Creation of an Area of Specialization in Applied Statistics within the Applied Mathematics and Scientific Computation (AMSC) Program

I. Overview of Proposal

This is a proposal to change the name of the `Applied Mathematics and Scientific Computation` M.S. and Ph.D. degree programs and to create within them an Area of Specialization in Applied Statistics leading to the M.S. and Ph.D. degrees. The proposed changes are as follows:

A. The name of the approved M.S. and Ph.D. degree programs in Applied Mathematics and Scientific Computation will be changed to: *Applied Mathematics and Statistics and Scientific Computation*.

B. Complete tracks in Applied Statistics leading to AMSC MS and PhD degrees are proposed, which differ in their requirements from the degrees with Statistics specialization obtainable within the current AMSC program. The differences are:

(i) required core Statistics courses, which for both M.S. and Ph.D. must be courses from a designated list or their equivalents;

(ii) the addition of a required 3-credit one-semester *Practicum* project for the PhD;

(iii) an altered comprehensive examination structure, for the PhD and the MS without thesis, consisting of two written examinations plus a required independent two-week intensive Data Analysis Project structured as a 1-credit course; and

(iv) altered guidelines for students in the Applied Statistics Area, which specifically emphasize skills in data analysis and presentation skills, including proficiency in the oral and written presentation of data-analytic results.

C. The AMSC governing structure will be augmented to include a faculty Committee to create and evaluate the required Data Project component of the comprehensive examinations, and an agreement that the instructor of the most recently offered core Multivariate Statistics course to be given each January and August.

II. Rationale

Although AMSC students can currently pursue an applied statistics path within the existing AMSC framework, the creation of an Applied Statistics Area of Specialization (a term used interchangeably in this Proposal with "Applied Statistics Track") will offer several advantages:

1) It will attract mathematically trained students entering graduate school with specific interests in applied statistics.

2) A targeted track in applied statistics can emphasize, through its requirements and candidacy evaluation criteria, necessary skills (design and collection of data, process of data analysis, statistical computation and simulation experience in applying statistical tools to real data, technical writing, and graphics of data display) for the modern applied statistician but currently left to the initiative of individual AMSC (or other subject-matter department) students and thesis advisors.

3) A Practicum involving students in projects at agencies or scientific laboratories — to be run in cooperation with a newly proposed campus Graduate Internship Program in Statistics to be administered by the Campus Statistics Consortium — will provide students with practical experience in data analysis not currently available in most campus programs with an applied statistics component.

4) Establishment of this new Area of Specialization in applied statistics should lead to increased awareness and visibility among both faculty and students of the extensive expertise and educational opportunities in statistics that exist on our campus.

The existence of an applied statistics Area would likely enhance future NRC rankings of campus graduate programs in statistics. The existence of many smaller programs including statistics has led to an incorrect outside perception of lack of critical mass in statistics here at College Park. Enhancing the visibility of campus-wide statistical activity on our campus should be instrumental in improving our rankings in the NRC survey.

Graduates of the new Area will be highly marketable. They will be very well qualified for federal and research laboratory positions in applied statistics, as well as for academic positions in many different disciplines, since faculty who are knowledgeable both in statistics and in an area of application are in high and growing demand, as evidenced by recently developed initiatives, both of the NSF and the National Institutes of Health, to increase the number of individuals with cross-disciplinary training.

A. Relationship to Existing Programs

The Applied Statistics Area of Specialization in AMSC will be substantively different from existing programs on campus. The discipline of statistics can vary from development of abstract theory to the fairly practical aspects of applying methods to the analysis and interpretation of a set of data. The existing Statistics Program (STAT) housed in the Mathematics department emphasizes theory including advanced courses that require proficiency in real analysis including Lebesgue measure theory. The students in this mathematically oriented Statistics

program do not ordinarily receive advanced training in an area of application. There are existing degree programs on campus that emphasize applied statistics, for example, programs in business (BMGT) and education (EDMS), but students in these programs do not typically take the advanced courses in statistical theory being emphasized in this new AMSC Area. The Joint Program in Survey Methodology (JPSM), as its name implies, only covers a narrow but important aspect of statistics articulating with social sciences, business, and public policy.

The idea for the Applied Statistics Area of Specialization within AMSC has been discussed widely with statistical AMSC faculty across campus, whose guidance concerning its desirable features has been followed. Letters of support from the campus departments housing statistical methodologists have been solicited and many have been received and attached to this proposal, including letters from all of the departments and programs (MATH, EDMS, BMGT, JPSM, ANSC and ENST [pending]) most directly affected by it.

B. Common Ground Between AMSC Specializations

The older Applied Mathematics Area of Specialization has no required courses other than a requirement to take a single course in Numerical Analysis. This reflects the broad interdisciplinary nature of the Program: a core of mathematical courses to be coupled with suitably advanced coursework in an area of application, as approved by a Study Advisory Committee (SAC) and ratified by the Graduate Committee for Applied Mathematics (GCAM). The courses of both types would prepare the student for the written qualifying examinations (or thesis, in case of MS with thesis) and (in the PhD program) for the later candidacy examination to confirm that the student has brought together the necessary tools for research.

The Scientific Computation Area of Specialization requires a core of Scientific Computing and Computer Organization Courses: these courses are the heart of this specialization, and culminate in long projects which serve in lieu of qualifying examinations. However, other courses in the Scientific Computation Area are not specifically required and are subjected to the same tests of intellectual coherence and research relevance, enforced for each student by the student's SAC and the AMSC Program's GCAM.

The new Applied Statistics Area involves a core of required Statistics and Statistical Computing courses, plus required Data Project and Practicum. These courses and project requirements will develop common skills for all Applied Statistics Area students, assessed in the qualifying examinations. These same core courses (but not the Data Analysis Project and Practicum courses, which will be new) have often been chosen as AMSC core and electives by students working in applied probability and statistical topics within the Applied Mathematics Area of Concentration. Coursework beyond these required courses will be approved and ratified by the same structure of SAC and GCAM as in the other two Areas within AMSC.

III. Organizational Changes

The following organizational changes in the re-titled "Applied Mathematics and Statistics and Scientific Computation (AMSC)" degree programs will be made to accommodate the new Area of Specialization in Applied Statistics.

Areas of Specialization

Three Areas of Specialization or Tracks will be available for students in AMSC: the two which exist now, Applied Mathematics as it has existed since the late 1970's, together with Scientific Computation which was first established in 2000 after being formally approved as an Area of Concentration, plus the new Applied Statistics Area with requirements and administrative structure described in this document.

The new Applied Statistics Area of Specialization will emphasize computational, data-analytic and presentation skills across the broad spectrum of statistical applications, with uniform core requirements in these skills, and less emphasis on formal mathematical theory than in the Mathematical Statistics Program. The Applied Mathematics and Scientific Computation areas will continue in their current forms, including the possibility of degrees involving probability-modeling and statistical topics under the current rubric.

Advising Structure

Advising in the Applied Statistics Area of Specialization, exactly as in the Applied Mathematics Track and Scientific Computation Area of Concentration, will be based on a three-person Study Advisory Committee (SAC) of faculty, formed for each student.

Additional Administrative Structures

The faculty administrative structure of AMSC will continue in its present form, together with one new Data Project Administrative Committee, which will oversee the design, administration and grading of the yearly Data Project portion of the Applied Statistics comprehensive requirements, described more fully below.

Faculty and Administration

The present AMSC program, administered by a Director and elected faculty Graduate Committee, includes at least 15 participating departments and approximately 137 associated faculty. The AMSC Applied Statistics Area will be supervised by those AMSC faculty with an interest in Statistics, broadly defined. It is expected that faculty already on campus with statistical interests will be urged to join the AMSC faculty. In addition, there is an interdisciplinary body of campus faculty – the Statistics Consortium – through which new faculty will be solicited to join. The Consortium will administer the new Graduate Statistics Internship program, which although administratively separate from AMSC will play an important role in the success of the Applied Statistics Area's Practicum.

New Resources Required

The following resources will be required for the new Applied Statistics Area:

(i) Augmentation of the AMSC Program's staff for administrative support of additional advising and paperwork for the students in the new Area, to coordinate the Practicum, to maintain necessary liaison both with faculty mentors and the administrators of the campus Graduate Statistics Internship programs within the Statistics Consortium, and also to support the additional Data Analysis examination for the Applied Statistics Area. Sufficient resources will be: an addition of 1 graduate student GA FTE Administrative Assistant.

(ii) Resources amounting to roughly 1/4 faculty FTE will be needed to guarantee that STAT 741 and BIOM 602 – existing courses which will become alternative core courses in the Applied Statistics Area – will be offered annually. The guarantee that a second core course – in Multivariate Statistics, initially spread over four possibilities [BMGT 882, EDMS 771, STAT 750, BIOM 621] – will run annually, has required the agreement of cross-departmental partners of the AMSC Statistics Program (MATH, EDMS, BMGT, ANSC, and ENST). See attached letters of support.

(iii) Three new courses are proposed: AMSC 760 Applied Statistics Practicum (3 credits), AMSC 761 Applied Statistics Seminar (1 credit), and AMSC 762 Data Analysis Project (1 credit). Detailed descriptions of these courses are given below, under Section IV.B on Requirements in the Applied Statistics Area. Faculty resources (5 credits per year) covering teaching of these courses are promised in attached letters of support.

No new computing resources will be needed: there are adequate resources in existing computer labs and departmental networks. Adequacy of campus library resources is documented in attached "Assessment Letter" from the Director of Collection Management of the UMCP Libraries, Desider Vikor.

All resources for the new Area of Concentration are in place.

IV. Degree Requirements under the new Area

A. Current AMSC Program

The conditions and educational policies governing the AMSC doctorate and MS degrees with and without thesis, both under the standard Applied Mathematics (AM) Area of Concentration and the Scientific Computation (SC) Area of Specialization, are described in detail in the web-pages `http://www.amsc.umd.edu/programs/phd.html` and `http://www.amsc.umd.edu/programs/masters.html`.

Table 1: Credit hours required, by category, in Applied Mathematics (`AppMath`), Scientific Computation (`SciComp`) and Applied Statistics (`AppStat`) Areas, for MS degrees with and without thesis and PhD degrees. 'AMSC Core' means MATH, STAT, and AMSC courses. * means not required. Seminars are approved AMSC seminars or Research Interaction Teams.

Degree	Category	AppMath	SciComp	AppStat
MS nonthesis	AMSC Core	14	9	18
	Core Science	*	6	*
	Advanced SC	*	6	*
	Seminar	1	*	2
	Data Project	*	*	1
	Application	6	3	6
	Electives	9	6	6
MS thesis	AMSC Core	11	9	18
	Core Science	*	6	*
	Seminar	1	*	1
	Application	6	3	6
	Electives	6	6	0
	Thesis	6	6	6
PhD	AMSC Core	16	9	18
	Core Science	*	6	*
	Advanced SC	*	6	*
	Seminar	2	*	3
	Data Project	*	*	1
	Practicum	*	*	3
	Application	6	6	6
	Electives	6	9	3
	Thesis	12	12	12

The course, thesis, and seminar credit requirements are summarized in Table 1. For all AM degrees, 3 of the credits in the common core courses must be in a course in numerical analysis. In the AM specialization PhD and MS without-thesis degree programs, students take three written examinations, at least one of which must be in a Mathematics area and at least one in an area of application. For the SC degree specializations, the Examinations requirement is replaced by the mandated performance at average grade 3.5 in the required Scientific Computing courses (SC I & II, and also Advanced SC I & II in the PhD and MS without-thesis programs) and Computer Organization and Programming (COP) course. (In the Table, the AMSC Core for SC programs refers to the combination of the SC I & II and COP courses.)

B. Proposed Applied Statistics Area of Specialization

Credit requirements for the Applied Statistics Area of Specialization in the Ph.D. and M.S. degree programs are displayed in Table 1. The comparison with the older Applied Mathematics and Scientific Computation Areas shows clearly the heavy emphasis the new Area places on core courses and on the Data Analysis Project, Seminar and Practicum requirements. As noted below, because of the highly interdisciplinary aspects of this program, the student's advisory committee may ask students to complete more than the minimum number of credits displayed in Table 1.

Core Statistics Requirements

All masters and doctoral students entering the Applied Statistics Area will need to complete the equivalent of the following 6 course requirements, representing 18 core credits. Complete descriptions of the core courses listed below can be found in the Graduate Catalog.

Mathematical Statistics: Two semesters on statistical inference given by the STAT program.

STAT 700 `Mathematical Statistics I` (3 credits) Offered only in Fall.
Prerequisite: STAT 410 or equivalent.
Statistical concepts, sampling distributions, and optimality principles.

STAT 701 `Mathematical Statistics II` (3 credits) Offered only in Spring.
Prerequisite: STAT 700 or equivalent.
Hypothesis testing and optimality concepts; parametric and nonparametric theory and examples; large-sample theory.

Linear models and regression: Two semesters on linear models, the first given only by the STAT program, the second given either by STAT or with BIOM 602 on Experimental Design as an allowed equivalent.

STAT 740 `Linear Statistical Models I` (3 credits) Offered only in Fall.
Prerequisite: STAT 420 or STAT 700 or equivalent.
Least squares, general linear models, regression, analysis of variance and covariance.

STAT 741 `Linear Statistical Models II` (3 credits) Offered only in Spring.
Prerequisite: STAT 740 or equivalent.
Experimental design, random effect and mixed models, and generalized linear models.

Statistical computing: The modern practice of applied statistics requires intensive computing and sophisticated software tools. Students may complete the statistical computing course requirement by taking STAT 705, or by another course approved by the student's SAC which develops statistical computing expertise in high-level statistical packages and includes appropriate simulation techniques (e.g. Monte Carlo and bootstrap methods) and numerical methods.

STAT 705 (formerly STAT 798C) Statistical computing; (3 Credits).
Prerequisite: STAT 420 or STAT 700 or equivalent.
Introduction to statistical computing using `Splus/R` and `SAS` including Monte Carlo simulation techniques and numerical methods (numerical maximization, smoothing and linear algebra).

Multivariate statistics: The required Multivariate Analysis course covers many of the classic topics including discrimination, MANOVA, Hotelling's T-square, Principal Component Analysis, Factor Analysis, and Canonical Correlation. Any of several courses on campus — including STAT 750, EDMS 771, BMGT 882 and BIOM 621 — can meet this requirement.

Other requirements

Practicum: Usually in the third year, doctoral students in the Applied Statisics Area will be required to complete a one-semester Practicum. The goal is to gain experience of statistical research in a real-world setting. After obtaining approval in advance for a Practicum project proposal submitted to the Study Advisory Committee, the student will participate actively in a semester-long applied statistical project, such as an internship or collaborative research assistantship involving more planning and expertise than the smaller projects assigned in a classroom setting. A new three credit AMSC course, detailed below, will formalize this requirement. Students will be encouraged to complete the Practicum off-campus in the setting of a government agency or off-campus commercial or non-profit research organization. One vehicle for arranging such an Internship project will be the campus Graduate Statistics Internship program, a newly proposed initiative of the campus Statistics Consortium. Another vehicle may be existing statistical Consulting/Practicum courses (e.g., BIOM 688).

AMSC 760 Applied Statistics Practicum (3 Credits). (New course, proposed)
Prerequisite: at least one full year of graduate study in Applied Statistics, plus approval by SAC of a written project proposal.
Students will work in an internship or collaborative research-laboratory setting, for a time equivalent to 10 hours per week for one semester, on a substantive applied quantitative project with significant statistical content, and present a formal written report of 15–30 pages.

AMSC 761 Applied Statistics Seminar (1 Credit). (NEW COURSE, PROPOSED)
Seminar taught once yearly on a rotating basis by faculty engaged in the Applied Statistics Area. Required of AMSC Applied Statistics Area doctoral students within one year following the completion of their Practicum project, AMSC 760, and open only to Applied Statistics Area students. The seminar will include sessions on presentation skills, but will consist primarily of oral presentations of students' past Practicum project results. Students attend throughout the term, give one talk (at least 1/2 hour), and draft a written version of the talk given, based on their Practicum paper.

AMSC 762 Data Analysis Project (1 Credit). (NEW COURSE, PROPOSED)
This course cannot be used to meet any of the Applied Statistics Area's seminar requirements. Offered yearly, required of and limited to MS non-thesis and doctoral students in the Applied Statistics Area, for whom the resulting Projects serve as a Qualifying Exam component. After 6–8 lectures or presentations on components of successful data analyses and writeups, 4–5 sessions will discuss previous student project submissions. The culminating project, to be completed in a two week period between semesters, is an analysis and written report of one of three project choices made available each year to represent a spectrum of realistic applied statistical problems.

Seminar requirement: Oral and written communications skills are critical for the applied statistician. Seminars provide a forum for students to learn to give oral presentations and hear presentations of others. Students will be strongly urged to attend more than the minimum required seminars listed below. PhD students in the Applied Statistics Area will be required to take at least 3 seminars with the following constraints.

1. The required seminar AMSC 761 concerns presentation and discussion of the results of the Practicum.

2. One seminar must include both written and oral presentation. Students will normally meet this requirement by participating for a semester in a Research Interaction Team (RIT) with a focus in an area of applied statistics and a required written report.

3. One seminar must be in the area of application, e.g. engineering, business, economics, biology, etc. It may be an RIT directed by a faculty member outside the Mathematics department. This seminar may not count towards Application area course credits.

Students pursuing the MS without thesis must complete the second and third seminar requirements in this list, and MS with-thesis students must complete the second or third.

Requirements in an area of application

The minimum application-course requirements for this Area of Specialization will be consistent with those of the other AMSC areas. For some applied subject areas, substantially

more coursework — either lecture courses or seminars — may be needed, as determined by the student's Study Advisory Committee.

Comprehensive Qualifying Examinations

The examination requirements for the Applied Statistics Area, both for the Ph.D. and for the Masters' without thesis, include two written examinations and a Data Analysis Project (AMSC 762) . The written examinations are similar to those in the standard Applied Mathematics program, while the Data Analysis project requirement is analogous to the Scientific Computing Area's qualifying requirements involving projects.

Scholarly Paper – MS Without Thesis

Applied Statistics Area students in the non-thesis Master's program, after meeting their examination requirements, must write a scholarly paper with the same guidelines as other MS non-thesis students the Applied Mathematics program.

Candidacy

In order to advance to candidacy, doctoral students must complete all comprehensive exam requirements, the data project and the practicum, and must be in good academic standing. In addition, students must complete their preliminary core coursework before achieving candidacy, but may take up to 9 credits of electives afterwards. Students must also submit to their candidacy oral committees a written candidacy prospectus by approximately two weeks in advance of the required candidacy oral presentation. These guidelines are consistent with existing AMSC guidelines and guidelines of the UM graduate school.

Mandatory Advising

To prevent students from losing focus in an interdisciplinary and interdepartmental program such as the Applied Statistics Area, students will be required to schedule and attend a meeting each semester with (at least one of) their advisors, consisting of their SAC members until they acquire research advisors.

Reports

Students must file SAC reports, a candidacy prospectus and a dissertation proposal in a manner consistent with the other concentrations within AMSC. Students must also comply with regulations of the Graduate School.

Dual degrees

Some students may wish to complete a Master's degree in Applied Statistics and a PhD in an area of application (outside AMSC) or vice-versa. There is an approved Dual Degree

Program at the University, according to which the student is enrolled in a doctoral program but simultaneously earns a Masters' degree in a second program. The governing University rules are described in the Graduate Catalog web-page `http://www.gradschool.umd.edu/catalog/dual_doctoral_masters_new.htm` . The AMSC Applied Statistics track will encourage such arrangements for suitably prepared students.

V. Sample Program

The most likely program for students in the Applied Statistics Area would be as follows:

Yr. 1: (PhD & MS) `STAT 700-701 , STAT 705 (Spring), 2 courses in Application area, 1 seminar, & possibly a SAC-recommended elective.`

Yr. 2: (PhD & MS) `STAT 740 plus second semester of Linear Models or Experimental Design, Multivariate Stat course, 1 RIT (Seminar), plus SAC recommended elective or Application course(s). (MS) work on thesis or scholarly paper.`

Yr. 3: (PhD & non-thesis MS) `Practicum and Data Project, plus specialized research seminar or RIT with (potential) thesis advisor.`

A cross-classified and keyword-searchable index of applied statistical courses on the College Park campus, including the Core courses in the Applied Statistics Area together with many of the courses that sudents in the track might choose as electives, can be found at `http://www.jpsm.umd.edu/stat/coursesearch.asp`.

VI. Transition to New Curriculum

AMSC students currently enrolled in the Applied Mathematics track who have not yet attained candidacy and who elect to switch over to the Applied Statistics Area of Specialization will formally request the switch through the AMSC Director. Recognition of previously completed coursework and Qualifying Examinations within the Applied Statistics Area will be determined on a case-by-case basis by the Director and the SAC formed for the student.

Assessment Plans

The Assessment Plans for AMSC Applied Mathematics track include the currently available Statistics courses and degree programs. Initially, these Plans will be followed also for the new Applied Statistics Area of Specialization within AMSC. After the Data Analysis Project and Practicum courses have run at least once, these Plans will be adapted to new Assessment Plans for the Applied Statistics Area that will reflect the special features of the new program elements of this Area, especially the Data Project and Practicum and the skills they are designed to teach.

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