**FORM 2**

**COVER SHEET**
**NEW DEGREE PROGRAM PROPOSAL**
***Part I requires the completion of the following forms: Appendices B-4, B-5, and B-6.***



## Program Information

Program Name: Department of Applied Mathematics

Institution Name: University of Washington

Degree Granting Unit: College of Arts and Sciences

Degree: Master of Science Level: Master's Type: (of) Science

Major: Computational Finance and Risk Management CIP Code: 52.0801

Minor: NA

Concentration(s), NA

Proposed Start Date: Summer 2011

Projected Enrollment (FTE) in Year One: 21 FTE At Full Enrollment by Year: 46 FTE by 2013

Proposed New Funding: Self-sustaining with revenue of $750,000 in 2011-12 (no state funds required)

Funding Source: ___State FTE _X_ Self Support ___Other

## Mode of Delivery / Locations

_X_ Campus Delivery University of Washington, Seattle, WA

___Off-site

_X_ Distance Learning Online through PCE (EDGE) Program

Other NA

Note: If the program is the first to be offered at a given site or location, the submission must also include the information required for the establishment of a new teaching site as outlined in section B.1 of the Program and Facility Approval and Policy Procedures.

### Scheduling

_X_ Day Classes _X_ Evening Classes ___Weekend Classes Other *(describe)*_____

## Attendance Options

_X_ Full-Time _X_ Part-Time
Total Credits: Student must earn 40 credits from a curriculum offering 60 credits

## Contact Information (Academic Department Representative)

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Endorsement by Chief Academic Officer

February 25, 2011
Date

# Proposal to offer the Master of Science Degree in Computational Finance and Risk Management

Submitted by the
Department of Applied Mathematics
College of Arts and Sciences
University of Washington
February 11, 2011

# Professional MS Degree in Computational Finance and Risk Management

## Program Summary

The modern finance industry is comprised of a broad range of organization types that include endowments, pensions, family offices, insurance companies, hedge funds, funds-of-hedge funds and a broad range of quantitative asset management organizations. During the last decade the finance industry has increasingly made use of highly quantitative and computational approaches to investment decision making and financial risk management. This trend has led to the establishment of a new interdisciplinary sub-area in the fields of economics and business finance. Accordingly, we have witnessed the creation of a number of new "quantitative finance" Master's degree programs to educate quantitative financial professionals ("quants") such as research analysts, traders, portfolio managers, risk managers, investment committee members, and financial information technology professionals. The next generation of quants will be challenged to develop new quantitative methods of investment and risk management, methods that will be more effective in the face of local and global markets that have a high degree of complexity, interaction and potential instability.

The over-arching goal of the proposed Professional Master of Science in Computational Finance and Risk Management (PMS-CompFin) is to provide world class education to the next generation of quantitative finance professionals. Such education will include on-going coverage of the most modern quantitative finance methods and computational tools for investment decision making and financial risk management.

The PMS-CompFin program will be fee-based and self-sustaining. The majority of the students will be working professionals enrolled in online course offerings on a part-time basis. The remainder of the students will be enrolled on a full-time basis in either online or simultaneous on-campus course offerings. Online students may view the lectures live via streaming video, and both online and on-campus students may download the lectures to their personal computers for further study and review. The online component of the program will be delivered in a partnership between the Department of Applied Mathematics (AMATH) and the UW Educational Outreach (UWEO) organization. The resident component will be offered by the Department of Applied Mathematics. Graduates of the program will be prepared to do one of the following: (a) advance themselves professionally in their current and future quantitative finance job positions, (b) enter the quantitative finance field as their first profession, or (c) change careers and enter the quantitative finance field. There is currently no MS degree program in the entire Northwest region that is at all comparable to the one we are proposing.

Two existing AMATH online programs at the University of Washington provide strong evidence that the proposed PMS-CompFin program is highly viable. The first is a fee-based online MS in Applied Mathematics complement to the long-standing MS degree in Applied Mathematics for resident matriculated students. This new online degree was fully operational and self-sustaining ever since its creation in the Fall of 2007, with net profits that support the Applied Mathematics Department in important ways. The second program is a new online Computational Finance Certificate launched in fall quarter 2010 by the Applied Mathematics Department. This three-quarter sequence enrolled 30 students and is projected to be substantially profitable in 2010-11 and beyond.

It is our belief that the proposed PMS-CompFin will generate sufficient revenue to fund at least two new faculty positions to help mature the program into a top-five ranked MS degree program in the U.S., with the first such position likely fundable in 2012-13.

# 1. PROGRAM NEED

## 1.A RELATIONSHIP TO INSTITUTIONAL ROLES AND MISSION

In the subsections below we first state the missions of the University of Washington, the College of Arts and Sciences and the Department of Applied Mathematics, and then describe the elements of several existing programs that have evolved in recent years as a foundation for the proposed PMS-CompFin, and collectively help fulfill the unit missions.

### 1.A.1 University of Washington Unit Missions

"The primary mission of the University of Washington (UW) is the preservation, advancement, and dissemination of knowledge. ... the University is committed to maintaining an environment for objectivity and imaginative inquiry and for the original scholarship and research that ensure the production of new knowledge in the free exchange of diverse facts, theories, and ideas. ... The University cultivates in its students both critical thinking and the effective articulation of that thinking ...The academic core of the University of Washington is its College of Arts and Sciences."[1]

The Vision and Goals of the College of Arts and Sciences (CAS) includes "We will generate innovative and significant scholarship that will yield new knowledge, shape how we teach and learn, and contribute to a deeper understanding of the natural and cultural worlds", along with the following goals: "(i) Enhance the ability of faculty, students, and staff to achieve significant and meaningful scholarship within and across traditional and emerging disciplines, (ii) Integrate scholarly activities into teaching, learning and service throughout the college, and (iii) Enrich the quality of graduate student experience as fundamental to the scholarly enterprise."[2]

The Department of Applied Mathematics (AMATH) that resides in the College of Arts and Sciences and emphasizes "Applied and Computational mathematics as encompassing some of the most diverse and interdisciplinary research in the physical, engineering and biological sciences",[3] Expanding the AMATH areas of teaching and research into the realm of computational finance and risk management with the proposed PMS-ComFin program is a natural step in diversifying and expanding the application areas of applied mathematics into growing areas in economics, business and social sciences. In particular, during recent years it has become fairly common for such programs to be housed in an Applied Mathematics or Mathematics Departments (see Section 1.D.1).

### 1.A.2 The Online MS Degree in Applied Mathematics

The Department of Applied Mathematics has offered an MS degree since 1972. In the Autumn Quarter of 2007, the Department of Applied Mathematics introduced the online MS degree in Applied Mathematics. Beginning with relatively small numbers of 15-25 full- and part-time students, our online enrollments have continued to increase steadily and dramatically, leading to a three times increase in numbers in just three years. At the beginning of Autumn Quarter 2010, the program had in the neighborhood of 90 full- and part-time students. The current ratio of resident MS degree students to online students is approximately 25%. We currently plan to hold the number of resident MS degree students constant at around 20 students due primarily to office space limitations. On the other hand, there has been no evidence of a leveling off of enrollments and applications for the online MS degree, which is less constrained by physical space limitations. Indeed, the program continues to grow in popularity, especially as the department has continued to raise its research profile in the community over the last few years. With the recent National Research Council rankings further establishing the UW Applied Mathematics department as one of the very best in the country (tied for first with Princeton University), we anticipate a continued demand for this professional degree. Indeed, the department is without peer in the online professional M.S. degree arena, both in terms of academic reputation and cost for a M.S. degree. We anticipate that the proposed PMS-CompFin will build upon the established online success, reputation, and know-how of the Applied Mathematics program.

### 1.A.3 The UW Computational Finance Graduate Certificate Background

In recognition of the needs of the modern finance industry as it emerged in the early 2000's, a new interdisciplinary Computational Finance Graduate Certificate Program (CFGCP) was proposed in 2004 by Professors Doug Martin in Statistics and Eric Zivot in Economics, who ultimately became Director and Co-Director respectively of the program. This program, which requires students to take 6 courses from a prescribed curriculum, was approved by the Board of Regents and launched in fall quarter 2004 with the Graduate School as the program home. For further details about the program see www.amath.washington.edu/studies/compfin. New courses for this program were developed using UW Tools for Transformation funding (no longer available) in the amount $110K. The program received no other direct UW funding.

The CFGCP is aimed at Ph.D. students from a wide range of science and engineering departments including applied mathematics, economics, mathematics, statistics, physics and computer science. Correspondingly Martin and Zivot and the participating faculty members in the departments of Mathematics and Finance have had strong research activities focused on Ph.D. students (see the "Faculty" page of the above web site). As a tiny program it had on average 15-20 students in the program by 2008 and "graduated" 13 students between 2006 and 2010, placing 10 of them in excellent finance industry jobs and 3 in university faculty positions. Of these 13 students, 7 were in Statistics (6 were Martin's Ph.D. students), 4 were in Economics (Zivot's Ph.D. students), one was a Computer Science Ph.D. student and one was a Physics Ph.D. student.

As an interdisciplinary program with both a cutting edge research and teaching focus, the CFGCP fits well within the missions of both UW and CAS. During spring quarter 2010 a five-year review of the CFGCP was conducted. The review committee consisted of two UW faculty members and two outside members as follows:

| | |
|---|---|
| Nathan Kutz | UW AMATH Professor and Chair of AMATH (Chair of Committee) |
| Mark Damborg | UW Electrical Engineering Professor |
| George Zinn | Corporate Vice President and Treasurer, Microsoft |
| John Lehoczky[4] | Thomas Lord Professor of Statistics and Dean of College of Humanities and Social Sciences, Carnegie Mellon University |

The committee completed a thorough review of the program and delivered their report on June 8, 2010. Here we restate verbatim the parts of the report that are most relevant with regard to the current PMS-CompFin proposal:

1) The computational finance graduate certificate program (CFGCP) has been successful and should indeed be continued.

2) For the program to be continued, its foundation must be strengthened. Specifically, the certificate program needs to (i) find a UW departmental home that would take responsibility for the CFGCP and work with Martin and Zivot to further develop it, and (ii) develop a revenue stream, most likely from a fee based master's program, to support both the CFGCP and the master's program on a self-sustaining basis.

3) There is clear interest in computational finance from the student perspective. Further, computational finance is a field of growing importance and demand. The lack of support for the current program at the University of Washington is surprising given that many universities have turned such programs into strong revenue sources for academic departments.

4) Despite the negative or indifferent responses from the potential home departments of Statistics, Economics, Business, Industrial Engineering, and Mathematics, the exercise proved useful by identifying Applied Mathematics as a potential home for the certificate program, one in which the program would be supported and encouraged to grow.

In response to CFGCP review report comments (2)-(i) and (4) above, discussions ensued between Martin and Zivot and the AMATH department with the result that AMATH has become

the home for the overall UW Computational Finance program consisting of the current CFGC, a new online Computational Finance Certificate program and the proposed PMS-CompFin.

### 1.A.4 The AMATH Online Computational Finance Certificate

In view of the CFGCP review report comment (2)-(ii) above, AMATH and UWEO jointly decided to take a quick first step in the direction of offering a fee-based revenue-generating MS degree by launching a fee-based revenue-generating Online Computational Finance Certificate (OCFC) in fall quarter 2010. The OCFC is a three-quarter program consisting of three 4-credit courses, one each. One of the courses is an existing course that has been taught for a number of years as part of the GCFCP, and two are newly developed. These three courses will also serve as required core courses for the proposed PMS-CompFin as discussed in Section 2.B.2.

With a very short launch and marketing period of 2.5 months in the summer of 2010, the program enrolled 30 highly motivated students, 20 of whom work and reside in the greater Puget Sound area, and appreciate the ability to have occasional direct interaction with faculty members teaching courses in the program. This online computational finance certificate program is projected to be highly profitable in 2010-11, and the proceeds will be devoted to help develop the proposed PMS-CompFin program.

### 1.A.5 The PMS-CompFin Program

The proposed PMS-CompFin degree program will offer 16 courses for a total of 60 credits. Of these 15 courses 13 will be offered by AMATH (some of them jointly listed with other departments), and the remaining 2 courses will be offered by the Economics Department (Professor Zivot's courses) under a memo-of-understanding to be put in place between AMATH and Economics. The above course offerings will include a Risk-Management concentration pathway consisting of a new three-course three quarter sequence.

The PMS-CompFin degree requires 40 credits to be selected from the above 60 credits. This requirement can be completed in two-and-a-half years by part-time students who take one course per quarter, and can be completed in twelve to fourteen months by full-time students. Initially there will be a majority of online students and only a small number of resident students, in part because of a severe limitation in office space for such students.

Professor Martin will serve as Academic Director of the program, working closely with an Applied Mathematics Oversight Committee that will include Professor Zivot. Given that all of Martin's teaching, research and service efforts will be for AMATH, and because a new program such as this needs reasonable near-term stability, it will be appropriate that Martin's position be transferred from Statistics to Applied Mathematics and Martin has made this request to the CAS Dean.

It should be noted that a number of courses in the PMS-CompFin program will be taught by local finance industry professionals (bios are provided in Appendix D). This will not only bring very valuable practitioner experience into the curriculum, it will also foster interaction with a number of local finance industry companies and support building a strong relationship with a component of the Puget Sound business community (see next sub-section).

### 1.A.6 Partnerships with Local Finance Industry and Organizations

An important component of our program is the development of mutually beneficial relationships with the finance industry and organizations in the Puget Sound area where face-to-face interaction is possible, and elsewhere where targets of opportunity exist. As a first step in developing such relationships we have obtained the verbal commitment on the part of five such finance industry professionals to teach practitioner-oriented courses in the PMS-CompFin program. These individuals are from organizations such as Russell Investments (who recently moved their head-quarters and primary operations center from Tacoma to Seattle), Parametric and Morgan-Chase, whose involvement with the PMS-CompFin will add considerable distinguishing value to the program.

As a second step we have initiated discussions with individuals at companies such as those above concerning possible internship positions for PMS-CompFin students, and possible joint research projects, both of which we anticipate occurring by 2011-12. In the longer term we will seek annual subscription donations in support of the ComFin program, and hold an annual event for the subscribing companies at which students and faculty make research presentations (similar to what the Department of Computer Science and Engineering at the University of Washington currently does).

We have also had discussions with three finance organizations, the national office of the Global Association of Risk Professionals (GARP), the local chapter of the Chartered Financial Accounts (CFA), and the Seattle Alternative Investments Association (SAIA), that we believe will lead to effective partnering relationships. See Section 1.B.3.

Appendix A contains letters of support for the proposed PMS-CompFin from the following organizations: Blackrock, Russell Investments, the Microsoft Treasury, the UW Endowment (UW Investment Mangement), the Global Association of Risk Professionals (GARP) and the Seattle chapter of the Chartered Financial Analysts (CFA).

### 1.A.7 Strategic Importance of Online Learning at UW

Like the online Master of Science degree in Applied Mathematics, the proposed PMS-CompFin degree offers the University of Washington a decisive strategic advantage over other institutions in the online learning space. The proposed programs are highly innovative, strongly market driven, and provide a unique and formative professional development platform for qualified students. In addition to providing leadership in this arena, the programs are much more than self-sustaining programs. Indeed, in Applied Mathematics the online program revenue has allowed the department to step up its efforts to recruit and retain elite PhD students, run a world-class seminar series, and provide critical faculty support for research. Thus, the revenue created by such programs is having a transformative impact on Applied Mathematics and its goal of retaining its status of one of the elite programs in the country. If used correctly, the revenue and partnership from both the applied mathematics and computational finance MS degree programs can be used together to further establish the University of Washington as a world-leading institution, thus further increasing our ability to draw in the most gifted faculty and students in the world.

### 1.A.8 New Courses for Matriculated Graduate Students that Would not Otherwise Exist

We note that the PMS-CompFin program will result in the creation of a number of new courses that would not otherwise exist (see Section 2.B). Our experience with the CFGCP and OCFC programs described above indicate that matriculated graduate students in a number of engineering and science departments across the College of Arts and Sciences and the College of Engineering will have a strong and rapidly growing interest in taking some of the new courses. In this regard the AMATH PMS-CompFin program will provide a significant additional benefit to the two colleges and the university.

In Summary: The discussion in this Section 1.A reflects beneficial evolutionary growth of the overall Applied Mathematics Department through planning and implementation, jointly with UWEO/PCE of: (a) a successful online MS degree in Applied Mathematics, and (b) a successful new online Computational Finance Certificate program that effectively leverages an existing Computational Finance Graduate Certificate program. A next logical step in this evolution is reflected in this PMS-CompFin proposal.

## 1.B DOCUMENTATION OF NEED FOR PROGRAM

### 1.B.1 Student Demand

We document student demand for the PMS-CompFin in terms of recent history of demand for graduate instruction in quantitative finance by: (i) resident students in the Computational Finance

Graduate Certificate Program (CFGCP), (ii) online students in the UW AMATH Online Computational Finance Certificate (OCFC), (iii) national rates of application to top quantitative finance programs in the U.S.

CFGCP Student Demand

This CFGCP program was launched in 2004 and details concerning the program may be found at www.amath.washington.edu/studies/compfin. The original proposal to the Graduate School set a target of having 15 students enrolled in the program within two to three years. This number was in fact exceeded by the fall of 2005 and as of autumn quarter 2010 the program had 29 students enrolled, almost all of whom are Ph.D. students and three of whom have completed all the certificate requirements described at the above web site. As is typical with quantitative finance graduate programs in the U.S. this cohort of students are enrolled in a diverse set of academic departments, namely: Applied Mathematics, Computer Science, Economics, Electrical Engineering, Finance, Industrial Engineering, Mathematics and Statistics.

Quantitative finance graduate programs tend to attract students with high academic performance records, and this has been the case with the CFGCP. For example, 22 of the above 29 students have a grade-point average (GPA) higher than 3.7, 10 have GPA's above 3.8 and 5 have GPA's higher than 3.9. If these students were not already Ph.D. students many of them would very likely be interested in pursuing the PMS-CompFin.

OCFCP Student Demand

The new Online Computational Finance Certificate (OCFCP) was launched in autumn quarter 2010. Details of the program may be found at www.amath.washington.edu/studies/compfin. This is a purely online program, and the decision to launch the program was taken only at the end of June 2010. Marketing efforts commenced in mid-July, and with this exceedingly short run-way for a program launch, we ended up with 30 students enrolled, 20 of them from the state of Washington and the remainder from other regions in the U.S. Of these 10 hold MS degrees in science or engineering, 5 hold MBA's and 2 hold Ph.D.'s.

Most of students in this OCFCP cohort are working professionals, mostly in the finance industry with titles such as Director of Research, Risk Manager, Research Associate for Risk Management, Head of Quantitative Strategies, Senior Portfolio Manager, Trader, Software Developer, etc. The average age of the cohort is 31 years and the average number of years worked is 9.

We believe that the combination of the exceedingly short time to launch the program, the size of resulting cohort, the nature of their job roles and the percentage that are expect to apply for the PMS-CompFin makes a very strong case for our proposal. We foresee PMS-CompFin to have a majority of its students in the online component of the program in the near term of the next 3-5 years, with increased enrollments not only in Washington State but also nationally (see next sub-section) and in the far east, while at the same time building a brand-name for the program and slowly building the number of resident students (physical space on the UW campus permitting).

National Student Demand

At the national level there is an exceedingly high student demand for an MS degree programs in "quantitative finance", i.e., MS degrees in "Computational Finance", "Financial Engineering" and "Mathematical Finance". This has resulted in a proliferation of such degrees, the majority of which are not very strong programs (see Section 1.D). As evidence of national level student demand Figure 1 displays the history of applications to four of the top ten quantitative finance MS degree programs (labeled generically "Financial Engineering programs" in the figure), Baruch, Princeton, UC Berkeley and Stanford from 2006 through 2010.[5] Ignoring Stanford, the figure reveals substantial growth in the number of applications for the 2006, 2007 and 2008 fall entering classes, followed by the expected decrease in applications for fall 2009 due to the financial markets collapse in 2008-9, and a rebound toward 2008 levels in applications for Baruch and Princeton for the fall 2010 entering classes. It is not clear why the Berkeley program has

continued to see a decline in applications for 2010. The relatively small Stanford program maintained a surprisingly constant number of applications in the face of the financial crisis.

Table 1 (same source as Figure 1) provides applications, acceptance and enrollment data for 9 of the top 10 quantitative finance MS degree programs, including the 4 in Figure 1. Enrollments as a percentage of applications range from as low as about 4-6% for a few of the schools to about 20% for some others. Note that the MIT and UCLA programs are both quite new and quite strong, and the number of applications for the MIT program jumped from 175 a year ago to a stunning 950 this year (it didn't hurt that Nobel prize winner Robert Merton came out of retirement to support the MIT program).

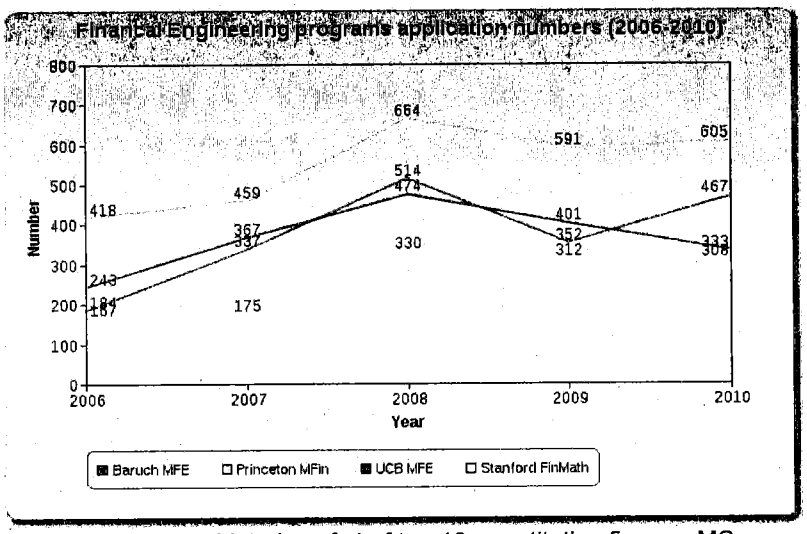



Figure 1: Applications histories of 4 of top 10 quantitative finance MS programs

The message from Table 1 concerning the projected size of the pool of applicants to quantitative finance MS degree programs, barring future finance market meltdowns, is likely in the range of

**Table 1**: Admitted/Enrolled/Applied numbers

| | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| **Baruch MFE** | 36/26/184 | 42/35/337 | 57/40/514 | 29/24/352 | 35/28/467 |
| **CMU MSCF** | - | - | 135*/97/880 | 100*/70/700* | 128*/97/850 |
| **Columbia MFE** | - | - | - | 110/57/517 | 110/60/607 |
| **MIT MFin** | | | | 36/27/175 | 90/60/950 |
| **NYU MathFin** | -/33/500 | -/31/750 | -/30/900 | -/27/650 | -/38/700 |
| **Princeton MFin** | 46/27/418 | 48/35/459 | 40/30/664 | 24/19/591 | 31/25/605 |
| **Stanford FinMath** | 30/-/167* | 30/-/175* | 50/-/330* | 19/13/312 | 22/14/308 |
| **UCB MFE** | 91/59/243 | 83/65/367 | 90/65/474 | 101/65/401 | 105/67/333 |
| **UCLA MFE** | | | | -/39/175 | -/41/205 |

- - numbers unavailable or programs declined to provide
- * numbers calculated using partial data gleaned from archived webpages.
- Stanford FinMath only provides detailed admitted/enrolled/total numbers since 2009. Prior to that, it only provides the admit numbers as percentage.
- The UCLA MFE and MIT MFin programs enrolled its first class in 2009.
- The numbers for NYU program do not take into account part-time/non degree/certificate numbers

at least 1,200 to 1,400 (adjusting for the fact that not all applicants apply to all programs and there are 44 such programs in the U.S.). The 9 programs in Table 1 enrolled a total of 430 students, indicating that on the order of 800 to 1,000 applicants did not enroll in a top 9 program. Taking into account that none of these programs contain online offerings, we believe there is a significant market opportunity for the proposed PMS-CompFin.

### 1.B.2 Employer Demand

National Demand

It is difficult to get hard data on finance industry segment employer demand. However the large numbers of applicants to MS degrees in quantitative finance discussed in the previous sub-section, and growth in the number of MS degree programs in quantitative finance (see Section 1.D.1), would not have occurred without sufficient job opportunities in the finance industry. In spite of the fact that the 2008-9 financial markets crisis resulted in a severe contraction in job opportunities in the finance industry, particularly in the world-wide "Wall Street" segment of large banks and hedge funds in the large U.S. financial centers, employment opportunities have started to rebound. As noted in the previous sub-section, the same is true of the overall number of applications to MS degree programs in quantitative finance.

We believe that the following finance market segments will have an increasing need for quantitative methods and demand for graduates of programs such as our PMS-CompFin:

- Most pensions, endowments, funds-of-hedge funds and family offices have not been very quantitative in their approach to investment decisions and risk management, at least when compared with many asset management groups in large banks and hedge funds. There is evidence that this is in the process of changing and many such organizations are moving toward quantitative complements to qualitative investment decisions. See last paragraph of next sub-section and end-note.[6]
- The need for improved risk management is on the minds of many and the demand for the next generation of quantitative risk manager is evident. We provide here relevant quotes from four articles whose links are provided in an endnote.[7]
    - (Reuters, June 16, 2009) - Risk management, an area once seen as a dreary necessity on a Wall Street obsessed with high-stakes trading bets, is suddenly hot "
    - (A.E. Feldman, Jan. 7, 2009) – "Risk management will continue to be in the spotlight in 2009. Companies have never been more motivated to revisit risk management, according to CFO.com. A recent report argues that risk management is a discipline that is being taken far more seriously these days thanks to the current financial crisis. In fact, a survey of 125 CFOs in September found that 62% of finance executives blamed the crisis on risk management's inability to understand complex financial instruments."
    - (Aon Energy, Feb. 24, 2010) - "Today's energy environment is impacted by a wide range of risks, and the ability to manage them effectively is critical to success. Those who have the tools and resources to make more informed risk decisions will produce better results for stakeholders."
    - (Insurance & Technology, April 15, 2010) – "It's not as if the math suddenly ceased to work. Rather, the credit/financial crisis has shown not only that insurers must better manage the interaction of the art and science of risk management, but that risk modeling - and the increasingly sophisticated technology that supports it - is more important than ever. "
- New financial regulation rules seem likely to require more well trained quants to verify, enforce and evolve the rules to the benefit of society.

Puget Sound Area Employment Opportunities

While the Puget Sound area is not a major finance industry center, there are none-the-less a surprising number of local asset management companies that are potential employers that could benefit from hiring graduates of the PMS-CompFin. In Washington state there are approximately 217 asset management firms of one type or another, with a total of $321 billion in assets under management (AUM), and all but 11 of these are in the Puget Sound area. Table 2 displays the breakdown of the number of firms according to ranges of AUM. The Russell Investment group dominates the $10B+ AUM group with $150B AUM, and it is important to note that Russell recently moved its head-quarters from Tacoma to downtown Seattle thereby facilitating interactions with the PMS-CompFin program (internships, seminars, guest lecturers, etc.).

There are three types of asset management organizations in Washington that are not reflected in Table 2, namely: (i) corporate treasuries that have investment organizations, e.g., the Microsoft Treasury, (ii) college and university endowments, e.g., the UW endowment that in 2010 has $1.65B in AUM, and (iii) pension plans of which 17 plus 22 public funds are managed by the Washington State Investment Board (WSIB) with a total of $74B AUM in 2010.

**Table 2: Washington Asset Management Firms**

| AUM Range | # of Firms | AUM Total ($B) |
|---|---|---|
| $10B+ | 8 | 222.0 |
| $1B to $10B | 30 | 70.0 |
| $500M to $1B | 12 | 8.0 |
| $250M to $500M | 23 | 8.4 |
| $100M to $250M | 49 | 7.4 |
| $50M to $100M | 50 | 3.6 |
| $20M to $50M | 45 | 1.5 |
| **Total** | **217** | **321** |

Based on communication with finance professionals at local firms it appears that since there has been no MS degree in quantitative finance in Washington, the hiring of such graduates has focused on individuals who earn an MS degree in quantitative finance from one of the programs listed in Section 1.D (primarily those with the University of California Berkeley Financial Engineering MS degree). With the proposed PMS-CompFin in place, we expect this situation to quickly change in favor of UW graduates. Some evidence that well trained quantitative finance students can be hired by Washington asset management firms is provided by the fact that four of thirteen Ph.D. students who completed the CFGCP certificate were hired by Puget Sound asset management firms. It is particularly note-worthy that one of these students was hired by the UW Endowment fund as an Investment Research Analyst in 2009, the first such hire at the UW Endowment (now called UW Investment Management). The other student was hired by the Washington State Investment Board (WSIB, manager of many pension plans in Washington) as a Risk Analyst, the first such hire at WSIB.

### 1.B.3 Community Demand

The main type of community demand is in the form of positive responses to the prospect of there being a UW PMS-Compfin degree by the following three finance organizations, with a view toward forming mutually beneficial partnering relationships:

- Chartered Financial Analysts (CFA)
- Global Association of Risk Professionals (GARP)
- Seattle Alternative Investments Association (SAIA)

The Chartered Financial Analysts (CFA) organization is a global professional association with over 100,000 members world-wide and a highly regarded Institute that offers CFA certification at various levels (see www.cfainstitute.org). The local Northwest chapter of the CFA has over 930 members and its current President is Jeff Lippens. We believe that the PMS-CompFin course offerings will prepare individuals very well for the more quantitative parts of the CFA Certificate exams. Jeff has indicated that the local CFA is very eager to form a cooperative relationship with the PMS-CompFin program and that it will directly serve the needs of some of their members (see CFA letter of support in Appendix A).

The Global Association of Risk Professionals (GARP) has approximately 150,000 members world-wide, and the organization runs a highly regarded Financial Risk Management (FRM) Certificate program. During 2009 and 2010 there were in excess of 23,000 FRM candidate registrations each year. GARP's mission is to advance the risk profession through education, training and the promotion of best practices globally. There is a local Seattle chapter of GARP whose President has left the Seattle area and the position is currently vacant. We have had extensive discussions with GARP Senior Vice President and FRM Program Manager Bill May that will lead to an attractive partnership between the PMS-CompFin and GARP as described in Section 1.D.2. It is an open possibility to have UW as the home of the local Seattle GARP chapter upon launch of the PMS-CompFin.

The Seattle Alternative Investments Association (SAIA) was formerly called the Northwest Hedge Fund Society. It holds meetings on topical subjects on a quarterly basis. We have just opened the dialog with SAIA and it also appears to have good potential to be a local community partner with the PMS-CompFin. Further discussions along these lines will take place in winter and spring quarters 2011.

### 1.C FIT TO 2008 STRATEGIC MASTER PLAN FOR HIGHER EDUCATION

The Higher Education Coordinating Board (HECB) of Washington published a strategic master plan in 2007, and in 2008 released a document to assist with implementing the plan. The plan aims to expand degree-earning opportunities for Washington State residents and to develop a post-secondary education system that "increases economic prosperity, innovation and opportunity." The PMS-CompFin program would be the sole educational opportunity for students seeking professional finance preparation not only in the state of Washington but also in the entire Washington, Wyoming, Alaska, Montana and Idaho (WWAMI) region. Thus the PMS-CompFin program serves the primary and overarching goal of the HECB strategic master plan.

The implementation document identifies four priorities, all of which are in alignment with the PMS-CompFin program. The four priorities and its relation to the CompFin program are as follows:

1. The progress we have made by sustaining current levels of support for higher education.

The PMS-CompFin program addresses priority number 1 by implementing the program as a self-sustaining activity, thereby not drawing upon any state funds. Moreover, the revenue generated by the CompFin program is used almost exclusively for strengthening on campus faculty, staff, and graduate student infrastructure. This is especially critical now in our state as funding levels continue to decrease and alternative means of revenue generation are required to run programs at their current level. With AMATH's recent elite ranking (tied for first with Princeton University), the additional online revenue is crucial for maintaining the department's elite status while sustaining, and even increasing, the level of support for higher education.

2. Build a larger 'pipeline' to postsecondary education that captures more students radiating from our K-12 schools and more working adults.

The PMS-CompFin program addresses priority 2 through a program that focuses on working professionals, enhancing their ability to contribute to their company and society. Moreover, the field of computational finance gives students a dynamic and engaging area of expertise while also

supporting strong quantitative thinking and mathematical science skills which are critical for the state's vitality. The program will enable students to complete studies in a reasonable amount of time as per the choice of students because it has both full-time and part-time options.

3. Expand on demand by targeting growth and tailoring institutional plans to respond to known demographic, regional and workforce needs.

The PMS-CompFin addresses priority 3 by focusing on computational finance and risk management as among the significant emerging employment sectors of the last decade. Our analysis shows a clear and growing demand in this sector, especially as it pertains to high-level quantitative skills.

4. Redesign the delivery system for higher education by creating a new process to determine when and where to build new campuses or centers, develop new programs, expand eLearning and other delivery modes, and change college and university missions.

The PMS-CompFin program addresses priority 4 through a distance learning delivery approach. Distance learning provides an opportunity for students to earn degrees because it reaches out to place (space and time)-constrained students. Place-constrained students are constrained by lack of geographic mobility (e.g. they would have to give up a job) or by lack of temporal mobility (not the right time in family cycle), either of which can hinder a person from attending university for advanced education. Just like the current AMATH online program, the PMS-CompFin program provides a unique, and highly-distinguished educational opportunity that is unmatched by any computational finance program in the country. Moreover, AMATH has demonstrated remarkable success and veteran leadership on the UW campus in efficiently carrying forward this new mode of graduate training.

## 1.D RELATIONSHIP TO OTHER INSTITUTIONS

### 1.D.1 Duplication

There exists no other educational institution in the state of Washington, and indeed none in the entire Washington, Wyoming, Alaska, Montana and Idaho (WWAMI) region, that offers a program such as the PMS-CompFin. Below we provide information on similar MS degree programs at the national level, none of which have online offerings.

As of the end of 2009 there were 44 quantitative finance MS degree programs in the U.S. according to data at www.globalderivatives.com. Given that PMS-CompFin will have the Applied Mathematics Department as its home, one might ask whether this is typical for such programs. The display below shows the Mathematics and Applied Mathematics departments are the home for these programs almost as frequently as business schools.

| HOME UNIT | BUSINESS | MATH/AMATH | ENG'G | ECON | STAT | TOTAL |
|---|---|---|---|---|---|---|
| Number of Programs | 19 | 16 | 7 | 1 | 1 | 44 |

A ranking of the top 23 of MS programs provided by Quant Network (www.quantnet.com ) is displayed in Appendix D. It is our belief that only the top ten or so of these programs are of very high overall quality, and we display some of their characteristics in Table 3. Note that Quant

**Table 3: Top Ten MS Degrees in Quantitative Finance**

| School | MS Program Name | Tuition | Type | Duration | Online |
|---|---|---|---|---|---|
| Carnegie Mellon University | Computational Finance | $73,800 | FT/PT | 1.5 years | NO |
| Columbia University | Financial Engineering | $47,160 | FT | 1 year | NO |
| Princeton University | Finance | $73,220 | FT | 2 years | NO |
| Stanford University | Financial Mathematics | $37,380 | FT | 1.5 year | NO |
| University of Chicago | Financial Mathematics | $44,892 | FT/PT | 1 year | NO |
| Baruch College | Financial Engineering | $20,700* | FT/PT | 1.5 years | NO |
| Columbia University | Mathematics of Finance | $35,032 | FT/PT | 1 year | NO |
| Cornell University | Financial Engineering | $37,050 | FT | 1.5 years | NO |
| New York University | Mathematics in Finance | $45,972 | FT/PT | 1.5 years | NO |
| UC Berkeley | Financial Engineering | $50,402 | FT | 1 year | NO |

* Out-of-state tuition, in-state tuition is $11,040

NOTE: "1 Year" usually means 12 months and "1.5 Years" means 3 semesters

Net has grouped these top ten only according to the top five and the next five, with no implied order within each group of five (in our opinion the Carnegie Mellon program, which was the first such program and led the way for many subsequent programs, is still the top program).

### 1.D.2 Uniqueness of Program

The PMS-CompFin program is unique in a number of ways described below.

Live Online Delivery

The program will be the first such degree offered primarily online, where students can listen to the lecture live with modern delivery technology (see Section 2.D). Students can also download the streaming videos at convenient times for initial viewing of any missed lectures, and for further study of the lecture material. Review sessions will also be delivered with a modern online group meeting technology (see Section 2.D). Students who are resident on the UW campus will be able to attend lectures in a class-room that is specially equipped to capture lectures live for the above online delivery.

Major Focus on Working Professionals

The program will focus primarily on working professionals who are either already in the finance industry or who wish to make a change of career into the finance industry. Such individuals cannot afford the time to enroll in a full-time resident MS degree program, but can take courses on a part-time basis, typically one course at a time. In the short term only very small cohorts (e.g., 5-6 and not more than 10-12) of resident full PMS-CompFin full-time students who have very high prior academic performance will be admitted. The resident cohort size will be grown over time judiciously as we build a brand name and reputation.

Geographic Uniqueness

The program is the only MS degree program in quantitative finance of any kind west of Minnesota and north of California (except for a new thin program at the University of Hawaii).

Risk Management Emphasis

The program will be the only program with a strong risk management emphasis as reflected in a three-course risk management sequence rather than a single course (see Section 2.B), combined with a partnership with the Global Association of Risk Professionals (see Section 2.B.2).

R Programming Language Computing Emphasis

The MS degree in Computational Finance and Risk Management will be the only quantitative finance MS degree that focuses on the open source R programming language and system for data analysis and statistical modeling, both as a vehicle for instruction and as an environment for rapid development and deployment of cutting edge quantitative finance methods. R is the most rapidly growing open source computing environment of its kind today (see http://sites.google.com/site/r4statistics/popularity), and R is seeing rapidly increasing use in quantitative finance (see, e.g., http://dirk.eddelbuettel.com/papers/mfa2009.pdf)

Certificate Bundles and Stand-Alone Practitioner Courses

The program will leverage the PMS-CompFin for additional revenue by offering one or more online certificates, consisting of subsets of existing curriculum courses, to working finance professionals who are not able or ready to commit to the time or expense of an MS degree. The program will also leverage the PMS-CompFin by offering selected practitioner-oriented online courses on a single-course enrollment basis for additional revenue generation.

Applied Mathematics Home

The online component of the PMS-CompFin will be launched by an Applied Mathematics Department that has already demonstrated the capability to successfully launch and operate an online MS degree program (www.amo.uw.edu), in partnership with UWEO/PCE, that is academically and economically successful to the net benefit of the AMATH department and UW.

Director and Co-Director Experience

In addition to the their experience in computational finance related academic research and instruction, program Director Doug Martin and Co-Director Eric Zivot have both had extensive experience in the finance industry and development of commercial computational finance software. Among other things Martin was founder and CEO (2006-8) of FinAnalytica, Inc., a company that develops the Cognity portfolio construction and risk management software focused on tail-risk ("Black Swan" risk) and markets to quantitative asset managers and funds-of-hedge funds. Zivot was responsible for the S-PLUS FinMetrics software product and has been a consultant at Blackrock in recent years. For further information see Section 2.F.

## 2. PROGRAM DESCRIPTION

The name "Computational Finance" is one of three commonly used names to describe MS degree programs in "quantitative finance". The other two names are "Financial Engineering" and "Mathematical Finance". We have opted to use "Computational Finance" in our MS degree name "Computational Finance and Risk Management" for the following reasons. The term "Mathematical Finance" indicates too narrow an emphasis on only the mathematical aspects. "Financial Engineering" tends to indicate too much an emphasis on derivatives and in the aftermath of the financial markets collapse of 2008-9 a considerable amount of partly justifiable blame has been put on the miss-use of derivatives. Finding the previous two names not so desirable we chose to follow the model of the ground-breaking, and to this day market-leading Carnegie-Mellon University (CMU) MS degree in Computational Finance. CMU introduced the term "Computational Finance", before anyone knew what it meant, to represent the content of a multi-faceted educational program that combined basic financial theory (of capital markets, portfolio construction and derivative pricing) with modern statistical modeling methods, optimization methods and Monte Carlo simulation methods. It is important to recognize that "Computational Finance" embodies all of these subject matter areas, and does not mean simply "computational methods in finance". Some additional background context is provided in the next two paragraphs.

In recent decades, spurred by the enormous importance and wide-spread use of financial derivatives and modern portfolio theory in the finance industry, a need for sophisticated

computational technology in finance has developed. For example, to price an American put option – which gives the right but not the obligation to sell an asset at a fixed price over a specified period of time – requires a sophisticated computational method of one kind or another, e.g., a binomial tree method, a Monte Carlo simulation method, or the numerical solution of a free-boundary partial differential equation. As another example, to minimize the risk of a portfolio with many (e.g., as many as 1,000 to 2,000) assets, taking into full account various trading constraints, can require solving a highly complex optimization problem in high dimensions subject to equality and inequality constraints. As a third example, to minimize downside risk (so-called "tail" risk) of a portfolio at various asset groupings levels, as well as at the portfolio level in a manner that accurately reflects the non-normality of asset returns, requires the use of not only a complex numerical optimization algorithm but also the fitting of sophisticated fat-tailed skewed non-normal distribution models and the fitting of non-linear correlation models to capture the higher correlations among assets when markets suffer large losses. As a result, fast and accurate numerical algorithms have become essential tools to model asset returns distributions and correlations, price financial derivatives, and to more accurately analyze and manage portfolio risk. The required computational methods aggregate to the new field of Computational Finance.

In parallel to the development of computational finance, the field of financial risk management has undergone a similar explosive development. Financial risk encompasses several distinct types of risk. For financial investments, the main type of risk is market risk, the risk of a change in the value of a financial position due to changes in the value of the underlying components on which that position depends, such as stock and bond prices, exchange rates, commodity prices, etc. The next important type of risk is credit risk, the risk of not receiving promised repayments on outstanding investments such as loans and bonds, because of the "default" of the borrower. A further risk category is operational risk, the risk of losses resulting from inadequate or failed internal processes, people and systems, or from external events. Other important types of risk are liquidity risk and model risk. The former is the risk that a given security or asset cannot be traded quickly enough in the market to prevent a loss (or make a required profit), and the latter is the risk associated with using an inappropriate model for measuring risk. Financial risk management involves the use of mathematical and statistical technical techniques to accurately measure the different types of financial risk, and the sophisticated use of portfolio construction and financial derivatives to manage these risks. The financial markets meltdown of 2008-9 has underscored the need for improved risk management methods, and the finance industry appears to be responding accordingly as was pointed out in Section 1.B.2. Consequently we expanded the name of our MS degree from "Computational Finance" to "Computational Finance and Risk Management".

## 2.A GOALS AND OBJECTIVES

The PMS-CompFin program is designed to address the demand in the financial services industry for advanced computational finance and quantitative financial risk management skills. The events surrounding the financial crisis of 2007-08 suggest that computational methods for financial and risk modeling will gain new impetus in the years ahead. The emerging profession of financial risk management (see www.garp.org and www.primia.org ) demonstrates the growing importance of the area. People who understand "risk" are required throughout the world of financial services, and quantitative modeling experts are in particularly short supply. For students with advanced mathematical and quantitative skills, this is an exciting new career path to consider.

The goals of the PMS-CompFin program are to:

- Deliver the highest quality MS degree education to current and likely future quantitative finance industry professionals in both online and resident student formats, enabling them to be more effective in their work and able to rapidly advance in their chosen career path.
- Provide a curriculum whose course offerings educate students in best computational finance and risk management practices, including new cutting edge methods that have

the potential to reduce and control investment risk and deliver higher risk-adjusted returns.

- Become a top ten MS degree in quantitative finance within five years, thereby providing a new distinguishing element to the AMATH, the CAS and the UW.
- Create a financial operating model that enhances the AMATH department goals of excellence, by building on its existing strengths and developing the PMS-CompFin program and associated research and instruction into a sustainable program with a goal of achieving at least a top-ten U.S. ranking in five years.

## 2.B M.S. DEGREE CURRICULUM

The courses for the degree program will be delivered online from the UW Seattle campus, using EDGE technology and associated special class rooms, mostly offered in the late afternoon and early evening. The large majority of the MS degree students and all of the certificate students (see Section 2.C) will make use of this online delivery. A small number of resident PMS-CompFin students will take the courses in the EDGE class rooms where the online lectures are captured.

The integrity of homework and exams taken at remote locations by online students is supported by an "approved proctor" process that has been in place for the Applied Mathematics online MS degree for some time, and is supported by UWEO/PCE when appropriate (e.g., they arrange for exam room locations for online students in the greater Puget Sound area with UW proctors, and have created a set of requirements and a formal agreement with proctors in remote locations).

In order to graduate with a PMS-CompFin a student must complete the following requirements: (a) a minimum of 40 credits, all graded numerically on the UW 4.0 scale, from the curriculum described below, (b) a GPA of at least 3.3, and (c) a Final Examination that meets UW Graduate School requirements as described at www.amath.washington.edu/studies/ms/ .

### 2.B.1 Program Prerequisites

The program is ideally suited to individuals with an undergraduate degree in science or engineering, including applied mathematics, economics, mathematics, physics, statistics, computer science and electrical engineering, and a strong academic record. Admission requirements are the same as those for Admission to graduate study in the Applied Mathematics and these requirements may be found at www.amo.uw.edu/admissions/applying.asp. In addition an applicant must show proficiency in: (a) calculus through partial differentiation and constrained optimization using Lagrange multipliers, (b) matrix algebra, (c) probability and statistics at the level of UW courses ECON/STAT 481 and STAT/AMATH 506, and (d) computer programming. Students lacking proficiency in any of these areas will need to complete one or more online self-study modules provided by the Department of Applied Mathematics prior to commencing the PMS-CompFin program.

### 2.B.2 Program Courses, Core Courses, Required Courses and Pathways

The PMS-CompFin program will offer a total of 16 courses for a total of 60 credits as displayed in three groups in Table 4. The degree requires completion of at least 40 credits. In the case of joint listed courses the first named course indicates the home department of the course. The Status column indicates whether the course currently exists in some form or is new. Courses

**Table 4. PMS-CompFin Curriculum**

| | | | |
|---|---|---|---|
| Core Courses | 33 | | |
| AMATH 540/**ECON 424** Intro. to CompFin. & Fin. Econ. | 5 | EXISTING | ECON |
| AMATH 541 Investment Science | 4 | EXISTING | AMATH |
| AMATH 542 R Programming for Computational Finance | 4 | EXISTING | FIP |
| AMATH 543/STAT 549 Portfolio Construction & Risk | 4 | EXISTING | AMATH |
| AMATH 544/STAT 547 Options and Derivatives | 4 | EXISTING | AMATH |
| AMATH 545/FIN 562 Introduction to Risk Management | 4 | EXISTING | FIP |
| AMATH 546/**ECON 589** Quantitative Risk Management | 4 | PARTNEW | ECON |
| AMATH 547 Credit Risk | 4 | NEW | FIP |
| Electives Group 1 | 14 | | |
| AMATH 548 Monte Carlo Simulation Methods in Finance | 4 | NEW | AMATH |
| AMATH 582 Computational Methods for Data Analysis | 5 | EXISTING | AMATH |
| AMATH 583 High Performance Scientific Computing | 5 | EXISTING | AMATH |
| Electives Group 2 | 13 | | |
| AMATH 551 Introduction to Electronic Trading | 3 | NEW | FIP |
| AMATH 552 Time Series Modeling and Forecasting | 2 | NEW | FIP |
| AMATH 553 Endowment Investment Management | 2 | NEW | FIP |
| AMATH 554 Portfolio Performance Analysis | 2 | NEW | FIP |
| AMATH 555 Optimization Methods in Finance | 4 | NEW | FIP |

labeled "Existing" are either regular departmental courses, or are courses being offered for the first time as part of the new OCFC during 2010-11 under an AMATH 500 Special Topics offering. The regular departmental courses in Table 4 include: ECON 424, ECON 589, STAT 547, STAT 549, FIN 562, AMATH 582, and AMATH 583. We note that AMATH 582 and 583 are also regularly offered online. The courses being offered online for the first time in 2010-11 using AMATH 500 Special Topics titles are: AMATH 541, 542 and 543. The "PARTNEW" entry for ECON 589/AMATH 546 indicates that an existing Financial Econometrics course will be partly modified and renamed by Professor Zivot to create a quantitative risk management course. Economics is the home department for AMATH 540/**ECON 424** and AMATH 546/**ECON 589**.

The "Instructor" column lists the anticipated departmental or organizational affiliation of the instructor, and "FIP" stands for "Finance Industry Professional" lecturer. Three of the courses taught by FIP's are 4 credit Core Courses that will be taught in one or two evening sessions per week, and the other five are Group 2 electives (one is a 4 credit course, another one is a 3 credit course, and the remaining three are 2 credit courses that will be taught one evening per week). Note that all but one of the new courses in Table 4 will be developed by FIP's who possess unique practitioner knowledge. Their participation as instructors is crucial in creating a high quality degree program with a balance of theory, methods and applications that will serve graduates well in pursuing a career in the finance industry. Further details regarding the FIP's are provided in the Faculty Section 2.G.

Required Courses

The required courses are those in the first six rows of the Core Courses section of Table 4, for a total 25 credits. The remaining 15 credits needed for the degree may be selected from any combination of the remaining core courses and the two elective groups in Table 4.

Pathways

The curriculum will contain the following two natural pathways that emphasize two distinct types of specialization:

- *Risk Management Pathway.* In this case the student would take all the Core Courses, thereby earning 33 credits, plus at least 7 credits from the two electives group.
- *Computing Pathway.* In this case the student would take the 6 required courses for 25 credits, plus AMATH 582, AMATH 583 and AMATH 555 for an additional 12 credits. Transfer credits for a JAVA, C++ or C# programming course taken at an accredited university or college for an additional 3 credits will be accepted, bringing the total to 40 credits.

Timing of Courses

Table 5 provides course offerings by quarter, and for the sake of compactness we have listed only the home department in joint listed courses. It should be noted that Economics is the home department for AMATH 540/ECON 424 and AMATH 546/ECON 589, and Eric Zivot's teaching of

**Table 5 Curriculum Course Offerings by Quarter**

| Summer | Fall | Winter | Spring | |
|---|---|---|---|---|
| **AMATH 540/ECON 424** Intro. to Comp. Finance and Financial Econometrics | **AMATH 541** Investment Science | **AMATH 542** R Programming for Computational Finance | **AMATH 543/STAT 549** Portfolio Construction and Risk Mgm't. | |
| **AMATH 551** Introduction to Electronic Trading | **AMATH 544/STAT 547** Options and Derivatives | **AMATH 545/FIN 562** Introduction to Risk Management | **AMATH 546/ECON 589** Quantitative Risk Management | **AMATH 547** Credit Risk Management |
| | **AMATH 552:** Financial Time Series Forecasting | **AMATH 582** Computational Methods for Data Analysis | **AMATH 583** High Performance Scientific Computing | |
| | **AMATH 553** Endowment Investment Management | **AMATH 554** Portfolio Performance Analysis | **AMATH 548** Monte Carlo Methods in Finance | **AMATH 555** Optimization in Finance |

these two courses will be covered by a memo-of-agreement (MOA) between the Applied Mathematics and Economics departments.

During the academic launch year 2011-12 we will be able to offer all the courses in the first two rows of Table 5), plus AMATH 582 and 583 which are in any event offered every year. This requires use of three FIP instructors for the three courses AMATH 542, 547, 551, and we have currently have instructors who are firmly committed to developing and delivering these courses (in fact AMATH 542 is being offered in winter 2011 by one of these instructors under an AMATH 500 Special topics title).

One or more of the additional courses in Table 5 may be offered in 2011-12, depending upon program start-up demand and economic viability. In any event we expect to offer the additional course in Table 5 starting 2012-13.

Target Degree Completion Times

Online PMS-CompFin part-time students (the majority) will be able to finish the degree requirements in two-and-a-half years on average when taking one course each quarter.

Full-time students (online or resident) will be able to finish the degree in 12 or 14 months on average, taking at most one course in months 13-14 if they are in the Risk Management pathway or Computing pathway.

## 2.C ONLINE CERTIFICATE PROGRAMS

The above PMS-CompFin program will easily support offering separate online certificate programs consisting of subset bundles of the courses in Section 2.B.2. These certificate programs will be operated in a manner to generate net profits for the overall CompFin program and AMATH department. In 2011-12 we will offer two such online certificate programs through UWEO/PCE, the first being a slightly modified version of the currently successful Online Computational Finance Certificate (OCFC) and the second one a new Online Risk Management Certificate (ORMC), as described below.

The pre-requisites for these certificate programs will be identical to those for the PMS-CompFin described in 2.B.1. Based on feedback from students who took AMATH 541 (Investment Science) in autumn 2010, many students applying for the certificate programs will need to make use of the self-study modules mentioned in 2.B.1 and we will strongly recommend these to certificate program applicants. We may ultimately offer these as online pre-requisite courses for both certificate applicants and PMS-CompFin applicants.

Students enrolled in these certificate programs consist of two types: (a) finance industry professionals who wish to increase their skill set to perform better in their current job and to enhance their career advancement potential but have no intention of pursuing the PMS degree, and (b) individuals who anticipate applying to enter the PMS degree program upon completing the certificate. To accommodate those in the first group who wish to receive course grades on a credit/no-credit basis we will either create a separate class section that is graded CR/NC or allow them to use S/NS grading. For other students in the first group and all students in the second group the grading will be standard UW numeric grading.

### 2.C.1 Online Computational Finance Certificate (OCFC)

A Computational Finance Certificate will be awarded to individuals who successfully complete the following four-course sequence, which may be accomplished in 12 months: AMATH 540/ECON 424, AMATH 541, 542 and 543. We note that the Online Computational Finance Certificate currently offered in 2010-11 consists of only the last three of these four courses. Student feedback obtained while teaching AMATH 541 (Investment Science) in autumn 2010 revealed that many students need the preparatory material provided by AMATH 540/ECON 424 "Introduction to Computational Finance and Financial Econometrics" before taking AMATH 541. Thus we decided to move to the above four-course online certificate sequence in 2011-12.

### 2.C.2 Online Risk Management Certificate (OCRMC)

A Computational Finance Risk Management Certificate (OCRMC) will be awarded to individuals who successfully complete the following five-course sequence which can be completed in 14 months: AMATH 540/ECON 424, AMATH 541, AMATH 545, AMATH 546/ECON 589 and AMATH 547.

### 2.C.2 Preparation for the GARP Financial Risk Management Certificate

Students who earn the Online Computational Risk Management Certificate (OCRMC) and perform well in the program will be well prepared to obtain the Global Association of Risk

Professionals (GARP) Financial Risk Management (FRM) certificate with relatively little additional self-study.

Because of the strong complementary nature of the OCRMC and the GARP FRM, we have agreed with GARP to establish a mutually beneficial partnership arrangement that will involve: (a) GARP guidance on evolving the focus and content of the OCRMC in response to finance market needs, (b) OCRMC as a feeder to the FRM program, and (b) marketing of the PMS-CompFin program on the GARP web site and in other GARP materials. See the GARP letter in support of the PMS-CompFin in Appendix A.

### 2.D STAND-ALONE ONLINE COURSES

Many of the PMS-CompFin courses in 2.B.2 have the potential to serve well as stand-alone courses via UWEO "single course enrollment" (SEC) offerings. For example courses such as AATH 540/ECON 424 "Introduction to Computational Finance and Risk Management", AMATH 551 "Introduction to Electronic Trading", AMATH 553 "Endowment Investment Management" and AMATH 554 "Portfolio Performance Measurement" require minimal pre-requisites and would be attractive to both relative beginners and relatively experienced professionals. On the other hand courses such as AMATH 543 "Portfolio Construction and Risk Analysis", AMATH 546/ECON 589 "Quantitative Risk Management" and AMATH 548 "Monte Carlo Methods for Finance" would be attractive and accessible only to experienced finance professionals.

We will consider making SEC offerings on a case by case basis where the course offering will generate net profits to support a rapidly growing a high-quality CompFin program. In particular we will experiment carefully in 2011-12 with one or two such courses to test the market viability before creating a broader range of SEC offerings.

### 2.E COMPUTATIONAL FINANCE GRADUATE CERTIFICATE PROGRAM

The findings and recommendation of the Computational Finance Graduate Certificate Program (CFGCP) five-year review were that the CFGCP is successful and should be continued (see list item 1 in Section 1.A.3). Thus we intend to continue the CFGCP program with the understanding that Professor Zivot will be responsible for the administration of the program in his role as Co-Director of the overall CompFin program.

To date the CFGCP has been housed administratively in the Graduate School. We have recently made a request to the Graduate School to transfer administration of the CFGCP to the Applied Mathematics Department.

We believe that a number of the Ph.D. students in the CFGCP program will want to obtain the PMS-CompFin degree in close time proximity to receiving their Ph.D. Subsequent to approval of the PMS-CompFin program, we will consider the feasibility of allowing such students to transition to the PMS degree.

### 2.F USE OF TECHNOLOGY

We are currently using three very useful technology tools provided by UWEO/PCE program support (see Section 2.I). The first is the EDGE infrastructure that supports live lecture broadcast and capture, with operator assisted camera direction throughout the lecture, delivered in certain special Loew Hall lecture rooms. The second is the use of Adobe Connect for online group meetings and discussion with the class concerning lecture, homework and exam related questions. The third is the use of Moodle for general online distribution of streaming videos of the lectures (see next two paragraphs), lecture slides, homework, exams, announcements, and as a general forum for student-to-student interaction and student-instructor interaction.

The specific software tool used for the live lecture broadcast and capture is called Media Site and is new via EDGE this year. From the user viewpoint, Media Site is a very attractive technology

that supports two windows on the desktop that may be arranged side-by-side, or one large and one small. Typically one window captures the instructor's computer screen, e.g., Power Point or pdf display, and the other window captures the instructor talking at the podium or writing at the white-board and in the latter case focuses on the writing sufficiently for viewers to see the writing clearly. The viewer can instantly interchange the large and small windows via a "swap", and can also enlarge one of the windows for more detailed viewing. In addition to live viewing of a lecture, a Media Site library is created in Moodle and the student can download the streaming videos of the lectures for initial viewing in case a live lecture is missed, and for reviewing lecture material as needed, at times that are most convenient for the student.

In Summary: We have found Media Site to be a very high-quality product in support of online learning and students taking online courses have found it to be a very attractive delivery mechanism. Similarly Adobe Connect is a very effective tool for online discussion meetings with classes and Moodle is an effective platform for non-live online interaction with and among the class. We will always be looking for "new and better" technologies and strive to move to them as soon as feasible.

## 2.G FACULTY

The PMS-CompFin program is supported by 5 AMATH faculty members and one Economics faculty member, all of whom are full professors, and by 10 finance industry faculty members as shown below. The latter will have the title "guest lecturers" and we refer to them as "financial industry professional lecturers" (FIP's) for short. Bios for the FIP's are provided in Appendix C.

A total of 35 credits for the PMS-CompFin are delivered by UW professors and 25 credits are delivered by FIP's. Required courses for a total of 25 credits are shown in bold font below. Of these, 17 credits are delivered by UW professors and 8 credits are delivered by FIP's.

### 2.G.1 Applied Mathematics Faculty (26 credits)

| | Course (credits) | Status |
|---|---|---|
| Nathan Kutz, Professor & Chair | AMATH 582 (5) | Existing |
| Randy LeVeque, Professor | AMATH 583 (5) | Existing |
| Doug Martin, Professor & CompFin Director | **AMATH 543/STAT 549** (4)<br>**AMATH 544/STAT 547** (4) | Existing<br>Existing |
| Ka-Kit Tung, Professor | **AMATH 541** (4) | Existing |
| Hong Qian, Professor | AMATH 548 (4) | New |

### 2.G.2 Economics Faculty (9 credits)

| | | |
|---|---|---|
| Eric Zivot, Professor | **AMATH 540/ECON 424** (5)<br>AMATH 546/ECON 589 (4) | Existing<br>Part New |

### 2.G.3 Finance Industry Faculty (25 credits)

| | | |
|---|---|---|
| David Carino, Russell Investments | AMATH 554 (2) | New |

| | | |
|---|---|---|
| Mike Dueker, Russell Investments | AMATH 552 (2) | New |
| Brian Everitt & Gino Perrina, Blackrock/Russell | **AMATH 545/FIN 562** (4) | Existing |
| Keith Ferguson & Garth Reistad, UW Endowment | AMATH 553 (2) | New |
| Jay Henniger, JP Morgan Chase | AMATH 547 (4) | New |
| Steve Murray, Russell Investments | AMATH 555 (4) | New |
| Guy Yollin, R-Programming.org | **AMATH 542** (4) | Existing |
| Brian Tomeo, Private Investor | AMATH 551 (3) | New |

## 2.H STUDENTS

### 2.H.1 Student Population to be Served

There are two dimensions describing the student population to be served: one is their academic profile and the other is their current work status.

Academic Profile

The student population to be targeted for the PMS-CompFin consists of individuals with very strong undergraduate or graduate academic records in any field of science or engineering (e.g., applied mathematics, computer science, economics, electrical engineering, mathematics, physics, statistics), MBA students with an exceptionally strong academic record and quantitative skills.

Work Status

The majority of the students to be served will be working professionals with the above academic background profile who will take PMS-CompFin courses online on a part-time basis. These individuals wish to learn both standard and modern quantitative finance concepts and methods in order to achieve one or more of the following goals: (a) be more effective in the their current finance industry job, (b) progress more rapidly in their current finance industry job, e.g., advance from Assistant Portfolio Manager or Analyst to Portfolio Manager, advance from Junior Trader to Trader, advance from Assistant Risk Manager to Risk Manager, advance from Risk Manager to CIO, etc.), (c) make a transition from a job that is not in the finance industry to one in the finance industry and pursue a career in the latter.

A minority of the students to be served by the PMS-CompFin program will be those recently graduated from an undergraduate or graduate degree program with the above academic profile, wishing to pursue a career in the finance industry. In particular we will target high-performing undergraduates in engineering and science departments at UW and other Washington colleges and universities, as well as the UW Foster School of Business to the extent that this is viable.

### 2.H.2 Projected Enrollments

Table 6 displays the projected enrollments for the following components of the CompFin program:

1) PMS-CompFin Online Students (16 credits per 12 month year)
2) PMS-CompFin Resident Students (40 credits in 12 months)
3) Computational Finance Online Certificate (17 credits in 12 months)
4) Risk Management Online Certificate (21 credits in 14 months)

PMS-CompFin Online Students

These students will typically take four courses per year at an average of 4 credits each, and so earn 16 credits per year. These students therefore complete the degree requirement of 40 credits in two-and-a-half years. The enrollments in Table 6 for the PMS-CompFin Online students assume 90% retention from one year to the next. We believe these numbers are reasonably conservative targets for 2011-12, and with respect to the growth rates.

It should be noted that each part-time online student at 16 credits per year is equivalent to approximately 40% of a full-time student who takes 40 credits in a year. Thus for example the 20 PMS-CompFin Part-Time Online students in 2011-12 is equivalent to 8 full-time students, resulting in a total of 33 equivalent full-time students in 2011-12.

**Table 6. PMS-CompFin Program Student Enrollment Projections**

| | 2011-12 | 2012-13 | 2013-14 |
|---|---|---|---|
| **PMS Online** | | | |
| 2010 Carry | 10 | 9 | |
| 2011 New | **10** | 9 | 8 |
| 2012 New | | **15** | 13 |
| 2013 New | | | **20** |
| TOTAL | **20** | **38** | **51** |
| **PMS Full Time** | | | |
| TOTAL | **5** | **8** | **10** |
| **CF Certificate** | | | |
| TOTAL | **10** | **15** | **20** |
| **Risk Certificate** | | | |
| TOTAL | **10** | **15** | **20** |
| **TOTAL STUDENTS** | **45** | **76** | **101** |

PMS-CompFin Resident Students

These students will average at least 10 credits per quarter for four contiguous quarters from summer quarter of one year through spring quarter of the following year, plus possibly one additional course in following summer quarter depending on their course selection, for a total of at least 40 credits.

It is assumed that the fee-based financial model for Resident PMS-CompFin students will be similar to that for online students through UWEO/PCE financial structuring, and will include not only faculty buyout for instruction but also payment for any use of state funded facilities.

Online Certificate Students

It should be noted that working professionals who are not ready to commit to the time and expense required for the PMS-CompFin may be interested in either the online CompFin or Risk Management Certificate and may be willing to commit to the smaller time and expense involved in one of these certificates. Some of these individuals will subsequently decide that they have approximately half the work done for the PMS-CompFin degree, and then decide to continue with

the degree program. Thus we can anticipate that the two certificates will act to some degree as feeders to the PMS-CompFin Online MS degree program.

Rationale for 2010-11 Enrollment Projections

The reasonableness of the 2011-12 projections are based on the following observations. We had 30 students enrolled in the Online (OCFC) program for 2010-11 as of the end of September 2010 with an extremely short two-and-a-half months to market the program that previously had no market exposure. At that time about half of those 30 students indicated they would be interested in an MS degree program if it got launched, and in a December 2010 survey 10 indicated they intended to continue with the MS degree and 3 said they were considering it. Thus we use the number 10 in the "2010 Carry" row of Table 6. Five initial PMS-CompFin Resident students is quite conservative based on inquiries we have had about the degree by existing UW graduate students. As for the two online certificates, projecting 10 for the CompFin Certificate based on the 30 we had in 2010-11 seems reasonable. Projecting 10 for the Risk Management Certificate seems reasonable given the increased interest in risk management and our partnership with GARP (see 1.A.6), the resulting preparation value for the GARP FRM (2.C.2), and associated market exposure on the GARP web site.

### 2.H.3 Scholarships and Financial Support

No scholarships or financial support are available for the PMS-CompFin program, except possibly in the case of underrepresented students as discussed in the next section. The program's web site will list external sources of possible financial support that students can pursue.

### 2.H.4 Program Diversity Plan for Graduate Admission

The Department of Applied Mathematics continues to aggressively pursue strategies for recruiting minority and underrepresented students in the mathematical sciences. Most recently, the department has targeted a large number of historically African American colleges for our recruiting efforts. With our recent elite rankings, it is our hope to successfully diversify our student population while retaining one of the nation's most elite group of graduate students. One example of our success in this area is Trachette Jackson, Professor of Mathematics at the University of Michigan. Trachette is a former PhD student from our department and is perhaps the most prominent African American woman mathematician in the country today. Her formative years of PhD training were conducted in this department. Our hope is to continue to produce students like Trachette to help build a stronger and more diverse infrastructure in the academic arena.

It is very timely and relevant at this point in history to start recruiting and training underrepresented groups in the financial sciences. With the development of the computational finance degree, we will be able to provide a platform for providing top quality educational infrastructure in this intellectual arena for outstanding underrepresented candidates. In order to facilitate the recruiting of underrepresented students we will create a scholarship fund for such students based on an adequate program net profit to create such a fund.

## 2.I ADMINISTRATIVE AND SUPPORT STAFF

Program Directors

By mutual agreement between AMATH and UWEO/PCE the PMS-CompFin Program Director (CompFin Director) will be Professor R. Douglas Martin, whose teaching and research focus has been in Computational Finance since 2002. He has been the Director of the UW Computational Finance Graduate Certificate Program (CFGCP) since its launch in 2004. Martin's UW faculty position has been in the Department of Statistics since 1980, and his tenure line is expected to remain in Statistics. However, a memo-of-agreement (MOA) was signed between AMATH, Statistics and Martin that guarantees his role in the PMS-CompFin until he retires.
Professor Eric Zivot, who served as de facto Co-Director of the CFGCP since its inception in 2004, will serve as PMS-CompFin Co-Director. Zivot is highly committed to the PMS-CompFin program and will be teaching two of the core courses listed in 2.B.2 (see also Section 2.G.1).

Applied Mathematics Administrative Support

Applied Mathematics will be the administrative home of the overall Computational Finance program consisting primarily of the new online PMS-CompFin degree program and ancillary online CompFin certificates, but also the resident Graduate CompFin certificate. The PMS-CompFin Director and instructors will work closely with the current staff of Applied Mathematics to develop an administrative strategy for handling admission applications and decisions, web based materials, advising and graduation administration. By integrating resources, both PMS-CompFin and Applied Mathematics benefit and experience a cost savings, allowing for the use of resources for more strategic initiatives.

Currently, Applied Mathematics has a departmental administrator, fiscal specialist, computer systems administrator, graduate program specialist, and a web developer. Although not all the staff are relevant for the purposes of the program, the fiscal administration of the program, graduate advising, and professional web development are highly relevant and can be used directly for the needs of the program. Moreover, the staff of Applied Mathematics is already familiar and experienced with managing various aspects of the online program that pertain to their job title. Indeed, the graduate program advisor and web developer are currently hired on the department's existing online program income.

If additional staff is needed, the income from the online program is capable of supporting the requisite extra staffing needs. In particular, it is anticipated that in the first two years of the program, the current staffing in Applied Mathematics is capable of handling the additional administrative requirements of the PMS-CompFin. However, if the projected number of students does scale up as anticipated, then the PMS-CompFin can easily pay directly from the program budget for the necessary additional support. No new state funds are being requested for managing the program.

Internal CompFin Oversight Committee

Applied Mathematics has appointed the following oversight committee for the PMS-CompFin program:

- Doug Martin, Chair
- Eric Zivot, Economics
- Ka-Kit Tung, Applied Mathematics
- Hong Qian, Applied Mathematics
- Bernard Deconinck, Applied Mathematics

This committee is responsible for oversight of academic, contractual and fiscal aspects of the overall CompFin program, and reports in an advisory role to the AMATH Chair Nathan Kutz. Subject to approval by the AMATH faculty, the committee will plan and implement all necessary components of the strategic mission, both academically and fiscally, of the CompFin program.

UWEO/PCE Program Support

Offering the overall online CompFin program consisting of the PMS-CompFin degree, the two online certificates and the single course enrollment (SCE) offerings would not be possible without the administrative and technology delivery support of the University of Washington Educational Outreach (UWEO) organization and of the associated Professional and Continuing Education (PCE) organization. AMATH and UWEO/PCE already have a history of working together effectively in delivery of the AMATH online MS degree program. This relationship was further evolved with the launch of the Online Computational Finance Certificate (OCFC) program in autumn 2010, with professors Martin and Zivot joining in the partnership effort that resulted in 30 students registered with only a two-and-a-half month marketing runway in the summer of 2010.

UWEO/PCE will work with the PMS-CompFin program director Martin and AMATH for the online degree program partnership. The PCE program director interacts with the department chair, faculty, academic staff, and department program director to ensure the program is implemented in a manner that achieves the academic, student services, and fiscal goals of the Department and College. A PMS-CompFin program coordinator will be appointed by mutual agreement between AMATH and PCE. The PCE program coordinator communicates with degree program students, department coordinators, and program advisors to ensure smooth course logistics and registration. To this point, AMATH has been exceptionally pleased with the support of current PCE program officers Bill Anderson and Richard Lewis. It is our hope that these two colleagues would continue to be the primary members of PCE who work directly with AMATH.

The PMS-CompFin program director and coordinator draw upon centralized program management resources in UWEO and PCE operational units. Their services include:

- Public relations for the program
- Market research
- Marketing and promotion
- Dedicated marketing website for program
- Student recruitment
- Student registration and tracking
- Building/coordinating advisory board under the Applied Mathematics Dept. direction
- Troubleshooting operational issues
- Budgeting and pricing, under Applied Mathematics guidance
- Facilitating classroom assignments, as necessary
- Supporting online learning course design, delivery, and technical support
- Paying faculty and other program costs
- Financial accounting services for the program
- Delivering online exit surveys annually for each course
- Risk management
- Funding resources during dedicated program development periods

Graduate Service Appointments

All graduate service appointments will be paid by the self-sustaining program. Students will come from the regular Applied Mathematics graduate program. Each of two teaching assistants at .5 FTE each will support the course instructor (administer lab assignments, grade, provide software consultation) in 4 core curriculum courses per calendar year during year one (2011-12). Graduate operating fee will be paid by the program.

External Advisory Committee

Upon approval of the program, an external advisory committee (CompFin Advisors) of approximately five or six top academic and finance industry professionals will be created. The role of the CompFin Advisors will be to provide guidance to the UW CompFin program, through its Director and internal CompFin Oversight Committee described above, on how to best evolve the PMS-CompFin degree program to quickly gain and sustain a national top-ten position among such programs. Such guidance needs to be informative with regard to changes needed in the PMS-CompFin curriculum based on: (a) changes in the needs of the finance industry including adherence to new regulations, and (b) changes in the competitive MS degree programs. By the beginning of spring quarter 2011 the CompFin Director will provide a list of approximately 10 names to the internal Oversight Committee, which will decide upon the final set of external CompFin Advisors. The CompFin Director will then get the CompFin Advisors committee in place and functioning not later than the end of spring quarter 2011.

No new state funds are being request for managing the program as it is self-supporting.

### 2.J INFRASTRUCTURE REQUIREMENTS

There are no additional infrastructure requirements beyond those already available through the UWEO/PCE and existing AMATH infrastructures. Owing to AMATH MS graduate student office space limitations we cannot accept more than 5-6 resident students into PMS-CompFin program. While the PMS-CompFin program can be quite successful primarily as an online program as proposed, it is likely desirable to grow the resident-students component of the program over time as the program matures with a strong brand name. Among other things this will result in increased UW revenue at Professional MS degree market rates. In order to grow the resident student component of the program AMATH UW will need to allocate additional graduate student office space. If there is substantial demand for resident students in the PMS-CompFin program and UW is unable to provide the needed graduate student office space, AMATH will rent off-campus space to meet the demand if such action is economically viable.

### 2.K ACCREDITATION

No special accreditation will be sought in the near term of the next few years. It remains to be seen whether or not this may be needed in the long term.

## 3. PROGRAM ASSESSMENT

### 3.A ASSESSMENT PLAN

The quality of the instruction that we deliver and the appropriateness of the curriculum content for maximizing the professional success opportunity of the PMS-CompFin degree and certificates are absolutely critical to the growth and achievement of top national rankings for this fee-based program. Consequently we take student, course and program assessment very seriously.

#### 3.A.1 Student Learning Outcomes

A student who completes the PMS-CompFin degree requirements will have a graduate level knowledge base and applications capability that includes the following:

- Basic computational finance methods and financial econometrics concepts
- MBA level Investments course concepts at a higher quantitative level.
- Options and derivatives theory and applications
- Classical mean-variance portfolio construction
- Modern coherent downside ("tail") risk measures
- Modeling fat-tailed skewed non-normal asset returns distribution
- Modeling non-linear correlations
- Modern portfolio optimization and risk management using tail risk measures
- Portfolio optimization with different and mixed asset classes
- Use of different types of factor models in portfolio construction and risk management
- Practical applications of risk management
- Quantitative risk management methods
- Credit risk management
- Simulation methods in finance
- Use of R programming language for implementation of standard and advanced methods

- Use of R to develop complex trading and portfolio management systems

Students will be competitive in the job marketplace with students graduating with an MS degree from any of the top-ten quantitative finance MS degree programs (see Appendix D), and will be well-qualified for an entry level or advanced position with one of the following job titles:

| | |
|---|---|
| Chief Investment Officer | Quant Analyst Production Risk Group |
| Desk Quant/Modeler | Quant Developer |
| Developer Quant Strategies & Modeling | Quant Research Analyst |
| Equity Research Analyst | Risk Management Developer |
| Fixed Income Research Analyst | Risk Management Director |
| High Frequency Quant Trader | Risk Manager |
| Investment Banking Quant Analyst | Risk Manager Associate |
| Junior Portfolio Manager | Risk Modeler Associate |
| Junior Risk Manager | Risk Modeler Manager |
| Managing Director | Senior Quant Risk Associate |
| Model Validation Group Quant | Senior Quantitative Developer |
| Quant Analyst | Software Developer Equity |
| Quant Analyst Mortgages | Trading System Developer |

### 3.A.2 Student Assessment

PMS-CompFin Students

This group of students will receive standard numeric grading for all courses they take. Their resulting MS degree GPA will be made available to their current or prospect employer.

We anticipate that growth and success of the PMS-CompFin program will lead to the Applied Mathematics Departments accepting Ph.D. students who wish to pursue education and research in Computational Finance and Risk Management. In that case PMS-CompFin students with high GPA's, e.g., not less than 3.7, will be recruited to the Applied Mathematics Ph.D. program.

Certificate Students

These students will have the choice to be in a numeric graded section or a CR/NC section for each course they take. The reason is that some certificate students will be testing the water so to speak, thinking that they may wish to continue with the PMS-CompFin degree program. Such students will need to enroll in course sections that use standard UW numeric grading, and if they apply for the PMS-CompFin degree program their certificate GPA will be taken into account in deciding whether or not to admit them.

### 3.A.3 Course and Program Assessment

Course Assessment

There will be an online course evaluation and suggestions-for-improvement survey done every quarter for every course offered by the program. We will design this survey in a manner we believe will be more effective for purposes of our online courses than the standard UW teacher evaluation form. We will also test the efficacy of one-on-one conversations with selected students after each of the first few courses to gather more detailed information, particularly suggestions for improvements that speak to the background, nature and goals of the students in the program.

Program Assessment

We will do one-year and three-year follow-up surveys of students who earn the PMS-CompFin degree or a certificate, to assess the extent to which the degree or certificate has benefitted their professional career. These surveys will be supplemented with phone call discussions with selected students to gain further insight into program improvement needs, including re-focusing to meet evolving skill set needs of graduates.

On an annual basis we will carefully analyzed the curricula, program emphases and marketing pitches of the top-ten or so quantitative finance MS degree program in the U.S., with a view toward being light on our feet with respect to needed changes in our own program. We will also monitor web sites such as www.quantnet.com for rankings and reviews of our program to get a good reality check on how we are being viewed by others, including graduates of our program and unsolicited contributors.

Finally, we will request annual written feedback from our external Advisory Committee on how they believe we are doing, what our strengths and weaknesses are, and what improvements have the highest priority.

## 4. FINANCES

The financial model developed for the PMS-CompFin program is based upon standard fixed costs established by PCE associated with online delivery. The key components and expenses of the online program are associated with streaming video recording of lectures, production of the online content and overall management of course materials. In addition, the online portion of such courses must buyout a portion of the faculty member's teaching time (approximately $8500 per course) along with paying for a graduate teaching assistant support for each course (approximately $7500 per course, which includes tuition and benefits). Thus each course has approximately $16,000 in expenses for core teaching personnel. Additional expenses are for: class capture, UWEO-PCE charges, UW overhead, CompFin program Director, staff support, marketing, and program activities such as seminar speakers and hosting of local finance industry events.

A breakdown of the financial model for 2011-12 is provided in Table 7 below. The model we have developed with UWEO/PCE for 2012-13 and 2013-14 indicates that we will be able to hire one new faculty, initially without tenure (WOT), for each of those years with ample cash cushion. A final version of the model will be completed as part of the MOA between AMATH, UWEO/PCE and the College of Arts and Sciences in the next two weeks.

**Table 7. Financial Operating Model for 2011-12**

| | |
|---|---|
| **Total Tuition Revenue** | **753,225** |
| **STAFFING AND SALARY COSTS** | |
| Full-Time Faculty | -109,279 |
| Program Director | -66,000 |
| Teaching Assistants | -44,630 |
| Classified Staff | 0 |
| Professional Staff | -40,000 |
| Hourly Instructors | -21,705 |
| Sub Total | -281,613 |
| Benefits | -82,347 |
| **Total** | **-363,960** |
| **OTHER CONTRACTUAL SERVICES COSTS** | |
| Marketing | -25,000 |
| | |
| Seminar Speakers, Catering, Travel | -20,000 |
| | 0 |
| Video Production Services (DL MediaSite ClassCapture-EDGE) | -83,200 |
| DL Learning Mgmt System (LMS) | -8,000 |
| **Total contractual services** | **-136,200** |
| **ADMINISTRATIVE SERVICES COSTS** | |
| UWEO Program Management - Salary and Benefits | -31,082 |
| UWEO Infrastructure - Salary and Benefits | -21,193 |
| UWEO Risk-Opportunity Fund* (6% FY12, 5% FY13, 4% FY14) | -45,194 |
| UW Overhead Charge (4.73%) | -35,628 |
| **Total Administrative Expense** | **-133,096** |
| | |
| **Program Income** | **119,969** |

## 5. EXTERNAL EVALUATION OF THE PROPOSAL

External evaluations of this proposal were received from:

1) Carnegie Mellon University (CMU) Professor and Dean John Lehoczky, who was co-founder of the CMU Computational Finance MS degree program and who remains active in that program.
2) Dr. John Moody, International Computer Science Institute, University of California, Berkeley, and Managing Director of the hedge fund JEMoody in Portland, OR. Founder and former Director of the Computational Finance MS degree program at the Oregon Graduate Institute (OGI). John shut down the program and left OGI after the Oregon Health Sciences University took over OGI.

The two evaluations and the Department's response to the evaluations are provided as separate attachments.

# Appendix A: Letters of Support for Program

See attachment that contains letters of support from the following organizations:

- Blackrock Alternative Advisors
- Chartered Financial Analysts (CFA) Seattle Chapter
- Global Association of Risk Professionals (GARP)
- Microsoft Treasury
- Parametric Portfolio Management
- Russell Investments
- University of Washington Endowment (UW Investment Management)

# Appendix B: UW Faculty Bios

**Professor R. Douglas Martin, UW Computational Finance Program Director**

Martin is Professor of Statistics, Adjunct Professor of Finance and Director of Computational Finance at the University of Washington, and former Chairman of the Department of Statistics. Martin was a consultant in the Mathematics and Statistics Research Center at Bell Laboratories from 1973 to 1983. In 1987 he founded Statistical Sciences to commercialize the S language for data analysis and statistical modelling in the form of S-PLUS. Subsequently he was a co-founder and Chairman of FinAnalytica, Inc., developer of the Cognity portfolio construction and risk management system, and served as CEO from 2006 to 2008. Martin has authored numerous publications on time series and robust statistical methods, and is co-author of two books: Modern Portfolio Optimization (2005), and Robust Statistics: Theory and Methods (2006). His research is on applications of modern statistical methods in finance and investment, He holds the Ph.D. in Electrical Engineering from Princeton University.

Education: EE/Physics B.S.E., Princeton; M.S. in Electrical Engineering, University of Washington; Ph.D. in Electrical Engineering, Princeton.

**Professor Eric Zivot, UW Computational Finance Program Co-Director**

Eric Zivot is the Robert Richards Chaired Professor in the Economics Department, Adjunct Professor of Statistics, Adjunct Professor of Finance, and Adjunct Professor of Applied Mathematics (effective September, 2011). He regularly teaches courses on econometric theory, financial econometrics and time series econometrics, and is the recipient of the Henry T. Buechel Award for Outstanding Teaching. He was an associate editor of the *Journal of Business and Economic Statistics*. He is co-author of *Modeling Financial Time Series with S-PLUS* and co-developer of S+FinMetrics, and has consulted on the use of S-PLUS and R in the finance industry. He has published in the leading econometrics journals, including *Econometrica*, *Econometric Theory*, the *Journal of Business and Economic Statistics*, *Journal of Econometrics*, and the *Review of Economics and Statistics*, and in empirical finance journals including the *Journal of Empirical Finance*, the *Journal of Financial Markets*, and the *Journal of International Money and Finance*. He holds the Ph.D. in Economics from Yale University.

Education: Undergraduate Economics/Statistics, University of California Berkeley; Ph.D. in Economics, Yale University.

**Professor Nathan Kutz, Department of Applied Mathematics Chair**

See www.amath.washington.edu/people/J.Nathan.Kutz/

**Professor Randy LeVeque, Department of Applied Mathematics**

See /www.amath.washington.edu/people/Randy.LeVeque/

**Professor Hong Qian**

See www.amath.washington.edu/people/Hong.Qian/

**Professor Ka-Kit Tung, Department of Applied Mathematics**

See www.amath.washington.edu/people/Ka-Kit.Tung/

# Appendix C: Course Descriptions

**AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics**

This course is an introduction to data analysis and econometric modeling using applications in finance. Equivalently, this course is an introduction to computational finance and financial econometrics. As such, the course utilizes concepts from microeconomics, finance, mathematical optimization, data analysis, probability models, statistical analysis, and econometrics. Topics include:

- Probability and statistics (univariate and multivariate distributions, covariance, descriptive statistics, time series concepts, estimation, hypothesis testing, Monte Carlo simulation, bootstrap)
- Optimization methods involving equality and inequality constraints
- Matrix algebra
- Asset return calculations
- Statistical distributions and models for asset returns
- Value-at-risk, expected shortfall and portfolio risk budgeting
- Mean-Variance Portfolio Theory
- Statistical analysis of portfolios
- Capital Asset Pricing Model
- Investment performance measurement and analysis

Instructor: Eric Zivot (Economics is home department)

Textbooks: Zivot. E., Intro. to Computational Finance and Financial Econometrics, manuscript in preparation. Ruppert, D (2010). Statistics and Data Analysis for Financial Engineering, Springer.

Software: R and R Finance Packages

Prerequisites: A year of calculus (through partial differentiation and constrained optimization using Lagrange multipliers), some familiarity with matrix algebra, a course in probability and statistics using calculus, intermediate microeconomics and an interest in financial economics.

**AMATH 541 Investment Science**

This course is an introduction to the mathematical, statistical and financial foundations of investment science. Learning of the theoretical concepts will be re-enforced through use of R computing exercises. The material is similar in scope to an MBA level investments course, but at a significantly higher quantitative level. Topics include:

- Basic Theory of Interest Rates (compounding, present value, internal rate of return)
- Fixed Income Securities (bonds, value formulas, yield, duration, convexity, immunization)
- Term Structure of Interest Rates (term structure, discount factors, forward rates, short rates)
- Mean-Variance Portfolio Theory (efficient frontiers, quadratic utility, benchmark tracking)
- Factor Models (CAPM, linear regression and prediction, multi-factor models, intro. to APT)
- General Principles (expected utility maximization, coherent risk measures, tail risk measures)
- Futures and Forwards (futures and forward prices, margin, hedging with futures)
- Options Part 1: (option payoffs, trading strategies, binomial models, risk neutral pricing)

- Options Part 2: (Ito process and lemma, GBM, Black-Scholes, hedging, implied volatility)

Instructors: K. K. Tung, R. Douglas Martin

Textbook: D. G. Luenberger (1998). *Investment Science*, Oxford University Press

Software: R and R Finance Packages

Prerequisites: Probability and statistics at the level of STAT/AMATH 506 or STAT/AMATH 481. AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics, or equivalent, including experience with R.

**AMATH 542 R Programming for Computational Finance**

This course is an in-depth hands-on introduction to the R statistical programming language (www.r-project.org) for computational finance. The course will focus on R code and code writing, R packages, and R software development for statistical analysis of financial data including topics on factor models, time series analysis, and portfolio analytics. Topics include:

- The R Language. Syntax, data types, resources, packages and history
- Graphics in R. Plotting and visualization
- Statistical analysis of returns. Fat-tailed skewed distributions, outliers, serial correlation
- Financial time series modeling. Covariance matrices, AR, VecAR
- Factor models. Linear regression, LS and robust fits, test statistics, model selection
- Multidimensional models. Principal components, clustering, classification
- Optimization methods. QP, LP, general nonlinear
- Portfolio optimization. Mean-variance optimization, out-of-sample back testing
- Bootstrap methods. Non-parametric, parametric, confidence intervals, tests
- Portfolio analytics. Performance and risk measures, style analysis

Instructor: Guy Yollin

Textbooks: D. Ruppert (2010). Statistics and Data Analysis for Financial Engineering, Springer and J. Adler (2009). *R in a Nutshell: A Desktop Reference*, O'Reilly Media

Software: R and R packages.

Prerequisites: AMATH 541 Investment Science or equivalent educational experience. Introductory probability and statistics at the level of STAT/AMATH 506 or STAT/ECON 481, or equivalent. Familiarity with matrix algebra, multivariable calculus and optimization with Lagrange multipliers. Basic computer programming experience.

**AMATH 543/STAT 549 Portfolio Construction and Risk Management**

This computationally oriented course uses R and R+NuOPT for portfolio construction and risk management. The course is unique in focusing on not only classical mean-variance optimization methods but also on post-modern optimization based on new downside risk measures for dealing with fat-tailed and skewed asset returns distributions. Topics include:

- Portfolio risk analysis: Volatility, VaR and ETL risk at asset group level and portfolio level
- Mean-variance review and mean-ETL optimization: Basic theory of mean-ETL optimization.
- Numerical mean-variance optimization: Using R+NuOPT with real-world constraints, penalties
- Numerical mean-ETL optimization: R+NuOPT as above and Cognity for fat-tailed distributions
- Estimation error: Classical sampling distribution methods and bootstrap methods

- Active management: Alpha, benchmarks, information ratios, IC's and TC's
- Long-short portfolios: Market neutral versus dollar neutral, 130-30
- Factor models: Three types, optimization and risk management applications, robust fitting
- Leverage: Types of leverage, return versus risk considerations
- Liquidity and market impact: Liquidity risk, Sadka liquidity risk beta, market impact models
- Risk budgeting*: Volatility risk versus tail risk budgets, implied returns*
- Bayes methods: Bayes shrinkage, Bayes-Stein, Black-Litterman

Instructor: R. Douglas Martin

Textbooks: Scherer and Martin (2011). *Modern Portfolio Optimization*, 2nd edition, Qian, Hua and Sorensen (2007), *Quantitative Equity Portfolio Management*, Chapman and Hall/CRC Financial Mathematics Series.

Software: R, R-NuOPT, selected R packages, FinAnalytica's Cognity portfolio optimization and risk management system. Other commercial portfolio optimization and risk management products, arrangements with vendors permitting.

Prerequisites: AMATH 541 Investment Science plus AMATH 542 R Programming for Computational Finance, or equivalents.

**AMATH 544/STAT 547 Options and Derivatives**

This course provides basic knowledge of the theory, statistical modeling and computational methods of pricing options and other derivative products. The course blends mathematical and statistical theory with hands-on computing. The first part of the course will emphasize options on stocks, stock indices, currencies and futures, and the latter part will focus on interest rate derivatives. Course work includes assignments in theory and computation, and either a final exam or a project.

- Brief review of forwards, futures, and options basics
- Black-Scholes theory and dynamic hedging with the Greeks
- Volatility estimation, implied volatility, the volatility smile
- Option prices using additive and multiplicative binomial, and use of trinomial trees
- Option pricing under fat-tailed non-normality
- Computational methods for exotic options and complex derivatives
- Brief review of interest rate basics: zero rates, forward rates and term structure
- Interest rate derivatives: standard market models, short rate and advanced models
- Analytic models and tree models for pricing interest rate derivatives
- Valuation of bonds with embedded options, option adjusted spreads

Instructor: R. Douglas Martin

Textbooks: Hull, J. C. (2009). *Options, Futures and Other Derivatives*, 7th edition (or most recent edition available at time of course offering), Prentice Hall. Tuckman, B. (2002). *Fixed Income Securities*, 2nd edition, Wiley

Software: R and selected R packages

Prerequisites: AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics and AMATH 541 Investment Science coverage of forwards, futures and options, or equivalent. AMATH 542 R Programming for Computational Finance is desirable.

**AMATH 545/FIN 562 Management of Financial Risk**

This course covers the methodologies used to manage financial risk. Emphasis is given to fixed income and foreign exchange derivatives. The topics covered include:

- An overview of fixed income products.
- Duration and convexity and risk management of fixed income portfolios.
- Black and Scholes model. Hedging and trading parameters.
- Pricing options and swaps.
- Introduction to term structure models.
- Introduction to credit derivatives.
- Introduction to mortgage-backed securities and asset-backed securities.
- Introduction to hedge fund strategies and risk management.

Instructors: Mark Everitt (Blackrock) and Gino Perrina (Russell Investments)

Textbooks: Assigned readings.

Software: Microsoft Excel

Prerequisites: FIN 509 Foundations of Finance or AMATH 541 Investment Science, or equivalents. FIN 561 Financial Futures and Options Markets or AMATH 544 Options and Derivatives is a plus. Students must be comfortable with calculus and statistics.

**AMATH 546/ECON 589/ Quantitative Risk Management and Financial Econometrics**

This is a course in quantitative risk management and financial econometrics. The focus will be on the statistical modeling of financial time series (asset prices and returns) with an emphasis on modeling volatility and correlation for quantitative risk management. The learning goals/objectives of the course are to (1) survey the relevant theoretical and practical literature; (2) introduce state-of-the-art techniques for modeling financial time series and managing financial risk; (3) use the open source R statistical software to get hands-on experience with real world data. Topics to be covered include:

- Empirical properties and stylized facts of asset returns
- Probability distributions and statistical models for asset returns
- Risk concepts
- Volatility modeling
- Extreme value theory
- Multivariate dependence using copulas
- Introduction to credit risk models and management

Instructor: Eric Zivot (Economics is home department)

Textbooks: McNeil, Frey, and Embrechts, *Quantitative Risk Management: Concepts, Techniques, and Tools*, Princeton University Press, 2005. Jondeau, E., Poon, S.-H., and Rockinger, M. (2006). *Financial Modeling Under Non-Gaussian Distributions*, Springer-Verlag.

Software: R and R Finance Packages

Prerequisites: AMATH 542 R Programming for Finance and its pre-requisites, or equivalent.

**AMATH 547 Credit Risk Management**

This course is an introduction to the mathematical, statistical and financial foundations of models for analyzing, predicting, and mitigating credit risks. Students will learn the theoretical basis for widely-used modeling methods for credit risk assessment and implement those methods through programming assignments using R. The course will focus on both obligor-level and portfolio-level credit risks, as well as valuation and risk analysis of assets and derivatives with credit risk. Topics include:

- Credit risk drivers and portfolio diversification (idiosyncratic and systemic risks)
- Applied logistic regression (credit scoring models)
- Credit rating products for individuals and corporations (FICO, S&P, Moodys, Experian)
- Merton model for default risk
- Credit risk economic capital
- Basel II credit capital framework for banks
- Modeling loss frequency (PD) and severity (LGD)
- Credit risks in structured asset backed securities
- Credit default swaps, models for valuation and risk measurement

Instructor: Jay Henniger

Textbook: Servigny and Renault (2004). *Measuring and Managing Credit Risk*, McGraw-Hill Professional

Software: R and R Finance Packages

Prerequisites: AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics, AMATH 541 Investment Science and AMATH 545/FIN 562 Introduction to Risk Management, or equivalents. AMATH 546/ECON 589 Quant. Risk Management is desirable.

**AMATH 548 Monte Carlo Methods in Finance**

This course covers a broad range of standard and specialized Monte Carlo methods in finance with a focus on accurate derivative pricing. Students will learn the theoretical rationale for the methods and will gain applications knowledge through programming assignments using R or Matlab. The course will begin with an overview Monte Carlo methods and a review of basic derivative pricing method. Topics covered will include:

- Derivative pricing methods: replication, no-arbitrage, risk-neutral pricing, change of numeraire
- Random number generators: linear congruential generators, lattice structure, simulation error
- Sampling methods: inverse transform, acceptance-rejection methods
- Mulivariate random numbers: normal distributions, t-distributions, stable distributions
- Simulating sample paths: univariate and multivariate GBM, path-dependent options, short-rate models and bond prices
- Simulating advanced models: square-root diffusions and bond prices, forward rate models and pricing derivatives, jump processes

- Variance reduction methods: antithetic variables, control variates, stratified sampling, Latin hypercube sampling, matching methods, importance sampling
- Discretization methods: Euler method, second-order methods, applications to extremes and barrier crossings
- Estimating the Greeks sensitivity measures: finite-difference approximations, pathwise derivative estimates, likelihood ratio method,
- Pricing American options: random tree methods, stochastic mesh methods, regression methods
- Risk management applications: calculating VaR and CVaR, calculating VaR and CVaR portfolio risk decompositions, delta-gamma based variance reduction, methods for fat-tailed distributions

Instructor: Hong Qian

Textbook: Glasserman, P. (2004). *Monte Carlo Methods in Financial Engineering*, Springer

Software: R and R Finance Packages or Matlab

Prerequisites: AMATH 541 Investment Science and AMATH 544 or equivalents.

**AMATH 551 Introduction to Electronic Trading**

This course is an introduction to direct market access "DMA" trading. Students will learn how to enter orders through Interactive Brokers electronic trading platform. Students will learn in small groups in a simulated trading environment to get real world experience. The curriculum is the optimal final step necessary to put research into practice. Topics include:

- Mechanics of the Futures Market
- Introduction to Forex Trading
- Technical Analysis
- Options Parts 1, 2 and 3: Strategies, Greeks, Option Input Variables
- Order Types
- Technical Analysis
- Database Trading: Getting Started with the Interactive Brokers Java API
- Database Trading: Getting Started with the DDE for Excel API
- Database Trading: Getting Started with the ActiveX API

Instructor: Brian F. Tomeo

Textbooks: The New Science of Technical Analysis by Thomas R. DeMark, Bollinger on Bollinger Bands by John Bollinger, Options Futures and Other Derivatives by John Hull.

Software: Microsoft Excel, Microsoft SQL, Interactive Brokers Trading Platform

Prerequisites: AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics (may be taken concurrently). AMATH 541 Investment Science is desirable.

**AMATH 552 Times Series Modeling and Forecasting**

This course is an introduction to the role that forecasts can play in investment decisions, especially investing that involves views on short-term opportunities that are implemented through informed rebalancing or explicit asset class tilts away from benchmark. Learning of the theoretical concepts will be re-enforced through use of computing exercises. Topics include:

- Types of forecasts, dynamic forecasts, direct forecasts
- Forecasts by simulation for nonlinear models
- The role of macroeconomic forecasts in investing
- An approach to macroeconomic forecasting
- Asset class returns forecasts
- Ways to combine forecasts using dynamically updated weights
- Ways to account for nonlinearity
- Foreign exchange (FX) forecasts: carry trade motive, momentum strategies, incorporating long-run valuation correction

Instructors: Michael Dueker

Textbook: TBD

Software: TBD

Prerequisites: Probability and statistics at the level of STAT/AMATH 506 or STAT/AMATH 481. AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics, or equivalent.

## AMATH 553 Endowment Investment Management

The course will focus on the endowment management process and specific challenges facing institutional fund managers. These include evaluating the role of an endowment, portfolio construction, risk management, manager selection, and alternative asset class investing. As such, the course utilizes concepts from finance and investments, macroeconomics, and mathematical optimization. Specific topics include: Endowment policy background and philosophy, spending, risk and asset allocation, emerging market investing, fixed incomes role in endowment, liquidity and investing in private equity. Reading assignments will form the basis for class discussion and students areare expected to be prepared for case discussions.

Instructors: Garth Reistad, Keith Ferguson, and Yindeng Jiang

Textbooks: There is significant amount of reading for this course, including articles and investment research from multiple sources that will be assigned by the instructors.

Software: R will be useful in the event of some case applications.

Prerequisites: AMATH 541 Investment Science or equivalent. A general understanding of economics and a good background in core finance and portfolio optimization, e.g., AMATH 543 Portfolio Optimization and Risk Management is preferred.

### AMATH 554 Portfolio Performance Measurement

This course covers fundamental principles of portfolio performance measurement and benchmarking. Topics include:

- The role of performance evaluation in portfolio management
- Rate of return calculations for individual assets and for portfolios
- Manipulating returns: linking, averaging, annualizing
- Adjustments for inflation, currency, taxes, fees
- Cash flow methods: time-weighted returns, money-weighted returns, standard approximations
- Excess returns, arithmetic and geometric
- Sector-based performance attribution
- Volatility and asset pricing-based risk measures
- Risk-adjusted return measures
- Factor-based performance attribution
- Uses of indexes: benchmarking, asset allocation, and the basis for investment vehicles
- Benchmark construction principles and practical issues
- Index calculations, weighting, rebalancing, and maintenance
- Equity style indexes
- GIPS: Global Investment Performance Standards

Instructor: David R. Cariño

Textbook: J. A. Christopherson, D. R. Cariño, and W. E. Ferson (2009). *Portfolio Performance Measurement and Benchmarking*, New York: McGraw-Hill

Software: Spreadsheet applications and R

Prerequisites: AMATH 540/ECON 424 Introduction to Computational Finance and Financial Econometrics or equivalent, and AMATH 541 Investment Science or equivalent.

**AMATH 555 Optimization Methods in Finance**

This course provides an introduction to numerical optimization methods in finance. The course will discuss the theory and efficient solution methods for major classes of optimization problems. Theoretical concepts will be paired with example applications and computing exercises. Homework problems will include use of an industrial strength optimizer to solve finance applications. Topics include:

- Linear Programming Theory, Algorithms and Applications: feasible sets, duality, optimality conditions, simplex method, interior point methods, sensitivity analysis, asset/liability cash flow matching
- Quadratic Programming Theory, Algorithms and Applications: constrained and unconstrained programming, optimality conditions, solution methodologies, mean-variance optimization, relationships to statistical regression, Black-Litterman, returns-based style analysis, risk-neutral density estimation
- General Non-Linear Programming Theory, Algorithms and Applications: univariate and multivariate models, convexity, non-smooth optimization, GARCH model fitting, volatility surface estimation
- Integer Programming Theory, Algorithms and Applications: cutting plane methods, index replication
- Combinatorial and Network Programming Theory, Algorithms and Applications: shortest path, min-cost flow, foreign exchange, arbitrage checking

- Cone Programming Theory, Algorithms and Applications: second-order cone programming, tracking error and volatility constraints, estimating covariance matrices
- Dynamic Programming Theory, Algorithms and Applications: Bellman equations, forward and backward recursion, knapsack problem, option pricing, structured products
- Stochastic Programming Theory, Algorithms and Applications: data uncertainty, multi-stage models, recourse, value at risk, conditional value at risk, asset/liability management, CVaR, transaction costs
- Robust Optimization Theory, Algorithms and Applications: parameter uncertainty, robust constraints, robust objectives, single-period and multi-period portfolio selection
- Additional Topics: Decomposition and Column Generation, Genetic Algorithms, Non-gradient methods

Instructor: Steven Murray

Textbook: Cornuejols and Tutuncu (2007). *Optimization Methods in Finance*, Cambridge University Press.

Software: R and R-NuOPT. Other commercial portfolio optimization products such as CPLEX and Axioma, arrangements with vendors permitting.

Prerequisites: AMATH 541 Investment Science and AMATH 542 R Programming for Computational Finance. AMATH 543 Portfolio Construction and Risk Analysis is desirable.

**AMATH 582 Computational Methods for Data Analysis**

See www.amath.washington.edu/courses/582-winter-2011

**AMATH 583 High Performance Scientific Computing**

See www.amath.washington.edu/courses/583-spring-2010/index.html

# Appendix D: Finance Industry Lecturer Bios

**Michael J. Dueker, Ph.D., Chief Economist, Russell Investments**

Dr. Dueker writes regularly for Russell's Market Outlook publications, forecasting the business cycle and the target federal funds rate. He developed and maintains a business cycle indicator that is updated regularly on Russell.com. He also spearheads Russell's participation as a blue chip forecaster for both blue chip economic indicators and blue chip financial forecasts. Dueker brings state-of-the-art empirical modeling and forecasting techniques to key economic developments, the term structure of interest rates, currency markets and tactical asset allocation. He coordinates efforts to formulate globally consistent Russell views on the near-term macroeconomic outlook, including inflation and currency developments. Prior to joining Russell in 2008, Dr. Dueker was an assistant vice president and research economist at the Federal Reserve Bank of St. Louis from 1991 to 2008. His principal duties included briefing the bank president prior to monetary policy meetings and publishing articles in academic journals, such as the *Journal of Econometrics*, the *Journal of Monetary Economics,* and the *Review of Economics and Statistics*. Dueker served as an associate editor of the *Journal of Business and Economic Statistics*. He also was editor of *Monetary Trends*, a monthly publication of the St. Louis Fed.

Education B.A., Mathematics, University of Oregon, 1986; M.A., Economics, Northwestern, 1987; Ph.D., University of Washington, 1991.

**Mark Everitt, BSc, CFA, Managing Director, Blackrock**

Mr. Everitt serves not only as Managing Director for Blackrock but also as Director of Risk Management for BlackRock Alternative Advisors, BlackRock's fund of funds platform. Mr. Everitt joined BlackRock in 2007 following the acquisition of the fund of funds business of Quellos Group, LLC. At Quellos, he was a Principal responsible for overseeing the Risk Management Group. From 2000 to 2003, he was a Managing Director for Market and Liquidity Risk with BNP Paribas, leading a team responsible for risk management in fixed income, equity and commodity products in the Americas. Mr. Everitt joined BNP Paribas London in 1995, where he was the Global Head of the Counterparty Risk and Portfolio Analysis team, developing risk methodologies and sponsoring system developments which measured counterparty exposure risk and economic capital for derivative products. From 1988 to 1995, Mr. Everitt was a Senior Consultant at Price Waterhouse Management Consultants, as well as with NatWest Markets, where he completed the Graduate Program.

Education: Mr. Everitt has passed all the qualifying examinations for an Associate membership of the Chartered Institute of Bankers in the UK. He earned a BSc degree with joint honors in geography and topographic science from the University of Wales in 1988.

**Keith Ferguson, MBA, Chief Investment Officer, University of Washington**

Keith Ferguson is currently the Chief Investment Officer at the University of Washington in Seattle. Mr. Ferguson has over twenty years of experience in the investment business, primarily working as a portfolio manager and research analyst. Prior to his current role, Mr. Ferguson worked for Fidelity Investments in senior investment roles, including Chief Investment Officer for Asia Pacific based in Hong Kong.

Education: Mr. Ferguson received a BA degree from Princeton University and an MBA degree from the University of Washington.

**Jay Henniger, Ph.D., Senior Manager, JPMorgan Chase**

Dr. Henniger holds a Ph.D. in Applied Mathematics from Cornell University and is currently a Senior Manager at JPMorgan Chase working on modeling projects for credit risk regulatory and economic capital. Prior to his credit risk modeling work at Chase he was responsible for validation of interest rate risk and operational risk financial models at Washington Mutual. Henniger has a broad range of experience building and analyzing quantitative financial models, including models for asset valuation, default and prepayment risk, and for equity and interest rate derivatives. As a risk manager, he has worked on projects related to measuring and managing risks through VaR, Monte Carlo, and scenario-based analytics. His research focuses on optimization problems related benchmark tracking and hedging with small portfolios.

Education: BS in Math/Physics, Gettysburg College; Ph.D. in Applied Mathematics, Cornell University.

**Yindeng Jiang, Ph.D., Senior Investment Analyst, University of Washington**

Yindeng Jiang is a Quantitative Research Analyst with four years' experience with the investment program at the University of Washington. He is a member of the Seattle Society of Financial Analysts.

Education: Yindeng holds a BA degree from Peking University and a Ph.D. in Statistics from the University of Washington.

**Steven M. Murray, Ph.D., CFA, Director of Asset Allocation Strategies, Russell Investments**

Dr. Murray is Director of Asset Allocation Strategies for Russell Investments where he is responsible for portfolio construction research as well as the development and maintenance of model portfolios. Model portfolio research informs the management of multi-asset, balanced portfolios and supports client service and sales activities across regional institutional and retail business units. Dr. Murray also serves on Russell's endowment and foundation practice group. Murray joined Russell's investment research and development group in 1992, when his initial responsibilities were as a team member and project technical manager of customized asset/liability management models. These models were developed for large financial institutions, including banks and insurance companies. Dr. Murray's role included both developing theoretical algorithms and implementing large-scale stochastic programming models. Murray has led Russell's strategic forecasting group as well as the asset/liability analysis group, and his recent Russell research commentaries include an update to "Endowments, Foundations and the Inflation Challenge", "Are 5% Distributions an Achievable Hurdle for Foundations? Were They Ever?" and "Rebalancing and Enhanced Asset Allocation." He is a member of the CFA Institute and the Seattle Society of Financial Analysts and INFORMS (formerly the Operations Research Society of America). Dr. Murray is a recipient of 1999, 2001 and 2008 Russell Team Excellence Awards and a 2004 Russell Leadership Award.

Education: B.A., Mathematics, Whitman College; M.S., Operations Research, Stanford University; Ph.D., Operations Research, Stanford University; CFA Charterholder, CFA Institute.

**Gino Perrina, Ph.D., CFA, Global Head of Fixed Income Research, Russell Investments**

Dr. Perrina is global head of fixed income research for Russell Investments. He oversees a team of analysts responsible for recommending managers to Russell's consulting business and for inclusion in its $40B in fixed income assets around the globe. Prior to joining Russell, Perrina was a Managing Director with BlackRock Alternative Advisors. There, he was a member of the Risk Management Group focusing on absolute return strategy investments in addition to analyzing fixed income, derivative strategies and other quantitative analysis. Prior to joining the Risk Management Group, Dr. Perrina was a member of the ARS Manager Research group where he was responsible for the sourcing, performance of due diligence on and monitoring of hedge Fund managers. He joined BlackRock in 2007 following the acquisition of the fund of funds business of Quellos Group, LLC. At Quellos, Dr. Perrina served as a Manager focused on underlying manager due diligence. From 2005 to 2006, he was Director of Global Equities at

Tahoma Capital, LLC, a multi-strategy fund located in Bellevue, Washington. At Tahoma Capital, Dr. Perrina managed the global equities portfolio, including strategy and trade development and execution. From 2003 to 2005, Perrina served as a Director of Investment Management at IAC/Interactive Corporation, where he managed a fixed income portfolio in excess of $3B. He began his career in 1999 as a Financial Analyst and Portfolio Manager at Microsoft Corporation.

Education: Undergraduate degree in International Business, Seattle University; MBA, Clemson University; PhD in Finance, Texas Tech University.

**Garth Reistad, MA, CFA, Deputy Chief Investment Officer, University of Washington**

Garth Reistad is the Deputy Chief Investment Officer with over ten years' experience with the investment program at the University of Washington. Prior to joining the University, Garth worked as an Analyst at Bank of America in San Francisco. He is a member of the Seattle Society of Financial Analysts and a CFA charter holder.

Education: Mr. Reistad received a BS degree with highest honors in Economics from Montana State University and a MA in Economics from Columbia University.

**Brian Tomeo, AB**

Mr. Tomeo is a private investor and entrepreneur with over 19 years of financial markets experience. After graduating from Princeton University with an AB in Economics he joined the Emerging Markets sales desk at the Chase Manhattan bank (now JPMorgan Chase), where he was responsible for emerging market cross asset option structuring and derivative sales and origination. Tomeo's clients included hedge funds, financial institutions, private clients, banks, asset managers, corporations and government entities domiciled in Latin America. During this period Latin America experienced periods of extreme volatility starting with the Mexican Peso crisis in 1994, the Brazil crisis of 1999 and the Argentina default of 2001. Mr. Tomeo worked with JPM's clients to structure innovative trading and risk management solutions designed to assist the firm's clients in managing the unique cross border risks associated with investing and trading in emerging markets. He was promoted to Managing Director in 2004 and 2005 moved to London to run the firms currency & commodity corporate sales business in the investment bank. In 2006 he was promoted to co-head of the London currency dealing room with direct responsibility for sales marketing and distribution of the currency derivatives, structured products and cash. Brian's responsibility included developing the overall strategy and direction of the firm's business in London. Tomeo directly managed a team of professionals responsible for hedge funds, asset manager, multinational corporate, bank and private client sales. During this period he continued to work directly with JPMorgan customers to provide risk management solutions for cross border M&A and event driven transactions.

Education: AB in Economics, Princeton University, 1994.

**Guy Yollin, MS, Principal Consultant, R-Programming.org**

Mr. Yollin is the principal consultant for r-programming.org, a professional services organization that specializes in applying the R programming language to develop solutions in computational finance, quantitative risk management, and business analytics. Prior to founding this consultancy, Yollin served as a quantitative analyst, risk manager, and R language evangelist for two different Pacific Northwest hedge funds. In between these hedge fund roles, Mr. Yollin led the quantitative finance software development team at Insightful Corporation, developers of S-PLUS and S+FinMetrics. Yollin has given numerous talks on R/S programming for financial applications and has taught graduate courses in statistical computing and financial time series analysis.

Education: Yollin holds a BSE in Electrical Engineering from Drexel University and an MS degree in Computational Finance from the Oregon Health & Science University.

# Appendix E: Top 23 Quantitative Finance MS Degrees in U.S.*

| [illegible] | School | MS Program Name | Tuition | Length |
|---|---|---|---|---|
| 1-5 | Carnegie Mellon University | Computational Finance | $73,800 | 1.5 years |
| 1-5 | Columbia University | Financial Engineering | $47,160 | 1 year |
| 1-5 | Princeton University | Finance | $73,220 | 2 years |
| 1-5 | Stanford University | Financial Mathematics | $37,380 | 1 year |
| 1-5 | University of Chicago | Financial Mathematics | $44,892 | 1 year |
| 6-10 | Baruch College City University of New York | Financial Engineering | $11,040 (in-state) $20,700 (out-of-state) | 1.5 years |
| 6-10 | Columbia University | Mathematics of Finance | $35,032 | 1 year |
| 6-10 | Cornell University | FE concentration | $37,050 | 1.5 years |
| 6-10 | New York University | Mathematics in Finance | $45,972 | 1.5 years |
| 6-10 | University of California at Berkeley | Financial Engineering | $50,402 | 1 year |
| 11-15 | Boston University | Mathematical Finance | $37,910 | 1 year |
| 11-15 | Georgia Institute of Technology | Quantitative and Computational Finance | $15,561 (in-state) $50,313 (out-of-state) | 1.5 years |
| 11-15 | North Carolina State University | Financial Mathematics | $11,984 (in-state) $36,084 (out-of-state) | 2 years |
| 11-15 | Univ. of Illinois Urbana-Champaign | Finance | $40,255 | 1 year |
| 11-15 | University of Michigan | Financial Engineering | $30,348 (in-state) $56,502 (out-of-state) | 1.5 years |
| 16-20 | Claremont Graduate School | Financial Engineering | $59,427 | 1.5 years |
| 16-20 | Rutgers University | Mathematical Finance | $29,052 (in-state) $44,640 (out-of-state) | 1.5 years |
| 16-20 | Rutgers University | Quantitative Finance | $42,080 (in-state) $69,364 (out-of-state) | 2 years |
| 16-20 | University of Southern California | Mathematical Finance | $34,500 | 1.5 years |
| 16-20 | University of Toronto | Mathematical Finance | CAD 37,000 | 1 year |
| 21-23 | Florida State University | Financial Mathematics | $15,552 (in-state) $45,876 (out-of-state) | 2 years |
| 21-23 | Kent State University | Financial Engineering | $21,552 (in-state) $32,070 (out-of-state) | 1 year |
| 21-23 | Purdue University | Specialization in Computational Finance | $17,276 (in-state) $48,660 (out-of-state) | 2 years |

*Source: www.quantnet.com/mfe-programs-rankings/ .

NOTE: Average tuition using out-of-state tuitions is $45K, and is $35K with in-state tuitions.

[1] University of Washington UW Role and Mission Statement which may be found at site http://www.washington.edu/home/mission.html.

[2] The College of Arts and Sciences Vision and Goals document may be found at www.artsci.washington.edu/vision.asp.

[3] For information about the Applied Mathematics Department see www.amath.washington.edu.

[4] Lehoczky was a co-founder of the market leading CMU Computational Finance MS degree program, and remains an active participant in the program.

[5] The source of this data is www.quantnet.com/mfe-admission-numbers.

[6] Dialog with endowments and pension plans by portfolio construction and risk management software company FinAnalytica, Inc. while Professor Martin was CEO through 2008, and subsequent personal communications with FinAnalytica. Also, personal communication with the asset management software company Centaura Solutions, Inc. during 2009 and 2010.

[7] The links for the quotes, in the same order as the quotes are:

http://www.reuters.com/article/idUSN1642106820090616

http://blog.aefeldman.com/2009/01/07/risk-management-watch-cfos-cros-in-demand-as-companies-rethink-risk/

http://www.resourceinvestor.com/News/2010/2/Pages/Aon-Regulation-volatility-driving-demand-for-risk-management.aspx

http://www.insurancetech.com/security/showArticle.jhtml?articleID=224400279 .

# Appendix A: Letters of Support for Program

This Appendix contains letters of support from the following organizations:

- Chartered Financial Analysts (CFA) Seattle Chapter
- Global Association of Risk Professionals (GARP)
- Microsoft Treasury
- Parametric Portfolio Management
- Russell Investments
- University of Washington Endowment (UW Investment Management)

December 27th, 2010

Professor Doug Martin
Professor of Statistics
Adjunct Professor of Finance
Director of Computational Finance Program
University of Washington
Department of Statistics
Box 354322
Seattle, WA 98195-4322

RE: MS Degree in Computational Finance and Computational Finance Certificate

Professor Martin;

On behalf of the CFA Society of Seattle, I want to express our support for your proposed quantitative finance programs, the MS Degree in Computational Finance and the Computational Finance Certificate.

Our vision of the Seattle investment community, both the professional side and the research and academic side, is that of a broad range of well educated industry and academic participants. Quantitatively skilled financial experts are a critical part of this vision. The CFA program is a general financial proficiency accreditation that allows employers to understand that a person may be proficiently skilled in finance. But it is through programs like what you have proposed that allow individuals to build upon a skill set for greater expertise and competency in a more specialized area. This in turn creates deeper skill sets within the greater Puget Sound investment community, for the betterment of individuals, employers, and the investment community as a whole.

Having the Computational Finance MS degree program seminars open to Puget Sound area CFA members, such as the recent Cross-Section Volatility seminar by Jose Menchero from Barra and the forthcoming spring colloquium by Andrew Lo from MIT, will greatly foster beneficial interaction between your program faculty and students and the local CFA community.

Our support can take several forms, considering the online aspects, I would like to promote the programs to our working members that may find it attainable and attractive for their career, I would like to promote it as a means of supplementing CFA Candidates' quantitative skills, and I would suggest promoting it to more specialized members that are looking to master advanced quantitative skills.

CFA Institute is a global, not-for-profit organization comprising the world's largest association of investment professionals. With over 100,000 members, and regional societies around the world, CFA Institute is dedicated to developing and promoting the highest educational, ethical, and professional standards in the investment industry.

CFA Institute offers a range of educational and career resources, including the Chartered Financial Analyst (CFA) and the Certificate in Investment Performance Measurement (CIPM) designations, and is a leading voice on global issues of fairness, market efficiency, and investor protection.

The CFA Society of Seattle is the local Seattle chapter of the CFA Institute. The CFA Society of Seattle has over 930 members and is focused on locally applying the CFA Institute's mission, and fostering a vibrant and engaged investment community. Every major financial employer in the Pacific Northwest employs CFA Charterholders and the CFA Society of Seattle is engaged in enhancing their member's professionalism and expertise to satisfy employer's needs.

I believe your programs compliment the mission of the CFA Society of Seattle and we look forward to working with you on the success of these.

Sincerely,

Jeff Lippens, CFA

President, CFA Society of Seattle

GARP Global Association of Risk Professionals

December 13, 2010

Professor Doug Martin
Professor of Statistics
Adjunct Professor of Finance
Director of Computational Finance Program
University of Washington
Department of Statistics
Box 354322
Seattle, WA 98195-4322

Professor Martin:

It is with great enthusiasm that GARP (the Global Association of Risk Professionals) expresses its strong support for the proposed Master of Science Degree in Computational Finance and Risk Management at the University of Washington. Based on our review of the curriculum and conversations with you, we feel that the program is well designed and rigorous and should provide students with solid, relevant skills that will enable graduates to function effectively in the field of financial risk management. Financial risk management is one of the most sought after skill sets to have in the financial services industry today and offers excellent visibility and outstanding career potential. The risk profession has seen considerable growth over the past several years (and particular focus and intensity in the aftermath of the current financial crisis), fueled by the complexity of financial products, increased regulation, and recent notable failures.

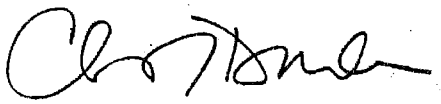
GARP is a not-for-profit independent association of over 150,000 risk management practitioners and researchers representing banks, investment firms, government agencies, academic institutions, and corporations from more than 150 countries worldwide. As the leading professional association for risk managers, GARP's mission is to advance the knowledge and expertise of financial risk management through education, training and the promotion of best practices globally. GARP is widely known for the Financial Risk Manager (FRM®): administered globally, it is a certification recognized by financial risk professionals worldwide. The FRM stands as the global standard in professional risk management certification, with over 23,000 FRM holders in 90 countries across the globe. Demand for this certification has grown rapidly and registrations in 2009 and 2010 were in excess of 23,000 new FRM candidates each year. Since its inception in 1996, over 100,000 individuals have registered to take the FRM.

The proposed curriculum you have provided to us, in particular those classes focusing on risk management, should position students to attempt the FRM examination with significant confidence if they choose to do so.

Programs such as the Master of Science Degree in Computational Finance and Risk Management provide a very important service to the risk community and help advance the field of risk management. GARP is very pleased to support it and to continue its growing relationship with you and the University of Washington.

Sincerely,

William May
Senior Vice President
FRM Program Manager
Academic Outreach Program Manager
Global Association of Risk Professionals



Christopher Donohue, Ph.D.
Managing Director
Research and Educational Programs
Global Association of Risk Professionals

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

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Microsoft

Professor Douglas Martin
Director of Computational Finance Program
Department of Applied Mathematics
University of Washington

Dear Dr. Martin:

The coursework outlined for the proposed MS Degree in Computational Finance and Risk Management (MS-CFRM) at the University of Washington seems ideally designed for Microsoft's Capital Markets, Corporate Finance and Risk Management teams.

Microsoft's staff consists of distinct constituencies with various backgrounds in science, finance or math and people with an investment background. All of these groups could benefit from the MS in computational finance. For those with a math and science background, the program would help them translate their quantitative skills into the investment arena. For those with an investment background, it would extend their understanding beyond the general MBA or CFA curriculum.

It will be an advantage to have such a program locally where Microsoft can have a closer interaction with UW faculty and students associated with the program, including the possibility of increasing the number of internships and rotation analysts' positions within The Microsoft Corporation.

From a Microsoft perspective, someone coming out of this program would have the following capabilities, among others:

- A greater understanding of the math behind risk management tools like Barra, which we use here.
- An understanding of various markets and the quantitative techniques typically used in equity, currency, commodity, fixed income, and derivatives markets, as an example foreign exchange hedging.
- Ability to build computer models, simulation tools or perform backtests, like those we do for compliance reporting.

On the basis of the draft curriculum, for the proposed MS-CFRM and the experiences of our current rotation analyst and interns, I am confident that the program will graduate students with the above capabilities.

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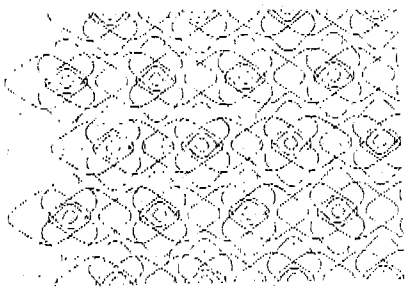
Microsoft

Based on the online after-hours format of the MS-CFRM, I will be encouraging a number of Microsoft employees to take advantage of it. I also think having a program like this locally will benefit Microsoft and other investment organizations in Washington State, helping us to become more competitive globally.

In summary, I support the proposed MS-CFRM at UW and recommend approval of the program by the University of Washington Graduate School and the State of Washington Higher Education Coordinating Board (HECB).

Sincerely,

George Zinn
Corporate Vice President
Worldwide Treasurer



Parametric

1151 Fairview Avenue North
Seattle, WA 98109-4416

Brian Langstraat
CEO, Parametric Portfolio Associates
1151 Fairview Avenue North
Seattle, WA 98109

Professor Douglas Martin
Director of Computational Finance Program
Department of Applied Mathematics
University of Washington

Dear Dr. Martin,

The coursework outlined for the proposed MS Degree in Computational Finance and Risk Management (MS-CFRM) at the University of Washington seems ideally designed for Parametric's portfolio management team and other individuals serious about furthering their careers in quantitative finance.

Parametric's investment staff consist of two distinct constituencies: people with a background in engineering or science and people with a general investment background. Both of these groups could benefit from the MS in computational finance. For those with a math and science background, the program would help them translate their quantitative skills into the investment arena. For those with a general investment background, it would extend their understanding beyond the typical MBA or CFA curriculum.

We have hired an employee with a Master's degree in a similar program (specifically, the University of California Berkeley Masters in Financial Engineering program) and they have been very successful at Parametric. It will be an advantage to have such a program locally where Parametric can have a closer interaction with UW faculty and students associated with the program, including the possibility of intern positions at Parametric for students in the UW MS-CFRM program, the possibility of Parametric professionals offering seminars from time to time on practical aspects of portfolio construction and risk management that inject real-world considerations into the learning process.

From a Parametric perspective, someone coming out of this program should have the following capabilities, among others:

T 206 694 5575
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- An understanding of the math behind optimization tools (like Northfield or ITG) and risk models (like Barra or Axioma). This will allow them to be knowledgeable users of those systems.
- An understanding of various markets and the quantitative techniques typically used in equity, currency, commodity, fixed income, and derivatives markets.
- Ability to build computer models, simulation tools, and backtests.
- Ability to express ideas clearly through graphics, written work, and in presentations.

On the basis of the draft curriculum for the proposed MS-CFRM and the experiences of our Director of Research who is enrolled in the Computational Finance certificate program, I am confident that the program will graduate students with the above capabilities.

Based on the online after-hours format of the MS-CFRM, we anticipate that a number of Parametric employees will take advantage of it. We also think having a program like this locally will benefit Parametric and other investment organizations in Washington State, helping us to become more competitive globally.

In summary Parametric strongly supports the proposed MS-CFRM at UW and recommends approval of the program by the University of Washington Graduate School and the State of Washington Higher Education Coordinating Board (HECB).

Sincerely,

Brian Langstraat, CEO

Russell Investments

December 30, 2010

Professors Doug Martin and Eric Zivot
Computational Finance Program
Department of Applied Mathematics
University of Washington
Seattle, WA 98105

Dear Professors Martin and Zivot,

Congratulations on the successful initial steps toward the creation of an MS Degree program in Computational Finance and Risk Management at the University of Washington in the form of new Online Computational Finance Certificate program now under way. We are very pleased to be well represented, with approximately 10 percent of the resident portion of your first class coming from current Russell associates. We are proud of the caliber of Russell people currently enrolled in this program.

The opportunity for Russell Investments to foster close ties to innovative programs, such as the computational finance program, at the University of Washington is a material benefit for the reason of our move to Seattle. Your proposed MS Degree program offers an attractive opportunity in this regard. It will provide an excellent professional education and advancement opportunity for our employees in a close-to-home, after-hours context. In addition, I understand that several of our finance professionals are in discussion with you about offering specialized courses in the degree program for which they are uniquely qualified, e.g., econometric forecasting (Dueker), introductory risk management (Perrina), performance measurement and benchmarking (Carino), and optimization of portfolios (Murray). This seems like an excellent combination to foster effective interactive and ties between Russell Investments and a new program at the University of Washington.

I understand that you will be submitting the formal proposal for the MS Degree in Computational Finance and Risk Management to the University of Washington Graduate School this month with anticipation of approval in January 2011 for a September 2011 launch. On behalf of Russell Investments, I would like offer our strong support for this program. In addition to providing a benefit to Russell and its associates, it will be a welcome resource for other asset management organizations in the Northwest region. We are confident that the relationship will be a long and successful one.

Again, please accept my congratulations for the success of your new online certificate program.

All the best,

Pete Gunning
Global Chief Investment Officer
Russell Investments

UNIVERSITY OF WASHINGTON

Investment Management

December 30, 2010

Professor Nathan Kutz, Chair
UW Department of Applied Mathematics
Guggenheim Hall #414
Box 352420
Seattle, WA 98195-2420

Dear Professor Kutz:

University of Washington Investment Management developed a partnership with the University of Washington Computational Finance Program about eight years ago. For Investment Management the partnership has included funding for research assistants, hiring a full time Computational Finance PhD graduate, ongoing discussion and research with Computational Finance staff, among other aspects.

While this partnership is mutually beneficial, the impact of this partnership on Investment Management is particularly noteworthy. Two of the most critical and complex aspects of endowment management – asset allocation and risk management – continue to be improved through this relationship. Furthermore, this partnership enabled Investment Management to develop a best in class risk and asset allocation process.

We are delighted to hear that the Computational Finance Program found a new home within the Applied Mathematics Department. We are eager to further our partnership through teaching an endowment management class on an annual basis. We offer our praise and support for the program and look forward to an enduring partnership.

Regards,

K Fer

Keith Ferguson, CIO
UW Investment Management

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# Carnegie Mellon

**College of Humanities & Social Sciences**
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**John P. Lehoczky**
Dean and the
Thomas Lord Professor of Statistics

January 31, 2011

Dr. James S. Antony
Associate Vice Provost and Associate Dean for Academic Affairs
G-1 Communications Building
Box 353770
University of Washington
Seattle, WA 98195-3770

Dear Dr. Antony:

I am responding to your letter of January 13, 2011 asking me to review the proposal for a new Master of Science degree in Computational Finance and Risk Management from the Department of Applied Mathematics at the University of Washington. I have completed my review, and my report is attached. As you will note, I strongly endorse moving forward and implementing the proposed program.

Very truly yours,

John Lehoczky

John P. Lehoczky

# Review of the Proposed Professional Master of Science Degree in Computational Finance and Risk Management

by
John Lehoczky
Carnegie Mellon University

## Background Comments

Masters programs in quantitative finance (also computational finance, financial engineering, etc) date back to 1993-1994 with the Carnegie Mellon MSCF program. Since that time, the field has exploded, and many of the finest universities both inside and outside the U.S. have launched programs. This phenomenon has been well documented in the Proposal. However, the world has relatively recently experienced a huge market crash and deep recession. This crash caused large layoffs and a restructuring of the financial services industry. Furthermore, rightly or wrongly, "quants" (for example, the graduates of the proposed computational finance program) were blamed by some for this crash. Thus, it might seem that the proposed program is no longer timely and that the "best and brightest" students will be seeking other disciplinary areas to pursue.

In fact, as logical as this gloomy view may be, it does not appear to be happening. In fact, the financial services industry is making a strong recovery from the crash and is hiring, although not as robustly as in prosperous times. Furthermore, the interest among students continues to be as strong or stronger than ever. While my view is very strongly influenced by Carnegie Mellon admissions and placement data, a set of financial engineering program directors periodically meet and share some information, so the following information is not entirely unique to Carnegie Mellon.

First, applications to the Carnegie Mellon MSCF program have recovered from the drop experienced in the last two years. Specifically, at Carnegie Mellon there were 420 applications for the class starting in Fall 2006 year, 740 for Fall 2007, 867 for Fall 2008, 631 for Fall 2009, and 784 for Fall 2010. Thus last year's Fall 2010 applications were approaching the all-time high experienced for Fall 2008 before the recent crash. We are roughly at the midway point for Fall 2011 and thus far we have 750 applicants, a 50% increase over last year's 500 at a comparable time. We will certainly have more than 1,000 applications, and we are not planning any increase in our class size. More importantly, the quality of the applicants is phenomenally high. Among those admitted are students from the finest universities (most often in Asia) with excellent standardized test scores, extremely high grade point averages (often ranked in the top 1 or 2 in their major), good work experience, and outstanding recommendations. So from the Carnegie Mellon vantage point, the "best and the brightest" students are still interested in quantitative finance, although the top part of the applicant pool is dominated by students from Asia, especially China.

Second, during the crash and subsequent financial services industry recession, placement of students for summer internships and jobs upon graduation has been very challenging for all quantitative finance programs. Carnegie Mellon has been able to place all of its students, both in internship positions and post-graduation employment in highly desirable positions at the same rate as was experienced during very strong years. Students had fewer choices and starting salaries were somewhat reduced, but the placement record over the worst period has been as strong as during the best periods. This record was achieved because we have a placement appparatus through the Tepper School of Business, and by heroic action on the part of placement and program personnel. It was very difficult to place a large block of new graduates in the face of massive industry layoffs, but it was accomplished. One interesting observation is that our own graduates were not the ones being laid off. Although there is a popular perception that the "quants" were the cause of the crash, the industry is embracing an upgrading of the quantitative talents of its personnel. Now the markets

have sprung back and placement has become a much easier task for us. The placement data from other quantitative finance program is generally not made publically available, but placement was rumored to be very difficult. There is a clear lesson that any program in quantitative finance must have a plan for the placement of its graduates.

## Response to Specific Questions

**1. Does the program demonstrate a coherent design, reflecting appropriate depth and breadth, curriculum, sequencing of courses, synthesis of learning, and assessment of learning outcomes?**
Yes, the proposed program has a coherent design for providing training in risk management, asset management, and computational methods. The sequence of courses and the assessment of learning outcomes are appropriate. In responses to subsequent questions, a possible broadening of the curriculum is outlined, although this should be undertaken after the program has been offered for a few years and is generating sufficient revenue to support new faculty hires.

**2. How does the program compare to other institutions' programs? Is it traditional? Is it innovating ("cutting edge") in some ways(s)?**
Professional masters degree programs in financial engineering (also known by many other names including "computational finance" and "quantitative finance") are a relatively recent phenomenon, but over the last decade, this has become a very crowded field with many top universities introducing programs. The proposed program focuses on three aspects: computation, risk management, and asset management. This combination of emphases should distinguish it and make it relatively unique in a crowded field. Furthermore, the combination of skills should be attractive to financial services firms in the Pacific Northwest region. This is amply demonstrated by the letters of support in the Appendix to the Proposal.

**3. Does the program respond to current trends in the field?**
Yes, because it is focusing on risk management and on computational skills. In light of the recent financial crash, risk management has become of ever-increasing importance in the financial services industry. Furthermore, computational skills are very important in most all areas of modern quantitative finance.

**4. Are student learning outcomes appropriate and clearly defined?**
The student learning outcomes enumerated in Section 3.A.1 are very appropriate. This list is focused primarily on asset management, risk management, and computational methods. My own view is that these objectives are very appropriate for an initial version of the program, but I would hope that the program would evolve so that it could offer a broader set of learning objectives. Specifically, it would be important for graduates of the program to have some specific training on 1) fixed income products, interest rates and term structure models, 2) the underlying mathematics of quantitative finance, 3) market structures for different asset classes (e.g. equities, derivatives, currencies, bonds, etc.), market microstructure, high frequency and algorithmic trading. It would also be ideal for the graduates to have had some group project experience; however, this would be very difficult to implement when many students are taking the program on-line. Some aspects of some of these topics are mentioned in the course descriptions but more depth is needed. This may seem impossible to achieve given that students need take only 40 units to graduate and some of the courses that an augmented list of learning objectives would entail are not conveniently available. My thought is that after the program becomes established, it will generate resources sufficient to hire new faculty who can contribute to the teaching mission. Moreover, each of the courses being offered is on a single focused topic. It is possible to modularize some of these courses (as is

apparently being done with most of the Group 2 electives, most of which are 2 unit courses, while most others are 4 unit courses).

**5. Is the student assessment system adequate, stellar, innovative? Why?**
The student assessment systems appears to be based on the traditional university system for quantitative subjects, homework assignments and examinations, thus it seems entirely appropriate. The challenge is to implement this system for students who are taking the program on-line. In this situation, I would urge that specific plans be implemented that will ensure the academic integrity of each course and of the overall program. On page 16, the proposal describes the "approved proctor" process that has been in place for some time for the Applied Mathematics on-line MS degree. It appears that this can be easily implemented for students in the Puget Sound area (indeed, it seems reasonable to ask such students to take exams at the University of Washington). However, at some point, the program will want to enroll students from all over the U.S. and potentially over the globe. As the geographic base expands, it seems like it would be very challenging to maintain a high standard of academic integrity. Program personnel must be acutely aware that lapses in academic integrity can have a profound negative impact on the credibility of the program and both its former and future graduates.

It seems appropriate to allow certificate students to take some of the coursework on a CR/NC basis (and I do not know the University of Washington standard for receiving a CR grade nor do I know the university's requirements for awarding a certificate, if any). Still, I was very surprised that there is no limit to the number of courses that could be taken on this basis. It seems to me that for the certificate to have any value, some of the work must be taken for a grade.

**6. Is the program assessment system adequate, stellar, innovative? Why?**
I think the proposed program assessment is very adequate. I especially favor the proposal to have an external advisory board. A well-chosen board can have provide good insight into the trends in the industry and the skill set that graduates should have. It will be especially challenging to do program evaluation when most of the students are taking the program on-line, but the proposal is a good start.

**7. Are the resources (faculty, administrative, facility, equipment) appropriate?**
The faculty teaching in the proposed program are of two types: (1) current faculty of the University of Washington and (2) industry practitioners. The first group (Martin, Zivot, Kutz, LeVeque, Qian and Tung) are all outstanding senior faculty at the university who have reached the highest levels of professional accomplishment. Still, from the descriptions of the research and teaching done by these faculty members provided in the proposal document, only Martin and Zivot have computational finance teaching or research experience. It will be important for those on the faculty with disciplinary knowledge to offer help to those who have less disciplinary knowledge, say by helping to provide examples and exercises that fit in the subject matter being taught.

The industrial practitioner group of faculty (Carino, Dueker, Everitt, Perrine, Ferguson, Reistad, Henniger, Murray, Yollin, and Tomeo) is somewhat more difficult to evaluate. With one exception, all seem to be well-credentialed, and all have strong knowledge and experience for the particular courses they are going to teach. In general, practitioner teaching can add a great deal to a program in computational finance. These individuals can, in principle, convey the subject matter as well as its applicability in the profession itself. They can also, in principle, keep the program content current with recent trends in the industry. There are a few aspects of practitioner teaching that require some oversight. First, in general these individuals are professionals in finance, but they are not professionals in education. Some care must be exercised to provide help with pedagogical matters like course planning, student learning, and student assessment/evaluation. Also, practitioners may

not be able to devote the time needed to deal with professor-student interactions outside of the classroom. For on-line students, this is an issue for all classes, while for resident students, the potential lack of contact outside of class can create frustration for them. Finally, practitioners may well be devoted to their teaching assignments; however, in times of stress, their professional obligations will take precedence over their teaching obligations.

The administrative structure is strong and the facilities and equipment, especially to support on-line learning, are fine, although it was not clear whether the on-line students taking the course live were able to interrupt and ask questions. Overall, there needs to be an adequate facility for students to ask questions of the instructor, preferably in real-time but outside of class hours as well.

Some of the courses for the proposed degree program are new and tailored expressly for it (AMATH 537, 538, and 541-545). Some courses are pre-existing. Of those, some are natural courses for the computational finance program (e.g. AMATH 530, 531, 532, 534, 535, 536) while some others contain material that is valuable for a quantitative finance graduate, but do not appear to have any specific finance content, say examples of methodology drawn from the field of finance (e.g. AMATH 582 and 583). In particular, it does not appear that these courses contribute directly to the list of "Student Learning Outcomes" enumerated in section 3.A.1 of the proposal. Some attempt should be made to introduce finance-related examples and exercises into their course material.

**8. What are the program's strengths and weaknesses?**
A number of strengths and weaknesses have been mentioned in the responses to some of the other questions and are not repeated here. Here are some additional comments:

**Strengths**

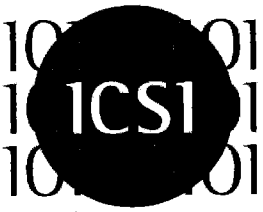
- The University of Washington is well-suited to offer a Masters Program in computational finance. Furthermore, it will likely be attractive to many of its senior undergraduates in technical, quantitative fields.
- New courses will be offered that will not only be taken by students enrolled in the degree program, but will also be attractive to other students outside the program.
- The program will be valuable to the financial services industry in the local region by providing employees with the opportunity to take courses to refresh and improve their training. Moreover, these companies will be able to hire graduates of the program. In the longer run, this program can help to provide a tighter linkage between the University of Washington and the local industry, something that will be good valuable both for the region and the university.

**Weaknesses**

- There is no plan for the placement of the graduating students. Students will have a reasonable expectation of help in locating suitable positions after graduation. I would conjecture that placement will be more challenging for on-line students who do not currently have positions in the industry and are seeking full time employment.

**9. What are your recommendations?**
I strongly recommend approval of the proposed Professional MS Degree in Computational Finance and Risk Management for the following reasons: 1) the degree is very timely and should attract a

strong applicant pool both from the ranks of the undergraduate students at University of Washington, students from around the world seeking to study computational finance, and practitioners from the Pacific Northwest seeking to gain new knowledge for their designated profession. The optimal curriculum for the program will require new faculty hires, something that is difficult in the current economic climate. The proposed program offers a strong start, and when it has reached a critical enrollment level, it should generate sufficient financial resources to be able to hire new faculty. At that point, it will be possible to modify the curriculum and provide additional courses to enrich the curriculum.




INTERNATIONAL
COMPUTER SCIENCE
INSTITUTE

Professor James Antony
Associate Vice Provost
The Graduate School
University of Washington

RE: Proposal Review for
Professional Master of Science in Computational Finance and Risk Management

11 February 2011

Dear Dr. Antony,

I am pleased to provide a review the proposed Professional Master of Science in Computational Finance and Risk Management from the perspectives of both an academic and a practitioner. My personal background is briefly described in the postscript.

The proposed PMS-CompFin curriculum is relevant, innovative and stands apart from most other programs in Computational Finance, Financial Engineering and Financial Mathematics.

Many such programs emphasize derivatives pricing models, stochastic calculus and numerical methods. These topics are important, but not sufficient. The PMS-CompFin curriculum offers balanced coverage of all key areas of quantitative finance, including derivatives, portfolio management, risk management and forecasting. In addition, the program offers solid foundational courses in statistics, R programming, scientific computing, Monte Carlo and financial time series. These are the skills needed for real-world work.

Rather than being something of a "finishing school" like the Berkeley MFE Program, the PMS-CompFin curriculum will give graduates highly relevant preparation for subsequent work in the broad financial industry. Derivatives pricing has become "commoditized", and most quant finance jobs are now in areas like asset management, risk management, market analysis and algorithmic trading. The PMS-CompFin faculty understands this, and the proposed program is more akin to the CMU, University of Chicago and Stanford Programs, which I have a very high regard for.

The PMS-CompFin will be particularly strong in statistics, computing and risk management, areas that too many programs are surprisingly weak in. Courses like Endowment Investment Management and R Programming for Computational Finance are unique to UW's program. The theme of heavy-tailed distributions and extreme event risk that runs through several of the courses is informed by recent research, and makes the program content cutting-edge.

The PMS-CompFin Program will be run by faculty who "get it". Doug Martin and Eric Zivot are extremely well-regarded for their academic work in statistics, econometrics and finance, and they are also

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www.icsi.berkeley.edu

well-known and highly respected in the financial industry. They have mobilized an impressive array of talent.

The establishment of this program in the nationally-ranked Applied Math Department, and the significant contributions of its stellar faculty, will provide credibility and horsepower. Furthermore, the program will draw upon solid adjunct faculty, including those from top firms like BlackRock and Russell. The result will be a potent combination of expertise and courses in Statistics, Econometrics, Applied Math, Computing and Finance.

Because of these factors, I believe that the PMS-CompFin curriculum will have great appeal for both students and prospective employers. Making the program available on-line from the outset will differentiate the PMS-CompFin from most of its competitors, and enable UW to project a national presence.

As the global financial industry continues to become more competitive and more sophisticated, the need for education in computational finance will only increase. This will make the PMS-CompFin sustainable for the foreseeable future, both economically and intellectually.

The PMS-CompFin program is a much needed addition to the Northwest educational landscape. In Portland, for example, there are a number of energy firms like PacifiCorp, Bonneville Power and Constellation Energy that will likely benefit from risk management courses. Actuarial professionals at companies like Standard Insurance and AON Consulting will also have interest. The Bay Area has a number of financial software firms that would be good sources of students, as well as targets for professional placement.

As the PMS-CompFin gains traction, I can imagine quite a few firms on the West Coast and nationally making use of its on-line courses. In fact, one of my R&D team members is currently taking UW's R Programming for Computational Finance on-line. His feedback is that the course is excellent.

While I think the PMS-CompFin will have a great faculty and curriculum, I have four suggestions for program implementation and enhancements:

- To recruit the best full-time students, package the PMS-CompFin as a clean 12-month full-time MS, and start it in the Fall. The proposed Summer offerings seem "tacked-on" at the beginning and end of the program, and the Summer quarter needs to be coherent and complete.

- The program needs a plan for marketing and recruiting high quality students regionally, nationally and internationally. This plan can be developed over the next two years.

- The mix of non-matriculated, certificate, part-time and full-time MS programs and on-campus / on-line delivery will lead to a diverse mix of students. While there is often a temptation to maximize

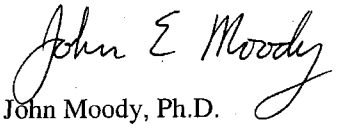
tuition revenues, it will be important to maintain high standards for MS admissions, so that the UW PMS degree carries weight.

- The success of any Professional Master's program depends on effective professional placement. Competitors like CMU's MSCF and Berkeley's MFE have built "professional placement machines". Their success in placing graduates at top-tier firms enables them to attract the best students. UW will need to develop such a "machine" as the program ramps up over the next two years.

To summarize, I recommend that the Washington State HECB approve the PMS-CompFin program for the following reasons:

- Innovative, balanced & solid curriculum.
- Excellent faculty from key disciplines.
- Highly relevant for professional work in quantitative finance.
- Satisfies regional needs while enabling UW to project a national presence.

Sincerely,



John Moody, Ph.D.
ICSI Algorithms Group
503-222-4588
moody@icsi.berkeley.edu

My Background:

From 1996 to 2002, I was the founder and director of the Master of Science in Computational Finance at Oregon Graduate Institute. The launch of OGI's MSCF in 1996 was coincident with that of the University of Chicago's Financial Math Program, and was preceded only by the establishment in 1994 of Carnegie Mellon's MSCF Program. After a merger with OHSU, OGI's Computer Science Department and MSCF Program were shut down. I'm now on leave from Berkeley's International Computer Science Institute, and run a successful quantitative hedge fund in Portland, OR. Further background can be found at www.icsi.berkeley.edu/~moody .

To: James Antony, Associate Vice Provost and Associate Dean of Graduate School
Augustine McCaffery, Senior Academic Program Specialist, Graduate School

From: Doug Martin, Statistics Professor, Director of Computational Finance Program
Nathan Kutz, Applied Mathematics Chair

Subject: Response to External Reviews of PMS-CompFin Program

Date: February 13, 2011

We thank Professor John Lehoczky and Dr. John Moody for their thoughtful reviews of our proposed Professional MS degree program in Computational Finance and Risk Management (PMS-CompFin). We respond on an item by item basis to the most important points raised by the reviewers, some of which we have already thought about and others that are in need of thought and action as we evolve the program.

## Response to Key Points Raised Lehoczky and Moody

Need to Broaden the Learning Objectives

We very much agree with Lehoczky's comment on the need to broaden the learning objectives and anticipate doing so during the second and third years of the program. If we achieve our enrollment projections for the next three years, our financial operating model will allow us to hire one new faculty member on a "without tenure" (WOT) basis for FY13 (academic year 2012-13) and a second new WOT faculty member during FY 14 (academic year 2013-14). This will allow us to add additional courses along lines he suggested and increase the required number of credits from 40 to somewhere in the range 48-52.

Modularization of Courses

As was noted, 2 credit courses in the proposal go toward this goal. Since we generate less revenue from 2 credit courses than the 4 credit courses but have equivalent costs for delivery, we need to determine more carefully the enrollments needed to assure the economic viability of such courses. As the program expands, the economic sustainability of such courses will not be an issue.

Academic Integrity of Online Program

Maintaining academic integrity of an online program is a challenge with respect to both exams and homework assignments. The integrity of exams is currently maintained as follows. For students who can take exams at an official exam site in a major metropolitan area there is no more problem than giving in-class exams on campus. For students who do not live near such an exam site, the student is permitted to specify an individual proctor according to UWEO guidelines. Such proctors need to sign an agreement concerning the conduct of the exam and the return of exams for grading. One way to improve this process would be to require some reasonable due diligence on individual proctors, and have a phone interview with such proctors. While this could be an expensive process, it may ultimately be necessary.

With regard to the integrity of analytic homework assignments: (a) homework graders need to pay special attention to detecting duplicate homework submissions and this has proven effective already this year, and (b) a potential improvement in detecting homework cheating would be to require delivery in MS Word documents and develop (or if available, purchase off-the-shelf) automatic duplication detection software. For computing homework assignments we have already been using an automatic software grading system called "scorelator". This software allows for detecting cheating in the form of duplicate programs and it has already uncovered one such attempt. We also note that the Department of Applied Mathematics has been working successfully with the academic integrity issue for the past four years of their online Masters program and no problems have been encountered.

Sharing Disciplinary Knowledge with AMath Faculty

Both CompFin Program Director Doug Martin and Co-Director Eric Zivot are committed to following Lehoczky's recommendation in this regard. In particular, Martin expects to work with Professor Nathan Kutz in adding quantitative finance related material to the existing AMATH 582 Computational Methods for Data Analysis course, and Zivot would like to work with Professor Randy Leveque in doing likewise with respect to AMATH 583 "High Performance Scientific Computing", in particular by focusing on the use of high-performance computing as applied to ultra-large financial data sets and to high-frequency algorithmic trading. The Department of Applied Mathematics is committed to the success of the program and will work towards achieving the best balance of disciplinary and mathematical knowledge.

Effective Use of Finance Industry Professionals as Instructors

In addition to the pluses and minuses of using finance industry professionals (FIP's) as instructors that Lehoczky commented on, we would add the following. Until one sees the actual performance of these instructors in the class-room, we are at risk that a poor instructor will damage the reputation of the program. We will mitigate this risk as follows: (a) Using profit from the Online Computational Finance Certificate (OCFC) being offered currently, we will engage the FIP instructors to make the first offering of their courses to existing Computational Finance Graduate Certificate program graduate students and other interested graduate students during 2011-12 at a reduced payment rate; (b) We will spend time making sure that the FIP instructors understand the course background of the students they will be teaching, how the courses they teach fit into the overall PMS-CompFin curriculum, how they can be effective as instructors, and how they can have effective contact with the online students, e.g., via special Adobe Connect Q&A meeting sessions with the support of a teaching assistant (TA). At the conclusion of each quarter, the FIPs will be evaluated for their teaching. Only those FIPs that develop a strong teaching record will be retained in the program.

Optimal Use of Live Online Technology for Instruction

Lehoczky asked whether or not online students could ask questions during the live lecture. This is not currently possible with Media Site technology, but is possible with the Adobe Connect technology that we used for Q&A sessions during the first OCFC course offering in the autumn quarter. However, we have been told that it is possible to add Media Site support for online students to ask questions, and we expect this to be in place by the launch of the PMS-CompFin program in the summer of 2011. We would add that there remains a question about exactly how to display and manage an online question queue without interrupting the flow of a lecture (in class questions may be

taken by seeing students hands raised to ask a question, whereas with the online students there would be a question queue to parse).

In general we see a challenge and opportunity to learn how to most effectively use online technology to deliver a best possible educational product. One small item along these lines is the need to have integrated management and use of different technologies. For example we have recently used not only Media Site and Adobe Connect but also Moodle, and these three products are not currently integrated.

Recruiting Plan

Moody cited the lack of recruiting plan. While we did not include such a plan in our proposal, we have key elements of such a plan in mind and they include the following:

1. We will create an exceptional PMS and certificate programs web site based on perusal of the web sites of the top ten or so quantitative finance MS programs. This will be implemented by a current AMath staff member who has excellent skills. We will use a variety of means to direct potentially interested students to the site, including some of those described below.
2. We have already purchased two mail lists (Barclay Hedge list and Pequin list) with over 12,000 names that include hedge funds, funds-of-hedge funds, endowments, pensions, and family offices. Short effective email blasts will direct potentially interested students to the above web site.
3. We will be using the two certificate programs, with their smaller time and money commitment than the PMS program, as both terminal programs and feeder programs to the PMS program. As evidence of the viability of this claim we note that the current 2010-11 OCFC program has 29 students and a survey of them revealed that 10 or 12 will apply for the PMS program and 3 others are considering it.
4. In addition to focusing on asset management organizations and new finance regulatory organizations for recruiting (and placing) students, we will focus on large financial data services and software companies, some of whose employees would obtain a significant professional development benefit by completing one of our certificate programs. We will leverage Martin's finance industry contacts in pitching our certificate and PMS degree programs to company management and HR organizations and offer them volume discounts. This could become a solid ongoing component of revenue for our overall computational finance program.
5. Lehoczky noted that CMU expects over 1000 applications to their Computational Finance MS degree this year, mostly of exceedingly high quality and many from Asia and especially China, and will accept only on the order of 100. We plan to heavily market our program to two segments in Asia and China: (a) high-quality online PMS students who will not come to the U.S. either because they cannot afford the cost of one of the top programs (e.g., $60K to $75K) or for personal reasons, and (b) employees in the top asset management firms in Asia. Program Director Martin, and possibly AMath Chair Kutz or former AMath Chair Kai-Kit Tung, will plan a trip to China in the spring or early summer to market the PMS and certificate programs.

Placement Plan

Both Lehoczky and Moody cited the lack of a placement plan and this is indeed a major omission in the proposal. If we attract high quality students to the PMS-CompFin (PMS) degree and are not able to place them in jobs that reasonably meet their expectations, the proposed program will ultimately fail to be very successful. We clearly need to develop a highly effective placement process that will involve investment in personnel to support the process. We offer the following relevant comments:

1. We have some time available to develop the placement process and the associated personnel. This is because we will only have to place the 2011-12 cohort of full-time PMS students, projected to be 5 students, in the summer or fall of 2012. The first cohort of part-time PMS students will not finish until sometime in 2012-13, when there are projected to be 9 such students, and these would not need to be placed until spring or summer of 2013. Likewise the second cohort of full-time PMS students, projected to be 8, would be finishing in summer of 2013 and would not need to be placed until late summer or autumn 2013.
2. Those quantitative finance MS degree programs that reside in Business Schools have the advantage of mature placement programs. However those placement programs need to serve the broad needs of the Business Schools, including placing large numbers of MBA graduates. We believe we can develop an effective placement program by focusing narrowly on those target companies and organizations and their senior management and human resources organizations that are a best fit for our PMS graduates. We can also leverage Director Martin's extensive contacts in the finance industry.
3. Unlike existing quantitative finance MS degree programs, the online nature of our PMS and certificate programs will allow us to serve not-only resident and remote full-time PMS students, but also a large percentage of working professionals in the finance industry who take courses on a part-time basis. We anticipate at least half and perhaps two-thirds of our students will be working professional who will not need the support of our placement services.
4. Our program is indeed initially designed to cover open space not well covered by competitive programs, i.e., by emphasizing the combination of asset management, risk management and computation. In addition its curriculum will also be evolved over time to graduate students whose skill set includes significant competitive capabilities relative to competing MS degree programs, e.g., energy and natural resource investment risks, high-performance computing for risk management and algorithmic trading.

Maintaining High MS Admissions Standards

Moody rightly cites the importance of maintaining high admissions standards, and not yielding to the temptation to maximize tuition revenues at the expense of lower admissions standards. In fact, we have learned from our current 2010-11 online Computational Finance Certificate (OCFC) admissions decisions that even for certificate students we need to apply more stringent admission conditions, and will do so going forward for both certificate and PMS degree applicants.

While the mix of non-matriculated, certificate, part-time and full-time PMS degree students poses a challenge, one mitigating factor is that we allow "terminal" certificate students, i.e., finance industry professionals who do not intend to pursue the PMS

degree, to be graded on a credit/no-credit basis. This will effectively serve the needs of finance industry professionals who wish to support their career development without the pressure of competing with PMS degree students for a high GPA while working full-time. On the other hand certificate students who want the option to pursue the PMS degree upon completion of a certificate will receive standard UW numeric grades. And all PMS degree courses will be graded numerically. This overall approach has proven to be quite effective for our OCFC program this year.

Annual Program Start Timing

Moody suggests that in order to attract the best students we should start the program in the autumn quarter. We do not believe this is essential. While most quantitative finance MS degree programs do start in the autumn, there are a few that do not. There are at least two or three that start in the summer, and the top ranked UC Berkeley MS in Financial Engineering program starts in the spring. We do not believe there is an intrinsic disadvantage to starting the program in the summer, and at this point we would have to do a lot of difficult timing changes for existing courses that are part of the PMS curriculum. Furthermore, the course AMATH 540/ECON 424 "Introduction to Computational Finance and Financial Econometrics" that will be offered by Professor Zivot in the Economics Department in the summer, serves as the key foundation course for the curriculum. As such this course includes needed mathematics and statistics review material as well as extensive introductory use of the R programming language that is used in all subsequent courses, and so is best taken by PMS program students prior to other courses in the curriculum. We will mitigate the possible risk of a summer start, particularly for this 2011-12 launch year with a short marketing time window, by capturing Zivot's lectures and offering the course as an early-start course in September 2011.

Sincerely,

Doug Martin

Nathan Kutz

# FORM 4 REQUIRED COURSE WORK

## Program Prerequisites

Students entering the program should have a baccalaureate degree in engineering, mathematics or science, plus the following course equivalents:

| Example UW Courses | Course Description | Credits |
|---|---|---|
| STAT 506 or ECON 481 | A calculus based course in probability and statistics | 4 |
| MATH 308/AMATH 352 and MATH 324 | Matrix algebra and multivariable calculus | 6 |

## Course Requirements

The curriculum offers 16 courses for a total of 60 credits as shown below. In order to earn the M.S. degree the student must successfully complete at total of 40 credits that include the required courses shown below.

| Required Courses (25 credits) | | Credits |
|---|---|---|
| AMATH 540 | Introduction to Computational Finance* | 5 |
| AMATH 541 | Foundations of Investment Science | 4 |
| AMATH 542 | Statistical Modeling and Analysis in R | 4 |
| AMATH 543 | Portfolio Construction & Risk Analysis | 4 |
| AMATH 544 | Options and Derivatives | 4 |
| AMATH 545 | Introduction to Risk Management | 4 |
| **Elective Courses (35 credits)** | | |
| AMATH 546 | Quantitative Risk Management* | 4 |
| AMATH 547 | Credit Risk Management | 4 |
| AMATH 551 | Introduction to Electronic Trading | 3 |
| AMATH 552 | Time Series Modeling and Forecasting | 2 |
| AMATH 553 | Endowment Investment Management | 2 |
| AMATH 554 | Portfolio Performance Analysis | 2 |
| AMATH 555 | Optimization Methods in Finance | 4 |
| AMATH 548 | Monte Carlo Simulation Methods in Finance | 4 |
| AMATH 582 | Computational Methods for Data Analysis | 5 |
| AMATH 583 | High Performance Scientific Computing | 5 |

## FORM 5 ENROLLMENT AND GRADUATION TARGETS

In the table below "PMS" stands for students in the Professional MS degree in Computational Finance and Risk Management, "CF Certificate stands" for Computational Finance Certificate students, and "RM" stands for Risk Management Certificate students. All students are part-time, taking one course online each quarter, except those labeled "PMS Full-Time" who are resident students taking a full load and finishing their degree in 12-14 months. Each part-time student represents approximately 40% of a full-time student, and according weighted in computing the total full-time-equivalent (FTE) students below.

| | 2011-12 | 2012-13 | 2013-14 |
|---|---|---|---|
| **PMS Part-Time** | | | |
| 2010 Carry | 10 | 9 | |
| 2011 New | 10 | 9 | 8 |
| 2012 New | | 15 | 13 |
| 2013 New | | | 20 |
| TOTAL | 20 | 38 | 51 |
| **PMS Full-Time** | | | |
| TOTAL | 5 | 8 | 10 |
| **CF Certificate Part-Time** | | | |
| TOTAL | 10 | 15 | 20 |
| **RM Certificate Part-Time** | | | |
| TOTAL | 10 | 15 | 20 |
| **TOTAL STUDENTS** | **45** | **76** | **101** |
| **TOTAL FTE STUDENTS** | **21** | **35** | **46** |
| **PMS GRADUATES** | **5** | **17** | **18** |

Also, the number of PMS Graduates each year is computed by adding the PMS Part-Time students who are in their terminal year to the number of PMS Full-Time students (who finish in roughly a year). For example 9 PMS Part-Time students finish at the end of academic year 2012-13, as do 8 PMS Full-Time students, for a total of 17 PMS Graduates at the end of 2012-13.

## FORM 6 PROGRAM PERSONNELL

## FORM 7 SUMMARY OF REVENUE AND EXPENSES

**For forms 6 and 7 please contact Mark Bergeson at 360-753-7881 or markb@hecb.wa.gov**