North Carolina State University

Department of Physics

Report of the Strategic Planning Committee

January 12, 2000

Sayers (chair), Aspnes, Beichner, Ellison, Fornes, Krim, & Mitchell

Charge: In consultation with all Physics Department stakeholders, develop a ten-year strategic plan for the Physics Department consisting of three parts: a) A vision statement and goals for the coming decade. b) Assessment indices comparing the Department with aspirational peer institutions c) An implementation strategy for achieving our ten year goals

Submitted by the Strategic Planning Committee January 10, 2000

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Department of Physics
Strategic Plan
Executive Summary

In its Strategic Plan the Physics Department of NCSU has set a vision of sharply increased recognition for its research and educational programs and improved service to the State of North Carolina by 2010. The implementation plan outlines the steps that we believe are needed to implement the Strategic Plan and accomplish the Physics Department vision. It will cover both general and specific aspects of faculty development, describe creative approaches for taking advantage of new opportunities in education, and outline goals for developing the undergraduate and graduate programs. It will also cover both short- and long-term space needs and proposed additions to the staff and the operational budget. The guiding principles and action items for each part of the plan are summarized here.

Faculty Development

Guiding Principles:

1. The concept of "replacing" a retiring faculty member will be abandoned.
   Hiring within a particular targeted research area will occur over an extended time period to secure a superior candidate.
3. The fact that a target area has been specified in no way guarantees that we will hire in that area.
4. Faculty from under-represented groups, as well as other "targets of opportunity", are welcomed at any time.
5. Decisions on hiring new faculty and promoting existing faculty will incorporate our commitment to excellence in undergraduate and graduate teaching.
6. The distribution of faculty research areas will reflect a balance between fundamental, applied, and interdisciplinary areas of physics.
7. The plan will be reviewed on a regular basis, in connection with Compact planning and in consultation with an External Advisory Committee.

Action Items:

1. Improve the performance and promote and enhance faculty prominence.
2. Identify, sustain, and enhance the most vital research programs.
3. Expand into at least two new research areas.
4. Increase the number of tenure track faculty from 33 to 43.
5. Create a standing faculty search committee.
6. Increase the NRC rating of faculty quality.

Instruction and Student Development

Guiding Principles:

1. We will remain aware of the needs of the students and provide learning opportunities that make our students maximally competitive upon graduation.
2. We will seek to improve teaching effectiveness through the use of innovative approaches and the implementation of new technologies.
3. We will raise awareness of science particularly physics in K-12 education.
4. We will find and enroll the best undergraduate and graduate students.

Action items, instruction:

1. Development:

a. Expand the SCALE-UP approach to additional sections of engineering physics, and add sections of algebra-based physics.
b. Collaborate with other departments to extend innovations to related areas.
c. Continue WebAssign efforts within the university and as a national outreach.
d. Develop additional versions of physics courses that appeal to non-science majors.
e. Expand current levels of instructional support as we improve instructional approaches and deal with increasing student enrollment.

2. Research:
a. Continue developing innovative approaches to teaching, including organization and presentation of material as well as the use of developing technologies.
b. Continue testing these approaches by performing regular assessments of learning for comparison to national norms and innovative classes.
c. Increase the number of Physics Education faculty by two, as noted in the
d. faculty development implementation plan.

3. Outreach:
a. Expand collaborations with the College of Education and Psychology to train pre-service and in-service teachers.
b. Continue support of Science House programs.
c. Promote faculty outreach to area schools.
d. Expand Public Demonstration Shows.

Action items, Undergraduate Program:

1. Increase the incoming students by 50%, from 20 per year now to 30 per year.
2. Increase both the number and size of scholarships and awards.
3. Enhance recruiting efforts.
4. Promote the BA as a second degree.
5. Continue to develop the curriculum to meet current needs.

Action items, Graduate Program:

1. Increase the number of graduate students.
2. Enhance the effectiveness of the recruiting process.
3. Ensure that we are providing the best education for our students.

Space

Guiding Principles:

1. We shall seek to use existing space as effectively as possible.
2. We shall seek means of generating more space, ideally to consolidate our currently fragmented Department.

Action items:

1. We will continue to press the College and the University for the ASB.
2. We will establish a space committee not only to work toward the ASB but to ensure that existing space is used effectively within the Department.

Other Infrastructure

Guiding Principle:

The number of support personnel and the size of the operating budget shall be consistent with the size of the faculty and the level of the research support.

Action Items, personnel:

1. Increase the number of support personnel in the department by five by 2005.
2. Add an additional five positions by 2010.

Action Items, budget:

1. Raise the operating budget of the Physics Department to $650,000 by 2005.
2. By 2010, the operating budget should be raised to $950,000, with state operating (continuing) providing $350,000, fees $200,000, and overhead $400,000

Department of Physics
North Carolina State University

Strategic Plan

January 10, 2000

Mission: The Physics Department faculty is committed to providing outstanding educational and research opportunities. Our highest priority is to help all students achieve their educational objectives. We serve the people of the State of North Carolina by:

- providing educational opportunities to undergraduate and graduate students in physics, through high quality curricula, faculty, and research facilities
- developing world-class research programs that advance scientific knowledge, contributing to the needs of the Nation and the State, and meriting national and international recognition for their high quality
- providing high-quality physics instruction to the University community
- supporting outreach activity that fosters improved public awareness and understanding of science

Vision: The Department of Physics at North Carolina State University will become a national model among public universities for its approach to and innovations in education, its excellent and diverse faculty and graduates, the significance of its research, and its contributions to other disciplines and to society in general. The Department will continue to improve its national and international stature and will be considered among the top ranked departments in the nation.

Long Term Goals (to be achieved by 2010):

General Goal: The department will raise its standing as evidenced by recognized measures such as the National Research Council (NRC) rankings. In the 1993 NRC rankings of Physics Departments, NCSU was ranked 51 out of 147 departments. By 2013, our goal is to be ranked in the top 30. The department will strive to become a model for public universities in the quality and diversity of its research, particularly seeking to develop new interdisciplinary partnerships, and for its innovations in education and teaching, to the benefit of students not majoring in physics as well as physics majors.

Faculty Development:

1. Increase the number of tenure track faculty from about 33 to 43, in part by increasing the diversity of the faculty by hiring from under-represented groups.
2. Increase faculty quality by hiring new faculty with excellent potential or experience and supporting the continued development of existing faculty.
3. Expand by at least two new research areas.
4. Enhance and sustain the most vital research programs by allocating available positions and providing the necessary space and start-up resources for new faculty.

5. Find resources to retain and develop existing faculty through investment in selected programs chosen on the basis of the departmental goals and the faculty member's career development plans.
6. Promote and increase the prominence of the faculty as evidenced by membership in the National Academy of Science, fellowships and elected positions in professional societies, and awards.

Instruction and Student Development:

1. Develop a nationally recognized research and development center for physics education aimed at improving methods for instruction, particularly in the introductory physics courses.
2. Increase the quality and quantity of the graduate program by:
   - **a. Increasing the entering graduate class from about 15 per year to 25 per year in step with the development of the faculty size.**
   - b. Increasing the number of fellowships to graduate students.
   - c. Increasing the number of Research Assistants funded from grants.
   - d. Increasing the quality of the graduate students.
3. Increase the number of physics majors and double majors from about 20 per year to about 30 per year by:
   - **a. Increasing the number of scholarships and fellowships available.**
   - b. Continuing the development of the major curriculum to reflect changes in the field and in our students.
   - c. Promoting the BA in physics.
   - d. Developing an undergraduate program in applied physics.

Space: Develop adequate space which will be appropriate for the size and quality of the department including:

- a. Consolidating space among existing programs and developing additional space for new faculty and expanded research programs on the Centennial Campus.
- b. Gaining approval for a new building, primarily for the Department of Physics, on the Centennial Campus with the quantity and quality of space appropriate for a department of our stature.

Other Infrastructure: Increase the infrastructure support for the department in proportion to with the growth of tenure track faculty, including additional technical and administrative support staff and an increased operational budget.

Department of Physics
North Carolina State University
Implementation Plan

January 10, 2000

I. Introduction:

The 1960's marked a period of dramatic growth of physics departments nationwide. As a result, the approaching decade will mark a period of unprecedented retirements around the country and at North Carolina State University (NCSU) in particular. Indeed, based on past retirement profiles, our Department will diminish from its present size of about 33 to 18 members by 2010 if no further hires are made. At the same time the nature of physics research is itself changing. Funding from Government agencies such as NSF is shifting away from core disciplines and the type of classical electronic-materials research that has supported physics departments for the last 30 years into new areas such as nanostructures, bioinformatics, interdisciplinary research, education, and "soft" materials including for example bio-electronic interfaces.

Consequently, the years from 2000 to 2010 will see a major reordering, restructuring, and reranking of physics departments nationwide. While the ever-increasing demand for technology will ensure that physics will continue to play a major role in research and education, competition within the physics community for new faculty and adequate funding will be intense. Visionary planning and disciplined implementation of plans will be required to meet this challenge, to make the most of this opportunity, and to emerge stronger at the end of the next decade.

Physics has been termed "the basic science" and, as such, seeks to find a unified set of laws governing matter, motion, and energy from the subatomic domain to the largest distances known. In recent years physics has not only emphasized its core knowledge but has played a major role in applying this knowledge to other disciplines. This has not only led to the formation of separate disciplines such as astrophysics, biophysics, geophysics, etc., but also to increasingly interdisciplinary research in many of the core areas that are still contained in traditional physics departments. In addition to the important knowledge involved in the study of physics, the problem-solving approaches that are emphasized provide vital skills for any college-educated person in this society.

In its Strategic Plan the Physics Department of NCSU has set a vision of sharply increased recognition for its research and educational programs and improved service to the State of North Carolina by 2010. The keys will be faculty development, both of existing faculty and new hires, and student development, through aggressive recruiting and the development of enhanced curricula and research programs, since it is the quality of the faculty as defined by their research and teaching accomplishments and the students as defined by the positions in which they can be placed that determine the quality of any academic department.

The present document outlines the steps that we believe are needed to implement the Strategic Plan and accomplish the Physics Department vision. It will cover both general and specific aspects of faculty development, describe creative approaches for taking advantage of new opportunities in education, and outline goals for developing the undergraduate and graduate programs. It will also cover both short- and long-term space needs and proposed additions to the staff and the operational budget.

In developing this plan several assumptions have been made. The first is that physics and a strong Physics Department will be a vital part of the NCSU of the future. Traditionally, physics is one of the few disciplines with an unusually high correlation between the ranking of the department and the overall ranking

of the institution itself. Because of fundamental nature of physics and the linkage that it provides between basic knowledge and applied research, that correlation is expected to be true in the future.

The second is that the fundamental changes that have occurred in the discipline in terms of funding and the interest of students in pursuing education in physics will continue to evolve. The end of the cold war with its emphasis on technologies closely coupled to physics and the emergence of information and computer science, and modern molecular biology, have led to a strong competition for the brightest young students. The net result of these factors has been some renormalization of the discipline regarding both size and emphasis. While this will result in a different way of "doing" physics in a university setting, it does not mean that physics will not and should not play a central role in the university of the future. This is particularly true at an institution where physics has established itself as one of the most successful departments, and particularly in an institution like NCSU with its land-grant tradition and its focus on science and technology.

The goal, then, of significantly increasing the ranking of the Physics Department seems to be reasonable and has been encouraged by the recent external review of the Department as well as by the Dean of PAMS. To accomplish this increase the Department has determined that it should evolve to a point where it serves as a model for how physics departments should function within the university of the future. In research this means maintaining a solid core of the basic disciplines with a balance of experiment, theory, and computation, while at the same time expanding relevant existing areas and developing new areas, in particular areas that emphasize interdisciplinary activities and/or those connected with new technology, especially those areas that can have the greatest impact on the State of North Carolina. In education, for both non-majors as well as majors, we need to continue to develop new ways of teaching students that emphasize interactive learning and improved problem-solving skills.

Our assumptions concerning the specific areas of emphasis and the numbers of people needed to have the impact that is our goal leads us to recommend that the Department be expanded from its present size of 33 to about 43. This appears to be a conservative number. It is also consistent with the sizes of departments that are currently ranked at the level that we seek to reach. Of course, if we are not able to expand as we propose, the general criteria of seeking excellent new faculty members and of striking a proper balance between traditional core and newer interdisciplinary areas of research still apply, but the results will almost certainly be less than to what we aspire .

II. Faculty Development:

The following faculty development implementation plan will assure that the Physics Department of NCSU will develop into a leading department nationwide and become a model for science departments at major research universities.

Guiding Principles:

1. The concept of "replacing" a faculty member who is leaving will be abandoned.

To "replace" a faculty member who is retiring or resigning is to emulate the past. Furthermore, there is no guarantee that a particular slot will be reallocated by the university administration. Future hiring will be determined by the needs and aspirations of the department and the quality of the available applicants.

2. Hiring within a particular targeted research area will occur over an extended time period to secure a superior candidate.

Our hiring procedures will change. Predetermined target areas will be defined based on the needs and goals of the department. Individual research groups will be encouraged to search on a continuing basis for faculty in the targeted areas to locate superior candidates. This is in contrast to hiring the "best" (or perhaps the second or third best) candidate in a particular field in a given year.

3. The fact that a target area has been specified in no way guarantees that we will hire in that

area.

All new faculty hiring must clearly enhance the reputation, vitality, and future interests of our department. Faculty hiring in non-targeted areas will always be considered if the candidate clearly represents a special opportunity to strengthen the Department.

4. Faculty from under-represented groups, as well as other "targets of opportunity", are welcomed at any time.

5. Decisions on hiring new faculty and promoting existing faculty will incorporate our commitment to excellence in undergraduate and graduate teaching.

6. The distribution of faculty research areas will reflect a balance between fundamental, applied, and interdisciplinary areas of physics.

7. The plan will be reviewed on a regular basis, in connection with Compact planning and in consultation with an External Advisory Committee.

Action Items:

1. Improve the performance and promote and enhance the prominence of the faculty.

Faculty members will be encouraged to improve their own performance in teaching and research and to generate opportunities for professional recognition in the following ways:

a. Through promotions based on clearly articulated criteria: to Associate Professor on demonstrated ability and potential for distinction, and to Full Professor on distinguished achievement.

b. By seeking leadership roles in professional societies, promoting other faculty members for invited talks and prizes, and soliciting superior candidates for hiring in target areas. To encourage this a new item will be added to the annual departmental report asking for an explicit description of such activities; for example: "List the teaching and/or research award nominations for colleagues that you helped to prepare, as well as any other activities promoting the prominence of our faculty."

2. Identify, sustain, and enhance the most vital research programs.

Internal and external polls, including discussions with an External Advisory Committee, will be employed to identify the most vital areas of research that need to be developed, enhanced, or sustained. In particular, faculty interested in hiring in, and/or developing, a particular program must promote that program through active participation in the University Compact Planning process or whatever other mechanisms for securing resources are available.

3. Expand into at least two new research areas.

The research areas that will be chosen are those that have a vital future, are attractive to potential students, and overlap and enhance other programs within the Department and other Departments at NCSU. Target areas of present interest are listed below. The present most likely areas for expansion are nanoscale science and technology, and biological physics.

4. Increase the number of tenure track faculty from 33 to 43.

This will be done by:

a. Hiring about two faculty per year from a list of targeted areas given below. We expect that these positions will be primarily at the junior level. At this rate, the department size would be approximately 38 in the year 2010. We propose to hire up to five more faculty through mechanisms (b) and (c) below.

b. Continually seeking candidates from underrepresented groups whose credentials will clearly enhance our reputation, vitality, and future interests. These will be hired whenever the opportunity arises.

c. Be aware of hiring opportunities for senior faculty with superior credentials, who will also be hired whenever the opportunity arises, particularly to lead the development of targeted new areas of research or to maintain the balance of experience in groups strongly impacted by retirement. However, the number of senior hires should not exceed the number of junior hires.

5. Create a standing faculty search committee.

This committee will be appointed by the Department Head in consultation with the elected advisory committee. The standing faculty search committee will screen applicants responding to a faculty position advertisement that is run annually.

6. Increase the NRC rating of faculty quality.

The NRC ranking is only one measure of quality, but it is the one that is most commonly cited. Its peer-driven nature puts NCSU at a disadvantage because we are a relatively new department with a smaller number of graduates in the profession and have no high-energy or plasma-physics programs whose members figure prominently in the ranking schemes. Nevertheless, NCSU can work toward the highest possible ranking by developing an excellent faculty through steps 1-5 above.

Target areas for hiring in the next ten years:

To plan for the extensive number of new faculty hires over the next ten years, we polled existing faculty and solicited comments from the recent Physics Department External Review Committee. The highest-priority areas to add or expand were selected based on anticipated future vitality of the fields, their relationships to existing programs at NCSU, and their ability to attract new students. Areas included in the existing Department Compact Plan are nanoscience and technology, high-performance computing, biological physics, biomaterials/soft condensed matter, and positions related to Oak Ridge National Laboratory and its Spallation Neutron Source (SNS). In the accompanying figure the present distribution of faculty by discipline, the distribution of existing faculty who will not have retired in 2010, and the proposed distribution of a faculty of 43 in 2010 are presented. The specific details regarding the distribution are only to serve as a model. This will be continually evaluated and may change depending on current opportunities and new priorities.

The specific targeted areas, in alphabetical order, are:

a. **Biological Physics/Biomaterials:** 6 positions: computational/theoretical, biosensors/nanoscale fluidics, biological interfaces, SNS-related soft condensed matter.

b. **High Performance Computing/Condensed Matter Theory:** 3 positions: theory and simulation of materials, quantum many-body theory, and high-performance computing.

c. **Nanoscale Science and Technology:** 3 experimental and 1 theoretical positions: nanoscale electronic materials, MEMS/sensors, scanning probe microscopy, and biosensors/nanofluidics.

d. **Nuclear physics:** 4 positions, one theoretical and 3 experimental. At least one of the experimental positions is to be SNS-related.

e. **Physics Education:** 2 positions.

f. **Theoretical astrophysics:** 1 position.

g. **Targets of opportunity:** 5 positions.

Comment 1: The target-of-opportunity positions allow some of the new positions to be chosen on the

basis of outstanding quality of a particular candidate and of changes that may occur in University or external priorities.

Comment 2: In a recently concluded external review of the Department, the External Review committee recommended that the faculty size be expanded or maintained in the following areas, listed in the order presented in the report: (a) theoretical nuclear astrophysics (add one faculty member); (b) nanoscale electronic materials; (c) soft condensed matter; (d) biophysics; (e) biomaterials; (f) maintain experimental condensed-matter group size while evolving towards the other areas; (g) computational physics, in particular hire several faculty in areas such as supernova hydrodynamics and physical phenomena at surfaces; (h) physics education and outreach, in particular hire one more faculty. An internal poll of faculty members reflected overwhelming interest for expansion in (a) nanotechnology and biophysics, with 90% support by the responding faculty, and (b) computational physics and astrophysics, with 85% support by the responding faculty.

Comment 3: The following figure illustrates the distribution of faculty at (a) the present time, (b) in 2010 if there was no additional hiring and historical retirement patterns were followed, and (c) a proposed faculty of 43 positions according to the hiring plan described above.

Comment 4: Note that the above categories and numbers are intended only for guidance. They are to be regularly reviewed and may change depending upon the assessment of the Departmental of its needs at the time of the review and of new opportunities as they that may arise.

III. Instruction and Student Development.

To achieve the Department goals we need to develop concomitantly instructional materials and technologies at both the undergraduate and graduate levels. We already have a long history in this area, with national visibility for high quality classroom teaching and support, technical innovations in education, outreach to K-12 teachers, research experiences for undergraduates, and leadership in the American Association of Physics Teachers. Chancellor Fox recently chaired the NRC committee that produced *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology,* a document that promises to be an important component in changing college-level teaching and learning. Non-science majors are presented with an expanding menu of interesting courses. Recent revisions in engineering accreditation standards can work to our advantage if we maintain good contacts with the College of Engineering and continue our efforts to improve both the quality and the nature of the service courses that we offer. Partly through the promotional efforts of the Department there has been a substantial growth in physics education research activities at other colleges and universities.

However, as mentioned in the Introduction, physics as a discipline is currently facing serious challenges. First, at the undergraduate level interest in pursuing physics degrees is lower nationally than at any time in the past 40 years. Bachelor's degrees awarded in physics in 1998 were the lowest total since before Sputnik. Maintaining the high quality of our program while continuing to attract strong student interest is the principal challenge we face. Second, the applications of physics are themselves changing. Consequently, we must be sure that we are teaching the right things: preserving the essential while adapting to current needs. In particular our programs must be consciously organized to serve a wide range of undergraduate students, who may use their physics degrees in different ways than we have used ours, or who may not be majoring in physics but would benefit from some training in physics. Thus, curriculum development needs to be an ongoing process, both to keep our core BS program current and to develop alternative paths that may attract, and benefit, more students. Despite these difficulties our entering students are among the best in the University (1998 and 1999 average incoming SAT scores were 1340, the highest of any Department), and upon completion of their training all of our 1998 and 1999 graduates entered graduate school or found good employment either before or immediately after graduation.

Nationally, graduate physics applicants have also fallen off, by almost one-third in the past three years. Nevertheless, our graduate program has remained remarkably stable throughout both the eighties and

nineties. Enrollment has increased slightly to its current level of 83 while the time-to-graduation has fluctuated somewhat between 5.5 and 6 years for the Ph.D. The average entering class size is 15 over the past 10 years. Diversity is manifest in the fraction of women (13 %) and African-American (6 %) students, both of which have maintained levels above the national average. The fraction of foreign students (19 %) is well below the national average. Graduate job placement has been healthy in industrial, national laboratory, and academic arenas.

Guiding Principles:

1. We will remain continually aware of the needs of the students and provide learning opportunities that make our students maximally competitive upon graduation.

The objectives of a University education are to broaden one's horizons and improve one's economic position. This means not only providing our physics students with the tools needed for critical thinking but also being continually aware of the job market and the needs of the local as well as the national economy. The same applies to the students taking the service courses that we teach. Consequently, we need to regularly evaluate the effectiveness of all courses. We note that this goal is completely consistent with the expanding role of land-grant institutions in the 21st century, which will turn increasingly to enhancing our store of knowledge and improving its application in technology.

2. We will seek to improve teaching effectiveness through the use of innovative approaches and the implementation of new technologies.

Evolving computer, display, communications, and information technology are providing new challenges but at the same time presenting new opportunities to universities in general. For example the development of the Internet leads to new possibilities in "distance" learning and at the same time new mechanisms by which other institutions can compete. The uniquely fundamental position of Physics in science positions us excellently well to attack these challenges and to provide creative solutions through Physics Education Research, where we are currently exploring new approaches toward presenting physics material and also innovative ways of using evolving technology. WebAssign and Scale-Up represent two such examples.

3. We will seek to raise awareness of science in general and physics in particular in K-12 education.

It is generally accepted that to function effectively a society has to be literate. It is less well accepted that to function effectively a society now has to be scientifically and technologically literate as well. Yet it is clear that scientific and technological literacy will become increasingly important. Thus our current emphasis on carrying science to the K-12 arena, as exemplified e.g. by Science House, not only needs to be continued but to be enhanced.

4. We will find and enroll the best undergraduate and graduate students.

The quality of the Department is dependent on the quality of the students as well as that of the faculty. As we act to improve the quality of our faculty, we will also act to improve the quality of our students.

Action items, instruction:

1. Development:

a. Expand the SCALE-UP approach to additional sections of engineering physics, and add sections of algebra-based physics.

b. Collaborate with other departments to extend innovations to related areas.

c. Continue WebAssign efforts within the university and as an outreach on the national scale.

d. Develop additional versions of conceptual physics courses that appeal to non-science majors.

e. Expand current levels of instructional support as we improve instructional approaches and deal with increasing student enrollment.

2. Research:

a. Continue developing innovative approaches to teaching, including organization and presentation of material as well as the use of developing technologies.

b. Continue testing these approaches by performing regular assessments of learning for comparison to national norms and innovative classes.

c. Increase the number of Physics Education faculty by two, as noted in the faculty development implementation plan.

3. Outreach:

a. Expand collaborations with the College of Education and Psychology to train pre-service and in-service teachers.

b. Continue support of Science House programs.

c. Promote faculty outreach to area schools.

d. Expand Public Demonstration Shows.

Action items, Undergraduate Program:

1. Increase the number of incoming students by 50%, from 20 per year now to 30 per year.

There are four main reasons for doing this: (1) internal allocation of resources requires that students demonstrate interest in our programs; (2) external recognition is partly linked to program size; (3) some of our best graduate students historically have been NC State undergraduates who chose to stay; and (4) we can provide an excellent educational experience that would be of great benefit to more students than now take advantage of it.

This goal is extremely ambitious, but one that we believe is attainable through more vigorous recruiting and more extensive (and better advertised) financial aid. However, in-state recruiting has almost reached saturation, and further progress will require attracting top out-of-state students and nontraditional physics students.

2. Increase both the number and size of scholarships and awards.

This is particularly desirable. Current scholarships of $1000/yr are too small to provide a significant recruiting edge and need to be increased to at least $2000/yr. Adding awards for continuing students will target transfers. If we wish to attract out-of-state students for whom the annual cost is about $18,000, we need at least one or two awards to bridge the gap between in-state and out-of-state tuition. Work-experience awards offer another alternative, with an added publicity advantage if they involve research.

3. Enhance recruiting efforts.

We can increase the pool of interested students by (1) increasing the number of visits of faculty to (mostly local) target high schools; (2) improving our website, for example by listing student careers and salaries and by providing contact information for Department graduates willing to talk about our programs with prospective students; (3) developing new materials that stress employment and career opportunities for

bachelors' graduates, thereby overcoming the general idea that "there are no jobs in physics"; (4) working more closely with local organizations such as the AAPT section, NC Science Teachers Association to publicize our programs and distribute materials; and (5) using summer programs to bring in strong high-school students from selected out-of-state schools such as Thomas Jefferson High School in Alexandria. Yields from these programs are quite high.

4. Promote the BA as a second degree, with Science Education as well as with any engineering degree.

Work with Engineering representatives to allow the maximal amount of equivalencies and double counting consistent with our delivering a respectable physics degree.

5. Continue to develop the curriculum to meet current needs.

It is essential to keep our programs up-to-date and to add new options that will make them attractive to nontraditional as well as traditional physics students. This will require (1) reviewing the BS curriculum; (2) add/ rearrange junior courses; (3) continue to develop informal junior-year laboratory exercises; (4) consider adding new BA-specific courses; and (5) plan new undergraduate programs such as applied physics.

Action items, Graduate Program:

1. Increase the number of graduate students.

This is a complex issue relative to the undergraduate situation, owing to the need to provide support through fellowships or teaching or research assistantships, and the need for the faculty to generate enough support and positions. Graduate education is significantly more highly specialized, with research topics that can change substantially according to federal funding. To justify a broad spectrum of graduate-level courses a critical mass of graduate students (and of faculty) is required. The optimum number of graduate students is therefore critically connected to the number of graduate faculty.

The graduate program currently fits the research needs of the Department fairly well. Most Physics Department research programs use physics graduate students, although some of our larger applied programs are using degree candidates from other departments, often engineering. Thus some growth in the graduate student population is warranted. This fact, along with the plans to add to the faculty size, result in a goal of increasing the number of entering graduate students from about 15 per year to about 25 per year to achieve a total enrollment of about 120 students.

Assuming that the faculty size increases as planned under Faculty Development, we can increase the number of graduate students by (1) actively recruiting in the new research areas of the department; (2) increasing the number of fellowships and research assistantships; (3) expanding the positions supported by the graduate school tuition remission policy; and (4) adding degree options such as instrumentation or applied physics.

2. Enhance the effectiveness of the recruiting process.

We have studied our market by surveying students who enter our program and those who do not. This analysis shows that our recruiting resources are best spent on two items: a) maintaining an attractive up-to-date webpage; and b) bringing prospective candidates to NCSU for a campus visit. If we are willing to change the student demographic profile, we can follow the recent advice of our visiting committee and accept highly qualified foreign students. Although it is not clear how much this can be supported by the graduate school tuition remission plan, we have decided to move in this direction. In particular, we are attempting to

increase the number of fellowships available to graduate students by seeking funding from NSF, private foundations, and industry

3. Ensure that we are providing the best education for our students.

We approach this by examining course profiles on the transcripts of recent graduates to determine the breadth and depth of the education these students have received and are considering changes in academic policy to ensure that the proper breadth and depth are manifest in all our graduates. Finally, we are examining our testing policy to determine if the departmental qualifying examination properly fulfills its goals.

Nevertheless, we lose a substantial fraction of our students to other disciplines and career paths. We are currently considering changes that can prevent this, a physics instrumentation degree, most likely at the MS level, and an applied physics degree. Above all we cannot dilute our degree program so as to impugn its academic integrity.

IV. Space.

Space is a critical resource required for the development of faculty, education, research, and developing a sense of community. The Department currently has 54,200 sq. ft. allocated to it in seven buildings on both North and Centennial Campuses. By the common measures used, this is inadequate for the level of research and teaching activity that presently exists within the Department, let alone an expanded version of the Department. Furthermore, division among seven buildings makes it difficult to maintain the collegial interactions and coherence needed to develop a first-rate department. Space needs are both short-term, to provide adequate space to allow the initial phases of faculty development that we propose, and long-term, to develop the case and then the funding for a building that would consolidate much of the department, most likely on Centennial Campus. While some relief can be obtained by using existing space more efficiently, we must make an effective case to the Dean and Provost that space needs are an integral part of our development plan.

In the short term, based on the number of new hires and the proportion of experimentalists to theorists the Department will need to provide about 25,000 sq. ft. of research and office space for the new faculty. While faculty projected to retire by 2010 currently occupy about 16,000 sq. ft., more than half of that will not become available until the last half of this period. The short-term need is therefore for about 5,000 sq. ft. of space, much of which for research laboratories.

In the long term, space needs will have to focus on Centennial Campus. The desired goal of NCSU to be considered among the top tier academic institutions cannot be achieved by advancing only the engineering and technology sectors alone, but by advancing the mathematical, physical, and natural sciences in parallel. Toward this end an 87,000 sq. ft. Physical Sciences Research Building (now referred to internally as the Applied Sciences Building, ASB) was formally requested by the Department in the late 1980s and has been on the College and University priority list for nearly a decade. It is intended to consolidate much of the spatially fragmented Department, to provide high quality space for research, and to enhance the interdisciplinary interactions of the departmental faculty with faculty in other units at NCSU and with external partners. It is included in Phase I in the currently proposed space plan for NCSU, a plan described in the Eva Klein report to the UNC Board of Governors. In addition, the College and the University are spending a disproportionate share of their annual indirect-cost redistribution on renting approximately 40,000 square feet. Construction of the ASB would free up these resources for other purposes. As a result we and the College strongly believe the ASB should be completed in parallel with completion of planned facilities on the Centennial Campus for the College of Engineering. *An explicit goal of the Department is to expedite the timetable to acquire significant new space on Centennial Campus, ideally by the construction of the ASB.*

On the academic side, major near-term plans are in place for adequate classroom/laboratory and

accompanying office space for teaching and academic support, including the construction of the Undergraduate Science Teaching Laboratory Building (summer 2002); the Harrelson Hall Infill, phase II (the Scale-Up Physics Lab, spring 2000); and transfer of space on the 5th floor of Cox Hall to Physics (spring 2000).

Guiding Principles:

1. We shall seek to use existing space as effectively as possible.

While expansion is ideal, we recognize that it is also the easy way out, and that constraints outside our control often dictate the amount of space allocated. Thus it becomes important to ensure that we are using the space already allocated efficiently and effectively.

2. We shall seek means of generating more space, ideally to consolidate our currently fragmented Department.

Our research program was the second best-funded among all NCSU departments over the past two decades. Quality research space is required if we are to continue this record of remarkable growth in sponsored research, and to enhance our competitiveness and participation in interdisciplinary research.

Action items:

1. We will continue to press the College and the University for the ASB.

We will do this effectively by assisting the Dean in making the internal and external case, which includes the development of a well-thought-out strategic plan to be presented to NCSU Administration and made available for the next Dean of PAMS. We will also ensure that the ASB remains prominently listed in the Compact planning document.

2. We will establish a space committee not only to work toward the ASB but to ensure that existing space is used effectively within the Department.

Among other tasks this Committee will develop a cross department/cross college effort to find at strategies for advancing the institution as a whole so that our competition is viewed as lying primarily outside NCSU. We will also remain aware of what's going on regarding relevant issues within the University, State, and Nation so as to be able to respond in a timely and effective manner.

V. Other Infrastructure:

Other infrastructure, including operating costs and non-tenure-track personnel expenses, will also increase as the Department grows and increases the amount of sponsored research that it does. The following lists targets in 2005 and 2010 for these areas assuming a linear growth to our target size of 43 by 2010.

Guiding Principle:

The number of support personnel and the size of the operating budget shall be consistent with the size of the faculty and the level of the external research support.

1. Personnel:

As of 01 Jul 1999 we had 8 administrative/secretarial positions, 2 teaching support positions plus partial support for one-quarter of a position, 2 technical positions supporting the general department, and 2 technical support positions assigned to specific research programs funded by state appropriations or overhead. These positions are listed in detail in appendix A.

Action Items, personnel:

1. Increase the number of support personnel in the department by five by 2005.

If faculty positions are added at the rate proposed above and the research funding in the department

increases as planned, then by 2005 we will need two more secretarial positions and one more office staff position to support the increasing administrative load in the main office. Secretarial positions should be provided at a ratio of about one per four research-active faculty.

Because of the increasing reliance on computers in instruction we will need one additional teaching support person specifically devoted to maintaining the instructional computing system, and one additional general technical support person for maintaining research and administrative computers and networks.

2. Add an additional five positions by 2010 if the faculty size and research activity develops as planned.

By 2010 we will need two additional secretaries, one additional teaching support position, and two additional technical positions to support large research efforts that are expected to begin as a result of faculty development.

2. Operating Budget:

As defined here the operating budget is that derived from continuing funds and fees for operation as well as special projects and overhead funds allocated to the Department by the Dean. For 1997-98 the total was $479,057. For the same academic year spending for general expenses, start-up, and research and teaching lab equipment and amounted to $478,517. These figures are detailed in the spreadsheet in Appendix B. Because of the variable nature of the University and state budgeting processes it is hard to assume that any year is typical. However, the $172,000 designated as the base operating budget is clearly inadequate and has always been supplemented. The additional funds proposed below are based on the budget of $480,000 for 1998-99 as a starting point.

Action Items, budget:

1. Raise the operating budget of the Physics Department to $650,000 by 2005.

The income would be broken down as follows: $300,000 from state operating (continuing); $150,000 from laboratory fees; and $200,000 from overhead directed towards startup and research support. General expenditures would be $250,000; start-up and research support $250,000; and teaching lab equipment support $150,000. Lab-fee income is expected to grow as enrollment increases and essentially represents a pass-through since each year this money is spent on teaching support equipment. Overhead costs are assumed to proportional to the amount that the Department generates within the College assuming a return of 20%. We expect start-up costs to average between $500,000 and $1,250,000 per year, with our amount representing about 25% of the start-up total consistent with the typical division of 25% Department, 25% College, and 50% University.

2. By 2010, the operating budget should be raised to $950,000, with state operating (continuing) providing $350,000, fees $200,000, and overhead $400,000.

We propose that general expenses be budgeted at $350,000, start-up and research support at $400,000, and teaching lab equipment support at $200,000. An additional $100,000 should be provided for non-tenure teaching support. This is to provide additional teaching capacity, particularly at the lower division level so that regular faculty are available to teach advanced courses and to increase the offerings of new courses.

Appendix A. Current Physics Department Support Staff

SPA Admin	Gill	Wilma	Acct Tech I
	Savage	Rebecca	OA IV

	Smith	Anita	AA I
	Breedlove	Phyllis	OA IV
	Outlaw	Jennifer	OA IV
	Upchurch	Cecilia	OA IV
	Allen	Jennifer	OA IV
	Hockenberger	Theresa	AA I
Teaching Support	Rieg	Beth	EPA Teach Tech
	Gjertsen	Peg	EPA Teach Tech (25%)
	Foster	Howard	Lab Manager
Tech Support	Jenkins	Steve	Electronic Tech IV
	Matthews	Joe	Research Tech II
	Lyerly	Jay	Com Sys Ad III
	Haney	Sean	Research Tech II

Appendix B. Present and proposed budget information for the Department (FY 1999 Dollars)

		1998-99	2005	2010
Income				
	Operating (cont.)	$171,716	$300,000	$450,000
	Operating (fees)	$137,341	$150,000	$200,000
Dean's Additional	Special Projects(fee)	$70,000		
	Overhead	$100,000	$200,000	$300,000
	Total Income	$479,057	$650,000	$950,000
Expenditures				
	General Expenses(1)	$171,176	$250,000	$350,000
	Startup/ Research	$100,000	$250,000	$400,000
	Teaching Lab Equipment	$207,341	$150,000	$200,000
	Total	$478,517	$650,000	$950,000
(1) General Expenses	Computers	$5,193	$25,000	$50,000
	Copying	$18,656	$20,000	$25,000
	Freight	$8,957	$5,000	$10,000
	Furniture	$3,659	$12,000	$15,000
	Travel	$39,980	$40,000	$50,000
	Postage	$5,444	$6,000	$10,000
	Repairs	$16,838	$20,000	$40,000
	Supplies	$15,895	$25,000	$35,000
	Telephone	$60,503	$70,000	$80,000
	Training	$4,075	$0	$0
	Maintenance Contracts	$2,734	$3,000	$5,000
	Rental	$3,742	$4,000	$5,000
	Misc Expenditures	$4,755	$20,000	$25,000
	Other Expneditures	$19,381	$0	$0
	Total General Expenses	$209,812	$250,000	$350,000