Cost Estimation for Implementation of a B.S. Program in Mechatronics Engineering Technology

Mauricio Torres
Northern Kentucky University
torresm1@nku.edu

Morteza Sadat-Hossieny
Northern Kentucky University
sadathossien@nku.edu

Abstract

The purpose of this paper is to provide a chronicle on the implementation cost estimation for a multidisciplinary B.S. in Mechatronics Engineering Technology program based on the needs of industry in Northern Kentucky / Southern Ohio regional areas.
The new mechatronics programs are intended for students who are prepared to be hired by industry as multi-disciplinary professionals. Colleges and universities currently offering electronics technology, electrical systems, mechanical & manufacturing engineering technology, electromechanical engineering technology, industrial engineering, robotics and computerized control systems are in an advantageous position to implement those programs, as some of the required resources may already been in place.
This program is a 2+2 degree program between Cincinnati State Technical and Community College (CSTCC) and the bachelor degree programs at Northern Kentucky University (NKU). The courses in the curriculum will be selected among existing courses in the associate degree programs at CSTCC and the bachelor degree programs at NKU. New courses will be added to meet the educational and/or industry needs. A pathway to B.S. degree completion for graduates from CSTCC is also envisioned, in the form of a transfer agreement.

Introduction

Founded in 1968, Northern Kentucky University (NKU) is a metropolitan university with approximately 16,000 students, located in Highland Heights, KY, in the greater Cincinnati area. NKU currently offers Bachelors of Science degrees in Engineering Technology (Electronics - EET and Mechanical and Manufacturing - MMET), with the support of local industry, who provide most of the students with Co-op opportunities. The MMET and the EET are long-standing programs at NKU. These programs have catered to the manufacturing industry in Northern Kentucky / Southern Ohio areas for more than two decades.

Cincinnati State Technical and Community College (CSTCC) is a technical and community college located in Cincinnati, Ohio; it was chartered by the Ohio Board of Regents in 1969. The college offers over 75 associate degree programs and majors, and over 40 certificate programs, being one of the ten largest co-op education programs in the nation, as measured by the number of student placements. Recently, Cincinnati State created a new division named the Center for Innovative Technologies (CIT), which combines the Engineering Technology and Information Technology divisions.

Northern Kentucky and Southern Ohio areas host many advanced manufacturing companies producing high value-added products. Companies such as Mazak, ZF Steering Systems, General Electric, Procter & Gamble, Fives, Johnson Controls, Toyota and others play a significant role in the region's economy. The availability of adequately trained individuals is paramount to fulfill their human resource needs as has been repeatedly expressed to the local institutions' faculty and administrators. [1]. To address these needs, a new B.S. in Mechatronics Engineering Technology (MET) is proposed.

A 4-year plan to satisfy the requirements for the Associate of Applied Science in Electro-Mechanical Engineering Technology degree at CSTCC, leading to the MET B.S. degree at NKU will be implemented in the form of a transfer agreement. By completing the Associate of Applied Science degree at CSTCC with a satisfactory GPA, students will receive credit for as many courses in the bachelor's degree program as possible. Transfer credits will be based on approved course equivalencies to be defined. An NSF Advanced Technological Education (ATE) grant proposal was submitted for funding the curriculum development, faculty professional development, acquisition of new equipment and upgrades on existing laboratory equipment and therefore, the budget is organized accordingly.

Mechatronics

The term mechatronics was first used in the late 1960s by a Japanese Electric Company to describe the engineering integration between mechanical and electrical systems. It is an integrated comprehensive study of electromechanical systems, integrating electrical, mechanical and computer engineering areas [2].

ASME describes mechatronics as "where electronics meets mechanical engineering, computing, optics, actuators, sensors, digital controls and robotics. From its inception in computer-controlled machining and factory automation, mechatronics has incorporated these engineering disciplines and more, plus bioengineering and nanotechnology. Examples of mechatronic systems include aircraft flight control and navigation systems, automotive electronic fuel injection and anti-lock brake systems, automated manufacturing systems including robots, numerical control machining centers, packaging systems and plastic injection-molding systems, artificial organs, health monitoring and surgical systems, copy machines and many more. A common element of all these systems is the integration of analog and digital circuits, microprocessors and computers, mechanical devices, sensors, actuators and controls [3].

Project Plan

Curriculum at NKU and CSTCC follow the general guidelines for accreditation defined by ABET-ETAC [4]. Mechatronics curriculum design includes development of goals and objectives, programs of study and curriculum guides, courses, laboratories, textbooks, instructional materials, experiments, instructional sequencies and the supplemental materials focusing to accomplish a wide range of educational goals [2].
The cross-curricular approach is reflected at the level of the targeted goals and the targeted contents. The use of new technologies and of the computer as a working tool will determine the student's educational course [5].
The mechatronics courses are intended to develop a comprehensive understanding and the ability to apply theoretical and experimental concepts in design, optimization and implementation of electromechanical systems posing different levels of complexity. These objectives are achieved by the delivery of electromechanical systems theory as well as fundamentals of engineering programing and software. A balanced coverage can be assured by a careful blend of courses chosen from those offered by NKU and CSTCC.

Faculty and Enrollment

A new cross-disciplinary faculty member will be needed in the MET program. This position will keep the new program current in the areas of automation and industrial controls while incorporating aspects of electro-mechanical systems into the curriculum. Also, for accreditation purposes, ABET requires programs to have full time dedicated faculty member(s) [6]. Table 1 shows the current faculty composition, where the full time faculty are able to offer a total load of 84 credit hours (including a prospective new faculty member). The remaining credit hours are distributed among part-time faculty members.

As shown in Table 2, the Engineering Technology (EGT) programs offered 37 courses during the fall 2015-2016, with a total enrollment of 665 seats. The required credit hours to be taught are 111. We expect to see some increase in students enrolled in the EGT programs as the new MET program is in place. We also expect some migration of students from the current programs (EET, MMET) to the MET program. Our industry needs survey indicated that 84.7% of respondents anticipate the hiring (each one) of 1 to 15 mechatronics professionals and 7.7% will hire 16 to 50 in the next 5 years. Additional pressure on our faculty body can be anticipated as we will be required to attend to that demand by our constituents.

Table *3* shows exceptional growth in EGT enrollment during the last five years, mostly due to the increase in numbers of international students and also due to organic growth resulting from the rebound of the U.S. economy. These facts fully support the creation of a new faculty line to be fulfilled by a new faculty member, as shown in table 1, with an annual salary (according with CUPA [7]) of $66,289.00. The total yearly cost for this position can be estimated by applying 13.85% for employment taxes and adding the amount of $4,000.00

for benefits [8]. Therefore, the total estimated payroll cost for the new faculty position will be $79,470.00.

Table 1. NKU EGT program faculty qualifications and status

Faculty Name	Highest Degree Earned-Field and Year	Rank [1]	Type of Academic Appointment [2] T, TT, NTT	FT or PT [4]	Years of Experience			Professional Registration/ Cert.	Level of Activity H, M, L		Expected teaching Load (per semester, except Summer, (CH)
					Govt./Ind. Practice	Teaching	This Institution		Professional Development	Consulting/summer work in industry	
NKU											
Fac. 1	PhD 1989, Iowa State University	ASC	T	FT	5+	19+	13		M	M	12
Fac. 2	Ph.D. 1998, Ohio State University	ASC	T	FT .875 in MMET	6	9	9		H	M	12
Fac. 3	MS. 1966, Univ. of Cincinnati	ASC	T	FT .875 in MET	32	19	16	PE	M	L	12
Fac. 4	Ph.D. 2011 Florida International University	AST	TT	FT .875 in MMET	30	4	2		M	M	12
New Faculty Member	Ph.D. - TBD	AST	TT	FT 1.0 in MET	TBD	TBD	TBD		M	M	12
Fac. 5	Ph.D. University of Massachusetts	AST	TT	FT .125 in MMET	15	7	2		M	M	12
Fac. 6	MS. North Carolina A&T State University	I	NTT	FT .875 in the program	2	8	1		M	M	12
Total credit hours taught by FT faculty per semester											**84**
Fac. 7	Ph.D. Aerospace	A		PT	19+	3	3				TBD
Fac. 8	Ph.D., M.E., 2004 Eastern Mediterranean U.	A		PT	2	6	1		H	M	TBD
Fac. 9	M.SCE, 1988	A		PT	33	22	22	PE	20 cr hrs/yr in tech. legal & manage	Several hrs./Month	TBD
Fac. 10	M.S.	A		PT							TBD
Fac.11	BSIE 1983, MED 1993	A		PT							TBD
Fac.12	B.S.	A		PT							TBD
Fac.13	MBA Communications	A		PT	15	15	1		M	M	TBD
CSTCC											
Fac. 1	B.S. Electrical Engineering, 1991	ASC	T	FT		15	15		H	M	
Fac. 2	M.S. Electrical Engineering, 2011	AST	TT	FT		5	5		H	M	

(1) Code: P = Professor ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other
(2) Code: TT = Tenure Track T = Tenured NTT = Non Tenure Track
(3) The level of activity, high, medium or low, should reflect an average over the year prior to the visit plus the two previous years.
(4) At the institution
MMET - Mechanical & Manuf. Eng. Technology; EET - Electronic Eng. Technology; MET - Mechatronics Eng. Technology

Table 2. EGT classes required credit hours

	2015-2016 Fall	2014-2015 Su	2014-2015 Sp	2014-2015 Fall
Enrollments (seats)	665	167	753	839
Classes	37	12	46	47
Required credit hours per semester	111	36	138	141

Table 3. EGT classes enrollment (*source: Institutional Research Office – NKU*)

Credit Hour Production by Course Discipline	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**1 Year % Change**	**5 Year % Change**
EGT	**654**	**801**	**1050**	**1914**	**2913**	**2553**	**-12.4%**	**290.4%**
Lower Division	291	312	489	759	1014	765	-24.6%	162.9%
Upper Division	363	489	561	1155	1899	1788	-5.8%	392.6%

First Major by Discipline	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**1 Year % Change**	**5 Year % Change**
Electronics Engineering Tech Major	29	42	58	91	116	109	-6.0%	275.9%
Mech. & Manuf. Engineering Tech Major	70	83	125	197	246	210	-14.6%	200.0%

Faculty Professional Development

Faculty currency in the subject matter that they teach involves continuing scholarly activities and professional interaction. These strengthen the faculty member's knowledge of his/her field and its interdisciplinary advancements, best business practices, newest technology developments, best learning theory implementations and most effective teaching practices and innovations [9].

Due to the rapid evolution in electro-mechanical and electronic systems and the ever-changing aspects involved in modern industry, the maintenance of professional and academic currency is absolutely essential. An annual faculty professional development plan is proposed in a rotation schedule in order to provide opportunities to faculty members to stay current. The plan follows the framework proposed by Odden et al. [10] (where applicable) and is depicted in Table 4.

Table 4. Cost Structure for Professional Development

Provision for 2 faculty members per year in a rotation schedule, to be assigned by the program administration					
Cost Element	**Ingredient**	**How cost is calculated**		**Per Faculty**	**For 2 faculty Members**
Materials, Equipment and Facilities Used for professional Development	Materials	Materials for PD, including the cost of classroom and supplies.	Office materials, clerical supplies.	300.00	600.00
	Equipment	Equipment needed for PD activities	TI hardware, sampling equipment, lab kits	500.00	1,000.00
	Publications	Articles, books, subscriptions		300.00	600.00
	Facilities	Rental or other costs for facilities used for PD	Conference rooms, teaching aids	N/A	N/A
Sub Total (Materials, Supplies and Publications for PD)				**1,100.00**	**2,200.00**
Travel and Transportation for Professional Development	Travel	Costs of travel to off-site PD activities	Subsistence (4 days NKU rate, 3 trips)	432.00	864.00
			Lodging (4 nights, approx. rate, major metro area, 2 trips)	1,120.00	2,240.00
			Transportation (air ticket, taxi, rental car, 2 trips)	2,000.00	4,000.00
	Transportation	Costs of Transportation within the district for PD	200 miles @ $0.47 - NKU reimbursement rate	94.00	188.00
Sub Total (Travel)				**3,646.00**	**7,292.00**
Tuition and Conference Fees	Tuition	Tuition payments or reimbursement for university-based PD	1 Conference fee	800.00	1,600.00
			1 Trade show admission + conference	430.00	860.00
			1 technical training fee	2,000.00	4,000.00
Sub-total (PD)				**3,230.00**	**6,460.00**

Facilities - NKU

Engineering Technology Programs occupy nine rooms on the second floor of the Business Center to accommodate faculty and program secretary offices. All laboratory classes are taught in the following rooms (all located in the first floor): BC108, 115, 117, 121, 125. EGT also uses some conventional classrooms on an as-needed basis. The Business Center Building floor plan (first floor) as well as its location on the campus is depicted in Figure 1.

Facilities - CSTCC

Over the past few years, the EMET program at Cincinnati State has been retooling to reflect advanced manufacturing and automation needs in our area. One major component of the

retooling is the upgrade to our robotics laboratory, anticipated to be outfitted with the following robotic equipment:

- FANUC LR Mate w/Vision (Quantity – 3)
- FANUC Touch Screen iPendant for RoboGuide (Quantity – 12)
- FANUC M-1iA w/Vision (Quantity – 1)

The CSTCC equipment requested for this grant will be housed on the Main Campus, 3520 Central Parkway, Cincinnati, OH 45223. The three FANUC LR Mate robots and the one FANUC M-1iA robot will be located in room Main 148. Main 148 will require no upgrades to accommodate these robots, as this has already been completed with a third party donation valued over $10,000. The FANUC Touch Screen iPendants will be located in Main 150 and will not require computers, as these already exist in that location.

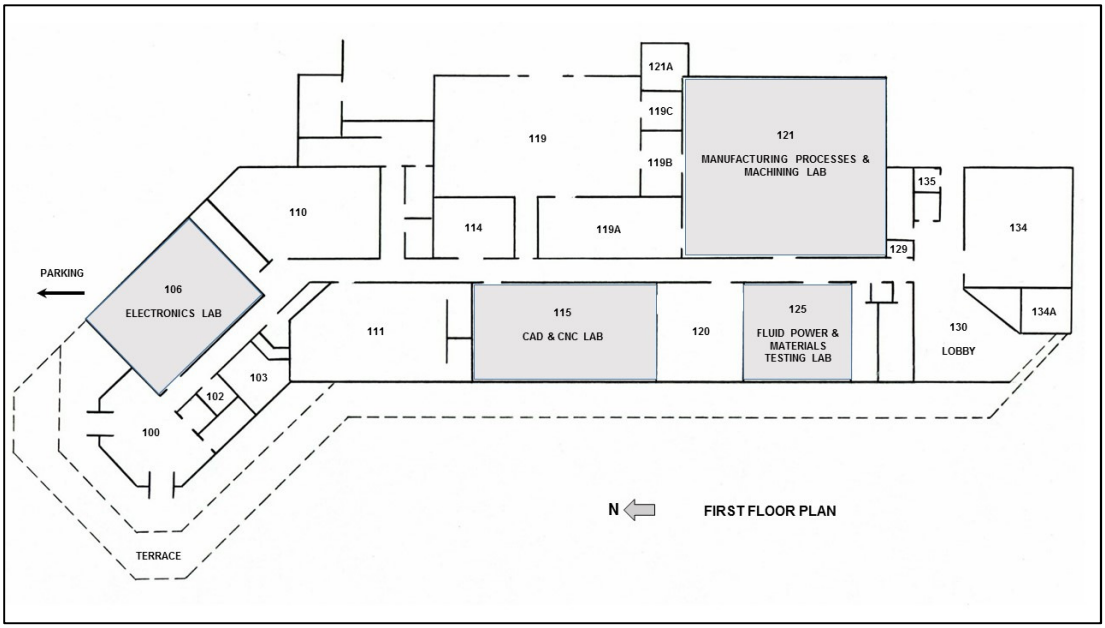

Figure 1. BC building' first floor. The lab spaces are shaded.

Laboratory Implementation and Improvement Guidelines

A solid understanding of multi-domain dynamic systems with accompanying modeling and analysis techniques are the key technical skills that mechatronics engineers should master [11]. To support the classes in mechatronics systems and to emphasize the correlation between different subjects (applied engineering and pure sciences), the implementation of new and/or improvement of existing facilities will follow the procedure adopted by Yu et al. [12] in designing each specific laboratory, as depicted in Figure 2.

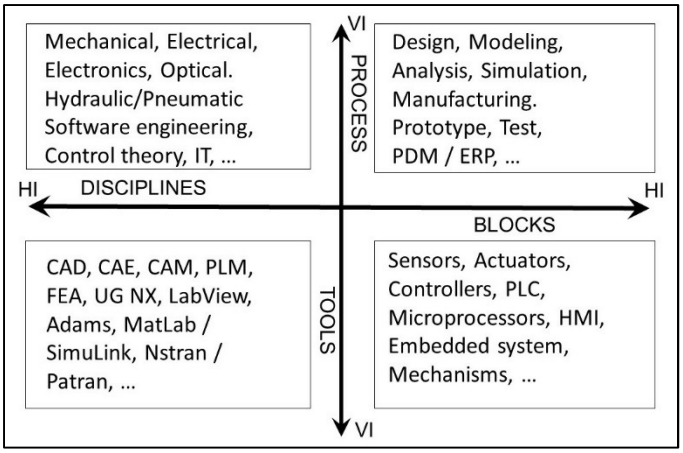

Figure 2. Horizontal integration (HI) and vertical integration (VI) of mechatronics

The NKU existing facilities offer support for the current engineering technology programs (MMET and EET). However, a dedicated mechatronics laboratory is necessary not only to support the new program, but also to improve the classes that will became part of the new program. The proposed list of new and updated equipment is depicted in Table 5 and

Table *6*.

Table 5. Proposed list of new equipment for the MET program at CSTCC

New Equipment						
Robotics Learning Equipment						
FANUC	LR Mate w/ Vision	Electric Servo Drive Mini-Robot	3	40,000.00	120,000.00	Various
FANUC	I-Pendant	Touch-Screen Controller	12	5,500.00	66,000.00	

FANUC	M-1iA w/ Vision	Light-Weight Assembly Robot	1	38,000.00	38,000.00	
				Sub-Total	224,000.00	

Table 6. Proposed list of new and updated equipment for the MET program at NKU

Laboratory Upgrades						
Hydraulic / Electro-Mechanic Systems Learning Equipment Retrofit						
Brand	Item	Description	Qty.	Unit Cost	Ext. Cost	Classes where the item will be used
Amatrol	850-CTBU	Controls Technology Double Sided A-Frame Bench Upgrade for Older 850-C1	3	2,996.00	8,988.00	EGT361, EGT386, EGT417
Amatrol	85-BH	Basic Hydraulics Learning System	3	7,222.00	21,666.00	
Amatrol	16019	24VDC Power Supply	3	772.00	2,316.00	
Amatrol	N/A	Repair parts for 85EF panels	1	1,746.00	1,746.00	
Test Equipment						
Instrom		Load Frame for Monotonic and Fatigue Loading	1	90,000.00	90,000.00	EGT300, EGT261, EGT280, EGT417
				Sub-Total	124,716.00	

New Equipment						
Mechatronics Learning Equipment						
Amatrol	870-PS7314	Mechatronics Learning System for Siemens S7-300 with Profibus Platform	7	5,675.00	39,725.00	EGT267, EGT320, EGT365, EGT386, EGT465, EGT408, EGT448, EGT417
Amatrol	82-900-12	Siemens Step 7 PLC Software - 12 seats	1	10,895.00	10,895.00	
Amatrol	72024	PC programming interface for Siemens S7 PLCs	7	1,344.00	9,408.00	
Amatrol	87-MS1	Pick and place feeding station	1	10,362.00	10,362.00	
Amatrol	87-MS2	Gauging Station	1	10,542.00	10,542.00	

Amatrol	87-MS3	Orientation-processing station	1	12,252.00	12,252.00	
Amatrol	87-MS4	Sorting-Buffering Station	1	8,477.00	8,477.00	
Amatrol	87-MS5-C1	Servo robot assembly station for existing Fanuc cart	1	17,063.00	17,063.00	
Amatrol	87-500F	Amatrol-Fanuc integration Package	1	3,588.00	3,588.00	
Amatrol	87-MS6	Torque assembly station	1	8,517.00	8,517.00	
Amatrol	87-MS7	Inventory Storage Station	1	10,322.00	10,322.00	
Amatrol	90-START-4	Start-up and installation	1	5,500.00	5,500.00	
				Sub-Total	146,651.00	

Recruitment and Dissemination Initiatives

NSF statistics on the state of education in the United States indicate a decreasing tendency in domestic students enrolling in and successfully concluding degrees in Science and Engineering [13]. There is a gap between the number of vacant positions in industry and the number of graduates with the right qualifications to fill those positions. In order to reverse that trend, initiatives are being proposed through NKU/CSTCC to increase high-school students' awareness of STEM disciplines and to attract students from minority groups to the new program within NKY and the Southern Ohio areas. These initiatives and respective budgets are depicted in Table 7.

Table 7. Recruitment and Dissemination Initiatives

Initiative	Description		Estimated Cost		
			Unit Cost	Qty.	Total
STEM Summer Camp	Camp 1: Grades 7 and 8, hands-on 5 days, 4 hours per day summer camp. This camp could be run at Cincinnati State and/or NKU 98 t0 12 students)		5,000.00	1	5,000.00
Host Women in Trades, Technology and Sciences Workshop	Cincinnati State National Institute for Women in Trades, Technology and Science (IWITTS) two-day training workshop	IWITTS Workshop Trainer, trainer travel and lodging	10,000.00	1	10,000.00
		IWITTS Workshop Breakfast (40/Day)	10.00	80	800.00
		IWITTS Workshop Lunch(40/day)	12.00	80	960.00
		IWITTS Workshop room rental, housekeeping, and A/V needs, etc.	700.00	1	700.00
Dual Enrollment Courses Offered in Grade 12	CIT 105 OSHA 10 General Industry Safety (1 Credit. 1 Lecture Hour. 0 Lab Hour). No text required. May need to get high	CIT-105 Dual Enrollment Course OSHA 501 OSHA Course	800.00	2	1,600.00

	school teacher trained to teach OSHA, but initially Cincinnati State could supply instructor. OSHA 511Occupational Safety and Health Standards for the General Industry	CIT-105 Dual Enrollment Course OSHA 511 Trainer Course	800.00	2	1,600.00
	EMET 150 Introduction to Controls and Robotics (2 Credits. 1 Lecture Hour. 2 Lab Hours)	EMET-150 Dual Enrollment Course Text Book: Basic Robots 1st Edition ISBN13: 978-1-133-95019-6	91.95	26	2,390.70
		EMET-150 Dual Enrollment Course Lab Equipment	100.00	26	2,600.00
			Total per year		**25,650.70**
			Total for 4 years		**102,602.80**

Principal Investigators Compensation

The principal investigators (P.I.s) will be compensated according to the schedule depicted in Table 8.

Table 8. Principal Investigators Compensation

Inst.	Role	Weekly Rate	Qty. per year	Year 1	Year 2	Year 3	Year 4	Total
NKU	PI	1,973.58	4	1,973.58	2,003.19	2,033.23	2,063.73	32,294.95
NKU	Co-PI	2,249.77	4	2,249.77	2,283.51	2,317.76	2,352.53	36,814.29
NKU	Co-PI	2,052.23	4	2,052.23	2,083.01	2,114.26	2,145.97	33,581.86
						Total NKU		**102,691.11**
CSTCC	Co-PI	1,460.81	3	1,460.81	1,482.72	1,504.96	1,527.54	17,928.10
CSTCC	Co-PI	1,395.14	2	1,395.14	1,416.07	1,437.31	1,458.87	11,414.80
						Total CSTCC		**29,342.90**
Includes fringe benefits (7.5% for NKU) and adjustment for cost of living @ 1.5% per year								

Grant Evaluation

A qualified external evaluator will be responsible for the evaluations and will submit a written final report at the end of each project year. Measurable data will be used to describe project accomplishments in reports sent to the National Science Foundation. Following a general guideline provided by NSF [14], we will allocate 5% of the project cost for evaluation, including payment for external evaluator compensation and travel expenses for the evaluator and team members. This allocation will be distributed equally along the 4 years' period.

Assessment

We are focused in the budgetary aspects of the program implementation and therefore assessment is not in the scope of this paper. A complete assessment and evaluation plan for this program have been proposed by the authors [15], where the outcomes will be established and assessed through a process consistent with the current ABET criteria for accrediting engineering technology programs guidelines of ABET-ETAC. [6]. It involves identification of the needs of Program constituencies, the accomplishment of Program objectives, alignment with the ABET-ETAC Criteria "a" through "k", and consistency with the recommended outcomes for Mechanical Engineering Technology as well as Manufacturing Engineering Technology.

NKU Administrative fees

NKU charges an administrative fee of 32.5% (Not calculated on tuition, equipment under $5K, capital or contract amounts under $25K).

Budget Summary

The combined budget for this proposal is depicted in Table 9**.**

Table 9. Combined Budget Summary NKU-CSTCC

Budget Summary - NKU						
Description	Expenditure Type	Period	Reference	Amount per year	Number of years	Amount
NKU Laboratory / Testing Equipment Upgrades	Equipment, capital	Initial Investment	Section 3.3	124,716.00	1	124,716.00
NKU New Mechatronics Learning Equipment	Equipment, capital	Initial Investment	Section 3.3	146,451.00	1	146,451.00
NKU Faculty Professional Development, 2 faculty members	Training, expense	Yearly	Section 3.2	6,460.00	4	25,840.00
Travel	Travel, expense	Yearly	Section 3.2	7,292.00	4	29,168.00
NKU P.I.s Compensation	Payroll, expense	Yearly	Section 3.5	See Section 4.3	4	102,691.11
Materials, Supplies and Publications for PD	Supplies, Materials, Expense	Yearly	Section 3.2	2,200.00	4	8,800.00
NKU Annual Evaluation Costs	Evaluation, expense	Yearly	Section 3.6	13,590.00	4	54,360.00
					Sub-total	492,026.11
NKU indirect cost (Administrative fee)	Administrative expense	Yearly	Section 3.7	See Section 3.7	4	71,779.00
					Total	**563,805.11**

Budget Summary CSTCC						
CSTCC Robotics Learning Equipment	Equipment, capital	Initial Investment	Section 3.3	224,000.00	1	224,000.00
CSTCC Recruitment and Students' Awareness Initiatives	Recruiting & Dissemination, expense	Yearly	Section 3.4	25,651.00	4	102,604.00
CSTCC P.I.s Compensation	Payroll, expense	Yearly	Section 3.5	See Section 3.5	4	29,342.00
					Total	**355,946.00**

Conclusion

The implementation of this new program is in line with the goals established by the 2013 – 2018 NKU Strategic Plan and therefore is supported by the administration at both the university and college levels. At the time of this writing, the NSF (ATE) grant proposal is being revised and will be resubmitted during the Fall 2016.
Additionally, the new curriculum is under analysis by the Kentucky Council of Postsecondary Education. We do however, expect this new program to start in the spring of 2017. The formulation of this budget can be used as a model for cost estimation for implementation of new engineering technology B.S. programs at medium sized institutions.

References

[1] M. Torres and M. Sadat-Hossieny, "Modifying the Curriculum of an Engineering Technology Program to Meet the Needs of Local manufacturing Consortium," in IAJC, Orlando, 2014.

[2] S. E. Lyschevski, "Mechatronics Curriculum - Retrospect and Prospect," Mechatronics, vol. 12, pp. 195-205, 2002.

[3] R. G. Allen, "Mechatronics Engineering: A Critical Need for This Interdisciplinary Approach to Engineering Education," in IJME - INTERTECH Conference, Union, NJ, 2006.

[4] ETAC, 2013-2014 Criteria for Accrediting Engineering Technology Programs, ABET (Accreditation Board for Engineering and Technology), 2012.

[5] S. F. Pop, "Cross-curricular Teaching Approaches Favouring the Active Learning of Mechatronics at Secondary Level," Procedia - Social and Behavioral Sciences, vol. 142, pp. 123-126, 2014.

[6] ETAC, 2015-2016 Criteria for Accrediting Engineering Technology Programs, ABET (Accreditation Board for Engineering and Technology), 2014.
[7] College and University Professional Association for Human Resources - CUPA, "Tenured/Tenure-Track Faculty by Carnegie Classification," [Online]. Available: http://www.cupahr.org/surveys/fhe4-tenure-surveydata-2015.aspx. [Accessed 25 July 2015].
[8] J. Hadzima, "Practical Advice for Entrepreneurs," MIT, [Online]. Available: http://web.mit.edu/e-club/hadzima/how-much-does-an-employee-cost.html. [Accessed 28 August 2015].
[9] Wichita State University, "Academic and Professional Currency," W. Frank Burton School of Business, [Online]. Available: http://webs.wichita.edu/?u=business1&p=/facultyandstaff/academicandprofessionalcurrency. [Accessed 24 July 2015].
[10] A. Odden, S. Archibald, M. Fermanich and H. A. Gallagher, "A Cost Framework for Professional Development," Journal of Education Finance, vol. 28, no. 1, pp. 51-74, 2002.
[11] M. Ghone, M. Schubert and J. R. Wagner, "Development of a Mechatronics Laboratory Eliminating Barriers to Manufacturing Instrumentation and Control," IEEE Transactions on Industrial Electronics, vol. 50, no. 2, pp. 394-397, 2003.
[12] Y. Wang, Y. Yu, C. Xie, H. Wang and X. Feng, "Mechatronics education at CDHAW of Tongji University: Laboratory guidelines, framework, implementations and improvements," Mechatronics, no. 19, pp. 1346-1352, 2009.
[13] National Science Foundation, "Science and Engineering Indicators 2012," [Online]. Available: http://www.nsf.gov/statistics/seind12/c2/c2s2.htm. [Accessed 16 September 2015].
[14] National Science Foundation, "The 2002 User-Friendly Handbook for Project Evaluation," Washington, DC, 2002.
[15] M. Torres and M. Sadat-Hossieny, "Implementation of a Bachelor of Science in Mechatronics Engineering Technology," in ASEE, New Orleans LA, 2016.

Biographies

MAURICIO TORRES is currently assistant professor in the Engineering Technology programs at Northern Kentucky University. Dr. Torres received his B.S. in Business Administration from City University of Sao Caetano do Sul, B.S. in Mechanical Industrial Engineering from Braz Cubas University, Brazil, M.S. in Engineering Management and Ph.D. in Industrial and Systems Engineering from Florida International University. He has extensive experience in manufacturing and his interests are manufacturing processes, enterprise engineering and engineering/technology education. Dr. Torres may be reached at torresm1@nku.edu.

MORTEZA SADAT-HOSSIENY is currently associate professor and director of Engineering Technology Programs at Northern Kentucky University. Dr. Sadat received his B.S.in Manufacturing Engineering Technology from Oklahoma State University, M.S.

Manufacturing Eng. Tech from Murray State University and Ph.D. Industrial Technology, Iowa State University. His areas of concentration are CAD, industrial automation, alternative power generation methods and his research interests are globalized engineering/technology education, and innovative curriculum development. Dr. Sadat-Hossieny may be reached at sadathossien@nku.edu.