PROGRAM REVIEW 2015-16

DEPARTMENT: Mathematics & Statistics, CNSM
PROGRAM: Mathematics
DEGREE: MS

PROGRAM PRODUCTIVITY AND EFFICIENCY

1) Discuss or provide context for the following components of the PAIR data, and provide an explanation of any numbers that may seem out of place given the size and capacity of your program:
   a. Total SCH
   b. Number of majors
   c. Number of degrees
   d. Time to degree
   e. Department budget
   f. FTEs
   If the data do not accurately reflect the program, explain why not. Also, discuss trends, e.g., is enrollment growing or decreasing? Why?

In the previous program review year (2014-2015), the Department of Mathematics and Statistics (DMS) prepared an extensive program review for the BS and BA programs. The current document uses the more recent, and more accurate, PAIR data for the MS Mathematics program. Nonetheless a parts of the current document re-use content from the previous program review, because many distinctive features of DMS have not changed.

Total SCH

The student credit hours (SCH) of "MATH - Grad" courses listed in the current (dated 11/5/15) PAIR data is spread over a number MATH 600-level courses. From the point of view of the MS Mathematics curriculum, these courses are in two types: required core courses and largely-service elective courses.

On a two-year cycle we teach four core courses required of all MS Mathematics students:
- MATH 631 Algebra I
- MATH 641 Real Analysis
- MATH 645 Complex Analysis
- MATH 651 Topology

These courses have MS Math and PhD Math students almost exclusively, with roughly 90% of these being from the MS program.

Most remaining MATH 600-level courses---especially
- MATH/PHYS 611, 612 Mathematical Physics I, II
- MATH 614 Numerical Linear Algebra
- MATH 615 Numerical Analysis of Differential Equations
- MATH 660 Advanced Mathematical Modeling
- MATH 661 Optimization
- MATH 663 Graph Theory

and certain topics courses offered on an ad-hoc basis---are significantly "service" courses with students from other majors including the sciences, engineering, computer science, and statistics. Though the fraction of "MATH Grad" SCH which actually represents students of the MS Math program is unknown in the PAIR data, it is only reasonable to suppose that fraction is between 50% and 75% for these elective/service courses. That is, the number of MS Math SCH is more likely to be 100 per year than the 145.6 SCH average per year for "Math - Grad" SCH.

MS Mathematics students do take some 400-level math courses, but this is likely to be at the 5% to 15% level of the 600-level course SCH.

Number of majors

The numbers of majors reported in the PAIR data are reasonable compared to our record-keeping (though the exact PAIR query is unknown).

However, roughly 50% of our students, including many listed as current majors, are unfunded. Such students are likely to have been accepted based on adequate credentials (undergraduate course preparation, grades, GRE scores, and letters of recommendation) which are, however, not competitive with the students who are offered funding at admission. Unfunded students are likely to take much longer to graduate as they are generally employed elsewhere in Fairbanks, often full-time. They are unlikely to sustain the 9-10 credits per semester required to graduate in two years, and as required of Teaching Assistants. This reduced load taken by unfunded students is strongly reflected in the "Majors' Average Annual SCH Load".

Almost all funded majors are in Teaching Assistantships (TAs) and thus they contribute significantly to DMS's undergraduate teaching. Roughly 5 TAs are awarded each year for MS Math students in the review period. They are responsible as graders, recitation (section) instructors, and lead teachers for an important fraction, though probably under 10% given the large part of the load carried by adjuncts and full-time instructors especially, of the "MATH-Lower" and "MATH-Outside" SCH delivered by the Department.

It takes some students more than two years to graduate, especially for those who are not funded by the Department. While the average of new students (new admission and attendance) is about 5 or 6 per year, about 2 students per year drop out due to personal reasons, poor performance, or switching to another major (especially MS Statistics, thus still within DMS). Thus our graduation rate is above 50%, but it is more like 70% for funded students, which we believe is healthy number as we maintain high standards and rigorous requirements. (Yes, students do fail their Comprehensive exams; over time at a rate of 10-20%.)

The Department could sustain a larger graduate program but the number of TA positions is limited. Research funding is also quite limited *nationwide* for mathematics research, and this is reflected in the low and sporadic ability of the mathematics faculty to support MS Mathematics students through Research Assistantships. In fact students have been supported by RAs through grants which are strongly applied in focus (e.g. geophysics and biology faculty collaborations).

Number of degrees

The number of degrees reported in the PAIR data is accurate compared to our record-keeping. We believe that two students graduated in 2011, however, not one, although that difference may be an artifact of the timing of the start of the fiscal year.

Time to degree

As an indirect measure of "time to degree" we may use the "Majors/Degrees" reported on the recent PAIR data. (No "time to degree" is directly reported.) We believe the value of 5.6 is high because of unfunded students who continue to make slow progress. If we recompute as "(*Funded* Majors)/Degrees" for FY11-FY15, using the "5 TAships/year" for MS students as above, the number would be 25/9 = 2.8, which is more in line with our experience that funded MS Mathematics students complete the degree in two years, often with a summer or extra semester devoted to project/thesis completion.

Department Budget

As reported by the CNSM Dean, the total Department budget for FY11-FY15 is $2,035,586 average per year.

The fraction of this budget spent on teaching and supervision of MS Mathematics students is, however, quite small. As an estimate based on SCH, using the FY11-FY15 totals of "MATH - Grad" divided by the total DMS SCH, we get 1.4% of the budget or $28,000 yearly.

Such a low fraction does not reflect the appropriately-small student/teacher ratios which apply to grad courses in DMS and nationwide. The actual budgetary fraction devoted to the MS Mathematics program is, however, very hard to calculate, not least because it is hard to separate the teaching of graduate students from the time spent by DMS faculty in doing research with graduate students, and generally the time spent working collaboratively with graduate students across a broad range of tasks.

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FTEs

The most relevant line in the PAIR data, for graduate programs, is "Faculty FTEs". Note that most DMS faculty are in 9 month positions, that about 3 Faculty FTE are statistics faculty who do not teach courses with significant MS Mathematics SCH, and that instructors (2 to 4 FTE depending on year) mostly are not involved in MS Mathematics teaching and advising. Also, one faculty member has a joint DMS/Education position.

With these caveats, a reasonable estimate of Faculty FTE who share responsibility for MS Mathematics program teaching and advising is $0.75 * 10.5 = 7.9$ Faculty FTE.

> 2) Describe the way this program fits into the department as a whole.
> What other programs are offered in the department and how are they connected with this program?
> What percentage of faculty and staff time is devoted to this program as opposed to others offered?
> What are the budgetary needs associated with this program in particular, e.g., how many faculty teach exclusively or predominantly the courses required for this program?
> Do those courses meet requirements for other programs?
> Are there any special equipment, space, commodity or other needs associated with the program that are not covered by student fees?

Other programs in DMS, with connections to the MS Mathematics program

DMS is responsible for five different degree programs:

1. B.A. in Mathematics
2. B.S. in Mathematics
3. M.S. in Mathematics
4. M.S. in Statistics
5. Ph.D. in Mathematics.

In addition, we offer a minor in Statistics, a minor in Mathematics, and a Graduate Certificate in Statistics. Within the B.A. and B.S. degrees in Mathematics, there is an option to concentrate in Statistics.

DMS acts as an integrated whole: all permanent faculty with research responsibilities teach at all levels of the curriculum (undergraduate and graduate), while the four (current) instructors teach almost exclusively at the 100-level, plus some 200-level calculus courses. Also, one instructor both runs the Math Lab, where graduate TAs do the tutoring part of their job, and teaches the 1.0 credit MATH 600 Teaching Seminar for graduate students.

MS Mathematics students are the majority of Teaching Assistants in the Department, with a smaller fraction from the PhD program.

Percentage of faculty time devoted to the MS Mathematics program

All permanent research DMS faculty are involved in all aspects of the undergraduate (B.A. and B.S.) and graduate programs. Faculty are not pigeon-holed into teaching particular courses as is commonly found in, say, the sciences. An instructor with a Ph.D. in Mathematics can teach all courses at the undergraduate level in MATH and across a broad choice of graduate-level MATH courses.

All permanent research DMS faculty are involved in the comprehensive exam process for MS Mathematics, and as committee members, and/or committee chairs, for MS students.

However, the **vast** majority of MATH and STAT teaching effort is dedicated to service courses at the level of MATH 253 or below ("MATH-Lower" and "MATH-Outside"). Permanent research MATH DMS faculty with a typical 60/30/10 contract will, in a typical year, teach three undergraduate courses and perhaps one graduate course.

DMS offers six MATH graduate courses per year which are shared among ten (7.9 FTE) math faculty. Though research MATH faculty teach four courses per year, they teach **at most** one graduate course for the MS program per year.

Regarding faculty time spent supervising MS Mathematics research, however, note that nationwide a large fraction, often 100%, of mathematics research occurs at a level which does not and cannot include MS Mathematics students. Indeed, in contrast to laboratory and field sciences especially, even PhD students are rarely helpful to their advisors in a research capacity. The relationship between faculty and MS student is strongly of mentoring and minimally of teamwork when proving mathematical theorems.

What are the budgetary needs of this program in particular?

The whole DMS faculty, and its Chair, work in an integrated manner to support the MS Mathematics program. No permanent faculty member (research faculty or instructor) is exclusively devoted to the program, though there an uncompensated Graduate Coordinator position held by a faculty member, with primary responsibility for the timing and execution of the comprehensive exam process. As noted above, the majority of DMS teaching is at the undergraduate level, even for research faculty. Thus there is probably no reasonable way to fully separate the budgetary impact of the MS program from the other DMS MATH programs (esp. BA/BS and PhD).

Of the time spent teaching graduate courses, a significant part is "service" to other departments. For instance applied mathematics courses routinely have half or more of their students from other majors (see below), but these courses are also important

electives for MS Mathematics majors. There may be no reasonable way to separate MS Mathematics teaching and graduate service teaching in terms of budget impact.

Support for faculty and graduate student travel has been minimal. Despite the high costs of travel to and from Alaska, we believe travel support is much less than at many of our peer institutions. This is unfortunate, since research in the mathematical sciences is often stimulated by the personal interactions that occur through professional travel.

Do these courses meet requirements for other programs?

Yes! Of the **fifteen** 600-level MATH courses listed in the current catalog, all of which have been taught in the review period, **seven** (611, 612, 614, 615, 660, 661, 663) are used as electives by graduate students outside of DMS to satisfy advancement-to-candidacy requirements. Of these courses, at least five (esp. 611, 612, 614, 615, 660) have more than 30%, and over 50% in some courses, of non-MATH major enrollment.

Also, several 200-, 300-, and 400-level mathematics courses are used by non-MATH graduate students to resolve weak math backgrounds, or to satisfy advancement-to-candidacy requirements. Note MATH 421 can be used to satisfy the catalog requirements of the Ph.D. in Geophysics.

Are there any special equipment, space, commodity or other needs associated with the program that are not covered by student fees?

Certain graduate MATH courses would serve students better if technology could be an integral part of the class experience. However, computer lab space is not available for most courses. (Historically, when the Computer Science (CS) Department split off from DMS to join CEM in 2005, they became sole owner of the previously joint MATH-STAT-CS computer lab in Chapman.)

There is a **pressing need for a Computer Lab** for DMS. It is hard to believe there exist other PhD-granting universities which do not support the teaching of mathematics and statistics with such a facility.

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> 3) Does this program have sufficient resources (people, space, time, funding, student interest) to adequately meet its objectives in a sustainable manner?

DMS does not have sufficient full-time faculty to effectively offer all the courses needed for our preferred MS Mathematics curriculum, but it can minimally meet the objectives of the program with our current faculty.

Space for DMS in Chapman Hall is severely limited, and it remains unclear how this will be addressed. We use two converted seminar rooms and a temporarily-vacated office "borrowed" from CS for graduate student and adjunct office space. Other graduate students and faculty are in windowless offices with no ventilation systems. There is no private office space available for all four current instructors on a long-term basis. Space for a badly-needed computer laboratory remains elusive.

DMS has one full-time administrative assistant, one part-time staff member who serves the Math Bridge program, and one or two student office assistants. This small staff supports more than 10,000 SCH per year, as seen in the PAIR data, across all degree programs and service obligations of DMS.

> 4) Describe the productivity of the program faculty in publication, scholarship, teaching, funded research and service. Mention specific Unit Criteria if they will help the committee to assess the level of scholarly productivity. List any grant funding associated with the program faculty during the review period.

The current make-up of full-time faculty in DMS is ten mathematicians (Allman, Avdonin, Bueler (75% DMS), Berman, Faudree, Gimbel, Maxwell, Rhodes, Rybkin, Williams), one mathematics educator (Rickard 50% in DMS), three statisticians (Barry, McIntyre, Short), plus four instructors without research responsibilities. That is, there are 14 members of DMS with research appointments. We restrict our answer to this question to these fourteen individuals.

Research papers

Research faculty members with appointments in DMS have been extremely productive: over the 5 years of this review, a total of 122 papers have been published, along with 158 research presentations. This works out to be almost two papers published per faculty member per year. DMS research faculty is exceedingly productive, particularly when measured using the publication norms in the mathematical sciences (below).

We note that the **culture of mathematics is very different** than that of the physical and natural sciences. The main professional organization of research Mathematicians in the United States, the American Mathematical Society (AMS) each year publishes a "culture statement" to make known more broadly the norms for productivity and grant funding in mathematics. According to the AMS (see culture statement 2006 on publication rates included in the appendix), the publication rate in mathematics is modest in comparison with other sciences. To highlight this point, this document examined the publication rates during five years preceding the awards of Sloan and Guggenheim Fellowships and found that 70% of the Sloan awardees and fewer than 50% of the Guggenheim awardees published more than two articles annually. The culture statement goes on to explain that in mathematics *quality* not *quantity* is the measure of productivity.

The approved DMS unit criteria reflect this cultural norm, and states that it

> "expects faculty with a 30% research load to be publishing at a rate of approximately one paper per year. At a 50% level or above there should be approximately two. However, it should be emphasized that this is only an approximate goal. The more important goal is quality research."

As noted, mathematics research, especially in "pure" areas, often has no available role for MS students. However, during the review period one faculty member (Rybkin) authored 5 papers with graduate students (3 are published, one accepted, and one submitted).

External Funding

In regard to grant funding, DMS research faculty is also highly successful. We note first that grant funding in mathematics is very limited in comparison to other sciences, and that individual grants are typically of smaller value. Moreover, some sub-areas of mathematics are not funded at all by federal funding agencies. To substantiate this assertion, we quote from the 2006 "culture statement" of the AMS devoted grant funding (see appendix),

> "... In 2006, across all fields of science, 46.9% of those employed in academia received Federal support for their research: 56.3% of physical scientists, 43.9% of computer scientists and 57.9% of life scientists, as compared to 34.8% of mathematicians.
>
> As compared to other natural sciences, there is also a large disparity in the per capita level of funding available to mathematicians. In FY2006, across all fields of science and engineering, the Federal government provided about $260,000 per academic researcher. By field, this breaks down to $360,000 per academic researcher in Computer Science, $140,500 per academic researcher in the Physical Sciences, and $430,000 per academic researcher in the Life Sciences. By contrast, in 2006 the Federal government provided about $47,000 per academic researcher in Mathematics.
>
> When compared to other fields of science and engineering, opportunities for external funding in mathematical sciences are very limited. The vast majority of mathematicians receiving Federal support have just one, single investigator, NSF grant."

The DMS Unit Criteria also reflect this reality:

> "Certain disciplines found in mathematical sciences have little opportunity in the way of external funding. Accordingly, the ability to find funding speaks well for a candidate at any level. However, absence of funding may not necessarily speak against the candidate. DMS does not consider the funding of grant proposals to be the goal of any research project. Rather, we focus on what is achieved with or without research funding."

Over the review period, research faculty in DMS applied for 41 grants of various types, ranging from small travel grants of a few thousand dollars to large grants from the NSF and NASA for hundreds of thousands of dollars. See table below for data on funded grants. Remarkably, when restricting to grants over $100,000, we see that six faculty members (some repeatedly) were funded by NSF or NASA during the last five years. Moreover, 6/14 ≈ 43% of the faculty were funded by large federally-funded research grants; compare the fact that nationally less than 35% of mathematicians are supported by federal grants.

The following table describes these grants:

Allman	**NSF** "Enhancing Phylogenetic Methods and Theory via Algebraic Perspectives" 2007-2012 with co-PI J. Rhodes ($486,450)
	NSF "Participant Support: 2011 Mittag-Leffler Institute" ($48,515)
	Erskine Fellowship, University of Canterbury 2013
	NIMBioS short-term visitor grant
	AIM SQuaRE grant (2011-2013)
	NIMBioS working group grant
	GCAT Workshop on synthetic biology
	Mittag Leffler Institute Research Fellowship
	University of Tasmania Visiting Scholar
	SAMSI Research Fellow
Avdonin	**NSF** grant 2014--2017, "Control and Inverse Problems for Differential Equations on Graphs" ($147,000)
	Australian Research Council grant, ``Interrogation and Estimation of Differential Equation Networks'' (with W. Moran and M. Morelande) 2013--2015
	NSF grant 2007--2011, "Boundary Inverse Problems in Glaciology" with M. Truffer and D. Maxwell ($385,000)
Barry	**U.S. Fish and Wildlife**, support for a graduate student for two years. (Study of the

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Berman	Simons Foundation Collaboration Grant for Mathematicians 7/1/2011 – 8/31/2016 ($35,000)
Bueler	Ed Bueler (PI), Mark Fahnestock (Co-I), Andy Aschwanden (Co-I), and Constantine Khroulev (senior personnel), Understanding measured variability in the Greenland ice sheet using the Parallel Ice Sheet Model (PISM), **NASA** Modeling Analysis and Prediction, NNX13AM16G, funding period June 2013--June 2017 ($737,000)
	Ed Bueler (PI), Regine Hock (Co-I), David Maxwell (Co-I), and Martin Truffer (Co-I), A high resolution Parallel Ice Sheet Model including fast, sliding flow: advanced development and application, **NASA** Modeling Analysis and Prediction, 2009--2013. ($994,000)
Gimbel	Czech National Science Foundation Scholarship
	Charles University Research Fellowship
Maxwell	**NSF** FRG: Collaborative Research: Analysis of the Einstein Constraint Equations, 2013-2014, ($150,000)
	Ed Bueler (PI), Regine Hock (Co-I), **David Maxwell** (Co-I), and Martin Truffer (Co-I), A high resolution Parallel Ice Sheet Model including fast, sliding flow: advanced development and application, **NASA** Modeling Analysis and Prediction, 2009--2013. ($994,000)
	NSF grant 2007--2011, "Boundary Inverse Problems in Glaciology" S. Avdonin with M. Truffer and **D. Maxwell** ($385,000)
Rhodes	**NSF** Grant #0714830: Enhancing Phylogenetic Methods and Theory via Algebraic Perspectives, Division of Mathematical Sciences, Program in Mathematical Biology; with co-PI Elizabeth Allman 2007-12 (partially in this period, but awarded earlier) ($486,450)
	AIM SQuaRE grant (2011-2013)
	Mittag Leffler Institute Research Fellowship and other fellowships
	NIMBioS short-term visitor grant
	Erskine Fellowship, University of Canterbury 2009
	University of Tasmania Visiting Scholar
Rybkin	**NSF** DMS-1411560, Integrable PDEs and Hankel operators, 09/01/14-08/30/17 ($213,000)
	NSF DMS 1126006, REU supplement; 06/10/11-06/30/14 ($36,126)
	NSF DMS 1009673, Inverse Scattering Transform and non-decaying solutions of completely integrable nonlinear PDE's, 07/01/10-06/30/14 ($200,000)

	NSF DMS 0907801, REU supplement, 06/10/09-08/31/10 ($45,000)
	NSF DMS 0707476, Titchmarsh-Weyl m-function and integrable nonlinear PDE's; 09/01/07-08/31/10 ($115,000)
Williams	Fields Institute Travel Grant

Teaching:

As described in detail above, DMS contributes to teaching at all levels; it provides an important part of the baccalaureate core, it provides quantitative training for engineers and other technical disciplines, and it provides quality graduate education both for its majors and in a service role for other graduate programs.

Service:

Members of DMS contribute to service in all its forms: department, university, professional, and public service.

DMS frequently has representatives serving on college-wide and university-wide committees. During the time of review, this included Faculty Senate, Program Review, University-wide Promotion and Tenure, Curriculum Review (both college- and university-wide), General Education Revitalization, Curricular Affairs, Unit Criteria and Faculty Affairs. There are several university-wide committees that have required DMS participation, including Core Review (which was chaired by the DMS representative for several years during the period under review) and Student Academic Development and Achievement.

Members of DMS have also served on various ad-hoc committees, such as the *Educate* Subcommittee of the Strategic Planning Committee at UAF, the UAF Life Sciences Informatics Advising committee, and the system-wide General Education Learning Objectives committee.

After analyzing student success rates in lower-division MATH and DEVM courses, DMS initiated a Subcommittee on Math Placement which suggested using a new mechanism (the ALEKS placement test) for placing students into their MATH and DEVM (and STAT 200) courses in fall 2014. Roll-out of this new placement scheme involved faculty and staff across all areas of the university.

In addition, DMS faculty served on the Joint Health Care Committee and on the Honors Faculty Advisory committee, and one DMS faculty member served as the Chief Negotiator for the current Collective Bargaining Agreement.

DMS faculty members regularly serve as judges at local science fairs, and one person recently was the plenary speaker for the New Mexico High School State Mathematics contest.

Research faculty are also highly involved with service to the discipline. This includes service as peer reviewers for professional journals, and as editors of peer-reviewed mathematics journals.

NEED FOR PROGRAM

> 1) UAF'S mission and Core Themes are attached. How does this program contribute to that mission and those themes? Is this program uniquely central to the mission?

Mathematical and Statistical training are central to UAF's mission and fit well into UAF's core themes.   Part of the University's responsibility is to provide for adequate quantitative training of its citizens; to prepare Alaska's future workforce (e.g. mathematics teachers, scientists and engineers with advanced quantitative skills, statisticians for jobs in state positions, etc.) and to advance the boundaries of mathematical and statistical knowledge.

Any academically strong mathematics department needs to have a strong graduate program in order to fullfill the mission of a research university. Funding agencies like NSF explicitly require addressing broader impacts, and explicitly target support for research that works with students, so maintaining a graduate program with adequate UAF support is crucial to securing external funding in an extremely competitive market. Our Department is unable to offer postdoc fellowships, but it consistently supports both strong graduate research training and undergraduate research experiences (see REU below, for example).

The Mission Statement of the University of Alaska Fairbanks says that the university "... advances and disseminates knowledge through teaching, research and public service...". DMS directly contributes to this part of the Mission by providing quality teaching to a majority of students who attend the university through the required core mathematics requirement or through program requirements such as the calculus sequence. Research knowledge is advanced and disseminated by publications in mathematics and statistics in peer-reviewed journals, and by contributing to the discipline and the general public in a service capacity, including as local science fair judges, statistical consultants, organizers of math contests, as well as serving on local boards.

The MS Mathematics directly contribute to all of UAF's Core Themes, namely **Educate**, **Discover**, **Connect, Prepare**, and **Engage.**

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Educate: Courses used to fulfill requirements for the Math MS program are taken by students across UAF's science and engineering disciplines. Some courses (MATH 611, 612, 614, 615, 660, 661) are used to fulfill advancement-to-candidacy requirements by graduate students from other units. The MS Mathematics degree appeals to different populations of students, including those interested in mathematics research at the PhD level, a career in mathematics teaching, especially at the college level, and those interested in working in the public sector or in industry.

Discover: The department has researchers who are highly productive, in a variety of mathematical and statistical disciplines. Departmental researchers frequently present at national and international conferences and are involved in collaborations around the world. They also mentor students, both at graduate and undergraduate levels, to discover their own paths to mathematical research.

Prepare: Courses that satisfy requirements for the Mathematics MS are used to prepare graduate students in mathematics, science, and engineering. The program also contributes to preparing the mathematics teachers, and the leaders of mathematics education, of Alaska.

Connect: Through eLearning and the offering of MATH and STAT courses at rural campuses, DMS connects students all over Alaska with mathematics and statistics instruction and training.

Engage: MATH and STAT courses are taken by students of all age demographics in Alaska and in lifelong learning. As many job qualifications now require significant quantitative training (statistics, engineering), the role of DMS in offering its undergraduate courses is a boost to the economic development of Alaska.

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2) List any active academic, community, or industry partnerships associated with this program, and briefly explain what the partner contributes (including but not limited to monetary and in-kind contributions).

Graduate training for quantitative fields at UAF

On a day-to-day basis, one of the most important partnerships is with other Departments, especially in science and engineering, through the DMS role in training students in advanced quantitative skills. A significant fraction of the total CNSM and CEM graduate curriculum occurs through courses listed on the advancement-to-candidacy requirements for non-math graduate students. This partnership comes from the dual role of MS Mathematics courses as electives within the major and as service courses, typically in applied mathematics, outside the major.

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Research Experience for Undergraduates (REU)

For the review period, DMS research faculty member Rybkin has raised over $100,000, mostly through NSF REU supplements, with some contributions from GI and URSA, to support REU activity of 17 undergraduate students. The students participated in 8 distinct projects on math modeling, six on nonlinear water wave phenomena important to tsunami modeling, and two on other applied math topics. This activity has resulted in 1 published research paper, 1 submitted, 1 in final stage of preparation, and 1 in preparation, 16 talks (in colloquium series, domestic and international professional meetings). Besides Rybkin, Dr. Dmitry Nicolsky of GI was actively involved in 5 projects, and Dr. Efim Pelinovsky of Institute of Applied Physics, Russia was actively involved in 2 projects.

Joint MATH-CS Graph Theory Research Group

Members of DMS (Berman, Faudree, Gimbel, Williams) and the Computer Science department meet weekly to discuss research problems in graph theory. During the period under review, this collaboration has resulted in 2 papers which are currently in review.

Partnerships with Biology and Wildlife

Faculty members Rhodes and Allman collaborate with faculty in Biology & Wildlife to help increase the quantitative knowledge of students and faculty in biology. They both have Research Faculty appointments with IAB, and have served as informal and formal advisors on biology Ph.D. committees.

They have also developed an interdisciplinary undergraduate course MATH/BIOL 393 in synthetic biology, and a graduate course in "Theory of Phylogenetics" that attracts students and faculty in biology and fisheries in addition to those in mathematics and statistics. The last time the "Theory of Phylogenetics" course was offered, students and faculty from UAA and UAS enrolled remotely.

Parallel Ice Sheet Model project

The Parallel Ice Sheet Model (PISM; www.pism-docs.org) is an open-source scientific software project based on a partnership of DMS with other parts of UAF, and of UAF with several other institutions. The principle investigator is DMS faculty Bueler, with MS Mathematics graduate Constantine Khroulev as lead programmer, MS Mathematics graduate Jed Brown as the former lead programmer, and DMS faculty member Maxwell as a former Co-I. Two MS Mathematics students, along with several non-mathematics UAF graduate students, have worked on PISM-related projects and theses since 2011.

UAF researchers account for about 85% of the software code base of this scientific and mathematical modeling project. It has active collaboration with researchers at the following institutions among many others who use PISM:

* Danish Meteorology Institute, Copenhagen, Denmark
* Max Planck Institute for Meteorology, Hamburg, Germany
* NASA Goddard Institute of Space Studies, USA
* Potsdam Institute for Climate Impact Research, Germany
* Victoria University, Wellington, New Zealand

Collectively, such collaborations, in the form of PISM model usage, have yielded 51 peer-reviewed publications since 2011, including 10 in the prestigious *Nature, Science,* and *Proceedings of the Natural Academy of Science* journals.

These collaborations represent a high degree of international visibility for UAF-based mathematics and geophysics faculty and students. The project also represents a strong intra-UAF partnership between DMS, the Geophysical Institute (GI), and the Arctic Region Supercomputing Center (now part of GI). Each of the four NASA grants supporting PISM, totaling $2.4M for the 2001-2017 period, have had at least one DMS and at least one GI investigator, and each is based on high performance computing resources from ARSC/GI .

3) Is this program duplicated within the UA system? If there is another program within the system, does this one have any important differences from the other program(s)?

Though UAA and UAS have BS/BA in mathematics, only DMS at UAF offers a MS degree in Mathematics (or a PhD). There are no alternatives for graduate-level mathematics degrees in the state of Alaska.

Only DMS offers graduate-level (600-level) service courses needed by science and engineering graduate students for completion of their studies. There are no alternatives for graduate-level training in quantitative sciences in the state of Alaska.

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4) Describe the demand for the program by students and the prospective job market for program graduates. (For assessing the job market, you may find the following publication useful (http://labor.alaska.gov/trends/), particularly their annual employment forecast. The national Bureau of Labor Statistics also has potentially applicable information (http://www.bls.gov/ooh/).
If your program tracks actual job placement of its graduates, please provide that information. However, it's recognized that not all degrees qualify recipients for specific occupations, so in some cases, you may need to address this question in broader terms, e.g., what skill set does the degree represent? What kinds of jobs are graduates obtaining?

The MS Mathematics program has a steady applicant pool which suggests a steady demand for this kind of education. Many students are from Alaska and have either the goal of finding employment within the state using these skills, or the goal of getting started on a mathematics research-level education, which necessarily must be followed by PhD-level education. Of the current 10 MS Mathematics majors, two were secondary teachers from the state of Alaska, and one more was an out-of-state teacher.

Regarding MS Mathematics graduates, they are successful at continuing on into PhD programs, both in mathematics and in other sciences, or in finding professional jobs using their MS-level background, according to their goals and abilities. This statement can be made with no qualifications.

In fact, in the review period, 10 students graduated from the program with a MS in Mathematics. Of those students, *all* **graduates in the review period either proceeded to more-advanced graduate education** *or* **are employed in positions which use the training and education provided by the program** (with initials):
- five are currently enrolled in PhD programs, (V.G., M.H., V.M., W.M., J.B.)
- one is a full-time instructor in DMS, (O.B.)
- one is an adjunct instructor in DMS, (Y.Z.)
- one is teaching mathematics at an out-of-state junior college, (K.K.)
- one works as a software engineer, (L.G.)
- and one as a bioinformatics programmer. (M.L.)

Of the above 10 graduates, note that 3 remain at UAF as employees or students. In fact, here is a probably-incomplete list of **graduates of the MS Mathematics program currently employed by UAF**:

- Ron Barry, Professor, DMS
- Odile Bastille, Instructor, DMS
- Latrice Bowman, Instructor, DMS
- Tim Carlson, Assistant Professor, Bristol Bay Campus
- Joe Dart, Adjunct Instructor, DMS
- Sarah Garland, Program Director, Osher Life-Long Learning Institute

- Constantine Khroulev, Research Professional, GI
- Julie McIntyre, Associate Professor, DMS
- Dmitry Nikolsky, Research Assistant Professor, GI
- Tony Rickard (MAT Mathematics), Professor, DMS
- Kat Sorenson, Instructor, DMS
- Dana Thomas, Vice Provost and Accreditation Liaison Officer, retired, UAF
- Jane Weber, Assistant Professor of Developmental Studies
- YuanYaun Zhao, Adjunct Instructor, DMS
- Beth Zirbes, Instructor DMS

It is thus no exaggeration to say that, just to function, UAF depends on graduates of the MS Mathematics program. Concretely, meeting the demand of DMS to teach a large number of SCH at the "MATH-Lower" and "MATH-Outside" levels (about 9,000 SCH per year) has only been possible through the education and hiring of MS Mathematics graduates as instructors and adjuncts within DMS.

MISSION FULFILLMENT

Attach the most current Student Learning Outcomes (SLOA) plan and most recent SLOA summary.