

Statistical Engineering Curricula Development: Panel Discussion

Geoff Vining

Ronald Does

Allison Jones-Farmer

Ray Hill

Jim Simpson

Outline

- Geoff – Virginia Tech
 - Overview of this Effort
 - VT Plans
- Ronald – University of Amsterdam
- Allison – Miami University
- Ray – Air Force Institute of Technology (AFIT)
- Jim – AFIT, IDA, Independent Consultant

Overview

- Paradigm for Statistical Engineering: Chemical Engineering
 - True Origins of Chem E: MIT's "Course X (Ten)" Circa 1888
 - Spread to Other Universities over Next 20 Years
 - University of Pennsylvania, 1894
 - Tulane University, 1894
 - University of Michigan, 1898
 - Tufts University, 1898
 - American Institute of Chemical Engineers – 22 June 1908
- Critical to the Development: The Academic Departments

Why Are University Curricula Vital for SE?

- Reality: University Curricula Define Technical Disciplines!
 - Defines the Basic Required Skills and Knowledge
 - Certifies Student Comprehension
 - Publishes the “Theoretical” Foundations to Advance the Discipline
- Success Requires Appropriate Organizational Partnerships
- ISEA Has Important Roles
 - Handbook!
 - Facilitating Cooperation among Universities and Organizations

Virginia Tech Plans

- Joint Effort between Statistics and ISE
- Vision Is a Much Broader Collaboration
 - Other Engineering Departments
 - Other Science Departments
 - Business School
 - Psychology
- Northern Virginia Is Fundamental to this Effort
- General Direction Defined by White Paper – May 2019

Virginia Tech Plans

- Overall SE Effort – Curricular and Research Efforts
- Spring 2020, Introduction to SE
 - 4000/5000 Level
 - Pre-requisite: Two Semesters of Engineering Stat or Equivalent
 - If Possible, Offered via Streaming/Distance to NOVA
- Short-Term
 - Certificate Program
 - Capstone Course – Supervised Work Experience
 - “Tool Set” Courses – Industrial Statistics, Data Science, IE, OR

Virginia Tech Plans

- Longer Term
 - Masters of Statistical Engineering
 - Modeled on MBA
 - Two Required Courses: Intro to SE, Capstone Work Experience
 - Complete University Masters Requirements
 - Technical Courses – Industrial Statistics, Data Science, IE, OR, Subject Matter
 - “Soft” Courses – Organizational Psychology, Emotional Intelligence, Etc.
 - Not a Research Degree
 - Bachelors Concentration within ISE
- Do Not Envision Ph.D. Program in Near Future

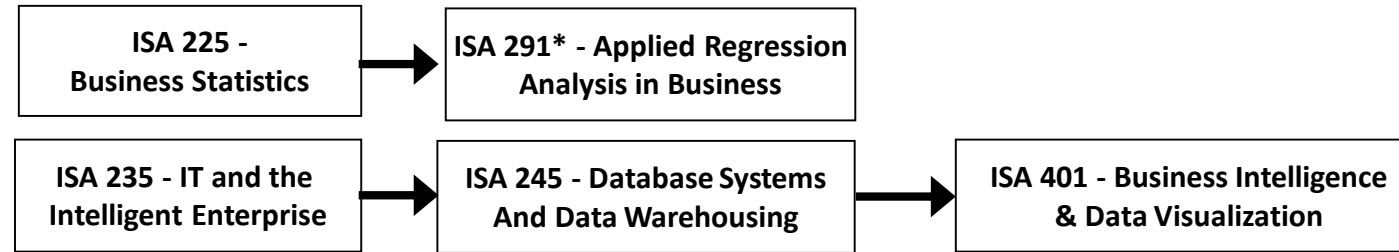
Allison's Slides Below

Miami University's Business Analytics Programs

Business Analytics Minor

09/17/19

Required Courses



Choose 1

Choose 1

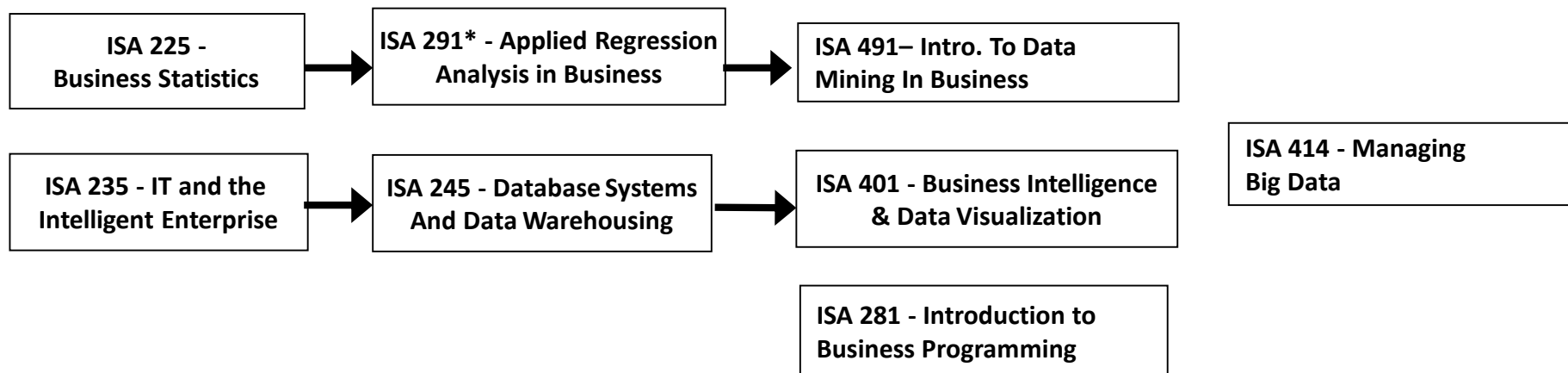
ISA 321 - Quantitative Analysis of Business Problems	IMS/IRS/STA 404 – Advanced Data Visualization	ISA 321 - Quantitative Analysis of Business Problems	IMS/IRS/STA 404 – Advanced Data Visualization
ISA 365 - Statistical Monitoring and Design of Exp.	STA 402 - Statistical Programming	ISA 365 - Statistical Monitoring and Design of Exp.	STA 402 - Statistical Programming
ISA 444 - Business Forecasting	STA 483 - Analysis Of Forecasting Systems	ISA 444 - Business Forecasting	STA 483 - Analysis Of Forecasting Systems
ISA 480 - Topics in Decision Sciences (3 credit hours)		ISA 480 - Topics in Decision Sciences (3 credit hours)	ISA 414 - Managing Big Data
ISA 491– Intro. To Data Mining In Business		ISA 491 – Intro. To Data Mining In Business	ISA 281 - Introduction to Business Programming
ISA 496 Practicum in Business Analytics		ISA 496 Practicum in Business Analytics	ECO 411- Advanced Empirical Methods

KEY: Required
 Elective

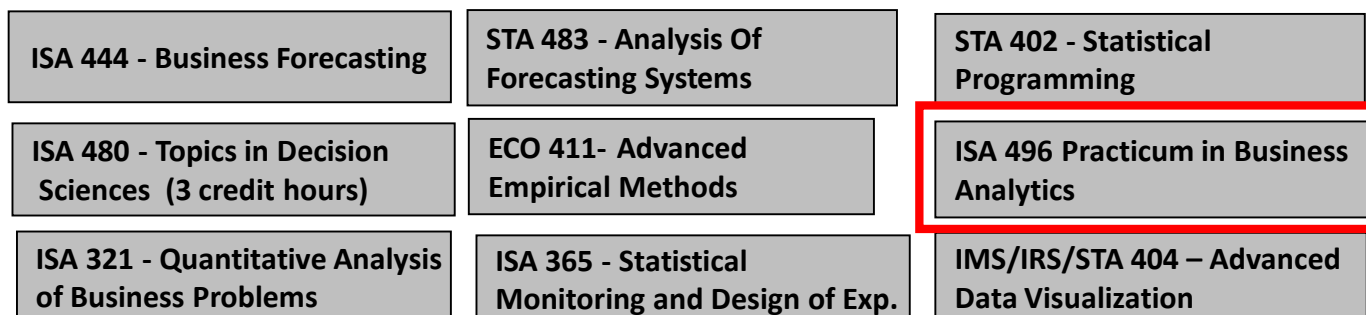
* Economics Majors may substitute ECO 311 for ISA 291.

Business Analytics Major

Required Courses



Electives-Choose 2



KEY:

☐ Required
☒ Elective

* Economics Majors may substitute ECO 311 for ISA 291.

Master of Science in Business Analytics

Prerequisites

Undergraduate Certificate Foundations of Analytics

- **ISA/STA 250 Basic Math for Analytics**
- **ISA 225 Principles of Business Analytics**
- **ISA 243 Database and Programming for Analytics**
- **ISA 291 Applied Regression Analysis**

Master of Science in Business Analytics

Graduate Certificate in Analytics

▪ Courses

- ISA 412/512 Data Warehousing and Business Intelligence
- ISA 491/591 Intro to Data Mining in Business
- ISA 414/514 Managing Big Data
- ISA/STA 516 Communicating with Data

Graduate Certificate in Advanced Business Analytics

▪ Courses

- ISA 630 Machine Learning Applications in Business
- ISA 632 Big Data Analytics and Modern AI
- ISA 633 Prescriptive Analytics
- ISA 634 Analytics Solution Deployment and Lifecycle Management

6-Hour Culminating Experiential & Research Component

Master of Science in Business Analytics

6-Hour Culminating Experiential & Research Component

- ISA 650 Business Analytics Practicum
- Offered January term and spring term
- Projects with real clients that involve
 - Problem framing
 - Synthesizing data from multiple sources
 - Preparing the data for analysis
 - Modeling and analysis
 - Drawing conclusions
 - Communicating with multiple audiences as appropriate
 - Providing actionable insights

Business Analytics Practicum



Business Analytics Practicum-Example

Client: Major International Provider of Legal Information Services

Goal: Understand customer perceptions of three information services products. Specifically, why is the “net promoter score” lower on one product and declining?

Data: Emails, call logs, and structured survey responses related to three information services products.

Interaction with Client:

- Client visited campus to kick off project.
- Students set up a google sheet with questions and had biweekly WebEx calls with client contact as needed.
- Students presented final project on-sight.

Business Analytics Practicum-Example

Structure of Class:

- Twenty students
- Four teams
- Competition for Best Solution-jointly judged by professor and client

Lessons Learned:

- Problem framing
- Data acquisition, cleaning
- “Bag of Words”, Topic Modeling, Sentiment Analysis
- Survey analysis, instrument reliability
- Client Interaction
- Reproducibility (code, documentation)
- Technical Communication (written reports, oral presentations)

The challenge of large, complex, unstructured problems in the classroom

- Course materials must be created “from scratch” by instructors
- No general agreement on how to approach unstructured problems
- No general agreement on how to approach teaching students to solve large, complex, unstructured problems
- Faculty don't want to (won't, don't have the skills to) teach these courses
- Industry partnerships for projects are difficult and time consuming to negotiate.



UNIVERSITY OF AMSTERDAM

Business Analytics at the University of Amsterdam

Ronald J.M.M. Does

University of Amsterdam

AMSTERDAM
BUSINESS
SCHOOL

Business

Education – AI and Data Science official degree programs in the Netherlands

● Science Faculty: Computer Science
 ● Science Faculty: Other
 ● Business / Econom(etr)ics Faculty
 ● Other Faculty

B = Bachelor
 M1 = Master's (1 year)
 M2 = Master's (2 year)
 /S = Specialization

Amsterdam VU

- Business Analytics (B, M2)
- Marketing Data Science (M1/S)
- Econometrics & Data Science (B/S)
- Artificial Intelligence (B, M2)
- Bioinformatics (w. UvA) (M2)

Amsterdam UvA

- MBA Big Data & Business Analytics (2 year MBA (part-time))
- Econometrics / Big Data Business Analytics (M1/S)
- Artificial Intelligence (B, M2)
- Information Systems / Data Science (M1/S)
- Behavioral Data Science (M1/S)

Leiden

- CS & Advanced Data Analytics (M2/S)
- Data Science: Computer Science (M2/S)

Rotterdam

- Econometrics / Business Analytics & Quant Marketing (M1/S)
- Data Science & Marketing Analytics (M1/S)

Tilburg (TU) / Eindhoven (TU/e) / JADS Den Bosch

- Data Science (B)
- Data Science & Entrepreneurship (M2)
- Data Science: B'ness / Governance (M1/S)
- Business Analytics & OR (M1/S)
- Data Science in Engineering (M2/S)
- Marketing Analytics (M1/S)
- EIT Data Science (M2/S)

Groningen

- Artificial Intelligence (B/M2)
- Data Science & Systems Complexity (M2/S)

Twente

- Data Science & Technology (M2/S)
- Data Science and Business (M2/S)

Utrecht

- Algorithmic Data Analysis (M2/S)
- Artificial Intelligence (B/M2)

Delft

- Data Science & Technology (M2/S)

Wageningen

- Bioinformatics (M2)

Nijmegen

- Artificial Intelligence (B/M2)
- Data Science (M2/S)

Maastricht

- Data Science & Knowledge Eng. (B)
- Artificial Intelligence (M2)
- Data Science for Decision Making (M2)

What is considered a Business Analytics program?

- Graduates need to be able to combine "A/AI", "B" and "C" at various levels of "depth", to execute independently a project from start to finish
- "A" stands for "**Analytics**" and it includes *Mathematics, Statistics, Econometrics, and Operations Research*.
- The subset "AI" stands for **Artificial Intelligence** and it includes: *Machine Learning, Deep Learning, Data Mining, Process Mining and similar courses*;
- "B" stands for **Business**, with courses like *Accounting, Entrepreneurship, Finance, HR & Leadership, Marketing, Operations, Strategy, etc*
- "C" stands for **Computer Science**, with courses like *Programming, Datastructures & Algorithms, Databases & Infrastructures, etc.*

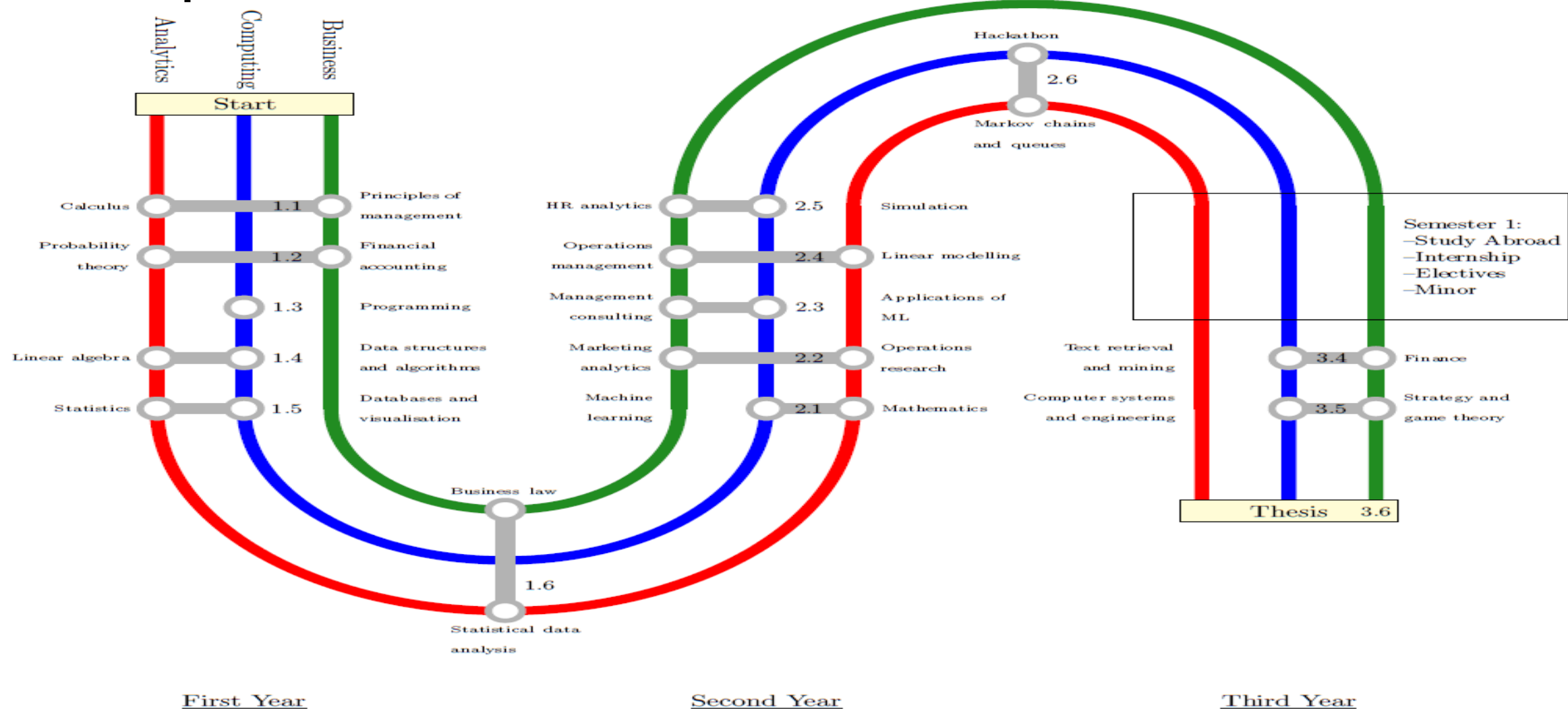


Bachelor and Master Business Analytics at the UvA

- Pillars: Analytics/AI, Business, and Computing
- It enables graduates to execute independently a project of a large, unstructured, complex and data rich problem from start to finish
- Combination of quantitative and computer science skills and rigorous thinking in business related subjects
- Hackatons, Internships and Management Consulting skills allow the student to run projects within organizations and show how evidence based decisions rely on

Bachelor Program

Start 1 September 2020



MSc Business Analytics-1

1. *Statistical Engineering* (A+B+C): An overview course at the beginning of the MSc program, where the students would get familiar with the entire Data Science pipeline – from problem formulation, data collection and analysis to the result presentation and formulation of actionable advices and policies. Each step of the pipeline would be addressed in detail by the subsequent courses.
2. *Fintech* (A+B+C): Machine learning and Block-chain technologies in finance.
3. *HR Analytics and Organization* (A+B+C): Follow-up of the introductory HR Analytics course given in the BSc BA program.
4. *Accounting Analytics* (A+B+C): Follow-up of the course “Introduction to Finance and Financial Accounting” from BSc BA program.

MSc Business Analytics-2

5. *Deep Learning for Business* (B+C): Deep learning applications in computer vision for e.g. autonomous driving, production control, online help desks and conversational agents.
6. *Fairness, Ethics, Model Interpretability and Explain Ability* (A+B+C): The course will focus on some of the core data science challenges identified by the ACM, and IMS.
7. *Simulation, Optimization and Process Mining* (A+B+C): This advanced course is building on the introductory Process Mining course from BSc BA program.
8. *Advanced Marketing Analytics* (A+B+C): This course will go broader than the Marketing Analytics course from the BSc BA.
9. *Tools and Infrastructure for Large-scale Data Analysis* (B+C): The course will build upon the Computer Systems and Engineering from the BSc BA.
10. *Master Thesis*



AFIT Approach to Graduate Education in Data Analytics / Data Science

Raymond R. Hill

AFIT POC: Darryl K. Ahner, PhD, P.E.



AFIT Education Excellence:

Inspiration → Imagination → Innovation → Invention → Implementation → Impact





AFIT has offered a DL-based applied statistics certificate, the T&E Certificate Program

- **Sequence of 5 courses, all via asynchronous DL, mirror of in-residence**
 - **Probability and Statistics**
 - **Empirical Modeling**
 - **Design of Experiments**
 - **Reliability, Maintainability and Availability**
 - **Forecasting and Response Surface methods**
- **Cohorts start each January, 25 in each cohort**
- **Currently compiling cohort 12**
- **Open to AF active duty and civilians**
- **Completing about 70% of those that start**



Certificate (<12 qtr hours)

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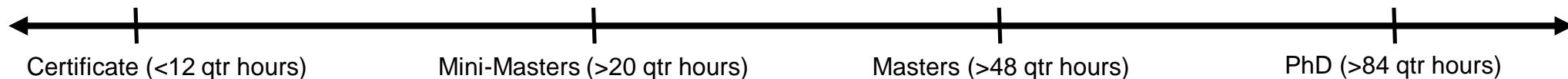


Bottomline

AFIT is approaching Air Force analytic education needs through the following offerings

- A quickly-developing **distance learning** MS in Data Analytics for a broader Air Force audience
 - A Mini-Masters is the core of this program and receives a completion credential
- A developing **in-resident** MS and PhD in Data Science
- A **long-standing** MS and PhD in Operations Research
- An **in-resident** Data Science **certificate** that can be earned *in addition to* the base degree being earned

Additionally, I am advocating the following position: “A center of excellence focused on assisting data analysts in the field with technical quality control and generation of tools that consists of a key number of data scientists and operations research analysts should be established to further empower quality analysis.” – an Air Force Operational and Data Analytics Center of Excellence.



AFIT Education Excellence:

Inspiration → Imagination → Innovation → Invention → Implementation → Impact





Types of Air Force Analysis

Types of Air Force Analysis

Approached
most effectively by
Data Analytics

LESS

MORE

- Resource Allocation Analysis
- Operational and Campaign Analysis
- Weapon Systems Performance Analysis
- Process Analysis (personnel, accessions, logistics, supply chain)
- Analytical Intel Analysis (as contrasted to subject matter expert analysis conducted through tradecraft)

MORE

Approached
most effectively by
Operations Research

LESS





Identifying type of program

■ Mini-Masters in Data Analytics

- DASC 500 Introduction to Data Analytics (minor use of Python)
- DASC 501 Databases (Design, Use and Management)
- DASC 511 Object Oriented Programming (Python)
- DASC 512 Applied STATS (use of Python)
- DASC 522 Machine Learning (use of Python)

Note: An AF data set and programming thread (Python) would ideally support the desired outcomes

Note: AF Chief Data Officer concurs in principle with the approach of a Mini-Masters toward a full Masters



Curriculum Thoughts – Framework Pieces

- Undergrad
 - Like engineering with the same engineering core courses and senior design (SE topic) project
 - Like Operations Research should be multidisciplinary with math/statistics/business/analytics/engineering all playing a role
 - Engineering school should be the host – credibility as engineering discipline, same core pre-reqs, senior design
- Grad
 - Can be hosted in department appropriate for the university and faculty
 - Should have universal set of core classes (see Geoff, Ronald, Allison, Ray's ideas) plus electives featuring faculty strengths
 - Analytics and statistical data science, with Python/R/Matlab featuring prominently
 - Case study intensive

Statistical Engineering curriculum context

- Curriculum and degree is only first step up the SE education and competence staircase
- Other two:
 - Internship, residence, OJT, with coaching to gain invaluable apprenticeship experience
 - Development and refinement of interpersonal, relations, oral / written communication, and management / leadership skills



Discussion

- Time for clarification, drilling down, counter points, related topics
- Possibilities if you need a nudge:
 - Can we just take someone with a related degree and just train them up?
 - What is the best related degree and why?
 - What about the BS / MS / PhD need?
 - What about career progression after the degree?