Resolution to Approve B.S. in Computational Modeling and Data Analytics

Documents included:

1. Resolution to Approve a B.S. in Computational Modeling and Data Analytics (CMDA)
2. B.S. in CMDA Degree Proposal
3. Professor Eric Smith – Degree Presentation

RESOLUTION TO APPROVE THE BACHELOR OF SCIENCE DEGREE IN COMPUTATIONAL MODELING AND DATA ANALYTICS

WHEREAS, Computational Modeling and Data Analytics (CMDA) encompasses rapidly emerging, scientifically critical areas within mathematics, statistics, and computer science, and

WHEREAS, CMDA provides the blend of mathematical, statistical, and computational skills needed to prepare data scientists that are able to confront the ever-increasing data challenge that is revolutionizing disciplines across the scientific spectrum, including genomics, network analysis, climate and environment, communications systems, security and defense, energy systems, and heath care to name a few, and

WHEREAS, CMDA is integral to the extraction of information from large data sets, in which the analyses and solutions of complex data-based problems are made possible through modeling, simulation and optimization, as well as through new mathematical and statistical innovations realized from growing computational power, and

WHEREAS, the Bachelor of Science in CMDA will provide students with the computational skills needed to work with vast data sets and to develop code for specialized applications, the mathematical skills needed to develop the intricate models describing such data, and the statistical skills required to assess uncertainty and make predictions, and

WHEREAS, the Bachelor of Science in CMDA will prepare graduates for interdisciplinary research and education, with employment in the private sector, employment in state and federal government agencies, and for post-baccalaureate training, and

WHEREAS, the College of Science, with help from the College of Engineering, is in an excellent position to initiate a Bachelor of Science in CMDA in that it draws from the expertise of three historically strong departments at Virginia Tech (Statistics, Mathematics and Computer Science), and because of recent additions of junior and senior faculty who are actively engaged in research in computational modeling and data analytics, and

WHEREAS, the degree is unique in the Commonwealth of Virginia, and will be one of only a few similar programs in the United States, establishing Virginia Tech and the Commonwealth as key leaders in education for one of the most critical technologies of the future.

NOW, THEREFORE BE IT RESOLVED that the Bachelor of Science in Computational Modeling and Data Analytics be approved effective Spring 2015 and the proposal forwarded to the President, the Board of Visitors, and the State Council of Higher Education for Virginia (SCHEV) for approval, and to the Southern Association of Colleges and Schools (SACS) for notification.

RECOMMENDATION:

That the resolution to approve the bachelor of science in computational modelling and data analytics be approved.

March 24, 2014

Virginia Tech Degree Proposal
Bachelors of Science in Computational Modeling and Data Analytics
(CIP: 27.0304)

Type of degree action (circle one): (New) Spinoff Revision Discontinuance

Program description

The College of Science at Virginia Tech requests approval for a new Bachelor of Science degree in Computational Modeling and Data Analytics (CMDA) to commence in the fall semester of 2014. This program draws on expertise from three historically strong departments at Virginia Tech: Statistics, Mathematics, and Computer Science. By combining elements of these traditional disciplines with new, innovative, interdisciplinary courses, we have developed a model quantitative sciences program that will train students in emerging computational techniques for a wide spectrum of application areas, including the sciences, engineering, industry, business, and more. Students completing this degree will be able to formulate and answer questions that, due to their complexity, would otherwise be unapproachable in any systematic fashion. The CMDA degree program focuses on extracting information from large data sets, and on analyzing and solving problems through modeling, simulation, and optimization. It draws on the vast and growing computational power that has made these techniques feasible, and on the mathematical and statistical innovations that power has enabled. This degree will produce students able to understand, and solve, the emerging, complex, data-based problems of the 21st century.

In combining knowledge from three existing majors (Statistics, Mathematics, and Computer Science) with several newly developed integrated courses, the CMDA degree creates a synthesis of modeling, data-centered research, and computational analysis that is currently not possible solely within these or any other major. Accordingly, the CMDA curriculum is not a juxtaposition of these three sciences: it is an integration of complementary fields of knowledge to create a degree that will produce a strong analytical scientist. While computational thinking and informatics/digital fluency are becoming basic skills needed in all disciplines, this program is specifically designed to develop individuals into applications-oriented leaders in these areas. Graduates of this degree program will be sought by "big data" companies, by companies who develop algorithms and mathematical/statistical models for quantitative attacks on otherwise intractable problems, and by companies that require computational tools for high-tech manufacturing. For the same reasons, they will be sought by government agencies and national labs, and be attractive to graduate programs. As an interdisciplinary degree, CMDA will be housed within the College of Science's Academy of Integrated Science (www.science.vt.edu/ais).

Curriculum summary

The B.S. in Computational Modeling and Data Analytics comprises 120 credits, earned following either of two paths.

In the *general option* credits are distributed across courses in the following categories: 1) Curriculum for a Liberal Education (38 credits), 2) Entry-level courses (25 credits), 3) CMDA Required Core (18 credits), 4) Restricted Electives (12 credits), and 4) Free Electives (27 credits).

Curriculum for a Liberal Education (38 credits)
Area 1: Writing and Discourse (6)
Area 2: Ideas, Cultural Traditions, and Values (6)
Area 3: Society and Human Behavior (6)

Area 4: Scientific Reasoning and Discovery (8)
Area 5: Quantitative and Symbolic reasoning (MATH 1205-6, Calculus, 6)
Area 6: Creativity and Aesthetic Experience (3)
Area 7: Critical Issues in a Global Context (3)

Entry-level Statistics, Mathematics, and Computer Science Courses (25 credits)
CS 1114: Introduction to Software Design (3)
CS 2114: Software Design and Data Structures (3)
MATH 1114: Elementary Linear Algebra (2)
MATH 1224: Vector Geometry (2)
MATH 2214: Introductory Differential Equations (3)
MATH 2224: Multivariable Calculus (3)
STAT 3005-6: Statistical Methods (6)
STAT 3104: Probability and Distributions (3)

CMDA Required Core (18 credits)
CMDA 3605: Mathematical Modeling I (3)
CMDA 3606: Mathematical Modeling II (3)
CMDA 3634: Computer Science Foundation for Computational Science (3)
CMDA 3654: Introductory Data Analytics and Visualization (3)
CMDA 4654: Intermediate Data Analytics and Machine Learning (3)
CMDA 4864 CMDA Capstone (3)

Restricted Electives (12 credits from the following):
CS 3114 Data Structures and Algorithms (3)
CS 4104 Data and Algorithm Analysis (3)
CS 4214 Simulation and Modeling (3)
CS 4604 Database Management Systems (3)
STAT 4004 Methods in Statistical Computing (3)
STAT 4204 Experimental Design (3)
STAT 4214 Regression (3)
STAT 4364 Statistical Genomics (3)
STAT 4444 Applied Bayesian Statistics (3)
STAT 4504 Applied Multivariate Analysis (3)
MATH 4144 Advanced Linear Algebra (3)
MATH 4425-6 Fourier Series PDE (6)
MATH 4445-6 Numerical Analysis (6)
BIOL 4075-6 Bioinformatics Methods (6)
PHYS 4755-6 Computational Physics (6)
CMDA 4664 Computational Stochastic Modeling (3)
CMDA 4964 Field Study (3)
CMDA 4994 Undergraduate Research (3)
CMDA 4604 Intermediate Topics in Mathematical Modeling (3)

A sample plan of study for students entering as freshmen and going through the general option:

Year	Fall Semester	Spring Semester
Freshman	Area 5: MATH 1205 Calculus (3)	Area 5: Math 1206 Calculus (3)
	Math 1114 Linear Algebra (2)	Math 1224 Vector Geometry (2)
	Area 1: COMM 1015 Comm Skills (3)	Area 1: COMM 1016 Comm Skills (3)
	Area 6: Creativity and Aesthetic (3)	Area 4: PHYS 2305 Foundations of Physics I (4)
	Area 7: Critical Issues Global (3)	CS 1114 Intro to Programming (3)
Sophomore	STAT 3005 Statistical Methods I (3)	STAT 3006 Statistical Methods II (3)
	MATH 2214 Introductory Differential Equations (3)	MATH 2224: Multivariable Calculus (3)
	CS 2114 Software Design (3)	STAT 3104 Probability & Distributions (3)
	Area 4: PHYS 2306 Foundations of Physics II (4)	Area 2: Ideas, Cultural Traditions (3)
	Free Elective (3)	Free Elective (3)
Junior	CMDA 3605 Mathematical Modeling(3)	CMDA 3606 Mathematical Modeling (3)

	CMDA 3634 Comp. Sci. for CMDA (3)	CMDA 4654 Intermediate Data Analytics and Machine Learning (3)
	CMDA 3654 Introductory Analytics (3)	Restricted elective (3)
	Restricted elective (3)	Area 3: Society and Human Behav. (3)
	Free Elective (3)	Free Elective (3)
Senior	CMDA 4864 Capstone (3)	Restricted elective (3)
	Restricted elective (3)	Area 3: Society and Human Behav. (3)
	Area 2: Ideas, Cultural Traditions (3)	Free Elective (3)
	Free Elective (3)	Free Elective (3)
	Free Elective (3)	Free Elective (3)

In the *Integrative Quantitative Science* (*IQS) option*, students enroll in the newly created, entry-level Integrated Quantitative Science sequence (CMDA 2005-2006). This novel sequence, a 12 credit sophomore-level offering, integrates many of the fundamentals from mathematics and statistics employed in subsequent courses. By covering these topics in an integrated format, rather than as the separate courses found in the general option, the IQS option is able to require three fewer entry-level credits. The total of 120 credits in the IQS option are distributed across courses in the following categories: 1) Curriculum for a Liberal Education (38 credits), 2) Entry-level courses (22 credits), 3) CMDA Required Core (18 credits), 4) Restricted Electives (12 credits), and 4) Free Electives (30 credits).

Curriculum for a Liberal Education (38 credits)
Area 1: Writing and Discourse (6)
Area 2: Ideas, Cultural Traditions, and Values (6)
Area 3: Society and Human Behavior (6)
Area 4: Scientific Reasoning and Discovery (8)
Area 5: Quantitative and Symbolic reasoning (MATH 1205-6, Calculus, 6)
Area 6: Creativity and Aesthetic Experience (3)
Area 7: Critical Issues in a Global Context (3)

Entry-level Statistics, Mathematics, and Computer Science Courses (22 credits)
CMDA 2005: Integrated Quantitative Science (6)
CMDA 2006 Integrated Quantitative Science (6)
CS 1114: Introduction to Software Design (3)
CS 2114: Software Design and Data Structures (3)
MATH 1114: Elementary Linear Algebra (2)
MATH 1224: Vector Geometry (2)

CMDA Required Core (18 credits)
CMDA 3605: Mathematical Modeling I (3)
CMDA 3606: Mathematical Modeling II (3)
CMDA 3634: Computer Science Foundation for Computational Science (3)
CMDA 3654: Introductory Data Analytics and Visualization (3)
CMDA 4654: Intermediate Data Analytics and Machine Learning (3)
CMDA 4864 CMDA Capstone (3)

Restricted Electives (12 credits from the following):

CS 3114 Data Structures and Algorithms (3)	CS 4104 Data and Algorithm Analysis (3)
CS 4214 Simulation and Modeling (3)	CS 4604 Database Management Systems (3)
STAT 4004 Methods in Statistical Computing (3)	STAT 4204 Experimental Design (3)
STAT 4214 Regression (3)	STAT 4364 Statistical Genomics (3)

STAT 4444 Applied Bayesian Statistics (3)
STAT 4504 Applied Multivariate Analysis (3)
MATH 4144 Advanced Linear Algebra (3)
MATH 4425-6 Fourier Series PDE (6)
MATH 4445-6 Numerical Analysis (6)
BIOL 4075-6 Bioinformatics Methods (6)
PHYS 4755-6 Computational Physics (6)
CMDA 4664 Computational Stochastic Modeling (3)
CMDA 4964 Field Study (3)
CMDA 4994 Undergraduate Research (3)
CMDA 4604 Intermediate Topics in Mathematical Modeling (3)

A sample plan of study for students entering as freshmen and going through the IQS option:

Year	Fall Semester	Spring Semester
Freshman	Area 5: MATH 1205 Calculus (3)	Area 5: Math 1206 Calculus (3)
	Math 1114 Linear Algebra (2)	Math 1224 Vector Geometry (2)
	Area 1: COMM 1015 Comm Skills (3)	Area 1: COMM 1016 Comm Skills (3)
	Area 6: Creativity and Aesthetic (3)	Area 4: PHYS 2305 Foundations of Physics I (4)
	Area 7: Critical Issues Global (3)	CS 1114 Intro to Programming (3)
Sophomore	CMDA 2005 Integrated Quantitative Science I (6)	CMDA 2006 Integrated Quantitative Science II (6)
	CS 2114 Software Design (3)	CMDA 3634 Comp. Sci. for CMDA (3)
	Area 4: PHYS 2306 Foundations of Physics II (4)	Area 2: Ideas, Cultural Traditions (3)
	Free Elective (3)	Free Elective (3)
Junior	CMDA 3605 Mathematical Modeling (3)	CMDA 3606 Mathematical Modeling (3)
	CMDA 3654 Introductory Analytics (3)	CMDA 4654 Intermediate Data Analytics and Machine Learning (3)
	Restricted elective (3)	Restricted elective (3)
	Free Elective (3)	Area 3: Society and Human Behav. (3)
	Free Elective (3)	Free Elective (3)
Senior	CMDA 4864 Capstone (3)	Restricted elective (3)
	Restricted elective (3)	Area 3: Society and Human Behav. (3)
	Area 2: Ideas, Cultural Traditions (3)	Free Elective (3)
	Free Elective (3)	Free Elective (3)
	Free Elective (3)	Free Elective (3)

Students selecting the CMDA major early in their college career will be guided to the IQS option, while those who come to the major later, having already established a foundation in entry-level quantitative courses, will typically be guided towards the general option. The IQS option takes students immediately into the integrated world of CMDA, and while this is preferable, not all students will settle on the major soon enough to take this route. The general option, so named for its accessibility to students with a general quantitative background, provides the flexibility to accommodate those who have originally embarked on a traditional major such as statistics or computer science. This also includes transfer students and any others who have already built up a significant portion of relevant, entry-level credits. Both the general and the IQS option rest on the same core.

Among the six core courses, CMDA 3634 is a 3-credit course focusing on computational methods, including the introduction and analysis of data structures and algorithms and parallel computing. CMDA 3605-3606 are two three-credit courses equipping students with the tools of mathematical modeling. CMDA 3654 and 4654 are likewise two three-credit courses, these providing the statistical methods associated with data management and data analytics. CMDA 4864, the capstone course for the CMDA degree, will involve every student in a guided research

project, requiring application of the integrated mathematics, statistics, and computer skills they have developed through the degree program.

Relevance to university mission and strategic planning

Virginia Tech has long noted the need to develop both strong quantitative skills and deep interdisciplinary foundations if students are to reach their maximum potential, be it for entering the constantly changing job market, or for going on to graduate school. *A Plan for a New Horizon* (http://www.president.vt.edu/strategic-plan/2012-plan/2012-strategic-plan.pdf), the university's recently revised strategic plan, emphasizes that "We live in a data-driven, networked society. Economic, technological, and social progress depend on the development of an analytically savvy, multidisciplinary workforce." Virginia Tech is committed to empowering students "to be knowledgeable, wise, and effective participants in an increasingly digital age in areas ranging from art to science to civic discourse." Moreover, "The questions that can be asked and the methods and data sets that can be used to solve complex problems are being fundamentally altered by technology and the information sciences. Being effective in this environment means being able to apply and manage information technology while taking advantage of networking, collective intelligence, simulation, data mining, and modeling."

Clearly one of the main goals of the university is the training of students to be quantitatively adept and ready to meet the needs of industry, government and academics in an era of abundant (in some cases, over-abundant) data. CMDA aspires to the pinnacle of this goal. Again from *A Plan for a New Horizon*:

> "Virginia Tech is committed to a progressive agenda that provides the educational opportunities, computational infrastructure, and learning spaces necessary to prepare students and faculty to excel in this environment. Emphasis will be given to developing core competencies in computational thinking, information literacy, and analytical methods."

The Bachelor of Science degree in CMDA is not only timely with regard to this perspective, it moves far beyond the baseline objectives that have been set for the university as a whole. CMDA will build deep, expert knowledge on a richly developed computational core to produce Virginia Tech's most highly skilled, integrated practitioners of quantitative science.

Justification for the proposed program

STEM education is a critical focus area in Virginia. A recent news article (https://news.virginia.edu/content/governor-education-leaders-call-more-focus-stem-h-efforts) summarizes a call by the Virginia Business Higher Education Council for stronger initiatives in STEM education, pointing out opportunities and issues associated with educating students to have top quantitative skills:

> "An opportunity for the commonwealth is that Virginia is among the nation's leaders when it comes to the number of STEM-H jobs projected to be created in next four years. These are the engineers, computing experts, doctors and others whose professions reside under the high-paying umbrella of science, technology, engineering, mathematics and health. One problem, however, is that the state's colleges and universities aren't yet in position to fill those jobs with ample numbers of graduates, and the United States overall faces stiff international competition."

At that meeting, Gov. Robert F. McDonnell noted "The pace of innovation around the world is breathtaking. Are we going to be prepared to be able to keep up with it?" The governor also focused on STEM education in his cover letter for the document entitled Virginia STEM-H TRACT (http://www.education.virginia.gov/STEM-H-TRACT-2012.pdf) :

> "It is our responsibility to ensure that each and every citizen of Virginia has the skills and knowledge to be competitive in this global society. With an evolving demand for science, technology, engineering, mathematics and health (STEM-H) competencies, education institutes and industries must work together to build strong, innovative and economical career paths. The more Virginia students who attend our schools, colleges and universities and emerge with the skills and training necessary to compete for the best jobs in the 21st century, the stronger our state will be in the years ahead. It will make Virginia an even greater jobs magnet with a highly skilled workforce."

Data and especially big data are an integral component of 21st-century science and industry. Advances in genomics, medicine, drug development, astronomy and more are intimately connected to, indeed are made possible by, the ability to collect large volumes of data and to perform the analysis and modeling needed to extract information from that data. There are numerous application areas in physical sciences, medical and health sciences, security, and even the arts, only recently made possible by the tools and techniques that comprise the basis for CMDA. To take one example, genomics and the revolution in genetic information have been built on data sets that are often of terabyte size. Likewise, brain imaging generates terabytes of information requiring extensive processing and filtering before the highly complex modeling process can even begin. Models from climatology are not only large and mathematically complex, they add multiple layers of stochastic complexity to incorporate uncertainties at different scales. CMDA will train students to better understand, analyze and communicate information embedded in these massive data sets and to tackle the analysis problems these data present. This goes to the heart of the STEM-H call by the governor and Virginia educators.

Not only is a strong job market anticipated for those earning the CMDA degree, these students will be ideally positioned, should they so choose, to pursue advanced degrees in the quantitative sciences, particularly in computationally-based programs in mathematics, in statistics, and in related fields. Those moving on to a Master's or Ph.D. degree should expect even stronger employment opportunities. CMDA also offers sufficient flexibility to allow a second major or a minor, further enhancing graduates' marketability.

To summarize, CMDA will train students in the computational skills needed to work with vast data sets and to develop code for specialized applications, in the mathematical skills needed to develop the intricate models describing such data, and in the statistical skills required to assess uncertainty and make predictions. As illustrated by the examples listed above, the complexity of emerging problems requires collaboration across multiple disciplines; these problems do not yield to the individual approaches born of isolated thinking so commonly employed in the past. CMDA provides a new and needed pathway for imbuing students with the needed collaborative inclination and integrative skills, while incorporating the strengths of analytical thinkers, data scientists, coders, and modelers. The CMDA synthesis of statistical, mathematical, and computing methodologies will produce the graduates desired by the quantitatively technical job and academic markets of today and of the foreseeable future.

Student Demand

The College of Science has been tracking student interest for the CMDA program over the past year. Students contacted have included incoming freshmen during orientation and prospective students visiting Virginia Tech during Hokie Focus weekends, spring break visits, and weekly information sessions at the College of Science. Of these students, 24 have expressed significant interest in CMDA by requesting additional information, either in person or by email. Many of them are particularly excited about the opportunity to integrate knowledge across mathematics, statistics, and computer science in connection with big data applications. Interdisciplinarity is proving to be a key attractor for the CMDA program.

Fall 2013 is the first semester that one of the new courses, CMDA 3605, is being offered. With little promotion and no degree in place, the enrollment for this course is 12 students. Existing courses illustrate the great potential for populating CMDA courses. Table 1 shows total enrollment for relevant courses in statistics, mathematics, and computer science from 2009 to fall 2013. Listed are the restricted electives for the CMDA curriculum, these being good indicators of student interest in CMDA areas. Note particularly that the enrollment in almost all of these courses has grown substantially over the five-year period. Also listed is a recently introduced graduate course, STAT 5525, in data analytics. Drawing from the much smaller graduate population, this course has grown to 24 students for Fall, 2013.

Table 1. Total enrollment for Restricted Elective courses in the CMDA curriculum from 2009 to 2013 (data retrieved from Banner on 8/30/2013)

Existing Courses	2009	2010	2011	2012	2013
CS 3114	45	95	82	211	281
CS 4104	NA	NA	NA	85	107
CS 4214	NA	NA	NA	NA	31
CS 4604	23	42	35	NA	39
MATH 4425-6	51	44	41	51	71
MATH 4144	NA	NA	NA	8	7
MATH 4445-6	86	70	92	112	122
STAT 4214	27	34	30	41	77
STAT 4004	14	13	14	18	27
STAT 4204	24	27	29	27	37
STAT 4444	25	6	17	8	12
STAT 4504	NA	10	NA	5	15
STAT 5525	NA	NA	12	11	24

Market Demand

Summary data from the Bureau of Labor Statistics and discussions with industry leaders project strong demand for CMDA graduates. This demand will emanate from both industry and government, as indicated next.

In the industrial realm the jobs are numerous and from a diverse set of companies. Large employers such as ComScore, IBM, Google, Yahoo, Netflix, Amazon, and many others seated in the ever-expanding internet-based economy, use vast amounts of both publicly available and privately obtained data to guide advertising, product development, and market expansion. They

create high demand for individuals with the skills to handle, process, and understand such data, the very skills that CMDA will impart. Closer to home, tech companies in northern Virginia (cited below) have emphasized the need for students with the blend of skills in statistics, computer science and mathematics that CMDA will provide.

Chis Chmura, president and chief economist of Chmura Economics and Analytics of Richmond, in addressing the September 2012 meeting of the Virginia Business Higher Education Council (cited at the top of this section), stated that STEM-H job growth in Virginia through 2016 is projected at 2.5 percent annually, while overall job growth is projected at just 1.7 percent "During that period, she said, Virginia can expect to see 79,000 STEM-H jobs, either newly created or replacements for retiring professionals. But the state's colleges and universities are not graduating enough people in those fields to fill the jobs." This is a gaping hole that CMDA will help to fill.

Government agencies in every administrative arm employ quantitative scientists to improve the quality of the data available for policy analysis and to provide state-of-the-art quantitative analysis. The data-dependence of these agencies continues to increase, and with it the strength of a job market where CMDA graduates will be among the best qualified. Reflecting growth in research and development in the physical, engineering, and life sciences, where skills in design of modeling procedures and assessing results prove highly useful, a number of agencies have initiatives related to big data and complex modeling. Included are: ***Department of Defense*** – Data to Decisions; ***National Institutes of Health –*** 1,000 Genomes Project Data Available on Cloud; ***Department of Energy –*** Scientific Discovery Through Advanced Computing; and ***US Geological Survey –*** Big Data for Earth System Science**.**

Letters of support for CMDA have been received from Agilex, Extreme Networks, IBM, JPI, Paragon Technology, NetApp, Outcome Capital, Salient Systems, Spear and ICF International. Some comments from the companies follow.

"IBM has precise interests in this new major. Specifically, we are interested in participating in the development of a workforce suitable for creative use of massive datasets for predictive, actionable, and risk analysis. We envision that the educational platforms to be investigated in this proposal such as integrated quantitative science, mathematical modeling, data analytics, and computational physics will play a significant role in fulfilling our nation's future talent needs."

"As an innovation leader in the data storage industry, NetApp sees an enormous requirement for developing new talent in the data management and analytics field. This need transcends day-today business operations to the mission-critical applications that defend the security of our nation. The criticality of this curriculum and the resulting innovative outcomes will reinforce Virginia Tech's position at the cutting edge of research and forefront of economic contribution."

"We are confident that the this collaborative initiative, combining cutting edge curriculum and research from multiple scientific and engineering disciplines with the strengths of industry mentors can lead to advances in data intelligence that address critical state and national needs. … If given the opportunity, Spear will support this curriculum assuming that the degree development proceeds as planned."

There is, of course, no specific job title corresponding to the interdisciplinary CMDA degree. An indication of job demand is given in Table 2 for relevant job categories available at the Bachelor's degree level from the Bureau of Labor Statistics. The percentage change is quite high in these three fields. The market is expected to be even stronger in the northern Virginia and Washington DC area.

Table 2. Degree-related employment projections 2010-2020

Occupational Title	SOC Code	2010 Employment	Projected 2020 Employment	Percent change
Survey Researchers	19-3022	19,600	24,300	24.1%
Computer Systems Analysts	15-1121	544,400	664,800	22.1%
Operations Research Analysts	15-2031	64,600	74,000	15.0%
Software Developer	15-1132	913,000	1,183,900	29.7%

(data from http://www.bls.gov/ooh/, accessed May 2013)

Resource Needs/Savings

The newly created CMDA courses will be delivered by the departments of Statistics, of Mathematics, and of Computer Science. It is anticipated that two new hires at the assistant professor rank in the field of data analytics/statistics will be assigned to the CMDA program. These faculty members will be housed jointly within the Academy of Integrated Science and the Department of Statistics. Graduate students (four) will be responsible for running recitation sessions for students in CMDA courses. One staff member will be hired to provide administrative support and advising services. This person will support not just CMDA, but all Academy degree programs, so effectively ¼ of this position is for CMDA.

RESOURCE	ESTIMATED COSTS (NA if not applicable)
Faculty (salary & fringe)	$223,093
Administrative Staff (salary & fringe)	$45,850
Graduate Teaching Assistants (stipend, fringe & tuition)	$113,564
Space	NA
Library	NA
Equipment	NA
Other	NA
Total	$382,507

The faculty hires are associated with re-distribution of new hires within the College of Science. The College initiated cluster hiring in 2004 as a means of strategically re-aligning resources to better meet the needs of the university, of positioning the College to address interdisciplinary grand challenges in science, and of educating our students in a more comprehensive manner. Hiring in clusters, rather than specific disciplines, is a strategy for the college to seek and acquire the best faculty to promote our research and educational agenda and thereby achieve a stronger institution. Reallocation/realignment of resources to make faculty hires in CMDA is a continuation of the College's on-going strategic initiatives.

Attachment D

B.S. DEGREE IN COMPUTATIONAL MODELING AND DATA ANALYTICS (CMDA)

Eric P. Smith

A collaboration between
Statistics, Mathematics, and Computer Science
Peter Haskell, College of Science Barbara Ryder, College of Engineering

VirginiaTech
Invent the Future

Background

- Increased need for workers trained in the analysis of “Big Data”
  - **Precision agriculture:**
    Using predictive weather analytics to feed future generations
    - http://www.research.ibm.com/articles/precision_agriculture.shtml
  - From FitBits To Clinical Studies: How Big Data Could Change Medicine
    - http://www.forbes.com/sites/matthewherper/2013/12/16/from-fitbits-to-clinical-studies-how-big-data-could-change-medicine/
  - Supercomputing the Climate: NASA's Big Data Mission
    - http://www.csc.com/cscworld/publications/81769/81773-supercomputing_the_climate_nasa_s_big_data_mission
  - Big Data and the Future of Ecology
    - Stephanie E Hampton, Carly A Strasser, Joshua J Tewksbury, Wendy K Gram, Amber E Budden, Archer L Batcheller, Clifford S Duke, and John H Porter 2013. Big data and the future of ecology. *Frontiers in Ecology and the Environment* **11**: 156–162.http://dx.doi.org/10.1890/120103

Preparation

- National and state initiatives associated with STEM-H
- Discussion with former students and VT-Serge
- Demand from companies such as IBM, Comscore, NetApp, Salient, and Capital Federal for workers with background in statistics, mathematics, and computer science
- A need to train students
  - Who can work in teams
  - Know how to combine science, mathematics and algorithms
  - Who have experience with real data connected to real problems
  - Who are able to communicate results of an analysis

Needs and the program at Virginia Tech

- Train the new quantitative student by providing background in
  - Statistics
  - Computer Science
  - Mathematics
- Skilled in
  - Manipulating large data sets
  - Data cleaning
  - Predictive and mathematical modeling
  - Data art, infographics and integrative presentation

These need to be integrated not separated

New undergraduate program

Undergraduate program

- **Integrated** courses in statistics, mathematics and computer science
- **New** courses on tools for big data, analytics and computational mathematics
  - Focus on **applications**
  - Room for "**tracks**" or double majors
  - Opportunities for internships

Sample Program

Year	Fall Semester	Spring Semester	
Freshman	Area 5: MATH 1205 Calculus (3)	Area 5: Math 1206 Calculus (3)	Prepare
	Math 1114 Linear Algebra (2)	Math 1224 Vector Geometry (2)	
	Area 1: COMM 1015 Comm Skills (3)	Area 1: COMM 1016 Comm Skills (3)	
	Area 6: Creativity and Aesthetic (3)	Area 4: PHYS 2305 Foundations of Physics I (4)	
	Area 7: Critical Issues Global (3)	CS 1114 Intro to Programming (3)	
Sophomore	CMDA 2005 Integrated Quantitative Science I (6)	CMDA 2006 Integrated Quantitative Science II (6)	Integrate
	CS 2114 Software Design (3)	CMDA 3634 Comp. Sci. for CMDA (3)	
	Area 4: PHYS 2306 Foundations of Physics II (4)	Area 2: Ideas, Cultural Traditions (3)	
	Free Elective (3)	Free Elective (3)	
Junior	CMDA 3605 Mathematical Modeling (3)	CMDA 3606 Mathematical Modeling (3)	Core
	CMDA 3654 Introductory Analytics (3)	CMDA 4654 Intermediate Data Analytics and Machine Learning (3)	
	Free Elective (3)	Free Elective (3)	
	Free Elective (3)	Area 3: Society and Human Behav. (3)	
	Restricted elective (3)	Restricted elective (3)	
Senior	CMDA 4864 Capstone (3)	Restricted elective (3)	Advanced
	Restricted elective (3)	Area 3: Society and Human Behav. (3)	
	Area 2: Ideas, Cultural Traditions (3)	Free Elective (3)	
	Free Elective (3)	Free Elective (3)	
	Free Elective (3)	Free Elective (3)	