CONNECTICUT BOARD OF REGENTS FOR HIGHER EDUCATION
Connecticut State Colleges & Universities
*APPLICATION FOR **MODIFICATION OF ACCREDITED PROGRAM***

SECTION 1: GENERAL INFORMATION

Institution: Central Connecticut State University | Date of Submission to CSCU Office of the Provost: March 25, 2019

Most Recent NECHE Institutional Accreditation Action and Date: April 12, 2019

Original Program Characteristics

CIP Code No. 15.0405 Title of CIP Code Robotics Technology/Technician

Name of Program: Robotics and Mechatronics Engineering Technology

Degree: Title of Award *(e.g. Master of Arts)* **BS**

Stand-Alone Certificate: *(specify type and level)*

Date Program was Initiated: Fall 2012 OHE#: 16962

Modality of Program: X On ground Online Combined

If "Combined", % of fully online courses?

Locality of Program: X On Campus Off Campus Both

Original Program Credit Distribution

Credits in General Education: 42-48

Credits in Program Core Courses: 45

Credits of Electives in the Field: 1-7

Credits of Free Electives: 0

Cr Special Requirements *(include internship, etc.):* 36

Total # Cr in the Program *(sum of all #Cr above)*: 130

From "Total # Cr in the Program" above, enter #Cr that are part of/belong in an already approved program(s) at the institution: 130

Type of Program Modification Approval Being Sought (mark all that apply):

X Significant Modification of Courses/Course Substitutions*

Offering of Program at Off-Campus Location (specify new location)

Offering of Program Using an Alternate Modality (e.g. from on ground to online)

X Change of Degree Title or Program Title

***Significant** is defined as "more than 15 credits in a previously approved undergraduate degree program or more than 12 credits in a previously approved graduate degree program.

Modified Program Characteristics

Name of Program: Robotics and Mechatronics Engineering Technology

Degree: Title of Award *(e.g. Master of Arts)* **BS**

Certificate[1]: *(specify type and level)*

Program Initiation Date: Fall 2020

Modality of Program: X On ground Online Combined

If "Combined", % of fully online courses?

Locality of Program: X On Campus Off Campus Both

Modified Program Credit Distribution

Credits in General Education: 42-48

Credits in Program Core Courses: 55

Credits of Electives in the Field: 6-9

Credits of Free Electives: 0-3

Cr Special Requirements *(include internship, etc.):* 24

Total # Cr in the Program *(sum of all #Cr above)*: 130

From "Total # Cr in the Program" above, enter #Cr that are part of/belong in an already approved program(s) at the institution: 108

Total Number of courses and course credits to be modified by this application: 16 courses; 42 credits

If program modification is concurrent with discontinuation of related program(s), list information for such program(s):

Program Discontinued: CIP: OHE#: Accreditation Date:

Phase Out Period Date of Program Termination

Other Program Accreditation:

- If seeking specialized/professional/other accreditation, name of agency and intended year of review: ETAC-ABET
- If program prepares graduates eligibility to state/professional license, please identify:

(As applicable, the documentation in this request should addresses the standards of the identified accrediting body or licensing agency)

[1] If creating a Stand-Alone Certificate program from existing courses belonging to a previously approved baccalaureate/associate degree program, enter information about that program in the "Original Program" section.

Institutional Contact for this Proposal: Ravindra Thamma Title: Chair Tel.: 860-832-3516 e- mail: thammarav@ccsu.edu
Institution's Unit *(e.g. School of Business)* and Location *(e.g. main campus)* Offering the Program: School of Engineering, Science, and Technology. Main campus in New Britain.

SECTION 2: BACKGROUND, RATIONALE AND NATURE OF MODIFICATION

(Please Complete Sections as Applicable)

Background and Rationale *(Please provide the context for and need for the proposed modification, and the relationship to the originally approved program)*

The BS in Robotics and Mechatronics Engineering Technology was accredited in 2012. Since then, the fields of Robotics, Mechatronics, machine vision, and programmable logical controllers have rapidly advanced, necessitating curriculum updates. These changes were informed by our Industrial Advisory Board to meet industry and market requirements. Further, these changes will better position the program for reaccreditation by ABET. The proposed curriculum will also open more industrial opportunities to CCSU students.

As applicable, please describe:

How does the program address CT workforce needs and/or the wellbeing of CT society/communities? *(Succinctly present as much factual evidence and evaluation of stated needs as possible):*

Courses prepare students for employment in the fields of Robotics, Mechatronics, General Automation, Controls, Manufacturing Automation, Programmable Logic Controllers, and Electromechanical Industry.

Local industry including United Technologies and Lockheed Martin regularly employ graduates with this degree.

- How does the program make use of the strengths of the institution (*e.g. curriculum, faculty, resources)* and of its distinctive character and/or location?

CCSU's BS in Robotics and Mechatronics Engineering Technology was the first such program in the Northeast and the fifth in the United States. Many current faculty are founding members of this program. The curriculum emphasizes a 2+2 model (2 hours in the classroom and 2 hours in the laboratory), which balances strong theory and hands-on application with high-impact educational practices including a senior capstone, internship, and experiential learning. Our graduates are prepared to directly enter the workforce.

The new engineering building scheduled to open in Fall 2021 will house three new Robotics and Mechatronics Engineering Technology laboratories with state-of-the-art equipment mirroring that used by local industry.

With United Technologies headquartered in Farmington, CCSU's robotics and mechatronics program is in an ideal location to supply an educated workforce to its central location and to its affiliates including Pratt and Whitney and Collins Aerospace.

The two closest competitors are currently Worcester Polytechnic Institute and Western New England University. However, their programs are full engineering programs; CCSU is still the only institution in the local area to support an application-based engineering technology program. Notably, University of Hartford is implementing a Robotics Engineering BS in Fall 2020.

- Please describe any transfer agreements with CSCU institutions that will become instituted as a result of the approval of this program *(Please highlight details in the Quality Assessment portion of this application, as appropriate):*

  Current transfer agreements will continue.

- Please indicate what similar programs exist in other institutions within the CSCU System, and how unnecessary duplication is being avoided

  None.

- Please provide a description/analysis of employment prospects for graduates of this proposed program:

By their junior year, 100% of students in this program have internship and/or job placements. Job titles for recent graduates include Automation Engineer, Controls Engineer, Robotics Engineer, Mechatronics Engineer, Instrumentation Specialist, Fluid Power System Designer, Workcell Architect, and System Integrator. The closest analogs to these job titles and their employment outlooks are listed in the following table:

Job Title	# of Postings on Jan 2020	CT Companies	Average Annual Wages Statewide	Growth Rate / Annual Job Openings
Mechatronics Engineer	4	ASML, Cybercoders, United Technologies	$101,975	1.2%/122
Robotics Engineer	0		$101,975	1.2%/122
Electromechanical Technician	5	United Technologies, General Dynamics Information Technology, Northtrop Grumman, Coherent	$58,969	2.5%/n/a
Computer Numerically Controlled Machine Tool Programmers	10	Randstad, QuEST Global, Belcan, United Technologies, Kelly Services, CyberCoders, Electro-Methods	$67,057	2.9%/111

Data from CareerOneStop, sponsored by the U.S. Department of Labor.

According to JobsEQ, in the past 6 months (as of February 2, 2020), there have been 25 job postings for electromechanical technicians, 6 ads for robotics technicians, and 8 ads or robotics engineers.

Present side-by-side listing of curricular modification: (From **Original** to **Modified**)

Original Course	Course Type	Credits	Modified	Course Type	Credits
CHANGE ROBO 260: Programmable Controllers	Core	3	**TO** ROBO 260: Programmable Controllers	Core	3+1
CHANGE ROBO 330: Fluid Power Systems	Core	3	**TO** ROBO 320: Fluid Power Control	Core	4
CHANGE ROBO 380: Mechatronics	Core	3	**TO** ROBO 380: Mechatronics	Core	3+1
REMOVE ET 251: Applied Mechanics I – Statics	Special Requirement	3	**ADD** ROBO 210: Engineering Mechanics for Automation	Core	4
REMOVE ET 252: Applied Mechanics II - Dynamics	Special Requirement	3	**ADD** ROBO 340: Modeling and Simulation in Mechatronics	Core	3
REMOVE ET 357: Strength of Materials	Special Requirement	3	**ADD** ROBO 390: Robotics, Theory and Application	Core	3
REMOVE ET 358: Applied Thermodynamics	Special Requirement	3	**ADD** ROBO 425: Advance Programmable Logic Controllers	Electives in the Field	3
			ADD ROBO 440: Machine Vision and Image Processing	Electives in the Field	3
MOVE ROBO 450: Autonomous and Intelligent Mobile Robots	Core	3	**TO** ROBO 450: Autonomous and Intelligent Mobile Robots	Electives in the Field	3
MOVE ROBO 470: Robotics Systems Engineering and Analysis	Core	3	**TO** ROBO 470: Robotics Systems Engineering and Analysis	Electives in the Field	3

The addition of one credit to two existing 3-credit courses fulfills the 2+2 nature of the curriculum for classes that are heavily dependent on hands-on lab work, which increases student contact hours.

Description of Related Modification *(Provide a summary of other changes necessitated by curricular modification such as admissions or graduation requirements ,mode of delivery etc., and concisely describe how the institution will support these changes.)*

None.

Description of Resources Needed *(As appropriate please summarize faculty and administrative resources, library holdings, specialized equipment, etc. Details to be provided in the next section, as appropriate)*

The only incremental expense for this modification is12 credits of additional part-time faculty support per academic year. If enrollments significantly increase, we would consider adding one full-time faculty member to meet demand.

Other Considerations

The Robotics and Mechatronics Engineering Technology BS received exemption from BR# 14-111 to offer this program at 130 credits. University of Hartford's new program is 131 credits. Our next closest competitor, Worcester Polytechnic Institute, is on a quarter system making direct credit comparisons difficult. Widener University in Chester, PA also offers a 130-credit degree program. Thus, CCSU's program is comparable to other programs' credit requirements while offering the most affordable option.

Previous Three Years Enrollment and Completion for the Program being Modified

ACTUAL Enrollment	Fall Term, 2017		Fall Term, 2018		Fall Term, 2019	
	Full Time	Part Time	Full Time	Part Time	Full Time	Part Time
Transfers In						
New Students	13	1	15	0	16	3
Returning Students	27	6	29	10	28	9
ACTUAL Headcount Enrollment	40	7	44	10	44	12
Fall FTE accounted for by Program Majors	42.7		48.7		49.5	
Size of Credentialed Group(s) for Given Year	4		6		9	

Curriculum Details for a Program Modification (to be used as appropriate for specific modification request)[2]

Course Number and Name [3]	**L.O. #**	**Pre-Requisite**	**Cr Hrs**	**Course Number and Name**	**L.O. #**	**Cr Hrs**
Program Core Courses				**Other Related/Special Requirements**		
ROBO 110 Introduction to Robotics and Mechatronics	1,8,9,10,11	None	3	CET 236 Circuit Analysis	--	3
ROBO 210 Engineering Mechanics for Automation*	2,3,4,5	PHYS125	4	CET 270 Electronic Circuits and Devices for Robotics	--	3
ROBO 220 Parametric Modeling and Simulation	2	None	3	CET 363 Digital Circuits	--	3
ROBO 240 Electric Machines	2,3,7	CET236	3	MATH 221 Calc. II	--	4
ROBO 260 Programmable Controllers	2,3,7	None	4	MATH 226 Linear Algebra and Probability for Engineers -OR- MATH 228 Introduction to Linear Algebra	--	4
ROBO 280 Embedded Systems Design	2,3	CET363	3	MATH 355 Introduction to Differential Equations	--	4
ROBO 310 Data Acquisition & Processing	2,3,6,7	CET270 & CET363	3	MM 216 Manufacturing Processes	--	3
ROBO 320 Fluid Power Control*	2,3,6,7	ROBO 210	4			
ROBO 340 Modeling and Simulation in Mechatronics	2	MATH 221 and CET236	3			

[2] **Details of course changes for Community College institutions should be provided with enough detail to introduce necessary changes in the centralized programmatic database for that system.**
[3] Make any detailed annotations for individual courses as needed to understand the curricular modifications taking place

Course Number and Name [4]	L.O. #	Pre-Requisite	Cr Hrs	Course Number and Name	L.O. #	Cr Hrs
ROBO 350 Applied Control Systems I	2,3,6,7,11	MATH355, ROBO260 & ROBO320	3			
ROBO 370 Mechanisms for Automation	2,3,6	ROBO220, ROBO210, MATH226 & MM216	3			
ROBO 380 Mechatronics	2,3,6,11	ROBO240, ROBO280 & ROBO350	4			
ROBO 390 Robotics, Theory and Application*	2,3,10, 11	ROBO370 & ROBO280	3			
ROBO 460 Applied Control Systems II	2,3,6,7,11	ROBO350	3			
ROBO 480 Industrial Robotics	2,3,6, 10,11	ROBO310 & ROBO390	3			
ROBO 496 Industrial Internship			3			
ROBO 497 Capstone: Senior Project	2,5,8,9,10,11		3			
Core Course Prerequisites				**Elective Courses in the Field**		
PHYS 125			4	**ROBO 425 Advanced Programmable Logic Controllers***	2,3,7,8,10	3
MATH 152 Calc. I			4	ROBO 440 Machine Vision and Image Processing	2,3,6,7	3
MATH 221 Calc. II			4	ROBO 450 Autonomous and Intelligent Mobile Robots	2,3,4,5,6,10,11	3
MATH 226 Linear Algebra and Probability for Engineers -OR- MATH 228 Introduction to Linear Algebra			4	ROBO 470 Robotics Systems Engineering and Analysis	5,8,9,10, 11	3
MATH 355 Introduction to Differential Equations			4			
CET 236 Circuit Analysis			3			
CET 270 Electronic Circuits and Devices for Robotics			3			
CET 363 Digital Circuits			3			
MM 216 Manufacturing Processes			3			
Total Other Credits Required to Issue Modified Credential						

1) An ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities;
2) An ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;

[4] Make any detailed annotations for individual courses as needed to understand the curricular modifications taking place

3) An ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;
4) An ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives;
5) An ability to function effectively as a member or leader on a technical team;
6) An ability to identify, analyze, and solve broadly-defined engineering technology problems;
7) An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;
8) An understanding of the need for and an ability to engage in self-directed continuing professional development;
9) An understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
10) A knowledge of the impact of engineering technology solutions in a societal and global context; and
11) A commitment to quality, timeliness, and continuous improvement.

***New Courses**

ROBO 210: Engineering Mechanics for Automation. The course objective is to introduce the basic knowledge with application in robotics and automation and it includes the following topics: Forces, Moments, and Couples. Equilibrium. Center of mass. Moment of inertia. Friction. Beams, Cables. Kinematics and kinetics. Newton's laws. Work-Energy. Impulse-Momentum. Conservation laws. Rigid body dynamics. Reflected inertia. Gyroscopic motion. Free and excited vibration. Transmissibility and Isolation. Credits: 4. Prerequisite: Physics 121 or 125

ROBO 320: Fluid Power Control. Study of the design and fabrication of fluid-based power systems, including hydraulics and pneumatics. Study includes fluid statics and dynamics, Bernoulli equation, momentum, energy, different types of flow, pipes, pumping systems, actuators and valves. Thermal control of mechatronics devices and implementing of control systems for real industrial systems. Credits: 4. Prerequisite: ROBO 210.

ROBO 390: Robotics, Theory and Applications. The course will cover topics such as: Joints, Drives, Transmission, and Sensors. Joint and space frames. Forward and Inverse kinematics. Lagrange-Euler dynamics. Jacobian. Static and dynamic joints' forces and torques. Path generation. Robot control methods. Interaction with the environment. Credits: 3. Prerequisite ROBO 210.

ROBO 425: Advanced Programmable Logic Controllers. Programming technique, addressing formats, input/output instructions, development of advanced ladder logic, sequential flow logic. Implementation of controllers, Supervisory control & data acquisition, DCS, communication protocol and networking, and development for process system. Credits: 3. Prerequisites: ROBO 260 or Permission of Instructor.

SECTION 3: RESOURCE AND FINANCIAL CONSIDERATIONS

Cost Effectiveness and Availability of Adequate Resources

(Please complete the Pro-Forma Budget – Projected Revenues and Expenditures on the following page. Provide any necessary annotations for the Pro-Forma Budget and other commentary regarding the cost effectiveness and availability of adequate resources for the proposed modification below:

Projected Enrollment	Fall Term, 2020		Fall Term, 2021		Fall Term, 2022	
	Full Time	Part Time	Full Time	Part Time	Full Time	Part Time
Transfers In						
New Students	18	1	20	1	22	1
Returning Students	25	11	25	10	25	10
ACTUAL Headcount Enrollment	43	12	45	11	47	11

[i]Projected enrollments are based on actual enrollment trends. Despite the overall enrollment decline in Fall 2019, students enrolled in the Robotics and Mechatronics BS actually increased. Considering that CCSU's program is the only Robotics baccalaureate degree offered at a public institution in Connecticut, we expect sustained enrollment with modest growth. Further, the opening of the new Robotics facilities in Fall 2021 could draw additional students to the program.

[ii]Tuition revenues are based on AY 2019 in-state undergraduate rates and include tuition per semester ($2,962) plus the University General Fee less accident insurance ($1908). We assume that PT students will take 7 credits per semester, which would result in $3,815 of revenue ($58 registration fee plus $545 per credit: $247 tuition, $298 General Fee per credit). No tuition increases for 2020-22 are assumed. Because the program is 130 credits, faculty recommend taking two summer classes to graduate within 4 years.

[iii]Students pay a $40 lab fee for each lab course with a maximum of $80 per semester. For each Fall semester, all FT undergraduates are expected to pay $80 in lab fees. PT students are expected to pay $40 in lab fees each semester.

[iv]A program coordinator from the full-time faculty will receive one credit of reassigned time per Fall and Spring semester for managing the program. Replacement costs of a part-time Class B lecturer with 31% fringe would be $2,311 ($1,764 in wages; $547 in fringe).

[v]We estimated instructional costs assuming that 36 credits would be offered each Fall with 20 credits taught by full-time faculty and 16 credits taught by part-time faculty. We estimated FT salary using the median FY20 salary of current faculty teaching with the program ($93,724) and median fringe ($89,506). We estimated PT instruction as a Class B lecturer ($1,764 per credit) with 31% fringe ($547 per credit). Projected increases in enrollment can be fully absorbed by the current estimates.

[vi]An administrative professional is anticipated to spend approximately 25% of their time in direct support of this program. We have projected expenses based on current salary and fringe and anticipate a 3% COLA each year ($28,862). In addition, a lab technician and a computer technician each devote approximately 5% of their time in direct service of the program. Building in a 3% COLA, these costs are $6,988 and $10,439, respectively.

[vii]Replacement costs for equipment are nearly covered by the lab fees collected as revenue.

[viii]Other costs include a 3-year marketing plan. Given that the University of Hartford is launching their Robotics BS in Fall 2020, CCSU is committed to solidly positioning this program. Marketing efforts include submitting a press release; advertising on radio, video, digital, and/or print platforms; and developing a program brochure, posters, and/or flyers. The Office of Enrollment Management purchases the names of SAT and ACT test takers and develops communications plans to introduce them to the University. Admissions staff also spend a significant amount of time recruiting in the high schools and community colleges throughout the state and region. The Office of Enrollment Management will also be working with university and recruitment partners overseas to recruit international students into the program. We expect to spend up to $2,500 in Year 1, $2,000 in Year 2, and $1,000 in Year 3.

PRO FORMA Budget - Projected Revenues and Expenditures
(Whole Dollars Only)

PROJECTED Program Revenue[i]	Fall 2020	Fall 2021	Fall 2022
Tuition (do not include internal transfers)[ii]	$ 259,806	$ 265,793	$ 275,693
Program-Specific Fees[iii]	$ 3,920	$ 4,040	$ 4,200
Other Revenue (Annotate in narrative)	$ -	$ -	$ -
Total Estimated Program Revenue	**$ 263,726**	**$ 269,833**	**$ 279,893**

PROJECTED Program Expenditures*	Fall 2020	Fall 2021	Fall 2022
Administration (Chair or Coordinator)[iv]	$ 2,311	$ 2,311	$ 2,311
Faculty (Full-time, total for program)[v]	$ 152,692	$ 152,692	$ 152,692
Faculty (Part-time, total for program)[v]	$ 36,973	$ 36,973	$ 36,973
Support Staff[vi]	$ 44,299	$ 45,628	$ 46,997
Library Resources Program	$ -	$ -	$ -
Equipment (List as needed)[vii]	$ 4,500	$ 4,500	$ 4,500
Other (e.g. student services)[viii]	$ 2,500	$ 2,000	$ 1,000
Estimated Indirect Costs (e.g. student services, operations, maintenance)	$ -	$ -	$ -
Total Estimated Program Expenditures	**$ 243,275**	**$ 244,104**	**$ 244,473**

*Note: Capital outlay costs, institutional spending for research and services, etc. can be excluded.

This PRO FORMA Budget provides reasonable assurance that the proposed program modification can be established and is sustainable. Some assumptions and/or formulaic methodology may be used and annotated in narrative on page 4 of Application.