



SYSTEMS
ENGINEERING
RESEARCH CENTER

Final Report

Task Order: Task Order 0079, RT-179

**Missile Defense Agency Research and Course Development –
Verification, Validation, and Accreditation and Monte Carlo Simulation**

Award: \$64,379.27

Period of Performance

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Completion Date: 11 May 2018

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Research Team:

University of Alabama in Huntsville

Sponsor:

MDA, ODASD(SE)

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EXECUTIVE SUMMARY

The University of Alabama in Huntsville (UAH), in support of Missile Defense Agency (MDA) requirements for professional education of its technical workforce, developed two two-day professional education short courses, one on Monte Carlo Simulation (MCS) and the other on Verification, Validation, and Accreditation (VV&A).

To develop the MCS and VV&A courses, UAH investigated how models and simulations are used at MDA, with a focus on MCS and VV&A. UAH then developed course materials that addressed MDA's needs for MCS and VV&A instruction. Those course materials included both general background content on MCS and VV&A and custom content that should be of particular use to MDA.

UAH taught each of the two courses four times, for a total of eight course offerings. Four of the course offerings (two of each course) were taught in Huntsville Alabama and four of the offerings (two of each course) were taught in Colorado Springs CO. A total of 119 MDA students participated in the eight course offerings. After each course offering, UAH made corrections and enhancements to the content based on feedback from the MDA students in the courses.

In addition to the MCS and VV&A courses, UAH developed, but did not teach, two additional two-day professional education short course on the subjects of Fundamentals of Modeling and Simulation (FMS) and Physics-Based Modeling (PBM). This contact did not include funding or tasking to teach these courses. However, they were developed and are ready to be taught when MDA requires them.

PROJECT ACTIVITIES AND ACCOMPLISHMENTS

This report provides the final status for the Research Task RT-179: Missile Defense Agency Research and Course Development – Verification, Validation, and Accreditation and Monte Carlo Simulation.

BACKGROUND

Modeling and simulation are becoming increasingly important in systems engineering. Given the complexity of today's complex weapon systems, engineers often work with abstract representations of these systems in order to conduct tradeoff analyses and make decisions regarding system functionality, design, integration and tests. Modeling and simulation offers significant cost savings in two cases - (1) in the case where a test of the real system is very expensive, such as a missile intercept, and (2) in the case where a test must be repeated often. The use of modeling and simulation to lower testing costs supports the Better Buying Power initiative, since the missile intercept tests are very expensive.

The Missile Defense Agency (MDA) uses modeling and simulation (M&S) extensively for many purposes, including concept development, engineering design, test planning and support, and operational analysis. MDA would like to provide its personnel who are not already knowledgeable regarding M&S with professional training in M&S that is both academically rigorous and well connected to MDA applications. The training should allow MDA personnel to identify appropriate uses of models, develop and execute models effectively, prepare input data for them correctly, interpret and validate their results accurately, and plan simulation events efficiently.

The University of Alabama in Huntsville (UAH) is a national leader in M&S education. UAH's M&S graduate degree program awards M.S. and Ph.D. degrees in M&S and has already graduated students at both levels. UAH has provided customized M&S instruction and tutorials for a number of clients, included the U. S. Army Software Engineering Directorate, the U. S. Marine Corps Systems Command, and the U. S. Missile Defense Agency, and in a number of formats, including single day tutorials and multi-day short courses. UAH researchers and faculty were also the authors of the questions used in the current version of the Certified Modeling and Simulation Professional Certification Examination.

RESEARCH WORK

To develop the MCS and VV&A courses, UAH investigated how models and simulations are used at MDA, with a focus on MCS and VV&A. UAH then developed course materials that addressed MDA's needs for MCS and VV&A instruction. Those course materials included both general background content on MCS and VV&A and custom content that should be of particular use to MDA.

ACTIVITIES AND ACCOMPLISHMENTS SUMMARY

During the period of performance, the following activities and accomplishments were completed:

Monte Carlo Simulation (MCS)

- A total of 276 lecture slides were developed.
- A total of 20 example MCS models were implemented (in Excel and/or in R).
- A total of 4 separate classroom exercises were developed; 4 exercises were found to be sufficient for the time available for exercises.
- The MCS course was taught to 25 MDA students at the University of Alabama in Huntsville in Huntsville AL on August 7-8 2017. This was the first of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the August 7-8 2017 course offering was delivered to Ms. Dawn Irons in digital form.
- Based on the initial August 7-8 2017 offering, a number of clarifications and additions were made to the lecture slides and exercises.
- The MCS course was taught to 10 MDA students at the Parsons facility in Colorado Springs CO on September 6-7 2017. This was the second of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the September 6-7 2017 course offering was delivered to Ms. Dawn Irons in digital form.
- Based on the September 6-7 2017 offering, a number of clarifications and additions were made to the lecture slides and exercises.
- The MCS course was taught to 17 MDA students at the University of Alabama in Huntsville in Huntsville AL on December 13-14 2017. This was the third of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the December 13-14 2017 course offering was delivered to Ms. Dawn Irons in digital form.
- Based on the December 13-14 2017 offering, a number of clarifications and additions were made to the lecture slides and exercises.
- The MCS course was taught to 11 MDA students at the Parsons facility in Colorado Springs CO on April 11-12 2018. This was the fourth of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the April 11-12 2018 course offering was delivered to Ms. Dawn Irons in digital form.

Verification, Validation, and Accreditation (VV&A)

- A total of 340 lecture slides were developed.
- A total of 7 example VV&A case studies were implemented (in Excel).
- A total of 5 separate classroom exercises were developed; 5 exercises were found to be sufficient for the time available for exercises.
- The VV&A course was taught to 14 MDA students at the University of Alabama in Huntsville in Huntsville AL on August 9-10 2017. This was the first of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the August 9-10 2017 course offering was delivered to Ms. Dawn Irons in digital form.
- Based on the initial August 9-10 2017 offering, a number of clarifications and additions were made to the lecture slides and exercises.

- The VV&A course was taught to 12 MDA students at the Parsons facility in Colorado Springs CO on September 26-27 2017. This was the second of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the September 26-27 2017 course offering was delivered to Ms. Dawn Irons in digital form.
- Based on the September 26-27 2017 offering, a number of clarifications and additions were made to the lecture slides and exercises.
- The VV&A course was taught to 17 MDA students at the Parsons facility in Huntsville AL on January 23-24 2018. This was the third of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the January 23-24 course offering was delivered to Ms. Dawn Irons in digital form.
- Based on the January 23-24 2018 offering, a number of clarifications and additions were made to the lecture slides and exercises.
- The VV&A course was taught to 13 MDA students at the Parsons facility in Colorado Springs CO on May 1-2 2018. This was the fourth of four planned offerings of this course.
- A complete set of lecture slides and exercise files used for the May 1-2 2018 course offering was delivered to Ms. Dawn Irons in digital form.

Fundamentals of Modeling and Simulation (FMS)

- A total of 376 lecture slides were developed.
- A total of 8 classroom exercises were developed.
- MDA was advised that the FMS course was ready to be taught.

Physics-Based Modeling (PBM)

- A total of 240 lecture slides have been developed.
- A total of 6 classroom exercises were developed.
- MDA was advised that the PBM course was ready to be taught.

All work (course development and teaching) was performed by the project's Principal Investigator, Mikel D. Petty, Ph.D. (UAH), except for the development of the PBM course materials, which was performed by Wesley N. Colley, Ph.D. (UAH/Torch).

DELIVERABLES

Reports

Date	Deliverable
May 17, 2017	Submit Technical and Management Plan/Kickoff - Submitted
July 14, 2017	Submit bi-monthly status report to SERC (May/June) - Submitted
Sept 15, 2017	Submit bi-monthly status report to SERC (July/Aug) - Submitted
Nov 15, 2017	Submit bi-monthly status report to SERC; (Sept/Oct) - Submitted
Jan 15, 2018	Submit bi-monthly status report to SERC; (Nov/Dec) - Submitted
Mar 15, 2018	Submit bi-monthly status report to SERC; (Jan/Feb) - Submitted
May 11, 2018	Final Technical Report - This report

A010 Live face-to-face instruction of the Monte Carlo Simulation course.

(Four offerings, two in Huntsville AL and two in Colorado Springs CO)

Offering 1, August 7-8 2017, Huntsville AL, **Complete**.

Offering 2, September 6-7 2017, Colorado Springs CO, **Complete**.

Offering 3, December 13-14 2017, Huntsville AL, **Complete**.

Offering 4, April 11-12 2017, Colorado Springs CO, **Complete**.

A011 Live face-to-face instruction of the Verification, Validation, and Accreditation course.

(Four offerings, two in Huntsville AL and two in Colorado Springs CO)

Offering 1, August 9-10 2017, Huntsville AL, **Complete**.

Offering 2, September 26-27 2017, Colorado Springs CO, **Complete**.

Offering 3, January 23-24 2018, Huntsville AL, **Complete**.

Offering 4, May 1-2 2018, Colorado Springs CO, **Complete**.

A013 Final Technical Report - **This report**

In addition, the MCS and VV&A course materials (both slides and exercises) have been provided to MDA in digital form after each course offering.

PUBLICATIONS, CONFERENCES, INVITED TALKS

The project's Principal Investigator, Mikel D. Petty, Ph.D., gave a presentation covering the MCS and VV&A courses' goals, structure, and content at the SERC SERC Sponsor Research Review on November 8 2017.

COLLABORATOR COURSES THAT INTEGRATE RESEARCH RESULTS

The University of Alabama in Huntsville's College of Professional and Continuing Studies offers a wide range of non-credit professional education short courses in areas that include engineering, cybersecurity, information technology, management, and leadership.

Two of the UAH short courses include content developed for or from the short course content that makes up this task. Those professional education short courses are:

- Simulation Verification, Validation, and Accreditation (14 hours)
- Monte Carlo Simulation (14 hours)

For more information, see PCS.uah.edu/PDSolutions.

TRANSITION PLAN AND ACTIVE TRANSITION(S)

Future offerings of all four courses development in this project (MCS, VV&A, FMS, and PBM) are being considered by MDA.

CONCLUSION

A total of 119 MDA employees were provided useful professional education as a result of the project. The student course feedback collected by MDA after each course was consistently very positive for both the content and the instructor. Four substantial and relevant courses were developed and are available for use for future MDA professional education.

APPENDIX A: LIST OF PUBLICATIONS RESULTED

No publications have resulted from this research.