LOYOLA UNIVERSITY MARYLAND

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17007

February 18, 2018

James D. Fielder, Jr., Ph.D.
Secretary of Higher Education
Maryland Higher Education Commission
6 N. Liberty Street
Baltimore, MD 21201

Dear Secretary Fielder:

Please find attached a proposal from Loyola University Maryland for a Bachelor of Science in Data Science. This program will complement our M.S. in Data Science, The B.S. in Data Science's primary focus is upon the application of analytical skills and the use of data science to inform decision making complemented by an ability to communicate to technical and non-technical audiences.

Loyola University Maryland looks forward to working with the Commission on the recommendation of this proposal. Accompanying this letter you will find payment of $850 for the program review fee. Should the Commission have any queries on the proposal, please contact Dr. Westley Forsythe, Director of Academic Assessment and Compliance, at 410-617-2317 and wforsythe@loyola.edu.

Sincerely,

Amanda M. Thomas, Ph.D.
Interim Vice-President for Academic Affairs

cc: Dr. Steven Fowl, Dean, Loyola College of Arts and Sciences.
        Dr. Jenny Lowry, Associate Vice-President for Academic Affairs

PROPOSAL FOR:

X NEW INSTRUCTIONAL PROGRAM

_____ SUBSTANTIAL EXPANSION/MAJOR MODIFICATION

_____ COOPERATIVE DEGREE PROGRAM

_____ WITHIN EXISTING RESOURCES or _____ REQUIRING NEW RESOURCES

(For each proposed program, attach a separate cover page. For example, two cover pages would accompany a proposal for a degree program and a certificate program.)

Loyola University Maryland
Institution Submitting Proposal

Fall 2018
Projected Implementation Date

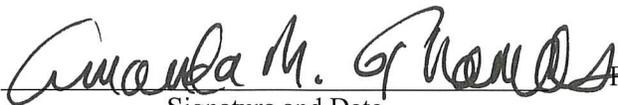|	
B.S.	**Data Science**
Award to be Offered	Title of Proposed Program
0702-01	**11.0401**
Suggested HEGIS Code	Suggested CIP Code
Loyola College of Arts and Sciences	**Dr. Dawn Lawrie**
Department of Proposed Program	Name of Department Head

Dr. Westley Forsythe	**wforsythe@loyola.edu**	**410-617-2317**
Contact Name	Contact E-Mail Address	Contact Phone Number

Amanda M. Thomas President/Chief Executive Approval
Signature and Date

02/14/2018
Date

Date Endorsed/Approved by Governing Board

Executive Summary

The Computer Science and Mathematics and Statistics departments, and the Sellinger School of Business and Management propose to offer a Bachelor of Science in Data Science. The academic content includes data management and data analysis skills needed to collect, manage and analyze an organization's data to create new knowledge. The curriculum would consist of sixteen courses in the three subject areas supported by liberal arts courses in written and oral expression, ethics, and mathematics. The course count is in the mid-range of similar programs. We believe that including business along with a strong humanities core from the liberal arts and sciences makes the degree compelling and competitive. The area of data science is a foundation for some of the fastest growing occupations in the US from 2014-2024 according to the Bureau of Labor Statistics and is a core skill set for various fields that are data-intensive.

A. Centrality to mission and planning priorities, relationship to the program emphasis as outlined in the mission statements, and an institutional priority for program development

One of the fundamental characteristics of a Loyola education is its Jesuit heritage. Jesuit ideals focus on academic excellence and care of the whole person, which will be central to this program. Care of the whole person is demonstrated through student-faculty relationships, mentoring beyond the classroom and course sizes that encourage the development of relationship. Fr. Kolvenbach, former Superior General, declared in 2000, that tomorrow's whole person is one "who is educated in solidarity

for the real world.[1]" This solidarity is developed through contact rather than concepts. Exposing students to real world situations through partnerships with not-for-profits and industry permits this contact. The Jesuits have always recognized the need to meet students where they are and to adjust to the changing times in which we live. Decree 15th of the 34th meeting of the General Congregation called Jesuits to understand the changes that are occurring[2] which acknowledges both the advancement of technology and the need for programs such as this that complementarily meet a societal need. The data science curriculum is current, relevant and meets students where they are by providing a curriculum that is diverse and permits practical application of learned concepts through a capstone practicum that transfers the classroom skills to the marketplace.

Recent job forecasts indicate that the need for data scientists has risen from 6,000 jobs in 2013 to 7,500 jobs in 2015, in the Baltimore region alone there are at least fifty companies seeking data scientist[2] The program also complements the university's strategic plan that extols the need to 'address changing career expectations and requirements, global citizenship, and the adaptability needed in today's working world, while continuing to hold fast to the values of *eloquentia perfecta* and critical thinking.'[3] We propose a senior capstone project of interest to a student using data from a variety of fields.

The program integrates Ethics as a fundamental tenet of several courses, reflecting one of the program's primary learning aims, and buttressed by students' participation in practicum experiences where they partner with local businesses,

[1] Kolvenbach, H. (October 8, 2000) Commitment to Justice in Jesuit Higher Education," at Santa Clara University (California), [2] GC 34

[2] Personal communication October 27, 2015

[3] Loyola University Maryland, *The Ignatian compass: guiding Loyola University Maryland to ever greater excellence, strategic plan 2017-22,* (Baltimore, 2017), p. 10.

industry and not-for-profits. Additionally, Decree 17 of the 34th General Congregation for the Society of Jesus (the Jesuits), calls for interdisciplinary work to inform new perspectives and new areas of research.[4] This interdisciplinary program answers that call.

B. Critical and compelling regional or Statewide need as identified in the State Plan

The state plan's 'strategy 8' extols institutions 'to develop new partnerships between colleges and businesses to support workforce development and improve workforce readiness'[5] The strategy also declares: 'More than ever, employers seek employees who have the flexibility to understand changing conditions and solve emerging problems. Technical knowledge is not enough. A competitive workforce can work with diverse people, understand emerging technologies, communicate clearly, and find effective answers to questions that have never been asked. To keep Maryland at the forefront of innovation, the postsecondary community needs to improve or develop new partnerships with businesses and industries.'[6]

This proposed program, complemented by Loyola's commitment to the principles of Ignatian pedagogy, ensures graduates' education with both the disciplinary and sector knowledge augmented by a liberal arts education that will equip this program's graduates to make a significant and unique contribution in their chosen careers.

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[4] General Congregation 34 Decree 17 (1995)
http://www.sjweb.info/documents/education/CG34_D17_ENG.pdf
[5] Maryland Higher Education Commission, *State plan for postsecondary education: increasing student success with less debt, 2017-2021,* (Baltimore, 2017), p. 28.
[6] Ibid., p. 66.

Market supply

Table 1: Annual enrollments in Maryland programs with the following Classification of Instructional Program (CIP) codes, 52.1301 Management Science, 52.1302 Business Statistics, 52.1304 Actuarial Science, and 11.0401 Information Science[7]

School Name	Degree Level	Program Name	CIP	2009	2010	2011	2012	2013	2014	2015	2016
Bowie State University	Post Baccalaureate Certificate	Information Systems Analyst	110401	0	0	0	2	2	2	1	2
Coppin State University	Bachelors	Management Information Systems	110401	0	0	0	7	17	17	22	25
Frostburg State University	Bachelors	Computer Information Systems	110401	1	2	9	16	23	26	34	29
Frostburg State University	Bachelors	Actuarial Science	521304	0	0	0	0	0	0	0	0
Salisbury University	Bachelors	Information Systems	110401	82	108	135	149	160	137	133	137
Towson University	Bachelors	Information Systems	110401	276	256	206	174	192	168	169	186
Towson University	Bachelors	Information Technology (Btps)	110401	13	10	4	2	1	0	0	0
Towson University	Doctorate (Prior To 2009)	Applied Information Technology	110401	0	0	0	0	0	0	0	0
University Of Baltimore	Bachelors	Applied Information Technology	110401	107	105	112	96	82	84	95	88

[7] Maryland Higher Education Commission, *Trends Data,* (2016). Retrieved on January 26, 2018 from https://data.mhec.state.md.us/mac_Trend.asp

School Name	Degree Level	Program Name	CIP	2009	2010	2011	2012	2013	2014	2015	2016
Univ. Of Md, Baltimore County	Bachelors	Informarulertion Systems Management	110401	511	542	556	603	628	646	673	757
Univ. Of Md, Baltimore County	Masters	Information Systems	110401	403	315	272	320	338	348	372	351
Univ. Of Md, Baltimore County	Masters	Human Centered Computing	110401	23	41	38	41	45	38	42	34
Univ. Of Md, Baltimore County	Doctorate (Prior To 2009)	Information Systems	110401	0	0	0	0	0	0	0	0
Univ. Of Md, Baltimore County	Doctorate (Prior To 2009)	Human Centered Computing	110401	0	0	0	0	0	0	0	0
Univ. Of Md, Baltimore County	Doctorate(Research & Scholarship)	Information Systems	110401	58	50	46	56	48	53	55	58
Univ. Of Md, Baltimore County	Doctorate(Research & Scholarship)	Human Centered Computing	110401	5	10	17	21	18	19	12	15
Univ. Of Md, College Park	Bachelors	Management Science & Statistics	521301	0	0	0	0	0	0	0	0
Univ. Of Md, College Park	Bachelors	Operations Mgmt And Business Analyt	521301	83	86	75	54	38	33	40	50
Univ. Of Md, College Park	Bachelors	Information Science	110401	0	0	0	0	0	0	0	91
Univ. Of Md, College Park	Bachelors	Information Systems	110401	65	83	95	112	121	123	127	143
Univ. Of Md, College Park	Masters	Marketing Analytics	521302	0	0	0	0	0	0	35	48
Univ. Of Md, College Park	Masters	Information Management	110401	146	100	74	78	142	165	160	147
Univ. Of Md University College	Bachelors	Information Systems Management	110401	1046	961	915	924	794	1038	1219	1360
Univ. Of Md University College	Bachelors	Computer Networks & Security	110401	1154	1239	1359	1580	1876	2321	3090	4490
Univ. Of Md University College	Post Baccalaureate Certificate	Foundations In Business Analytics	521302	0	0	0	0	0	10	13	20

School Name	Degree Level	Program Name	CIP	2009	2010	2011	2012	2013	2014	2015	2016
Univ. Of Md University College	Post Baccalaureate Certificate	Predictive Analytics	521302	0	0	0	0	2	13	8	1
Univ. Of Md University College	Post Baccalaureate Certificate	Informatics	110401	8	16	13	13	11	12	9	3
Univ. Of Md University College	Post Baccalaureate Certificate	Leadership And Management	521301	39	56	39	45	51	45	44	53
Univ. Of Md University College	Post Baccalaureate Certificate	Database Systems Technology	110401	21	20	18	18	20	20	14	8
Univ. Of Md University College	Post Baccalaureate Certificate	Information Assurance	110401	55	79	52	34	39	29	35	32
Univ. Of Md University College	Post Baccalaureate Certificate	Foundations Of Information Technolo	110401	12	13	17	15	8	15	8	2
Univ. Of Md University College	Masters	Data Analytics	521302	0	0	0	0	45	193	284	357
Univ. Of Md University College	Masters	Health Informatics Administration	110401	121	167	182	155	166	194	243	346
Univ. Of Md University College	Masters	Information Technology	110401	1776	2012	1879	1779	1518	1483	1547	1460
Morgan State University	Bachelors	Actuarial Science	521304	0	14	21	21	24	20	22	27
Morgan State University	Bachelors	Information Systems	110401	74	75	94	99	101	114	136	147
Capitol Technology University	Post Baccalaureate Certificate	Client-Server & Wireless Devices	110401	0	0	0	0	0	0	0	0
Capitol Technology University	Masters	Electronic Commerce	110401	0	0	0	0	0	0	0	0
Capitol Technology University	Masters	Internet Engineering	110401	6	9	8	9	12	12	16	6
Capitol Technology University	Doctorate(Research & Scholarship)	Management And Decision Sciences	521301	0	0	0	0	0	0	11	27
Hood College	Post Baccalaureate Certificate	Geographic Information Systems	110401	0	0	0	0	1	1	1	2

School Name	Degree Level	Program Name	CIP	2009	2010	2011	2012	2013	2014	2015	2016
Johns Hopkins University	Bachelors	Information Systems	110401	32	0	0	0	0	0	0	0
Johns Hopkins University	Post Baccalaureate Certificate	Geographic Information Systems	110401	5	14	11	18	12	4	13	13
Johns Hopkins University	Post Baccalaureate Certificate	Information Systems Engineering	110401	0	1	1	1	2	0	2	1
Johns Hopkins University	Post Baccalaureate Certificate	Information Security Management	110401	4	5	1	0	0	0	0	0
Johns Hopkins University	Masters	Geographic Information Systems	110401	0	0	0	0	18	38	67	89
Johns Hopkins University	Masters	Information Systems Engineering	110401	216	187	123	120	102	123	129	150
Johns Hopkins University	Post-Masters Certificate	Information Systems Engineering	110401	0	0	0	0	0	0	0	2
Kaplan College	Bachelors	Information Technology	110401	0	0	0	0	0	0	0	0
Mount St. Mary's University	Post Baccalaureate Certificate	Public Sector Info Mgmt & Analysis	110401	0	0	0	0	0	0	0	0
Notre Dame Of Maryland University	Bachelors	Computer Information Systems	110401	13	10	12	13	6	8	5	5
Notre Dame Of Maryland University	Masters	Analytics	110401	0	0	0	5	8	2	6	6
Sojourner-Douglass College	Bachelors	Information Systems Administration	110401	0	15	6	10	6	0	0	0
Stevenson University	Bachelors	Business Information Systems	110401	55	67	53	58	57	50	47	36
Stevenson University	Masters	Business and Technology Management	110401	46	68	104	116	125	159	120	122
Washington Adventist University	Bachelors	Information Systems	110401	8	12	14	11	7	16	12	29
Total annual enrollments				**6464**	**6748**	**6561**	**6775**	**6866**	**7779**	**9071**	**10955**

Institution	Award Level	Program Name	CIP	2011	2012	2013	2014	2015	2016
Bowie State University	Post Baccalaureate Certificate	Geo. Info. Systems & Image Processi	110401	0	0	0	0	0	0
Bowie State University	Post Baccalaureate Certificate	Information Systems Analyst	110401	0	0	0	0	10	34
Coppin State University	Bachelors	Management Information Systems	110401	0	0	0	2	1	6
Frostburg State University	Bachelors	Computer Information Systems	110401	0	0	3	5	12	9
Frostburg State University	Bachelors	Actuarial Science	521304	0	0	0	0	0	0
Salisbury University	Bachelors	Information Systems	110401	35	54	64	64	67	56
Towson University	Bachelors	Information Systems	110401	79	72	39	54	51	38
Towson University	Bachelors	Information Technology (Btps)	110401	6	3	0	0	1	0
Towson University	Doctorate (Prior To 2009)	Applied Information Technology	110401	0	0	0	0	0	0
University Of Baltimore	Bachelors	Applied Information Technology	110401	18	22	25	19	19	17
Univ. Of Md, Baltimore County	Bachelors	Information Systems Management	110401	144	147	147	167	170	186
Univ. Of Md, Baltimore County	Masters	Information Systems	110401	118	117	94	93	145	138
Univ. Of Md, Baltimore County	Masters	Human Centered Computing	110401	6	18	10	20	14	16
Univ. Of Md, Baltimore County	Doctorate (Prior To 2009)	Information Systems	110401	0	0	0	0	0	0
Univ. Of Md, Baltimore County	Doctorate (Prior To 2009)	Human Centered Computing	110401	0	0	0	0	0	0
Univ. Of Md, Baltimore County	Doctorate(Research/Scholarship)	Information Systems	110401	7	6	4	6	4	7
Univ. Of Md, Baltimore County	Doctorate(Research/Scholarship)	Human Centered Computing	110401	0	0	0	2	2	3

[8] Ibid.

Institution	Award Level	Program Name	CIP	2011	2012	2013	2014	2015	2016
Univ. Of Md, College Park	Bachelors	Management Science & Statistics	521301	0	0	0	0	0	0
Univ. Of Md, College Park	Bachelors	Operations Mgmt And Business Analyt	521301	47	50	35	28	14	24
Univ. Of Md, College Park	Bachelors	Information Systems	110401	72	75	76	87	88	102
Univ. Of Md, College Park	Masters	Marketing Analytics	521302	0	0	0	0	35	34
Univ. Of Md, College Park	Masters	Information Management	110401	61	32	29	43	81	53
Univ. Of Md University College	Bachelors	Information Systems Management	110401	208	190	189	174	225	195
Univ. Of Md University College	Bachelors	Computer Networks & Security	110401	150	201	239	300	379	437
Univ. Of Md University College	Post Baccalaureate Certificate	Foundations In Business Analytics	521302	0	0	0	0	7	16
Univ. Of Md University College	Post Baccalaureate Certificate	Predictive Analytics	521302	0	0	0	0	3	19
Univ. Of Md University College	Post Baccalaureate Certificate	Informatics	110401	9	7	5	11	6	7
Univ. Of Md University College	Post Baccalaureate Certificate	Leadership And Management	521301	47	66	65	43	65	54
Univ. Of Md University College	Post Baccalaureate Certificate	Database Systems Technology	110401	13	9	12	3	11	4
Univ. Of Md University College	Post Baccalaureate Certificate	Information Assurance	110401	53	47	30	28	27	33
Univ. Of Md University College	Post Baccalaureate Certificate	Foundations Of Information Technolo	110401	32	30	28	28	18	28
Univ. Of Md University College	Masters	Data Analytics	521302	0	0	0	0	0	23
Univ. Of Md University College	Masters	Health Informatics Administration	110401	23	30	30	33	30	45
Univ. Of Md University College	Masters	Information Technology	110401	409	442	482	396	451	447
Morgan State University	Bachelors	Actuarial Science	521304	0	1	2	7	2	6
Morgan State University	Bachelors	Information Systems	110401	9	14	14	14	19	30
Capitol Technology University	Post Baccalaureate Certificate	Electronic Commerce Mgt.	110401	0	0	0	0	0	0
Capitol Technology University	Post Baccalaureate Certificate	Component Tech & Online Collaborati	110401	0	0	0	0	0	0
Capitol Technology University	Post Baccalaureate Certificate	Client-Server & Wireless Devices	110401	0	0	0	0	0	0

Institution	Award Level	Program Name	CIP	2011	2012	2013	2014	2015	2016
Capitol Technology University	Masters	Electronic Commerce	110401	0	0	0	0	0	0
Capitol Technology University	Masters	Internet Engineering	110401	3	1	2	4	5	8
Hood College	Post Baccalaureate Certificate	Geographic Information Systems	110401	0	0	0	5	3	7
Johns Hopkins University	Bachelors	Information Systems	110401	9	2	0	1	0	1
Johns Hopkins University	Post Baccalaureate Certificate	Geographic Information Systems	110401	4	4	4	6	5	4
Johns Hopkins University	Post Baccalaureate Certificate	Information Systems Engineering	110401	0	0	0	1	1	2
Johns Hopkins University	Post Baccalaureate Certificate	Information Security Management	110401	5	2	1	1	0	0
Johns Hopkins University	Masters	Geographic Information Systems	110401	0	0	0	2	7	10
Johns Hopkins University	Masters	Information Systems Engineering	110401	65	51	33	33	27	33
Johns Hopkins University	Post Masters Certificate	Information Systems Engineering	110401	3	1	0	4	0	0
Kaplan College	Bachelors	Information Technology	110401	0	0	0	0	0	0
Mount St. Mary's University	Post Baccalaureate Certificate	Public Sector Info Mgmt & Analysis	110401	0	0	0	0	0	0
Notre Dame Of Maryland University	Bachelors	Computer Information Systems	110401	1	2	3	3	1	2
Notre Dame Of Maryland University	Masters	Analytics	110401	0	0	0	2	3	3
Sojourner-Douglass College	Bachelors	Information Systems Administration	110401	0	0	0	0	0	0
Stevenson University	Bachelors	Business Systems	110401	0	0	0	0	0	0
Stevenson University	Bachelors	Business Information Systems	110401	19	16	11	21	14	14
Stevenson University	Masters	Business And Technology Management	110401	18	25	38	48	42	50
Washington Adventist University	Bachelors	Information Systems	110401	4	6	5	1	7	4
Total annual graduations				**1677**	**1743**	**1719**	**1759**	**2072**	**2205**

Market demand

Table 3: Maryland Department of Labor, Licensing, and Regulation, annual employment projection, 2012-2022[9]

| Occupational code | Occupational title | Employment | | | Change | | | Education value |
		2012	2022	Change	Replacement	Total	
15-2011	Actuaries	295	315	20	84	104	Bachelor's degree
25-1011	Business Teachers, Postsecondary	1,785	2,044	259	268	527	Doctoral or professional degree
11-1011	Chief Executives	3,428	3,515	87	730	817	Bachelor's degree
15-1111	Computer and Information Research Scientists	3,492	4,099	607	549	1,156	Doctoral or professional degree

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[9] Department of Labor, Licensing, and Regulations, annual employment projections, 2012-2022, retrieved on January 29, 2018 from https://www.dllr.state.md.us/lmi/iandoproj/

Occupational code	Occupational title	Employment			Change			Education value
		2012	2022	Change	Replacement	Total		
11-3021	Computer and Information Systems Managers	10,671	12,245	1,574	1,483	3,057		Bachelor's degree
15-1199	Computer Occupations, All Other	14,195	14,113	-82	2,231	2,231		Bachelor's degree
25-1021	Computer Science Teachers, Postsecondary	592	667	75	89	164		Doctoral or professional degree
11-1021	General and Operations Managers	50,595	54,798	4,203	9,465	13,668		Bachelor's degree
13-2053	Insurance Underwriters	1,652	1,367	-285	448	448		Bachelor's degree
25-1022	Mathematical Science Teachers, Postsecondary	833	927	94	125	219		Doctoral or professional degree
15-2031	Operations Research Analysts	2,850	3,577	727	641	1,368		Bachelor's degree

Occupational code	Occupational title	Employment		Change			Education value
		2012	2022	Change	Replacement	Total	
15-1133	Software Developers, Systems Software	14,020	17,124	3,104	1,797	4,901	Bachelor's degree
15-2041	Statisticians	3,166	3,730	564	1,003	1,567	Master's degree
19-3022	Survey Researchers	1,013	1,169	156	139	295	Master's degree
Employment projections total		**108,587**	**119,690**	**11,103**	**19,05**	**30,522**	

Table 2 above demonstrates that in 2016 Maryland institutions educated 2,205 individuals from programs with the CIP code 52.13 ('Management Sciences and Quantitative Methods'), and 11.0401 Information Science) denoting that they completed programs taxonomically similar to that recommended in this proposal.

Meanwhile Table 3, reflects the potential Maryland employment demand for graduates of these programs. These projections reflect a cross-referencing of the program's general taxonomical category with corresponding Maryland Department of Labor, Licensing, and Regulation employment projections. These employment projections indicate that Maryland has an average annual employment need of 3,052 for positions that graduates of the B.S. in Data Science could fulfil. While consideration of workforce demand should accommodate other programs that might fulfil this needs of these occupations, it does indicate a very healthy marketplace into which graduates will pursue a career.

Additionally, the number of companies seeking employees with data science skills grew from 6,000 in December 2013 to 7,500 in January 2015. Locally, there is a need to support the business and governmental sectors. Recently, fifty companies were identified in the region seeking to hire data scientists. [10]

The program also plans to recruit international students from China, India, the Middle East, and elsewhere, to create a thriving program with sufficient students. Given the employment needs and the wide draw of students, the outlook for this degree is promising. In fact five programs are available in Chicago, and all are thriving.[11]

D. Reasonableness of program duplication, if any;

Table 1 identifies those programs with a CIP code analogous to Loyola's proposed B.S. in Data Science; the broad and inter-disciplinary nature of the area identifies a large number of programs offered in Maryland, with the following CIP codes: 52.1301 Management Science; 52.1302 Business Statistics; 52.1304 Actuarial Science; and 11.0401 Information Science.

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[10] *Data Science Central,* retrieved on October 20, 2015 from
https://www.datasciencecentral.com/profiles/blog/list?month=01&year=2015

[11] Faculty consultations with peers throughout Summer 2015.

Loyola's proposed B.S. in Data Science is an inter-disciplinary program representing a blend of the taxonomical CIP descriptors and is a collaboration between three departments and two schools. This feature alone engenders a very distinct and arguably unique program.

Additionally, many of these programs are obviously non-duplicative of Loyola's proposed program, being much more concerned with subjects like Geographic Information Systems, e-commerce, and health information. Additionally, given the robust demand for graduates in this emerging area there is ample scope for an additional program in this arena.

E.   Relevance to the implementation or maintenance of high-demand programs at HBIs;

According to an analysis of MHEC trend data, no Historically Black College or University offers a Bachelor's program in data science.

F.   Relevance to the support of the uniqueness and institutional identities and missions of HBIs;

At this time, Loyola does not envisage this program having an impact upon the uniqueness or institutional identity and mission of a Historically Black College or University.

G.   Adequacy of curriculum design and delivery to related learning outcomes consistent with Regulation .10 of this chapter;

Data Science, B.S.

Foundational Component:

(**13 required courses**)

CS151 - Computer Science 1 (Core)

CS212 - Object-Oriented Data Structures

CS295 - Discrete Structures or MA295 - Discrete Structures or MA395 - Discrete Methods

CS312 - Object-Oriented Software Design

IS251 - Information Systems or BH 251 - Information Systems

IS353 - Data Management and Database Systems or CS485 - Database Management Systems

IS358 - Business Intelligence and Data Mining

MA251 - Calculus I (Core) (or MA151 with permission of the program director)

ST210 - Introduction to Statistics or ST265 - Biostatistics or EC220 - Business Statistics

ST310 - Statistical Computing

ST465 - Experimental Research Methods

ST472 - Applied Multivariate Analysis

DS496 - Ethical Data Science Capstone

Elective Component:

Choose **3 courses** from among the following:

CS484 - Artificial Intelligence

CS487 - Big Data

IS453 - Information Systems Analysis and Design

IS460 - Data Visualization

IS465 - Text Mining

MA301 - Linear Algebra

MA302 - Programming in Mathematics

ST461 - Elements of Statistical Theory I: Distributions (MA351 is a prerequisite)

ST466 - Experimental Design

EC420 - Econometrics

EC 425 - Applied Economic Forecasting

Up to 2 graduate DS courses may be taken with approval from the graduate director

An internship as DS499 may be taken for university credit, but does not count as an elective in the BS DS.

It is not anticipated that this course would substitute for the capstone as the ethical component in the capstone is particularly important. This aspect would not necessarily be present in the internship.

Instead it is expected that the internship experience may enhance the capstone experience for the student by providing the relationship from which the student can develop the capstone project.

It is recommended that students take EC102 and EC103 for their social science core.

Up to eight courses may be cross-counted between the DS major and another major or minor.

Cross-counting requirements in other majors or minors may vary.

Proposed sequence of courses

Fall Semester Spring Semester

First Year MA251, CS151 CS212, ST210/EC220,7

IS251/BH251

Second Year CS/MA295/MA395, CS312 ST310, IS353/CS485

Third Year ST465, IS358 ST472, elective

Fourth Year elective, elective DS496

Note: Offerings in the third and fourth years may need to be rearranged due to timing of departmental offerings of these courses (some courses are offered in a two-year cycle). For example, ST465 is offered in the Fall semester of odd years and ST472 is offered in the Spring semester of even years.

The Core and the Major

Mathematics/Statistics and Additional Science Core Courses in major:

· MA251 - Calculus I (4 credits)

· CS151 - Computer Science 1 (4 credits)

Social Science Core courses (Recommended for major):

· EC102 – Microeconomics

· EC103 – Macroeconomics

University Core Courses (17 courses, 53 credits)

17 courses – 2 required of major = 15 other core courses

Composition WR100 _____

History HS101_____ HS300-level elective _____ List course:

English EN101 _____ EN200-level elective _____ List course:

Philosophy PL201 _____ PL200-level elective _____ List course:

Theology TH201 _____ TH202-299 _____ List course:

Ethics PL300-319/TH300-319 _____ List course:

Language Competency _____ List language taken:

Social Science SS Elective EC102 SS Elective EC103

(Recommended by major) (Recommended by major)

Fine Arts FA Elective _____ List course:

Natural Science I _____

Mathematics/Statistics II MA251/ST210/ST265 (fulfilled by major)

Natural Science II or Mathematics/S II or Computer Science or Engineering CS151 (fulfilled by major)

Diversity Requirement**:** Students must complete one designated diversity course ("D" will follow course number in course booklet) which includes substantial focus on global, justice, or domestic diversity awareness. In many cases, a designated diversity course also fulfills one of the core course listed above.

_____ (check off when completed) _____ (list diversity course taken)

University electives = 9 courses

Justification of size of the major

First, the following is how a data science student would earn a degree of forty courses.

Total counts of 3.0 credit courses

16 courses counted in the major

15 other core courses (not counted in the major)

9 University elective courses

This course count is in the middle relative to other institutions offering a data science degree. We found

Smith requires 11 courses (+3 prerequisite math courses)

Luther College: 12

USF: 14

College of Charleston: 17 (+ 5 in an area)

Becker College: 20 (+ 4 in a "specialization")

None of the smaller programs (Smith, Luther, and USF) require any business courses. Eliminating business from the major would cut down on the size of the major because it would no longer be an interdisciplinary degree between 3 programs; however, including business along with a strong humanities core from the liberal arts and sciences is what makes the degree a compelling and competitive degree. In a recent article (3 reasons why data scientist remains the top job in America), data scientists were described as

"Business leaders are after professionals who can not only understand the numbers but also communicate their findings effectively."

And "Not only will you learn the analytical skills required for a data science position but you'll also receive training for the softer skills that are becoming more and more common in data science roles – skills such as managing projects and teams across multiple departments, consulting with clients,

assisting with business development, and taking abstract business issues and turning them into analytical solutions."

This second quote was promoting data science boot camps, but it also describes our vision of the degree. This vision is strongly supported by Loyola's Industrial Board for the MS in Data Science. Both of these quotes point to the importance of the liberal arts and business courses in this degree. The examples of Smith, Luther College, and USF should not be followed to merely shrink the size of the major.

Bachelor of Science

First Year

Fall Term

MA251 - Calculus I

CS151 - Computer Science 1

Social Science Core (EC102 recommended)

WR 100 Effective Writing

Language Competency

Spring Term

CS212 - Object-Oriented Data Structures

ST210 - Introduction to Statistics or ST265 - Biostatistics or EC220 - Business Statistics

IS251 - Information Systems or BH 251 - Information Systems

Social Science Core (EC103 recommended)

Non-departmental elective

Sophomore Year

Fall Term

CS295 - Discrete Structures or MA295 - Discrete Structures or MA395 - Discrete Methods

CS312 - Object-Oriented Software Design

EN 101 Understanding Literature

HS-100 level course

PL 201 Foundations of Philosophy or TH 201 Introduction to Theology

Spring Term

ST310 - Statistical Computing

IS353 - Data Management and Database Systems or CS485 - Database Management Systems

English core

Fine Arts core

Non-departmental elective

Junior Year

Fall Term

ST465 - Experimental Research Methods

IS358 - Business Intelligence and Data Mining

Natural Science Core

Theology Core

Elective

Spring Term

ST472 - Applied Multivariate Analysis

DS Program Elective

History Core

PL 200-level

Non-departmental elective

Senior Year

Fall Term

DS Program Elective

DS Program Elective

Ethics Core

Elective

Elective

Spring Term

DS496 - Ethical Data Science Capstone

Non-departmental Elective

Elective

Elective

Elective

Curricular sequence

This sequence is based on the above proposal. These courses are color coded based on current offerings. Several of the required courses are already offered every semester, many with multiple sections. These courses appear in green. Orange courses are currently offered every fall. Red courses are only offered in the spring. Blue courses are currently offered every other year. This only applies to three courses --- CS485, ST465, and ST472. Initially these courses are likely to remain on that schedule, but could be offered more frequently if demand warranted it. Finally, there are two courses in purple.

Both are new courses. ST310 is also being introduced for the Statistics major. DS496 is the only course that will be offered exclusively for data science majors. It will first be offered in Spring 2022.

Table 4: curricular sequence

Semester	Class of '22	Class of '23	Class of '24	Class of '25	Class of '26
Fall 2018	CS151				
	MA251				
Spring 2019	CS212				
	ST210/ST265/EC 220				
	IS251/BH251				
Fall 2019	CS/MA295/MA3 95	CS151			
	CS312	MA251			
Spring 2020	ST310	CS212			
	IS353/CS485	ST210/ST265/E C220			
		IS251/BH251			
Fall 2020	ST465, IS358	CS/MA295/MA 395	CS151		

Semester	Class of '22	Class of '23	Class of '24	Class of '25	Class of '26
	elective	CS312	MA251		
Spring 2021	ST472	ST310	CS212		
		IS353/CS485	ST210/ST265/E C220		
			IS251/BH251		
Fall 2021	elective	ST465	CS/MA295/MA 395	CS151	
	elective	elective	CS312	MA251	
Spring 2022	DS496	ST472	ST310	CS212	
		IS358	IS353/CS485	ST210/ST265/E C220	
				IS251/BH251	
Fall 2022		elective	ST465	CS/MA295/MA 395	CS151
		elective	elective	CS312	MA251
Spring 2023		DS496	ST472	ST310	CS212
			IS358	IS353/CS485	ST210/ST265 /E C220
					IS251/BH251

Semester	Class of '22	Class of '23	Class of '24	Class of '25	Class of '26
Fall 2023			elective	ST465	CS/MA295/ MA 395
			elective	elective	CS312
Spring 2024			DS496	ST472	ST310
				IS358	IS353/CS485
Fall 2024				elective	ST465
				elective	elective
Spring 2025				DS496	ST472
					IS358
Fall 2025					elective
					elective
Spring 2026					DS496

Course Descriptions:

Required Courses:

Computer Science:

CS 151 - Computer Science I

(4.00 cr.)

Introduces students to problem solving with the fundamentals of programming, enabling them to decompose complex problems into elementary steps for effective implementation in a modern programming language. Students work with numeric and textual data, procedural programming with conditionals and loops, basic linear data structures, and on testing their solutions. Problems may draw on topics in computer security, data encoding, graphics, games, financial analysis, physical models, and others. Provides a general survey of some of the major areas of computer science, such as digital logic, software engineering, computer graphics, artificial intelligence, theory of computation, object-oriented programming, and ethical and societal issues in computing. F irst course in the major's sequence. Must be passed with a C- or better to move to the next course. F ulfills one math/science core requirement.

CS 212 - Object-Oriented Data Structures

(4.00 cr.)

Prerequisite: C S 151 or, with an appropriate programming background, written permission of the department chair. Students learn to program in a high level object-oriented language, with emphasis on data storage and manipulation. Students should have previous experience in programming but do not need experience in an object-oriented language. Students learn essential object-oriented concepts including object, class, message, method, inheritance, and polymorphism. They also learn the analysis of algorithms to determine if a program is correct and efficient. They apply the object-oriented and analysis concepts to data structures such as stacks, queues, priority queues, maps, and trees, as well as algorithms such as sorting and searching. R equired for computer science and data science majors.

CS 295 - Discrete Structures

(3.00 cr.)

Prerequisite: C S 201 ; MA 109 or a score of 56 or better on Part I of the Math Placement Test or one year of high school calculus. Boolean algebra, combinatorics, inductive and deductive proofs, sets, graphs, functions, and recurrence relations. S ame course as MA 295. (Fall only)

CS 312 - Object-Oriented Software Design

(3.00 cr.)

Prerequisite: C S 202 or CS 212. A continuation of CS 212 . Students learn how to design and implement flexible, reusable, and maintainable object-oriented programs. The course fosters a deeper understanding of object-oriented programming, including generics, inheritance, and composition as dual techniques for software reuse, forwarding versus delegation, and sub-classing versus sub-typing. Students apply these methods to the implementation and analysis of advanced data structures such as balanced trees, heaps, graphs, and related algorithms. R equired for computer science and data science majors. C losed to students who have taken CS 301.

CS 485 - Database Management Systems

(3.00 cr.)

Prerequisite: C S 212 or CS 301 . Concepts and structures necessary to design, implement, and use a database management system: logical and physical organization; various database models with emphasis on the relational model; data description languages; query facilities including SQL; the use of embedded SQL.

Economics:

EC 220 - Business Statistics

(3.00 cr.)

Prerequisite: M A 151 or MA 251 or equivalent. MA 151 or MA 251 may be taken concurrently. Introduces the concepts and application of statistics in management. Students learn to apply estimation and hypothesis testing to univariate and multivariate business problems. Topics include descriptive statistics and statistical inference; multiple regression; correlation; and trend and seasonal time series analysis. G T Information Systems:

IS 251 - Information Systems

(3.00 cr.)

Prerequisite: CS 111 or CS 118 or CS 151 or CS 218 or HN 218 or HN 318. Open to freshmen, sophomore, junior and senior students. Students are immersed in the strategic use of information technology (IT) to solve business problems. They examine the role of IT in organizations and the integration of information systems (IS) into business activities enabling quality, timeliness, and competitive advantage. Students apply database, spreadsheet, and presentation skills to solve real world business challenges. Recommended completion during sophomore year.

IS 353 - Data Management and Database Systems

(3.00 cr.)

Prerequisite: C umulative GPA of 2.500 and EC 220 or ST 210 or ST 265, IS 251 or BH 251 , MA 151 or MA 251 ; or written or electronic permission of the department chair. O pen to freshmen, sophomore, junior and senior students. Students analyze, create a logical design, and implement the physical design for a database information system-a cornerstone of business transactions. The course includes a database project from a current situation at a real company that allows students to analyze the data needs of an organization, translate user requirements into a database system, and implement the system using leading database management systems.

IS 358 - Business Intelligence and Data Mining

(3.00 cr.)

Prerequisite: E C 220 or ST 210 or ST 265, IS 251 or BH 251 , MA 151 or MA 251 ; or written permission of the department chair. O pen to sophomore, junior and senior students. Students are introduced to data mining as a technology to discover information and knowledge from large datasets for business decisions. Students utilize SAS Enterprise Miner™ to perform data mining using methods such as clustering, regression and decision trees. Students develop a project using current business intelligence technology for data mining. Forms the foundation for customer relationship management in marketing and forensic accounting.

Mathematics:

MA 251 - Calculus I

(4.00 cr.)

Prerequisite: M A 109 or a score of 56 or better on Part II of the Math Placement Test or one year of high school calculus. A rigorous approach to Calculus for all majors. Topics include limits, definition, interpretation, and applications of the derivative; differentiation rules; antiderivatives; definition of definite and indefinite integrals; and the Fundamental Theorem of Calculus. Degree credit will not be given for both MA 151 and MA 251. I FS

MA 295 - Discrete Structures

(3.00 cr.)

Prerequisite: C S 201 ; MA 109 or a score of 56 or better on Part I of the Math Placement Test or one year of high school calculus. Boolean algebra, combinatorics, inductive and deductive proofs, sets, graphs, functions, and recurrence relations. S ame course as CS 295. (Fall only)

MA 395 - Discrete Methods

(3.00 cr.)

Prerequisite: M A 252 . The logic of compound statements, mathematical induction, set theory, counting arguments, permutations, combinations, and probability. Problem solving is stressed.

Statistics:

ST 210 - Introduction to Statistics

(3.00 cr.)

Prerequisite: M A 109 or a score of 48 or better on Part II of the Math Placement Test or one year of high school calculus. A non-calculus-based course covering descriptive statistics; regression model fitting; probability; normal, binomial, and sampling distributions; estimation; and hypothesis testing. D egree

16 credit will not be given for more than one of EG 381 or ST 210 or ST 265 or ST 381 . C losed to students who have taken EC 220 or EG 381 or PY 292 or ST 265 or ST 381 . G T/IFS

ST 265 - Biostatistics

(3.00 cr.)

Prerequisite: M A 109 or a score of 48 or better on Part II of the Math Placement Test or one year of high school calculus. A non-calculus-based course covering descriptive statistics, regression model fitting, probability, distributions, estimation, and hypothesis testing. Applications are geared toward research and data analysis in biology and medicine. D egree credit will not be given for more than one of EG 381 or ST 210 or ST 265 or ST 381 . C losed to students who have taken EC 220 or EG 381 or PY 292 or ST 210 or ST 381 . I FS (Spring only)

ST 310 - Statistical Computing (to be added to the catalog)

(3.00 cr.)

Prerequisite: ST210 or ST265 or EC220 or written permission of the program director. Reviews a number of statistics topics as a vehicle for introducing students to statistical computing and programming using

SAS and R for graphical and statistical analysis of data. Statistics topics include graphical and numerical descriptive statistics, probability distributions, one and two sample tests and confidence intervals, simple and multiple linear regression, and chi-square tests. SAS topics include data management, manipulation, cleaning, macros, and matrix computations. Topics in R include data frames, functions, objects, flow control, input and output, matrix computations, and the use of R packages. Lastly, this course also includes an introduction to the resampling and bootstrap approaches to statistical inference.

ST 465 - Experimental Research Methods

(3.00 cr.)

Prerequisite: E C 220 or EG 381 or PY 292 or ST 210 or ST 265 or ST 381. C orequisite: S T 365 is required for students pursuing a statistics major. Concepts and techniques for experimental research including simple, logistic, and multiple regression; analysis of variance; analysis of categorical data. (Fall only) (Odd Years)

ST 472 - Applied Multivariate Analysis

(3.00 cr.)

Prerequisite: E C 220 or EG 381 or PY 292 or ST 210 or ST 265 or ST 381. R estricted to sophomores, juniors, or seniors. Applications of multivariate statistical methods, such as principal components, factor

analysis, cluster analysis, discriminant analysis, Hotelling's T -square, and multivariate analysis of variance. An applied journal article is read and summarized verbally, in written form, and in rewritten form. A final course project based on an original study is presented verbally, in written form, and in rewritten form. (Spring only) (Even Years)

Data Science:

DS 496 - Ethical Data Science Capstone

(3.00 cr.)

Prerequisite: C S312 and ST310 and (IS353 or CS485) and Senior Standing. Students work with an external client on a substantial data science project. Students gather project requirements through consultation with their clients and document them in a proposal approved by the client and the course instructor. Classroom discussions focus on social and ethical issues in data science. An oral presentation and a formal paper conclude the course.

Elective Courses:

Computer Science:

CS 484 - Artificial Intelligence

(3.00 cr.)

Prerequisite: C S 301 or CS 312; ST 210 or written permission of the instructor. An introduction to basic concepts and techniques of artificial intelligence. Topics include search, logic for knowledge representation and deduction, and machine learning. Some current application areas such as natural language, vision, and robotics are surveyed.

CS 487 - Big Data (to be added to the catalog)

(3.00 cr.)

Prerequisite: C S 301 or CS 312 or written permission of the instructor. Covers a range of topics from big data storage and processing to large-scale machine learning libraries. As a hands-on programming course, students learn the details of the design and administration of a cluster, as well as how to apply these details to process "big data". By the end of the course, students should understand the challenges associated with big data, and the tools available to support answering big data questions.

Economics:

EC 420 - Econometrics

(3.00 cr.)

Prerequisite: E C 102, EC 103 , and EC 220 or ST 210 . A grade of C or better required in all prerequisites. Develops and applies the tools of economic theory, mathematics, and statistics to economic phenomena. Students learn to investigate the specification, estimation, and interpretation of empirical economic relationships using least squares techniques. Simple and multiple regression, alternative specifications, and simultaneous equations are used in case studies to form a foundation of experience for students to become applied statisticians and economists.

EC 425 - Applied Economic Forecasting

(3.00 cr.)

Prerequisite: E C 103 , EC 420 or ST 381 , MA 151 or MA 251 . A grade of C or better required in all prerequisites. Forecasts play a crucial role in the formation of economic policy and business decisions. As a result, accurate predictions of the future are critical for the public and private sector alike. This course introduces students to the techniques used by professional economists in business and government to model the complex processes generating data through time and to make real world forecasts. The steps and methods required to develop a forecast-from understanding the properties of time-series data to forecast evaluation-are defined. Topics include modeling trends, seasonality and cycles, ARMA and

ARIMA models, forecast combination, vector-autoregression, and nonlinear methods. (Spring only)

Information Systems:

IS 453 - Information Systems Analysis and Design

(3.00 cr.)

Prerequisite: I S 353 or CS 485; or written permission of the department chair. Prepares students to play a significant role in the development of information systems in organizations. Students learn to complete the phases of the systems development life cycle-feasibility, analysis, design,

implementation, and maintenance-using structured tools and techniques, project management, and oral presentations.

Topics also include the roles of systems analysts, designers, and programmers, as well as global and ethical concerns in systems development.

IS 460 - Data Visualization

(3.00 cr.)

Prerequisite: IS 353 or CS 485; or written permission of the department chair. Students investigate human processing of information and appropriate representation of data in a visual form. Data come in many forms such as structured data in databases and unstructured data in social media and images. Some data are called semi-structured and have characteristics of both types. This course will focus on presentation of data in visual form for humans using current techniques such as Tableau and Qlik.

IS 465 - Text Mining

(3.00 cr.)

Prerequisite: I S 353 or CS 485, IS 358; or written permission of the department chair. Students are introduced to mining textual data to discover information and knowledge embedded in formats such as social media and electronic text documents. Students utilize technologies such as SAS Enterprise Miner™ to perform text mining using methods such as clustering, regression and decision trees. Students

develop a project using current business intelligence technology for text mining.

Mathematics:

MA 301 - Introduction to Linear Algebra

(3.00 cr.)

Prerequisite: M A 252 or CS 295 or MA 295. An introduction to the basics of matrices, linear transformations, and vector spaces along with selected applications. Topics include linear independence, dimension, solutions of linear systems, eigenvalues, and diagonalization. Applications are drawn from areas such as computer graphics, input-output analysis, and least squares. The computer package MATLAB is introduced and used throughout the course.

Statistics:

ST 461 - Elements of Statistical Theory I: Distributions

(3.00 cr.)

Prerequisite: E C 220 or EG 381 or PY 292 or ST 210 or ST 265 or ST 381 ; **MA 351** . Probability, discrete and continuous distributions, moment generating functions, multivariate distributions, transformations of variables, and order statistics. (Fall only) (Even Years)

ST 466 - Experimental Design

(3.00 cr.)

Prerequisite: M A 301 , ST 365 , ST 465. A continuation of ST 465. The theory of linear models and its relationship to regression, analysis of variance and covariance. Coverage of interaction, blocking, replication, and experimental designs: split-plot, nested, and Latin squares. (Spring only) (Even Years)

University Elective - Internship (Does not count toward the DS major.)

DS 499 - Internship in Data Science

(3.00 cr.)

Prerequisite: CS 312, IS 358, ST 310, or written permission of the program director. Students participate in individual study, company-sponsored projects, team project development, and reflection while working in a data science - related position for an enterprise. Students work with a data science professional, performing tasks that are matched with Loyola coursework. Each internship is supervised by a data science professor in consultation with the on-site internship supervisor. Only one internship course may count toward graduation credit.

LEARNING AIMS

- Students will understand the underlying principles of data science and be able to keep up with this expanding field.
- Students will be proficient in analyzing complex data from diverse sources by discovering key relationships within the data.
- Students will be able to model data using machine learning techniques.
- Students will be able to model data using statistical models.
- Students will be able to predict future outcomes that can be used to advise decision makers on their course of action.

H. Adequacy of any articulation;

The program does not anticipate a requirement for articulation agreements, and the institution's standard credit transfer policy, found in its catalogue, will apply to students seeking to transfer credits.

I.   Adequacy of faculty resources consistent with Regulation .11 of this chapter;

As is evident from the planned and anticipated program, full-time faculty will deliver well in excess of half the program. Additional resources for this program will be modest. The university will not need to offer new sections or courses until the program's third year. The university anticipates adding two new sections in its third year, one of which is the new capstone course. The following table lists courses and the status of the faculty who will teach them. The projected increase in enrollments and concomitant increase in some courses' sections will necessitate a modest increased reliance on adjunct faculty; however, the majority of courses associated with the major requirements will involve full-time faculty and full-time tenured faculty's fundamental role in the delivery of Loyola's Core Curriculum (general education) will further buttress that outcome.

Course	Faculty	Faculty status
MA251	Mathematics Faculty	Full-time and adjunct
CS151	Computer Science (CS) Faculty	Full-time and adjunct
CS212	CS Faculty	Full-time and adjunct
ST210	Statistics (Stat) Faculty	Full-time and adjunct
ST265	Stat Faculty	Full-time and adjunct
EC220	Economics Faculty	Full-time and adjunct
CS295/MA295/MA395	CS or Math Faculty	Full-time and adjunct
IS251/BH251	Information Systems (IS) Faculty	Full-time and adjunct
CS312	CS Faculty	Full-time
ST310	Stat Faculty	Full-time
IS353	IS Faculty	Full-time
CS485	CS Faculty	NTT, TT, or T
ST465	Stat Faculty	Full-time
ST472	Stat Faculty	Full-time
IS358	IS Faculty	Full-time
DS496	Faculty from one of the three departments	Full-time
CS electives	CS Faculty	Full-time and adjunct
IS electives	IS Faculty	Full-time and adjunct
Stat electives	Stat Faculty	Full-time and adjunct
Economics electives	Economics Faculty	Full-time and adjunct

Books

Based on faculty requests over the past year and a review of the currency of our relevant holdings, the library's book collection should be updated. At an estimated cost of $100 per book, 25 print books would cost $2500. The library can cover this expenditure as a one-time cost.

Datasets

The library currently subscribes to iPoll and RiskMetrics datasets. If specialized data sets are required, cost will exceed $1000.

K. Adequacy of physical facilities, infrastructure, and instructional equipment consistent with Regulation .13 of this chapter;

Loyola University Maryland, established in 1852, is accredited by the Middle States Commission for Higher Education is entirely equipped to offer graduate programs, including doctoral programs in select areas. This includes the necessary classroom resources, technology, student support and development assets and laboratory space. Additionally, a study of other schools' infrastructural requirements have demonstrated that Loyola's Computer Science department can accommodate any needs for this program's first cohort and to develop the processing speed and capacity, and data storage necessary for subsequent cohorts. Additionally, while the preference is to retain this support as in-house, the university can avail of additional

resources and capacity through Amazon Web Services (AWS), if unanticipated demand and need arises.

L.   **Adequacy of financial resources with documentation consistent with Regulation .14 of this chapter;**

    Please see attached at Appendix I the MHEC expenditures and resources financial tables .

M. Adequacy of provisions for evaluation of program consistent with Regulation .15 of this chapter;

The institution's Assessment Plan will accommodate this program for the evaluation undergraduate learning aims.[12]Additionally, Academic Affairs will incorporate regular review of the program within its cyclical review of programs through its Academic Program Review calendar.

N. Consistency with the Commission's minority student achievement goals; and

Loyola remains committed to an inclusive and diverse academic environment and upholding and fostering the principle enshrined in Title VI of the 1964 Civil Rights Act. This year's freshman class is Loyola's most diverse and reflects its long-term commitment to diversity

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[12] Loyola's undergraduate learning aims, retrieved on January 30, 2018 from
https://www.loyola.edu/admission/undergraduate/academics/learning-aims

and social justice. At Loyola University Maryland, diversity related programs and offices are plentiful throughout the campus. African, Latino, Asian, and Native American Services (ALANA) support programming throughout the year that is focused on multicultural diversity and student support. The Center for Community Service and Justice engages students and the broader Loyola community in education through service for a just and equitable world. OUTLoyola is a group of faculty, staff, and administrators of all backgrounds who are interested in promoting equality for the LGBT members of the campus community and informed dialogue about LGBT issues at Loyola.[13]

Additionally, this program anticipate enrolling a not inconsiderable number of international students, and as it common amongst its graduate programs, to enroll students from the Baltimore area, which considering the socio-economic and demographic milieu, necessitates a commitment to minority students' achievement.

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[13] Maryland Independent Colleges and Universities Association, *Cultural diversity report, 2015,* p. 14. Retrieved on October 19, 2015 from http://www.micua.org/images/2015MICUACulturalDiversityReport.pdf   Cf.
The Alana website http://www.loyola.edu/department/alana/about

Appendix 1: Financial tables

Table 1: Resources

Resource categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Reallocated funds					
2. Tuition/fee revenue	$138,060.00	$274,920.00	$390,720.00	$368,720.00	$380,583.00
a. Number of full-time students	10	29	20	20	21
b. Credit hour rate	767	790	814	838	863
c. Annual credit hours	18	12	24	22	21
d. Total full-time revenue (a x b x c)	$138,060.00	$274,920.00	$390,720.00	$368,720.00	$380,583.00
e. Number of part-time students					
f. Credit hour rate					
g. Annual credit hours					
h. Total part-time revenue	0	0	0	0	0
3. Grants, contracts, and other external sources					
4. Other sources					
Total	$138,060.00	$274,920.00	$390,720.00	$368,720.00	$380,583.00

Table 2: Expenditures

Expenditure categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Faculty (b+c below)	$50,135.25	$82,877.51	$117,826.05	$155,050.85	$160,309.19
a. No. FTE faculty					
b. Total salary	$38,625.00	$63,654.00	$90,150.00	$118,179.00	$121,723.00
c. Total benefits	$11,510.25	$19,223.51	$27,676.05	$36,871.85	$38,586.19
2. Administrative staff	$2,340.29	$2,417.81	$4,999.28	$15,585.25	$20,990.35
a. No. FTE administrative staff					
b. Total salary	$1,803.00	$1,857.00	$3,825.00	$11,879.00	$15,938.00
c. Total benefits	$537.29	$560.81	$1,174.28	$3,706.25	$5,052.35
3. Support staff	0	0	0	0	0
a. FTE administrative staff					
b. Total salary					
c. Total benefits					
4. Equipment					
5. Library	3,500				
6. New or renovated space					
7. Other expenses					
Total	$55,975.54	$85,295.32	$122,825.33	$170,636.10	$181,299.54

Addendum

17007 B.S. Data Science program learning outcomes and financial narrative

Assessment Plan

The program learning aims are

Students will be able to:
1. Utilize statistical descriptive and inferential methods to solve data-intensive applied problems.
2. Write computer programs in languages used for data science (e.g. Python, R) to collect, clean, and analyze data.
3. Formulate data science questions and apply a variety of data analysis techniques for data

discovery, description, prediction and prescription.

4. Communicate data science results in oral, written, and visual forms to technical and non-technical audiences.
5. Advocate for ethical decisions in the use of data.

Each learning aim will be assessed based on the artifacts described below. Exemplars with criteria will be developed to define the degree of competency based on a scale with five different categories:

1. Poor
2. Below standard
3. At standard and expected of a student at the completion of the program
4. Above standard
5. Excellent

Faculty members that are completing the assessment will place each student into a category. The expectation is that 70% of students will be judge to at a level of 3 or above. If fewer students achieve a sufficient level of mastery, courses where the outcome is introduced and practiced will be examined to identify improvements in the curriculum.

Outcome 1 will be mastered in ST465, while the other outcomes will be mastered in DS496. ST465 will use the final exam as the artifact for assessment. Student competency in using statistical descriptive and inferential methods will be ascertained. DS496 will require students to produce an individual or small group semester project, which will bring together the knowledge that was acquired during the completion of the major. The project will required students to submit

- programs in current data science programming languages to assess Outcome 2,
- their exploratory statistical analysis to assess Outcome 3,
- a written description and oral presentation of their project to assess Outcome 4, and
- a separate paper, not necessarily tied to their project, to assess Outcome 5

The computer programs will be reviewed to ensure that students are competently writing programs that accomplish the required tasks for their projects. The statistical analysis will be reviewed to determine that students competently use the techniques and interpret the results. The written paper will be reviewed based on its success to describe the analysis performed and relate the results in a technical and non-technical manner. Similarly, the oral presentation will be reviewed based the clarity of the ideas presented in a manner understandable to a non-technical person and then described in details that are necessary to convey the analysis to a technical audience. Finally, the ethical paper will demonstrate a student's ability to understand ethical dilemmas faced by data scientists and how they can advocate for the ethical use of data.

Faculty teaching DS496 will complete the assessment of most of the program outcomes. One outcome will need to be assessed in ST465 and will need to be done by a faculty member teaching this course. ST465 is already being assessed for Stat, so a similar assessment will be used for the data science program. Faculty teaching courses that are part of the data science major will be expected to attend a yearly meeting lead by the director to discuss assessment data and determine, which parts of the program need to be adjusted to respond to the data and any changing demands to keep the degree current. The Industrial Advisory Board for the MS in Data Science will expand its charge to review

assessment data and provide feedback on the program to ensure it remains current and meets the needs of employers in the area.

Curricular Map

Institutional Learning Aim	Program Learning Aim	Course(s)
The ability to use mathematical concepts and procedures competently, and to evaluate claims made in numeric terms	Utilize statistical descriptive and inferential methods to solve data-intensive applied problems.	Introduced - ST210/EC220/ST265 Practiced - ST472, electives Mastered - ST465
The ability to find and assess data about a given topic using general repositories of information, both printed and electronic *and* the ability to analyze and solve problems using appropriate tools	Write computer programs in languages used for data science (e.g. Python, R) to collect, clean, and analyze data.	Introduced - CS151, ST310 Practiced - CS212, CS312, IS353/CS485, electives Mastered - DS496
The ability to analyze and solve problems using appropriate tools	Formulate data science questions and apply a variety of data analysis techniques for data discovery, description, prediction and prescription.	Introduced - ST210/EC220, IS251 Practiced - IS358, ST465, DST472, electives Mastered - DS496
The ability to use speech and writing effectively, logically, gracefully, persuasively, and responsibly	Communicate data science results in oral, written, and visual forms to technical and non-technical audiences.	Introduced - WR100, EN101, IS251 Practiced - EN200, HS100, HS300, PL201, PL202, TH201, TH202, IS353, IS358, ST310, ST465, ST472 Mastered - DS496
A willingness to act as an agent for positive change, informed by a sense of responsibility to the larger community	Advocate for ethical decisions in the use of data.	Introduced - Ethics Core, IS251 Practiced - DS496 Mastered - DS496

Table 1: Resources

Resource categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Reallocated funds	0	0	0	0	0
2. Tuition/fee revenue	138060	274920	390720	368720	380583
a. Number of full-time students	10	29	20	20	21
b. Credit hour rate	767	790	814	838	863
c. Annual credit hours	18	12	24	22	21
d. Total full-time revenue (a x b x c)	138060	274920	390720	368720	380583
e. Number of part-time students	0	0	0	0	0
f. Credit hour rate	0	0	0	0	0
g. Annual credit hours	0	0	0	0	0
h. Total part-time revenue	0	0	0	0	0
3. Grants, contracts, and other external sources	0	0	0	0	0
4. Other sources	0	0	0	0	0
Total	138060	274920	390720	368720	380583

There are no reallocated funds associated with this program. Tuition increases are based upon a projected annual 3% increase. The credit load is based upon student projections, individual student credit load, and individual students taking courses that fulfill the Data Science requirements for other minors or majors.

Table 2: Expenditures

Expenditure categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Faculty (b+c below)	50135.25	82877.508	117826.05	155050.848	160309.191
a. No. FTE faculty	0.625	0.625	0.625	0.625	0.625
b. Total salary	38625	63654	90150	118179	121723
c. Total benefits	11510.25	19223.508	27676.05	36871.848	38586.191
2. Administrative staff	2340.294	2417.814	4999.275	15585.248	20990.346
a. No. FTE administrative staff	0	0	0	0	0
b. Total salary	1803	1857	3825	11879	15938
c. Total benefits	537.294	560.814	1174.275	3706.248	5052.346
3. Support staff	0	0	0	0	0
a. FTE administrative staff	0	0	0	0	0
b. Total salary	0	0	0	0	0
c. Total benefits	0	0	0	0	0
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	0	0	0	0	0
Total	52475.544	85295.322	122825.325	170636.096	181299.537

Benefits are based upon a salary overhead of 29.74%, 30.24%, 30.74%, 31.24%, and 31.74% in years one through five respectively. Faculty salary is based upon 0.625 of 1.0 fte.