented upon in two respects: first, regarding their internal governing structures, and second with respect to the relation of such governance to the established dominant mode of governance through faculty lines.

Looking at the internal governance of the Strategic Areas, one should first mention the important function of the Strategic Areas' **Boards** which play a strategic and advisory role in most areas as well as ensuring access to larger scale strategic industrial or political perspectives. Most boards have significant industrial presence. ICT has organised boards even for sub-focus areas (ICT). In general, these boards seem to have been vital for the increased strategic awareness and visibility of the areas. In order to keep their presence at a sufficiently high multiplier level, it is important that there be a limited number of such boards. Otherwise it will not be possible for the central NTNU leadership to pay due attention to the boards of the areas, which provides an important additional weight and impact to these boards and contacts. External board members should be key institutional partners of NTNU and be looked after accordingly. NTNU leadership seems to have done an excellent job of doing this. Hence care should be taken tomake sure that such attention can also be paid in the future.

The relation of the Strategic Areas' leadership to the **NTNU board** is described as excellent in so far as the NTNU is seen as having acted very positively as "coaches" and door openers in national and international contexts. In particular, the institutional support for strategic international relations was highly appreciated as an excellent and vital help (E&P).
Of course, the rector is the key person in the whole enterprise of the Strategic Areas. As head of both the basic structure of the university and the thematic areas the **rector** is the most important function for the university "to play the matrix well" (ICT). Indeed the main academic relation of the Strategic Area to the university structure is judged to be through the work of Rector. After the administrative reorganisation of the university in 2005, the Prorector of Research, handles relations to the Strategic Areas from the central level, supported by the staff of Rector. While this distribution of responsibilities is in the interest of efficiency or institutional support, it should be ensured that the Strategic Areas still receive sufficient direct support and strategic attention from the rector. The link to quality enhancement and innovation in teaching should also be looked after at institutional level through focussed meetings on the links between the Strategic Areas and institutional

development measures in teaching and learning. It seems that in this area, significant potential could still be realised.

The director of the Strategic Areas is clearly decisive for its momentum, development and success. The scientific vision, persistence, communicative openness toward external stakeholders and negotiative abilities of the director contribute enormously to the development of the areas. A very positive example of such leadership was witnessed, for example, in the Strategic Area Energy.

Four Strategic Areas have decided to ensure smooth interface with the host faculty by making its **dean** their **director**. As the ICT report comments: "That the Dean at IME holds the double position as Director of ICT makes it easier to "play the matrix well" between basic ICT and applications." Likewise, the Medical Technology Strategic Area "recognized from the beginning that the strategic area of medical technology should be directed by the Dean of the Faculty of Medicine, combining a good link to the university hospital and good integration with university policy and priorities." In the Materials Area, the deans of two faculties sit on the board. While the dean-directorship clearly offers negotiating and operational advantage vis-à-vis the host faculty, this arrangement does not strengthen its position in the other faculties, as is reported by the Marine Technology Area, Materials, Medical Technology and Globalisation. Moreover, several deans acknowledge that the work load of being a devoted director of a Strategic Area as well as being a dean of a large faculty is practically infeasible. Thus the Materials Evaluators note that there is an insufficient number of common meetings, for example, that would help include researchers from other departments keep informed and that there is even inherent conflict of interest (and time, and commitment) between Faculty duties and Area duties. Last not least, the evaluators point out that the dean's own scientific work is not central to the thrust of the area which does not help to sustain the drive and enthusiasm it needs to push such a major enterprise forward. The institutional argument (presented in documents before the evaluation meeting) that a dean has the budget authority to push an area more effectively, was revealed to be weak since the Faculty of Natural Sciences and Engineering have hardly benefited from being the one most widely involved in the Strategic Areas.

Therefore, to the evaluators, it would seem preferable to solve the problem of governance between faculty structures and Strategic Areas in a fundamental and transparent manner, rather than the more make-shift solution through coinciding directorship and deanship.

For the future, the **director position should become a full position**, combinable with some research duties but should be granted dispensation from teaching duties in order to make sure that sufficient time may be invested into the further development of the area. Particularly successful internationally renowned scientists or scholars with excellent record in management and networking should be appointed to the position, to allow international and national visibility. As confirmed by reports from the Strategic Areas, pro-active ambitious development of such cross-disciplinary and cross-faculty efforts have to be led by "champions" in order to thrive. As will be described in section 3.4, the Strategic Areas should be able to dispose over sufficient resources and positions to allow for strategic manoeuvring. In addition, the consultation, decision-making and reporting structures between the faculty lines and the Strategic Areas should be made clear. If NTNU decides to maintain the current governance structures and resources of one, several or all areas, these should be renamed Interdisciplinary Platforms or Clusters, to avoid misunderstanding.

The relation of the Strategic Areas to faculty structures is a salient point of concern and attention in all Areas. Several areas have taken care to create executive boards which represent the different faculties involved in the area. In the MedTech Strategic Area, activities were initially organised in thematic groups, each often spanning several faculties. In order to strengthen integration of medical technology into the strategies of all the relevant NTNU faculties and increase their commitment to the strategic area, the organisation was revised in 2006 to have the five relevant NTNU faculties directly represented in the management group of the strategic area. In addition, research and educational activities are further organised in thematic network groups, covering professors, researcher scientists, PhD students and post-docs from the different faculties and departments in each specific area. In ICT, the head of each Programme, who is appointed by the director of ICT after discussions within the scientific community and leaders of the departments involved, is always selected from different Faculties in order to embed cross-faculty co-operation in the formal structure.

However, here as well as in all the other areas, leaders emphasise that **cross-disciplinary cooperation within and between faculties** should be more recognized at central level, made not only visible but also be **given more power of assertion, in order to meet NTNU objectives for the future**. **Problems with respect to the relations between the Stratgic Areas and the faculties** are reported in all Strategic Areas, in the Self-Evaluation Reports as well as during the interviews. A very clear description of the problem, which applies just as much to the other areas, is given in the MedTech report:

> "NTNU has a strong focus on the faculties with respect to organisation. Through inter-faculty collaborations we have experienced that this often can be a significant obstacle with respect to collaboration. In many cases such collaborations are penalised rather than rewarded. (p.15)

> Inter-disciplinary research meets a number of challenges since its activities have to go across borders between the traditionally discipline-oriented faculties of NTNU. There is also a trend that academic activities tend to be the subject of increasing organisation in terms of planning, financing, and reporting. And these activities are all channelled through the NTNU faculty structure and have a tendency to create new hindrances for collaboration between faculties and departments. Inter-disciplinary projects that previously could be organised in an informal and ad hoc manner now must be formally included in the activities of respective faculties. This is of importance for more focussed leadership in the university, but problems arise when the administrative procedures do not facilitate management of inter- faculty activities to the same extent as they facilitate intra-faculty activities. In establishing the organisation of NTNU, emphasis has naturally first been on establishing good procedures for intra-faculty activities, whereas corresponding facilitation of inter-faculty activities may be lacking. Inter-disciplinary activities of the individual researcher may be marginalised and considered of low merit within her/his home department. Inter-disciplinary projects may be considered of low priority since they fall outside the mainstream activity of the unit in question. This applies both on the level of departments and faculties at NTNU, as well as in evaluation of research proposals within the various study sections of the Research Council of Norway and other granting bodies. Establishment of the strategic research areas at NTNU is certainly intended to alleviate the above-mentioned problems. Much has been achieved, but problems are still experienced e.g. in prioritising research projects and allocating stipend resources, in sharing credit and expenses of inter-faculty activities, as well as in daily administrative procedures." (p.17)

The Marine Technology Area also mentioned problems, e.g. with respect ot fellowship distribution: While some fellowships were distributed directly to the Strategic Areas, others were allocated to the strategic programmes at faculty or departmental level. Here many difficulties arose because of faculty priority setting as against SFA interests. PhD candidates may also experience some difficulties with respect to what some of them have termed 'double belonging', fearing that this might hinder progression in their own projects. This is especially noticeable in the final year of the PhD period.

3.4 Resource Allocation

NTNU's Interdisciplinary Strategic Areas are in double need of support. First, because cross-disciplinarians are not always positively received by disciplinarians so that top-level support is necessary to push their ideas and plans forward. Second, they deserve prioritised support because they were identified as those areas in which NTNU has particular potential to develop international visibility and scientific leadership. Until now, the Strategic Areas have received an annual 2 million Norwegian Krona (€260637), in addition to 10% of the internal PhD positions p.a.. Thus, the Strategic Areas have not yet benefited from true strategic prioritisation in terms of resources and had to rely mostly on resources from external sources, which implies that funding became available for research projects and project-related equipment and PhD positions but not for larger infrastructures or, most importantly, for more permanent positions. Indeed, the overall budget development of NTNU does not seem to reflect the choice of Strategic Areas at all. If we look at the development of faculty budgets over the relevant period, the two faculties with the highest growth rate (around 40% since 2002) were those with the least involvement in Strategic Areas (in terms of volume of researchers) such as the Faculties of Social Sciences and Humanities and the Faculty of Arts while those with the highest engagement, such as the Faculty of Engineering Sciences, Medicine show significantly slower growth (10% or -8% respectively). Natural Sciences and Information Technology, Mathematics and Engineering are placed in the middle range. Likewise, in faculty positions, we find no reflection of the Strategic Areas in terms of hiring priorities in the same period (see also 3.1).

The evaluators all agreed that the third institutional "profiling" goal which NTNU defined in its Strategy NTNU 2020 ("to be internationally leading in selected Strategic Areas") is indeed attainable with the right kinds of investments and support, and that Strategic Areas, if supported accordingly can greatly assist in moving NTNU upward in both international institutional rankings or research performance. But while the Strategic Areas are the right approach and concept, the required funding and implementation instruments must be made commensurate with the new mission for these Areas. NTNU's Strategic Areas cannot be effective if the institutional investments are diffuse, i.e. spreading money and positions around by a process which does not follow Strategic Area goals. Until now the Strategic Areas were only used as interdisciplinary cooperation platforms from which internal and external development could become more visible. However, as new opportunities and common interests have had a few years to emerge and ripen, they have matured enough to deserve prioritised investment to reflect true institutional commitment to the Areas as "Strategic Areas".

The evaluators have noted with interest that NTNU's Strategic Means have increased from 11% to 16% of the budget. It appears from the order of magnitude of these funds that these strategic means encompass a lot more than the aforementioned annual support for coordination and events or a few PhD positions. As emphasised before, it would be helpful for insiders and outsiders of NTNU to have a full overview of all strategic priorities which clearly comprise more than the Strategic Areas, such as, e.g. the Centers of Excellence and the Nanolab. Naturally, the full range of strategic priority areas would also include disciplinary areas of excellence which should have the same status and visibility as the interdisciplinary Strategic Areas since it is the excellence of academic standards that is responsible for the prioritised status. In any case, the internal selection and evaluation process and criteria, consequent support measures (in terms of hiring priorities and other strategic resources) and other forms of public and international relations support should be made transparent for

internal and external users, as a measure for ensuring institutional peace (through rational process) but also as an incentive for new areas to rise to that status.

3.5 Effect on Teaching and Graduate structures

With respect to **teaching**, the Strategic Areas have the mandate to propose whole study programmes and courses integrated in other study programmes. However, study programmes are the responsibility of the faculties, which poses some problems with respect to recognition of interdisciplinary course modules i.e. for their integration into existing teaching offer.

While the Strategic Areas have resulted in the development of several international masters and other programmes (see 2.2) it is not clear that the new opportunities which emerged in the context of new collaborative projects with industry or SINTEF, have resulted in new opportunities for research or other projects at advanced undergraduate level. Also, as mentioned before the possibilities for transferable skills development which the close relations with industry may offer in this context seem to not be exploited fully.

The biggest opportunity, however, lies in the development of internationally competitive graduate structures. Such graduate schools are currently being developed with great success and appeal to qualified graduate students all over Europe, following the success but not the model of the graduate schools of American research universities, with multiple opportunities for disciplinary and interdisciplinary exchange fora, integrated intnerational mobility, coached opportunities to foster presentation and assertion skills at international conferences, closer interchange between graduate students and senior researchers from other relevant fields (apart from their supervisors) and sometimes also opportunities for mentoring from industry leaders. Such well structured collectively reflected support structures are highly appreciated by graduate students, as recent experience shows (see reports of the Graduate Training support at DFG in Germany, the British good practice examples collected by the UK Graduate Programme or the Ecoles Doctorales in France, such as the one in Paris VI Pierre et Marie Curie).

NTNU's Strategic Areas are already in an optimal position to offer such optimised graduate support since the larger scientific exchange platforms have already been created, subject specific programme content developed and international visibility systematically promoted even at institutional level. If the Strategic Areas could take these ingredients and add agreed highest standards of quality of (co-)supervision and coaching, subject-specific career development measures (with a view also to careers in research intensive industry) and integrated promotion of access for young researchers to the international scientific community, including privileged occasions to discuss scientific interests with well-known scientists from other institutions abroad, NTNU would establish itself as a highly competitive research environment for the best graduate students from all over the world. Joint projects and programmes and close partnership with other institutions in Norway or abroad, would form an integral part of such structures but the quality standards and expectations regarding graduate profile and exposure to external stakeholders would follow NTNU's own unique institutional profile. Combined with the already remarkable proactive and strategic approach to international relations, such graduate schools would be an ideal method to spread news about NTNU's strengths to a large range of international communities. The evaluators agree that such opportunities should not be missed. One may also point out that they do not necessarily

require a heavy administrative structure. The Dutch examples of Research Schools may provide a helpful model in this respect.

Given the overlap of research policy interests and communicative tasks the position of dean of the graduate school could be filled by the director of the Strategic Area, provided that position is organised in the manner recommended above in 3.3.

3.6 Sharing and joint development of infrastructures

In several Strategic Areas, such as Medical Technology, Marine Technology and Energy, joint development and use of major scientific infrastructures has been an important feature and success of the areas' activities. Such developments are of course highly commendable, not only as an increase of efficient use of resources but also from the point of view of connecting infrastructural development with strategic priorities. For the future, infrastructural development, especially with respect to major scientific facilities should continue to be treated as an integral part of strategic development, connected also with hiring policy which ma often imply investments in scientific infrastructure. Developing and sharing scientific facilities may even become in some instances a connective tissue between different research groups as examples in life sciences and science parks often show.

3.7 Measuring and monitoring success

Strategic aims require strategic information in order to judge current position, define realistic but ambitious targets, to observe progress and to know whether the targets are met. Without such information, steering becomes virtually impossible. NTNU has set ambitious aims for itself, in its most recent strategic plan as well as in the Strategic Areas. At the moment. However, NTNU is not yet in a position to be able to measure its success or progress toward these aims, as the rectorate openly admitted. Thus, a set of key sets of information and data has been put together as a basis for future reference. The evaluators agree that action on this fron is urgently needed since setting a basis for comparable data may take some time and progress can currently not be measured in terms of the goals that were set. In addition to internationally comparable bibliometric and other quantitative data to measure quantity of output and international visibility, qualitative data is needed. Other institutions which are interested in international positioning, often resort to letting the faculties or units themselves define what the best internationally recognised journals or invited talks or key notes or other awards may be, so that the measures of success really reflect quality rather than quantity of output. In addition to such absolute data on NTNU's successes in research, teaching and innovation, the evaluators have found a curious absence of comparative information or benchmarking reflections on NTNU's position in relation to other Norwegian universities and international competitors in related areas, to help define uniqueness of profile and possible gaps in competences needed to complete the niche in which NTNU could claim international leadership. To reach its ambitious positioning goals, NTNU should develop this competitive and comparative awareness of its co-runners, not just at the level of individual research groups where this probably already happens, but also at the level of the Strategic Areas. Such benchmarking analysis of strengths and weaknesses (of a qualitative nature, but supported by quantitative data) of NTNU's position vis-à-vis others in the arena, should form part of the Strategic Areas' or Faculties' proposals for hiring and infrastructural development, since it underpins the design of future positioning of the area. Especially for the purposes of major investments such as highly competitive hiring of international scientists from expensive

research environments, such a sense of comparative strengths and weaknesses should be a conditio sine qua non.

To conclude, one should emphasise again that, as yet, there is a considerable disconnection between the recently sharpened and ambitious broad institutional goals for the Strategic Areas ("raising the level of NTNU in world opinion"), and the methods and means of implementation currently in place. While the current goals were formulated after the Strategic Areas were established with a different set of primary aims, the evaluators believe that the Strategic Areas can be instrumental in accomplishing the new goals, on the condition that they be given sufficient resources and resolve. The proposal of a SINTEF representative who thought that most of the problems with implementation of the Strategic Areas could be addressed by simply multiplying the allocation by 10, to NOK 20 million per year, per area, may not be an unreasonable suggestion, at least for some areas. But resources are not the only point on the list of what the evaluators believe would be required to give the "Strategic" Areas more strategic thrust:

1. Appointment (in consultation with the current Strategic Area faculty) of **Directors** who do not have other administrative duties, who are central to the scientific and technical thrust of the Area, and who have the time, initiative, skills, commitment, contacts and persistence to accomplish the objectives in the long term. The competences and resources given to these directors should be commensurate to the responsibility.

2. Provision of **resources** (money and/or faculty positions) **commensurate with the goals** and objectives. As a possible guideline, half of new faculty positions (and correlated funding) could be allocated to the Strategic Areas, through the Director. By leveraging these resources in negotiation with Faculties and Partners, this should provide a double impact. This investment would represent more than 5% of the NTNU budget, as opposed to the current ratio of approximately 0.5% allocated to Strategic Areas.

3. Increased **transparency with respect to the entire range of strategic areas and centers, and instruments of support**, with previously agreed criteria of selection, criteria of (dis)continuation or support, **concrete goals** and **objectively measurable or intersubjectively verifiable targets,** by the Rectorate for Strategic Areas (hiring record for vacancies, recruitment success in terms of younger researchers, publications, external support, and so on), following the first steps taken in this direction through the formulation of the Strategic Performance Data. Naturally, the goals and targets and measures of success should be adapted to the areas' own criteria of excellence but should be of equal ambition across the fields. The goals should also be set inside of each Strategic Area in view of a Strategic Plan for the next 5-10 years. Thus careful monitoring of results can help rigorous and continuous self-improvement and possibly adapatation of goals.

4. Creation of **International Graduate Schools** linked to the Strategic Areas, with coherent excellence standards in terms of supervision, interdisciplinary exchange, access to other senior researchers and the international research community, subject-relevant transferable skills training and relations or mentoring by external partners.

5. Closer **connections and responsibility of Strategic Areas to the Rectorate**, not to the Faculties, including frequent meetings between the Rectorate and Directors, some of which should be one-on-one. Of course, all hiring should be negotiated also with Faculties and

Departments, who presumably will provide some of their resources to match the Strategic Area resources. The interlacing of faculty plans and Strategic Area plans will be an important success factor for the long term impact of the priorities.

5. Clarification and review of the **governance relations between the Strategic Areas and the Faculties**, especially with respect to strategy decisions.

6. **Resolved strategic leadership of the rector and his board** with respect to realisation of institutional priorities once these have been set on the basis of consensually agreed process and criteria.

6. **Periodic internal and external reviews of Strategic Area performance** informed by internationally comparable data, adapted to international excellence criteria in the areas, in addition to self and external evaluation (similar to the current one.) A light internal evaluation could be performed annually and form the basis of a forward-looking discussion of aims and targets between the Strategic Area's Director, the relevant deans and the rector.

ANNEX: Examples for Institutional Approaches to Fostering Interdisciplinarity

Universities worldwide have recognized that, in order to successfully facilitate interdisciplinarity, they must adopt new environments and practices.

1. Multiple Structures for Fostering Interdisciplinary Research and Learning

1.1 Stanford University:

For example, a grass-roots effort by faculty and students at Stanford University resulted in a new program called Bio-X, which explores the intersections among biology, computer science, medicine, and engineering. The program is housed in a new building, the Clark Center, which opened in 2003. Situated along the pathways between the university and the medical center, the Clark Center is designed to both express and facilitate the concept of interdisciplinarity. Each lab is equipped with at least two scientists from each of the participating disciplines, but they are by no means fixed: for example, walls can be moved (or eliminated), and all equipment is on wheels. The entire building is designed to facilitate interdisciplinary communication and to accommodate new, rapid, and unexpected growth as it occurs.

The Stanford **Medical School** has drawn attention to the challenges of interdisciplinary cooperation in its strategic plan: "To achieve our goal of strong interdisciplinary research, we will address the following initiatives:
- Hold a research retreat to establish new program priorities.
- Create a dean's reserve of funding for interdisciplinary programs.
- Develop governance mechanisms for interdisciplinary programs and organizational models for medical school institutes.
- Create a dean's research seminar series featuring interdisciplinary projects.
- Establish a faculty research network website to provide information on faculty research interests and collaborative opportunities.

Associated with these initiatives responsibilities have been fixed:
- Hold a research retreat to establish new program priorities: The Senior Associate Dean for Research will work with the faculty research committee to establish a focused program and agenda for a retreat to develop proposals to establish research program and resource priorities. An initial research retreat to be held in FY2002-2003.
- Establish guidelines for the creation and governance of interdisciplinary organizations: The Senior Associate Dean for Research will continue the development of the proposed policies and procedures for medical school institutes, in general, and a Stanford Cancer/Stem Cell Biology Institute, in particular. Both documents will be reviewed by the faculty research committee and brought to the medical school executive committee for review and approval. The other Institutes currently slated for development include the Stanford Neurosciences Institute, Stanford Cardiovascular Institute and the Stanford Institute on Infection and Immunity. Initial guidelines are targeted for review in FY2002-2003.
- Create a faculty research network website: The Senior Associate Dean for Research with support from the Senior Associate Dean for Information Resources and Technology, will continue the development of a Faculty Research Network website. An initial production version of the website is currently scheduled for completion in FY2002-2003.

Another example is Stanford's initiatives and programs in the area of **environment and sustainability** (http://environment.stanford.edu/) which is both oriented to public awareness of environmental issues as well as seeking to enable students and faculty to better respond to these same challenges. Included in this domain is the Earth, Energy, and Environmental Sciences (EEES) graduate program which aims to complement the disciplinary Earth Science and Engineering programs offered within the departments of the School of Earth Sciences. It trains graduate students to integrate knowledge from these disciplines through tools and methods needed to evaluate the linkages among physical, chemical, and biological systems of the Earth, and understand the dynamics or evolution of these integrated systems and the resources they provide. Interestingly, a key emphasis is placed on new student qualifications and training a new generation of versatile experts and leaders: "Students in EEES must make significant headway in, and combine insights from, more than one scientific discipline. For example, a student whose goal is to understand the structure of the Earth's interior using computational methods might design a study plan that includes high-level mathematics, numerical modeling, and geophysical imaging techniques. A student interested in water management might integrate water flow analysis

and modeling, geophysical imaging, geostatistics, and satellite remote sensing of changes in agricultural intensity and land use. A student interested in marine carbon cycling might use knowledge and tools from numerical modeling, marine biogeochemistry and geochemistry, oceanography, and satellite imaging. The key to the program is its academic flexibility and ability to exploit an increasingly interdisciplinary faculty, particularly in the School of Earth Sciences, but also in the greater Stanford community."

Likewise, new student qualifications and the ability to address new, larger and more complex research questions are at the heart of Stanford's Interdisciplinary Graduate Program in Environment and Resources as well as its Woods Institute. The former draws upon 50 members of faculty from all seven schools at Stanford to assemble a team of advisors who provide guidance on their research design, methods and connections beyond Stanford. Beyond or behind the program there is the Woods Institute as well as other researchers who are loosely coupled to the area. ("More than 250 faculty and research professionals from across all seven schools, plus independent labs and centers, conduct environmental research at Stanford; of those, nearly 100 are involved directly with the Woods Institute.") Interdisciplinary research and teaching is seen to be required in order to address new scientific and societal challenges: "because these challenges are too complex to solve by traditional disciplinary approaches alone, we must work on far broader interdisciplinary scales than we ever have. We also must bridge our knowledge with the applied expertise of decision-makers outside the university, so that effective ideas get translated into action. We are working with many partner organizations, from research institutions and other universities to NGOs and local, regional, national and international government agencies. Finally, we must concentrate our work in areas where our expertise affords us the greatest potential to make the most significant contributions."

One should note that the institutional structures and interrelations seem quite intransparent, with centers, programs, departments and institutes overlapping and interlacing in rather free-spirited manner. The only thing they all have in common is that they all receive substantial extra institutional and external support, attention and networking opportunities.

The Interdisciplinary Program and Institute is linked to selected focal areas "where Stanford already has great strengths and where we believe our efforts are likely to have the biggest impact" (Energy and Climate Systems, Land Use and Conservation, Oceans and Estuaries, Freshwater).

To encourage collaborative research with external researchers and stakeholders, the Woods Institute is developing three major research programs:
1. Environmental Venture Projects: The EVP program provides seed funding for promising, potentially transformative research involving interdisciplinary teams of Stanford faculty.
2. Strategic Collaborations.: The institute supports major collaborations involving outstanding Stanford researchers who are combining forces with organizations beyond the campus to address global sustainability challenges. Current collaborations focus on natural capital, climate change goals in California, energy efficiency, food security and oceans.
3. Affiliates program: The Woods Institute will be launching an affiliates program to help businesses meet sustainability challenges. Interdisciplinary teams of Stanford experts will work with participating companies on issues ranging from end-use energy efficiency to supply-chain security to sustainable land-use management. The program will support a variety of activities, including
   - exploratory research into novel solutions to issues of common concern;
   - strategic problem-solving workshops;
   - Ph.D. support programs that match students with company mentors in areas of mutual interest; and
   - opportunities for company scientists to collaborate with Stanford researchers on a visiting basis.

The ability to attract highly qualified motivated students is a strong driving force for the area, as reflected in its web site for future students:

This is an exciting time to be at Stanford. Through the university-wide Initiative on the Environment and Sustainability, we are literally changing the way the university engages with the world on critical issues that will affect human health and the environment for decades to come.

The Woods Institute for the Environment serves as the interdisciplinary catalyst and hub for this effort, involving students, faculty and staff in exciting, ground-breaking research, education and leadership, and problem-solving activities. There are many outstanding opportunities here for involvement by undergraduate and graduate students; we encourage you to learn more!

1.2 ETH Zurich

ETH Zurich's approach to interdisciplinary cooperation and prioritised support is embedded in a highly differentiated internal research fund which comprises different research incentives for different purposes. These funds are allocated on a competitive basis by ETH's internal Research Commission, with support from international peers. There are several types of support for

- individual risky research and
- interdisciplinary projects (polyprojects)
- Larger consortia/ interdisciplinary platforms with a need for increased coordination and external visibility
- Innovation Initiatives (Strategic Areas with future hiring potential)
- Competence Centers
- Common Research Facilities

12- 20 Million CHF (8 – 14 Million Euro) or ETH's annual budget are reserved for these internal research innovation incentives as strategic institutional reserves, to complement external third party funding opportunities.

ETH's Planning commission looks after interdisciplinary hiring interests, on the basis of an analysis of departmental plans. The Planning Commission and the Research Commission combine forces to evaluate the Innovation Initiatives and to suggest consequences in terms of future hiring.

An important additional perspective is brought in by the President's comparatively large competence on hiring decisions. He or she has the last word on the composition of the hiring commissions (upon faculty proposal), e.g. by safeguarding the interdisciplinary and qualitative standards of the commissions, safeguards consideration of relevant disciplines in the advertisement of positions, may propose clusters advertisements in cognate areas, and disposes over strategic funds for larger hiring initiatives (e.g. systems biology) or high-cost hiring. He or she also negotiates with the candidates and has means to do so.
10% of new vacancies are reserved for strategic hiring in response to outcomes of the strategic Innovation Initiatives.

2. Coherent Institutional Approaches to Interdisciplinary Initiatives

2.1 University of British Columbia, Canada:

After years of abundant interdisciplinary initiatives and programs, UBC nevertheless saw the need to create an institutional structure to serve the interests of such activities. In October 2006, UBC's Senate approved the creation of a new College for Interdisciplinary Studies, effective January 1, 2007. The 35 interdisciplinary research units, two Colleges, and twelve interdisciplinary programs previously within the Faculty of Graduate Studies moved to the College, and the mandate was broadened to include supporting interdisciplinarity across the entire university at both undergraduate and graduate levels. Almost all of the 93 current faculty members in the College are jointly or cross-appointed between a research unit within the College and at least one other research unit, department, or faculty.

2.2 University of Toronto, Canada:

In its strategic plan "Stepping Up", the University of Toronto prioritises interdisciplinary initiatives as one of five key areas for its future actions: "2. Bring scholars and students from diverse disciplines together to meet scholarly challenges through interdisciplinary, interdepartmental, interdivisional and collaborations across campuses and with affiliated institutions."[2]

Toronto leadership believes that interdisciplinary activity is most successful when it emerges from interactions among faculty and students. Therefore, the University facilitates on an ongoing basis the development and maturation of focal areas for interdisciplinary activities that have been identified as priorities by multiple divisions.

In developing interdisciplinary initiatives, particular attention is paid to the tri–campus and multi-site structure. This includes ensuring that faculty and students from multiple campuses can be engaged in those initiatives that span across more than one campus, and also identifying initiatives that are unique to individual campuses. In addition, the University has affiliation with a wide variety of institutions and initiatives involving these institutions should be cultivated and nurtured.

A workshop conducted by the Provost's office identified some key challenges to interdisciplinary activity, such as: the extra work that is often required to engage in interdisciplinary activities; the lack of recognition at times for this type of work from colleagues; the lack of alignment of budgetary systems and incentives with such activity; the administrative challenges of sustaining smaller centres and institutes; and the sometimes unclear reporting arrangements for interdisciplinary groupings. Any changes to the University's budget model must ensure that the specific challenges in working across divisional boundaries are addressed. Success of these initiatives is measured through benchmarks that evaluate the quality and quantity of interdisciplinary, interdivisional and intercampus teaching and scholarship.

2.3 Aachen|s Interdisciplinary Forums

In 1989, RWTH Aachen University established five interdisciplinary forums with the goal of intensifying the exchange between Research and Development within the University, of planning and coordinating interdisciplinary research projects, as well as carrying out interdisciplinary courses and advanced training. The Forums are seen as indispensable instruments to open up innovation potential at the interfaces between the faculties. The Forums, which are not limited in time, are seen as flexible networks between faculty structures (interaction platforms), as contacts for interdisciplinary initiatives and as instigators for new research approaches such as Collaborative Research Centres, Research Training Groups, etc. The Forums are administered by a Central Office, independent of the Faculties. The Forums are financed by membership fees of the professors (who voluntarily join the Forums) and by the Rectorate through the allocation of positions for the administration. Controlling takes place through the Forums' Speaker's Council and a number of Collaborative Research Centres and Research Training Groups.

In addition to interdisciplinary research carried out by the representatives of the different working groups within the Forums, the scientists of the Forums offer interdisciplinary classes and degree programmes in order to give students an insight into the diversity of science beyond disciplinary boundaries. Communication with external

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[2] *http://www.steppingup.utoronto.ca/synthesis2.asp#2*

stakeholders and research and innovation partners is the third key dimension of the forums. Focal areas comprise:

- **Environmental research** (Energy, Water, Biomass, Resource and waste management)
- **Materials science research** (Materials science, Materials technology)
- **Computer Science** (Mobile communication, Virtual/augmented reality , eLearning)
- **Life Sciences** (Intra- and intercellular communication, Bioactive molecular connections, Biohybrid systems, biomaterials, cell surface interaction)
  Technology and Society (Technology cultures, Man and automatisation, Intercultures)
- **Transport** (Assistance systems, Mobility and transport, Automotive engineering)