MOUNT ST. MARY'S UNIVERSITY

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January 28, 2020

Dr. James Fielder, Secretary
Maryland Higher Education Commission
6 North Liberty Street, 10th Floor
Baltimore, Maryland 21201

Dear Dr. Fielder,

On behalf of Mount St. Mary's University, I am submitting to you a new major program proposal for a bachelor of science in Data Science. Mount St. Mary's University is seeking approval from the Maryland Higher Education Commission to offer this program through our School of Natural Science and Mathematics.

Thank you in advance for your timely consideration of this proposal. I look forward to hearing from you.

Sincerely,

Boyd C

Boyd Creasman
Provost

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MHEC
Creating a state of achievement

Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	Mount St. Mary's University

Each action below requires a separate proposal and cover sheet.

- (●) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted:	Payment Type:	Payment Amount:	Date Submitted:
(●) Yes ( ) No	( ) R*STARS (●) Check	$850.00	

Department Proposing Program	Department of Mathematics and Computer Science	
Degree Level and Degree Type	Bachelor of Science	
Title of Proposed Program	Data Science	
Total Number of Credits	120	
Suggested Codes	HEGIS: 079900	CIP: 30.7001
Program Modality	(●) On-campus	( ) Distance Education (*fully online*)
Program Resources	(●) Using Existing Resources	( ) Requiring New Resources
Projected Implementation Date	(●) Fall ( ) Spring ( ) Summer	Year: 2020
Provide Link to Most Recent Academic Catalog	URL: https://catalog.msmary.edu/	
Preferred Contact for this Proposal	Name: Kraig E. Sheetz	
	Title: Dean, School of Natural Science and Mathematics	
	Phone: (301) 447-8399	
	Email: k.e.sheetz@msmary.edu	
President/Chief Executive	Type Name: Timothy E. Trainor	
	Signature: [signature]	Date: 01/28/2020
	Date of Approval/Endorsement by Governing Board:	01/27/2020

Revised 3/2019

Mount St. Mary's University

Proposal for a Baccalaureate Degree

Data Science

Developed by the Department of Mathematics and Computer Science

A. Centrality to Institutional Mission and Planning Priorities

Program Description

1. *Provide a description of the program, including each area of concentration (if applicable), and how it relates to the institution's approved mission.*

A Bachelor of Science Degree in Data Science is proposed within the Department of Mathematics and Computer Science at Mount St. Mary's University. For purposes of this degree proposal, data science is defined as the extraction of complex data from a variety of sources, completion of data engineering and statistical analysis to identify patterns within that data, and creation of a data product leveraging the identified patterns.

While the terminology *data science* and *big data* could be considered trendy, the foundations of the discipline are not. Computer models and simulations have been utilized for decades; statisticians and scientists have formulated theories and gathered data to validate those theories for hundreds of years. The terminology *data science* may have existed for a limited number of years, but the foundational skills and expertise exist within several long standing disciplines.

The demand for professionals with expertise beyond foundational statistics and computer science skills, and the aptitude to transform complex data into useful data products, is growing rapidly. Recent data science applications have expanded traditional concepts significantly to include specialized new skills, tools, and practices related to the extraction of data, data engineering, and data tool creation and deployment. Extracting meaning from complex data requires data scientists to develop skills in the statistics, mathematics and computer science curriculum along with newer machine learning and data engineering concepts.

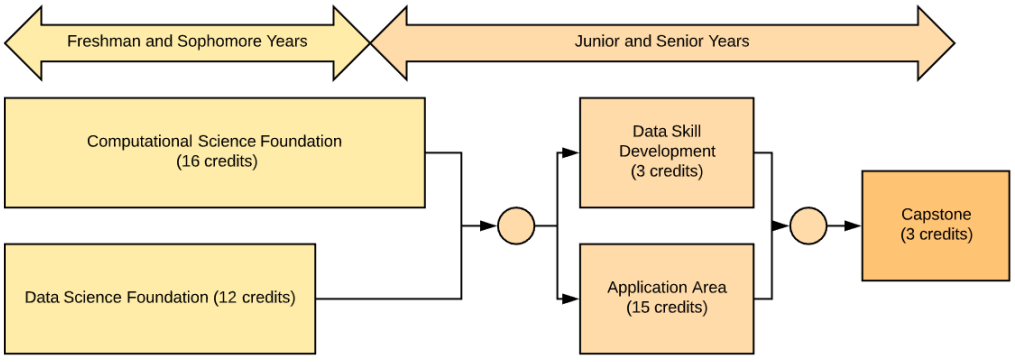
Data science models can be found in all scientific disciplines, in medical systems planning, in complex systems such as fire modeling growth and egress, in human resource departments

attempting to identify the "perfect employee," in marketing campaigns, in stock market portfolio analysis, in crime data analysis, and embedded within Internet web applications related to user access patterns. Domain areas continue to grow and expand. Extracting meaning from complex data requires data scientists to develop subject matter expertise within domain areas, and to become proficient in applying technical skills within the constraints of those domain areas.

Data scientists often have the additional responsibility for the data storage infrastructure as well as the security related to that data infrastructure. Securing data often extends to handling restricted and confidential information in addition to sensitive information that could identify an individual's lifestyle patterns. Critical skills for success for practicing data scientists include the ability to communicate results in written and verbal form, the ability to make inferences in new situations, the ability to make sound judgements in scenarios that are not clear cut, and the ability to learn new techniques and new applications of data science.

The proposed Data Science degree at Mount St. Mary's University is designed to weave together traditional curriculum in mathematics and computer science along with newer curriculum related to current data science techniques to prepare graduates for success in a variety of application domains. A significant portion of the curriculum needed is already in place at Mount St. Mary's University with a flourishing Computer Science major, Data Science minor, Data Science Post-baccalaureate certificate, and many data science application courses developed within programs across the university. This proposal for a Data Science major would enable Mount St. Mary's University to use the existing curriculum targeted at preparing individuals with the key technical (hard) data science skills while relying on the Core curriculum in developing the key soft skills such as communication and ethical thinking. Utilizing the concept of application areas within the curriculum framework enables students to explore a variety of cross-disciplinary application domains.

The Data Science major curriculum consists of 49 credit hours. The curriculum can be summarized within five critical elements: computational science foundation, data science foundation, data skill development, application area exploration, and a demonstration of skills learned within a problem domain through the capstone course. For purposes of this proposal, computational science is defined as the use of advanced computing capabilities, *e.g.,* models and simulations, in order to solve complex problems within systems.



The structure of the program of study begins with a common technical foundation during the freshman and sophomore years. Three foundational courses in data science concepts, two foundational courses in computer programming, data structures, and courses in calculus and linear algebra complete the required courses. Three 1 credit special topics to be completed in the sophomore or junior years allow students to explore potential areas of interest for deeper study in future. Data specific skills are developed through selection of one (1) course in data engineering and related skills. Students complete their data science degree by selecting an area of interest to develop domain level expertise; completing an additional five (5) courses in junior and senior years. An initial group of application areas has been specified in detail within the curriculum section of this proposal. The application area framework introduces an opportunity for interdisciplinary collaboration, and provides flexibility for the university to adapt to new application areas in future, thus expanding the areas of interest for future students. A capstone course is included to demonstrate mastery of concepts completed throughout the major and applied within the student's selected application area.

Relationship of Proposed Program to the University's Mission

The proposed program is designed to graduate students from the program that fully align with the university's mission:

> *As a Catholic university, Mount St. Mary's graduates ethical leaders who are inspired by a passion for learning and lead lives of significance in service to God and others.*

As data science solutions continue to shape the world around us, it is imperative that universities, like Mount St. Mary's University, participate in the preparation of professionals who "see and seek to resolve the problems facing humanity, and who commit themselves to live as responsible citizens." Data science has the power to positively influence lives, but it has the potential to be a negative influence in those same lives. Mount St. Mary's University Core curriculum plays a key role in the development of ethical thought processes.

Mount St. Mary's University is well positioned to develop data science leaders with specific technical skills, the ability to adapt to new technical skills, and a critical ability to always question "why." A data science program within a university dedicated to the development of ethical leaders enables Mount St. Mary's University to graduate data science practitioners that will evaluate all potential data science applications not only in light of what can be done but also in light of what should be done. Graduates of the data science degree program will develop not only the hard skills specific to developing data science products, but the soft skills critical to considering the ethical implications of those products prior to creation.

Offering a Data Science degree at Mount St. Mary's University provides students with the opportunity to learn from existing technology curriculum within the structure of a university committed to smaller, student-focused, class sizes, fully integrated within an ethics focused framework.

Relationship to Strategic Goals

2. *Explain how the proposed program supports the institution's strategic goals and provide evidence that affirms it is an institutional priority.*

Mount St. Mary's University 2018-2023 Strategic Plan is organized around three strategic priorities: Student Success, a Faith- and Values-Based Campus Environment, and Financial Sustainability and Stewardship. The plan expands the three strategic priorities further into 13 goals, 53 objectives, and approximately 100 actions. The proposed Data Science major aligns to a large number of the identified goals and objectives. This proposal focuses on the most significant alignments.

Strategic Priority: Student Success
Goal 1: Intellectual Excellence
Objective 1.1: Improve Intellectual Growth: Increase to an even higher level student attainment of learning outcomes, such as critical thinking and skills of analysis, interpretation, communication, and problem-solving.

1.1.1 Strengthen the integration of major programs with the Core in light of our mission.

Goal 2: Human Excellence
Objective 2.2: Integrate all Developmental Programs Integrate more thoroughly the Core curriculum, co-curricular programs, major programs, and extracurricular activities and align them with the student formation plan (in 2.1 above).

The proposed major in data science is fully integrated with the Mount St. Mary's Core curriculum not only as a university expectation, but because that Core curriculum plays a critical role in developing future data scientists in alignment with our mission. The emphasis at the university on developing mature thought processes, integrating ethical considerations throughout, and communicating impacts, not only from a technical but from a human aspect, are critical to our success in this area.

Strategic Priority: Student Success

Goal 1: Intellectual Excellence
Objective 1.2: Premier Academic Programs: Develop distinctive, nationally-recognized academic and instructional programs that prepare students for relevant careers consistent with the needs of changing job markets.

Since 2016, Glassdoor has consistently reported data scientists in the top spot of the 50 best jobs in America. Data engineer comes in at number 8 on the most recent list, and data analyst is number 31. In a March 2017 article, Inside Higher Ed emphasized "a shortage of job candidates with fluency in data science and analytics is among the nation's most yawning of skills gaps." The article stated a need for fixes by both higher education and businesses, and a recommendation that all undergraduates should complete coursework in data science. With the explosion of data availability across industry, service, government and research organizations, the demand for data scientists is equally wide spread across a diverse discipline spectrum. The need for individuals who have some knowledge within a subject area as well as knowledge of the

means to leverage the vast quantity of data related to that subject area to support decision-making processes has become critical.

Strategic Priority: Student Success
Goal 1: Intellectual Excellence
Objective 1.4: Academic Partnerships: Expand partnerships with other academic institutions in order to enhance academic program offerings and collaborative faculty research.

Strategic Priority: Financial Sustainability and Stewardship
Goal 10: Sustainable Financial Resources
Objective 10.3: Diversify Revenue Streams: Increase diversity of funding sources used to support critical activities. Rate of growth of total revenue should exceed rate of growth of net student revenue.

> *10.3.1 Increase grant funding each year as an additional source of revenue for building educational programming, capital expenditures, and the development of the Office of Sponsored Research and Grants.*

Goal 12: National Reputation
Objective 12.2: Support Scholarship: Increase the Mount's national stature through renewed commitment to supporting research and scholarship and developing programs on socially important topics consistent with our mission.
Objective 12.3: Develop Partnerships: Establish value-added public/private partnerships that bring needed resources to the Mount and enhance our surrounding communities.

Mount St. Mary's University submitted a grant request in 2018 to the Maryland E-Nnovation Initiative Fund (MEIF) to establish the *Partnership for Innovative Advancement in Computational Science* at Mount St. Mary's University. The fund was established by the Maryland Department of Commerce to allocate funding annually in order to establish endowed positions within critically needed computational program areas at universities throughout the state. Key elements of that proposal include:

1) Create an Endowed Professor of Computational Sciences and Mathematics position, whose designee will: conduct original research in the field; formalize MSMU's active partnerships with area technology employers; and create research and industry-based learning pathways for students.
2) Deepen faculty and student research engagement, build and strengthen relationships with local and regional laboratories and research facilities, and strengthen the integration of computational science research within MSMU's undergraduate curriculum.
3) Establish a collaborative partnership with Leidos Advanced Biomedical Computing Center (ABCC) at the Frederick National Laboratory, through which MSMU's Endowed Professor of Computational Sciences and Mathematics will hold a Visiting Scientist appointment. Leidos will also host undergraduate student research fellows.
4) Cultivate a pipeline of graduates with data and research skills to fulfill Maryland's need for skilled data scientists, thereby generating economic growth in data-driven industries.

The grant proposal was approved and fully funded by the state of Maryland for $1M. With an additional $1M in matching funds from Mount St. Mary's University, an Endowed Professorship in Computational Sciences and Mathematics has been established to conduct original research in partnership with area technology employers. Additionally, a partnership with Leidos Advanced Biomedical Computing Center (ABCC) at Frederick National Laboratory was formally

established that will provide the opportunity for the Endowed Professor to hold a Visiting Scientist appointment at Leidos in academic year 2020-2021. The proposed data science major positions Mount St. Mary's University to achieve the critical elements listed above in partnership with technology partners like Leidos. Formalized partnerships have also been established with The MITRE Corporation and the Food and Drug Administration (FDA) with similar goals to deepen faculty and undergraduate student research engagement beyond the classroom.

Additionally, the topic of data science as a critical curriculum element within the STEM curriculum as well as within cross-disciplinary studies has been discussed frequently with both the Board of Trustees and the School of Natural Science and Mathematics Board of Advisors. The proposed Data Science major moves these conversations forward into action benefitting current and future Mount St. Mary's graduates.

Funding Adequacy and Institutional Commitment

3. *Provide a brief narrative of how the proposed program will be adequately funded for at least the first five years of program implementation. (Additional related information is required in section L.*
4. *Provide a description of the institution's commitment to:*
    a) *ongoing administrative, financial, and technical support of the proposed program*
    b) *continuation of the program for a period of time sufficient to allow enrolled students to complete the program.*

Relying on existing curriculum to fullest extent possible, the proposed Data Science major will require limited new expertise beyond current faculty resources and the Endowed Professor in Computational Sciences and Mathematics. The major will join an existing program offering degrees across mathematics, computer science, and cybersecurity. This program has been very successful in scaling course offerings to the growing numbers of students within the existing program majors. Scaling has been accomplished by 1) maximizing utilization of common courses 2) building a skills bench of potential adjunct faculty with industry experience and interest in teaching across the program 3) building relationships with industry partners to provide extracurricular learning opportunities and 4) revising course projections annually based on current program enrollments and entering freshman interest in the program degrees or minors.

The application area of the major will draw from courses in existence across the university whenever possible. For programs interested in partnering within the application area, the Mathematics and Computer Science department will collaborate to identify existing course curriculum or to create new curriculum in alignment with the degree goals specific to the selected application area. These courses could then be available not only in the Data Science major application area, but potentially within the disciplinary degree programs as well. This maximizes utilization of these courses for a variety of majors, not just the proposed Data Science major.

A small number of new courses are anticipated within the first 2-3 years of degree rollout. Expertise for development of these new courses will come from existing faculty along with the Endowed Professor in Computational Sciences and Mathematics. The Endowed Professor position will be hired for the academic year 2020-2021 through funding provided by the E-

Nnovation grant and matching contributions. Over time, program demand could necessitate additional fulltime faculty. Need would be evaluated by the administration based on sustained course needs within foundational courses and high demand applications areas, new course development needs, and critical expertise gaps.

The proposed Data Science degree will be an integral component of the Mathematics and Computer Science department, a program that has been offering Cybersecurity as a major for three years, Computer Science as a major for over 20 years, and Mathematics as a major for much longer. The numbers of students completing degrees within any one of the program's existing majors can vary over time. However, the course offerings remain consistent year to year. Because the major is built on the foundation of existing program courses, the current support structure will be expanded to support the proposed major. For students entering the Data Science degree, this means there is no reason for concern that the university might fail to support completion of the degree once started.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

1. *Demonstrate demand and need for the program in terms of meeting present and future needs of the region and the State in general based on one or more of the following:*
    a) *The need for the advancement and evolution of knowledge*
    b) *Societal needs, including expanding educational opportunities and choices for minority and educationally disadvantaged students at institutions of higher education*
    c) *The need to strengthen and expand the capacity of historically black institutions to provide high quality and unique educational programs*

In 2016, as Mount St. Mary's University was evaluating direction specific to the data science curriculum, a market research study was conducted by Illumine8 Marketing and PR. Results of that study provided a summary of job demands within regions of the country specific to data science. Highlighted on the report were the Washington-Northern Virginia area consistently within the top 5, #3 at the time of the study, along with the Baltimore-Towson area at #11.

Mount St. Mary's University offered a Data Science minor within the Mathematics and Computer Science department for the first time in the academic year 2016-17. In 2018 and 2019, Mount St. Mary's University students from a variety of majors graduated with the Data Science minor. Those graduates have been highly successful in obtaining employment within data related careers as well as pursuing advanced studies in data science related disciplines throughout the Mid-Atlantic region. In the timeframe since first offering the minor, the number of students enrolled in the required sequence of courses for that minor has tripled. Enrollment in the initial course within that sequence has expanded to two full sections every year with plans to expand further in the coming academic year 2020-2021. A Data Science Post-baccalaureate certificate for non-technical working professionals became available at Mount St. Mary's Frederick campus for the academic year 2019-2020. Both curricular programs are highlighted here to demonstrate the substantial interest expressed by traditional as well as non-traditional, technical as well as non-technical, students in pursuing data science educational goals.

Alignment with Maryland State Plan for Postsecondary Education

2. *Provide evidence that the perceived need is consistent with the **Maryland State Plan for Postsecondary Education**.*

As highlighted in the **Maryland State Plan for Postsecondary Education**, Maryland has proven highly competitive in terms of the concentration of technology jobs in the private sector (fifth among the states) and in the overall Maryland workforce (sixth among the states). Building toward the future, Maryland places eighth related to technology industry wages as well as technology gross state product, and ninth for new technology startups. Maryland ranks third for percentage of the population 25 and over with at least a bachelor's degree. With the integration of data science into all disciplines within today's workforce, expanding the data science curriculum to the bachelor's degree level within Maryland higher education is well suited to moving Maryland forward. Traditional technology companies as well as non-technical companies are seeking to benefit from the data science technical skillset. Designing the degree with the flexibility within the applications area ensures that the degree continually adapts to the changing needs within Maryland and the mid-Atlantic region.

Traditionally, data science skills have been taught at the graduate level to individuals who had significant experience in computational programs such as computer science, mathematics, statistics, etc. While the demand for individuals with graduate level degrees continues, the opportunities for individuals working in the data arena with bachelor's level degrees has been increasing rapidly as well. A position inquiry completed through Indeed on August 29, 2019 for job title: *Data Scientist* and location: *Maryland* returned 1315 job postings. Example positions returned included a *Junior Data Scientist* at a small startup company as well as a *Data Scientist* at a government agency; both requiring Bachelor's Degree level knowledge. The range of positions returned crossed the private and public sector, technical and non-technical companies, and a significant number were open to individuals with only an undergraduate level education. A similar search on Indeed for job title: *Data* and location: *Maryland* returned 26,445 jobs including *Data Analyst, Data Storage Engineer, and GIS Data Analyst* among many others. Skills developed through the proposed *Data Science* major would prepare individuals to successfully apply for many entry level jobs in the state of Maryland.

Specific to the strategic goals within the Maryland State Plan, the following alignment is achieved by the proposed Data Science major.

Innovation Goal, Strategy 8: Develop new partnerships between colleges and businesses to support workforce development and improve workforce readiness

Innovation Goal, Strategy 10: Expand support for research and research partnerships.

In collaboration with faculty across the Data Science degree curriculum, the Endowed Professor in Computational Sciences and Mathematics will provide a bridge between the curricular and extracurricular opportunities for students within the program. This is achieved for all students within the program as new major courses are offered reflecting industry current practices within the data science field. This is achieved for all students within the program by providing

opportunities to complete undergraduate research with any of the faculty within the program. Opportunities are available for all students in the program to apply for fellowships related to the E-Nnovation grant, under supervision of the Endowed Professor. Opportunities are available for all students in the program to apply for undergraduate research fellowships already in existence in the School of Natural Science and Mathematics. As indicated previously, similar partnerships have been formalized with MITRE and the FDA that will provide internship opportunities within key program application areas. The intention of the department is to continue to expand partnership opportunities across a spectrum of application areas.

Frederick County is the third fastest growing county in Maryland with a 0.9% increase in population from July 2015 to July 2016. With its location equidistant to the Washington as well as the Baltimore metropolitan areas, the county has many professionals working in those regions across a broad spectrum of careers. Government is a big presence in both metropolitan areas and a large employer of residents within Frederick County. Additionally, government locations like FEMA in Emmitsburg and Ft. Detrick in Frederick are local employers with heavy reliance on data literate professionals. The opportunities to expand research and internship partnerships between a Mount St. Mary's University data science degree program and regional industry are unlimited.

The Mathematics and Computer Science department and the School of Natural Science and Mathematics at Mount St. Mary's University have a long-standing history placing graduates with top STEM employers in the region. Recent MSMU Mathematics and Computer Science graduates have been employed by Northrup Grumman, Raytheon, Lockheed Martin, Johns Hopkins Advanced Physics Laboratory, Patuxent River Naval Air Station, NSA, SAIC, and Booz Allen Hamilton, among many others. The proposed degree program will benefit from existing advisory connections with regional STEM employers comparable to other degree programs within the department. Alumni feedback from recent graduates is also a critical element to ensure degree programs align student outcome and employer needs.

Innovation Goal, Strategy 11: Encourage a culture of risk-taking and experimentation

By teaching the data science curriculum to undergraduate students, it will be necessary to scale the traditional graduate level curriculum to an audience that will not have the graduate level foundational rigor. Based on the dramatic gaps between supply and demand within data related careers in the state and region, and the demonstrated demand for students with bachelor's degree expertise, the risk in scaling the curriculum is justified.

The degree curriculum is designed in a manner that enables MSMU to integrate new application areas without modifying the foundational structure of the program. This approach enables the proposed data science major to advance the development of highly sought data literacy skills across a variety of discipline areas, now and in the future. A shared technology skill base within the program not only provides consistency in what participants have learned, but also minimizes impact to departments on campus that may have less experience with those technology skills. A shared technology skill base provides an opportunity to align technical material with any discipline as demand or interest develops, thus allowing the Data Science major to adapt to a changing workplace at minimal risk and expense.

With a consistent foundation in the basic skills, students from all application areas learn and grow side by side together; a pattern that will align to their future careers. This approach builds naturally on Mount St. Mary's University's Core curriculum focus to develop all aspects of our future leaders. The benefit to this approach is an expansion of data expertise to a broader audience than STEM students alone. The expectation is that for some students the motivation will also have been fueled to pursue advanced studies within data science to gain deeper understanding, and that this advanced study will occur within a variety of application areas. As MSMU has seen success in this area with only the data science minor in place, it is not an unreasonable expectation to achieve.

Finally, the program is designed to align to the expectation that not every graduate of the Data Science major will become a data scientist. While this may sound like a surprising statement on the surface, at the heart it is not surprising at all. Computer Science majors head into a variety of career directions all connected with computer science. Some will enter the information technology work force, others will focus on databases, others will move into analytics roles, and still others will become programmers and software engineers. Few will attain the title *Computer Scientist.* Graduates of the proposed data science degree program will be well prepared to become data scientists as well as data analysts, data engineers, data architects, or any future data oriented roles. Graduates will be well prepared for advanced study in a variety of fields from economics to science to mathematics. Graduates of the program will be well prepared to adapt to changes in the future data driven workplace.

Success Goal, Strategy 6: Improve student experience by providing better options and services designed to facilitate prompt completion of degree requirements

Success Goal, Strategy 7: Enhance career advising and planning services and integrate them explicitly into academic advising and planning

Many support systems exist within Mount St. Mary's University, beyond the classroom, with a focus on the success of every student. This includes the Center for Student Engagement and Success, workshops designed to teach critical organizational and time management skills, active faculty advisors, organizations aligned with student's curricular and future professional interests, and the Career Center focused on identifying internship and career placement opportunities. This existing infrastructure will be fully available to all students completing the proposed Data Science degree. For 2018-19, 69% of Mount St. Mary's University students completed internships prior to graduation. 98% of graduates were employed or in graduate school within one year of graduation, based on a 90% knowledge rate. Mount St. Mary's was named the #1 college for employment in Maryland for 2018-19 through federal data and the career guidance website Zippia.

C. Quantifiable Evidence of Market Supply & Demand Region and State

1. *Describe potential industry or industries, employment opportunities, and expected level of entry (ex: mid-level management) for graduates of the proposed program.*

2. *Present data and analysis projecting market demand and the availability of openings in a job market to be served by the new program.*
3. *Discuss and provide evidence of market surveys that clearly provide quantifiable and reliable data on the educational and training needs and the anticipated number of vacancies expected over the next 5 years.*

In a frequently referenced article, McKinsey Global Institute (MGI) and McKinsey's Business Technology Office indicated "*…The amount of data in our world has been exploding, and analyzing large data sets—so called big data—will become a key basis of competition, underpinning new waves of productivity, growth, innovation, and consumer surplus…*" Additionally, the report indicated "*…There will be a shortage of talent necessary for organizations to take advantage of big data. By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions…*" These same observations were restated in the March, 2017 Inside Higher Ed article in which the shortage of data literate job candidates was highlighted as among the nation's top skills gaps. LinkedIn highlighted in August 2018 that these projections had become reality as the number of individuals graduating with adequate skills to enter data professions demonstrated a gap between supply and demand of over 150,000 people.

In the Bureau of Labor Statistics Occupational Outlook, a summary of the 20 fastest growing occupations from 2016 to 2026 is provided. Among the occupations listed, statisticians are listed at #7, software application developers at #9, mathematicians at #10, information security analysts at #16, and operations research analysts at #18. A recent US News and World Report article highlights eight college majors with great job prospects. Computer Science is #3 on that list with Data Science at #4. Bankrate.com has evaluated and identified what they view as the best college majors for the money. On their list, applied mathematics came in at #5, mathematics and computer science at #23, computer science at #30, and statistics and decision science at #37. Graduates of the proposed data science degree program would have completed training sufficient to enter the job market or graduate study within any of these occupational areas.

In a March 2019 article, the Wharton Business School attempted to address the question What's Driving the Demand for Data Scientists. In that article, several key points were highlighted, including the significant difference between supply and demand, the utilization of data science skills outside high tech and software companies, and the widening gap between needs of organizations and the abilities of job candidates. The article includes a quote from "*The Future is Now: Closing the Data Analytics Skills Gap*" town hall in which it was highlighted that "…data science and machine learning-related jobs, taken together, represent five of the top 15 growing jobs in America today…"

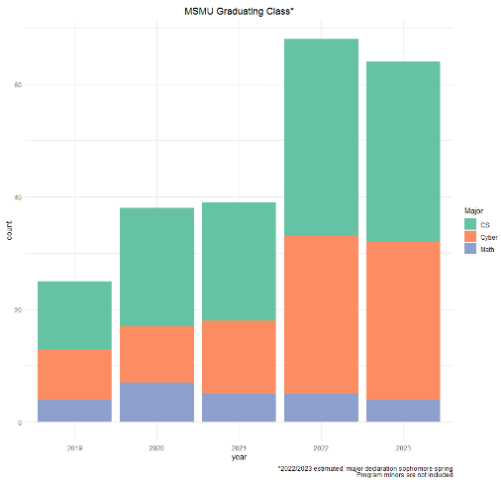
As highlighted previously, completing an open position search using the Indeed search engine returned 26,445 *data* related jobs on August 29, 2019. Among those positions included a *Junior Data Scientist* within the hotel industry, an entry level *Data Scientist* with a video game publisher and developer in Rockville, a *Junior Data Scientist* with Booz Allen Hamilton in Annapolis Junction, a *Junior Data Scientist* with a software company in College Park, a *Data*

Analyst to analyze utility energy data in Germantown, a *Data Analyst* at an insurance company in Frederick, a *Data Science Intern* in Baltimore for geospatial and weather data, an *Acoustic Signal Processing Data Scientist* in Millersville, and numerous *Data Scientist* positions at NSA. All positions highlighted required bachelor level degrees in data science related fields.

Data literate employees are needed across a spectrum of disciplines, and job titles. All of the positions highlighted above required bachelor's level education; many more were listed. The requirements stated in many of these positions included comfort with the variety of formats of data, how to acquire data, how to clean and engineer data, how to prepare data for decision making, how to generate commonly used machine learning models, and how to appropriately capitalize on that data in the decision making process. The technical tools specified align fully with tools already taught within the curriculum, or with tools projected to add to the curriculum as new courses through the introduction of the *Endowed Professor in Computational Sciences and Mathematics*.

4. *Provide data showing the current and projected supply of prospective graduates.*

Since the introduction of the Cybersecurity major three years ago, the program has seen dramatic increases in the number of entering students not only within Cybersecurity, but within related degree programs within the department.



As Cybersecurity majors increased, so did the Computer Science majors. Some of the increases were due to students choosing to double major in both Cybersecurity and Computer Science. Some of the increases were due to trends occurring within Computer Science across the country. Many students came to MSMU to study Cybersecurity, and chose to complete the double major. Based on the trend observed since the Cybersecurity major introduction, similar patterns are anticipated with introduction of the Data Science major. It is anticipated the program will see some level of increase within all three majors within the program. Given the application area element of the major, there is potential to see increase for other majors across the university curriculum that participate in the application domain areas.

Estimating numbers for undergraduate enrollment in the Data Science major is difficult as data science programs at the undergraduate level are relatively new for most schools across the country. This limits available data to use for projection purposes. A less formal data gathering related to MSMU current student population within the existing Data Science minor reflects over 50 freshman and sophomore level students entering the data science curriculum annually. The interest level is slightly higher as some students were waitlisted due to full enrollment in the initial course. Course enrollment for the first course in the minor sequence has more than doubled since the minor rolled out three years ago. As a result of current enrollment and wait lists, additional sections will be opened in the coming academic year. It is anticipated that the number of students entering the data science curriculum will be approximately 80 after

expansion of the initial course sections next year. While students take the initial course for a variety of reasons, the dramatic increases are still reflective of a high level of interest in this curriculum. In academic year 2017-2018, 3 students graduated with the Data Science minor. In academic year 2018-2019, 8 students graduated with the minor, and based on numbers of students currently enrolled in the final course in the minor sequence as well as counting additional students that have declared the Data Science minor, 27 students will graduate with the Data Science minor in academic year 2020-2021.

D. Reasonableness of Program Duplication

1. *Identify similar programs in the State and/or same geographical area. Discuss similarities and differences between the proposed program and others in the same degree to be awarded.*
2. *Provide justification for the proposed program.*

Evaluation of the current degree offerings for all 4-year institutions tracked at the Maryland Higher Education Commission site indicates there are few bachelor's degree programs in data science. Loyola University has offered a Data Science degree at the undergraduate level since 2018. Johns Hopkins offers a BS in Applied Mathematics and Statistics, Computer Science with Natural Language Processing focus area, and Computer Science with Big Data focus area. The University of Maryland, College Park offers a Computer Science degree with Data Science specialization. All other 4-year colleges and universities offer data science courses within mathematics and computer science curriculum, but offer neither a data science major nor a computer science with data science focus area degree.

Specific to the western Maryland area, there is no duplication related to proposed program. Hood College announced earlier this year a partnership with Google to offer data science courses within the computer science department, but does not offer a data science major or minor according to their web site.

The table below summarizes the proposed MSMU Data Science degree curriculum in comparison to existing data science programs within the state of Maryland.

Inst.	Degree Curriculum	Bachelor's Degree	Course Requirements	Additional Details
MSMU	Foundational courses within mathematics and computer science, interdisciplinary application area	Proposed BS, minor since 2016 AY	3 required CS (computer science), 2 required MATH (mathematics), 4 required DATA pulled from existing minor, 5 elective courses in application area, Capstone	16 total courses, 49 credits. Analytics for Business, Computational Science, Data Engineering, Operations Research application areas. Data Structures and Linear Algebra required; statistics taught throughout DATA curriculum, no separate course requirement. Ethics integrated through the university Core curriculum as well as foundational DATA course.
Loyola University	B.S. Data Science	Since 2018	12 required courses from existing CS (computer science),	15 total courses, 45 credits. 3 elective courses, no expectation elective selection within one application

of Maryland			IS (information systems), ST (statistics), MA (mathematics) curriculum; 3 additional electives	domain. Calculus I, no Linear Algebra required, Data Structures not required. Capstone integrates ethical concerns.
Johns Hopkins	B.S. Applied Mathematics & Statistics, B.S. Computer Science with NLP focus, B.S. Computer Science with Big Data focus	No Data Science specific degree	Computer Science degree options: 7 required CS courses, 3 required Math	Applied Mathematics & Statistics has traditional mathematics courses through Probability and Statistics with opportunity to integrate electives related to statistical learning; 52 credit Computer Science degree including course options within data science related focus areas. No capstone
UM College Park	B.S. Computer Science with Data Science specialization	Degree in Computer Science, data science specialization	3 required MA courses, 1 required STAT, 9 required CS, 4 electives	Computer Science degree with template related to specific courses to select within curriculum to obtain specialization; No capstone

The intention of the proposed Data Science degree is to include elements of Mathematics, Statistics, and Data Science throughout the curriculum while providing opportunities for students to focus their data science skills within an application area. The design of the curriculum enables common foundational concepts to be learned by students with interests in a variety of application areas prior to providing an opportunity for the student to focus within their selected application area.

While there is overlap in course curriculum with Johns Hopkins University as well as the University of Maryland, degrees at those institutions are foundationally computer science degrees with opportunities to complete electives within a data science related topic. There are no course requirements that enable the students to apply data science skills learned to a specific application area. Additionally, neither program includes a capstone requirement demonstrating skills learned as culmination of program. Finally, while ethics might be integrated within specific courses, there is no requirement that graduates of program would have completed an ethics based approach to data science as MSMU graduates would have achieved through the Core curriculum.

Loyola University has more of an overlap in terms of curricular expectations. However, that overlap exists only within the foundational computational skills. There is no expectation identified within the curriculum for students to then apply data skills to a specific application area. The design of the degree is more in alignment with Association of Computing Machinery (ACM) guidelines than the MSMU proposal, resulting in a degree that emphasizes the technical aspects of the discipline. As the goal of the MSMU proposed degree is to draw in students from variety of backgrounds to learn data science foundations, and to enable the degree to expand to new application areas in future, the differences between the data science degrees are by design.

As the Mount St. Mary's University proposed Data Science degree weaves together existing curriculum from traditional programs like Mathematics and Computer Science with courses specifically designed for the Data Science curriculum, the proposed degree has a unique foundation to that of existing programs within Maryland. Heavy reliance on an ethics focused

core curriculum within the university is a critical element of the proposed degree ensuring ethical concepts are taught to students at all levels throughout program completion. The focused application area required to complete the degree is distinctly unique from any of the potential overlapping degree programs currently in existence within the state of Maryland.

Finally, Mount St. Mary's University, as a Catholic institution, frequently draws from a different population of students than would be expected for either Johns Hopkins University or the University of Maryland, College Park. While Loyola University provides a comparable basis in Catholic teaching, the application specific elements of the Mount St. Mary's proposed degree remove duplication of degree direction. The focus for the Mount St. Mary's degree is to enable students with a variety of application interests to learn common data science techniques, and to complete the degree by applying those techniques within a chosen application area.

E. Relevance to Historically Black Institutions (HBIs)

1. *Discuss the program's potential impact on the implementation or maintenance of high-demand programs at HBI's.*

Potential impact on high-demand programs at HBI's

Not applicable. The proposed program does not duplicate or compete with programs at any of the regional HBIs.

F. Relevance to Identity of Historically Black Institutions (HBIs)

1. *Discuss the program's potential impact on the uniqueness and institutional identities and missions of HBIs.*

Potential impact on the uniqueness and missions of HBIs

Not applicable. The proposed program does not duplicate or compete with programs at any of the regional HBIs.

G. Adequacy of Curriculum Design, Program Modality, Learning Outcomes

Program Background

1. *Describe how the proposed program was established, and also describe the faculty who will oversee the program.*

The impetus for moving forward with a Data Science degree program was driven in part by the growing interest expressed by students participating in the Data Science minor, by inquiries from potential students and parents related to the Data Science program at university admissions events, and by the rate at which data science is expanding into every aspect of the modern workplace and daily life and our belief that our mission in developing ethical leaders can play a key role.

The development of the proposed curriculum was driven by several key goals. First, the degree should teach common technical skills for all participants, regardless of the application area. As students graduate from their individual degree programs, they enter a workforce that combines individuals from a variety of disciplines into teams, often performing the same tasks side by side. The ability to perform those tasks is highly dependent on the level of expertise the individual has developed, often in foundational skills. As data science expands into a variety of disciplines, each with their own particular domain expertise, the foundational concepts do not change. All of our graduates will grapple with technology in their future lives. All of our graduates will need to adapt and change as technology changes. All of our graduates will be faced with changes in the workplace that will make some career directions obsolete. It is critical that all of our graduates are able to adapt to that world, so it was deemed critical that all graduates of the proposed data science curriculum, regardless of application area, come prepared with the same foundational skills.

As data science application domains continue to expand, the data science curriculum should be prepared to adapt to future application areas across the full university. In order to do this, it will not be feasible to constantly introduce different flavors of a common degree, hire faculty teaching common skillsets, and deliver for our students in an environment that requires the ability to constantly adapt to the changing technology workplace. The goal was to design the degree to enable the university to quickly adapt as new disciplines choose to integrate data science concepts into their curriculum. By mixing and matching course building blocks from the existing data science curriculum, rollout to new application areas could be accomplished with minimal new course development specific to the application area. These building blocks allow the university to adapt at minimal risk and expense to the rapidly changing needs of our graduates' future workplace. As a result, this goal ensures that Mount St. Mary's University can work together as a community to adapt to the needs of current and future students.

Integration of the data science degree curriculum could be completed within three potential interdisciplinary scenarios:

1) A department is interested in providing data science experience to enable their majors to increase their job market skillsets. The Mathematics and Computer Science department would collaborate with these programs to identify courses within the Mathematics, Computer Science, Cybersecurity majors and minors to fulfill student needs through individual electives or potential minors.
2) A department is considering a new major that has minimal overlap with elements of the Data Science major such as programming and foundational courses. The Mathematics and Computer Science department would collaborate with these programs to identify courses within the data science and computer science curriculum that could be repurposed within the new major, without necessitating creation of new courses.
3) A department is considering a new major that has substantial overlap with elements of the proposed Data Science major. In this scenario, the Mathematics and Computer Science department would collaborate with these programs to determine if needs could be met through development of discipline specific application courses that could be integrated within the application area of the major. Examples where this approach could prove beneficial: bioinformatics, cheminformatics, computational biology, sports analytics,

human resource analytics, medical systems planning, communication data science, business analytics, and digitized record analytics.

Examples of application areas initially considered in developing the proposed degree curriculum included computational science, operations research, data engineering, data architecture, scientific analysis, business analytics, sports analytics, network science, and digitized record analysis. Four of these were selected for initial proposal in order to focus curriculum development in the initial degree rollout: Computational Science, Operations Research, Data Engineering, and Analytics for Business. A student designed application area provides option for interested students to pick courses from a combination of existing application areas, with a minimum of three courses required from the same application area.

Much consideration was given to whether a new degree should be introduced versus introducing a track or focus area within the existing Computer Science or Mathematics majors. As one of the primary goals for developing the degree was to ensure individuals with interest in other discipline application areas could participate, this approach would not achieve the desired goal. Aligning within Computer Science would have provided those interested in pursuing Computer Science with optional paths, but would not have opened a path for those with interests in business, or history, or science to potentially participate. Aligning within the existing Computer Science or Mathematics degree would not have achieved the building blocks goal that would provide data science opportunities across the curriculum, for those interested.

As mentioned previously, data science undergraduate degree programs are relatively new. In developing a curriculum for the proposed degree, limited frameworks were available to evaluate as a starting point. The proposed Data Science degree curriculum was designed using both the Association of Computing Machinery (ACM) Data Science Task Force Initial Report and the College of Charleston Data Science major as references. The ACM guidelines were referenced to identify the foundational technical skills. The College of Charleston was used as a guide for developing a major that can be repurposed across multiple disciplines. As a goal of the proposed Data Science major is to provide an avenue for students interested in a variety of discipline application areas to study side by side, some curriculum modifications specific to the ACM report were needed to ensure room for application area focus alongside critical technical skills. As a goal of the proposed Data Science major is to depend on all elements of the existing Core curriculum in the development of ethical thought processes, some reduction in the overall ACM course completion expectations was needed. The proposed degree program with 49 credits aligns closely with 48 credits for Cybersecurity degree, 43 credits for Computer Science degree, and 41 credits for Mathematics degree while retaining technical overlap within these partner degree programs.

The program will be housed in the Mathematics and Computer Science department at Mount St. Mary's University. This department supports the Mathematics, Computer Science, and Cybersecurity major curriculum as well as curriculum for four existing minors in Mathematics, Computer Science, Data Science, and Cybersecurity, and two post-baccalaureate degree programs in Data Science and Cybersecurity.

The department chair of the Mathematics and Computer Science department will have responsibility for ensuring that foundational technical content remains aligned to the proposed degree curriculum. Within the application area curriculum, the Mathematics and Computer Science department chair will have responsibility to ensure existing and proposed new interdisciplinary courses continue to align with degree objectives. The department chair will collaborate directly with the department chairs of participating disciplines to ensure this alignment occurs.

As new application areas are considered, these will be vetted first through the Mathematics and Computer Science department to ensure alignment with the degree objectives before engaging the faculty Committee on Curriculum and Assessment (CCA).

Educational Objectives and Learning Outcomes

2. *Describe educational objectives and learning outcomes appropriate to the rigor, breadth, and (modality) of the program.*

The proposed Data Science degree provides background in mathematics, statistics, computer science, and data specific skills throughout. The curriculum builds on the Core curriculum required of all Mount St. Mary's University undergraduates. The curriculum is further enhanced by the application areas to provide an opportunity for interdisciplinary focus in the learning experience. As the curriculum relies on existing components, educational objectives and learning outcomes are derived from the existing educational objectives and outcomes for the various majors within the department as well as from the curricular goals for university curriculum.

Data Science learning objectives are derived from university curriculum goals 3 and 4:

- Competencies (Goal #3): Master the skills of analysis, interpretation, communication, and problem solving.
- Major Field of Study (Goal #4): Understand the purposes and concepts of at least one major field of study and become proficient in its methodology

Data Science learning objectives are also derived from specific program goals related to the Mathematics and Computer Science degrees:

- MA1: Proficiency in important areas of undergraduate mathematics such as analysis, algebra, and discrete mathematics
- MA2: The ability to investigate clarify, and solve quantitative problems
- MA3: The ability to communicate mathematics with precision and clarity
- MA5: Preparation for success in graduate study and professional careers in business, industry, government, and teaching
- CS1: Proficiency in several sub disciplines of computer science such as software development, computer architecture, algorithm analysis, and artificial intelligence
- CS2. The ability to apply the tools and techniques of computer science to effectively investigate and solve quantitative problems

- CS3. The ability to communicate technical ideas from computer science with precision and clarity
- CS4. Preparation for success in graduate study and professional careers in business, industry, government, and teaching

Resulting educational objectives for the proposed Data Science major include:

- Provide students with relevant training from across mathematics, statistics, and computer science as well as interdisciplinary material from application specific domain areas.
    - Hands on experience building data science products from a variety of data sources
    - Experience applying data science within a variety of disciplinary backgrounds
- Provide foundations in statistical techniques, algorithmic and computational thinking, and experience with a variety of data formats and platforms
    - Develop ability to focus on "why" over "how"; skills are important; adapting is critical
    - Strengthen aptitude for learning new technical skills; "learn to learn" in order to adapt to future changes in techniques, domains, etc.
- Prepare students to consider not only technical aspects of data science problems, but social and ethical implications as well.
    - Build an ethical foundation to influence data decision-making in the development of future data science ethical leaders
- Provide broad exposure to data science applications to prepare graduates to adapt to a variety of problem domains, and to continue education at a graduate level
    - Provide numerous opportunities to experience techniques within application areas
    - Offer a variety of internship and undergraduate research opportunities for program participants
    - Integrate industry expertise in classroom instruction through industry partnerships

Specific Learning Outcomes for the proposed Data Science major include:

- LO1: Demonstrate an understanding of basic concepts related to data science, including the data science lifecycle; statistical techniques; data acquisition, management and governance fundamentals; data privacy and security; fundamentals of data engineering, data mining and data architectures; computing fundamentals of programming, data structures, and algorithms; machine learning models including assumptions and assessment of model performance; and big data and high performance computing techniques.
- LO2: Ability to apply the tools and techniques of data science to effectively investigate and solve real-world problems in general as well as within domain-specific applications
- LO3: Ability to communicate technical ideas with precision and clarity
- LO4: Demonstrate an understanding of the ethical issues within the data science profession so graduates are prepared to function as ethical leaders within the data science community
- LO5: Preparation for success in graduate study and professional careers

Student Assessment and Documentation of Learning Outcomes

3. *Explain how the institution will:*
    a) *provide for assessment of student achievement of learning outcomes in the program*
    b) *document student achievement of learning outcomes in the program*

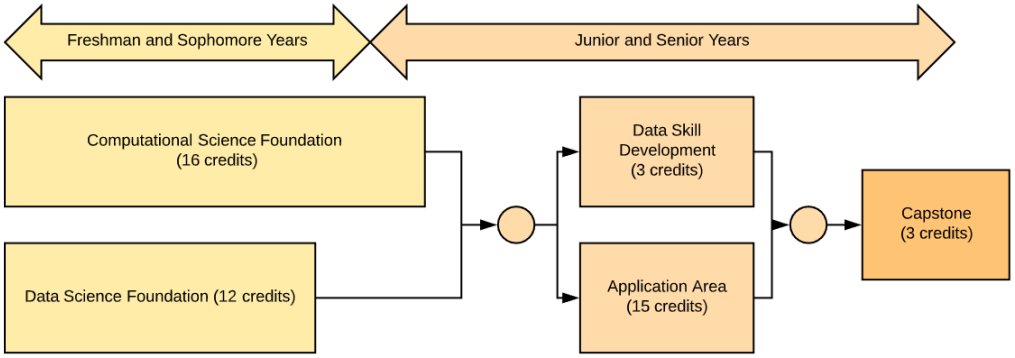
A similar approach to that used in developing educational objectives and learning outcomes from existing curriculum, assessment and documentation development will build on many of the elements currently in place within the department. ETS exams are utilized within Computer Science and Mathematics to measure some learning objectives, however, no ETS exam exists specific to Data Science. As a result, departmental exams will be developed that align with portions of several key data science certification exams such as the Certified Analytics Professional (CAP), Data Science Council of America (DASCA), and IBM Certified Data Architect and Watson IoT Data Science certificates.

Details of Data Science degree assessments in alignment with stated learning outcomes can be found in section M of this document.

Program Requirements

4. *Provide a list of courses with title, semester credit hours and course descriptions, along with a description of program requirements*

As discussed previously, the curriculum is divided into framework components designed to deliver against key objectives and goals. Details specific to each framework component are provided below. Course descriptions are provided in the Program Summary section.



Data Science Foundation (12 credits, all required)

Data Science foundation courses are designed to build on one another, and to develop the full data science lifecycle expertise while investigating a variety of application areas. While the rank order varies across review sources, the top three programming languages for data scientists consistently include R, Python, and Java. Data Science foundation courses make use of the R statistical computing environment as it is well suited for full data science lifecycle,

reproducibility, and seamless integration of communication with analysis and modeling steps. Python and Java skills are developed through the Computational Science Foundations courses. The Data Science foundation fulfills the primary goal of developing technical skills of students from a variety of discipline interests side by side.

Foundation courses are heavily project focused, and provide an opportunity for students to experience data science projects aligned to a variety of topic areas. This enables students to develop consistent data science skillsets while exploring specific application areas. All courses stress written and oral communication skills throughout, and challenge students to consider data science concepts not only from technical perspective but also from ethical implications within application areas.

Three 1-credit special topics to be completed in the sophomore or junior years keep data science skills (R, Python, Java) current after completion of foundation courses, and allow students the opportunity to explore potential areas of interest for application area study in future.

Required courses include: DATA200, DATA201, DATA210, DATA220 (12 credits)

Computational Science Foundation (16 credits, all required)
Computational Science foundation courses are designed to develop critical computational skills consistently leveraged throughout data science: algorithmic thinking, programming confidence, and foundational mathematics skills through linear algebra. Computational Science foundation courses make use of Python (CMSCI120) and Java (CMSCI125) ensuring all data science majors have experience with the top Data Science languages. The Computational Science foundation fulfills the primary goal of developing technical skills of students from variety of discipline interests side by side.

Required courses include: CMSCI120, CMSCI125, CMSCI254, MATH247, MATH364 (16 credits)

Data Skills Development (3 credits)
Data skills development focuses on developing student's understanding of digital data storage, organization, retrieval, and utilization at a deeper level than can be achieved in foundational courses. Data specific skills are developed through selection of one course; the remaining courses in the Data Skills area are available for study in the Computational Science focus area.

Select one course from: CMSCI359, DATA320, DATA330, DATA340 (3 credits)

Application Area (select 5; 3+ at 300 level or above, 15 credits)
The Application Area aligns courses to specific discipline domains, thus helping formulate a direction for student focus. As data science continues to expand into other disciplines, new application areas can be introduced by using existing as well as creating some new courses without requiring changes to structure or intent of major. This provides flexibility to introduce new application areas with minimal curricular and resource impacts.

The initial Data Science degree curriculum includes four application areas: Computational Science, Operations Research, Data Engineering, and Analytics for Business. A student designed application area provides an option for interested students to pick courses from a combination of existing application areas, with a minimum of three courses from a common applications area.

Student Designed Focus Area
With program permission, select five courses from across focus areas to combine into area of interest for individual student

Capstone Course (3 credit project)
The capstone course provides an opportunity to demonstrate mastery of concepts completed throughout the major.

The full major is 49 credit hours, scaled sufficiently to enable students within some programs to complete double majors. Students from other majors who are unable to double major with Data Science will still have option to complete the Data Science minor which contains overlapping technical elements to the overall major.

Program Summary

Course Mapping to Foundational Skills				
	Foundational Concepts		Skills Development	Demonstrate Proficiency
Course	Data Science	Computational Science	Data	Capstone
CMSCI120 (3cr)		Required		
CMSCI125 (3cr)		Required		
CMSCI254 (3cr)		Required		
CMSCI359 (3cr)			Select 1	
DATA200 (3cr)	Required			
DATA210 (3cr)	Required			
DATA220 (3cr)	Required			
DATA201 (3cr)	Required			
DATA320 (3cr)			Select 1	
DATA330 (3cr)			Select 1	
DATA340 (3cr)			Select 1	
DATA475 (3cr)				Required
MATH247 (4cr)		Required		
MATH364 (3cr)		Required		

Application Areas (select 5 within 1 area)				
Course	Computational Science	Data Engineering	Operations Research	Analytics for Business
CMSCI349	x	x		
CMSCI359	x	x		
CMSCI449	x			
CMSCI459		x		
DATA320		x		
DATA330	x	x		
DATA340	x	x		
DATA350	x	x		
DATA410	x			
DATA420	x			

DATA430	x	x		
DATA492	x			
MATH228	x		x	
MATH332			x	
MATH387	x		x	
MATH388	x		x	
MATH389	x		x	
MATH390			x	
MATH464			x	
MATH488			x	
MATH/CMSCI489	x		x	
ACCT311				x
ACCT312				x
ACCT413				x
BUS250				x
BUS344				x
BUS350				x
ECON211				x
ECON402				x
ECON403				x

Course List and Descriptions

Computer Science courses

CMSCI120: Introduction to Computer Science I (3 credits)

- This is an entry-level course in computer science that covers problem-solving methods and the development of algorithms. Students are taught how to design, write, edit, test, debug and document simple computer programs. Principles of modularity and information hiding, good programming style and elementary data representation are covered.

CMSCI125: Introduction to Computer Science II (3 credits)

- A continuation of programming techniques from CMSCI120, this course emphasizes the object-oriented paradigm. Students learn about class design, inheritance, input and output to files, and arrays.

CMSCI254: Data Structures and Algorithms (3 credits)

- The study and implementation of computer algorithms that utilize data structures are examined in detail. Such structures include linked lists, stacks, queues, trees, heaps and graphs. Searching and sorting algorithms are discussed. Students learn about recursion and running-time analysis.

CMSCI349: Software Engineering (3 credits)

- This is an introductory course in software engineering. Techniques in software design and development are studied. Topics include structured design, structured programming, top-down design and development, segmentation and modularization techniques, iterative enhancement, design and code inspection techniques and correctness. Principles of object-oriented design and the Unified Process are stressed. Includes experience in applying techniques through the development of a large software project.

CMSCI359: Database Management Systems (3 credits)

- The design, organization, and implementation of database systems are studied. Topics include the relational model, entity-relationship modeling, normalization, SQL, and database programming.

CMSCI449: Introduction to Artificial Intelligence (3 credits)

- The concepts and applications of artificial intelligence are examined. Topics may include knowledge representation, searching state space, heuristic search, expert systems, natural language processing, propositional logic, learning and cognitive models, and computer vision.

CMSCI459: Database Implementation ***new*** (3 credits)

- Topics include physical and logical database design and schemas; file organization, local and distributed; buffer management; hash tables; advanced querying and query optimization; device management; database security.

Data Science courses

DATA200: Introduction to Data Science (3 credits)

- This course presents an overview of the discipline of data science: its goals, methods, tools, and scope. Descriptive and inferential statistics for univariate categorical and quantitative data is included. Writing intensive course focused on communicating with data for data manipulation, statistical analysis, visualization, and report writing. Ethical issues surrounding data collection and use are discussed.

DATA210: Exploratory Data Analysis (3 credits)

- Focus of course is the acquisition, cleaning, manipulation, transformation, and analysis of data obtained from variety of sources. Descriptive and inferential statistics for bivariate categorical and quantitative data is included. Higher dimension data relationships and visualizations are explored for summarizing data numerically and graphically. Communication intensive course expanding abilities specific to describing statistical significance of data patterns identified.

DATA220: Machine Learning Models (3 credits)

- This course is an overview of supervised and unsupervised data science models, and their application. These include regression, classification, and clustering algorithms. Course seeks to examine the assumptions, capabilities, limitations, and advantages of these models within the context of application areas. Communication intensive course demonstrating full data science lifecycle and reproducibility of results. Ethical issues surrounding application of data models are discussed.

DATA201: Special Topics in Data Science (3 1 credit courses)

- Students work on advanced projects or study in some area of data science. Examples include machine learning, data mining, natural language processing, network science, interactive visualizations, and specific applications of data science. This course is offered at the discretion of the department with regard to the needs and aptitudes of the students

with preference to completion of DATA200 prior to enrollment. New skills are developed while building on skills learned in DATA200, DATA210, and DATA220.

DATA320: Data Architecture ***new*** (3 credits)

- Topics include Map-Reduce architectures selected from current technologies such as: Spark, Hive, Pig, Kafka, Hadoop, HBase, Flume, MongoDB, Cassandra; Cloud Analytics; container architectures; streaming, real-time platforms; Data as a Service (DaaS); data organization and security.

DATA330: Data Wrangling ***new*** (3 credits)

- Expansion of data exploration topics covered in DATA210 to include expanded data query access (relational databases), NoSQL, HTML, XML, JSON, RESTful and SOAP services, OAuth and social media, web scraping, text mining, image processing. Advanced techniques for data filtration and summarization are included.

DATA340: Advanced Data Visualization ***new*** (3 credits)

- Topics include geographical mapping; choropleth maps; integrating time elements; creating interactive visualizations; implementing web visualizations; network visualizations and social media; data dashboards; integrating with web application technologies like HTML, CSS, and JavaScript.

DATA350: Natural Language Processing ***new*** (3 credits)

- Topics include bag of words text classification and sentiment analysis, topic modeling, language modeling, speech recognition, n-grams and correlation.

DATA410: Advanced Machine Learning ***new*** (3 credits)

- Topics include bootstrapping, bagging, boosting; regression regularization techniques; dimensionality reduction; support vector machines; semi-supervised and reinforcement learning; deep learning; time series modeling.

DATA420: High Performance Computing ***new*** (3 credits)

- Topics include algorithm design for multicore and core shared memory, for distributed memory such as clusters and supercomputers and for parallel computing. Additional topics include grid computing, GPU and co-processor computing.

DATA430: Network Science ***new*** (3 credits)

- Topics include random networks, scale-free property, evolving networks, degree correlation, network robustness, communities, spreading phenomena, applications within social media and science.

DATA475: Data Science Capstone ***new*** (3 credits)

- The capstone project leverages specific technology skills taught throughout the major, aligning with the data science lifecycle, and utilizing a domain mentor to complete a specific problem application.

DATA492: Practicum ***new*** (3 credits)

- Practicum presents an opportunity to gain practical experience through a one semester internship. The nature of the work experience and the number of credits must be approved in advance by the department chair. (As needed)

Mathematics courses

MATH228: Discrete Mathematics (3 credits)

- This course introduces the basic techniques and methods of reasoning for discrete problem solving. Topics include induction, set theory, elementary combinatorics, and graph theory. Applications to computer science are emphasized.

MATH247: Calculus I (4 credits)

- Introduction to fundamental concepts of differential and integral calculus with an emphasis on limits, continuity, derivatives and integrals of elementary functions. Applications to curve sketching, max-min values, related rates and areas. Derivatives and integrals of elementary transcendental functions are developed.

MATH332: Graph Theory (3 credits)

- The theory and practical applications of graph theory are studied. Topics include paths and cycles, bipartite graphs, digraphs, spanning trees, connectivity, matchings, coloring, planarity, Hamiltonian cycles, and graph classes.

MATH364: Linear Algebra (3 credits)

- This course examines the mathematics of matrices and determinants with applications to systems of linear equations, vector spaces, linear transformations, eigenvalues and eigenvectors, and canonical forms.

MATH387: Probability (3 credits)

- An introduction to the theory of elementary probability. Topics include Kolmogorov's axioms of probability, conditional probability and independence, finite combinatorics, discrete and continuous distributions, moment, jointly distributed random variables, limit theorems, generating functions, Markov chains and random walks.

MATH388: Operations Research (3 credits)

- An introductory course in operations research. Topics are selected from linear programming, network models, project scheduling, stochastic processes, game theory, queuing theory, decision analysis, non-linear programming, dynamic programming, simulation, and forecasting.

MATH389: Numerical Methods (3 credits)

- This course examines a variety of numerical methods for applications of mathematics. Topics include the numerical solution to nonlinear equations, interpolation, numerical differentiation and integration, and the numerical solution to differential equations.

MATH390: Mathematical Statistics (3 credits)

- The course provides the mathematical foundations of statistics. Topics include functions of random variables, transformations of random variables, order statistical, sampling theory and distributions, introduction to the theory of point estimation and statistical inference, confidence intervals, hypothesis testing, likelihood ration tests, regression, correlation, analysis of variance and analysis of enumerative data.

MATH/CMSCI489: Modeling and Simulation (3 credits)

- This course develops mathematical models and techniques for constructing mathematical models. Topics may include population growth, epidemics, scheduling problems, predator-prey interaction, transportation, economics and stochastic models.

MATH464: Advanced Linear Algebra ***new*** *(*3 credits)

- This course provides the linear algebra background for advanced work in algebra and analysis. Topics expand on vector spaces, linear transformations, matrix factorizations, projections, canonical forms, eigenvalues, determinants, infinite dimensional linear spaces. Possible applications to approximation theory, computation, spectral theory, and numerical methods for eigenvalues.

MATH488: Stochastic Processes ***new*** (3 credits)

- An introduction to random processes and their applications with focus on discrete-time point of view with some discussion related to continuous-time. Common random processes including white noise, random walks, Gaussian processes, Markov processes, and Poisson processes are discussed. Instructor discretion to include more advanced statistical concepts including signal processing and spectrum estimation.

<u>Business courses</u>

ACCT311: Forensic Accounting and Fraud Examination

- This course is an introduction to the practice of forensic accounting and will examine the role of the forensic accountant in investigating fraudulent financial reporting and misappropriation of assets including the various schemes involves in financial statement fraud, theft, embezzlement, procurement and disbursements fraud, and money laundering. The course will emphasize the tools and techniques used by forensic accountants to detect and investigate these various frauds including digital analysis and other computer-based applications. Students will also ready and study actual case studies and apply the principles learned in this course to the fraud schemes perpetrated.

ACCT312: Forensic Account and Litigation Advisory Services

- This course explores the litigation advisory services discipline of forensic accounting, including the various litigation support services and expert testimony provided by forensic accountants. The course will focus on the US civil court system; commercial claims, torts, and intellectual property dames; and how forensic accountants compute economic losses and damages. In addition, the course will examine the forensic accountant's role in conducting business valuations and analysis. The course also explores proper evidence management, including a brief introduction to investigating electronic evidence, performing digital forensic analysis, and the role of the digital

forensic specialist. Students will study actual case studies and apply the principles learned related with these forensic disciplines.

ACCT413: Introduction to Forensic Data Analytics and Electronic Evidence

- This course examines the use of the computer and technology by both the perpetrators of fraud and other crimes along with how forensic accountants use the computer and technology as a means to detect and prosecute fraud and abuse. Students will learn and utilize modern forensic tools, techniques and computer-based applications used by forensic accountants in fraud investigations and other forensic work. Students will work with case studies and related data sets using certain forensic applications to uncover potential fraudulent transactions and information to aid in forensic investigations.

BUS250: Introduction to Business and Decision Making

- An exploration into the world of contemporary business from entrepreneurship and small business development, to organizational structure, finance, going global, data science, management, marketing, operations, and more. Students discover how problem solving and critical thinking are applied to decision making.

BUS344: Operations and Supply Chain Management

- An examination of the transformation process that converts inputs into outputs, and how it adds value to the outputs. Also investigates the concepts, insights, practical tools and decision support systems that are important for the effective management of supply chains. Long-term strategic design issues, shorter-term tactical and operational issues are closely examined. State-of-the-art concepts of globally optimal decision making, often across traditional organizational boundaries are emphasized.

ECON211: Intermediate Macroeconomic Theory

- Genesis of national income, consumption function, multiplier and the effect of money and credit conditions on output, prices and employment. Attention to public and stabilization policy, international trade, federal budgetary problems and the supply side of the economic model. Students are required to track the performance of the U.S. macroeconomy for one semester.

ECON402: Applied Economic Analysis

- Course introduces students to a practical economic analysis. Applied analysis in economics is on the cutting edge of economic research and it is necessary for making decisions. The knowledge of theoretical models, the application of those and the use of relevant information are critical to understanding how a project or policy initiative might impact a business, an industry, public policy or the public at large. This course has three main goals: learning basic theoretical models; applying economic analysis in the areas of Micro Theory, Economic Growth, Development, Poverty and Inequality, Spatial Econometrics, Experimental Economics, Behavioral Economics, Neuroeconomics and Public Policy.

ECON403: Econometrics

- Introduces students to some of the basic quantitative and statistical techniques used in empirical research in Economics. Students will learn how to formulate, estimate, evaluate, and interpret relationships between variables in the form of regression models with the help of Econometrics software, Stata. Topics covered include the classical linear regression model, hypothesis testing and evaluation of estimation results, specification of functional forms, implications of the violations of classical assumptions, introduction to time series data models, and introduction to binary dependent variable models. As part of the course requirements, students will apply some of the techniques learned in class to a research project of interest to produce a term paper.

General Education Requirements

5. Discuss how general education requirements will be met, if applicable.

General education requirements are met by Mount St. Mary's University Core curriculum. The Core curriculum is the academic embodiment of our Catholic mission. Rooted in the liberal arts, the program is a common and sequential curriculum that prepares students for success in the modern world, while giving them a solid grounding in the Catholic intellectual tradition.

More than just a set of requirements, the Core is integrated with every academic major, and includes leadership development and cultural components, giving every MSMU student a true liberal arts education in all of its dimensions—communication skills, cultural content and character formation.

Core requirements total 46-49 credits and have been aligned to general education requirements in the table below. Additionally, a sample 4 year plan for Data Science majors has been included that integrates the Core requirements along with major requirements. Potential double major paths have also been provided.

General Education Requirement	Applicable Courses	Credit Hours
Arts and Humanities	PHIL 103 Foundations of Philosophy	3
	PHIL 203 Philosophy in the Modern Age	3
	THEO 220 Belief in Today's World	3
	THEO 320 Encountering Christ	3
	THEO/PHIL 300 Ethics and the Human Good	3
	World Languages I, II	3-6
	WCIV 102 Origins of the West	3
	WCIV 201 The Western Imagination	3
	AMER 202 America in the World	3
	MO 300 Modernity in Art/Lit	3
	Global Encounters	3
English Composition	SFYM 101 First-Year Symposium	3

Social and Behavioral Sciences	Foundations of Social Science (ECON 101 or 102, EDUC 100, PSYCH 100, SOC 100)	3
Mathematics	MATH 211 Mathematical Thinking	3
Biological and Physical Sciences	Lab Sciences (selection from variety of courses)	4
TOTAL		46-49 credits

Sample Four Year Data Science Major Sequence			
Fall		Spring	
Courses	Credits	Courses	Credits
Freshman Year			
First Year Symposium	3	Origins of the West	3
World Languages I	3	World Languages II	3
Social Science	3	Foundations of Philosophy	3
Intro to Computer Science I	3	Intro to Computer Science II	3
Intro to Data Science	3	Exploratory Data Analysis	3
	15		15
Sophomore Year			
The Western Imagination	3	Belief in Today's World	3
Philosophy in the Modern Age	3	America in the World	3
Data Structures and Algorithms	3	Mathematical Thinking	3
Machine Learning Models	3	Linear Algebra	3
Calculus I	4	Data Skills Elective	3
	16	Data Science Special Topics	1
			16
Junior Year			
Modernity Lit/Art/Music/Theater	3	Ethics and the Human Good	3
Encountering Christ	3	Global Encounters	3
Application Area Elective	3	Application Area Elective	3
Application Area Elective	3	Elective	3
Elective	3	Lab Science	4
Data Science Special Topics	1		16
	16		
Senior Year			
Application Area Elective	3	Data Science capstone	3
Application Area Elective	3	Elective	3
Data Science Special Topics	1	Elective	3
Elective	3	Elective	3
Elective	3	Elective	1
	13		13
		Total credits	120

Sample Four Year Data Science/Mathematics Double Major Sequence

Fall		Spring	
Courses	Credits	Courses	Credits
Freshman Year			
First Year Symposium	3	Origins of the West	3
World Languages I	3	World Languages II	3
Social Science	3	Foundations of Philosophy	3
Calculus I	4	*Calculus II*	4
Intro to Data Science	3	Exploratory Data Analysis	3
	16		16
Sophomore Year			
The Western Imagination	3	Belief in Today's World	3
Philosophy in the Modern Age	3	America in the World	3
Intro to Computer Science I	3	Mathematical Thinking	3
Machine Learning Models	3	Linear Algebra	3
Calculus III	4	Intro to Computer Science II	3
	16	Data Science Special Topics	1
			16
Junior Year			
Modernity Lit/Art/Music/Theater	3	Ethics and the Human Good	3
Encountering Christ	3	Global Encounters	3
Data Structures and Algorithms	3	DS Application Area Elective^	3
DS Application Area Elective^	3	*Discrete Math*	3
Math Elective	3	*Differential Equations*	3
Data Science Special Topics	1	*Math Seminar I*	1
	16		16
Senior Year			
Lab Science	4	Data Science capstone	3
DS Application Area Elective^	3	DS Application Area Elective^	3
DS Application Area Elective^	3	*Algebraic Structures*	3
*Elective or Math Elective^*	3	Elective	1
Data Science Special Topics	1	*Math Seminar II*	1
	14		13
		Total credits	120

^MATH387, MATH388, MATH389, and MATH489 count as Data Science electives within the Computational Science or Operations Research application areas as well as Math electives. Two of the selected Data Science Application area electives can be counted toward both degrees.

Sample Four Year Data Science/Computer Science Double Major Sequence			
Fall		Spring	
Courses	Credits	Courses	Credits
Freshman Year			
First Year Symposium	3	Origins of the West	3
World Languages I	3	World Languages II	3
Social Science	3	Foundations of Philosophy	3
Intro to Computer Science I	3	Intro to Computer Science II	3
Intro to Data Science	3	Exploratory Data Analysis	3
	15		15
Sophomore Year			
The Western Imagination	3	Belief in Today's World	3
Philosophy in the Modern Age	3	America in the World	3
Data Structures and Algorithms	3	Mathematical Thinking	3
Machine Learning Models	3	*Principles of Software Dev*	3
Calculus I	4	*Discrete Math*	3
	16	Data Science Special Topics	1
			16
Junior Year			
Modernity Lit/Art/Music/Theater	3	Ethics and the Human Good	3
Encountering Christ	3	Global Encounters	3
Computer Architecture	3	DS Application Area Elective^	3
DS Application Area Elective^	3	*CS elective*	3
CMSCI 442, 453, or 485	3	*CS elective*	3
Data Science Special Topics	1	Data Science Special Topics	1
	16		16
Senior Year			
Lab Science	4	Data Science capstone	3
DS Application Area Elective^	3	DS Application Area Elective^	3
DS Application Area Elective^	3	*CS Senior Project*	3
CMSCI 442, 453, or 485	3	*CS elective*	3
CS Senior Project Proposal	1		1
	14		
			13
		Total credits	122

^DATA220 counts as a Computer Science elective, leaving three additional electives to complete. CMSCI349 and CMSCI359 along with DATA330, DATA340, DATA350 count for both Computational Science or Data Engineering application areas as well as Computer Science electives. At most one of the remaining three CS electives can be counted toward both degrees

Specialized accreditation or graduate certification requirements

6. *Identify any specialized accreditation or graduate certification requirements for this program and its students.*

   Not applicable

Contracting with another institution or organization

7. *If contracting with another institution or non-collegiate organization, provide a copy of the written contract.*

   Not applicable.

Timely Critical Information

8. *Provide assurance and any appropriate evidence that the proposed program will provide students with clear, complete, and timely information on the curriculum, course and degree requirements, nature of faculty/student interaction, assumptions about technology competence and skills, technical equipment requirements, learning management system, availability of academic support services and financial aid resources, and costs and payment policies.*

As part of the university curriculum, the proposed Data Science major will benefit from all existing support mechanisms in place to ensure students are fully engaged and aware of their path to success. This includes providing detailed information related to sample course sequencing examples as well as recommended hardware requirements, supporting departmental program question and answer sessions, and providing training on learning management systems, financial aid resources, and costs and payment policies at freshman/transfer student orientation. Students are assigned to an advisor in the first semester of freshman year. That advisor is also their freshman symposium instructor where reinforcement of keys to success, learning management systems, and other information are discussed. Students meet with advisor at least twice each year prior to course registration for the coming semester. Advisors work with students at those advising sessions to map out and continually revise a plan to complete desired major within a four year timeline goal.

Advertising, Recruiting, Admissions Materials

9. *Provide assurance and any appropriate evidence that advertising, recruiting, and admissions materials will clearly and accurately represent the proposed program and the services available.*

The proposed Data Science major will benefit from existing mechanisms in place within the Mathematics and Computer Science department, and within the overall university. This includes detailed information in the undergraduate course catalog, departmental web pages, and marketing literature. Sample course sequencing examples are typically provided to potential students at admission events. Additionally, folders with departmental information aligning with each individual major and minor are used at all admissions open house events, scholarship

events, as well as readily available for any students attending campus tours or other admissions events.

H. Adequacy of Articulation

1. *If applicable, discuss how the program supports articulation with programs at partner institutions. Provide all relevant articulation agreements.*

Within the Mathematics and Computer Science department, articulation agreements are in place with several regional community colleges specific to the Mathematics, Computer Science, and Cybersecurity degrees. The department has been working with additional schools in the region to expand articulation agreements further in order to provide more students with the opportunity to transfer into these degree programs. Additionally, a pipeline specific to the Cybersecurity program has been developed that enables students to start at Frederick Community College, transfer to Mount St. Mary's University to complete a BS, and then complete a MS at Hood College within a five year timeline. Articulation agreements are also in place between Hood College and Mount St. Mary's related to the Computer Science degree path. The proposed Data Science major would result in development of new articulation agreements in collaboration with all existing articulation partners.

I. Adequacy of Faculty Resources

1. *Provide a brief narrative demonstrating the quality of program faculty. Include a summary list of faculty with appointment type, terminal degree title and field, academic title/rank, status (full-time, part-time, adjunct) and the course(s) each faulty member will teach in the proposed program.*
2. *Demonstrate how the institution will provide ongoing pedagogy training for faculty in evidenced-based best practices, including training in:*
    a) *Pedagogy that meets the needs of the students*
    b) *The learning management system*
    c) *Evidenced-based best practices for distance education, if distance education is offered.*

The proposed Data Science major will be housed administratively within the Mathematics and Computer Science Department. The faculty who will teach foundational courses in the program will come from that department. These faculty have already demonstrated their ability to teach computer science, mathematics, and data science concepts within the curriculum. As mentioned previously, the Endowed Professor of Computational and Mathematical Sciences will be hired to begin teaching in the fall of 2020. This individual will hold a dual appointment as a Visiting Scientist at Leidos.

In the first iterations of the Data Science degree, faculty teaching the applications courses will come from a small cross-disciplinary group highlighted below. As the program matures, the expectation is that other application areas will be identified and integrated into the applications framework of the degree program.

The majority of the faculty listed below have terminal degrees in their field and many are experienced Associate and Full Professors.

Data Science, Computer Science Courses

Rebecca Portier, M.S. in Computational Mathematics – Ms. Portier has extensive experience in industry applications related to data and data models including roles as Operations Research Analyst, Mathematician, and Technology Manager. Prof. Portier teaches Computer Science and Data Science curricula. [Assistant Professor of Computer Science, Full-time]

Brian Heinold, Ph.D. in Mathematics – Dr. Heinold has taught across the Mathematics, Computer Science and Cybersecurity curricula [Associate Professor of Mathematics and Computer Science, Full-time]

Frederick J. Portier, Ph.D. in Computational Mathematics– Dr. Portier has taught across the Mathematics, Computer Science and Cybersecurity curricula including early iterations of the current Data Science minor courses [Professor of Mathematics and Computer Science; Full-time]

Scott Weiss, M.S. in Computer Science– Mr. Weiss has taught across the Computer Science curricula including Artificial Intelligence and Theory of Computation [Assistant Professor of Computer Science, Full-time]

Mathematics Courses

Brian Heinold, Ph.D. in Mathematics – Dr. Heinold has taught across the Mathematics, Computer Science and Cybersecurity curricula [Associate Professor Mathematics and Computer Science, Full-time]

Frederick J. Portier, Ph.D. in Computational Mathematics– Dr. Portier has taught across the Mathematics, Computer Science and Cybersecurity curricula including early iterations of the current Data Science minor courses as well as Operations Research, Numerical Methods, and Modeling/Simulation courses [Professor Mathematics and Computer Science; Full-time]

Melanie Butler, Ph.D. in Mathematics – Dr. Butler has taught across the Mathematics curricula including significant experience teaching statistics curricula [Professor Mathematics and Computer Science; Full-time]

Jonelle Hook, Ph.D. in Mathematics – Dr. Hook has taught across the Mathematics curricula including the Calculus, Linear Algebra and Graph Theory courses [Associate Professor Mathematics and Computer Science; Full-time]

Business Courses

Lawrence Hoffman, M.Acc in Accounting and GC in Forensic Accounting – Professor Hoffman teaches the Forensic Accounting and Auditing curriculum [Assistant Professor of Accounting and Forensic Accounting; Full-time]

Timothy Stanton, Ph.D. in Economics – Dr. Stanton teaches Foundations of Economics (Macro), Foundations of Economics (Micro), Data Mining, and Web Design [Associate Professor of Economics and Information Systems; Full-time]

Solomon Tesfay Tesfu, Ph.D. in Economics – Dr. Tesfu teaches Statistics and Econometrics [Assistant Professor of Economics and Statistics; Full-time]

Fr. Elias Yelovich, M.L.S. and M.S.I.S – Fr Yelovich teaches Information Systems, Business Technical Skills, Database and Senior Seminar [Assistant Professor of Information Systems; Full-time]

Alejandro Cañadas, Ph.D. in Economics – Dr. Cañadas teaches Foundation of Economics (Macro) and Corporate Finance [Associate Professor of Economics; Full-time]

Patrice Flynn, Ph.D. in Economics – Dr. Flynn teaches Global Business and the Economy, Introduction to Business and Decision Making in addition to numerous other courses within the business and economics curricula [Professor of Business and Economics; Full-time]

Over time, this list will expand to include application courses by full time faculty members across the university curricula.

J. Adequacy of Library Resources

1. *Describe the library resources available and/or the measures to be taken to ensure resources are adequate to support the proposed program.*

Mount St. Mary's University's Hugh J. Phillips Library currently contains over 200,000 bound volumes and a rapidly expanding collection of scholarly information databases that provide convenient access to e-books, journal articles and a variety of data sources. Included in our e-library are more than 25,000 professional and scholarly journal publications that are carefully chosen to support each of the University's academic programs.

The library has an excellent E-resources collection that includes discipline specific databases including the complete JSTOR back files. Content from Sage, EBSCO, ProQuest, Duke e-journals, ATLA and many others is available from the library's website http://libguides.msmary.edu/phillipslibrary. The library recently implemented the *EBSCO Discovery Service* that performs a single search of all library resources from one search interface. Computer Science, Applied Mathematics, Statistics, and many discipline specific subscriptions are currently available. Requests for additional resources can be made each year.

Our library staff includes four faculty librarians who provide research assistance and information literacy instruction to individuals and groups. A faculty librarian with theological training maintains the theology collection of approximately 46,000 volumes. Our main desk services,

resource acquisitions, cataloging and interlibrary loans are provided by four student/faculty-focused employees, with the help of several dedicated student assistants.

The Phillips Library is a founding member of the Maryland Interlibrary Consortium and collaborates with Hood College, Baltimore International College, Washington Adventist University (formerly Columbia Union College), Loyola College-Notre Dame University Library, and Stevenson University. Through this consortium, Mount students and faculty have direct access to the collections of each member library through electronic and physical delivery services. The average delivery time for print materials is within 24hours.

Table 1. 2017-18 Library Statistics		
Volumes	149,042	
Per FTE student	70	
Journal Titles-Paper	233	
Journal Titles-Digital	26,652	
Librarian Research Transactions	1,033	
Participation in Instruction Sessions	922	
Databases	133	
Videos	1,935	
Total Library Expenditures	$834,043	
Library expenditures per FTE student	$ 391	

Source: Mount St. Mary's Factbook 2019

K. Adequacy of Facilities, Infrastructure and Instructional Equipment

1. *Provide an assurance that physical facilities, infrastructure and instruction equipment are adequate to initiate the program, particularly as related to spaces for classrooms, staff and faculty offices, and laboratories for studies in the technologies and sciences.*
2. *Provide assurance and any appropriate evidence that the institution will ensure students enrolled in and faculty teaching in distance education will have adequate access to:*
    a) *An institutional electronic mailing system, and*
    b) *A learning management system that provides the necessary technological support for distance education*

The Data Science program will be offered primarily at the Mount St. Mary's University Emmitsburg location with some entry level course instruction for non-traditional students potentially offered at the Frederick campus. As part of the Mathematics and Computer Science department, the Data Science degree program will have access to the Coad Science Building facilities utilized by the program. Coad is a 48,000 ft^2 building that holds classrooms, faculty and staff offices, specialized laboratories, a vivarium, a computer lab, and a greenhouse. Existing computer laboratory space was recently renovated to expand utilization for the new Cybersecurity major. Those renovations were done with data science needs in mind as well, and will provide access to servers that will support any custom software or data access needs of the program.

The Frederick Campus is a 25,000 ft^2 facility with classrooms, offices, large conference room, two dining areas, chapel, and kitchen. The facility has some unused capacity in terms of classroom space so it will support the 1-2 additional courses per term that the Data Science program will introduce. Although it is a technical program, laboratory facilities are not needed at this site. Faculty instructors have access to the full resources of the facility including photocopiers, scanners, audio-visual equipment, phones, and office supplies. Administrative assistants provide administrative support and faculty also may avail themselves of the resources of the MSMU Career Center, Learning Services, Information Technology Support Center, and Health and Wellness Center.

Numerous online data and programming resources are available and will be integrated throughout the curriculum. Participants will be expected to provide their own computer. Required software will be predominately open source programming languages such as Python and R with integration to a variety of readily available open source tools like Spark, Hadoop, Shiny, MySQL, etc. Governments across the country and around the world have numerous Open Data database sources readily available for access and analysis. Interfaces with existing websites through API's, including a variety of social media sites, will be leveraged by participants.

In summary, this program can be offered with existing institutional resources and infrastructure.

L. Adequacy of Financial Resources

1. *Complete **Table 1: Resources and Narrative Rationale**. Provide finance data for the first five years of program implementation. Enter figures into each cell and provide a total for each year. Also provide a narrative rationale for each resource category. If resources have been or will be reallocated to support the proposed program, briefly discuss the sources of those funds.*
2. *Complete **Table 2: Program Expenditures and Narrative Rationale**. Provide finance data for the first five years of program implementation. Enter figures into each cell and provide a total for each year. Also provide a narrative rationale for each expenditure category.*

The proposed Data Science major would be offered for students beginning in the fall of 2020, in alignment with the hiring of the Endowed Professor in Computational Sciences and Mathematics. In order to derive resource and expenditure information, it is important to evaluate the timing of new course offerings. A companion table has been created to reflect courses needed in a 1 year through 5 year timeline. Courses in the 1 year rollout timeline include required courses within the curriculum as well as one additional data skills course to support student options. These courses will be sufficient to offer the Computational Science and the Operations Research applications areas with initial rollout. Courses within the Analytics for Business application area are already in existence. Courses in the 3 year rollout timeline provide sufficient courses to offer the Data Engineering applications area. The remaining courses support the E-Nnovation grant goals of increasing overall curriculum to include more computational science and advanced computing capabilities.

Course Rollout Timing					
New Courses	**Year 1 (2020-2021)**	**Year 2 (2021-2022)**	**Year 3 (2022-2023)**	**Year 4 (2023-2024)**	**Year 5 (2024-2025)**
CMSCI459			x		
DATA320			x		
DATA330	x				
DATA340			x		
DATA350			x		
DATA410				x	
DATA420				x	
DATA430				x	
DATA475	x				
DATA492	x				
MATH464					**x**
MATH488					**x**

TABLE 2: RESOURCES					
Resources Categories	**Year 1 (2020-2021)**	**Year 2 (2021-2022)**	**Year 3 (2022-2023)**	**Year 4 (2023-2024)**	**Year 5 (2024-2025)**
1. Reallocated Funds	$0	$0	$0	$0	$0
2. Tuition/Fee Revenue **(c+g)**	$123,510	$251,958	$428,330	$699,040	$802,152
a. # F.T. Students	3	6	10	16	18
b. Annual Tuition/ Fee Rate (Discounted rate)	$41,170	$41,993	$42,833	$43,690	$44,564
c. Annual Full Time Revenue **(a x b)**	$123,510	$251,958	$428,330	$699,040	$802,152
d. # Part Time Students	0	0	0	0	0
e. Credit Hour Rate	$1340	$1367	$1394	$1422	$1450
f. Annual Credit Hours	15	15	15	15	15
g. Total Part Time Revenue **(d x e x f)**	$0	$0	$0	$0	$0
3. Grants, Contracts, & Other External Sources	$125,000	$125,000	$125,000	$125,000	$125,000
4. Other Sources	$0	$0	$0	$0	$0
TOTAL (Add 1-4)	**$248,510**	**$376,958**	**$553,330**	**$824,040**	**$927,152**

Credit Hour Rate: The rate for 2019-20 for undergraduates is $1340 per credit. We project an increment of 2% per year which is a typical amount of increase at MSMU.

Based on increases observed within the Cybersecurity major since rollout, student enrollment increases are expected as well with rollout of the Data Science major. The department is aware that there will be shifting among current majors into the new proposed major, so an attempt to estimate with net increases is reflected. A conservative estimate of net increase for first year is 3 students that would not have entered program otherwise. This increases slightly within each of the subsequent

years, while remaining substantially under the increases seen within Cybersecurity in the three years since rollout.

Revenue reflected under grants reflects funds drawing from the earnings related to the invested $2M total funds from the E-Nnovation grant.

TABLE 3: EXPENDITURES					
Expenditure Categories	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1. Faculty **(b+c below)**	$120,600	$123,012	$125,472	$127,982	$130,541
a. # FTE	1	1	1	1	1
b. Total Salary	$90,000	$91,800	$93,636	$95,509	$97,419
c. Total Benefits	$30,600	$31,212	$31,836	$32,473	$33,122
2. Admin. Staff **(b+c below)**	$0	$0	$0	$0	$0
a. # FTE	$0	$0	$0	$0	$0
b. Total Salary	$0	$0	$0	$0	$0
c. Total Benefits	$0	$0	$0	$0	$0
3. Support Staff **(b+c below)**	$3,350	$3,417	$3,485	$3,555	$3,626
a. # FTE	0.05	0.05	0.05	0.05	0.05
b. Total Salary	$2,500	$2,550	$2,601	$2,653	$2,706
c. Total Benefits	$850	$867	$884	$902	$920
4. Equipment	$0	$0	$0	$0	$0
5. Library	$0	$0	$0	$0	$0
6. New or Renovated Space	$0	$0	$0	$0	$0
7. Other Expenses (see Table 3)	$0	$0	$0	$0	$0
8. TOTAL (Add 1 – 7)	**$123,950**	**$126,429**	**$128,957**	**$131,537**	**$134,167**

Faculty: By AY2020-2021, we will have hired a faculty member into the Endowed Professor in Computational Sciences and Mathematics position. This individual, in combination with existing faculty, will teach the data science curriculum needed for year 1 as well as develop course curriculum for courses needed within the 3 year timeline. Salary reflected aligns with budget derived for the original E-Nnovation grant.

Support Staff: We estimate a time commitment equivalent to 5% of a person's workload in the Communications Office for marketing and promotion. A salary of $50,000 was assumed and benefits are 34% of the salary. The salary was incremented by 2% per year.

M. Adequacy of Provisions for Evaluation of Program

1. *Discuss procedures for evaluating courses, faculty and student learning outcomes.*
2. *Explain how the institution will evaluate the proposed program's educational effectiveness, including assessments of student learning outcomes, student retention, student and faculty satisfaction, and cost-effectiveness.*

The program will rely on significant portions of curriculum from the existing Data Science minor and will work with other disciplines in the identification and development of data science

applications courses. The program will be part of the Middle States Accreditation of the university. Course evaluations will be completed for each course as designated by the College/School in which the course resides and the university. Full-time faculty are reviewed at least every five years. Part-time faculty are reviewed on a course/semester basis. Each program is reviewed every seven years, using an outside consultant. The following table details departmental Learning Outcomes specific to the data science major.

Learning Outcome	Assessment	Benchmark	Timing
LO1: Demonstrate an understanding of basic concepts related to data science	A departmental exam will be developed	No benchmark set	Annually as part of Data Science capstone
LO2: Ability to apply the tools and techniques of data science	Rubric assessment of projects in DATA220	No benchmark set	Annually as part of DATA220
LO3: Ability to communicate technical ideas with precision and clarity	Rubric assessment of Capstone project presentation	No benchmark set	Annually as part of Capstone
LO4: Demonstrate an understanding of the ethical issues within data science	Rubric assessment of ethic scenarios submitted in DATA200 and DATA220	No benchmark set	Annually as part of DATA200 and DATA220
LO5: Preparation for success in graduate study and professional careers	One and five year surveys of alumni	No benchmark set	Spring every year

N. Consistency with the State's minority student achievement goals

1. *Discuss how the proposed program addresses minority student access & success, and the institution's cultural diversity goals and initiatives.*

The Data Science degree program at Mount St. Mary's University will be promoted along with other degree programs in the School of Natural Science and Mathematics. In 2018-19, the proportion of students of color was 16% in the graduate programs and 31% in the undergraduate programs.

Nondiscrimination Statement
It is the policy of Mount St. Mary's University not to discriminate on the basis of race, color, national or ethnic origin, political or religious opinion or affiliation, age, sex or handicapping condition in the recruitment or admissions of students, or in the administration of the university's educational policies, admissions policies, scholarship and athletic programs, and other university-administered activities and programs.

Center for Student Diversity
The Center for Student Diversity was established to aid Mount St. Mary's University in its efforts of fostering inclusion, collaboration, and relationship building across campus. The Center provides academic, social, and transitional support in addition to programming, leadership training and inclusive workshops for ALL students and promotes exchange and dialogue between individuals of diverse backgrounds.

The Center for Student Diversity oversees the intercultural development programs, the Horning Fellowship, student support programs (including Third Century Scholars program and the American Indian program), and cultural programs. The office also supports cultural organizations, conducts diversity awareness programs, assesses the needs and climate of diverse groups and advocates on behalf of underrepresented students.

O. Relationship to low productivity programs identified by the Commission

1. *If the proposed program is directly related to an identified low productivity program, discuss how the fiscal resources (including faculty, administration, library resources and general operating expenses) may be redistributed to this program.*

Not applicable. There are no identified low productivity programs at MSMU.

P. Adequacy of Distance Education Programs

1. *Provide affirmation and any appropriate evidence that the institution is eligible to provide Distance Education.*
2. *Provide assurance and any appropriate evidence that the institution complies with the C-RAC guidelines, particularly as it related to the proposed program.*

Mount St. Mary's University was authorized for National Council for State Authorization Reciprocity Agreements (NC-SARA) institutional participation on September 3, 2019. This authorizes the university to deliver distance education courses across state lines. NC-SARA uses the C-RAC guidelines.