Proposed B.A. Degree Program in Computer Science

Department of Computer Science
University of Colorado
Colorado Springs

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A Description of Program

A.1 Background and Basic Concept

The Faculty of the Department of Computer Science in the College of Engineering and Applied Science (EAS) proposes to create a new Bachelor of Arts (BA) degree in Computer Science for undergraduates enrolled in the College of Engineering and Applied Science (EAS) by Fall 2020. The program will present a framework for making a computing degree accessible to a larger population of students, equipping them with the knowledge to become software designers and developers, and also allowing for specialization in a few areas within the general field of Computer Science. A focus of the proposed degree program will to allow for several useful and topical application tracks within Computer Science, but a beneficial future byproduct is likely to provide ways to integrate foundational knowledge of Computer Science with a variety of areas so that some our graduates are trained to use computation felicitously in traditionally non-computing disciplines. In developing this proposal, we have carefully considered the implication of the BA versus the existing Bachelor of Science (BS) in Computer Science. Even though the two degrees would share many of the same courses, the BS degree focuses on the *science and engineering* of computing as contrasted to the BA, which will focus on the *application*s of computing. The BS degree requires depth in mathematics and theoretical computer sciences to prepare future computer scientists and engineers who can push the envelope of computing-focused knowledge whereas the BA degree will focus on a balance of knowledge in software design and development, and effective and impactful applications of computing. We see this application focus facilitating the use of computing in areas such as cybersecurity, game design, and machine learning. The BA in Computer Science will impart a powerful set of computing skills that can be immediately applied to these areas, and potentially to many other areas in the future.

Computer science, broadly defined, is the theory and practice of the digital representation, processing, and use of information; it is the scientific and mathematical approach to computation, and specifically to the design of computing machines and computational processes. The field is still in its infancy, yet encompasses a large and rapidly growing body of knowledge concerning algorithms, information processing, communication, programming languages and information systems. It employs both theoretical as well as experimental approaches to advance the state of knowledge in these areas. It offers a powerful paradigm for modeling complex phenomena such as

cognition and life, and representing, processing, acquiring, and communicating knowledge that is new in the history of humanity.

Computer Science is a scientific discipline that is driving the creation of new knowledge backed by experimental, quantitative and qualitative techniques and driving innovation in many other disciplines. Historically, Computer Science departments have evolved from either Engineering or Math departments, reflecting the development of *computational theory* (typically by mathematicians and logicians) as well as the later development of *computational devices* (usually by electrical engineers, such as pioneers at the University of Pennsylvania) and later *software.* Indeed, innovations in computing and computational science have profoundly affected every area of science, healthcare and medicine, transport and communication, commerce and industry, art and entertainment, and homeland security including cybersecurity, spawning new industries and transforming others. Computing is poised to continue to make similar societal contributions in the decades ahead and to contribute to our nation's most pressing challenges in every conceivable area. However, rising to these challenges requires fundamental changes to our vision of computing and the processes by which we train future citizens. We propose to extend the ability of the University of Colorado Colorado Springs to address those future needs by creating a BA program in computing with a focus on educating the next generation of computational and information scientists.

In particular, one high impact area we would like to highlight in the context of the proposed BA in Computer Science is cybersecurity. As the region focuses on government, military, and commercialization applications in cybersecurity and the ability to use software to secure systems, this area has become a driver for workforce demands. The cybersecurity community has demonstrated a workforce demand that is staggering in scope and is looking to UCCS to provide a skilled workforce in this area. The workforce will likely consist of professionals with Associate, Bachelor, Master, and Doctoral degrees. UCCS is in a unique position to contribute in each degree area. While Pikes Peak Community College has a popular cyber degree at the associate level, they do not currently have a clean path into a bachelor's degree at UCCS enabling depth in the discipline. Typically, the PPCC students in cyber lack depth in mathematics which precludes immediate entry in the BS in Computer Science. The BA would enable entry into a UCCS four-year degree opportunity for PPCC as well as veterans transitioning into the public sector.

In 2018, according to U.S. News & World Report, the University of Colorado Colorado Springs was ranked 35th among Regional Universities West, and 6th in among Top Public Regional Universities in the West. It was ranked 137th among all Engineering Programs (doctorate) in 2018. The Computer Science program at UCCS is not ranked by US News and World Report, but is ranked by csrankings.org, maintained by academics based on selective publications by faculty. Considering all areas of computer science from 2009 to 2019, it ranks UCCS's CS program at rank 109 in the country. We should note that it ranks Colorado State University's CS program also at 109, School of Mine's at 76 and Boulder's at 35. Rankings on a few selected sub-fields of Computer Science, according to csrankings.org are given in Table 1. Considering that UCCS's Computer Science department is much smaller (15 TTF and 6 instructors, as of Fall 2019, and has traditionally been even smaller) than those of CSU (28 faculty members, 22 TTF and 6 instructors) and UC-Boulder

(approx. 63 faculty members, 53 TTF and 10 instructors, as of Fall 2019), these numbers are notable. Note that these rankings are normalized for the size of the department. We should also note that the single PhD in Engineering at UCCS was tri-furcated into PhD in Computer Science, PhD in Security and PhD in Engineering (with tracks in Electrical Engineering, and Mechanical and Aerospace Engineering) by the Board of Regents in October 2018.

Table 1: Ranking of Colorado Universities in Computer Science by csrankings.org as of September 7, 2019, based on publications from 2009 to 2019. NA means the university did not have publications in highly rated conferences in the area during the period. Top ranks in Colorado are in bold font, runners up are in italics.

Sub-field	UCCS	UC-Boulder	UC-Denver	CSU	Mines	U-Denver
Overall CS	102	**31**	162	119	*80*	NA
AI	119	**44**	NA	138	*48*	NA
Machine Learning and Data Mining	121	**53**	NA	121	*92*	NA
Comp. Vision	66	88	NA	**62**	*64*	NA
Nat. Lang. Proc.	*87*	**25**	NA	NA	NA	NA
Comp. Arch.	*59*	66	NA	NA	**53**	NA
Comp. Networks	*68*	**27**	NA	NA	NA	NA
High Perf. Comp.	*53*	**50**	NA	79	**50**	NA
Cybersecurity	NA	**46**	NA	*102*	NA	NA
Software Engg	*95*	**73**	NA	NA	NA	NA

In preparation for this proposal, we looked at the websites of tens of Departments of Computer Science in the US. A considerable number of universities have both BS and BA programs in Computer Science. These include University of Virginia, University of Arizona, University of Indiana—Bloomington, Texas State University, Iowa State University, Georgetown, Rice and Cornell. University of Colorado Boulder started a BA program (within the College of Arts and Sciences) in addition to its BS program in Computer Science in 2012. University of Colorado Denver started a BA program in Computer Science (within the College of Engineering, Design and Computing) in 2018. Our program is inspired by these programs, especially the one at Boulder. The program at CU-Denver is called CS+ allowing possibilities for double majors or double degrees in a large number of other fields that may benefit from computing knowledge.

Why does this distinction between Engineering and non-Engineering flavors of computing matter? At a high level, the distinction reflects history—Computer Science programs in Engineering schools are heavy on mathematical and theoretical requirements in addition to programming or coding. However, the use of computational techniques has become integral to many areas of arts and entertainment, science and technology, commerce and business, law and order and defense, and these different fields have differing prerequisites, cultures and careers. For example, cybersecurity requires one to marry knowledge of computing with knowledge of Information Technology (IT), and sleuthwork based on methodical logical thinking. Game Design requires knowledge of computing, but also that of storytelling, design, production, editing, and user interface. Artificial

intelligence and machine learning require knowledge of computing as well as statistics, human psychology, cognitive science and natural language. Computational biology and bioinformatics require that students have a solid understanding of biology and genetics in addition to computing, but place less emphasis on calculus and physics, both of which are required in engineering disciplines.

As many universities have found, it is impossible to address all the ways in which computation is used in a single degree program with a single set of prerequisites. The solutions to this problem are varied, but most universities have addressed these problems by having multiple *programs as well as tracks*. The Computer Science department at UCCS offers a BS degree geared toward those who want engineering, computing, mathematical and scientific rigor in their training; and a Bachelor of Innovation (BI) degree in Computer Science for those who want to learn about core computer science along with a business core. However, we believe that there is an issue with our program offerings that needs to be addressed. Both our programs allow for only a low number of credit hours for those who want to learn the fundamentals of computing and software, but then additionally want to develop expertise in a specialized application area, closely allied with computer science, such as cybersecurity, game design or artificial intelliigence. This problem also extends to those students who have interest in computing and software, but in an area that falls in the purview of another college on campus. For example, we do not offer programs that are more suited to those students who are interested both in computing and another STEM field, even non-STEM and non-Business fields. We believe the time is opportune to address this gap for the Computer Science department at this time. We believe there is significant demand by new students for a degree program in Computer Science beyond the BS and BI. We also believe that a degree program that satisfies this demand can be created through the use of our existing curriculum combined with special-topic courses within computer science. Instead of creating a proliferation by proposing multiple degree programs to suit various needs, we intend to address the gap we perceive by creating a flexible and encompassing BA program that has enough elective credits to allow for a variety of tracks within computer science, in addition to leaving the door open for the future for a variety of dual degree programs or dual majors.

The issue can be reiterated in another way. As society becomes more and more dependent on technology, there is growing need for a very large number of diverse computing professionals beyond the stereotypical ones that are graduated by our current Bachelor programs. Employers in Colorado and the US also need, in great numbers, computer scientists who are well-versed in the core of computer science, and are additionally good game designers or cybersecurity professionals, without going for a specialized Masters degree in such areas. Thus, the proposed BA program in CS is going to fulfill an important employer need as well.

A.2 Student Learning Goals

The proposed BA degree program has as its primary educational outcome the production of students who have strong skills in computing and information technology that can be applied in general or within a variety of specialized areas in business, industry or research contexts. To

achieve this outcome, the BA degree program aims to produce students that at the time of graduation have the ability to:

- analyze a problem and identify the computing requirements appropriate to its solution;
- apply knowledge of computing and mathematics in a variety of application contexts;
- design, implement, and evaluate a computer-based software system, process, component, or program of varying complexity, to meet desired needs;
- apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices;
- function effectively on multi-disciplinary teams to accomplish shared design, evaluation or implementation goals;
- understand professional, ethical, legal, security, and social issues and responsibilities related to the computing profession;
- communicate effectively about computing topics with a range of audiences;
- engage in continuing professional development.

In addition, the proposed BA program has as its primary objective the production of alumni that within three to five years after graduation:

- are prepared to be valued individual contributors in a software-oriented organization, to be programmers and designers to lead small projects and generally begin preparation for a management career, or in an entrepreneurial pursuit, or to succeed in rigorous postgraduate programs;
- are prepared, where appropriate, to further specialize in a broad spectrum of computer science sub-disciplines as well as application areas;
- are able to focus their careers on pure computer science technology or to bring computer science expertise to another discipline.

To clarify, these are the skills our graduates will have after graduating and working in computing and IT-related fields for 3-5 years. We expect to provide them with a solid foundation that enables them to succeed in their chosen careers.

B. Concerns to be Addressed

B.1 Student Demand and Workforce Demand

B.1.a. Student Demand

There are several categories of students who will be drawn to a BA in Computer Science:

(i) New major opportunities,
(ii) Engineering Prep, Intent and Undecided students,
(iii) Transfer students from other colleges within UCCS,
(iv) Transfer students from community colleges,
(v) Veterans who are retooling skills for civilian careers, and

(vi) Dual majors and dual degree opportunities, and

New major opportunities: We propose the BA-CS degree at the UCCS, inspired by the evolution and growth of the same degree program at the University of Colorado Boulder. BA-CS degrees have been quite popular around the country, and the same has been true at CU-Boulder. The BA-CS degree was initiated at CU-Boulder in 2013. Table 2 gives the number of students enrolled in and graduating from CU-Boulder in BA-CS in the past few years. The number of students enrolled and the number of graduates in the BA-CS program have surpassed those of BS-CS program in a few years.

Table 2: Enrollment and Graduation for BA-CS Degree in CU-Boulder

Semester	BS-CS Enrollment	BS-CS Graduation	BA-CS Enrollment	BA-CS Graduation
Fall 2013	378		222	
Spring 2014	368	89	267	4
Fall 2014	421		457	
Spring 2015	442	79	494	26
Fall 2015	475		627	
Spring 2016	497	100	634	57
Fall 2016	560		782	
Spring 2017	600	97	796	97
Fall 2017	654		918	
Spring 2018	703	141	939	134
Fall 2018	838		1204	
Spring 2019	773	151	1152	174
Fall 2019			1187	

It is to be noted that the BA-CS program at CU-Boulder was originally pitched in 2011-12 as a way for students in the College of Arts and Sciences (CA&S) to pursue a double major in Computer Science along with another major in CA&S. However, over the past eight years, the BA-CS at CU-Boulder has ended up being mostly a stand-alone major. Of the 1187 BA-CS majors in Fall 2019, 1043 (87.8%) have it as their only major. There are 123 (10.4%) double majors and 21 (1.7%) triple majors. The CA&S majors that are most frequently partnered with the BA-CS are Math (43 students, 3.6%), Physics (18, 1.5%), Economics (18, 1.5%), Astronomy (8, 0.6%), Psychology (8, 0.6%), Japanese (7, 0.6%), Molecular Biology (5, 0.4%), International Affairs (5, 0.4%) and Studio Art (5, 0.4% The reason that the BA-CS major has become largely a stand-alone major is that it has become the fall back degree for students who were not admitted to Engineering or Business but were admitted to CA&S at Boulder. 531 (44.8%) of the 1187 BA-CS majors initially applied to a college other than CA&S at CU-Boulder. The program is housed in CA&S in CU-Boulder, although

the Computer Science department now wants to move it to College of Engineering and Applied Science, a move opposed by CA&S.[1]

Learning from the evolution of CU-Boulder's program, we propose that BA-CS at UCCS be housed in the College of Engineering and Applied Science (EAS), with an altered admission standard. We also believe that most of students who become BA-CS majors at UCCS are likely to be single major students, and new opportunities for UCCS.

Engineering Prep, Intent and Undecided students: There is a large number of students at UCCS in various programs such as Engineering Intent, Engineering Prep and Engineering Undecided. The label given to these students has been changing over the past few years, but Institutional Research provided us with the numbers, given in Table 3. These are mostly students, who want to transfer to the College of Engineering and Applied Science, but cannot do so because they do not meet admission requirements, and are housed in the College of Letters, Arts and Sciences, with the hope of transferring eventually. Table 3 gives the number of Engineering Intent students in the past few semesters. Most of these students cannot transfer because their Math preparation does not meet the EAS College's admission requirements. We believe and anticipate that a good fraction of such students will apply for and will be accepted to the BA-CS program. We note that the curriculum for the proposed BA in CS program, given in details later, will make fewer assumptions about math and programming/coding preparedness of the students.

Table 3: Number of Engineering Intent Students, housed in the College of Letters, Arts and Sciences

Semester	No of Eng. Intent/Prep/Undecided Students
Fall 2017	534
Spring 2018	519
Fall 2018	646
Fall 2019	351[2]

Transfer students from other colleges within UCCS: In general, the College of Engineering and Applied Science receives a lot of students who change their majors from another college, as shown in Table 4. According to Institutional Research, of the 1401 total EAS undergraduates we had enrolled in Fall 2018, 346 changed their plan from a program outside of EAS to a program in EAS at some point in their career. In particular, 32% of students currently enrolled CS-BS changed their major to CS-BS from a major outside of one of the three (BS-CS, BI-CS and BI-CS Security) offered

[1] This paragraph is based on communication between Interim Dean of LAS at UCCS and an Associate Dean of CA&S at CU-Boulder in late October 2019.

[2] Institutional Research at UCCS has started enumerating Engineering Intent/Prep/Undecided in a different way starting Fall of 2019 and the number given here may not be comparable to the numbers from previous years.

by the Computer Science Department. We expect that the proposed BA program in CS will attract students transferring from within UCCS, in addition to new students. We expect that students will be transferring into the new BA program in CS as well.

Table 4: Major change to BICS-BI (Computer Science BI), BISC-BI (Security BI) or CSCI-BS (Computer Science BS) students enrolled in a Computer Science Bachelor program in Fall 2018. The table does not count changes between computer science majors (e.g., changes from the CS BI to BS or BS to BI)

Plan	No Major Change		Prior Major Change*		Total
	(N)	(%)	(N)	(%)	(N)
BICS-BI	50	64.10%	28	35.90%	78
BISC-BI	59	61.46%	37	38.54%	96
CSCI-BS	204	68.46%	94	31.54%	298
Total	313	66.31%	159	33.69%	472

This information demonstrates that a substantial number of students per year are willing to invest the effort it takes to meet the transfer requirements imposed by the College of Engineering and Applied Science in order to join the existing BS and BI degree programs in Computer Science. We believe the same will be true for the BA-CS program.

Transfer students from community colleges: The EAS College gets a number of transfers from Pikes Peak Community College (PPCC). We have an articulation agreement that allows students completing an Associate degree to transfer to UCCS in a felicitous manner. In particular, we will create a Cybersecurity track in the BA in CS, and have started discussions with PPCC in Fall of 2019, with a view to enabling students in the AAS program in Cybersecurity at PPCC to transfer into this track. We expect that this will fulfill an identified and crucial need. See footnote on Page 17 as well.

Veterans transitioning to civilian careers: UCCS is a veteran friendly school. For example, Victory Media, Pittsburgh, Pennsylvania, publisher of "G.I. Jobs" and several other publications for veterans and their families, named UCCS a Gold Level Military Friendly school in its 2017 Military Friendly Schools and Employers listing. Ranking factors included student veteran retention, graduation, job placement and loan repayment. We anticipate that a small percentage of students attracted to the BA-CS program will be enlisted military veterans transitioning to a 4-year college, especially those who were trained in some information technology or engineering type professions within the military. We believe that it is easier for veterans to acquire secret clearances than others in the general population and they also have the mindset for it, making them suitable for future careers in cybersecurity. As a result, qualified veterans are likely to be attracted to the BA-CS track in Cybersecurity, with appropriate marketing and advising. Most veterans are also likely to be enlisted personnel, with background in Math better suited to BA-CS.

Dual major and dual degree opportunities: The number of students who would pursue Computer Science as double major or dual degree (*e.g.* with math or biology) is likely to be small, since the

barriers for such study are currently high[3]. This has been true in case of the BA-CS program at CU-Boulder, as seen in Table 1. We believe this percentage is likely to be less than 10% among all students drawn to the BA-CS program at UCCS, if such programs are created in the future.

B.1.b Workforce Demand

The Bureau of Labor Statistics projects that jobs in computer science occupations will rise from 8,313,000 in the US in 2016 to 10,866,000 in 2026[4], a rise of 30.7%. These professions had a mean salary of $101,790 in 2017. The growth in computer science related jobs comes right after health-related and food preparation and serving related jobs. Other engineering disciplines do not appear in the top 20 occupations with the highest anticipated percentage growth between 2016 and 2026. There are plentiful jobs related to computer science occupations in Colorado. A search of indeed.com on September 8, 2019, found the following numbers of new jobs corresponding to keyword searches. The keywords are given in double quotes: "computer": 28,278; "software": 15,436; "information technology": 8,601; "software engineer": 4,704; "computer science": 3,716; "software developer": 2,750; and "computer security": 4,993 . The graduates of our BS degree program certainly encounter no difficulties finding employment after graduation; almost all of our graduates finds a job soon after graduation, most before graduation. Exit interviews with graduating students in December 2019 show that about 75% have jobs before graduation, with salary range from $65,000 to $105,000 based on academic performance and prior experience such as internships during college. There are a large number of employers, primarily defense contractors, within even the Colorado Springs Metropolitan area, not to speak of entire State of Colorado. Many of our undergraduates, by the beginning of their third or fourth year, are interning at some of these companies, and then gaining full-time employment after graduation. We believe that there will be healthy workforce demand for graduates of the proposed BA program, especially as these students will not only have acquired a strong set of computational skills but will have also acquired skills in the proposed high-demand tracks.

Since we plan to develop a cybersecurity track in the proposed BA in Computer Science, we provide some relevant statistics. The tremendous immediate need for cybersecurity specialists is buttressed by statistics. There are 2.93 million cybersecurity positions open and unfilled around the world, according to non-profit IT security organization (ISC). According to CyberSeek, an initiative funded by the National Initiative for Cybersecurity Education (NICE), the United States faced a shortfall of almost 314,000 cybersecurity professionals as of January 2019. A quick search of the premier job search site indeed.com on August 30th, 2019, showed 22,522 jobs in the US in cybersecurity, 653 in Colorado, 181 of them in Colorado Springs itself. Monster.com, another job search site listed 41,587 jobs in cybersecurity in the USA, 1,345 jobs in cybersecurity in Colorado, 266 in Colorado Springs.

[3] It takes an additional 3-4 semesters on average to pursue double majors or dual degree programs at UCCS, on average, according to Mr. Curtis Evans, one of our Engineering advisors.

[4] https://www.bls.gov/emp/tables/occupations-most-job-growth.htm

Another one of the proposed tracks is Game Design, and hence we add a few additional relevant facts here. The video game industry has out-paced all predictions in the last 10 years for growth and is currently a $138 billion industry. It is currently predicted to reach $300 billion by 2025 (according to Technology Thematic Research); the SmartPhone market alone is expecting exponential growth to reach $125 billion by 2025. The Bureau of Labor Statistics expects Software Application Development jobs to grow by 30.7%, and Multimedia Artists and Animators to grow by 8.4% by 2026. According to Recruiter.com, job opportunities for Multimedia Arts and Animators will enjoy an increase of 29.95% per year for the next few years. Video Game Designer positions are expected to grow annually 11.59% and Colorado has the 7th highest rate of growth in the country of 22.22%. In 2016, there were 14,390 Video Game Designers employed in Colorado, making it the state with the 5th largest collection of employed designers according to Career Explorer.com. Game development also extends beyond the entertainment industry into Serious Games – a $3.5 billion industry (as reported by Statista) projected to grow at a rate of about 19.2% per year until 2023 (according to Allied Market Research) to $17 billion. Serious Games are becoming a popular approach to education, training, health care and gamification supporting Marketing, Government, and Educational organizations internationally. A search of indeed.com on September 20, 2019, for 'game design' resulted in 3,448 jobs in USA, 57 in Colorado, and 8 in Colorado Springs; for 'game developer' resulted in 5, 383 jobs in USA, 121 in Colorado, and 8 in Colorado Springs.

A third proposed track is Artificial Intelligence and Machine Learning, a sub-discipline within Computer Science, which is impacting greatly on all aspects of our computer-mediate data-driven society, industry and government. A search for 'machine learning' on indeed.com shows 42 jobs in Colorado Springs,598 in Colorado and 31,940 jobs in USA; for 'artificial intelligence' shows 25, 200 and 12,158 jobs; for 'AI' shows 15, 350 and 19,414 jobs; and for 'data scientist' shows 10, 216 and 11,772 jobs.

B.2 Role and Mission Criteria

The proposed degree is in line with the role and mission of the University of Colorado Colorado Springs as given below:

The Colorado Springs campus of the University of Colorado shall be a comprehensive baccalaureate and specialized graduate research university with selective admission standards. The Colorado Springs campus shall offer liberal arts and sciences, business, engineering, health sciences, and teacher preparation undergraduate degree programs, and a selected number of master's and doctoral degree programs.

The proposed Bachelor of Arts degree program will be housed in the College of Engineering and Applied Science, like at the University of Colorado Denver, and unlike at the University of Colorado Boulder. This is because like UCD's CS+ program, we would like to provide a number of tracks so that we are able to admit new students into the EAS College to begin with, with potential to grow later. This new program will enable a larger pool of students to major in Computer Science and improve the career opportunities for such students, providing an improved, well-trained and

enlarged technical workforce for Colorado's computing industry. Students coming out of this program will likely provide a broad array of talents for Colorado Springs's and Colorado's technology industry.

The Bachelor of Arts in Computer Science degree program would help achieve CU's goal of keeping the best students in Colorado institutions by providing a BA in CS program designed to attract students already strong in STEM disciplines at the high school level to gain skills and knowledge in the burgeoning field of computing and information technology. The high demand for students with computing skills suggests that the University of Colorado Colorado Springs and the State of Colorado would benefit greatly from an undergraduate major in this field, supplementing the benefits provided by the existing Bachelor of Science and Bachelor of Innovation degrees in Computer Science. This new degree will allow a number of students to specialize in chosen tracks and will help produce a workforce that will aid both the State of Colorado as well as the rest of the nation. It is also clear from the rapid pace of growth of the BA-CS program on the sister CU-Boulder campus, reaching almost twelve hundred majors in a few years, that there is such a great demand for the program in Colorado that another program on the Colorado Springs campus will also be well-received and flourish quickly. The number of undergraduate students on the Colorado Springs campus (10,196 in Fall 2019) is about 34.4% that of the Boulder campus (29,624 in Fall 2018), and thus, the expected growth in the number of majors in such a new major is expected to be proportionate.

B.3 Duplication

In preparing this proposal, we reviewed the computer science programs at fourteen other institutions of higher education located in Colorado. Only three institutions currently offer a Bachelor of Arts degree in Computer Science. All others offer B.S. degrees in Computer Science or offer minors, certificates or degrees in related (but not equivalent) fields.

Table 6: Computer Science and Related Programs in Colorado

Institution	**Degree Program**
Adams State University	Mathematical Sciences - Computer Science or Information Technology emphases
Colorado College	*B.A. in Computer Science*
Colorado School of Mines	B.S. in Computer Science
Colorado State University, Fort Collins	B.S. in Computer Science, BS in Applied Computing Technology; BS in Computer Information Systems in the Business School
Colorado State University, Pueblo	B.S. in Information Systems
Colorado Technical University	*B.S. in Computer Science; B.S. in Computer Systems Security; B.S. in Software Engineering; B.S. in Data Science*
Fort Lewis College	BS in Computer Engineering, no Computer Science degree

Colorado Mesa University	B.S. in Computer Science
Metropolitan State College of Denver	B.S. in Computer Science; B.S. in Computer Information Technology
United States Air Force Academy	*B.S. in Computer Science*
University of Colorado at Boulder	B.S. and B.A. in Computer Science
University of Colorado at Denver	B.S. in Computer Science, and BA in Computer Science+
University of Northern Colorado	Computer Information Systems emphasis as part of a B.S. in Business Administration
Western State Colorado University	B.S. in Computer Science

Of these programs, the three in italics are universities that are not real competitors because Colorado College is a national liberal arts college; the Air Force Academy is a military academy, with very selective national intake of students; and, Colorado Tech is a professional college, with mostly adult working students, a lot of them trying to change their careers. Of all the other universities, only UC-Boulder has a BA-CS program, as described earlier; and, UC-Denver has a newly established program called Computer Science+, with goals and objectives like Boulder's original goals. We do not consider ourselves to be competing with UC-Boulder because the entrance requirements for the two campuses are different, with Boulder's being more stringent than UCCS's. In addition to attracting students from all across Colorado, UC-Boulder attracts many more out-of-state and foreign students. UC-Denver's students are mostly local, and so are UCCS's, focused on Southern Colorado. We do not consider UCCS to be competing with UC-Denver.

It is widely recognized that computing skills are critical for the next generation of workers in STEM disciplines; our program will help position the University of Colorado's three campuses as being the ones in the State of Colorado helping to produce workers with strong computing and computational thinking as well as practical skills.

C. Program Quality and Institutional Capacity

C.1 Admission, Transfer and Graduation Standards

C.1.a Admission Requirements

The College of Engineering and Applied Science will develop new criteria for admission to its new BA program in Computer Science, in order to attract students with profile that are different from those who apply for our BS and BI in Computer Science. This will take into account the facts that the sequence of math and computer science classes for the BA program have been designed to start at a lower level of preparation than the BS program in Computer Science.

Currently, for the BS-CS program, the assured admission requirements are rank in upper 30% of high school graduating class, ACT score of 25 or SAT score of 1190. For the BA-CS program, we propose assured admission requirements of being in upper 40% of high school graduating class,

ACT score of 21 or SAT score of 1150. This is comparable to the admission requirements for the College of Business and Administration at UCCS. The Director of Admissions, the Registrar and the Provost at UCCS have accepted the idea of having separate admission requirements for the BA in Computer Science program compared to the BS in Computer Science program, although the complete details need to be ironed out still.

C.1.b Requirements for Transfer Students

New admission criteria for transfer students will be developed; these will be commensurate with the fact that the BA in Computer Science program is geared toward students who want to be proficient programmers and software developers, without the need for some of the advanced mathematical and theoretical classes that are required of the ABET-accredited BS students in Computer Science. We anticipate adapting the existing transfer guidelines for our current BS degree to the new program while also ensuring compatibility with the admission guidelines for this BA program.

The BS-CS program allows seamless transfer from community colleges in Colorado. In particular, the BS-CS program has Best Choice articulation plans with Pikes Peak Community College and Pueblo Community College. These will be modified to fit the BA-CS program.

In addition, the Computer Science Department at UCCS has already started conversation with Pikes Peak Community College to facilitate transfer of students in its BAS program in Cybersecurity into one of the tracks (Cybersecurity track) of the proposed BA-CS program. The presence of 42 hours of electives in the proposed curriculum makes it a little easier to fit a variety of transferred programs.

C.1.c Enrollment Restrictions

With the anticipation that the Computer Science department will be able to obtain the requested resources as the BA-CS program grows as outlined in the accompanying proforma, we do not currently plan to limit enrollment in the BA in CS degree program. However, if the program grows substantially beyond expectation and no further resources become available, the program will either consider capping enrollment commensurate to the resources available, or raise entrance requirements.

C.1.d Continuation and Graduation Requirements

Graduation with a BA degree in Computer Science will require the completion of the curriculum presented below, consisting of 120 semester credit hours with a University of Colorado cumulative grade point average of 2.00 or higher. A grade of C or better will be necessary in all required Computer Science courses, with a cumulative grade point average in Computer Science courses of 2.00 or better. Good academic standing and academic probation and suspension will be determined by the policies of the College of Engineering and Applied Science.

C.2 Curriculum Description and Assessment Process

The goals of the BA in Computer Science will be achieved through a series of courses that will initially emphasize, programming skills and the foundations for the construction of modern software systems, allowing for later specialization with Computer Science through the design of tracks.

C.2.a Program Requirements

Requirements for a BA degree will include completion of 120 semester hours of required and elective courses. A student will not be allowed to earn both a BA and BS in Computer Science at UCCS.

The 120 hours consist of 36 hours of Computer Science technical courses and 12-hours of mathematics along with up to 30 hours to complete university-wide Compass Curriculum requirements. The remaining 42 semester hours (the total remaining hours depends on the classes chosen) can then be allocated to completing one of CS-specific curriculum tracks, minors or even a second major or degree in other academic disciplines.

The Foundation courses will provide a strong introduction to the field of Computer Science along with a sufficient introduction to mathematics to allow students to sample a wide variety of upper division courses in Computer Science, leading to the tracks. The initial tracks we define are a General track, and tracks in Cybersecurity, Game Design, and Artificial Intelligence and Machine Learning.

As alluded to earlier, to help students best make use of the large number of credits of electives, we will provide our students with "paths to graduation" that will include curriculum tracks within Computer Science, designed to acquire useful specialized knowledge. Note that most current dual majors or degrees are quite onerous at UCCS, often requiring 3-4 additional semesters of full-time study. Our detailed plans, presented in Section C.2.b., bring this down to scenarios in which no extra semesters are needed in some cases, although requiring a few extra credits per year. However, detailed design of dual majors or dual degrees is left to the future.

We present the initially proposed tracks later in this section. We follow it by presenting a few minors, and dual majors that the BA in CS program will easily make possible for enterprising students, although as noted earlier, these are likely to be not so common. *We clearly note here that this document does not propose these minors or majors, but simply states that such programs are possible.*

Additional within-CS tracks can be defined, that aid students in charting a path to particular academic outcomes. The CS Curriculum Committee and the Chair of the Department of Computer Science will first review the track proposal. If approved, it will be discussed in a faculty meeting of the Computer Science department and approval sought from the faculty. If approved, it will then be referred to the EAS curriculum committee to ensure that the new track complies with EAS

guidelines. Once approved by the EAS curriculum committee, the proposed track will be added officially to the BA in CS degree program and advising materials and the UCCS catalog will be updated to include the new track.

In the future, dual majors or dual degree programs may be proposed by another bachelor program on campus working with the Computer Science department. The curriculum will have to be endorsed by curriculum committees of the respective departments and respective colleges, as well as the campus undergraduate oversight body.

The proposed track-based system will allow the BA in CS program will pave the way for expanding the BA in CS program to support students interested in additional tracks within Computer Science, and even dual majors or dual degrees[5]. *With this mechanism in place, the BA in CS degree will be flexible enough to support students demands, as they become pronounced*.

C.2.b Program Curriculum, Tracks, Minors and Potential Double Majors

Requirements for the Computer Science General Track

The total number of credits to graduate is 120. This includes:

- 36 hours of Computer Science
- 12 hours of Mathematics
- Up to 30 hours for Compass Curriculum, including two writing classes
- Rest (42 or more) of the hours as needed to finish a BA in a CS track or to obtain additional minor(s) or majors or degrees, if and when proposed and approved in the future.

Computer Science Requirements: The 36 hours of required computer science content for the general track are accounted for as follows:

- CS Foundation Classes: 15 hours of required introductory courses including: CS 1120: Computational Thinking with Beginning Programming (3); CS 1150 Computer Science I: Principles of Programming (3 hours); CS 1450 Computer Science II: Data Structures (3 hours); CS 2060 Programming in C (3 hours); CS 3020: C++ OR CS 3060: C#/.NET or CS 3080: Python (3 hours).
- CS Core Classes: 15 hours of courses that provide core knowledge of Computer Science from the following classes: CS 2160: Computer Organization and Assembly (3 hours); CS 3160 Concepts of Programming Languages (3 hours), CS 3300: Software Engineering (3 hours), CS 4200: Computer Architecture (3 hours), CS 4720: Algorithms (3 hours), CS 4500: Operating Systems (3 hours), and CS 4100: Automata (3 hours).
- CS Upper Division Classes: The remaining 6 hours necessary to reach 36 hours in the major can consist of any 4000-level or above computer science courses.

[5] When a student does dual majors, he/she receives only one diploma, but with dual majors the student receives two separate diplomas. Dual majors are usually in related areas, whereas dual degrees are in disparate areas.

Table 6: Overview of Requirements for the Proposed BA CS Degree

<table>
<tr><td></td><td colspan="3">Overview of Degree Requirement</td></tr>
<tr><td>General Track</td><td>General Track</td><td>All Tracks</td><td rowspan="2"></td></tr>
<tr><td>36 CS hours

CS Foundation: 15
CS Core: 15
CS Upper Division: 6</td><td>12 hours of Math

Math 1040 (see below)
Discrete Math, Linear Algebra
Prob & Stat (see below)</td><td>Compass Curriculum & Writing skills: at most 30

Gateway Seminar (3): GPS 1010
Writing Skills (6)
Explore (3): Arts, humanities and cultures
Explore (3): Society, behavior and health
Explore (3): Physical & natural world
Navigate (3): Non-major class, 3000+
Summit (3): Major upper-level
Writing intensive: (2 classes, 3000+, can be in major)
Inclusiveness (3, can be in major)
Sustainability (3, can be in major)</td><td>Electives: 42 or more
Rest of the hours can be used to complete the BA in CS in a certain track within Computer Science, or can be used toward a minor in one or more areas, or a major in another area in any college. At least 16 of these hours must be upper-division (above 3000 level) classes.</td></tr>
<tr><td></td><td colspan="3">120 hours total</td></tr>
</table>

Math Requirements: The required math classes are Math 1040: College Algebra (3 hours) OR Math 1350 Calc I (4 hours); CS 2150: Discrete Structures[6] (3 hours); CS 2300: Computational Linear Algebra (3 hours); CS 2200: Introduction to Computational Statistics (3 hours).

Compass Curriculum: There is a set of campus-wide requirements called Compass Curriculum, which is up to 30 hours as given in Table 6 above.

Rest of the Credit Requirements (42 or more): These hours can be used to complete a BA in a CS track. Dual majors or degrees may be added in collaboration with other departments on campus, in the future.

The intent of the overall degree requirements and the curriculum track mechanism is also to provide enough flexibility to be quickly responsive to any increase in computer science relevant trends, while ensuring that all students can complete the B.A. degree within 120 credit hours.

[6] The CS department has created a new class called 2310: Discrete Structures that is more geared toward Computer Science, with emphasis on computation and algorithms. There are many such classes around the country. Ours is particularly molded after CU-Boulder's class with the same name. This is scheduled to be offered in Fall 2020.

To illustrate the flexibility of the curriculum track mechanism, here are several example proposals for curriculum tracks. First, it describes several tracks within Computer Science. In addition, the proposal describes a double major with Mathematics since among the dual programs, it is the most popular in UC-Boulder at 3.6% of students enrolled.

Requirements for a BA in CS with specialization tracks within Computer Science

The proposed BA program will have tracks that enable careers in specific areas or an option for breadth. We have considered an array of choices, but have settled on four areas with the ability to add more on demand. Below, we illustrate with how tracks in several areas can be incorporated. A student does not have to be on a track to get a BA, it is optional.

1. *BA Computer Science -- General Track*: This track is focused on creating breadth in the discipline. Students will have the opportunity to take courses from multiple areas as they consider Computer Science electives. In particular, the student will have to take 6 additional classes, covering a breadth of topics in Computer Science. The classes will have to be approved by the student's CS faculty advisor. Of these, only two can be below 4000-level.
2. *BA Computer Science -- Cybersecurity Track*: We can introduce a BA in Computer Science with a Cybersecurity track fairly easily. For the Cybersecurity track, we will need the student pick 6 classes (18 hours) that he/she has not taken already, out of the following: CS 2910: Secure Mobile and Cloud Computing (3 hours), CS 3910: Systems Administration and Security (3 hours), CS 4910: Introduction to Computer Security (3 hours), CS 4920: Applied Cryptography (3 hours), CS 4930: Privacy and Censorship (3 hours), CS 4940: Ethical Hacking (3 hours), CS 4950: Homeland Security (3 hours), and CS 4970: Anonymous Networks. This adds 18 more hours. These can be incorporated into the 42 hours of electives available in the last column of Table 6. We have carefully looked at the Associate of Applied Science in Cyber Security degree at Pikes Peak Community College and have already laid out a pathway for such students to transfer expeditiously into the Cybersecurity track at UCCS.[7]
3. *BA in CS with Game Design:* UCCS already offers a BI program in Game Design and Development (GDD). The GDD program is focused on the programming aspects of games. However, creating successful games requires much more than programming. Aspects such as development of characters, storytelling, artistic infusion, and user interface play a big role and there is no room for such classes in the GDD program. The Game Design track in BA-CS will make such a focus possible. This will require taking GDD 1100: Introduction to Game Development (3 hours) instead of CS 1120: Computational Thinking with Beginning

[7] There was a meeting on 11/13/2019 between representatives of the College of Engineering at UCCS (comprised of the Dean, the chair of the Computer Science department, and the campus and college directors of Cybersecurity) and representatives of Pikes Peak Community College (comprised of the Associate Dean of Business and Technology, and chairs of Computer Science and Computer Networking departments), to discuss this BA-CS program being proposed and how to facilitate transitioning some of the more than 250 AAS majors in Cybersecurity at PPCC into the proposed BA-CS track in Cybersecurity at UCCS. It was determined that all classes taken at PPCC can be mapped for transfer to the BA-CS program. Since AAS-Cybersecurity is considered a terminal program at PPCC, PPCC is also willing to explore the possibility of developing an AA in Cybersecurity with an eye toward attracting students who want to transfer to the BA-CS Cybersecurity track at UCCS.

Programming (3 hours) as a CS Foundation Class. In addition, the student will have to take 6 additional classes not taken already: GDD 2100: Game Design for Diverse Populations (3 hours); GDD 2200: Object-Oriented Design, Analysis, and Implementation (3 hours); GDD 2150: Fundamental Game Design Concepts (3 hours); CS 3350: Team-based Game Production (3 hours); GDD 3200: Team-Based Game Testing and Deployment; and CS 3100: User Experience and User Interface Design (3 hours) or GDD 3000: Level Design (3 hours) or GDD 3000: Game Concept Art (3 hours) or GDD 3100: User Interface Design for Games (3 hours) or GDD 3600: Developing Serious Games.

4. *BA in CS with Artificial Intelligence and Machine Learning Track*: This track will require the student to take 6 additional classes (18 hours) that he/she has not taken already, out of the following: CS 2200: Introduction to Statistical Data Analysis (3 hours), CS 3880: Introduction to Robotics[8] (3 hours), CS 4820: Artificial Intelligence (3 hours), CS 4860: Machine Learning (3 hours), CS 4710: Evolutionary Algorithms (3 hours), CS 4870: Artificial Neural Networks (3 hours), CS 4960: Natural Language Processing (3 hours), and CS 4440: Big Data (3 hours).

Our initial plan is start with a small number of tracks to begin with. Potential initial tracks include the Cybersecurity, Game Design and Computer Science tracks because we offer the required courses in these areas on a regular basis. Other tracks such as Software Engineering, Networking, Software Development in Science/Business may be introduced in later years. Classes may be updated as per recommendation of the CS Department's Curriculum Committee, with the approval of the Chair.

Requirements for a BA in CS track with a minor in Math or a double major[9] with Math

Double Major with Math: The Math department has several options (Pure Math, Applied Math, Statistics and Secondary Education), each of which (except Secondary Education) requires completion of at least 47 credit hours in Mathematics of which 31 credit hours must be Core Mathematics courses. The Teaching option requires 46 credit hours. Of the Core Mathematics courses required for any Math major, Calc I (4 credits) is required by the BA-CS, and thus, overlap and can be counted for both. We consider only the Pure Math option in the discussion below.

1. The student takes the General Track 36 hours of Computer Science as required.
2. We replace the CS Math requirements by all MATH classes. In particular, MATH 1040 is replaced by MATH 1350 (Calc I, 4 hours), CS 2300 by Math 3130 (Linear Algebra, 3 hours), and CS 2200 by MATH 3810 (Probability and Statistics, 3 hours) for math required in the BA-CS program. The student needs additional **34** credits to meet the **47** hours of Math requirements for BS-Math. The total is 36 + 47 = *83 hours so far.*
3. Compass Curriculum + LAS requirements: The student needs 54 more hours. Total *137 credits.*

[8] The CS Department has developed this class in Fall 2019, to be taught in Fall 2020.

[9] Dual Degrees allow more flexibility in double counting classes than Dual Majors, in general.

We see that the student will have to take 17 extra credits to dual major, getting a BA in CS and BS in Math at the same time. This means 6 additional classes beyond getting one BA or BS degree. In other words, the student has to take at most 3 extra hours per semester, for 6 semesters. As noted earlier, this is in contrast to a student who wants to double major at this time at UCCS, where it takes an extra 3-4 semesters, as per our advisors.

*Requirements for a BA in CS with a Minor in Mathematics***:** A Math Minor requires 24 hours of Math. We can replace the 13 hours of Math required by the BA-CS with more rigorous Math classes that are counterparts of these classes. We then have 11 hours left. These can easily fit into the last column of Table 6.

C.2.c Sample Curricula

We now also provide additional examples of paths through the proposed degree program by explicitly detailing the curriculum choices available to students. Table 7 provides a sample curriculum for a BA in Computer Science, with a specialization track within Computer Science.

It is important to note that the discussions here only serve to demonstrate that meeting the degree requirements are possible and NOT to represent the actual paths that students will take. In general, we expect that there will be more variations in the order of the classes than the logical progressions shown in these tables. We expect that students will chart their actual path through the curriculum with the help of their Computer Science advisors.

Table 7: Sample curriculum showing a. double major, BA in Computer Science with a track such as Cybersecurity, Artificial Intelligence and Machine Learning, Data Analytics.

	√	**FALL**	*Hours*	√	**SPRING**	*Hours*
Year One		ENGL 1310	3		ENGL 1410	3
		CS 1120	3		CS 1150	3
		MATH 1040 or MATH 1350	4		CS 2150	3
		GPS 1010	3		Humanities Elective	3
		Explore – Arts, Humanities & Cultures Course	3		Explore – Society, Behavior and Health Course	3
		TOTAL	16		**TOTAL**	15

	√	**FALL**	*Hours*	√	**SPRING**	*Hours*
Year Two		CS 1450	3		CS 2060	3
		CS 2300	3		CS 2200	3
		Explore – Physical & Natural World Course	3		Natural Science Elective (w/Lab)	4
		Social Science Elective	3		Social Science Elective	3
		Humanities Elective	3		General Elective	3

		TOTAL	15		**TOTAL**	16

Year Three	√	**FALL**	*Hours*	√	**SPRING**	*Hours*
		CS 3020, 3060, or 3080	3		CS Core Course	3
		Upper-Division (UD) CS Elective	3		CS Core Course	3
		Natural Science Elective	3		Social Science Elective	3
		Track (TR) Elective	3		TR Elective	3
		General Elective	2		TR Elective	3
		TOTAL	14		**TOTAL**	15

Year Four	√	**FALL**	*Hours*	√	**SPRING**	*Hours*
		CS Core Course	3		UD CS Elective	3
		CS Core Course	3		Natural Science Elective	2
		CS Core Course	3		TR Elective	3
		TR Elective	3		TR Elective	3
		TR Elective	3		UD General Elective	3
		TOTAL	15		**TOTAL**	14

C.2.d Assessment Plan

The BS CS program, administered by the Computer Science Department, is accredited by ABET. It has been accredited for more than 25 years. Its accreditation was renewed for five years recently. The BI CS program, also administered by the Computer Science Department, received a five-year accreditation, starting 2017. As part of its efforts to accredit its BS degree program, the Department of Computer Science has defined a continuous improvement policy that outlines the procedures and processes used to monitor our program's ability to meet its educational outcomes and objectives.

Broadly speaking, we make use of a range of quantitative and qualitative methods to perform our assessment. They include faculty assessment of individual courses to ensure that course-level learning goals are being achieved each time a number of representative undergraduate courses are taught. These course assessments are reviewed by the Department's ABET Coordinator and the Chair on an annual basis to monitor the health of the overall program and to respond as needed to problems and/or opportunities.

Once the proposed BA in CS program has been established, the Department will participate in any assessment procedures mandated by ABET for the classes that are common with BS-CS and BI-CS. There is no plan to apply for ABET accreditation for BA-CS, but we believe that the procedures required for accreditation of BS-CS will positively impact the courses needed for the BA-CS program since the required courses in BA-CS are also required in the other programs.

C.3.a Regional or Professional Accreditation

The University of Colorado Colorado Springs is accredited by the Higher Learning Commission (HLC), a regional accreditation agency recognized by the U.S. Department of Education. UCCS does not require additional assessment of ABET-accredited BS-CS and BI-CS programs. We believe that since the proposed BA-CS program will benefit from being closely related to the BS and BI programs, the requirements to be addressed for HLC will not be onerous.

C.3.b Timetables to Meet Requirements

We believe that the proposed program meets all the requirements for a BA program required by the Higher Learning Commission (HLC) that accredits UCCS, right from the beginning.

C.3.c Current Program Faculty

Faculty for the BA in Computer Science degree program will consist of the current faculty of the Department of Computer Science as we start the BA in Computer Science program.

Dr. Joshua Alcorn, Research Assistant Professor: Software-defined networks
Dr. Adham Atyabi, Assistant Professor: Cognitive and computational neuroscience, autism biomarker discovery, brain computer interface (BCI), eye tracking, image processing and signal processing, machine learning, deep learning and Big Data analytics, swarm and cognitive Robotics
Dr. Gedare Bloom, Assistant Professor: Computer system security with particular focus on real-time embedded systems
Dr. Philip N. Brown, Assistant Professor: Game theory, cyber-physical systems and society-scale economic systems
Dr. Terrance Boult, Professor: Computer vision, computer security, physical security, machine learning
Albert Brouillette, Senior Instructor: Teaches classes primarily in software engineering, at undergraduate and graduate levels.
Pamela Carter, MS, Instructor: Teaches freshman and sophomore level programming classes
Dr. Albert "Tim" Chamillard, Associate Professor: Software engineering, game design and development, educational software.
Dr. Sang-Yoon Chang, Assistant Professor: Network security, wireless communications, and applied cryptography
Dr. Edward Chow, Professor: Network security, software-defined networks, critical infrastructure protection
Michalea Gonzalez, MS, Instructor: Teaches freshman and sophomore programming classes
Dr. Kristen Justice, Assistant Professor: Software engineering, software testing and debugging in resource-constrained environments
Dr. Jugal Kalita, Professor: Natural language processing, machine learning, artificial intelligence
Dr. Rory Lewis, Associate Professor**:** Machine learning, computational neuroscience, artificial Intelligence

Dr. Shuai Li, Assistant Professor: Online privacy and anonymity, designing and measuring privacy enhancing systems
Christopher Malec, MS, Instructor: Teaches freshman and sophomore level classes in programming
Dr. Oluwatosin Oluwadare, Assistant Professor: Bioinformatics and computational biology, machine learning, deep learning, and Big Data analytics
Dr. Sudhanshu Semwal, Professor: Computer graphics, human-computer interaction, wearable computing, virtual reality
Dr. Richard White, Research assistant professor**:** Risk methods to homeland security
Dr. Dana Wortman, Senior instructor: Teaches game design and development
Dr. Qing Yi, Associate professor: Compiler design, high-performance computing
Dr. Charles Zhou, Professor: Cloud computing, distributed systems, autonomic and sustainable computing
Dr. Yanyan Zhuang, Assistant professor: Computer networking, application fault diagnosis, security and privacy, and software engineering

In addition to the faculty named above, the Department of Computer Science is hiring two tenure-track or tenured professors, and a full-time instructor during the Spring of 2020, to start in the Fall of 2020.

As the BA program in Computer Science grows in the coming years, we expect to hire new faculty members to support the instructional needs. This is discussed a little later in the proposal.

C.4 Institutional Factors

C.4.a Effect on Other Programs

The anticipated impact on other programs at the University of Colorado that are offered by the Computer Science Department is minimal. As mentioned several times already, the Department of Computer Science currently offers a Bachelor of Science in Computer Science, and three Bachelor of Innovation degrees: BI in Computer Science, BI in Computer Security, and BI in Game Design and Development. The BS-CS degree is quite a bit more rigorous than the proposed BA-CS degree in terms of math and computer science content. Therefore, it is possible that a few BS-CS students who may have difficulty with math or programming classes, may move to BA-CS. In the past, such students have usually transferred out to the College of Business and Administration, or the College of Letters, Arts and Sciences (LAS). Furthermore, we believe that students who choose BI as their degree are entrepreneurial in spirit, and are unlikely to be attracted to the BA-CS program where there is no such focus. We believe the student populations for BA and BI degrees are quite different. Moreover, the BI-CS program is ABET accredited, and we have no plan to seek accreditation for the BA-CS program. Thus, we believe that students who are in BI-CS or are attracted to BI-CS are unlikely to be attracted to BA-CS. The BI-GDD and BI-Cybersecurity programs are not accredited as of this time, and it is likely that mathematically weaker students in these programs, or students who thought they were entrepreneurial to begin with but later discovered the idea was not as appealing, may migrate to the BA-CS program. However, once again, the ethos,

temperament and mindset of the students in the BI programs are likely to be quite distinct from the students who are attracted to the BA-CS program.

As far as other programs in the EAS College goes, there are two other programs that can potentially be impacted. These are BS-Computer Engineering and BS and BI programs in the Data Analytics and Systems Engineering (DASE) area. The BS-CpE program is ABET-accredited, and mixes hardware and software topics almost equally; students attracted to BS-CpE like this mix and want to learn how hardware and software work together whereas the BA-CS will be exclusively focused on software development. The DASE program is new, and mixes ideas from data analytics and systems engineering to develop a well-integrated curriculum. It is starting to grow slowly, and is groomed for ABET accreditation. The BA-CS program is wholly software-oriented. Thus, the impacts on BS-CpE and DASE programs will be minimal.

As noted earlier, at CU-Boulder, the BA-CS program was initially proposed in the early 2010s to be a vehicle for offering a large number of dual degree and dual major programs. However, at this time, it is clear that the BA-CS program at CU-Boulder has turned out to be a mostly self-standing program, with 87.8% of its students. We believe that the same story is going to repeat itself at UCCS, and the number of potential dual majors or dual degree cases will be low. As a result, we have not proposed such programs in this document, although we have noted that such possibilities exist, and will be investigated and followed upon when demand arises.

Existing campus programs that are most likely to be impacted are the Engineering Prep, Engineering Intent and Engineering Undecided students. Many of these students may want to switch to the BA-CS program. However, this is a wholly desired outcome, since these students come to UCCS with a goal to getting into an Engineering program, but are unable to do so right away due to lack of math or other preparation. Many of these students may be able to get into the BA-CS program as designed and intended.

Table 8 gives details of enrollment and graduation in the various Bachelor programs the Department of Computer Science at UCCS runs. These programs are BS-CS, Bachelor of Innovation (BI)-CS, BI-Computer Security, BI-Game Design and Development. As we can see, the numbers of students enrolled in the three BI programs have increased gradually and have almost caught up with the number of students enrolled in the traditional BS-CS program. We anticipate the BA-CS program to grow like BI-CS programs at UCCS, possibly faster.

Table 8: UCCS BS CS and BI enrollment and graduation

Semester	BS-CS Enrollment	BS-CS Graduation	BI Enrollment	BI Graduation	Total Bachelor Enrollment	Total Bachelor Graduation
Spring 2014	172	26	102	7	274	33
Fall 2014	209	28	138	17	347	45
Spring 2015	205		140		345	
Fall 2015	252	39	245	27	497	66

Spring 2016	240		201		441	
Fall 2016	261	43	235	16	496	59
Spring 2017	204		223		427	
Fall 2017	272	38	260	12	532	50
Spring 2018	252		232		484	
Fall 2018	297	34	280	38	577	72
Spring 2019	281		261		542	

The rapid growth of the BI programs clearly indicates that there was a need for Computer Science education seamlessly integrated with Business education and the BI programs fulfill this need. However, as noted earlier, the integration of Business and Computer Science addresses only one of the needs that exist in the prospective student population. Not every student (outside of BS-CS) who wants to pursue a degree in Computer Science may want to do so with a heavy dose of entrepreneurship-related classes. The BA-CS program we propose here naturally follows the BI programs run by the Computer Science department, but opening up similar opportunities for those who want to pursue a career in computing and software development, with a little less emphasis on math and theory, or entrepreneurship. The propose BA-CS program will nicely compliment the BS and BI programs in Computer Science.

C.4.b. Expected Student Enrollment for First 5 Years

We divide the students into three groups: in-state Colorado students, US students from the Western States within the purview of the Western Undergraduate Exchange (WUE) program, and other US or foreign students called out-of-state students here. We assume a separate growth model for each of these groups.

In-state Colorado Students: We assume the number of freshmen will be 30, 40, 50, 60 and 70 in the first 5 years. We assume 70% will be retained from year to year. We do not show within-campus transfer students here, since they are not new as far as the campus is concerned[10]. We show the expected enrollment for in-state students in Table 9.

Table 9: Numbers of in-state students over first 5 years

Year	Freshman	Sophomore	Junior	Senior	Total
2020-21	30				**30**
2021-22	40	21			**61**
2022-23	50	28	15		**93**
2023-24	60	35	20	11	**126**
2024-25	70	42	24	14	**150**

[10] We also assume that 10 students will transfer in into the Sophomore year every year from another program within UCCS, 8 will transfer in into the Junior year, and 8 will transfer in into the Senior Year. These intra-campus transfers are not shown in Table 9.

Table 10 shows the expected number of WUE out-of-state students. We do not show any transfer-in students in any year; since the total numbers are small, these are likely to be even smaller. We assume 50% of the students persist from year to year.

Table 10: Enrollment of WUE out-of-state students over the first 5 years

Year	Freshman	Sophomore	Junior	Senior	Total
2020-21	2	0	0	0	**2**
2021-22	4	*1*	0	0	**5**
2022-23	6	*2*	*1*	0	**9**
2023-24	8	*4*	*1*	1	**14**
2024-25	10	*5*	2	*1*	**18**

Table 11 shows the expected number of foreign students. Once again, we do not assume any transfer-in students in any year. We assume 50% of the students persist from year to year.

Table 11: Enrollment of foreign students over the first 5 years

Year	Freshman	Sophomore	Junior	Senior	Total
2020-21	2	0	0	0	**2**
2021-22	4	*1*	0	0	**5**
2022-23	6	2	1	0	**9**
2023-24	8	4	2	1	**14**
2024-25	10	*5*	2	1	**18**

Table 12 shows the expected total number of enrolled students in the Bachelor of Arts in Computer Science program. As illustrated in Tables 9-12, we envision the BA program as substantially increasing the size of our department's undergraduate student body, such that it gets split more or less evenly among the BA, BI, and BS degree programs over time. We expect the BA program to grow as big as the BS-CS and BI-CS programs in 7-8 years, and continue to grow a little slowly after that for the foreseeable future.

Table 12: Expected total number of students in the BA in Computer Science program over the first 5 years

Year	2020-21	2021-22	2022-23	2023-24	2024-25
No of Students	34	71	111	155	186
New faculty hire			1 TTF	1 TTF + 1 INS	1 TTF + 1 INS
New GTA hire		1	2	1	1

C.4.c. Estimates of Space Need

With respect to existing resources, a significant impact is anticipated on the Department of Computer Science's only lab that sits approximately 30 students, as the new BA program grows. BI has its own well-appointed laboratory for classes; the BI lab is shared among all BI programs on campus, although the number of BI students affiliated with the Computer Science Department is the largest among all BI programs. The BS lab is about 900 square feet and the BI lab is 1,200 square feet. Both labs are busy from 9 AM to 6 PM Monday through Friday. The need for lab space will be paramount.

To get started, we propose to make use of nontraditional scheduling of our BS lab (i.e., beyond 8 AM – 6 PM or Saturdays) to provide the additional capacity. Thus, we do not ask for new space in order to launch the proposed BA degree. However, *by the beginning of the third year* as we are at the point in which the number of undergraduates in the BA-CS program has crossed 100, we will need to supplement the existing CS lab. The BI lab is used for three BI programs, Computer Science, Game Design and Development and Computer Security, and is overbooked every work day. We will need another lab of about 1200 square feet in the 3rd year, and another lab of the same size by the end of the 5th years as the number BA-CS majors hits close to 200. Thus, as a result of the anticipated increase in enrollment, we will need two additional labs, each of size 1,200 square feet, in 5 years. The growth may be a little slower or faster, but our estimate is that we need a lab of size 1,200 square feet for each 100 majors (approximately) in the program.

We also need offices for any faculty members that are hired to support the increased number of students taking Computer Science classes. Faculty need is discussed below.

C.4.d Estimates of Personnel Needs

We anticipate the program to have 186 students in 5 years. We request a faculty line starting in year three, and for each rise of 30 majors in subsequent years. Right now, the ratio between the numbers of tenure-track faculty and instructors is about 3:1. We increase the ratio to 2.5:1 so that we can work within the budget to cover the number of sections needed to be taught. Table 12 above also shows the expected personnel hires for the next five years to support the BA-CS program. Assuming the BA-CS program grows to 186 students in five years, we expect to make requests for 5 faculty lines, of which 3 will be tenure-track faculty (TTF) and 2 will be instructor.

We also propose to hire a teaching assistant (TA) starting in year two, and increasing by 1 TA for every 30 majors.

The numbers of sections of various classes to be taught during the first five years are given in Table 13. Lecturers will be hired to cover classes not covered by TTF and Instructors hired.

Table 13: Estimates of CS class sections needed. TR is a track related class. UD is an upper division CS class.

CS Classes	Freshman	Sophomore	Junior	Senior	Total Sections Needed

	3 (CS 1120, 1150, 2150)	4 (1450, 2300, 2060, 2200)	7 (3020, UD-1, Core-2, TR-3)	8 (Core-3, Ele-1, TR-4)	
Year 1	3 (CS 1120-1 section, 1150-1, 2150-1)				3
Year 2	6 (1120-2, 1150-2, 2150-2)	4 (1450-1, 2300-1, 2060-1, 2200-1)			10
Year 3	6 (2 sections each of three classes)	4 (1 section each of 4 classes)	7 sections needed, can be cut down to 3.5 sections with sharing with BS/BI		14
Year 4	9 (3 sections each of three classes)	8 (2 sections each of 4 classes)	7 sections needed, can be cut down to 3.5 sections with sharing	8 sections needed, can be cut down to 4 by sharing	25
Year 5	9 (3 sections each of three classes)	8 (2 sections each of 4 classes)	7 (1 section each of 7 classes)	8 sections needed, can be cut down to 4 by sharing	28

Support needed for the program includes an administrative assistant starting the 4th year, one additional administrative assistant to aid in the management of the overall BA program. We also identify the creation of one new advisor position to be housed in Campus Advising directly that will be responsible for the academic advising of all students enrolled in the proposed BA in CS degree program.

C.4.d.i Faculty Salaries

We include a special discussion on salaries for incoming TTF and instructors by comparing with the authoritative survey of US Computer Science faculty salaries done every year by Computing Research Association (CRA). This survey is called the Taulbee Survey[11] and has been carried out for

[11] https://cra.org/resources/taulbee-survey/

many years. We include two tables (Table S1 and Table S2) from the Taulbee Survey in this report below.

Table 13: Tables S1 and S2 from Taulbee Survey for professors in 2018-19

Table S1. Nine-month Salaries, 138 Responses of 195 US CS Departments, Percentiles from Department Averages

	Full Professor				Associate			Assistant	Non-Tenure Track		
	In rank 16+ yrs	In rank 8-15 yrs	In rank 0-7 years	All years in rank	In rank 8+ years	In rank 0-7 years	All years in rank		Teach	Research	Postdoc
N Depts	121	121	123	138	114	126	136	136	104	46	42
N Indiv	730	561	721	2,086	422	569	1,020	1,182	927	275	347
10 %tile	$134,550	$130,305	$125,483	$129,873	$99,437	$105,705	$102,998	$93,292	$63,464	$62,361	$44,219
25 %tile	$148,927	$147,364	$139,837	$145,563	$106,847	$113,170	$110,023	$98,266	$73,063	$66,841	$49,031
50 %tile	$172,929	$167,877	$153,056	$164,541	$114,288	$123,557	$119,484	$105,449	$83,657	$90,000	$56,016
75 %tile	$199,936	$195,279	$176,150	$186,517	$128,378	$133,802	$132,919	$114,529	$96,511	$122,661	$66,742
90 %tile	$223,616	$214,288	$194,443	$198,425	$140,267	$144,675	$145,257	$122,253	$117,765	$153,459	$72,004

Table S2. Nine-month Salaries, 102 Responses of 142 US CS Public (All Public), Percentiles from Department Averages

	Full Professor				Associate			Assistant	Non-Tenure Track		
	In rank 16+ yrs	In rank 8-15 yrs	In rank 0-7 years	All years in rank	In rank 8+ years	In rank 0-7 years	All years in rank		Teach	Research	Postdoc
N Depts	86	88	91	102	88	91	100	100	79	30	28
N Indiv	512	400	509	1,482	313	381	721	873	671	179	173
10 %tile	$134,183	$126,371	$124,630	$128,760	$99,189	$102,389	$102,165	$92,437	$61,786	$60,116	$43,598
25 %tile	$144,980	$145,329	$132,726	$142,409	$105,112	$108,959	$108,050	$96,165	$69,797	$65,655	$47,470
50 %tile	$163,739	$160,230	$149,663	$156,251	$113,088	$121,331	$116,519	$101,174	$79,155	$77,065	$52,679
75 %tile	$184,562	$183,754	$166,830	$177,710	$124,584	$128,358	$127,648	$109,777	$88,353	$117,960	$60,978
90 %tile	$203,165	$202,797	$184,672	$189,358	$138,826	$137,557	$137,676	$116,384	$102,221	$136,254	$65,337

Taulbee Table S1 shows salaries of faculty in 138 out of 195 Computer Science departments in the US, and Taulbee Table S2 shows salaries in 102 out of 142 public CS departments. Currently employed assistant professors in the CS department at UCCS are paid below 10 percentile compared to both tables. These include PhD granting as well as non-PhD granting departments. The Computer Science department at UCCS houses two distinct PhD programs, PhD in Computer Science and PhD in Security, each with about 40-45 students. These represent two of the five PhD programs on campus, excluding professional doctoral programs, and the graduates of these two programs and the funded research supported by these two programs have been instrumental in UCCS obtaining Carnegie R2 status in 2018.

Tenure Track Faculty: To attract and retain high quality faculty[12], we propose that incoming TTF get salary between 25 and 50 percentiles. If we consider the 25 percentile salary from Taulbee

[12] The CS department at UCCS lost three pre-tenure, highly successful assistant professors within the past five years, one leaving for Colorado School of Mines, the second to University of Texas at Arlington, and the third to California Polytechnique University in San Luis Obispo. A primary reason for leaving has been salary and a secondary reason has been lack of Graduate Teaching Assistants (GTA) at UCCS. In Computer Science and Engineering, GTAs provide for high quality students who help in teaching, but also perform research.

Table S1 for 2018-19, and assume increment of 3% every year, the salary becomes $110,599 for the first year when we propose to hire a new TTF in this proposal. If we consider the 50 percentile salary from Taulbee Table S1, the salary becomes $118,684. If we do the same with Taulbee Table S2, the 25 and 50 percentile salaries become $108,234 and $113,872 at the time of first TTF hire. To keep things simple, we propose that the assistant professor starting salary in the first year of hire is $110,000.

Instructor Salary: Performing similar calculations, we propose that we pay the instructor in the fourth year of the program $82,000.

GTA Salary: TAs will be paid at the rate of GTAs in the EAS College. In-state tuition will be covered.

Administrative Assistant Salary: We propose that the administrative assistant be paid $50,000 in the fourth year of the program, when he/she is hired.

C.7 Other Relevant Information

C.7.a Course Descriptions
Information on all of the courses listed in Section C.2 of this proposal is available at: https://www.uccs.edu/cs/academics/undergraduate-programs.

New courses developed in support of the proposed B.A. degree either to allow students to specialize in particular computer science sub-disciplines or to serve as classes that meet campus-wide Compass Curriculum requirements or requirements of specific dual major or dual degree programs will appear at the above URL. As part of its continuous improvement efforts, the Department continually updates existing courses with new content and develops new courses in response to new developments in the field of computer science or as a result of hiring a new faculty member in a new area of computer science. Students in the proposed BA in Computer Science degree program will benefit from all such changes and additions. The Department's Curriculum Committee will evaluate new or updated courses to consider whether they should be part of the proposed BA degree and will update its degree requirements as needed on an annual basis.

C.7.b Comparison of the proposed BA in CS degree with the existing BS in CS degree

The requirements for the B.S. in Computer Science degree are documented in detail at the following URL:
https://www.uccs.edu/cs/academics/undergraduate-programs/bachelor-of-science-in-computer-science.

The Bachelor of Science degree in Computer Science requires the following:

- Completion of at least 128 hours.
- A minimum 2.0 average in all CS courses taken and in all CU courses taken.
- CS majors must complete an exit interview the semester they intend to graduate.

Computer Science Core Courses (and their Pre/Co-Requisites)

- CS 1150 Principles of Computer Science 3 (HS Algebra, familiarity with computer concepts including file operations and text editing)
- CS 1450 Data Structures & Algorithms 3 (CS 1150)
- CS 2060 Programming in C 3 (CS 1150)
- CS 2080 Programming with UNIX 2 (CS 1450)
- CS 2160 Computer Organization & Assembly Language 3 (CS 1450, CS 2060)
- CS 3050 Computing Ethics (CS 2080)
- CS 3060 Object Oriented Programming in C++ 3 (CS 2060, CS 2080) **OR** CS 3020 Adv Object Tech Using C#/.NET 3 (CS 1450) **OR** CS 3080 Python Programming
- CS 3160 Concepts of Programming Languages 3 (CS 2060, CS 2160, CS 3020 **OR** CS 3060)
- CS 3300 Software Engineering 3 (CS 2080, CS 3160, CS 3020 **OR** CS 3060)
- CS 4100 Compiler Design 3 (CS 2160, CS 3160, CS 4700)
- CS 4200 Computer Architecture I 3 (CS 2160)
- CS 4500 Operating Systems I 3 (CS 2060, CS 2080, CS 4200)
- CS 4700 Computability, Automata & Formal Lang. 3 (MATH 2150, MATH 3130)
- CS 4720 Design & Analysis of Algorithms 3 (CS 1450, MATH 2150)

TOTAL 39 CREDITS

Computer Science Electives Complete 9 credit hours of CS courses numbered between 4000-5990 that are not being used for the CS Core. Total 9

Technical Electives Complete 9 hours of Technical Electives. Technical Electives should be chosen from the following areas: CS courses 3000+ not being used for CS Core or CS Electives; GDD courses 3000+; ECE courses 2000+; MATH courses 3100+, except MATH 4650; Additional courses from the Basic Science list or additional courses with prerequisites from the Basic Science list; Any course from the College of Business 3000+, except BUAD 3010, 3020 or 3030. Total 9

Mathematics (and their Pre/Co-requisites) All courses in this section must be completed.

- MATH 1350 Calculus I 4 (MATH 1050 or score of 10 on Calc. Readiness Exam)
- MATH 1360 Calculus II 4 (MATH 1350)
- CS 2150 Discrete Structures or MATH 2150 Discrete Mathematics 3 (MATH 1350)
- MATH 2350 Calculus III 4 (MATH 1360)
- CS 2300 Computational Linear Algebra (MATH 90) **OR** MATH 3130 Introduction to Linear Algebra 3 (MATH 1350)
- CS 2200 Computational Statistics OR MATH 3810 Intro. to Probability & Statistics **OR** ECE 3610 Engineering Probability & Statistics 3 (MATH 2350)

TOTAL 21

Basic Science (and their Pre/Co-Requisites) PES 1110 General Physics I 4 (Coreq. MATH 1350), 1120 General Physics II 4 (PES 1110, Coreq. MATH 1360) and 1160 General Physics Lab 1(Coreq. PES 1110) must be completed. Five additional hours of Basic Science are also required and may be chosen from the following courses (credit hours for each class are listed after the course number):

CHEM 1030-5, CHEM 1060-5, GEOL 1010-4, GEOL 1020-4, BIOL 1200-4, BIOL 1210-4 or any other PES course that has a prerequisite of PES 1110.
TOTAL 14

Writing Skills All courses in this section must be completed. Please note that ENGL 1410 can replace ENGL 1310 if the student desires a more challenging writing course. If you do not place in to ENGL 1310 you need to take ENGL 0990 as a prerequisite

- ENGL 1310 Rhetoric & Writing I 3 (Score of 19+ on ACT Engl or 450+ on SAT Verb ENGL 3090 Technical Writing and Presentation 3 ENGL 1310)
- ENGL 2090 Technical Writing & Presentation 3 (ENGL 1310 **OR** ENGL 1410)
- PORT 3000 Writing Portfolio Assessment (ENGL 2090)

TOTAL 6

Compass Curriculum Humanities/Social Science Requirements Complete 23 hours of Humanities/Social Science Electives. Complete a Gateway Seminar (GPS 1010), an Explore - Arts, Humanities, and Cultures course, an Explore - Society, Behavior, and Health course, an Explore - Physical and Natural World course (PES 1110), a Navigate course, a Summit course (CS 4100), two Writing Intensive Courses (at least one 3000+), an Inclusiveness course, and a Sustainability course. Some of these courses are already included in the major. For more information about these requirements, refer to the Compass Curriculum.
TOTAL 23

Free Electives Students need to complete 7 hours of Free Electives. The chosen course(s) can be selected from any discipline but may not include MATH 1040, MATH 1050, MATH 1110, and MATH 1120. Only 3 credit hours of CS course work numbered below CS 1150 may count towards the Free Electives.
TOTAL 7

With this description, the differences between the BS degree and the proposed BA degree are clear.

The BS degree requires more Computer Science classes 48 semester hours vs. 36 semester hours.

The BS degree does not have any tracks right now; the proposed BA degree will offer curriculum tracks with Computer Science itself, but also will easily accommodate a major or minor in a discipline outside of Computer Science. Although this proposal does not propose these dual degrees or double majors right now, we will do so in collaboration with other disciplines soon after the BA-CS program is initiated, if there is student demand.

In UCCS, each degree program is required to have a so-called SUMMIT course, which is like a capstone. The BS degree in Computer Science uses CS 4100: Compiler Design. The Computer Science department set up a new research based independent study class and a new entrepreneurship based independent study class, starting the Fall of 2019. These have been

already approved by the department and the college. These will be used to develop a SUMMIT course for the BA-CS degree.

Finally, the BS degree requires 21 semester hours of math rather than the 12 hours required by the B.A. degree. The BS degree requires 14 hours of natural science, but the BA degree does not have any such requirement.