

NPS-SW-01-001

# NAVAL POSTGRADUATE SCHOOL Monterey, California



**Master of Science in Software Engineering  
Academic Program Manual**

by

Luqi

July 2001

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Prepared for: Software Engineering Automation Center  
Naval Postgraduate School  
Monterey, CA 93943

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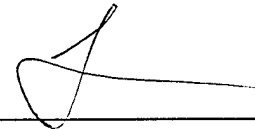
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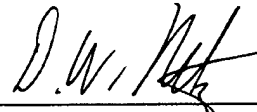
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# REPORT DOCUMENTATION PAGE

Form Approved  
OMB NO. 0704-0188

Public Reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comment regarding this burden estimates or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188,) Washington, DC 20503.

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE July 2001	3. REPORT TYPE AND DATES COVERED Technical Report
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4. TITLE AND SUBTITLE Master of Science in Software Engineering Academic Program Manual	5. FUNDING NUMBERS 38690-MA
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6. AUTHOR(S) Professor Luqi
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Software Engineering Automation Center, Naval Postgraduate School, Monterey, CA 93943	8. PERFORMING ORGANIZATION REPORT NUMBER NPS-SW-01-001
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9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING / MONITORING AGENCY REPORT NUMBER
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11. SUPPLEMENTARY NOTES  
The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

12 a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.	12 b. DISTRIBUTION CODE
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13. ABSTRACT (Maximum 200 words)  
This document contains the objectives, organization, policies and procedures for the Master of Science in Software Engineering degree program at the Naval Postgraduate School. It provides guidelines, templates, and procedures for the preparation and submission of the thesis proposal and the Master's thesis.

14. SUBJECT TERMS Software Engineering, Graduate Studies, Master's Degree, Distance Learning	15. NUMBER OF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION ON THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL
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***Section I***

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***Description of the MS Software  
Engineering Program***

# ***MS Software Engineering Program***

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## **1. INTRODUCTION**

The Software Engineering program at the U.S. Naval Postgraduate School provides military and government graduate students with an opportunity to learn all aspects of software development and the skills needed to efficiently and reliably plan and create large-scale software systems using the best available tools. These skills are essential for officers and civilians responsible for acquisition, development or maintenance of military software.

The program includes in-residence and distance learning MS and PhD degree programs, certificate programs, short courses, and laboratory support. The PhD program is the first-ever doctoral program in Software Engineering. The MS program offers four ways for students to earn a Master's degree: (1) MS Software Engineering Full-Time option, (2) MS Software Engineering Part-Time option, (3) MS Software Engineering with Combat Systems Sub-specialty option, and (4) MS Computer Science with Computer Science Sub-specialty option.

## **2. MASTER OF SCIENCE IN SOFTWARE ENGINEERING, FULL-TIME OPTION (369)**

The MSSE offers a six-quarter, full-time curriculum with entry date in October, and an optional refresher quarter that starts in July. The program has built-in electives to allow military students to complete both intermediate level Navy Professional Military Education (PME) and Joint Professional Military Education (JPME) Phase I at NPS. For more information, visit our website at <http://seac.nps.navy.mil> or email your inquiries to [se@cs.nps.navy.mil](mailto:se@cs.nps.navy.mil), or contact the Curricular Office at [clapacik@nps.navy.mil](mailto:clapacik@nps.navy.mil).

### ***2.1 Entry Requirements***

Any military or civilian personnel sponsored by the U.S. Government, holding an accredited baccalaureate degree in one of the engineering disciplines, computer science, or related field, with above-average grades in mathematics, and at least one year of software development, maintenance, or acquisition experience are eligible to apply.

Application information for the MS degree in software Engineering can be found at: <http://seac.nps.navy.mil>.



## ***MS Software Engineering Program***

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### **2.2 Sample Course Matrix**

#### **MS Software Engineering**

18 Month Curriculum for Military Students

Fall Input

Quarter 1 (Fall)	SW 3460 Software Methodology (3-1)	CS 3502 Computer Comms and Networks (4-0) / SW4555 Engineering of Network Centric Systems (3-1)	SW4582 Software Safety (3-1)	NW-3230 Strategy and Policy
Quarter 2 (Winter)	SW4500 Software Engineering (3-1)	W4580 Design of Embedded Real-Time Systems (3-0)	SW4591 Requirements Engineering (3-1)	NW-3210 NSDM: Directed Study Part I
Quarter 3 (Spring)	SW4520 Advanced Software Engineering (3-0)	S4300 Software Engineering and Management (3-2)	SW4590 Software Architecture (3-1)	NW-3211 NSDM: Directed Study Part II
Quarter 4 (Summer)	SW4540 Software Testing (3-1)	MN3309 Acquisition of Embedded Weapon Sys S/W (4-1) SW4581 Software Reliability & Quality Metrics (3-1)	SW4510 Computer Aided Prototyping (3-0) SW4530 Software R&D in DoD (3-1)	NW-3220 JMO: Directed Study Part I
Quarter 5 (Fall)	SW 0810 Thesis	SW 0810 Thesis	SW4570 Software Reuse (3-0) SW4592 Software Risk Assessment (3-1)	NW-3221 JMO: Directed Study Part II
Quarter 6 (Winter)	SW 0810 Thesis	SW 0810 Thesis	IS3171 Economic Evaluation of Information Systems II (4-1) EO4011 System Engineering for Acquisition Managers (3-2)	NW-3223 JMO: Directed Study Part I

*This track is notional. Please see the Software Engineering Academic Associate regarding possible substitutions for track-specific classes to accommodate focus areas pertinent to your thesis research.*

## ***MS Software Engineering Program***

Students who have enough computer and programming background and have no special military requirements may have some of the courses waived and finish the study in four quarters based upon the course matrix shown below.

### **MS Software Engineering**

#### 12 Month Curriculum for Civilian Students

#### Fall Input

Quarter 1 (Fall)	SW 3460 Software Methodology (3-1)	CS 3502 Computer Comms and Networks (4-0) / SW4555 Engineering of Network Centric Systems (3-1)	SW4570 Software Reuse (3-0) / SW4592 Software Risk Assessment (3-1)	SW4582 Software Safety (3-1)
Quarter 2 (Winter)	SW4500 Software Engineering (3-1)	SW4580 Design of Embedded Real-Time Systems (3-0)	SW4591 Requirements Engineering (3-1)	SW0810 Thesis Research
Quarter 3 (Spring)	SW4520 Advanced Software Engineering (3-0)	IS4300 Software Engineering and Management (3-2)	IS3171 Economic Evaluation of Information Systems II (4-1) / EO4011 System Engineering for Acquisition Managers (3-2)	SW0810 Thesis Research
Quarter 4 (Summer)	SW4540 Software Testing (3-1)	SW4510 Computer Aided Prototyping (3-0) / SW4530 Software R&D in DoD (3-1) / SW4581 Software Reliability & Quality Metrics (3-1)	SW0810 Thesis Research	SW0810 Thesis Research

*Note: This track is notional. Please see the Software Engineering Academic Associate regarding possible substitutions for track-specific classes to accommodate focus areas pertinent to your thesis research.*

## ***MS Software Engineering Program***

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### **2.3 Degree Requirements**

Students enrolled in the Software Engineering curriculum must complete the 12 courses approved by the program.

### **3. MASTER OF SCIENCE IN SOFTWARE ENGINEERING, PART-TIME OPTION (369)**

This is a twelve-quarter, part-time curriculum with entry date in October. The program has enough flexibility for sponsors to tailor the elective courses to meet their special needs. For more information, visit our website at <http://seac.nps.navy.mil> or email your inquiries to [se@cs.nps.navy.mil](mailto:se@cs.nps.navy.mil).

### **3.1 Entry Requirements**

Any military or civilian personnel sponsored by the U.S. Government, holding an accredited bachelor's degree in one of the engineering disciplines, computer science, or related field, with above-average grades in mathematics, and at least one year of software development, maintenance, or acquisition experience is eligible to apply.

Application information for the MS degree in Software Engineering can be found at <http://seac.nps.navy.mil>.

### **3.2 Sample Course Matrix for Software Acquisition Track**

#### **MS Software Engineering**

18 Month Curriculum for Military Students

Spring Input

Quarter 1 (Spring)	SW 3460 Software Methodology (3-1)	CS 3502 Computer Comms and Networks (4-0) / SW4555 Engineering of Network Centric Systems (3-1)	IS4300 Software Engineering and Management (3-2)	NW-3230 Strategy and Policy
Quarter 2 (Summer)	SW4500 Software Engineering (3-1)	SW4540 Software Testing (3-1)	MN3309 Acquisition of Embedded Weapon Sys S/W (4-1) / SW4581 Software Reliability & Quality Metrics (3-1)	NW-3210 NSDM: Directed Study Part I

## **MS Software Engineering Program**

### **MS Software Engineering, (continued)**

18 Month Curriculum for Military Students

Spring Input

Quarter 3 (Fall)	SW4570 Software Reuse (3-0)	SW4582 Software Safety (3-1)	W4592 Software Risk Assessment (3-1)	NW-3211 NSDM: Directed Study Part II
Quarter 4 (Winter)	SW4580 Design of Embedded Real-Time Systems (3-0)	SW4591 Requirements Engineering (3-1)	IS3171 Economic Evaluation of Information Systems II (4-1) / EO4011 System Engineering for Acquisition Managers (3-2)	NW-3220 JMO: Directed Study Part I
Quarter 5 (Spring)	SW 0810 Thesis	SW 0810 Thesis	SW4520 Advanced Software Engineering (3-0)	NW-3221 JMO: Directed Study Part II
Quarter 6 (Summer)	SW 0810 Thesis	SW 0810 Thesis	SW4510 Computer Aided Prototyping (3-0) / SW4530 Software R&D in DoD (3-1)	NW-3223 JMO: Directed Study Part I

*Note: This track is notional. Please see the Software Engineering Academic Associate regarding possible substitutions for track-specific classes to accommodate focus areas pertinent to your thesis research.*

### **3.3 Degree Requirements**

Students enrolled in the Software Engineering curriculum must complete the twelve courses approved by the Software Engineering Academic Associate. Completion of a master's thesis is required.

### ***3.4 Distance Learning Equipment Specifications***

Students participate in the distance Learning Program via our PictureTel 4000 Video Teleconferencing Systems using Integrated Services digital Network, Basic Rate Interface (ISDN RI) lines. This set-up allows two-way, interactive audio and video between distant sites and an NPS classroom. The students' site must have a standards-based (H.320-compatible) connection to a dial-up network (FTS2000).

Commercial networks may be used when FTS2000 is not available. NPS uses AT&T Accunet for commercial calls. NPS is currently establishing a program to lease VTC equipment to remote sites in order to provide the highest degree of compatibility and fidelity that the technology offers.

## **4. MASTER OF SCIENCE IN SOFTWARE ENGINEERING, COMBAT SYSTEMS SUBSPECIALTY OPTION (533)**

The Combat Systems Sub-specialty MSSE is an eight-quarter curriculum with entry dates in January and July. This is a systems engineering program with an emphasis on computer-based systems and DoD applications. This program is designed to meet Navy needs that go beyond software to treat whole system issues. If further information is needed, contact the Curricular Officer or the Academic Associate.

### ***4.1 Entry Requirements***

A baccalaureate degree with mathematics through differential and integral calculus and a calculus-based physics sequence are required for direct input. Courses in the physical sciences and engineering are highly desirable. Officers not having the required qualifications for direct input enter the program through the Engineering Science (460) Curriculum. An APC of 323 is required.

**4.2 Sample Course Matrix**

**MS Software Engineering**

Course Matrix for Students Entering in Summer

Quarter 1 (Summer)	PH1121 Mechanics I	MA1995 Math Methods I	MA1996 Math Methods II	NW3230 Strategy & Policy: The American Experience
Quarter 2 (Fall)	PH1322 E&MI	PH2151 Mechanics II	PH3991 Theoretical Physics	SW3460 Software Methodology
Quarter 3 (Winter)	PH1623 Modern Physics I	PH2351 E&M II	SE2013 Analog Techniques & Communications	SW4500 Software Engineering
Quarter 4 (Spring)	PH3352 E&MIII	PH3652 Modern Physics II	SE2014 Digital Techniques	SW4520 Advanced Software Engineering
Quarter 5 (Summer)	PH3292 Physics Optics	SE3015 Autonomous Combat Systems Design	SW 4510 Computer Aided Prototyping	SW4540 Software Testing
Quarter 6 (Fall)	SE3172 Physics of Weapon Systems	SW4592 Software Risk Assessment	SW4520 Software Engineering R&D in DoD	SW0810 Thesis Research
Quarter 7 (Winter)	SE3400 Physics of Sonar Systems	SW4580 Design of Embedded Real Time Systems	SW4591 Requirements Engineering	SW0810 Thesis Research
Quarter 8 (Spring)	SE4050 Physics of E&M Sensors	SE4860 Advanced Weapons Concepts	SW0810 Thesis Research	SW0810 Thesis Research

*This track is notional. Please see the Software Engineering Weapon Systems regarding possible substitutions for track-specific classes to accommodate focus areas pertinent to your thesis research.*

**4.3 Degree Requirements**

Students enrolled in the Combat Systems Sub-specialty MSSE curriculum must complete the 28 above listed courses. Completion of a master's thesis is required.

**5. MASTER OF SCIENCE IN COMPUTER SCIENCE, COMPUTER SCIENCE SUBSPECIALTY OPTION (368)**

The Computer Science curriculum is designed to provide the student with the technical knowledge and skills necessary to specify, evaluate and manage computer system design; provide technical guidance in applications ranging from data processing to tactical embedded systems; educate the student in the analysis and design methodologies appropriate for hardware, software and firmware; and provide the student with practical experience in applying modern computer equipment and research techniques to solve military problems.

The purposes of the Software Engineering track are to provide knowledge of all aspects of software development and to develop skills needed to efficiently and reliably implement military systems and application software using the best available tools and techniques.

The MSCS is an eight-quarter course of study with entry dates in April and October. Those requiring the six- or twelve-week refresher will begin study prior to those entry dates. If further information is needed, contact the Academic Associate of Curricular Officer.

For more information, visit our website at <http://seac.nps.navy.mil>, or email your inquiries to [se@cs.nps.navy.mil](mailto:se@cs.nps.navy.mil), or contact the Curricular Officer at [clapacik@nps.navy.mil](mailto:clapacik@nps.navy.mil).

**5.1 Entry Requirements**

A baccalaureate degree or the equivalent with above-average grades in mathematics (including differential and integral calculus), resulting in an APC of at least 325 is required for direct entry. Undergraduate degrees in applied science or engineering are highly desirable. Students lacking these prerequisites may be acceptable for the program through a six- or twelve-week refresher course, providing their undergraduate records and/or other indicators of success, such as the Graduate Record Examination (GRE) indicate an ability to work in quantitative subjects. While previous academic or practical experience in computer science is certainly helpful and can enhance the applicant's potential for admission, such experience is not a prerequisite.

**5.2 Sample Course Matrix**

**MS Computer Science  
Software Engineering Track**

18 Month Curriculum for URL Students (CS Undergrad)

Fall Input

Quarter 1 (Fall)	CS 377X Second Language (4-2)	CS 3502 Computer Comms and Networks (4-0)	SW 3460 Software Methodology (3-1)	NW-3230 Strategy and Policy
Quarter 2 (Winter)	SW4500 Software Engineering (3-1)	SW4580 Design of Embedded Real-Time Systems (3-0)	SW4591 Requirements Engineering (3-1)	NW-3210 NSDM: Directed Study Part I
Quarter 3 (Spring)	CS 3310 Artificial Intelligence (4-1)	SW4520 Advanced Software Engineering (3-0)	SW4590 Software Architecture (3-1)	NW-3211 NSDM: Directed Study Part II
Quarter 4 (Summer)	SW4510 Computer Aided Prototyping (3-0) / SW4530 Software R&D in DoD (3-1)	SW4540 Software Testing (3-1) / SW4581 Software Reliability & Quality Metrics (3-1)	CS 3320 Database Systems (3-1)	NW-3220 JMO: Directed Study Part I
Quarter 5 (Fall)	CS 0810 Thesis	CS 0810 Thesis	CS 3600 Intro Computer Security (4-2)	NW-3221 JMO: Directed Study Part II
Quarter 6 (Winter)	CS 0810 Thesis	CS 0810 Thesis	MV 4203 Interactive Computation Systems (3-2)	NW-3223 JMO: Directed Study Part I

*This track is notional. Please see the Software Engineering Academic Associate regarding possible substitutions for track-specific classes to accommodate focus areas pertinent to your thesis research.*



**5.3 Degree Requirements**

Students enrolled in the MSCS/Software Engineering track must successfully complete the 7 general Computer Science courses plus 7 advanced Software Engineering courses. Completion of research leading to a master's thesis is required.

**6. ADMISSION PROCEDURES**

The point of contact to request Naval Postgraduate School catalogs and admission to all degree programs is:

**Director of Admissions**  
Code 01B3, Naval Postgraduate School  
589 Dyer Rd, RM 103C  
Monterey, CA 93943-5100  
Telephone: (831) 656-3093  
DSN: 878-3093  
FAX: (831) 656-2891

Application information for the MS degree in Software Engineering can be found at:

<http://seac.nps.navy.mil>.

**II. QUARTERLY COURSE PRE-REGISTRATION PROCEDURE FOR DISTANCE LEARNING CLASSES**

1. In the first week of each quarter, the Software Engineering staff provides POCs at remote sites with the list of distance learning courses (course number, catalog description, instructor, lecture time). Remind POCs to have students fill out the Registration Information Sheet for Distance Learning Students form (Appendix 1) if taking NPS courses for the first time.
2. POCs at remote sites submit class lists to the Software Engineering office ([seac\\_ms@cs.nps.navy.mil](mailto:seac_ms@cs.nps.navy.mil)) via email no later than Friday of the third week.
3. Software engineering staff forwards the class lists to the Assistant Registrar ([mscheffel@nps.navy.mil](mailto:mscheffel@nps.navy.mil)) via email.

4. The MSSE coordinator forwards the list of distance learning courses and their lecture hours to the Scheduler (cwilson@nps.navy.mil) by Friday the fourth week.
5. The MSSE coordinator forwards VTC requirements to the Distance Learning Coordinator (dswalsh@npslnavy.mil) by Friday of the fourth week.

### **III. QUARTERLY STUDENT OPINION FORM (SOF) PROCEDURE FOR DISTANCE LEARNING CLASSES**

1. Software Engineering staff obtains SOF packages from the Scheduler (cwilson@nps.navy.mil) by Friday of the seventh week of each quarter.
2. Software Engineering staff asks the instructors to fill out the cover sheets.
3. Software Engineering staff mails the SOF packages (together with the instructions shown in Appendix 2) to the POCs at remote sites, asking them to have the distance learning students fill out the SOFs and return the packages to the Software Engineering office by Monday of the eleventh week.
4. Software Engineering staff sends reminder via email to the POCs at remote sites if he/she has not received the SOFs by Monday of the twelfth week.
5. Software engineering staff forwards the SOFs to the Scheduler (cwilson@nps.navy.mil) by Friday of the thirteenth week.

### **IV. QUARTERLY THESIS SUBMISSION PROCEDURE FOR DISTANCE LEARNING STUDENTS**

1. The first week of each quarter, Software Engineering staff notifies POCs at remote sites to submit the list of graduates (and their official names, postal address for diploma, thesis advisor, thesis title, and whether or not they will attend graduation ceremonies) in that quarter.
2. By the end of the second week, POCs at remote sites submit a list of those students graduating that quarter (and their information) to the Software Engineering office (seac\_ms@cs.nps.navy.mil).
3. Software Engineering staff forwards the graduation list and information to the Code 32 curricular office [jbrennan@nps.navy.mil, (831) 656-4679].

## ***MS Software Engineering Program***

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4. Software Engineering staff forwards the following attachments to the graduating students:

- Class checklist.
- Thesis preparation/distribution form
- Research information form
- Thesis Release Memo (thesis publication on the thesis web site)
- Sample thesis pages

5. By the end of the sixth week, graduating students must send thesis draft to the thesis processor for format check and incorporate the comments into the thesis draft:

Ms. Elaine Christian, Code 91/Ec  
Room Ha-236  
Naval Postgraduate School  
Monterey, CA 93943-5138  
Phone: (831) 656-1124  
Email: [echristian@nps.navy.mil](mailto:echristian@nps.navy.mil)

6. By the end of the seventh week, graduating students send thesis draft to advisors and second readers for content check.

7. By the end of the eighth week, thesis advisors will inform the Software Engineering office ([seac\\_ms@cs.nps.navy.mil](mailto:seac_ms@cs.nps.navy.mil)) via email if they find the thesis content acceptable for graduation. The Software Engineering staff will withdraw students from the graduation list (via email to Ms. Jean Brennan at the Code 32 curricular office) if their advisors have not sent approval to the Software Engineering office by the end of the eighth week.

8. By the end of the ninth week, graduating students must incorporate all the changes from their advisors and second readers and send the thesis draft to the thesis processor for a second format check.

9. By the end of the tenth week, graduating students must incorporate any changes required by the thesis processor and submit the final thesis to the NPS Software Engineering office.

- Student signs the signature page.

- If the thesis involves a co-advisor or second reader at a remote site, ask them to sign the thesis.
- Send three copies of the thesis, together with the thesis classification form, thesis advisor information sheet, thesis release memo, and a floppy disk containing the special abstract to the advisor at NPS for signature.
- Email an on-line copy of the thesis to the Software Engineering office (seac\_ms@cs.nps.navy.mil).
- Ask the advisor to forward the signed thesis, floppy disk, etc. to the Software Engineering office.
- The Software Engineering staff will obtain the signature of of the Software Engineering curriculum chair and then forward the thesis to the thesis processor.
- The Software Engineering staff will notify the student via email once the thesis processor has accepted the thesis.

10. Graduating students who attend the graduation commencement should arrive at NPS in the morning of the day before graduation commencement, get nametags from Ms. Jean Brennan [SP-404, (831) 656-4679, jbreannan@nps.navy.mil], and attend commencement rehearsal at 1300 hours on the day before graduation (usually on the Wednesday of the twelfth week).

## **V. THESIS PROPOSAL SUBMISSION PROCEDURE FOR DISTANCE LEARNING STUDENTS**

1. The Software Engineering staff requests MS thesis topics from all Software Engineering faculty two weeks before the end of the quarter when distance learning thesis students register for SW0810 for the first time in their MSSE study.
6. The Software Engineering staff sends the thesis guidelines, thesis procedures (from the MSSE Handbook), sample thesis proposal, and the list of thesis topics to the POCs at remote sites via email no later than Friday of the week before the end of the quarter. POCs at the remote sites forward the information to the thesis students.
7. The MSSE coordinator schedules a VTC meeting during the first week of the quarter to go over the thesis guidelines, thesis procedures, sample thesis proposal and the thesis topics with the distance learning students.

## ***MS Software Engineering Program***

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8. Thesis students study the list of thesis topics and discuss the topics with their potential advisors via email, audio phone, and individual VTC sessions.

9. By the end of the eighth week, thesis students must send a thesis proposal draft to their advisor and second reader for comments.

10. By the end of the tenth week, thesis students must incorporate all changes required by their advisors and second readers and submit the final thesis proposal to the NPS Software Engineering office (seac\_ms@cs.nps.navy.mil).

- Student signs the thesis proposal.
- If the thesis involves a co-advisor or second reader at a remote site, ask them to sign the proposal.
- Send a copy of the thesis proposal to the advisor at NPS for signature.
- Email an on-line copy of the thesis proposal to the Software Engineering office (seac\_MS@cs.nps.navy.mil).
- Ask the advisor to forward the signed thesis proposal to the Software Engineering office.
- The Software Engineering staff will obtain the signature of the Software engineering Curriculum Chair and then forward the thesis proposal to Ms. Jean Brennan (jbrennan@nps.navy.mil) at the Code 32 curricular office.

***Section II***

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***Appendices***

**NAVAL POSTGRADUATE SCHOOL  
OFFICE OF THE REGISTRAR  
CODE 01B1, 589 DYER ROAD  
MONTEREY, CA 93943  
REGISTRAR INFORMATION SHEET  
DISTANCE LEARNING**

(Please Print Legibly)

\_\_\_\_\_  
Last Name                      First                      Middle                      Social Security  
Number

Rank/Grade \_\_\_\_\_  
Service \_\_\_\_\_  
Degree Program (yes or no) \_\_\_\_\_  
Curriculum number \_\_\_\_\_  
Email Address \_\_\_\_\_  
Site/Location \_\_\_\_\_  
Course # \_\_\_\_\_  
Course Start Date \_\_\_\_\_

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SOFTWARE ENGINEERING THESIS PROPOSAL COVER PAGE

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To: Curricular Officer, Code 32

Via: (1) Thesis Advisor: Advisor's Name

(2) Chair, Software Engineering Curriculum: Dr. Luqi

Subj: Thesis Proposal

Encl: (1) Milestone Plan for research and thesis completion.

1. Tentative Title of Proposed Thesis:

**Development of a software evolution process for military systems composed of integrated commercial off the shelf (cots) components.**

2. General Area of Proposed Thesis Research:

Factors Affecting Government Software Evolution Management of Military Systems Composed of Commercial Off-the-Shelf (COTS) Software Components.

3. Enclosure (1) is a milestone plan (dates/events) for research and thesis completion.

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**SAMPLE THESIS PROPOSAL**

**A     GENERAL INFORMATION**

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2.     Curriculum:           Software Engineering (369)
3.     Thesis Advisor:       Advisor's Name
4.     Second Reader:       Second Reader's Name

**B     AREA OF RESEARCH**

Factors Affecting Government Software Evolution Management of Military Systems Composed of Commercial Off-the-Shelf (COTS) Software Components. Topics of interest include software requirements management, software configuration control, software test & evaluation, and software risk management.

**C     RESEARCH QUESTIONS**

***PRIMARY***

1.     Do traditional software evolution models support systems composed of COTS software components?

***SECONDARY***

2.     How does a Government Software Support Activity (SSA) manage system requirements when it does not control component source code?
3.     How does a Government SSA maintain system configuration control when it does not control version release dates?

## D DISCUSSION

The current trend in Department of Defense (DoD) acquisition policy is to make maximum effective use of COTS software components during system development. Traditional software evolution activities (i.e., those activities that occur after delivery of a software product to the fleet) typically consist of correcting software errors, adding new capabilities (enhancements), and adapting the software product to new environments. These traditional activities require maintainer access to and complete control over system source code. For systems that employ COTS software components, maintainers lose direct access to product source code.

A new software evolution model must therefore be developed to address executable vice source code management.

## E SCOPE OF THESIS

The main thrust of this thesis is to propose a new over-arching software evolution model for military systems that employ COTS software components. Specifically, the thesis will explore the software requirements analysis and the software configuration control aspects of the new model. For requirements analysis: the thesis will propose a multiple criteria decision model to aid the COTS software component selection/upgrade process. The model, based on the Electre method, will assess tangible and intangible COTS component costs and benefits. For configuration control: the thesis will evaluate the relational hypergraph model as a tool to aid COTS software component tracking. This thesis is limited to software evolution activities and excludes software development activities.

## F METHODOLOGY

This thesis will propose a new software evolution model for military systems that employ COTS software components. The general research methodology will include theoretical analysis of traditional software evolution methodologies, identification of COTS specific issues and concerns, and development of engineering processes to address extant methodology shortcomings. Real-world case studies and sidebars will supplement thesis conclusions. Case studies and sidebars will be drawn from various Department of Navy (DoN) Meteorological and Oceanographic (METOC) programs:

- The Tactical Environmental Support System (TESS) is an METOC legacy system that consists of approximately 2.5 million lines of source code.
- The Navy Integrated Tactical Environmental System (NITES), slated to replace TESS in late fiscal year 1999, is built around COTS software components.

## ***Appendix D***

---

The push to employ COTS software components in new military system developments is a recent DoD trend. Validation and verification of thesis conclusions will therefore require further analysis after this development strategy matures.

### **G     CHAPTER OUTLINE**

Introduction

Background

- Policy: DoD push to use COTS software components

Software Evolution Management

- Traditional Evolution Models: issues and concerns
- Proposed Evolution Model: Military Systems composed of COTS Components

Software Requirements Analysis

- COTS Component Investment: Multiple Criteria Decision Model (Electre Method)

Software Configuration Control

- COTS Component Tacking: Activity Based Model (Relational Hypergraph Model)

Conclusions

Appendices

Bibliography

### **H.     SCHEDULE**

- |    |                              |                 |
|----|------------------------------|-----------------|
| 1. | Literature Review:           | 15 Jun – 30 Jun |
| 2. | Conduct Research:            | 01 Jul – 30 Jul |
| 3. | Develop Draft Thesis:        | 01 Aug– 30 Sep  |
| 4. | Draft Thesis for Review:     | 01 Oct          |
| 5. | Final Thesis for Submission: | 01 Nov          |

I BENEFITS OF STUDY

There is a strong misconception among Government program managers that COTS software components provide an easy solution to software life-cycle cost and schedule overruns. The main benefits of this thesis are to address some of the problems associated with COTS software intensive systems and to propose possible software engineering solutions to those problems.

J ANTICIPATED TRAVEL/FUNDING REQUIREMENTS

None.

K. PRELIMINARY BIBLIOGRAPHY

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## **Appendix D**

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T. Bui, "Multiple Criteria Decision Making: The Electre Method," *Executive Planning with BASIC*, Sybex, 1992.

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Submitted in partial fulfillment of the  
requirements for the degree of

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**ABSTRACT**

Department of Defense (DoD) acquisition policy requires that military system acquisitions incorporate commercial-off-the-shelf (COTS) components into system architectures. Traditional DoD source code development and evolution methodologies do not effectively support COTS-intensive systems. To fully realize the benefits of COTS technologies and products, the DoD must adopt new ways to sustain system evolution in the face of a dynamic market environment subject to constant change.

This thesis proposes a new software evolution methodology to effectively maintain COTS-intensive military systems. The integrated COTS component evolution (ICCE) model provides evolution processes designed to support the maintainer as a consumer of software instead of a source-code developer. The ICCE model affords proactive risk awareness, market awareness, and user awareness activities. The ICCE model also supports a three-tier test and evaluation process. A case study for the U.S. Navy/Marine Corps Meteorological Mobile Facility Replacement (METMF(R)) program demonstrates the effectiveness of the ICCE risk management process.

**ACKNOWLEDGEMENT**

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## INTRODUCTION

### SUMMARY

Department of Defense (DoD) acquisition policy requires that military system acquisitions incorporate commercial-off-the-shelf (COTS) components into system architectures. Traditional DoD source code development and evolution methodologies do not effectively support COTS-intensive systems. To fully realize the benefits of COTS technologies and products, the DoD must adopt new ways to sustain system evolution in the face of a dynamic market environment subject to constant change.

This thesis proposes a new software evolution methodology to effectively maintain COTS-intensive military systems. The integrated COTS component evolution (ICCE) model provides evolution processes designed to support the maintainer as a consumer of software instead of a source-code developer. The ICCE model affords proactive risk awareness, market awareness, and user awareness activities. The ICCE model also supports a three-tier test and evaluation process. A case study for the U.S. Navy/Marine Corps Meteorological Mobile Facility Replacement (METMF(R)) program demonstrates the effectiveness of the ICCE risk management process.

### PURPOSE

The Department of Defense (DoD) is undergoing a significant change in the way it acquires and maintains software intensive systems. To alleviate software development costs and reduce schedule delays, the DoD is shifting towards the commercial market to fulfill system requirements.

The primary purpose of this thesis is to:

- Develop a new software evolution methodology that supports the DoD maintainer as a consumer of software instead of a source code developer.

The secondary purpose of this thesis is to:

- Develop and demonstrate a risk management process for military systems built around an integrated software component solution.
- Develop a formal qualification test and evaluation process for military systems built around an integrated software component solution.



## MOTIVATION

Acquisition managers must understand that choosing a COTS component may be a reasonable solution; however, the decision to use COTS should be the product of analysis, reasoning, and engineering decisions, not the desire to jump on the latest bandwagon. [Ref. 1]

Even though Brooks [Ref. 2] warned that silver bullets do not exist to solve software development and maintenance productivity problems, the DoD is pushing the commercial market as a silver bullet to reduce military system development costs and to mitigate schedule delays.

A review of software management and engineering literature illustrates some of the following expectations and realities that exist regarding the integration of COTS software components into military systems. Some of the expectations include:

- COTS software components will reduce development costs and overall schedule [Ref. 3].
- COTS software components are less risky [Ref. 4].
- COTS software components can be procured and modified faster and cheaper than developing the component from scratch [Ref. 4].
- COTS software components will satisfy all system requirements [Ref. 4].
- COTS software components are stable and error-free [Ref. 4].
- COTS components do not require testing [Ref. 5].
- COTS components are selected based on extensive evaluation and analysis [Ref. 5].
- Vendors will keep the component current and up to date with technology [Ref. 4].
- Vendors will utilize commercially accepted interface standards.
- Vendors will employ commercially accepted software engineering development practices.
- Vendor literature is accurate, complete and understandable [Ref. 4].

## **Appendix G**

---

- An open-system architecture solves the COTS component inter-operability problem [Ref. 5].

Some of the realities include:

- COTS software component integration can be expensive [Ref. 4].
- COTS software components require more testing because the integrator does not know how they were built [Ref. 5].
- COTS software components are typically selected based on slick demos, web searches, or by reading trade journals [Ref. 5].
- Selecting the wrong COTS component can be more expensive than fixing problems in custom-built software [Ref. 4].
- COTS software component vendors do not supply all services [Ref. 4].
- Features sell COTS components, not documentation [Ref. 5].
- COTS software components may not meet all the system requirements [Ref. 4].
- COTS software components may not be easy to modify [Ref. 4].
- The system developer will have little control over vendor quality and schedule [Ref. 4].
- The system developer's organization will have to change to accommodate COTS software components [Ref. 4].
- There is no standard definition for open-system and plug-and-play does not always work [Ref. 5].
- COTS software components introduce new tradeoffs, issues, constraints, assumptions, problems, and inadequacies [Ref. 1, 3, 5, 6, 7].

The large-scale integration of COTS software components into military system architectures introduces new engineering, management, and organization challenges:

- The system maintainer no longer controls software component specification.

- The system maintainer no longer controls software component source code.
- The system maintainer no longer controls software component release schedule.
- The system maintainer is no longer able to conduct developmental (white box) test and evaluation.

The purpose of software engineering is to improve the quality of software and software products [Ref. 8]. The primary motivation behind this thesis is to help DoD managers acquire and maintain effective COTS-intensive military systems. Specifically, this paper will attempt to convey the following essential points:

- DoD managers and engineers must have a clear understanding of the applicable risks and benefits associated with COTS-intensive system acquisitions.
- DoD managers and engineers must adopt new processes and activities to sustain effective COTS-intensive systems.

## ORGANIZATION

This thesis is organized into the following chapters:

- Chapter II identifies acquisition source documents and policy statements affecting the DoD push toward COTS integration into military systems.
- Chapter III provides a brief overview of traditional source code-based development and evolution activities.
- Chapter IV presents the integrated COTS component evolution (ICCE) model along with a brief overview of the major ICCE activities and processes.
- Chapter V presents the ICCE risk management process for COTS-intensive systems.
- Chapter VI presents a case study that demonstrates the effectiveness of the ICCE risk management process.
- Chapter VII presents the ICCE test and evaluation process for COTS-intensive systems.
- Chapter VIII provides thesis conclusions and recommendations.

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We certify that this student has met the minimum requirement for the Master of Science in Software Engineering degree.

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Chair, Software Engineering Curriculum                      Date

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## **Appendix J**

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\_\_\_ SW4510 Computer-Aided Prototyping (3-0)

\_\_\_ SW4520 Advanced Software Engineering (3-0)

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\_\_\_ SW4580 Design of Embedded Real-Time Systems (3-0)

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## **Appendix L**

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## **Appendix L**

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- Combat Identification
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- Military Operations on Urbanized Terrain
- Joint Readiness and Logistics and Sustainment of Strategic Systems
- Force Projection/Dominant Maneuver
- Electronic Warfare
- Chemical/Biological Warfare Defense and Protection and Counter
- Weapons of Mass Destruction
- Combating Terrorism
- Protection of Space Assets

Defense Technology Area Plan Defense Technology Objectives:

- Air Platforms
- Chemical/Biological Defense
- Information Systems Technology
- Ground and Sea Vehicles
- Materials/Processes
- Biomedical
- Sensors, Electronics, and Electronic Warfare
- Space Platforms
- Human Systems
- Weapons
- Nuclear Technology
- Battlespace Environments

Command Capability Issues:

- Battlespace Connectivity**
- Flexible Targeting
- Mine Warfare (Offensive and Defensive)
- Common/Consistent Tactical Picture
- Ship Self Defense/Force Protection
- Chemical/Biological Defense
- Coalition C4I
- Interdiction Operations, Sanctions Enforcement, and Counter-SOF
- Maintenance
- Information Warfare and Counter-GPS Jamming
- Integrated Fire Support
- Non-lethal Technologies
- Over-the-Horizon Sustainment and Resupply



- \_\_\_\_\_ Shallow Water ASW
- \_\_\_\_\_ Theater Air Defense
- \_\_\_\_\_ Fight in Adverse Environmental Conditions
- \_\_\_\_\_ Simulation and Training
- \_\_\_\_\_ Unmanned Tactical Reconnaissance

Future Naval Capabilities:

- \_\_\_\_\_ Autonomous Operations
- \_\_\_\_\_ Capable Manpower
- \_\_\_\_\_ Electric Ship and Combat Vehicles
- \_\_\_\_\_ Knowledge Superiority and Assurance
- \_\_\_\_\_ Littoral ASW
- \_\_\_\_\_ Littoral Combat and Power Projection
- \_\_\_\_\_ Missile Defense
- \_\_\_\_\_ Organic Mine Countermeasures
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