HISTORY MODULE

INTRODUCTION

In this module, you'll learn how innovations from antiquity to recent history have helped to build the foundation for today's field of Modeling and & Simulation. While learning about the development of these historical innovations, you'll also be discovering some of the essential concepts covered later in this course. This understanding will help you utilize key lessons from the past to develop a bright future for the field of M&S.

Modeling and Simulation, also known as M&S, while *perceived* as a relatively new field, actually has a rich history with many different individuals and organizations contributing to its development (Institute for Simulation and Training, 2000). This continual refinement over the centuries has not only helped to establish M&S as a 21st Century science, but has also woven a tradition of evolution into the field that still continues today.

ANTIQUITY

In this topic, you'll discover that the field of modeling and simulation began thousands of years ago. Lessons learned from the past can help us more effectively build the future of M&S.

The foundation of today's high tech world of M&S can be traced back to early innovations first applied thousands of years ago. The acceptance and implementation of many of these principles has enabled the field to become prevalent and pervasive in today's society.

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As early as 2500 BC, ancient civilizations used rudimentary models and simulations such as the use of clay figurines to depict the strength and location of opposing forces (Defense Modeling and Simulation Office, n.d, M&S 101; Institute for Simulation and Training, 2000). The use of wooden swords to safely learn and practice swordsmanship is also an example of early models and simulations.

Topic Summary: This topic just touched on a few examples of models and simulations from antiquity. It is important to realize that the field of M&S is not new. It has a long rich history.

Spotlight: Understanding the challenges and mistakes made in the past can help us to improve and shape the future of M&S.

Activity: Take a minute to answer a quick question that summarizes this topic area. Once you get it right, you'll earn a puzzle piece with a message about M&S in a pictographic code. After you complete all topic areas, and have all of your puzzle pieces, you'll be able to build the puzzle. Once the jigsaw puzzle is completed, the message about M&S will be revealed.

- Here's the question. "Which statement best summarizes the key message from this topic?" Click on the best answer.

  Answer 1: Clay figurines were used in antiquity.
  Response: No, while that is a correct fact, it's not the central message of this topic.
  Answer 2: Wooden swords were used in antiquity to practice swordsmanship.
  Response: No, while that is certainly a fact from this topic, it's not the main message.

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Answer 3: Modern high-tech models and simulations were built upon a rich, evolving history that can help us improve the future of M&S.

Response: Yes! The goal for this module is not to memorize isolated facts, but to think about what the facts mean to M&S today. It's important to know that there is a long history to M&S, because it's from this experience that we can learn important lessons that can guide us through current and future M&S challenges. Here's your puzzle piece!

RENAISSANCE OF M&S

In this topic, you'll learn about several of the advances in modeling and simulation that characterize this time period as the "Renaissance" of M&S. Many of these advances are still evident in the field today.

In India, around 700 AD, Chaturanga, a popular game with a sectioned board was created as a form of entertainment (Defense Modeling and Simulation Office, n.d., M&S Staff Officer Course). The game, which would later become what we now know as chess, was also used to depict armed combat.

In the 15th century, Leonardo Da Vinci used models to help them visualize and design new concepts, such as the helicopter and the parachute. They often used clay models to design and plan for larger marble sculptures. This notion of using less costly materials to model an object prior to investing more expensive materials and labor on the final product is one of the major applications of modeling and simulation today.

Spotlight: M&S can improve efficiency by saving materials and costs.

Later, in the 17th century, the Germans created a war game called Kriegspiel, or military chess (Defense Modeling and Simulation Office, n.d., M&S Staff Officer Course; Institute for Simulation and Training, 2000). Many consider this significant

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development to be "the birth of modern M&S." As German war games evolved, they introduced (Defense and Modeling and Simulation Office, M&S 101):

- scenario-based exercises
- detailed terrain maps on sand tables
- the consideration of time and distance implications
- and the use of probability to determine the effects of combat.

Spotlight: Many of the fundamental elements of M&S were introduced centuries ago and are still in use today.

Topic Summary: In this topic, you discovered several practices begun centuries ago that are still being utilized within the field of M&S.

Activity: Before moving on to the next Topic area, take a minute to answer this summarizing question, and earn another puzzle piece.

- Which statement best *summarizes the key message* from this topic? Click on the best answer.

  Answer 1: In the 17th century, the Germans created a war game called Kriegspiel, or military chess.

  Response: No. Although true, this is not the primary message of this Topic. However, Kriegspiel did lead to the further development of war gaming.

  Answer 2: Saving resources by using less costly materials to model an object prior to building the final product began centuries ago.

  Response: Yes, saving resources with modeling is a practice that began centuries ago and is still realized today. Increased efficiency can be a major benefit of M&S application. Here's your puzzle piece.

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U.S. INTRODUCTION OF M&S

In this topic, you'll discover how early advancements in war gaming introduced in the United States set the stage for modern day computer-assisted war gaming.

In 1879, U.S. Army Major Lawrence Livermore added increasingly complex elements to the existing German war games of the day (Institute for Simulation and Training, 2000). These important advances included: the tracking of supplies; the use of more sophisticated symbols to represent troops and equipment; the creation of indices for fire control (that is, the distance that a bullet will travel); and troop movement and how their speed is affected by various types of terrain.

Spotlight: Early war gaming helped lay the foundation for modern day computer-assisted war gaming.

Major Livermore's most significant advancement, however, was introducing the consideration of the *human element* into simulations by including the impact of time and its effect on fatigue.

Topic Summary: This topic has reviewed a few important developments that occurred in the United States during the 19th century.

Activity: Here's a question that asks you to think about *the significance* behind those facts.

- Which sentence best portrays *why* introducing the human element is so important for today's field of M&S? Click on the best answer.

  Answer 1: By considering the human element, we can learn how issues like time might affect fatigue.

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Response: Be careful. That *is* a significant advancement that Major Livermore introduced. However, it is *not the best* portrayal of *why* the human element is so important to M&S.

Answer 2: It's the human condition that we are ultimately trying to improve with M&S—not technology.

Response: That's right! The glamour of high-tech M&S tools can *sometimes* pull our focus away from the real issue at hand. Most of the time, our ultimate goal is to help the end-user—not to create fancy gadgets just because we can.

Here's another's another puzzle piece!

1900-1950

In this topic, you'll learn about advancements that were made in war gaming and in the use of simulation for training purposes. You'll also discover some of the challenges that emerged during this time period—challenges that those in the field of M&S are still encountering today.

By the 20th century, the continual refinement of war gaming by the military had led to the codification or, the systematic classification of, rules for war gaming (Defense and Modeling and Simulation Office, M&S 101)

The inclusion of these concepts in today's latest Modeling and Simulation applications is a continuation of the rich traditions that have evolved and been refined throughout the history of M&S. The field continues to evolve today.

The start of the 20th Century heralded a new era for the field of Modeling and Simulation. The increasing cost of military equipment and supplies led to the development of training exercises that utilized models and simulated equipment for soldiers to practice (Amico, 1984 Amico & Clymer, 1984). A major milestone was the development of the first aircraft simulator by Ed Link. This flight simulator was used as

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early as 1936 to train airmail pilots (Adorian, & Staynes, 1979; Institute for Simulation and Training, 2000).

However, the early 20th century was also when it was realized that the assumptions made while creating models and simulations must be reviewed, revised, and refined before *using* those models and simulations. There were several instances where commonly accepted norms or unfounded interference drastically impacted historical events.

Spotlight: A model is only as good as the data that support it.

For example, when the Wright Brothers were developing their first airplane, they were frustrated by the poor performance of their 1900 and 1901 gliders. Neither glider performed as well as the original model had predicted—achieving only 1/3 of the anticipated lift. Because of this discrepancy, the Wright brothers questioned their prior assumption that the existing model was built upon accurate aerodynamic data. So, they began to collect their own data using wind tunnel tests. In 1902, when the brothers had completed the revision of their model with accurate data, they once again designed an aircraft for flight testing. This new design—which was completed in 1903—was much more successful. The Wright Brothers' experience clearly demonstrates how important it is to continually question our assumptions that the data are accurate simply because they are widely used (Anderson, 1989).

Another example is how incorrect assumptions affected the outcome of one of World War II's most significant battles. During WWII, the Japanese used war gaming to simulate their attack on the Island of Midway in the Pacific Ocean. The war game had played out to where two of the Japanese carriers were sunk. The Japanese admiral in

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charge of the war game ordered the game restarted since, he postulated, there was no way the mighty imperial fleet would lose two of its carriers. Of course, he was wrong, they actually lost four carriers. The Battle of Midway is generally regarded as one of the deciding engagements of the war. This shows that human biases greatly effect the interpretation of results in a simulation (Freedberg, 2001). These examples underscore two important concepts for applying M&S correctly:

Spotlight: The end-user must trust the model that supports a simulation.

Spotlight: Although simulations *can* be used for analyzing concepts and anticipating consequences, simulations *cannot* actually predict the future.

Topic Summary: This topic reviewed several lessons from the early 20th century that you should keep in mind while working within the field.

Activity: Are you ready to earn another puzzle piece? Here's your question! Be careful, this one is a little tricky!

- Why is it so important to *review and revise our assumptions* when working within the field of M&S? Click on the answer that provides the *most encompassing* answer.

  Answer 1: If we assume a model uses correct data, we (like the Wright brothers), may find that our initial efforts fail. Just because people believe something is accurate, doesn't mean it actually is.

  Response: Be careful! While this answer does provide one reason for reviewing and revising our assumptions, it's not the most encompassing answer.

  Answer 2: If we assume that the result of a simulation is incorrect simply because it's something we had not anticipated, we might be setting ourselves up for failure—such as the Japanese experienced with war gaming in World War II.

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Response: Watch out! While this answer does provide one reason for checking our assumptions, it's not the most encompassing answer.

Answer 3: If we assume the M&S application is correct, we may trust when we shouldn't. Or, if we negate the results of an M&S application simply because they are counter-intuitive, we may fail to trust when we should**.**

Response: Yes, that's right! This is the *most encompassing* answer. If we don't review and revise our assumptions we might trust when we shouldn't or we may fail to trust when we should. Furthermore, we must remember that simulations are only tools to inform our decisions. They cannot actually predict the future. Good work! Here's your puzzle piece!

1950-1980

In this topic, you'll explore how M&S evolved through several historical developments, including advancements in computer technology, the cold war and the space race.

With the rapid advances of technology after World War II, modeling and simulation entered a new era of development. First, with the analog computer, then later with digital computing, the M&S community was now able to calculate increasingly larger models and create more complex scenarios.

Many developments during the second half of the 20th century in the field of modeling and simulation were results of the cold war and the space race (Institute for Simulation and Training, 2000). From weapons design and testing to figuring out how to put a man on the moon, M&S was helping to provide an increasing level of accuracy (Ryan, 2000). In fact, when Apollo Astronaut Neil Armstrong was asked what landing on the moon was like, his response was said to have been that it was "just like the simulator."

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The successes of these and many other advances in equipment design, training, and strategic planning led to an explosion of M&S applications for industry as well as the military. The increasing speed and robustness of computers in the late 1970's further fed this spiraling growth of modeling and simulation (Defense Modeling and Simulation Office, n.d., M&S Staff Officer Course).

Topic Summary: During this time period, technological advancements enabled us to create more sophisticated M&S tools. However, we soon learned that along with these new capabilities came *new* responsibilities and challenges. For example, just because *we can* create M&S applications with large-scale models, complex scenarios, and high levels of accuracy, doesn't mean we necessarily *should*.

Spotlight: the purpose of a model or simulation will affect how it will be created and how it should be used.

Activity: Here's an example of a simple, everyday situation that illustrates the point.

- Your eight-year-old son wants to learn how to use a camera. Click on the most appropriate response you would have to his request, and earn another puzzle piece.

  Answer 1: You purchase the latest, high-tech camera made for professional photographers.

  Response: If you purchased this camera, do think your son would learn to take pictures, or would he quickly become overwhelmed by the complexity of the tool? A similar reaction can occur with M&S applications if they are more complex than the end-user requires.

  Answer 2: You purchase a simple, disposable camera for him to learn with.

  Response: That's right! Most parents would only invest in the level of complexity needed to suit the child's needs. As you'll see in later modules, when developing and implementing M&S, we also have the

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responsibility and the challenge of matching the level of complexity with the end-user's needs. Great job! Here's another puzzle piece.

1980-2000

In this topic, you'll learn about several occurrences in recent history that have helped M&S establish itself as a powerful tool that can be utilized in numerous human endeavors—and that have helped M&S coalesce into a standardized field of practice.

By the 1980's, the complexity of models and simulations began to more closely resemble what we see today (Defense Modeling and Simulation Office, n.d., M&S Staff Officer Course). The increasing power of computers and communication software began to leverage the capabilities of what was becoming familiar to the public as the Internet. Users began to connect to each other. And networked simulations enabled multiple individuals to participate in a shared simulation from different locations.

In 1982, the SIMNET project connected widely dispersed tank simulators in a single training scenario (Defense Modeling and Simulation Office, n.d., M&S Staff Officer Course). It is widely regarded as the first successfully networked simulation. In so doing, SIMNET set the stage for the future of distributed simulation.

In 1987, SIMNET was teamed with another simulator technology, the UCOFT or Unit Conduct of Fire Trainer (National Training Systems Association, n.d., Effectiveness Section). The power of this simulation approach was clearly demonstrated when the United States used SIMNET and UCOFT to train for the Canadian Armor Trophy competition, an annual NATO event. Previously, the United States had routinely lost this competition. Even a new and improved tank did *not* change that outcome. However, after the US tank crews trained using SIMNET and UCOFT, they easily won the

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competition by a wide margin (Michael Macedonia, videotaped interview, ITSEC, December 2002, Orlando, FL: Integrity Arts & Technology, Inc.)

SIMNET and UCOFT not only reduced the cost of training by reducing the need for live ammunition and large tank training ranges, they also demonstrated that simulations could be used to improve performance. The *measurable* success of networked M&S applications was a primary factor that led to the increased acceptance of their use by the U.S. military and NATO forces.

Spotlight: The proper design and use of M&S can be a more efficient and effective way to train.

The Gulf War in 1991 put modeling and simulation on the front page of the news. The U.S.-led coalition utilized these latest military technologies to support the war effort. Even the battle plan for Operation "Desert Storm" was developed and refined through intense war gaming (Defense Advanced Research Projects Agency, n.d.; Defense Modeling and Simulation Office, n.d., M&S 101).

One of the best-documented tank battles in the Gulf War pitted a U.S. force against an Iraqi tank division. The U.S. soldiers credited their ability to easily defeat the enemy force to their prior simulation training that had been built upon the earlier successes of SIMNET (Institute for Simulation and Training, 2000), After the war, this engagement, called the Battle of 73 Easting, was carefully reviewed and then re-created as a computer simulation to allow specialists to explore the most likely outcomes of using different strategies under different environmental conditions (Defense Advanced Research Projects Agency, n.d.).

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In the early 1990's, several developments helped modeling and simulation begin to establish itself as a field of practice by creating standard terminology (Institute for Simulation and Training, 2000). For example, the Defense Science Board officially codified simulations into three categories: live, virtual, and constructive. These terms will be covered in more detail in the simulation module. Shortly thereafter, the Department of Defense (1995) officially released the Modeling and Simulation Master Plan, which included a glossary of terms that began to standardize the language of M&S.

Through the rest of the 1990's, M&S applications continued to expand in both the military and public arenas. Applications that had only resided on massive supercomputers a few years earlier could now be used on personal computers in people's homes. By the end of the millennium, the use of M&S as a tool was as commonplace as the many benefits it was helping to create for everyday life. Its use in weather prediction, advances in medicine, new manufacturing processes, and even entertainment made modeling and simulation a significant aspect of contemporary society.

Topic Summary:

In this topic, we reviewed developments in the late 20th century that demonstrate several key trends in the evolution of M&S.

First, with the advent of computer networks, it became possible for teams to utilize simulations at the same time from different locations. This is critical because distance collaboration is becoming a cornerstone of the 21st century. Second, the use of networked simulations like SIMNET and UCOFT demonstrated not only that simulations could save money, but that they can also increase performance more effectively than other training tools. And finally, recent work began to coalesce modeling and simulation

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activities into a recognized field with its own standards and concept definitions, such as the articulation of simulation categories and the creation of a standard glossary of terms.

Activity: Before moving on to the next topic, take a moment to answer the following question and earn another puzzle piece.

- Why do you think it's important for modeling and simulation efforts to coalesce into a field with established norms and terminology? Click on the *most encompassing* answer

  Answer 1: Establishing modeling and simulation as a field helps ensure that there is a common understanding of lessons learned from the past, official rules of practice, and standard terminology for communication.

  Response: Yes, this is the most encompassing answer, giving several compelling reasons for the need to establish M&S as an evolving field of study.

  And, they are also things you should think about as you study and work with models and simulations. For example, as you interact with others in the field, think about how they are using terms, and about how you can apply lessons from our past into effective rules of practice. Here's another puzzle piece.

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Answer 2: There are many terms and concepts in modeling and simulation that can be defined and used differently. If we don't establish a standard definition, we'll have difficulty communicating effectively.
Response: This is certainly true, but it's not the most encompassing answer.
Answer 3: Modeling and simulation has developed from a rich history of evolution in which people have learned many important lessons. If we don't bring these basic concepts and guidelines together in one field, we'll jeopardize the creation of effective models and simulations.
Response: While this is certainly a good point, it's not the most encompassing answer.

21ST CENTURY

So now that we have discussed the history of M&S, where is the field today and what is its future? This topic will attempt to answer this question by exploring several innovations from the start of the 21st century. These innovations may serve as possible indications of where the field is headed.

A major area of concentration within the military community is the continuing development of methods to network simulations so they can more easily communicate and share data – making them "interoperable" (DoD Directive 5000.59, 1994, P# 115). High Level Architecture, also known as HLA (Defense Modeling and Simulation Office, n.d., HLA; DoD Directive 5000.59, 1994, P# 100), is the current interoperability standard for the U.S. Department of Defense. The goal of this standard is for different types of simulations to be able to interact and work effectively with each other.

Building upon the success of previous networked simulations, Distributed Mission Training, or DMT, is a recent example of the U.S. military's goal to produce a large network of various simulators (Air Force Association Annual Convention, 1999).

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Such a DMT network would enable multiple users at multiple sites to engage in simulated training exercises with a high level of realism.

M&S is also being used for mission planning (Army Model and Simulation Office, n.d.) (determining how quickly supplies can be made available to troops as they move forward into battle); mission rehearsal (Naval Studies Board & National Resource Council, 1997b, Chapter 2; Schutzmeister, 2002) (flying a simulated bombing run before actually attacking a target); and analysis of alternative courses of action (thinking through the consequences of crossing a bridge or fording the river). These uses will continue to expand as our understanding of models and simulations improves.

Another exciting potential for M&S is the leveraging of models and simulations from diverse areas or domains, such as acquisition, training, and analysis. This evolving philosophy, sometimes called Simulation Based Acquisition or SBA (Defense Modeling and Simulation, n.d., M&S Staff Officer Course; Ivanetich, 1997; Wolff, 1999), or Simulation Modeling for Acquisition, Requirements, and Training (SMART) (SMART 2001, 2002; US Army Visual Information Center, 2002) seeks to incorporate modeling and simulation in all facets of the development, procurement, and use of equipment and procedures. All of these concepts will be discussed in more detail in the Simulations module.

DRILL DOWN, *SBA*

Ivanetich, R. (1997.). Simulation-based acquisition. In Naval Studies Board & National Resource Council, *Technology for the United States Navy and Marine Corps, 2000 – 2035: Becoming a 21st Century Force*. Volume 9. Retrieved on September 24, 2003 from http://www.nap.edu/html/tech_21st/msindex.htm

DRILL DOWN, *SBA/SMART*

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Wolff, R. (1999; December). Bringing together live fire testing and training: real world applications of a reconfigurable, high fidelity small arms simulator test bed. *Military Simulation & Training,* Halldale Media, pp. 1-4.

An extension of the world of modeling and simulation which uses storytelling techniques and technologies from the entertainment industry includes a new application termed "immersive training." BattleStations 21, a 109,000 square foot installation which will be located at Great Lakes Recruit Training Center north of Chicago, is the U.S. Navy's first large scale deployment of story-driven, immersive simulation (Bob Allen, personal communication, June 30, 2003). This simulated environment is *physical* and will require all Navy recruits to perform skills learned during basic training in a team. In this visceral environment, the training objectives are used to drive the creation of a plausible and compelling story which, in turn, is delivered via the technologies and systems that have evolved from both the large commercial theme-park industry and the field of M&S. The result is a completely controlled physical environment in which the participant is surrounded and involved via all five senses.

These recent advances indicate that there are even greater strides ahead for the field of M&S. New technologies, faster computers and more powerful software will continue to evolve and expand the capabilities of models and simulations. But as much as the technology continues to evolve, it's the people and the roles they play in the process of developing and using models and simulations that will ensure the continued growth and improvement of the field of M&S.

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Spotlight: The most important thing about the history of Modeling and Simulation is that it is still being written.

Topic Summary: Keeping the evolution of M&S in mind will help foster an understanding and appreciation for how the field of M&S is developing and continuing to define itself.

Activity: Where is the field of M&S headed? There are many answers. To find one, put the jigsaw puzzle pieces together and discover the hidden message. Here are all of your pieces. Drag them into the puzzle space, and look for matches.

> Good job! You built the puzzle. Now, you can see the entire message. Can you guess what it says? When you're ready, click on the Reveal button, and the M&S message will be revealed. Click Continue when you are ready to go on.
> Message: *You* have the power to shape the future of M&S.

> Great! You discovered one of the most important lessons in M&S—that you and every person working within this field, have the power--*and the responsibility*--to help shape the future of M&S. No matter how small or large our roles may be, each one of us has the ability to affect change. In the modules to come, keep your eye out for guiding principles that will help you build a promising future for modeling and simulation.

HISTORY MODULE SUMMARY

This topic reviews major concepts covered in the History Module.

While Modeling and Simulation has only recently begun to coalesce into a standardized field of practice, it has developed from a long tradition of evolution that began thousands of years ago. By studying lessons learned from this rich history, we can

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gather gems of wisdom that will help us build a bright future for Modeling and Simulation.

As you work through the course modules, and as you practice within the field, remember these lessons from the past:

- M&S can improve efficiency by saving materials and costs and enhance performance.
- It is the human condition that we are ultimately trying to improve with M&S—not technology.
- A model is only as good as the data that support it.
- The end-user must trust the model that supports a simulation.
- Although simulations *can* be used for analyzing concepts and anticipating possible consequences, simulations *cannot* actually predict the future.
- The purpose of a model or simulation will affect how it will be created and how it should be used.

But perhaps the most important thing about the history of modeling and simulation is that it is still being written and you have a role in helping to shape that future.

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