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CERTIFIED ROBOTICS PRODUCTION TECHNICIAN: THE SUPER TECHNICIAN

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The "Super Technician" is the next generation of robotics production technicians. Currently, unmanned robotics manufacturing technicians come with various educational backgrounds and experience. The greatest workforce issue facing robotics manufacturers is the lack of qualified manufacturing technicians with the unique qualifications that unmanned systems manufacturing presents today and in the future. The next generation will require additional training and will benefit from a nationally recognized certification program that insures a qualified technician that can meet the needs of the unmanned systems industry.

During the past eighteen months, the National Robotics Training Center (NRTC) developed the curriculum that will lead to a certification program for unmanned systems production technicians and a Certified Robotics Production Technician (CRPT) designation. This paper will present the approach used to develop this curriculum and the certification process required for national recognition. The NRTC has completed the initial curriculum and is in the process of designing the delivery modality to include an online program. To address this critical need of unmanned systems manufacturers, NRTC will finalize the certification program and will continue to work closely with manufacturers to bring the most current knowledge and skills to the robotics production technician workforce.

INTRODUCTION

The National Robotics Training Center was established through an Office of the Secretary of Defense, Joint Robotics Project contract to address two specific needs of small emerging robotics companies; a transitioning guide or methodology to move from design to production and the training of robotics production or manufacturing technicians. This paper will address the second of these two needs.

The unmanned robotics manufacturing workforce consists of several key positions to include production operators, production technicians, research technicians, design engineers, and research scientists. Note the first line under the title Robotics Workforce in Figure 1. The training and education associated with each of these positions is listed in the line above the U.S. Educational System title at the bottom of Figure 1. Note the flow of education and training to the previously

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listed workforce positions. For example, individuals can move through the current school system through high school and with some additional training become production operators. Likewise, students can matriculate from high school to colleges or universities to become research technicians, design engineers, and research scientists. Kyle Snyder, Director of Knowledge Resources at AUVSI stated in the March, 2009 issue of *Unmanned Systems*, "We continue to see a bright future of unmanned systems. The technologies are maturing that enable integration into commercial, domestic daily routines, so production, training, maintenance and further research are on the near horizon. These areas will present new opportunities for jobs and economic development around the globe." [1] However, currently there is no clear path from our education and training systems to produce highly qualified production technicians. Neal Blue was quoted in *Wired for War* as saying, "The future belongs to those people who will be thinking out of the box and delivering systems based on the technologies of the future" [2]. Without a highly trained production technician, we as a nation will not be able to keep up with the new technologies. It should be obvious that a gap exists in our education system that limits or even creates a shortage of production technicians for the unmanned systems manufacturing industry. This gap, in the center of and highly in white in Figure 1, is one of the goals of the NRTC, that is, to plan, design, implement, and evaluate a Certified Robotic Production Technician (CRPT) program that will lead to an associate in science degree that can be offered by any community or technical college throughout the country. Note also in Figure 1, that an individual may move from the production technician position with additional training in a community or senior college into any one of the more advanced positions.

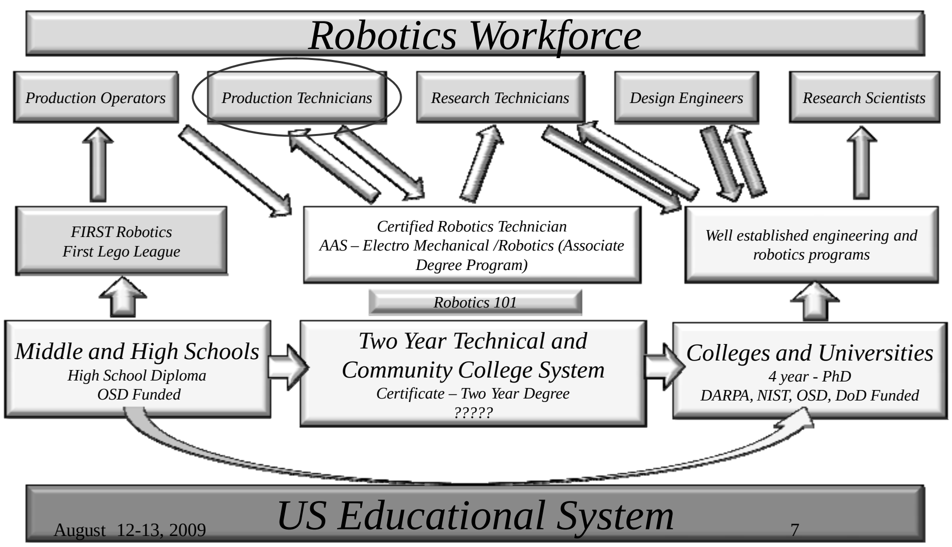

Figure 1. Robotics Workforce and US Educational System

Recently a Whitepaper on Robotics and Automation: Research Priorities for U. S. Manufacturing prepared by Henrik Christensen, Georgia Institute of Technology; Ken Goldberg, University of California-Berkeley; Vijay Kumar, University of Pennsylvania and Jeff Trinkle, Rensselaer Polytechnic Institute; was the product of some research that culminated in a workshop, "A Research Roadmap for Robotics in Manufacturing and Automation". This whitepaper was presented at the Congressional Robotics Caucus Luncheon Briefing entitled "National Robotics Technology Roadmap to be Unveiled: Industry and Academia to Call for a National 'Robotech' Initiative". In their whitepaper, Christensen, et al, stated, "The U.S. can only take advantage of new research results and technology if there is a workforce well-trained in the basics of robotics and the relevant technologies. This workforce should have a wide range of skill and knowledge levels – from people trained at vocational schools and community colleges to operate high-tech manufacturing equipment, to BS- and MS-level developers trained to create robust high-tech manufacturing equipment, to PhD-level basic researchers trained to develop and prove new theories, models and algorithms for next-generation robots. To train the best workforce, the education opportunities must be broadly available" [3]. However, in the proposed roadmap there is no provision for the "robotics manufacturing technician or production technician". Without highly trained manufacturing technicians there will be no one to build, maintain, and services these new technologies.

NRTC's educational and training objective is to develop and promote a Robotics Production Technician Certification program and a two year Robotics degree program and make it available throughout the United States with a variety of delivery modalities to include on site presentations, distance learning, and online.

CURRICULUM DEVELOPMENT

The NRTC is affiliated with Florence-Darlington Technical College and comes under the college's Southern Association of Colleges and Schools (SACS) accreditation and the curriculum development process. For the CRPT program there were eight steps or milestones to accomplish. The first was to create an Advisory Board that consisted of key people in the unmanned robotics manufacturing industry to include large as well as small businesses. Membership on the advisory board ranged from robotics manufacturers such as Foster-Miller, large corporations such as Raytheon and small businesses such as Mesa Robotics and Lite Machines, Inc. A complete list of NRTC's board is presented in Table 1.

Table 1. NRTC Advisory Board

- Derek Daly – Board Chairman – Foster-Miller
- Terry Downing – Raytheon
- Joe Dyer – iRobot
- Don Jones – Mesa Robotics
- Charles Maidens – Kuchera Defense Systems
- Bill Munslow – Lockheed Martin
- Jon Maynell – Lite Machines Inc.
- Paul McDuffee – Insitu, a subsidiary of Boeing
- Kyle Snyder - AUVSI

Once the advisory board was up and running and had approved the mission, objectives, and strategies of the curriculum development process, the next step in the process was to conduct job profiles on currently employed production technicians, workers that are currently technicians that manufacture unmanned systems. Three companies' manufacturing technicians were profiled, iRobot, Foster-Miller, and BlueFin Robotics Corporation. This process was conducted by a trained and certified WorkKeys® job profiler that spent several days on the job with each technician. WorkKeys® is an American College Testing (ACT) produce that is recognized by industry and establishes various levels of competencies that a technician would need to have to be successful on a particular job. For example, a certain level for Reading for Information, Applied Mathematics, Applied Technology, Teamwork, etc. would be required for a certain technician to be able to successfully accomplish his work objectives. Seven technicians at these three companies were profiled.

Job profiling set the base line for curriculum development. This process is followed by an in-depth Develop A Curriculum or DACUM process. We first researched the DACUM clearinghouse at Ohio State University (OSU) as well as other sources to see if a similar DACUM existed. We did not find any DACUMs in this area. The DACUM is a two day process that brings together content experts and a certified DACUM facilitator. Most DACUM facilitators are trained and certified by the OSU DACUM Center. It is usually a two day intensive exchange that is recorded with the identification of a series of duties and tasks required to perform each specific duty. The result is a DACUM Chart or matrix with the Duties listed in the left column and the Tasks or duties listed in various rows and columns to the right. The completed DACUM Chart consisted of eleven specific duties and as many as seventeen tasks for each duty. The final DACUM was reviewed and approved by the advisory board as well as by several other content experts. See part of the final DACUM Chart in Table 2.

Our curriculum develop experts next researched the existence of similar curricula to prevent us from duplicating current established curriculum. What we found was very interesting and reduced the curriculum development process tremendously. We found that the Manufacturing Skill Standards Council (MSSC) had gone though this same process for general manufacturing and created their Certified Production Technician (CPT) program. Many of the same duties and tasks we discovered in our DACUM were previously found to be required in general manufacturing and established the base for the CRPT. We found that we were dealing with a two tier certification process in which a candidate for the CRPT must first be competent and certified in the CPT program. See Table 3 for the Curriculum Chart that shows all duties required for a CRPT with the corresponding training modules provided my MSSC and the ones that NRTC would have to develop.

The training modules that are common to the CPT and the CRPT are; Safety, Quality Practices and Measurement, Manufacturing Processes and Production and Maintenance Awareness. A candidate going through this training would go through a two tier process and would become a MSSC Certified Production Technician (CPT), tier one and a NRTC Certified Robotic Production Technician (CRPT), tier two. See Figure 2 Certification Process.

Super Technician

Our research and DACUM process identified what has been coined by Robin Shoop at Carnegie Mellon University as a “Super Technician”. The basics skills of a manufacturing technician of mechanic, basic electronics, reads blueprints, general toolset, and works under direction, must now be supplanted with robotics technician skills to include, innovator, problem-solver, critical thinker, communicator and team player. See Figure 3 The Super Technician.

Table 2. Partial DACUM Chart

DUTIES		1	2	3	4	5	6	7
A	**(A) Comply with Safety Procedures / Policies**	(A1) Attend Safety Orientation	(A2) Learn Safety Requirements for Work Area / Job	(A3) Obtain PPe / Safety Equipment	(A4) Obtain Necessary Certifications (NFPA 70E / Forklift)	(A5) Inspect Worlk Area for Hazards	(A6) Use Electrical Safety Equiment (e.g. Anti-Static Mats, Wrist Straps)	(A7) Use ESD Safe Tooling
B	**(B) Assemble to Manufacture Specs**	(B1) Receive Certification Training	(B2) Obtain Document Procedures Meeting Customer Requirements	(B3) Obtain Approved Workstation	(B4) Confirm Tool Calibration is Current	(B5) Obtain Required Tools	(B6) Draw Proper Parts from Supply	(B7) Assemble to Current Requirements / Specs
C	**(C) Operate Robotic System / Station**	(C1) Check System Free of hazards	(C2) Perform Start-Up Safety Checks (e.g. E-Stops)	(C3) Power Up System	(C4) Install System Running Software	(C5) Make Mechanical Adjustments	(C6) Perfrom Functionally Test	(C7) Perform Vacuum Test
D	**(D) Conduct On-The Job (OJT) Training**	(D1) Complete "Train the Trainer" Training	(D2) Obtain Demo Materials as Training Aids	(D3) Conduct Classroom Training	(D4) Share Information on New Technology	(D5) Perform OJT Sequence	(D6) Document Training Completion	(D7) Receive Feedback from Trainer
E	**(E) Keep Skills Current**	(E1) Maintain Re-Certification Requirements	(E2) Participate in "In House" Training	(E3) Conduct Cross Training	(E4) Rotate Company Assignments	(E5) Read Technical Publications	(E6) Conduct Internet Searches (e.g. Course, Research, Web Conferences)	(E7) Apply Customer Feedback (from Customer Needs & Visits)
F	**(F) Verify Quality Workmanship**	(F1) Obtain Components	(F2) Establish Test Environment	(F3) Use Current Test Procedures	(F4) Use Current Operational Procedure	(F5) Check Calibration Limits	(F6) Gather Required Witnesses	(F7) Verify Pedigree of Component

Table 3. Curriculum Chart

Topic	Detail	Module #
Robotic Arm	Basic machines Center of gravity	MSSC OM12 MSSC OM13 MSSC OM14 MSSC OP1
Navigation device (GPS, inertia compass)	Overview Activity with GPS device Value/limitations of technologies	NRTC Mod 4
Cameras	Near infrared thermal infrared CCD Zoom Analog vs digital	NRTC Mod 3
Sensors	Infrared x-ray biological nuclear ultrasonic (overview options)	NRTC Mod 1 NRTC Mod 3
LED, light sources, lasers	Uses in robot for camera Alignment with mounting Distance sensing	NRTC Mod 3
Gears	ratio	MSSC OP3
Quality	Tolerances Measurement Lean manufacturing - six sigma (data charts) Non-conforming parts SPC Ethics	MSSC OQ3 MSSC OQ4 MSSC OQ7 MSSC OQ8 MSSC OQ9
Troubleshooting	Electrical systems Mechanical systems	MSSC OM1 MSSC OM2 MSSC OM5 MSSC OM6

Topic	Detail	Module #
Electronics	Printed circuit board component handling component identification basic electronics AC/DC diagnostic testing equipment anti static soldering de-soldering	MSSC OM1 MSSC OM2 MSSC OM3 MSSC OM4
Control systems (joystick)	Purpose; test; troubleshoot; control and feedback Closed vs open loop system	NRTC Mod 1
Operating systems (software)	Basic computer skills Microprocessors –basic function	NRTC Mod 1
Power Source (battery)	Chemistry safety Test under-load	NRTC Mod 1
Motors and motor control systems (electrical)	Microprocessors	MSSC OM15
Basic Mechanics and Mechanical systems		MSSC OP1 MSSC OP2
Communication systems	Transceiver RFID SWR (standing wave ratios) Analog vs digital RF Electrical signal over copper Pulses of light over fiber Modulation vs demodulation Coding & decoding Antennas	NRTC Mod 2
Mechanical linkages		MSSC OP2

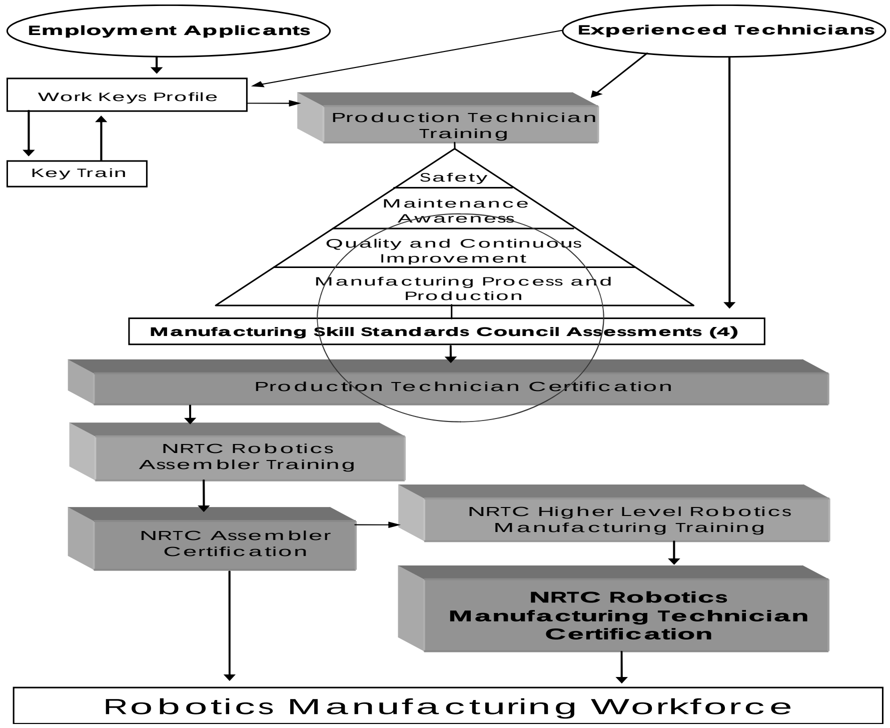

Figure 2. Certification Process

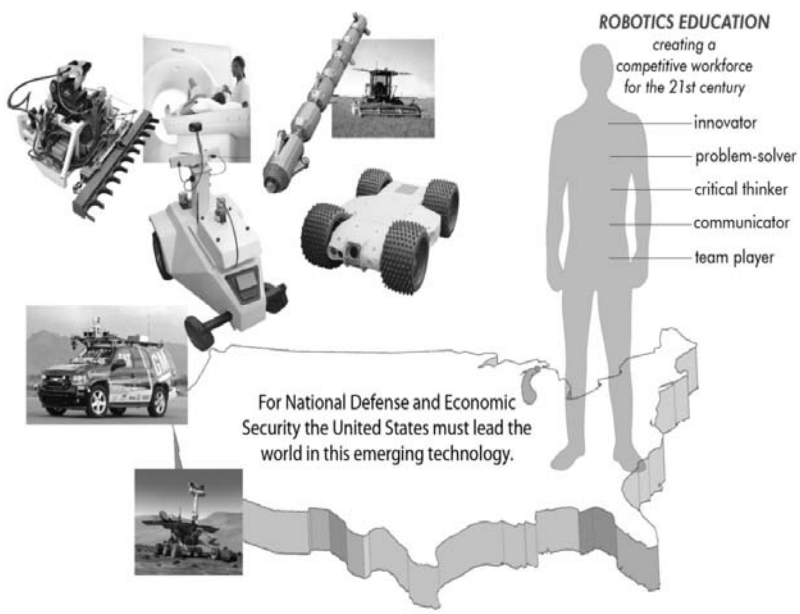

Figure 3. The Super Technician

MSSC Core Modules and the Robotics Module Content

To clarify the components of the MSSC CPT and the NRTC CRPT the following two tables are presented. Table 4 MSSC Core Modules and Table 5 NRTC Robotics Module Content are presented below.

Table 4. MSSC Core Modules

• Safety
• Quality Practices & Measurement
• Manufacturing Processes and Production
• Maintenance Awareness

Table 5. NRTC Robotics Module Content

• Introduction and Overview of Training Program
• Module 1: Computer Systems and Sensors
o Unit 1: Operating Systems
o Unit 2: Control Systems
o Unit 3: Power Sources
o Unit 4: Sensors
• Module 2: Communication Systems
• Module 3: Cameras, Photonics, and Light Sources
• Module 4: Robot Mobility and Navigation
• Module 5: Lean Manufacturing

Content experts in each of the five modules areas were identified by NRTC and were contracted to plan, design, and develop the curriculum content of each module. The next step was to conduct peer reviews of each module to insure current content and its applicability to current manufacturing. Steps to follow are the field testing in which each module will be taught and evaluated, and exam validation which is a process of giving exams and validating the results.

AN ASSOCIATE DEGREE IN ROBOTICS MANUFACTURING TECHNOLOGY

To establish a nationally recognized credentialing program that will be accepted by unmanned robotics manufacturers is the final evolution in this endeavor. The objective here is to establish at the NRTC not only a certification program but an associate degree in robotics manufacturing technology that will set the standard for robotics manufacturing technology and that can be offered anywhere and at any time throughout the United States. To that end, NRTC conducted a study of the community and technical colleges throughout the United States to determine if such a program currently existed. There are a few community colleges that have programs with an emphasis in robotics but none offer a degree or certification program in robotics manufacturing technology for robotics production technicians. NRTC also conducted a job needs assessment which is the first step in seeking full accreditation by the Southern Association of College and Schools (SACS) which is the accrediting body for eleven states in the Southeast. With support of the Association of Unmanned Vehicles Systems International (AUVSI) and the National Defense Industry Association (NDIA), NRTC conducted a job needs assessment to determine the job needs for the next three years in the unmanned robotics manufacturing industry and the need for certification and specific training for the "super technician". Results of this study are included in the paper's summary.

SUMMARY

It became clear during this almost two year process that a new type of technician was needed to meet the needs of unmanned robotic manufacturers and that a new type of training was needed to meet the job needs identified in the needs assessment. The results of this survey confirmed the need for this new "super technician". Unmanned systems manufacturers representing seventy-six companies responded.

Their responses indicated that the salary distribution for this type of technician would be in the range of:

$11.54/hour to $35.00/hour or $24,000/year to $72,800/year.

The statistical distribution was as follows:

Mean Salary: $17.71/hour or $36,840/year

Median Salary: $16.00/hour or $33,280/year

Mode Salary: $19.23/hour or $40,000/year.

Several conclusions were drawn from the survey results to include:

- Currently there are 684 technicians employed by the respondents,
- the majority of companies (66%) responding to the survey find too few well-qualified technicians,
- the majority of prospective technicians (98.1%) require additional training,

- according to the respondents (83.4%) two year colleges are not meeting the demand for this type of technician,
- the majority (87.2%) believe these is a need to improve technician education at two year colleges,
- the majority (59.6%) of companies responding believe that a certification program would make hiring easier,
- the majority (78.9%) would have more confidence in a technician's skills if they had a credentialing certification when hired,
- the majority (61.5%) believe a certification program would increase availability of technicians,
- the majority (80.7%) believe that there will be steady to rapid growth in the development, manufacture, and use of robotics in the United States over the next decade,
- within the companies responding there will be a need for 683 new technicians over the next three years,
- there will be a need for 185 replacements over the next three years,
- there will be a need for 1,886 new engineers, scientists, and other new jobs at the 4-year baccalaureate degree or higher degree level,
- there will be a need for 1,682 replacement engineers, scientists, and other new jobs at the 4-year baccalaureate degree or higher degree level,
- and finally the robot product type of the respondents were:
    - Ground – 38.9%
    - Air – 23.6%
    - Water – 12.5%
    - Industrial – 18.1%
    - Consumer – 6.9%.

Singer by quoting Richard Clarke in *Wired for War* makes it very clear; "Something very fundamental is happening in technology today. ….. There will be a real digital divide—people who don't have the skill set to compete anymore". Clarke sees anger brewing among those left economically disadvantaged by the technology. The manufacturing workforce of today will not be able to compete internationally unless they have the skills of a "super technician". It is imperative that we provide the technicians demanded by our manufacturers.

NRTC is committed to providing this training in the form of a certification program, the Certified Robotics Production Technician (CRPT) that will lead to an Associate in Science Degree in Electro-Mechanical Engineering Technology: Major in Robotics Manufacturing Technology. See the CRPT program in Table 6 and the AAS degree curriculum display in Table 7. These programs will have various delivery modes to include onsite training at a manufacturer's facility, on community college campuses, and online web based delivery. NRTC's goal is to provide these programs anywhere at any time.

Table 6. CRPT Curriculum

National Robotics Training Center
Certified Robotic Production Technician (Certification Program)

Course		**Contact Hours**
Tier One		
Manufacturing Skill Standards Council Certified Production Technician		
Principles of Safety (MSSC-CPT)		45
Principles of Maintenance (MSSC-CPT)		45
Principles of Quality & Continuing Improvement (MSSC-CPT)		45
Principles of Manufacturing Processes & Production (MSSC-CPT)		45
	Subtotal	180
Tier Two		
National Robotics Training Center Certified Robotics Production Technician		
Computer Systems and Sensors (NRTC-CRPT)		45
Communications Systems (NRTC-CRPT)		15
Cameras, Photonics, and Light Sources (NRTC-CRPT)		15
Robot Mobility and Navigation (NRTC-CRPT)		15
Lean Manufacturing (NRTC-CRPT)		15
	Subtotal	105
	Total Contact Hours	285

Table 7. AAS Degree

Florence-Darlington Technical College
Associate in Applied Science Degree in Electro-Mechanical Engineering Technology: Major in Robotics Manufacturing Technology (MSSC's CPT & NRTC's CRPT)

Semester 1 (Fall)

Course		**Class**	**Lab**	**Credit**
CPT XXX	Computer Systems and Sensors (CRPT)	2	3	3
COL 103	Colleges Skills	3	0	3
EGT 110	Engineering Graphics I	2	6	4
MAT 110	College Algebra	3	0	3
PHY 201	Physics I	3	3	4
		13	12	17

Semester 2 (Spring)

Course		**Class**	**Lab**	**Credit**
EET 113	Electrical Circuits I	3	3	4
MET XXX	Principles of Safety (MSSC)	3	0	3
EET XXX	Communications Systems (CRPT)	1	0	1
EET 131	Active Devices	3	3	4
ENG 260	Advance Technical Communications	3	0	3
CHM 110	College Chemistry I	3	3	4
		16	9	19

Semester 3 (Summer)

Course		**Class**	**Lab**	**Credit**
EGR 194	Statics & Strength of Materials	3	3	4
MET XXX	Principles of Maintenance (MSSC)	3	0	3
EET XXX	Cameras, Photonics, & Light Sources (CRPT)	1	0	1
EGT 151	Introduction to CAD	2	3	3
		9	6	11

Semester 4 (Fall)

Course		**Class**	**Lab**	**Credit**
MET XXX	Prin. of Quality & Cont. Improvement (MSSC)	3	0	3
MET XXX	Robot Mobility and Navigation (CRPT)	1	0	1
EET 145	Digital Circuits	2	3	3
EGR 170	Engineering Materials	2	3	3
MET 213	Dynamics	2	3	3
MET 214	Fluid Mechanics	2	3	3
		12	12	16

Semester 5 (Spring)

Course		**Class**	**Lab**	**Credit**
EGR 175	Prin. of Manufac. Processes & Production (MSSC)	2	3	3
MET XXX	Lean Manufacturing (CRPT)	1	0	1
MET 231	Machine Design	3	3	4
ECO 201	Economics Concepts	3	0	3
XXX XXX	Elective: Humanities/Fine Arts	3	0	3
		12	6	14

Minimum Total Credit Hours: 77

REFERENCES

[1] Kyle Snyder, “Knowledge Resources,” *Unmanned Systems*, Vol. 27, No. 3, 2009, p. 9.

[2] P. W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century*, The Penguin Press, 375 Hudson Street, New York, New York, 2009, p. 258.

[3] Henrik Christensen, Ken Goldberg, Vijay Kumar and Jeff Trinkle, Whitepaper on Robotics and Automation: Research Priorities for U. S. Manufacturing, February 11, 2009, p. 12.

[4] P.W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century*, The Penguin Press, 375 Hudson Street, New York, New York, 2009, p. 292.