

Analysis of Modeling & Simulation in Virginia

Technical Report

Prepared For

Commonwealth of Virginia

Virginia Department of Emergency Management (VDEM)

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Acronyms

BLS	Bureau of Labor Statistic
CAD/CAM	Computer-Aided Design/Computer-Aided Manufacturing
CAER	Center for Advanced Engineering and Research
CIT	Center for Innovative Technology
CNC	Computer Numerical Control
CommBus	Commercial Business
COV	Commonwealth of Virginia
CRCF	Commonwealth Research Commercialization Fund
DNR	Did Not Respond
DoD	Department of Defense
ED	Education
FMV	Full Motion Video
Gbps	Gigabits/second
GIS	Geographic Information System
GMU	George Mason University
GRP	Gross Regional Product
HC	Health Care
HR	House Resolution
HRPDC	Hampton Roads Planning District Commission
ISR	Intelligence, Surveillance and Reconnaissance
I/ITSEC	Interservice/Industry Training, Simulation and Education Conference
IMPLAN	Impact analysis for PLANning
IP	Intellectual Property
IT	Information Technology
JMU	James Madison University
LAB/RES	Laboratory/Research
LVC	Live, Virtual, and Constructive
M&S	Modeling & Simulation
MBC	Mid-Atlantic Broadband Cooperative
MMS	Modular Modeling System
MSA	Metropolitan Statistical Area
MSAC	Modeling and Simulation Advisory Council
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
NCMS	National Center for Manufacturing Sciences
NCSC	National Crosswalk Service Center
NDIA	National Defense Industrial Association
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Agency
NSF	National Science Foundation
NTSA	National Training and Simulation Association
ODU	Old Dominion University
QCEW	Quarterly Census of Employment and Wages

QOL	Quality of Life
R&D CAMEE	Research & Development Center for Advanced Manufacturing & Energy Efficiency
RFP	Request For Proposal
R&D	Research and Development
RTI	Research Triangle Institute
SISO	Simulation Interoperability Standards Organization
SO2	Studies of Organizational Opinion
SOW	Statement Of Work
STEM	Science, Technology, Engineering, and Mathematics
SVHEC	Southern Virginia Higher Education Center
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TIL	Transforming through Innovative Leadership
UAS	Unmanned Aircraft Systems
UAVs	Unmanned Air Vehicles
UNIV	University
US	United States
UVA	University of Virginia
UVS	Unmanned Vehicle Systems
VA	Virginia
VCU	Virginia Commonwealth University
VEDP	Virginia Economic Development Partnership
VMASC	Virginia Modeling, Analysis and Simulation Center
VR	Virtual Reality
VREP	Virtual Reality Educational Pathfinders

Executive Summary

MYMIC, LLC and The ASTA Group, LCC (The TEAM) are pleased to submit this report on *Analysis of Modeling & Simulation in Virginia* to the Commonwealth of Virginia. This work provides the Commonwealth and its Modeling and Simulation (M&S) stakeholders with a comprehensive analysis of the M&S business sector and a Strategic Plan for M&S growth in the Commonwealth. The comprehensive analysis enabled the identification of potential M&S growth opportunities and strategies for the Commonwealth.

This report was informed by multiple M&S sources including stakeholders, whose perspectives are presented herein. Major activities of the work included a meta-analysis, a regional business survey, focus group interviews, an economic analyses of the M&S sector and its workforce, and the inventory of Commonwealth M&S assets and Intellectual Property (IP). This information was used to develop a draft Strategic Plan for M&S growth in the Commonwealth.

This report presents analysis of the M&S workforce and its economic impact. It provides a single comprehensive (Commonwealth-wide) profile, and also ten regional profiles of the M&S industry, workforce, and economy in Virginia. Each is presented as a section of this report.

Attachments to this report include the M&S asset inventory and the M&S IP inventory. The draft Strategic Plan is also provided as an attachment to this report.

Process

The TEAM used a list of objectives, issues and sub-issues to guide study data collection and analyses, and also to frame the report findings. Data for this study was collected, inventoried, and analyzed at both Commonwealth and regional levels. There were ten regions designated for this report, based partly on the divisions of the Technology Councils in Virginia. Regional divisions are only intended as a method to enable identification analysis and reporting.

A meta-analysis was first conducted to provide a baseline for the economic and workforce analyses, and used to refine focus group and survey questions. Next, the regional business survey and focus group interviews captured industry opinion, and provided M&S asset and IP data. Fourteen focus groups were held across ten Commonwealth regions. The regional business survey was administered online, and 20% of the identified M&S assets responded to emailed invitations and responded to the survey.

The TEAM used scenario-based M&S profiles to complete the economic and workforce analyses, and leveraged data from the US Bureau of Labor Statistics as well as national industry data and crosswalks to build them. Commonwealth and regional economic and workforce analyses were conducted using IMPLAN Version 3 software.

The draft Strategic Plan was developed in collaboration with the Governor's Modeling and Simulation Council (MSAC), based on study data and findings, as well as input from stakeholders via the focus groups and survey.

Findings

Growth for Virginia's M&S industry will require continued success in its expansion into varied diverse markets beyond its longstanding DoD roots. A business model reorientation may be required for some businesses. A steady stream of skilled M&S workers will be needed. Increased

collaboration among Virginia's M&S assets will be the key to leveraging M&S strengths across the Commonwealth and promoting economic growth in each region.

Four hundred and forty-nine M&S assets were identified across Virginia. These included 325 businesses, 59 laboratory/research organizations, 41 educational organizations, 19 healthcare organizations (including both provider and training organizations), and five DoD organizations. Ninety-six of the assets participated in the business survey. Nineteen percent of survey respondents reported that M&S production accounted for over fifty percent of their annual budgets. M&S businesses responding to the survey were primarily small businesses, with over one-third reporting annual revenues of less than one million dollars. The workforce analysis showed that an estimated 11,650 to 17,000 skilled technical employees engage directly in M&S production, research, or teaching across the Commonwealth. This activity accounts for an estimated contribution of \$44 to \$66 billion to Virginia's Gross Regional Product (GRP).

The health and medical market was identified as experiencing current rapid growth for M&S. Markets identified as targets for expansion by stakeholders include:

- Emergency Disaster
- Utilities
- Health Wellness
- Agriculture
- Natural Resources
- Logistics
- Strategy Policy Planning
- Architecture
- Energy
- Environment
- Medical Technology
- Security
- Data Infometrics
- Meteorology
- Electrical

Study participants would like the Commonwealth to take an active role in facilitating businesses expansion to a more diverse marketplace. Key impediments identified were lack of stakeholder coordination which has limited M&S-based collaboration, and also lack of pivotal leader or organization to facilitate networking which has resulted in unrealized opportunities for growth.

Stakeholders in numerous regions called for locally-based, accessible M&S leadership to promote M&S networking and promote its use within their own regions, and also a key figure at the Commonwealth level to promote inter-regional networking. They hope that fostering effective regional networks and partnerships will provide access to venture capital for start-up businesses and thereby promote innovation. They want commercialization support, and help in identifying new customers, markets and opportunities outside of the DoD.

Stakeholders would like the Commonwealth to use M&S in its own projects when possible. They strongly agreed that there should be an equal emphasis on the existing M&S capabilities and opportunities across all regions of the Commonwealth. They see a need for the Commonwealth to take action in promoting and enabling collaboration between academia and industry. Many desire the use of tax incentives to attract new businesses and material suppliers to Virginia.

Study participants cited the need for programs and projects to support M&S. They want to set standards for M&S and vet new developments through Centers of Excellence and technology incubators and accelerators. They believe that investment in laboratories will promote research. Study participants would also like the Commonwealth to improve access to high performance computing and data centers not only to promote growth but to be able to handle technical support requirements once growth occurs.

Study participants emphasize that the future workforce should be cross-disciplined. Employees will need an understanding of both the science and the business needs of industry clients and their M&S products and/or services.

Regionally, the foothold of M&S varies. Some regions demonstrated the need to establish an M&S capable workforce and industry; others already have a trained workforce but need industry to utilize it. Some have industry in place with M&S requirements but there are not enough skilled workers in the region to meet specific needs.

Study participants assert that there is a lack of awareness about M&S products and services that are available within Virginia, and a lack of understanding about the untapped potential uses for M&S. Promotion of awareness of M&S will be necessary to inform the general public, potential customers, practitioners in different disciplines, and policy makers.

Outcome

Comprehensive data, analytic findings, and recommendations are presented in this report. These were leveraged to draft a Strategic Plan to grow M&S in the Commonwealth. The plan identifies and guides the implementation of specific strategic goals, objectives, and steps to leverage existing M&S and promote growth and expansion of the M&S industry.

Recommended goals and objectives within the Strategic Plan draft are aimed at improving the economic impact of Virginia's M&S Industry.

1. Goal 1: Increase Virginia's Investment in the M&S Community
2. Goal 2: Increase Inter-and Intra-Regional M&S Community Collaboration
3. Goal 3: Strengthen M&S Community Leadership and Awareness Within the Commonwealth
4. Goal 4: Raise Visibility of the M&S Community Outside the Commonwealth.
5. Goal 5: Enable a Healthy (Skilled and Available) M&S Workforce

These goals are discussed in depth in the draft Strategic Plan.

1 Introduction

MYMIC, LLC (MYMIC) and The ASTA Group, LLC (ASTA) are pleased to submit this report to the Commonwealth of Virginia in fulfillment of contract number Request For Proposal (RFP) 127-1-23-13, for the *Analysis of Modeling & Simulation in Virginia*. MYMIC and ASTA are referred to as the TEAM in this report. The TEAM has leveraged data provided by Commonwealth M&S stakeholders and from a variety of sources to inform this work, and complete this comprehensive analysis of M&S in the Commonwealth.

1.1 Study Objectives

This study provides the Commonwealth and its stakeholders with comprehensive analysis of M&S in Virginia. The analysis was informed by multiple perspectives, and included M&S stakeholders across the Commonwealth. The study was undertaken to provide analysis of the M&S workforce and its economic impact on both a comprehensive (Commonwealth-wide) level, and also a regional level. Profiles of Virginia's M&S industry, workforce, and economy are presented on both levels in this report. M&S assets and Intellectual Property (IP) were inventoried as part of this effort. They are included as attachments to this report.

Comprehensive study data and findings were leveraged to draft a Strategic Plan for M&S growth in the Commonwealth. The information presented in this report can also be used to guide stakeholders in leveraging M&S capabilities across the Commonwealth.

1.2 Study Definitions

The following definitions and assumptions were used by the TEAM to scope this effort. They were developed based on guidance provided by the Governor's Modeling and Simulation Advisory Council (MSAC) and industry standards, along with consideration of previously, published reports and objectives particular to this effort. These definitions were reviewed, modified, and approved for use in this study and all related reports by the MSAC.

Study definitions include the following:

A **Model** is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon or process.¹²³⁴

Simulation is a methodology for extracting information from a model by observing the behavior of the model as it is executed⁵ and a method of implementing a model of time.⁶

¹ From the "Proposal to add North American Industry Classification System (NAICS) Code for the Modeling and Simulation Industry" submitted to the Department of Defense by the National Training and Simulation Association (NTSA), Society for Modeling and Simulation International, Simulation Interoperability Standards Organization, National Center for Simulation, Alabama Modeling and Simulation Council, New England Modeling & Simulation Consortium, Mid-Atlantic Institute for Simulation and Analysis, and the Virginia Modeling, Analysis and Simulation Center (VMASC) on April 22, 2009.

² DoD Modeling & Simulation Glossary, January 1998.

³ Hampton Roads Planning District Commission (HRPDC), VMASC & Angle Technology (2005). The Hampton Roads Economy, Analysis and Strategies – Part 3: The Modeling, Simulation, & Visualization Cluster

⁴ Angle Technology (2007). The Economic Impact of Modeling, Simulation and Visualization in Hampton Roads

⁵ HRPDC, VMASC & Angle Technology, op. cit, and Angle Technology, op. cit.

⁶ DoD, op. cit.

Visualization is a methodology for using visual models and interactive visual environments to extract information from data.⁷

Models and simulations are representations of real systems, and may be physical, procedural or phenomenological, typically implemented on a digital computer with input(s) and output(s).⁸

Modeling and simulation (M&S) refers to the process of developing a model and then applying simulation to extract information concerning it. Visualization is often used to enhance the user's ability to understand, interpret, and interact with the data associated with M&S.⁹

Modeling Simulation & Visualization organizations are organizations that develop the tools and technologies, provide modeling, simulation, and visualization services, or use modeling, simulation, and visualization services or products.¹⁰

The M&S marketplace is conceptualized as the market sector that is affected by M&S, including the users as well as the industry and assets.

M&S industry is defined as collectively, the M&S organizations and workforce (including producers, suppliers, customers, and training organizations) engaged directly in the development, production, research, and training of the provision of M&S services and/or products. It is a subset of the M&S marketplace that includes M&S product and service sellers and supporting elements (e.g., suppliers and available workforce). This definition and classification is based on the definitions preceding, the needs of this particular study, and MSAC guidance.

M&S assets are the central core of the M&S industry. M&S assets include those entities, products, and holdings that contribute to the local, regional and Commonwealth-wide economy through their development, production, research, and/or delivery of M&S services and/or products. Essentially, assets are a subset of industry that only includes the sellers and their value (e.g., real estate, intellectual property, employed workforce).

Intellectual property (IP) encompasses a variety of rights that can be claimed by individuals or entities. For purposes of this study, these rights include copyrights, patents, and trademarks. IP, such as trade secrets, would not be sharable information and thus are not addressed in this report.

The M&S workforce is the labor pool engaged in the development, production, research and/or delivery of M&S products and/or services, as well as the training of M&S skills within formal academic environments.

1.3 Study Assumptions

This study assumes the validity of Impact Analysis for PLANning (IMPLAN) data, United States (US) Bureau of Labor Statistic (BLS) data, and the employment to industry alignment and data provided in information from the National Crosswalk Service Center (NCSC). Scenario-based M&S profiles for economic and workforce analyses were used to complete the economic and workforce analyses. Scenario development and the analytic processes used are described in Sections 2.6 and 2.7.

⁷ HRPDC, VMASC & Angle, op. cit.

⁸ DoD, op. cit.

⁹ HRPDC, VMASC & Angle Technology, op. cit, and Angle Technology, op. cit.

¹⁰ HRPDC, VMASC & Angle Technology, op. cit, and Angle Technology, op. cit.

2 Technical Approach

Multiple data sources and processes informed the work. Both existing data and new data were used. Stakeholders provided information across the Commonwealth through participation in a web-administered survey and fourteen focus group interviews.

The TEAM used a list of objectives, issues and sub-issues to guide study data collection and analyses, and also to frame the report findings. Data for this study was collected, inventoried, and analyzed at both Commonwealth and regional levels. There were ten regions designated for this report, based partly on the divisions of the Technology Councils in Virginia. Regional divisions are only intended as a method to enable identification analysis and reporting.

A meta-analysis was first conducted to provide a baseline for the economic and workforce analyses, and used to refine focus group and survey questions. A bibliography of these data sources is documented in Section 6. Input from the Commonwealth and stakeholders identified specific documents for use in the meta-analysis.

Next, the regional business survey and focus group interviews captured information and expert industry opinion. Fourteen focus groups across ten regions in the Commonwealth were held and a web-based survey was administered with a response rate of 20%.

Information from the focus groups, survey, and meta-analysis was used to build the asset and IP inventory. We identified, catalogued, and produced a database inventory of M&S assets, users, and IP. (See Attachments 2 and 3 for the Asset Inventory and IP Inventory, respectively.)

The TEAM used scenario-based M&S profiles to complete the economic and workforce analyses, and leveraged data from the US Bureau of Labor Statistics as well as national industry data and crosswalks to build them. Commonwealth and regional economic and workforce analyses were conducted using IMPLAN Version 3 software. Findings from all activities informed recommendations and drove development of study conclusions.

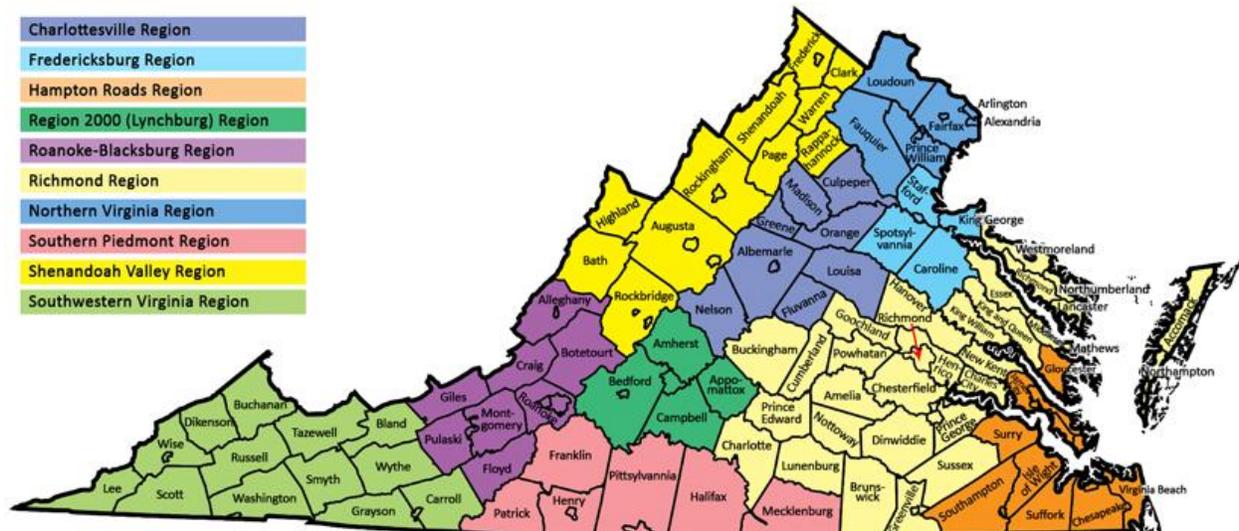
The draft Strategic Plan leveraged the findings and conclusions resulting from the activities described above. Through collaboration with the Governor's Modeling and Simulation Council (MSAC) the goals, objectives, and steps of the plan were developed and refined.

2.1 Regions Used for Analysis

Data was collected, inventoried, and analyzed at both the Commonwealth (state-wide) and regional level. Regional divisions were based on those of existing Commonwealth Technology Councils; however, some counties and independent cities in the Commonwealth were unclaimed by any of the existing Technology Councils. These unclaimed areas were assigned to councils based primarily on their proximity to an existing Technology Council. Specific counties and independent cities comprising each region are listed in Appendix A, Section 7.

The Technology Councils and regional assignments (made for purposes of this study) are defined and depicted in Figure 2-1, following.

Figure 2-1: Ten Virginia Regions Used in this Study



2.2 Study and Report Approach

A list of objectives, issues and sub-issues was developed based on stakeholder input using the SO2 process.¹¹ The list drove study data collection and framed findings. Key issues were identified in question form to support objectives; these were then decomposed into sub-issues; finally, questions were formulated to address sub-issues. The study objective, issues, and sub-issues were vetted by the customer during this process. For the complete SO2 framework and questions, see Appendix D – SO2 Framework, Section 10.

2.3 Approach to the M&S Asset and IP Inventory

The M&S Asset Inventory created during this study is a listing of over 400 assets within the Commonwealth. It is provided as Attachment 2 of this document. To produce the inventory, the TEAM identified and catalogued all M&S assets. The inventory also includes IP held by the assets. IP information was extracted as a sub-set of the asset data. The IP Inventory is provided as a separate attachment, Attachment 3. Both are constructed in Microsoft Excel®.

The process of identifying, sorting, cataloging, and verifying assets was an ongoing effort throughout the project. The initial inventory was conducted by accumulating contacts identified in professional association membership lists, vendor lists, conference registrations, and published reports. The TEAM provided draft versions of the inventory to the customer throughout the course of the project with a request to review and amend the list with other assets known to them. These exchanges provided valuable collaboration and information, and ensured production of an inventory in accordance with customer expectations. Focus group participants also identified additional assets in their region.

¹¹ Mastaglio, T.W. and Jones, P. (2007).

2.4 Stakeholder Participation

The TEAM conducted this study in collaboration with the Commonwealth and stakeholders to provide a voice to all participants, and to ensure that expectations were met with final products. Stakeholders provided primary data by participating in focus groups for their regions and by identifying assets and users. Stakeholders also facilitated the conduct of data collection by identifying industry points of contact, other survey and focus group participants, and by locating venues in which to conduct data collection.

2.4.1 Modeling and Simulation Advisory Council (MSAC) Meetings

Meetings were held with the Virginia Governor’s MSAC in Richmond throughout this study. The initial meeting served to gain consensus on study definitions and parameters. Follow-up meetings provided opportunities to discuss data collected, findings, and strategic plan recommendations. These collaborative meetings were used to develop consensus on study direction and progress, communicate interim findings, and discuss strategic goals and objectives. Meetings and their purpose are documented in Table 2-2.

Table 2-1: MSAC, Customer, and Contractor Meeting Collaboration

Meeting #	Date	Purpose
#1	07 May 2013	Presentation of Study Objectives and SO2 Issues, and Technical approach
#2	29 August 2013	Preliminary findings presented and draft strategic plan discussed
#3	15 October 2013	Strategic Planning discussion
#4	13 December 2013	Final Out-brief and discussion

2.4.2 Approach to Focus Groups and Stakeholder Interviews

Focus groups provided multiple perspectives on study topics and contributed to the formation of ideas for potential actions and solutions. Fourteen semi-structured focus groups across the ten study regions were conducted, with sixty-eight key stakeholders from the M&S community participating. Participants were identified from the asset inventory and through input from the Commonwealth MSAC and other stakeholders.

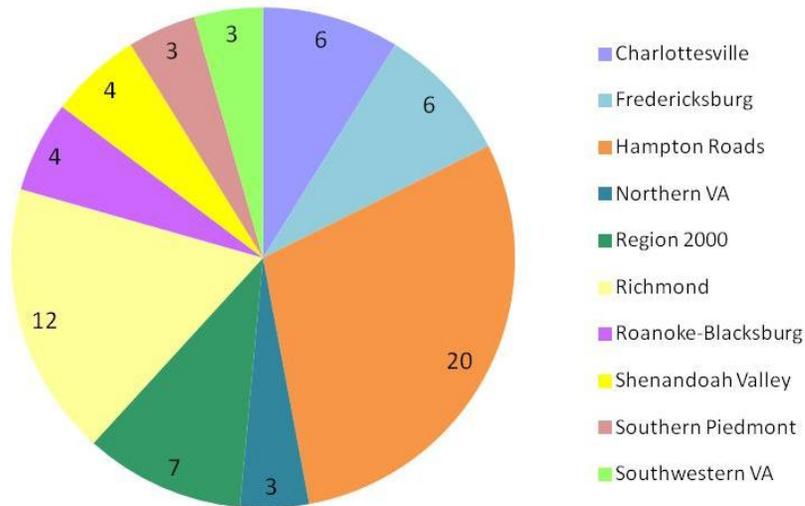
Focus groups were conducted from 08 to 19 July 2013. Each session was approximately ninety minutes in length. Participants were provided with information about the project purpose and goals, and asked to sign a consent form. This form is provided in Appendix C – Focus Group Consent Form of this report. There were two researchers present during each session. Sessions were recorded by the research team members, both through handwritten notes and audio recordings. Focus groups were conducted without attribution to individual participants.

In addition to the invaluable input and data, these focus groups also served to provide a valuable forum for participants to connect, vet ideas, and develop a collaborative M&S network. In some regions, no network existed previously and next connections were established as a result of focus group attendance.

Five to seven attendees were requested for each focus group session. In some instances regions had fewer participants per session. In the Hampton Roads and Richmond Regions, there were higher numbers of participants who wanted to attend sessions. Two sessions in each of these regions were held to accommodate participants and still keep the session number limited.

The distribution of focus group participants by study regions is presented in Figure 2-2.

Figure 2-2: Focus Group Participant Distribution by Study Regions
Focus Group Distribution



2.4.3 Regional Business Survey Approach

A web-based survey, developed based on questions identified through the SO2 process and Statement of Work (SOW) requirements, was administered to all M&S assets and users in the comprehensive asset inventory as of 23 July 2013. Survey invitations and weekly reminders were sent via email. An open invitation and link to the survey was also posted on MODSIM Connected.¹² The survey opened 24 July 2013 and closed 12 August 2013.

Survey questions consisted of both open-ended text and selection set responses. The survey had a 20% response rate—104 responses. (There were 102 responses from the emailed invitation and two responses through the MODSIM Connected website link.) The collected data (response sets) were reviewed for face validity and duplication. Data from two of the responses was deemed invalid¹³ while data from six responses was duplicated¹⁴ (i.e. two responses from the same organization). These eight responses were *retained* for review of their open-ended opinion-based

¹² See <http://modsimconnected.com>.

¹³ Two invalid response sets were identified. One response set was from a non-Virginia organization. A second response set clearly represented the organization's mission rather than reflecting the actual organization. These two response sets were removed for *only* quantitative responses so they would not skew the quantitative analyses. Both responses were retained for open-ended, opinion-based responses.

¹⁴ Six duplicate response sets were identified. Responses were deemed duplicate if more than one response was received from the same organization and, if provided, the same division. For example, two responses from the Computer Science Department within a university would be deemed duplicate; two responses from different departments within the same university would *not* be duplicates. One set of duplicate responses was retained for the quantitative analyses. Priority was given to the more complete response. Duplicate open-ended, opinion-based responses were retained for open-ended responses.

responses, but *removed* for quantitative responses. This left 96 quantitative responses for analysis.

Table 2-2 presents the distribution of survey respondents by organization type. Duplicate and invalid responses are excluded.

Table 2-2: Survey Respondents by Organization Type

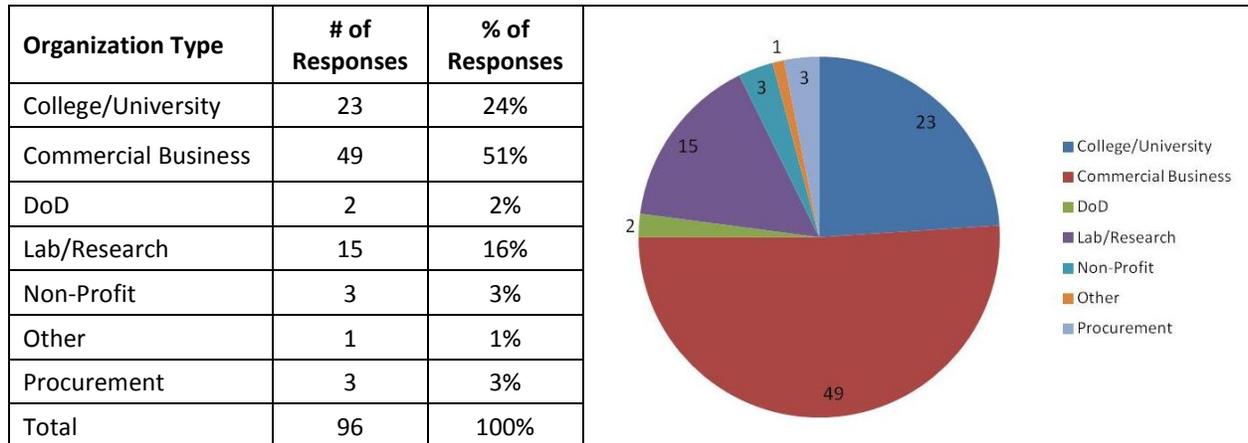
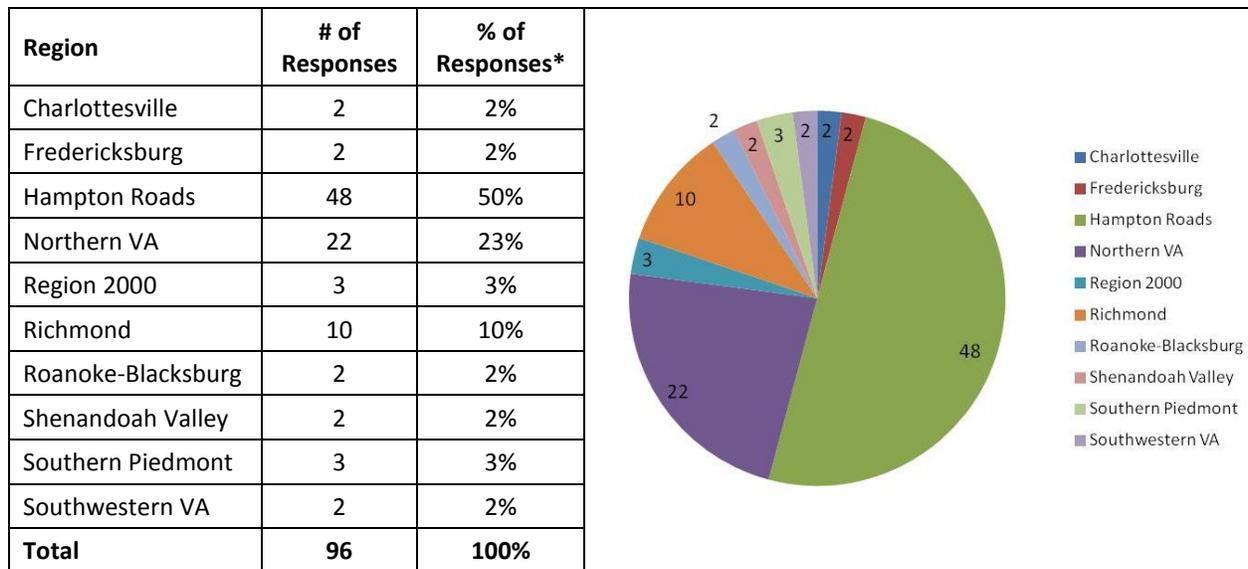


Table 2-3 presents the distribution of survey respondents by region. Duplicate and invalid responses are excluded.

Table 2-3: Survey Respondents by Region



*rounded to nearest whole number

Following data capture, analysis was conducted to identify emergent themes, comparing the information among regions and across the Commonwealth. This information was used in conjunction with other project data to inform findings and recommendations.

A copy of the survey is provided in Attachment 4. Data was reported and analyzed using Microsoft® Excel®. Findings are presented in Sections 3 and 4.

2.5 Meta-Analysis Approach

A list of documents to include in the meta-analysis was determined through a series of collaborative exchanges with MSAC members. The final list included:

- Hampton Roads Planning District Commission, Virginia Modeling and Simulation Council, & Angle Technology (2005). The Hampton Roads Economy, Analysis and Strategies – Part 3: The Modeling, Simulation, & Visualization Cluster
- Angle Technology (2007). The Economic Impact of Modeling, Simulation and Visualization in Hampton Roads
- Commonwealth IT Investment Board (2006). Commonwealth of Virginia Strategic Plan for Information Technology 2007-2011
- Virginia Modeling and Simulation Council (VMASC) / Hampton Roads Partnership (2010). Hampton Roads Strategy 2020
- CIT (2011). Commonwealth Research and Technology (R&T) Strategic Roadmap
- Chmura Economics & Analytics (2012). Modeling and Simulation in Hampton Roads
- Chmura Economics & Analytics (2012). Transforming through Innovative Leadership (TIL)
- Old Dominion University (ODU) Regional Studies Institute (2012). The State of the Region – Hampton Roads 2012
- The Governor’s MSAC (2013). Memo on recommendations of the Governor’s MSAC

Information was compared and contrasted from each of the documents above. To accomplish the meta-analysis, the TEAM extracted information and organized it into areas of common themes included across the documents. Any findings that could address items in the SO2 framework were compared. Meta-analysis findings are presented in Section 3.1.

2.6 Economic Analysis Approach

Commonwealth and regional economic and workforce analyses were facilitated with IMPLAN Version 3 software and data.¹⁵ The IMPLAN system is a general input-output model comprised of software and regional data sets. It measures economic impacts from data representing actual local economies and tracks all available industry groups in every level of the regional data, permitting detailed impact breakdowns. The TEAM used the 2011 IMPLAN State Package for Virginia¹⁶ to conduct the economic impact analyses. State Packages provided the ability to break the Commonwealth down into the 10 study regions for this study, and render state totals.

The TEAM developed an M&S industry profile by aligning IMPLAN sectors with NAICS codes.¹⁷ NAICS codes were selected based on industry standards, stakeholder input, and meta-analysis findings. Selected codes were matched to IMPLAN sector codes, and survey information was used to further refine the industries included in the profile. The resulting set, including core and related sector codes, defined the M&S industry used by the TEAM.

¹⁵ See <http://implan.com>. IMPLAN software © 2012 IMPLAN Group LLC.

¹⁶ This was the most recent package available.

¹⁷ No standard industry code or profile exists for M&S. Note that there was not one individual IMPLAN sector code assigned to every one of the thousands of NAICS codes; rather, some of the NAICS codes, which IMPLAN sectors align with, are broadly encompassing (i.e., larger industry) codes instead of NAICS subset codes.

The set of IMPLAN sector and coinciding NAICS codes included in the final profile are listed in Table 2-4.

Table 2-4: M&S Industry defined by IMPLAN Sector Codes and Corresponding NAICS Codes

IMPLAN Sector	IMPLAN Description	2007 NAICS Codes
345 (Core)	Software Publishers	51121
371 (Core)	Custom computer programming services	541511
372 (Core)	Computer systems design services	541512
374 (Core)	Management, scientific, and technical consulting services	54161, 5613
376 (Core)	Scientific research and development services	5417
380 (Core)	All other miscellaneous professional, scientific, and technical services	54191, 54193, 54199
133 (Related)	Pharmaceutical preparation (added post survey)	325412
213 (Related)	Other commercial and service industry machinery manufacturing	333319
290 (Related)	Ship building and repairing	336611
351 (Related)	Telecommunications	517
353 (Related)	Other information services	51911-2
369 (Related)	Architectural, engineering, and related services	5413
373 (Related)	Other computer related services, including facilities management	541513, 541519
393 (Related)	Other educational services	6114-7
397 (Related)	Hospitals	622

Since the economic data reflected all industry values, and not just M&S activity, scenarios had to be developed to estimate the proportion of only the M&S activity within each sector. These scenarios were developed based on meta-analysis findings and expert opinion.

Three separate scenario weights were determined for each of the ten study regions using the core and related IMPLAN sectors shown in Table 2-4. (The ten study regions were defined in Figure 2-1 previously). To account for the impact of Hampton Roads having a greater proportion of M&S activity than other regions, separate scenarios were developed to represent more accurately the proportion of M&S activity for Hampton Roads and other regions.

Table 2-5 presents the three scenario weights used for Hampton Roads and all other regions.

Table 2-5: Economic and Workforce Analysis Scenario Weights

Scenario	Hampton Roads Region		All Other Regions	
	Core Sectors	Related Sectors	Core Sectors	Related Sectors
Scenario 1 weights	15%	3%	1%	1%
Scenario 2 weights	20%	3%	1.5%	1%
Scenario 3 weights	25%	3%	2%	1%

2.7 Workforce Analysis Approach

The workforce analysis was also facilitated by the use of the IMPLAN data. For the purpose of this study, the M&S workforce is defined as a set of occupations. This list was initially compiled based on meta-analysis information. The list was refined in order to focus analysis on M&S activity specifically. Following is the list of occupations included in the workforce analysis:

1. Architecture and Engineering Occupations
2. Computer and Information Research Scientists
3. Computer and Information Systems Managers
4. Computer and Mathematical Occupations
5. Computer Control Programmers and Operators
6. Computer Hardware Engineers
7. Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic
8. Computer Occupations
9. Computer Occupations, All Other
10. Computer Operators
11. Computer Programmers
12. Computer Support Specialists
13. Computer Systems Analysts
14. Computer, Engineering, and Science Occupations
15. Computer-Controlled Machine Tool Operators, Metal and Plastic
16. Database and Systems Administrators and Network Architects
17. Engineers, All Other
18. Information Security Analysts, Web Developers, and Computer Network Arch
19. Network and Computer Systems Administrators
20. Software Developers and Programmers
21. Software Developers, Applications
22. Software Developers, Systems Software

To perform the analysis, the TEAM first aligned labor category data from the US Bureau of Labor Statistics (BLS) with IMPLAN sectors using the occupation to industry alignment provided by The National Crosswalk Service Center (NCSC)¹⁸. The resulting alignment provided the total 2011 employment and employment by each occupation for each industry, as well as projected replacement rates and employment change (i.e., growth or contraction) for each occupation from 2011 through 2020. These distributions and calculations determined the total employment for each of the fifteen sectors (see Table 2-4) that define the M&S Industry.

The TEAM next estimated M&S-specific employment (i.e., sector employment of M&S-related occupations) within the broader industry sectors. Given the availability of data for the Hampton Roads Region and the State Total in meta-analysis sources, the TEAM used this regional data as a basis of comparison to estimate state-wide employment totals.

¹⁸ The IMPLAN to BLS industry is not a 1:1 relationship for all codes. Occupations were assigned to the sector most applicable.

Based on previous studies (see Table 3-3), the total number of M&S employment increased from 3,524 in 2004 to over 5,000 in 2010 in Hampton Roads.¹⁹ A 2012 study estimated the total employment number in the M&S industry to be 4,800-10,000 for the Hampton Roads Region.²⁰ For the Commonwealth of Virginia, the estimated total ranged from 13,847²¹ to 14,100²² in 2012. These values were used to estimate the proportion of M&S-specific employment within the industry sectors. This proportion was then applied across all regional data.

The estimated number of new employment totals was calculated by multiplying the number of M&S employment by the annual percentage increase as determined by previous estimate analysis. Based on the projected replacement rates and employment change for each IMPLAN sector from 2010 through 2020, the TEAM was able to derive an annual percentage increase in each IMPLAN sector. The number of new employment totals in 2013 and 2020, calculated in the workforce analysis, was used to perform the Economic Impact Analysis of employees for all ten regions and Virginia as a whole.

Quality of Life (QOL) indicators were next identified. Qualitative information regarding these indicators informed analyses regarding regional business environment, particularly those related to workforce recruitment and retention. Specifically, survey respondents were asked which of the following QOL indicators negatively impacted the recruitment or retention of employees:

- Limited K-12 Education Opportunities
- Limited Access to Healthcare
- Transportation
- Limited Recreational Opportunities
- Affordable Housing
- Other (open-ended response question)

¹⁹ VMASC/Hampton Roads Partnership, 2010.

²⁰ ODU Regional Studies Institute, 2012.

²¹ Chmura Analytics, 2012.

²² ODU Regional Studies Institute, 2012.

3 Virginia Findings

Study findings begin with those of the Meta-Analysis in Section 3.1. Sections 3.2 – 3.5 present new findings for the entire Commonwealth. Section 4 presents region-specific findings.

3.1 Meta-Analysis Findings

The Meta-Analysis provided baseline information to guide many other aspects of this study. Section 2.5, *Meta-Analysis Approach* (previously) includes the list of documents used for the meta-analysis. Table 3-1 summarizes topic areas and information extracted from each document for this study. An “X” in the cell indicates information was found and used to inform this study.

Table 3-1: Meta-Analysis Document Topic Areas

Report/Document Producer and Year Published	HRPDC & Angle Technology, 2005	Commonwealth IT Investment Board, 2006	Angle Technology, 2007	VMASC / Hampton Roads, 2010	CIT, 2011	Chmura Economics & Analytics, 2012	Chmura TIL, 2012	ODU, Regional Studies Institute , 2012	VA MSAC , 2013
Hampton Roads Specific	x		x	x		x	x	x	
Workforce Gaps/Needs	x	x	x			x	x		
Workforce Goals/Recommendations	x	x				x	x		x
Workforce Data and Definitions			x			x			
Industry Gaps/Needs	x	x			x	x	x	x	x
Industry Development Recommendations	x	x			x	x	x	x	
Emerging Areas Identified	x	x	x	x	x	x	x		
Business Climate and Business Incentives Identified		x		x	x	x			x
IP Identified						x			
Marketing Gaps/Needs							x		x
Marketing Goals/Recommendations	x			x			x		x
K-12 Education Recommendations/Goals	x			x	x				
College / University Gaps/Needs	x			x		x	x		
College / University Recommendations/Goals				x					
Partnership Recommendations in Education				x					
Workforce Training Gaps/Needs						x	x		
Workforce Training Goals/Recommendations	x								
Technology / Infrastructure Gaps/Needs		x	x			x			
Leadership/Partnership/Enabling Organizations Gaps/Needs	x								
Leadership/Partnership/Enabling Organizations Goals	x			x			x		
Assumptions Provided	x		x			x			
NAICS Codes			x			x			
Data Included in the Report	x	x	X		x	x	x	x	

The TEAM examined the specific data and analysis strategies used in each report or study designated for inclusion in the meta-analysis. Table 3-2 summarizes this information.

Table 3-2: Data Sources and Report Analytic Strategies

Report and Data Sources	Report Analytic Strategies
HRPDC & Angle, 2005: The Hampton Roads Planning District Commission input the results of the survey conducted by ANGLE Technology, Inc., during the fall of 2004. Modeling software used was Regional Economic Models, Inc (REMI).	Impact estimates for existing industries and companies were generally estimated using counterfactual analysis, done. This assumes that each industry or company is leaving the area so all inputs are entered into software as negative values. The results show the impact of the loss of enterprise in the regional economy.
Commonwealth IT Investment Board, 2006: Focus group/survey opinions	Collaboration of 150 plus stakeholders during ongoing workshops and produced the strategic plan. The priorities, goals, and objectives in this report appear to coincide with information on opportunities for industry expansion. Only qualitative information was collected.
Angle Technology, 2007: Industry Survey	Survey Monkey results were combined and analyzed.
VMASC/Hampton Roads, 2010	Not detailed
CIT, 2011: the Climate / Capability Matrix compiled by Chmura Analytics	An iterative methodology was used to provide information from three perspectives, including the Commonwealth Innovation Index, economic development priorities, and leading and lagging indicators. An assessment of industry strengths and opportunities based on regional strategies was conducted and findings refined based on statewide economic development priorities. Identified industry sectors and subsectors were evaluated to identify favorable industry climate and capability metrics, based on a current snapshot of Virginia's workforce and business base.
Chmura, 2012: 1. Quarterly Census of Employment and Wages (QCEW) was used to collect data on past industry and wage growth and industry competitiveness (2011). 2. IMPLAN Pro® model 80 software, created by MIG, Inc., (2010). 3. Research and development data for national universities from the National Science Foundation (2004- 2009). 4. Federal contract data from U.S. General Services Administration's Federal Procurement database (2011). 5. Data on venture capital spending purchased from Thomson Reuters (2010).	Primary data was generated through an online survey, one-on-one interviews and focus groups. To assess the current condition of M&S secondary data was supplemented with primary data from a business survey. A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis synthesized both to provide baseline economic activity. Use of 4-digit NAICS codes to identify assets/baseline data. (Some assets identified as M&S through use of the NAICS codes did not consider themselves M&S companies.) QCEW and a business survey conducted by Chmura provided background data for the analysis of direct economic impact and employments for allied industries, respectively. Indirect and induced impacts on spending and job creation in the Hampton Roads Metropolitan Statistical Area for the identified M&S cluster were simulated using the IMPLAN software.
Chmura TIL, 2012: report on Modeling and Simulation in Hampton Roads, by Chmura Analytics and Economics, 2012 which used both primary (i.e., survey, focus group) and secondary data sources	A SWOT (see above) provided the baseline of M&S economic activity. From the baseline analysis, the TIL plan compared the infrastructure and capabilities of Hampton Roads' M&S assets to M&S assets and capabilities found in other M&S hubs. Employment by industry, occupations needed, education and training offerings were considered relative to the skills needed by the firms to identify gaps that need to be addressed in the strategic plan.
ODU Regional Studies Institute, 2012: The Virginia Economic Development Partnership	Not detailed
VA MSAC, 2013	Not detailed

3.1.1 Marketplace and Industry

Existing information about the M&S marketplace and industry was examined to inform study definitions and provide baseline data for the economic and workforce analyses; however direct comparison across all studies was complicated by variation in the analysis software used and metrics analyzed, as well as differences in definitions and terminology for the M&S Industry.²³ Methodology used in prior studies to define the M&S industry varied greatly, and revealed both the breadth of M&S across standard industries and the difficulty of defining the M&S industry in its own right. Because there are no set definitions or industry codes for M&S, profiles were woven together using data developed under other definitions, such as NAICS codes—the TEAM likewise used alignment and adjustment, discussed in sections 2.6 and 2.7 of this report.

Two studies²⁴ defined the M&S industry using the following 2007 NAICS codes:

1. Commercial and Service Industry Machinery Manufacturing (NAICS 3333)
2. Computer Systems Design and Related Services (NAICS 5415)
3. Scientific Research and Development (NAICS 5417)

Chmura 2012 further defined “allied” M&S industry. The following, additional codes were used to define the M&S Industry for their study and their resulting strategic plan:

- 334513 - Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
- 511210 - Software Publishers
- 541330 - Engineering Services
- 541511 - Custom Computer Programming Services
- 541512 - Computer Systems Design Services
- 541611 - Administrative Management and General Management Consulting Services
- 541618 - Other Management Consulting Services
- 541711 - Research and Development in Biotechnology
- 541712 - Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)
- 611210 - Junior Colleges
- 611310 - Colleges, Universities, and Professional Schools
- 813910 - Business Associations
- 927110 - Space Research and Technology

HRPDC & Angle Technology (2005) defined the following as key aspects of the M&S marketplace in Virginia:

- End Users: Government and Commercial organizations
- Tier 1 Service Providers: Prime Contractors
- Tier 2 M&S Developers: M&S software developers
- Tier 3 Enabling Technology Providers
- Facilitators: VMASC, Academia, small to medium enterprises, Trade Associations
- Resources: Unique facilities, ODU, labor force, other
- Infrastructure: Telecom, Power, Transportation, etc.

²³ An accurate picture of M&S in the Commonwealth can ultimately be achieved through consistency in effort scoping, analysis parameters, and dictated terminology in Statements of Work (SOWs) for future analysis efforts.

²⁴ Angle Technology, 2007 and Chmura Analytics, 2012.

Table 3-3 presents a comparison of growth indicators cited in these reports for the M&S industry as they defined it. Not every type of data was found in each study; “n/a” indicates that data is not available and/or provided in the report.

Table 3-3: Comparison of Growth Indicators Cited in Meta-Analysis Reports

Publisher	Angle, 2004	HRPDC & Angle, 2005	Angle, 2007	VMASC / HRP, 2010	ODU, 2012	Chmura, 2012	ODU, 2012
Year of data	2004	2004	2007	2007	Not stated	2012	n/a
# M&S employees/jobs	3,524	4,000	4,420	> 5,000	4,800* / 10,000**	13,947	14,100
Avg. salary/yr	60,212	n/a	82,733	83,000	n/a	73,436	n/a
Area analyzed	Hampton Roads / Hampton Roads Region						Virginia
Total M&S impact† in \$Million	n/a	n/a	n/a	639.5 “M&S Annual Impact”	364.0** “regional economic impact of the M&S industry”	n/a	1,700.0 “direct economic impact”
Total Output†† in \$Million	258.4	258.4 used Angle 2004 data	364.6	n/a	n/a	n/a	n/a
GRP††† \$Million	167.3 GRP in 2004 did not include exports and imports	248.0 reporting Angle 2004 data using the REMI 5.5 model	237.8	n/a	n/a	n/a	n/a
Software used, etc.	REMI ²⁵ Model Version 8.0 (constant 2000 dollars)	REMI Version 5.5	REMI Model Version 8.0 (constant 2000 dollars)	Cited unknown “Updated M&S Study”	Unstated report and sources	IMPLAN	Study cited VEDP data but no report specified

* VEDP data

**Unidentified 2007 study data

†Total Impact is not a single number reported by Angle and HRPDC, rather it is reported as a combination of 4 factors: Gross Regional Product (GRP), Total Employment, Total Output, and Avg. Annual Salary.

††Total Output = Durable Goods Manufacturing + Non-Durable Goods Manufacturing + Mining + Construction + Transportation & Public Utilities + Finance, Insurance, and Real Estate + Retail Trade + Wholesale Trade Services + Agriculture, Forestry, & Fishing Services + Government.

††† GRP = Total Consumption + Total Fixed Investment + Change in Business Inventories net Inventory Value Adjustment+ Miscellaneous + Exogenous Final Demand + Total Government + Total Exports + Total Imports.

A couple of notes about the previous table:

- *Hampton Roads Strategy 2020 and Recommendations of the Governor’s MSAC* were not included in the table because they did not include this type of information.

²⁵ Regional Economic Models, Inc., see <http://www.remi.com>.

- Chmura (2012) captures both the report and the Strategic Plan.
- Angle (2004) was not specified for inclusion in the meta-analysis; however, this data was discussed in HRPDC & Angle (2005) because the Hampton Roads Planning District Commission (HRPDC) used the survey information in Angle Technology, Inc. (2004) for its analysis, rendering numbers using two different versions of their analysis software.

Customers identified for the M&S industry in these existing documents were predominantly Government agencies, both within DoD (e.g., Army, Langley Air Force Base) and civilian agencies [e.g., National Oceanic and Atmospheric Agency (NOAA), US Geographical Survey (USGS)]. They also included private companies (e.g., Boeing, Lockheed Martin).²⁶ Private sector clients were concentrated within the Aerospace Product and Parts Manufacturing industry.²⁷

3.1.1.1 Growth Opportunities

The Meta-Analysis reviewed previously identified growth opportunities within the M&S industry. Opportunity industries outside of DoD included healthcare and private aerospace. Other industries identified as potential growth areas were intelligence, utilities, natural resources, social sciences, medicine and public safety. Specific opportunity areas and applications included biological, ecological and hydrological modeling of geospatial data, as well as retail, banking and finance, and telecommunications leveraging data management and data mining.

Potential growth areas identified across reports²⁸ included:

- Aerospace
- Cyber security
- Data mining
- Educational applications and tools
- Energy
- Environmental modeling, weather and climate
- Healthcare
- Homeland/National security/defense
- Infrastructure
- Logistics
- Manufacturing processes and manufacturing decision making
- Medical diagnostics and medical
- Remote monitoring and remote sensing
- Transportation/traffic

Additional areas cited for growth in earlier reports²⁹ included advanced materials manufacturing, emergency/hazard/ biohazard simulations and intelligence, weapons, Unmanned Air Vehicles (UAVs), and Live, Virtual, and Constructive (LVC) training. Key elements identified to support Virginia government business decisions were geospatial technology, data management applications, and data mining technology and applications.³⁰

Healthcare and aerospace/aviation are expected to experience significant growth in the Hampton Roads Metropolitan Statistical Area (MSA) into 2020, with the private aerospace industry expected to be a particularly strong market.³¹ Foreign markets, in general, were identified as

²⁶ HRPDC & Angle Technology, 2005.

²⁷ Chmura Analytics, 2012.

²⁸ Angle Technology, 2005; HRPDC & Angle Technology 2006; Angle Technology, 2007; VMASC/Hampton Roads Partnership, 2010; CIT, 2011; Chmura Economics and Analytics, 2012; ODU, 2012.

²⁹ Angle Technology, 2005; HRPDC & Angle Technology 2006; Angle Technology, 2007)

³⁰ Commonwealth IT Investment Board, 2006.

³¹ Chmura Economics and Analytics, 2012.

having potential for rapid growth. This was supported by the current focus group data.³² In 2005, the commercial market was identified as an untapped market.³³ According to focus group participants in the current study, this market is still underserved and underdeveloped.

3.1.1.2 M&S Industry Growth Factors

The meta-analysis indicates five primary factors that have influenced M&S industry growth over time. Current study data suggests these are still relevant for stakeholders today.

1. Standards, validation, certification, and accreditation of M&S tools.³⁴
2. Predominance of a large firm/government client business model. This was evidenced by the focus on government work as opposed to private sector projects³⁵ and the limited availability of R&D facilities to support private/public MS&V efforts.³⁶ This was also evidenced by the lack of a business development process for M&S entrepreneurs³⁷ and limited opportunities for small and medium enterprises across the MS&V cluster.³⁸
3. Venture capital availability for M&S in the Commonwealth. There has been a lack of focus on M&S in the entrepreneurial base despite its relative strength.³⁹
4. Information dissemination and communication. Stakeholders need more information about components, platforms, libraries, and SME availability.⁴⁰ Better communications about M&S stocks are needed for investors.⁴¹ The lack of regional level marketing messages⁴² and lack of a leader to espouse the marketing message⁴³ hinders growth.
5. Industry networking and leadership. The importance of this was a finding for the meta-analysis and the current study, where industry stakeholders reported of a lack of network and facilitative organizations.⁴⁴ Needs cited included more networking opportunities, particularly among private entities.⁴⁵ Leadership should function to promote M&S, organize stakeholders, foster collaboration, and facilitate partnerships. There has been, and remains, a need for defined industry leadership to promote M&S.⁴⁶

Though poor transportation infrastructure was cited as an impediment in some studies, the focal point of those investigations was Hampton Roads. In the current study, focus group opinions varied. Some participants in densely populated areas cited a need for transportation improvements, while others pointed out that traffic congestion in densely populated areas prompted companies to relocate to their own regions.

³² Chmura Analytics TIL, 2012.

³³ HRPDC & Angle Technology, 2005.

³⁴ Chmura Analytics, 2012.

³⁵ Chmura Analytics, 2012.

³⁶ HRPDC and Angle Technology, 2005.

³⁷ Chmura Analytics TIL, 2012.

³⁸ HRPDC and Angle Technology, 2005.

³⁹ Chmura Analytics, 2012.

⁴⁰ Chmura Analytics TIL, 2012.

⁴¹ Ibid.

⁴² Ibid.

⁴³ Ibid.

⁴⁴ Chmura Analytics, 2012 and Chmura Analytics TIL, 2012.

⁴⁵ Angle Technology, 2007.

⁴⁶ Chmura Analytics, 2012.

3.1.2 Workforce

In 2005, challenges for M&S included workforce training and development issues, availability of specialized training, and attracting a skilled workforce to the newly burgeoning M&S business sector in Hampton Roads. Mid-level operators, developers, mid-level analysts, engineers, architecture personnel, and general MS&V professionals with operational problem-solving experience were needed.⁴⁷ Studies completed by Angle in 2004 and 2007 indicated a significant concern with the lack of a trained labor force and support staff in Hampton Roads, with anywhere from 40-80 percent of respondents citing both as a problem.⁴⁸

In 2012, Chmura's Hampton Roads business survey showed that most businesses had no problems finding workers locally with the required technical knowledge; 64 percent of respondents to Chmura's business survey rated the supply (both quantity and quality) "above average to very good". Some respondents, though, desired job candidates with more *experience*. This finding was echoed in current data, in that candidates, while educated, lacked M&S skills specific to the industry they were being recruited into and had to be trained on the job.

Substantial growth in salaries of M&S employees has occurred, with private sector average wages increasing by 25 percent and public sector average wages increasing by 47 percent from 2004 to 2007 (Angle, 2007). Chmura (2012) reported that wages for their M&S core industry group were "more than double the statewide average for all industries" concluding that "the skills possessed by these workers are both rare and in high demand". The data may be reflecting the impact of an issue discussed in the Commonwealth's report, Commonwealth of Virginia Strategic Plan for Information Technology 2007-2011—that of a departing-experience base in the workforce due to employee retirement.⁴⁹

Despite salary growth, participants in the current study reported that wages were not keeping up with cost-of-living increases, particularly in Northern Virginia and Hampton Roads. The TEAM's collected data suggests that the DoD market emphasis, and the DoD emphasis on lowest price is making it more difficult to support experienced workers on DoD contracts. Contract prices do not support the wage required to employ highly experienced workers.

3.1.2.1 Training and Workforce Needs

The report by Chmura Analytics (2012) provided useful information on predicted workforce needs. Much of the reported information was echoed in focus groups conducted for the current study. Reported were needs for high-skilled/more experienced M&S engineers and developers⁵⁰ with growth in computer systems design, and architectural, engineering services predicted.⁵¹

⁴⁷ HRPDC & Angle Technology, 2005.

⁴⁸ The percentage of private sector survey respondents who moderately or strongly agreed that there was a lack of trained MS&V labor force in Hampton Roads in 2004 was 50%; in 2007, 60%. Public sector respondents noting a lack of trained MS&V labor force in Hampton Roads in 2004 was 80%; 2007--36%. The percentage of private sector survey respondents who moderately or strongly agreed that there was a lack of trained support staff in 2004 was 40%; in 2007--44%. Public sector respondents citing lack of support staff in 2004 were 80%. In 2007, 29%.

⁴⁹ The Commonwealth Investment Board 2006 report predicted significant knowledge loss and skilled labor shortages due to the retirement of "baby boom" workers.

⁵⁰ Chmura Analytics TIL, 2012.

⁵¹ Chmura Analytics, 2012, Figure 4-19.

Chmura Analytics (2012) determined which occupations would have the highest number of openings in the ten years following its analysis. M&S occupations with the highest projected annual openings from 2012 to 2022 included:⁵²

- Civil, industrial and mechanical engineers
- Chemists
- Medical scientists, except epidemiologists
- Biological technicians
- Computer programmers
- Computer systems analysts
- Network administrators
- Computer systems administrators
- Software developers, applications and systems
- Information security analysts
- Web developers and network architects

3.1.3 Recommendations for Proposed Actions and Investments

Recommendations for proposed actions and investments were extracted from the documents reviewed in the meta-analysis, and echoed in current study focus groups. These include, first and foremost, focusing on M&S market expansion beyond the DoD. Suggestions included medicine, transportation, and game-based learning.⁵³ Foreign markets might be identified through engineering, management, scientific, and technical consults for M&S solutions.⁵⁴ Secondly, increase regional networking by supporting and developing the activities of the many regional, economic development organizations.⁵⁵ Finally, develop and execute a strategic communications plan to expand the technology/vision base for decision support and other M&S applications.⁵⁶

3.1.3.1 Education

Many recommendations for K-12 education were identified. Most focused on developing an educational pathway from K-12, through graduate school, to employment and using studies to identify gaps, needs, and best practices being used in other MS&V hub areas.⁵⁷ Specific suggestions identified in the meta-analysis included the introduction of MS&V courses at the high school and community college level, perhaps aligning M&S curriculum offerings between high school and college programs.⁵⁸ One way to assess the effectiveness of these initiatives might be to track placement of students out of each degree level into employment.⁵⁹

3.1.3.2 Training

Regarding M&S workforce training, Chmura Analytics (2012) identified several areas wherein M&S growth would amplify workforce needs and produce worker shortages. These areas included education, energy, health, logistics, manufacturing, and medical.⁶⁰ Their findings also suggest that training should be provided in areas of architectural, engineering, and related services as well as computer systems design and related services.⁶¹ Additionally, Chmura (2012)

⁵² Chmura Analytics, 2012 using JobsEQ data. Period of projection uses the 2nd quarter of 2012 as a starting point.

⁵³ VMASC/Hampton Roads Partnership, 2010.

⁵⁴ Ibid.

⁵⁵ HRPDC & Angle Technology, 2005.

⁵⁶ VMASC/Hampton Roads Partnership, 2010.

⁵⁷ VMASC/Hampton Roads Partnership, 2010.

⁵⁸ HRPDC & Angle Technology, 2005; the VMASC/Hampton Roads Partnership, 2010; and CIT, 2011.

⁵⁹ VMASC/Hampton Roads Partnership, 2010.

⁶⁰ Chmura Analytics, 2012.

⁶¹ Ibid.

found that training concentrations for Commonwealth electrical and electronics engineers were 66% to 75% below the national average. They concluded that local, specialized courses could be developed to provide education and training to head off shortages in these areas.

Actions undertaken to address potential workforce shortages would be in line with identified state priorities, to ensure “an effective, skilled and productive workforce remains a priority for Virginia’s agencies.”⁶² In the current study, several participants pointed out the need for the inclusion of communications skills in M&S training to clarify exchanges regarding requirements and capabilities between parties. This recommendation was supported by meta-analysis findings in that Chmura, 2012 asserted that, “Developing effective simulations requires close communications between model builders and customers with operating experience.”⁶³

3.1.3.3 Marketing

Marketing Virginia’s M&S was a primary concern for stakeholders in the current study; meta-analysis findings support the assertion that M&S businesses need help marketing. In particular, previous studies found that vendors of M&S applications needed help to market their unique capabilities to other vertical domains⁶⁴ and that M&S lacked a marketing message and a common lexicon to inform these other markets.⁶⁵ The following marketing recommendations were made:

1. Brand the Commonwealth as the national M&S leader.⁶⁶
2. Develop a succinct, one-stop-shopping type, message and delegate a person or organization to lead the promotion effort and communicate the message.⁶⁷
3. Implement a strategic marketing communications plan.⁶⁸ This should:
 - Provide a strong linkage to STEM education, occupations, and industries.⁶⁹
 - Position M&S as a center of excellence in Virginia.⁷⁰
 - Provide a message with examples of how M&S can be used to perform tasks better, faster, and cheaper to demonstrate return on investment in the technology.⁷¹
 - Show how and why other industries use M&S.⁷²

3.1.3.4 Partnerships/ Enabling Networks

Partnerships and enabling networks were also a primary concern for stakeholders who participated in this study. The following meta-analysis recommendations agree with this finding:

1. Increase regional MS&V networking.⁷³
 - Start with existing organizations, industry affiliates, and study participants

⁶² Commonwealth IT Investment Board, 2006.

⁶³ Chmura Analytics, 2012.

⁶⁴ Ibid.

⁶⁵ Chmura Analytics TIL, 2012.

⁶⁶ VA MSAC, 2013

⁶⁷ Chmura Analytics TIL, 2012.

⁶⁸ VMASC/Hampton Roads Partnership, 2010.

⁶⁹ Chmura Analytics TIL, 2012.

⁷⁰ Ibid.

⁷¹ VMASC/Hampton Roads Partnership, 2010.

⁷² Ibid.

⁷³ HPRDC & Angle Technology, 2005.

2. Solicit industry, public and other private support.⁷⁴
 - Establish M&S laboratories in schools and develop internship and mentor programs.
3. Pursue non-DoD funding.
 - from federal and Commonwealth funding university-based M&S research⁷⁵
 - from the Department of Transportation and National Science Foundation⁷⁶
4. Use M&S tools and applications to manage Commonwealth projects, and programs.
 - Use M&S solutions in state/municipal projects to demonstrate the efficacy of the technology. (This was also recommended by participants in the current study.)
 - “Promote M&S to state government enterprises in order to benchmark common simulation frameworks for in state government. Maintain a leadership role in the technology adoption of M&S into state government operations.” (Chmura TIL, 2012)
 - Apply “decision support,” training, and analysis.⁷⁷

3.1.3.5 Technology Infrastructure

In 2004, about 24 percent of those surveyed by Angle Technology were concerned that the Commonwealth lacked technology infrastructure; by 2007, 45 percent were concerned.⁷⁸ The TEAM examined this potential issue as connectivity and speed capacity are vital for M&S growth. In 2005, the electronic infrastructure was cited as needing improvement.⁷⁹ In 2006, businesses were pleased with the progress made but growing use in work prompted concern.⁸⁰ Areas in the Isle of Wight, Suffolk, and Surry Counties lacked internet access in 2012.⁸¹ Focus group participants in the current study also reported a need for connectivity in rural areas.

3.1.4 Meta-Analysis Conclusions

The TEAM’s Meta-Analysis yielded several key findings leading to the following conclusions.

1. It is difficult to compare economic and workforce data without a consistent definition for the M&S Industry and a consistent set of labor and industry codes for analysis.
2. Some previously reported issues have been partially mitigated. Concern about workforce availability is waning, particularly in the urban areas. The recent emphasis on STEM education has improved the student pipeline into technical education. Rural broadband infrastructure coverage is improving, but still remains a concern.
3. Previously reported issues remain, including the need for diversification and expansion of the M&S marketplace and the need for regional partnerships and enablement of M&S networks. Also, Virginia’s M&S industry still lacks an effective promotional message.

⁷⁴ CIT, 2011.

⁷⁵ VMASC /Hampton Roads Partnership, 2010.

⁷⁶ Ibid.

⁷⁷ VMASC /Hampton Roads Partnership, 2010.

⁷⁸ Angle Technology, 2007.

⁷⁹ HPRDC & Angle Technology, 2005.

⁸⁰ Commonwealth IT Investment Board, 2006.

⁸¹ Chmura Analytics, 2012.

4. Obstacles to growth still exist. These include lack of industry leadership and lack of standards, accreditation and certification for tools and poor access to venture capital. An over-reliance on “big business – big customer” business models is still present.

3.2 Virginia M&S Challenges and Opportunities: Stakeholder Perspectives

It is clear that stakeholders seek Commonwealth guidance and assistance as they attempt to successfully grow the M&S industry, and reorient its focus on industry other than defense. Stakeholders also acknowledged that government cannot and should not be wholly responsible for the reorientation and spearheading growth of the industry M&S. As stakeholders are seeking new directions for M&S, it is unsurprising that they have numerous questions and concerns about the way forward.

Asset data is presented in this section, to provide better understanding of the profile of M&S in the Commonwealth. This information is followed by stakeholder input on the challenges faced regarding growth and reorientation of the M&S industry in section 3.2.2.

A synthesis of stakeholder ideas for initiatives and solutions to guide the way forward for M&S and leverage its diversity is presented in 3.2.3. In many instances these ideas are focused on Commonwealth actions and investments. Stakeholders are not devoid of ideas for private industry and investments, rather, in many regions, they are at the start of the process and require networking and enablement to further M&S.

3.2.1 Virginia’s M&S Asset Profile

Focus group participants consistently agreed that M&S will be a growth industry, that M&S applications are numerous and varied, and that M&S can be used in a wide variety of areas beyond defense. The varied industry applications, breadth of growth areas, and large occupation/employment profile found during the Meta-Analysis supports this perspective.

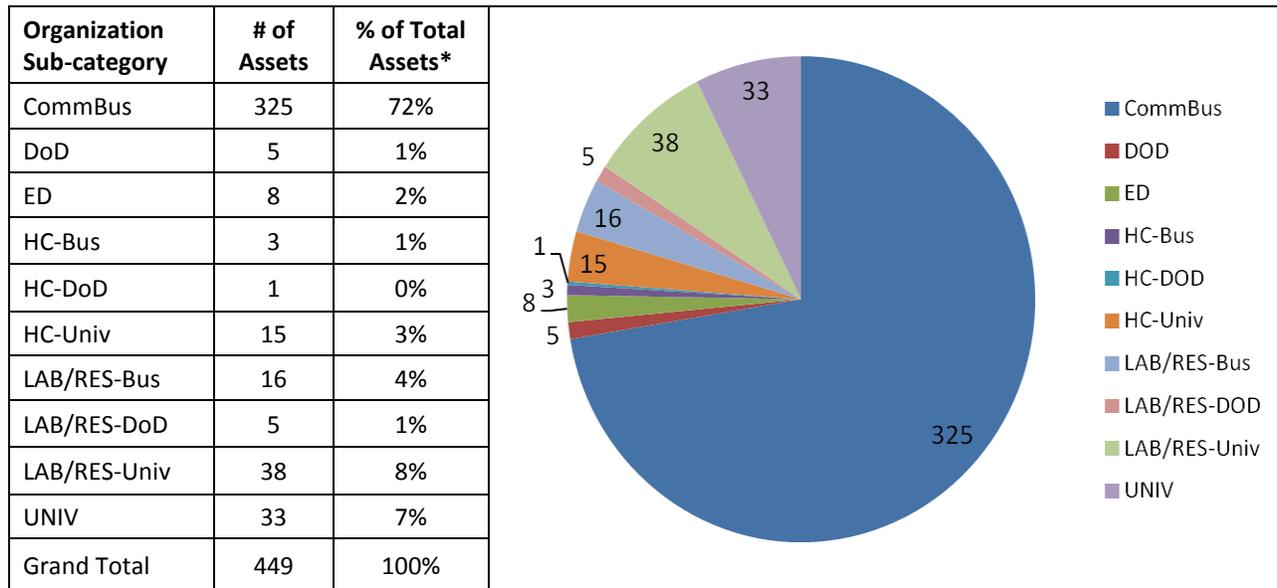
A total of 449 M&S assets were identified during the course of this study (see Section 2.3 for methodology). These assets are organized into six main categories, and ten sub-categories. Table 3-4 presents the asset categories and descriptions.

Table 3-4: Asset Categories and Descriptions

Category	Sub-Category	Description
Health Care (HC)	HC-Bus	Business focused on health (i.e., providing health care services)
	HC-DoD	DoD-based health care organization
	HC-Univ	University-based health care organization, typically providing HC training and/or HC services
Laboratory/Research (LAB/RES)	LAB/RES-Bus	Business based laboratory or research organization
	LAB/RES-DoD	DoD based laboratory or research organization
	LAB/RES-Univ	University based laboratory or research organization (includes community colleges)
Commercial Business (CommBus)	CommBus	Commercial businesses not otherwise specified
Department of Defense (DoD)	DoD	DoD not otherwise specific
University (UNIV)	UNIV	University or college not otherwise specified (includes community colleges)
Education (ED)	ED	Other education organizations (not universities, colleges, or community colleges)

Virginia-based M&S assets represent diverse organizations, as shown in Table 3-5.

Table 3-5: Virginia M&S Assets, by Sub-category



*results rounded to the nearest whole number

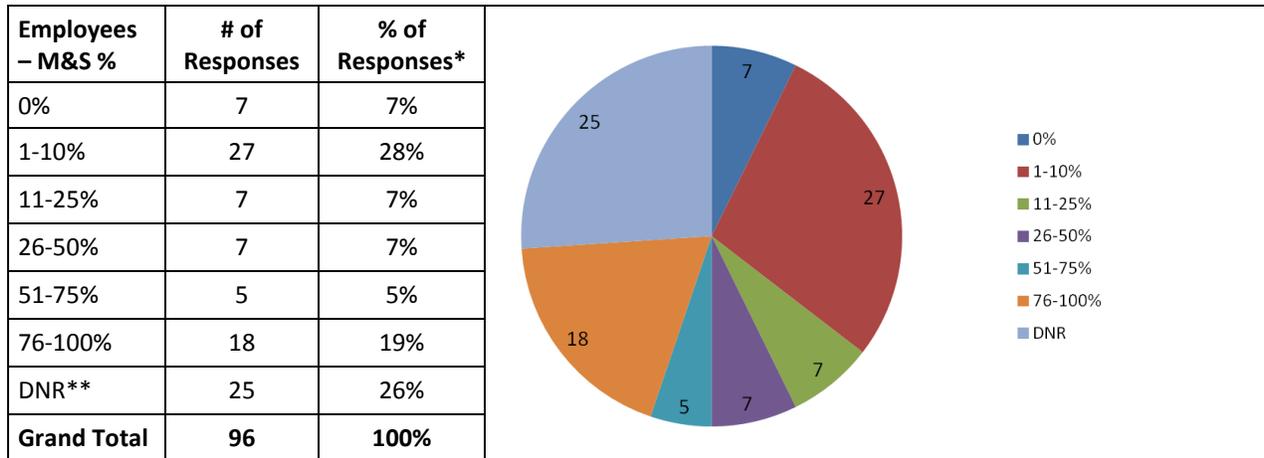
The preponderance of commercial business assets may be due to the initial SOW approach, which specified the use of trade and industry association lists as a starting point for the inventory.

Asset distributions by region are reported in Sections 4.1 through 4.10.

Since survey participants were identified via the asset inventory, information collected from them provided the TEAM with information about what capabilities exist in the Commonwealth, and about the profile of the assets themselves. Respondents were asked a set of questions in order to begin to understand how heavily invested Commonwealth assets are in M&S.

Among all organizations surveyed, more than one-third of survey respondents reported that ten percent or less of their employees are engaged in M&S activities, while nearly a quarter reported that more than half of their employees produce, research, or conduct M&S training (either internal employee training or external training as a service). This information is shown in Table 3-6.

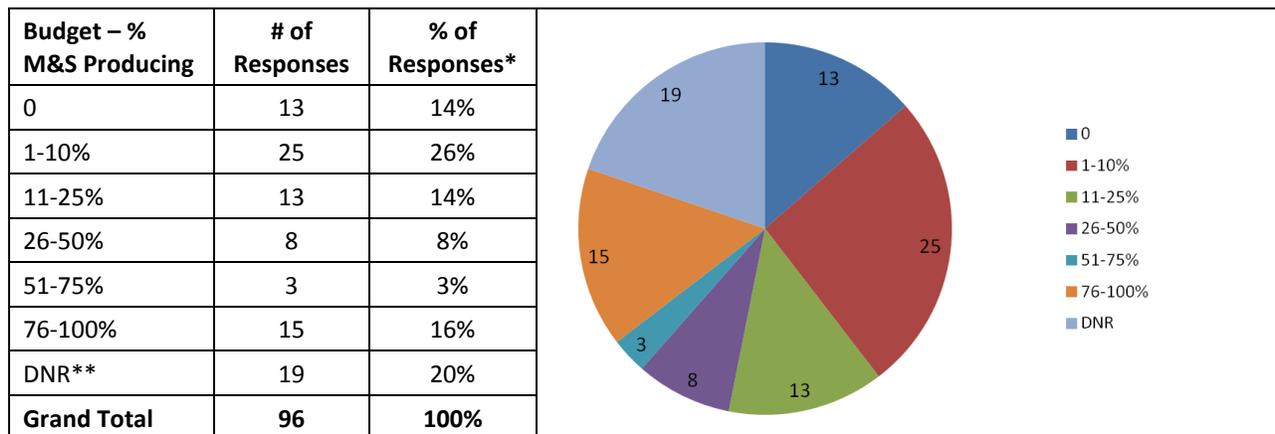
Table 3-6: Employees Engaged in M&S %, All Organizations



*results rounded to the nearest whole number; ** DNR= Did Not Respond to the question

Forty percent of all organizations surveyed reported that ten percent or less of their annual budgets are devoted to producing M&S products, and eighteen percent reported that more than half their budgets are set to produce M&S as shown in Table 3-7.

Table 3-7: Budget % Producing M&S, All Organizations



*results rounded to the nearest whole number; ** DNR= Did Not Respond to the question

3.2.2 Stakeholder Perspectives on M&S Challenges

The Virginia M&S industry and its stakeholders identified challenges to expansion and diversification during focus group discussions and in their survey responses.

3.2.2.1 Diversity and Identity of M&S

M&S represents a diverse set of technologies, tools, and products, as well as the organizations and occupations that employ them. This diversity both strengthens and challenges the goals, technologies, resources, and requirements across what is known as M&S. Many challenges are tied to the varied application of M&S across disciplines and its lack of a clear identity.

From a business perspective, customer identification and marketing are complicated by the diversity and ambiguous identity of M&S. Some stakeholders believe that awareness of potential

uses of M&S across domains (and therefore sales/networking/buy-in) would be achievable if there were a common language of M&S across disciplines, or if there were a larger number of individuals who understood M&S from various domains. For example, developers of bio-simulation are developing M&S tools that could also be used for education, but they have difficulty gaining a foothold in education because their products are pigeonholed as healthcare.

From an academic perspective, it has been difficult to attract professors and students to M&S because there is no clear cut identity for an M&S person. Most practitioners define themselves by their primary disciplines and not M&S. Consequently, employers have issues locating workers with specialized M&S skills to fill job vacancies.

M&S events are subject to the same challenges. Events fail to some attract people because many do not realize that the M&S technology, applications and services at an event are relevant to their particular business or industry. Moreover, in marketing, sales and networking, many potential assets, customers, and collaborative partners do not realize a capability exists for their needs.

3.2.2.2 M&S Industry Growth Factors

Industry growth factors identified as obstacles included limited access to capital, limited entrepreneurship, and restricted small businesses growth. Other factors were difficulties in bridging M&S industry applications, and a lack of consensus that M&S is an independent industry.

3.2.2.3 Knowledge and Communication

Numerous study participants cited a lack of knowledge about the potential benefits and uses for M&S as a primary impediment to industry expansion. This lack of knowledge may be a direct result of the issues surrounding how to communicate the both the potential of M&S products and services, as well as its applicability across different domains.

The lack of standards, accreditation and certification for M&S tools is another challenge and obstacle to industry growth. This may be due to the nebulous M&S industry definition.

Study participants want to increase public awareness and understanding of M&S at all levels of government in order to gain acceptance of its potential for multiple applications. Study participants point to a need for a common M&S industry language or lexicon in order to facilitate the use, networking, and growth of M&S. They believe that the formulation an industry definition is a necessary first step to overcome these obstacles and challenges.

Business issues with customer identification are tied to the challenges regarding M&S knowledge and M&S communication. The diversity of M&S requires proactive business development and creative thinking about emerging market needs, workforce, product development, and marketing. Companies now need managers, marketers, and sales and product development leaders who understand the technology in order to communicate with customers.

3.2.2.4 Networking

The lack of M&S based networking was a significant and oft-reported concern for study participants who reported that little to no communication occurs among stakeholders to facilitate M&S networking in some regions. This lack of networking both restricts potential industry growth, and presents an obstacle to the establishment of a clear identity for M&S. The lack of a clear identity for M&S is a key factor impeding networking; however, Virginia also lacks an

M&S industry leader and consistent message to promote networking. Moreover, study participants report that Virginia politicians fail to attend events to help build awareness of M&S. Study participants reported a need to grow regional and Commonwealth-wide M&S networks. They want the Commonwealth to promote and provide networking opportunities in order to generate enthusiasm for M&S as an industry and to offer platforms for stakeholder participation. They also stated the need for the identification of a common leader and the establishment of regional level organizations to facilitate M&S efforts.

3.2.2.5 Collaboration

Numerous study participants reported the need for more collaboration in M&S between industries, industries and academia, and government and industry to promote growth. Potential obstacles to collaboration were identified as IP protections, prohibitive fees and costs, limited funding, legal frameworks, barriers to data access, and a lack of communication. In industry-industry partnerships, it was pointed out that concerns stemming from protection of IP might impede participation in both collaborative exchanges and networking conferences.

Government partnerships have historically been undertaken with DoD and it has been a challenge for industry and academia to find other government partners. Stakeholders were open to other avenues and partners.

With the reported shift in M&S work toward productization, stakeholders were concerned that research institutions and academic institutions may not be equipped to deliver marketable products so they will need to partner with private industry to develop these products. Participants pointed out successful collaborative models for industry and academia, where research is performed by faculty (and students) who are allowed to partner with industry while maintaining their university positions. They see this as a potential model for Virginia universities to follow provided that IP protections do not deter these partnerships.

3.2.2.6 University Assets and Resources

Study participants generally believed that the Commonwealth would need to attract more professors to drive M&S workforce development. Universities might choose to offer perks (e.g., free tuition for faculty dependents) to secure qualified faculty. Participants firmly believed that it was necessary to keep university rankings high in order to attract talented faculty and students necessary for innovation in M&S.

Many study participants reported that student projects were needed for M&S disciplines; this need is expected to grow as M&S becomes more of an emphasis in education. M&S training and applications require real world examples of problems to solve. More companies will be needed to provide these opportunities, and more public-private collaboration will be needed in order to implement them. Ideally, projects will provide the essential hands-on experience necessary to create a cross-disciplinary workforce; therefore, projects should involve working with customers directly to elicit requirements, pose solutions, and sell capabilities and products.

3.2.2.7 Recognition of Regional Capabilities

Study participants in regions with pockets (or key individual capabilities) of M&S activity, such as Region 2000, Charlottesville, Richmond and the Blacksburg-Roanoke regions reported that they needed a spotlight shown on these capabilities. The Commonwealth-sponsored marketing

effort has done well in showcasing Hampton Roads as an M&S stronghold. Stakeholders believed a similar effort would benefit their own regions. The increase in visibility would attract M&S assets and customers. Most study participants agreed that Commonwealth should focus equal attention across all regions to benefit the entire Commonwealth.

3.2.2.8 Common Regional Questions

Study participants reported that they wanted the Commonwealth or other leadership to assist them in answering some questions about M&S industry growth. Some of these questions were common to many of the regions. Though the answers will likely vary per region, these common questions among regions included:

- How do we identify/select focus areas of M&S to concentrate on in each region?
- How can we attract desirable businesses to the region?
- How do we choose an anchor in the region?
- How can we attract desirable businesses to the region?
- How can we leverage workforce and market opportunities regionally?
- What VA-based M&S assets can support our workforce training programs?
- How can we promote the area's M&S technology and M&S opportunities?
- How can we overcome the negative perception of the region?

Some study participants cited quality of life concerns as impediments to workforce recruitment and retention, in particular transportation issues and lack of affordable housing.

Concerns specific to each region and findings are detailed in the regional sections in this report (Sections 3.6-3.15).

3.2.3 Proposed Actions and Investments

Study participants provided recommendations and examples of actions that would further the development of Virginia's M&S industry and capability. The TEAM categorized these recommendations into four areas:

1. meeting workforce requirements;
2. promoting the use of M&S;
3. fostering growth of M&S and related industries; and
4. overcoming obstacles to growth.

3.2.3.1 Meeting Workforce Requirements

Most study participants reported that their workforce needs were being met; yet, workers with better qualifications, including cross-disciplined training, education and experience were desired. M&S future growth will partly depend on the eligibility of employees to work in classified and secure environments, as they will likely handle sensitive and proprietary information.

Study participants generally agreed that an alignment of M&S-related academic programs and internships with workforce needs and apprenticeships would provide for the development of skills necessary in the M&S workforce. Numerous business study participants reported an interest in graduates of hands-on certification programs (vice purely academic programs). Business owners expressed that they wanted the Commonwealth to establish policies to help them offset the costs incurred from training employees and leveraging student interns.

Stakeholder recommendations to increase higher education output included supporting M&S training and education degree program expansion by:

- Establishing entry level M&S degrees in community colleges using both classroom-based and distance learning delivery modes
- Creating more educational entities able to produce gaming/simulation programmers
- Providing monetary support for graduate degree programs in M&S related areas
- Funding grant opportunities to expand simulation offerings in higher education
- Funding grant opportunities for M&S projects that provide student hands-on experience
- Funding more faculty positions to grow related academic departments

Their recommendations regarding M&S higher education programs and content included:

- Promoting data analysis
- Providing in-depth programming courses
- Emphasizing design and development of models and simulations
- Providing more mathematics and software programming background
- Emphasizing cross-disciplinary computer science/physical science
- Increasing logistics and supply chain management
- Implementing a business course for M&S application development and implementation

There was no agreement among industry study participants about whether “traditional” degrees (e.g., computer science and computer engineering) or M&S specific degrees provided better entry-level M&S employees. Several participants suggested that research should be conducted to determine the industry impact of various degrees (i.e., academic disciplines and degree attainment) to inform future education investment strategies.

Recommendations for K-12 education were also provided by stakeholders. These would impact the *potential* future M&S workforce. Recommendations included continuing the emphasis on STEM education, making more investments in hardware, hiring more qualified teachers, and providing hands-on experience in M&S to students through M&S educational tools (i.e., virtual reality and educational games). These recommendations suggest the need for a more M&S-trained teachers, and industry-school collaboration and mentorship programs.

3.2.3.2 Promoting the Use of M&S

A majority of study participants wanted the Commonwealth to spearhead efforts to promote Virginia’s M&S industry and capabilities. Future efforts should be focused on:

- **Educating** users about M&S benefits and capabilities.
- **Advocating** for M&S at the National and Commonwealth level.
- **Promoting** Virginia as a leader in M&S.

Current study data agreed with meta-analysis findings in that stakeholders want Virginia’s government to lead by example. Examples provided included demonstrating and publicizing how the Commonwealth incorporates M&S into its own planning and decision-making. Publicizing the role of M&S in Virginia’s governance would likely further national recognition of the Commonwealth as a leader in M&S. Demonstrating how M&S can be incorporated in governance would also provide a model for local and regional agencies to follow in utilizing

their own M&S assets. This would additionally foster networking and collaborative relationships among Government, industry, and academia to solve local and Commonwealth issues.

Stakeholders suggested that the Commonwealth might use M&S to improve garbage collection efficiency, in storm water management and planning, and should include it in employee education and training. Study participants suggested that the Commonwealth establish policies to incorporate M&S requirements, as appropriate, into Virginia contracts and requests for proposals, and require Commonwealth funded agencies and organizations to “Buy Virginia First” before going elsewhere to fulfill M&S needs.

In regards to marketing and promotion, study participants believed it imperative for the Commonwealth to establish a strategic and comprehensive vision and message. A key element of the marketing approach is that the message be comprehensible to a wide range of potential customers. Many participants reported difficulties communicating with other industries. Stakeholders suggested that the Commonwealth create a publication to provide a better understanding of how the Commonwealth governs industry access to funding.

Other marketing recommendations included advertising how M&S applications are being used in ways that are both unexpected and commonplace, showing how M&S touches peoples’ daily lives. This would also address the need for increasing public understanding of M&S.

Study participants believed that the Commonwealth should market Virginia M&S both nationally and internationally. Some believed that the Commonwealth should set up new offices to market reach foreign investors. Study participants felt that marketing M&S academic training programs, and targeting large government and commercial entities were prime avenues.

In order to promote public knowledge, participants suggested that the Commonwealth implement an M&S awareness initiative, stylized as an “Everything you didn’t know about M&S” informational campaign to build recognition and interest in M&S. Potential marketing messages posed included dubbing the Commonwealth the “Commercial capital of M&S.”

Participants also recommended leveraging House Resolution 487 for Federal advocacy in:

- Returning or relocating Federal and DoD work to Virginia locations
- Addressing lack of standards, accreditation, and certification for M&S tools and training
- Establishing an M&S NAICS code in partnership with other states and stakeholder organizations (e.g., National Training and Simulation Association)

3.2.3.3 Fostering Growth

Study participants provided several recommendations to foster growth. Efforts should meet regional needs and leverage local capabilities. A balance of short and long term growth opportunities should be identified; projects with no significant return should be avoided. Stakeholders in regions with an established M&S presence recommended incentivizing the use of M&S. Stakeholders in regions with a less established M&S presence wanted incentives for new business development or existing business relocation to Virginia.

Many thought that the Commonwealth should assist with market transition. Some suggested using government resources to aid businesses in developing plans for entering new markets. They recommended government promote business strategies that support incremental or agile growth and provide commercialization assistance, such as “how to” training, R&D funding or support. Stakeholders stressed that they needed the Commonwealth to help improve access to

capital, whether by facilitating venture capital investments or providing seed money to regional organizations. They suggested enabling organizations to secure their own funding by facilitating proposal and grant drafting. For example, provide resources to a nursing clinical simulation training center to aid them in developing business case models and marketing use of the center.

Study participants asserted that steps should be taken to establish Virginia (not just specific regions) as a “go-to” center for all technology-based solutions—not just for M&S. They recommended that the Commonwealth lead an effort to establish an East Coast corridor of excellence, similar to Silicon Valley. A corridor could achieve the potential of HR 487, facilitate approval of M&S NAICS codes, and position Virginia to compete globally for M&S.

A large proportion of study participants represented small businesses, and they wanted the Commonwealth to establish centers to incubate small businesses and promote the development of small technology businesses that have successfully navigated the start-up phase. These stakeholders need help working with banks to gain access to capital for small businesses in high-tech fields. They believed that community volunteer and student projects would serve to grow small businesses in less-established M&S areas. They would like the Commonwealth to facilitate small business’ access to university tools and expertise. Small businesses could be responsible for covering the direct expenses in terms of tools, materials and expertise.

Study participants asserted that technology investments would facilitate M&S growth. Their recommendations included that the Commonwealth invest in virtual labs and expand existing labs. They suggested that university data nodes be built, with sharing capabilities among assets. Many felt that the development of technology incubators would drive collaboration, and foster beneficial partnerships and commercialization. To grow M&S, data centers with super-computing power for large models will be needed, and fiber and broadband will have to be extended into less urban areas.

Many study participants would like Virginia to implement a tax policy that encourages M&S business growth. They provided a number of tax incentive recommendations. These included tax deductions and grants for new organic M&S companies. Also suggested were tax incentives for companies to relocate to Virginia, for businesses operating and investing in M&S technology, and for M&S investors in general. Credits suggested included one that would reward business collaboration for new products, or a credit or Work Force Investment Board Support to assist manufacturers and other companies with the cost of implementing M&S technologies.

3.2.3.4 Promoting M&S Networking and Collaboration

Improved M&S networking was cited as a primary concern and need for a majority of regions. Among the recommendations to enable and improve networking, the designation of a champion for M&S, whose responsibilities should be to unify Virginia’s M&S community and facilitate partnerships, and collaboration was a suggestion put forth numerous times. The Champion, according to study participants, could be in the form of a person (e.g., similar to efforts by the Secretary of Technology or Congressman Forbes), an organization (e.g., VMASC), or even an event (i.e., extend the MODSIM World mission). Potential network foundations were identified by study participants, including established Technology Councils, universities or colleges, established research or industry centers, or technology incubators.

Study participants believed that the M&S Champion should serve to facilitate the introduction of organizations with M&S needs to M&S organizations who can meet those needs. The

Commonwealth could facilitate these opportunities. For example, an annual conference might be established to bring together Virginia-based M&S stakeholders to share information, and collaborate. This might be an event, like the Capitol Hill exposition, and might be a traveling event, held in multiple regions. A database of M&S companies, government agencies, and educational institutions could be made accessible in order to facilitate networking.

Improved collaboration would also, by several stakeholder accounts, overcome several obstacles to growth. To facilitate collaboration between local businesses and universities, stakeholders suggested the following:

- Streamline the procedure and overhead expenses for collaboration between academia and industry. Provide businesses and universities with a sustained plan for collaboration, and a simplified process for working together.
- Train students who will be entering the workforce by providing internships to bring businesses and university together, thereby increasing awareness of the talent available at the university, and promoting careers in the region.
- Provide incentives and support for University spin-off companies to help transition innovative students into local work environments and retain them regionally.
- Form collaborative alliances with startups. Help them hire and train workers. Offer M&S capabilities to start-ups to model their possibilities and to get to the market.
- Form relationships with university and sources of venture capital to explore new areas for M&S development and application.
- Seed local activity through local government strategic investment. Provide capital investment, start-up money, and venture capital, possibly flowing funds through CIT or regional incubators. Include seed money for local government initiatives to apply M&S to local/regional problems.

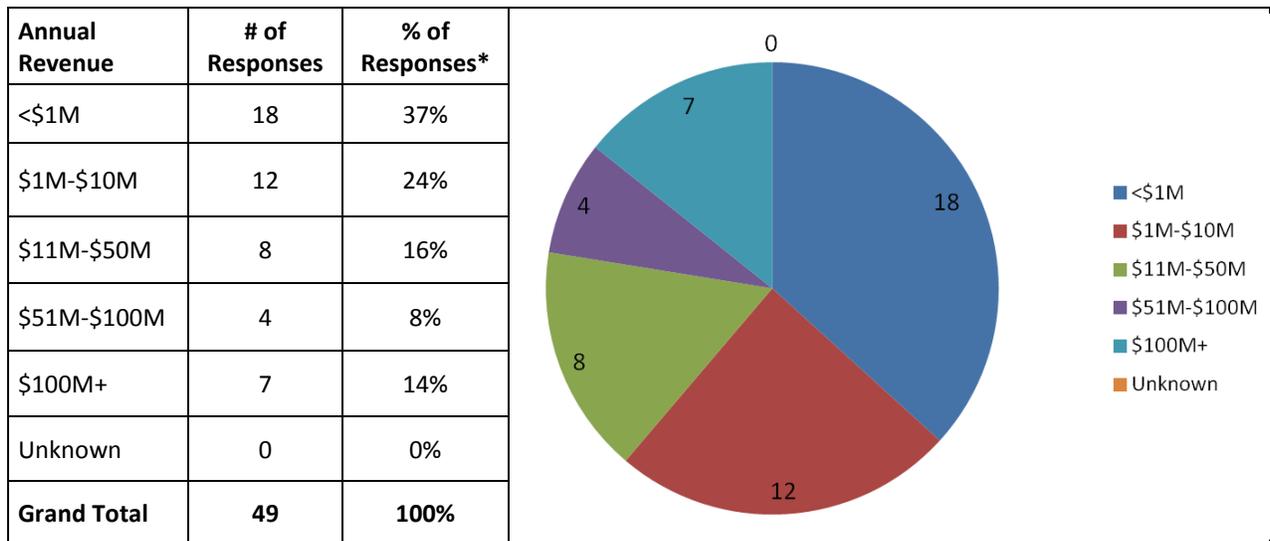
3.3 Virginia M&S: Economic Analysis

The TEAM conducted economic analyses of the Commonwealth as a whole and for each of the ten regions designated for the study. Following is information regarding M&S activities conducted by identified stakeholder organizations as reported in the current study survey data. Also discussed are findings about the economic impact of M&S in Virginia, including its growth sectors, barriers, and projections for M&S growth in the Commonwealth.

3.3.1 Commercial Businesses

Information about annual revenue and number of employees from commercial business survey respondents indicates presence of a significant number of small business concerns. More than one-third of commercial business survey respondents represented businesses with less than one million dollars in annual revenue, and over half with less than ten million dollars. This information is shown in Table 3-8.

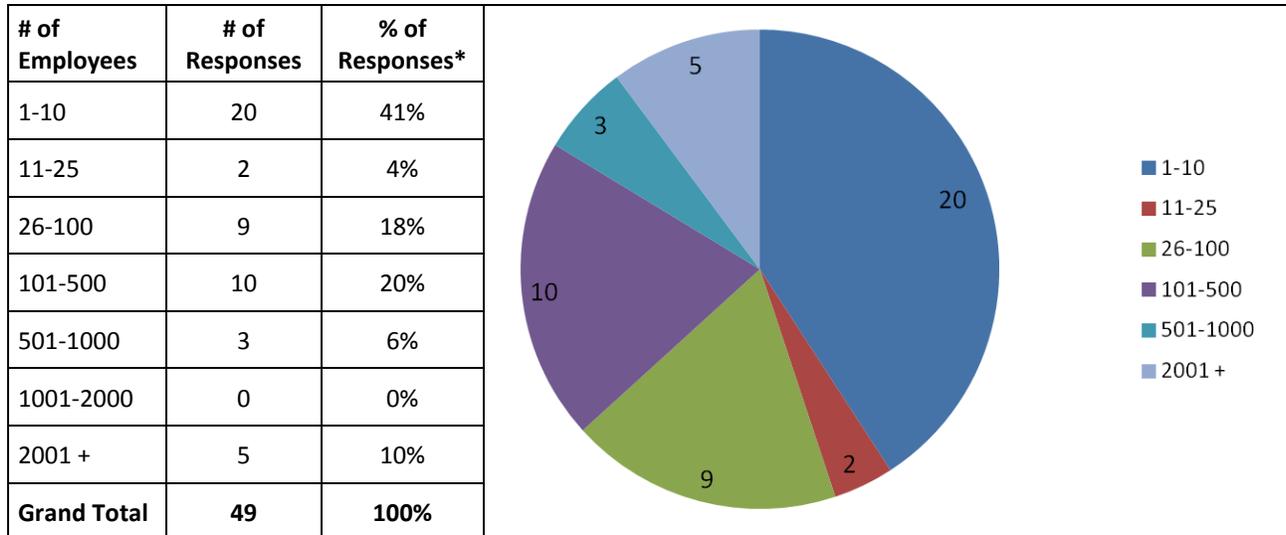
Table 3-8: Business Size – Annual Revenue, Commercial Businesses



*results rounded to the nearest whole number

Over forty percent of commercial business survey respondents represent businesses with ten or less employees. The number of employees among commercial business survey respondents is presented in Table 3-9.

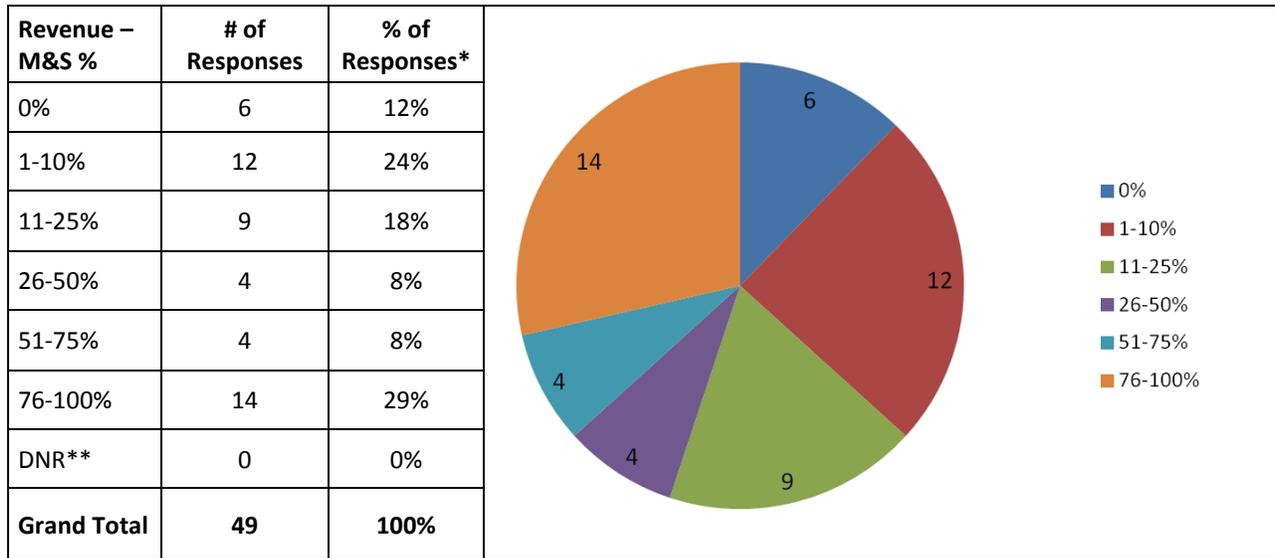
Table 3-9: Business Size – Number of Employees, Commercial Business



*results rounded to the nearest whole number

Commercial businesses responding to the survey were also asked to identify the percentage of total revenue generated by sales of their M&S products and/or services, shown in Table 3-10. This indicates how dependent the businesses are on M&S. Results varied, but in general, at least one-third of respondents' revenues are accounted for by sale of M&S products/services.

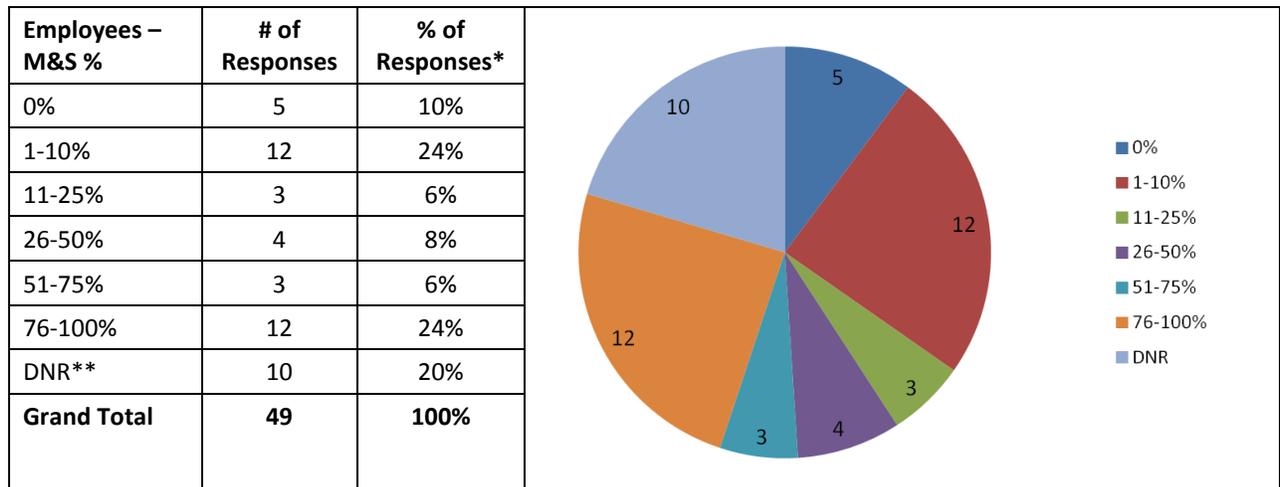
Table 3-10: Revenue % Accounted for by M&S, Commercial Businesses



*results rounded to the nearest whole number; ** DNR= Did Not Respond to the question

Reported percentages of commercial business’ employees engaged in M&S are shown in Table 3-11.

Table 3-11: Employees % Engaged in M&S, Commercial Business



*results rounded to the nearest whole number; ** DNR= Did Not Respond to the question

3.3.2 M&S Activity, Products Produced/Services Provided

Figure 3-1 compares the types of products organizations reported producing in terms of the number of responses from each organization type. Simulation and modeling products led in responses for commercial businesses, while laboratories/research entities more often identified other products.

Figure 3-1: Types of Products Produced, by Organization Type

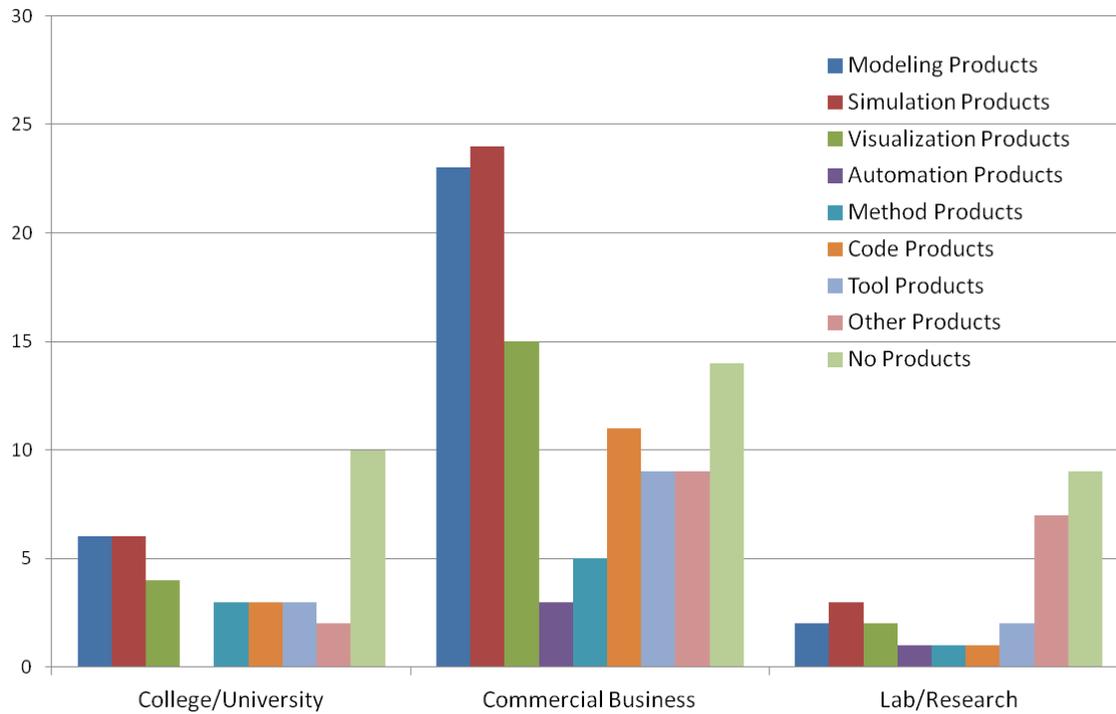
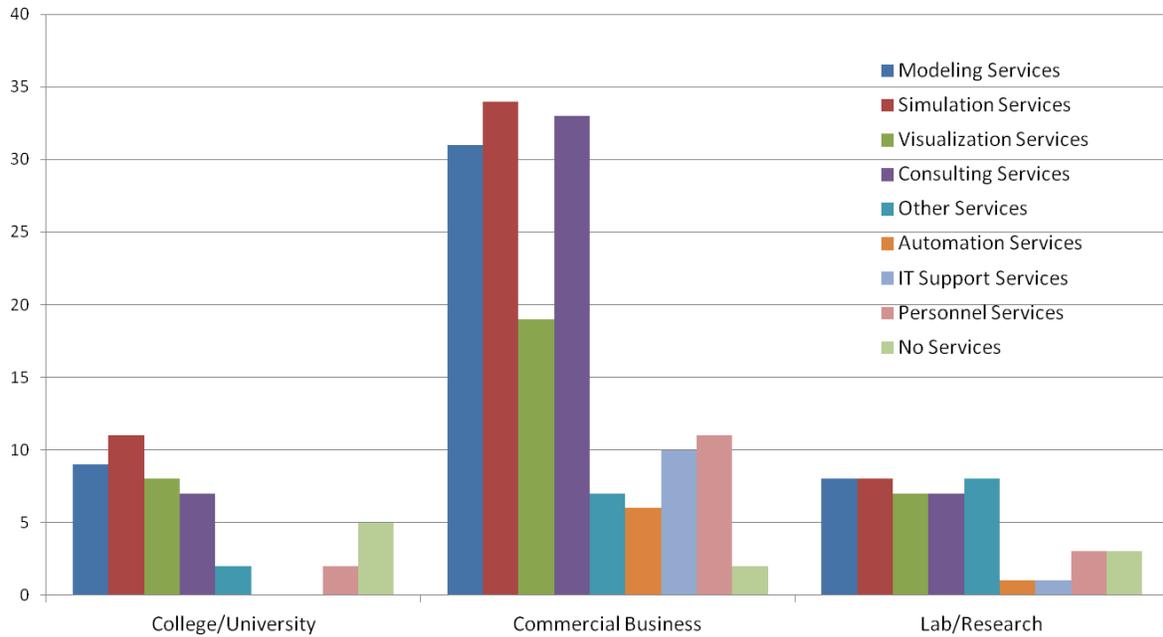


Figure 3-2 compares the types of services organizations reported that they are providing, by the number of responses from each organization type. Note the high number of consulting services by commercial businesses.

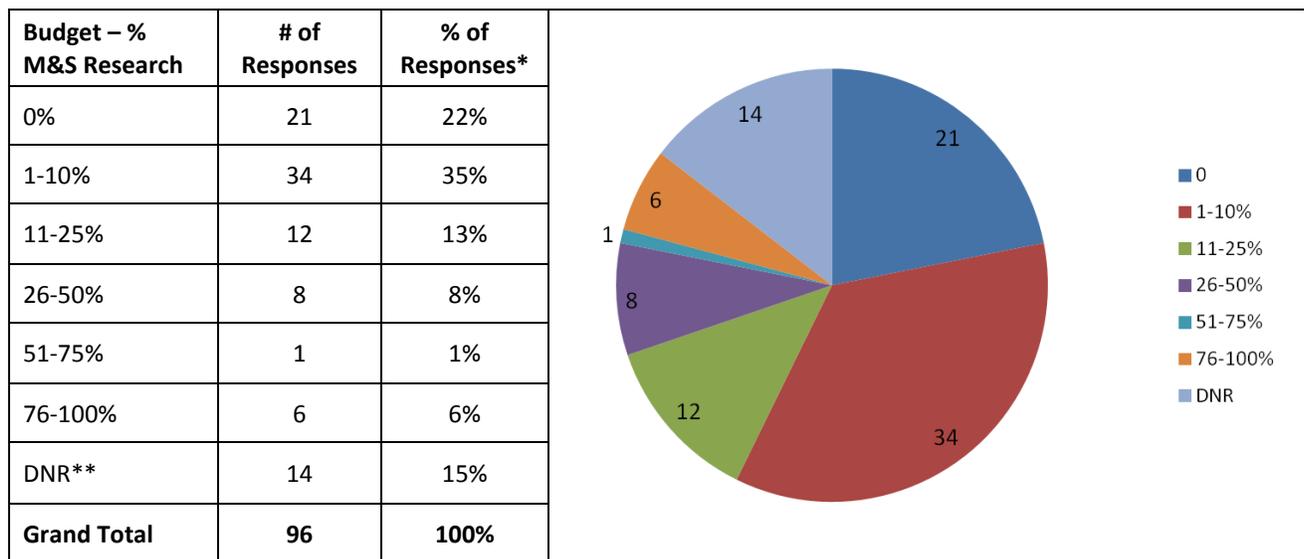
Figure 3-2: Types of Services Provided, by Organization Type



3.3.3 M&S Activity, Research

Table 3-12 presents data about what percentage of M&S organizations’ overall R&D budgets were reported by survey respondents to be devoted to M&S research. Over half of those reporting (82) indicated ten percent or less and one-quarter of those indicated zero percent devoted to M&S research.

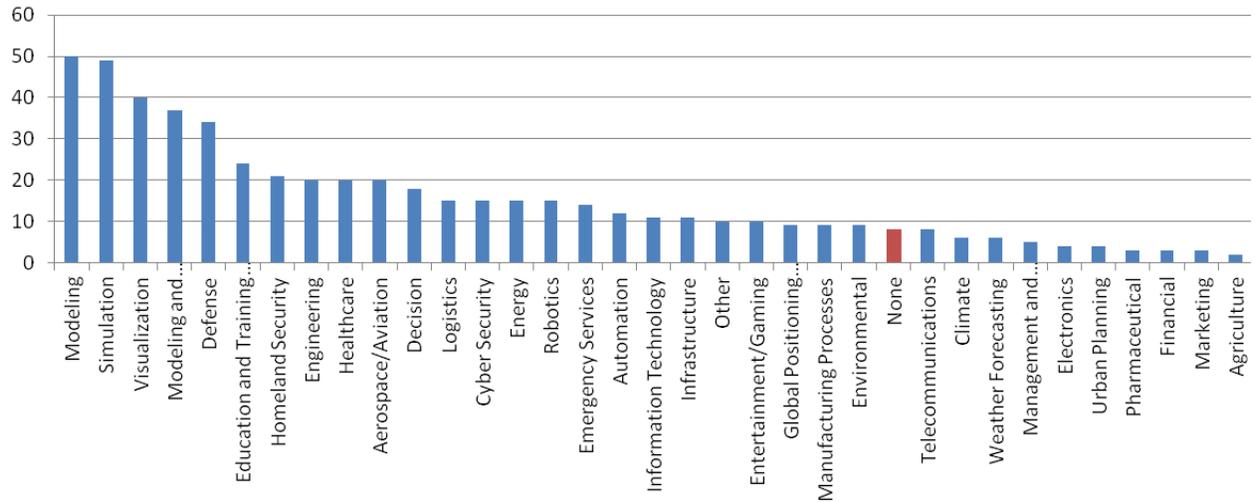
Table 3-12: Budget % - M&S Research, All Organizations



*results rounded to the nearest whole number; ** DNR= Did Not Respond to the question

A comparison of the types of M&S research reported among all surveyed organizations is presented in Figure 3-3. The numbers on the left-hand side of the graph indicate number of responses.

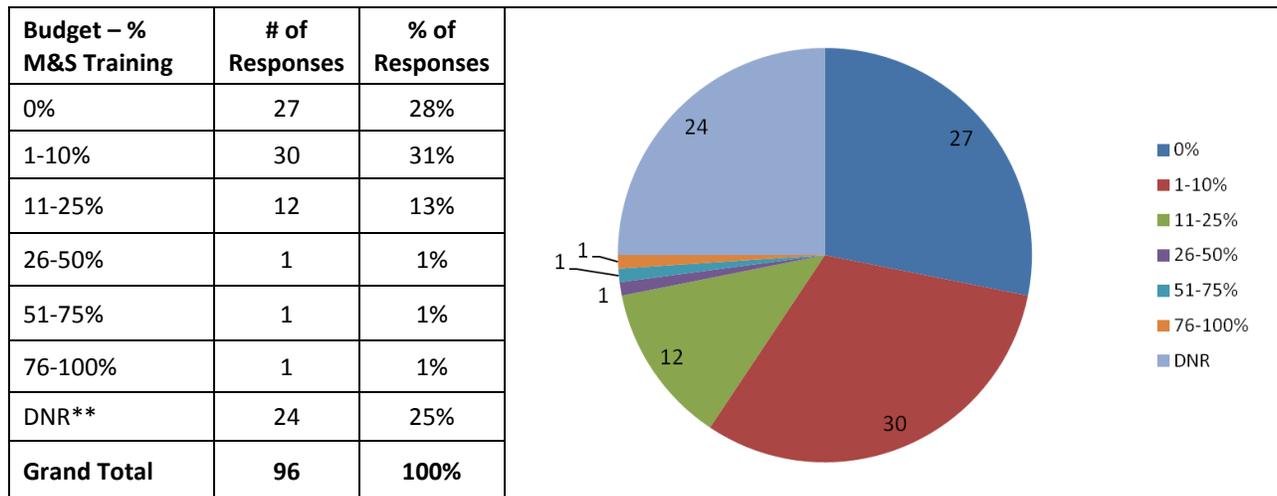
Figure 3-3: Types of M&S Research Conducted, All Organizations



3.3.4 M&S Activity, Training

The percentage of annual budget devoted to conducting M&S training among all organizations surveyed is presented in Table 3-13.

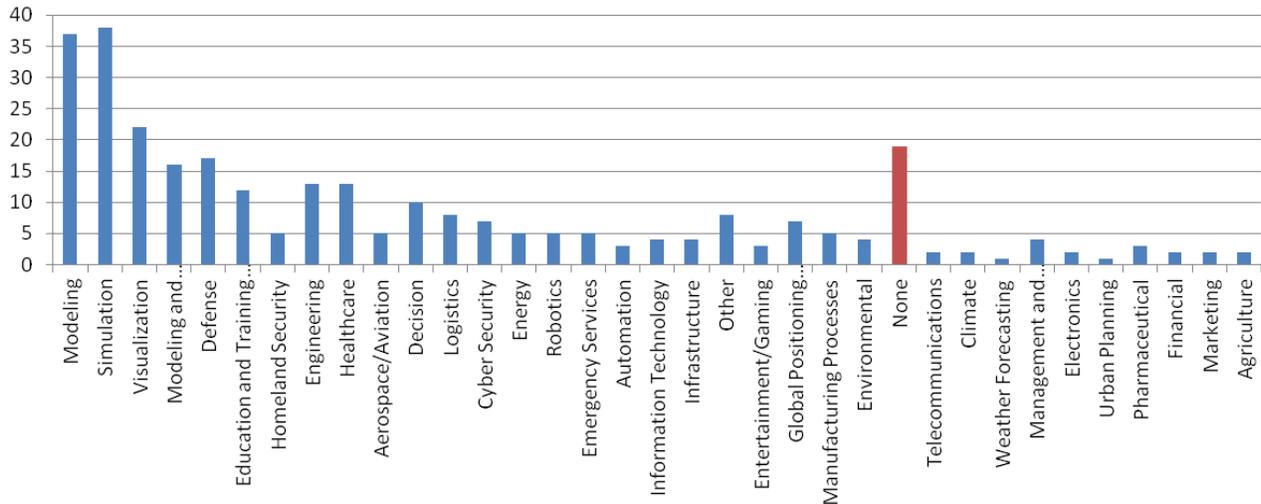
Table 3-13: Budget % - M&S Training, All Organizations



** DNR= Did Not Respond to the question

Information on Types of M&S training activity conducted as reported by all organizations surveyed is presented in Figure 3-4. The numbers on the left-hand side of the graph indicate number of responses among survey respondents.

Figure 3-4: Types of Training Conducted, All Organizations



3.3.5 Growth Sector Identification (Current M&S Economic Growth Drivers)

Continued M&S economic growth is dependent upon four growth drivers.

1. **Marketplace diversification.** Continued reliance upon DoD as the primary revenue source for M&S businesses will continue to cause both short-term and long-term revenue interruptions that will negatively affect Virginia M&S growth potential.
2. **Venture capital.** Diversification will increase risk, particularly in R&D expenditures to support new product and service development as businesses transition to new markets. Increases in R&D spending will be dependent, in part, on access to venture capital. This is particularly critical for smaller businesses that cannot support R&D from gross profits.
3. **Asset utilization.** Two types of assets will support M&S growth in Virginia.
 - a. **Universities and Colleges.** Stakeholders want to leverage the strong university network in Virginia. Collaboration between academia-industry could be improved by minimizing barriers to collaboration.
 - b. **Intellectual Property.** Existing IP can be leveraged to stimulate M&S industry growth throughout the Commonwealth. Seventy-nine unique IP items were identified in the study data, including 21 trademarks, eight copyrights, eight patents, and 42 other items uncategorized by the source.
4. **Workforce availability.** An M&S-trained workforce will be necessary for growth throughout the Commonwealth. While most regions report no workforce limitations at this time, future industry growth will require a diverse workforce with cross-disciplinary skills. This is dependent on production of M&S-related graduates by universities and colleges, and also the capacity for K-12 education to produce more high school graduates interested in pursuing related degrees and technical training related to M&S.

3.3.6 M&S Economic Impact

The breadth of the M&S Industry was defined using NAICS codes. Codes were selected based on previous M&S analyses and code concentrations as reported in the survey. The NAICS codes and descriptors were then aligned to IMPLAN sectors. Sectors were then separated into “core” and “related” sectors. This separation was accomplished using previous study findings, survey data, and expert opinion. Core sectors represent the most commonly cited NAICS codes and IMPLAN sectors. Related sectors represent NAICS codes and IMPLAN sectors that are represented in smaller concentrations in the meta-analysis documents and/or survey data.

To estimate the proportion of M&S activity within the selected core industries and the related M&S sectors, the TEAM first estimated the total employment for each of the fifteen sectors. This information is presented in Table 3-14. Core sectors are in bold. Total employment for the Commonwealth is listed in row 17 of the table, while total employment for the sectors used in the study is provided in row 16. Current total employments for each of the fifteen sectors selected for the current study as core or related to M&S are listed in rows 1-15. Based on these estimates, approximately 13% of Virginia total labor force is employed in the M&S sectors used for this study.

Table 3-14: Current Virginia Employment in M&S Study Sectors

Row #	Industry Sector	Total Employment
1	Pharmaceutical preparation manufacturing	1,649.20
2	Other commercial and service industry machinery manufacturing	156.50
3	Ship building and repairing	26,486.50
4	Software publishers	6,562.21
5	Telecommunications	34,303.28
6	Other information services	1,240.68
7	Architectural, engineering, and related services	75,315.83
8	Custom computer programming services	60,476.74
9	Computer systems design services	127,907.07
10	Other computer related services, including facilities management	14,619.09
11	Management, scientific, and technical consulting services	77,403.90
12	Scientific research and development services	36,315.89
13	All other miscellaneous professional, scientific, and technical services	10,120.13
14	Other private educational services	36,085.89
15	Private hospitals	100,299.73
16	Total Virginia Employment the Core and Related Sectors for the M&S Study	608,942.63
17	Total Virginia Employment	4,731,725.50

Bold text represents core sectors

The TEAM next estimated the proportion of M&S-specific activity within each of the core and related sectors. Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion of the economist.

Due to the significantly higher concentration of M&S activity in the Hampton Roads region, the scenarios used higher weights for Hampton Roads. Weights used to estimate the sector M&S proportion for each scenario are presented in Table 3-15.

Table 3-15: Economic and Workforce Analysis Scenarios

Scenario	Hampton Roads Region		All Other Regions	
	Core Sectors	Related Sectors	Core Sectors	Related Sectors
Scenario 1	15%	3%	1%	1%
Scenario 2	20%	3%	1.5%	1%
Scenario 3	25%	3%	2%	1%

In Table 3-16, the scenario weights from the table above are applied to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 3-16: Virginia M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Virginia M&S Employment	11658.431	14563.879	17469.326
Pharmaceutical preparation manufacturing	17.801	17.801	17.801
Other commercial and service industry machinery manufacturing	2.626	2.626	2.626
Ship building and repairing	791.394	791.394	791.394
Software publishers	125.037	176.945	228.854
Telecommunications	415.961	415.961	415.961
Other information services	15.746	15.746	15.746
Architectural, engineering, and related services	1085.894	1085.894	1085.894
Custom computer programming services	1394.870	1951.216	2507.561
Computer systems design services	2898.142	4058.093	5218.044
Other computer related services, including facilities management	161.112	161.112	161.112
Management, scientific, and technical consulting services	1381.474	1963.741	2546.007
Scientific research and development services	1126.451	1553.374	1980.298
All other miscellaneous professional, scientific, and technical services	342.162	470.214	598.267
Other private educational services	487.734	487.734	487.734
Private hospitals	1412.028	1412.028	1412.028

Bold text represents core sectors

Based on Virginia's total employment of 4,731,725.50 presented previously, scenario 1 in the table above estimates that 0.25% (11,658) is M&S specific. Scenario 2 estimates 0.31% (14,564). Scenario 3 estimates 0.37% (17,469). Among the core sectors, *Computer systems design services* has the largest proportion of M&S employment.

Economic impact was calculated using the estimates in Table 3-16 (previously). Calculations are shown in Table 3-17, based upon the three scenarios. Economic impact is reported using the following terms. Note that economic impact will be reported with these same terms for each region of this report. Regional economic impact will be discussed later in sections 4 to 4.10.

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated by another industry into their production.

Table 3-17: M&S Economic Impact, Virginia

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	229.9	21,191,393.90	25,136,394.80	40,602,883.40
Indirect Effect	88.0	4,855,208.50	8,112,904.30	12,738,155.10
Induced Effect	139.3	5,971,059.00	11,078,769.70	17,997,061.70
Total Effect	457.3	32,017,661.40	44,328,068.80	71,338,100.20
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	288.2	27,315,075.80	31,536,008.80	49,873,173.90
Indirect Effect	106.7	5,841,752.90	9,737,945.50	15,238,705.50
Induced Effect	177.4	7,600,767.80	14,102,440.50	22,908,968.60
Total Effect	572.2	40,757,596.50	55,376,394.80	88,020,848.00
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	346.4	33,438,718.10	37,935,568.40	59,143,388.90
Indirect Effect	125.3	6,828,289.50	11,362,974.30	17,739,236.30
Induced Effect	215.4	9,230,465.90	17,126,091.30	27,820,843.10
Total Effect	687.2	49,497,473.50	66,424,634.00	104,703,468.30

* values in \$1000

The estimated M&S contribution to the Virginia GRP (equal to value added, total effect) ranges from \$44.3 billion (Scenario 1) to \$66.4 billion (Scenario 3). The total economic impact of M&S on the Virginia economy ranges from \$71.3 billion (Scenario 1) to \$104.7 billion (Scenario 3).

3.3.7 Growth Projections

Future Growth was estimated using BLS national growth projections for 2010-2020. IMPLAN data represents 2011 data. Consequently, BLS projections were adjusted to project 2011-2020 growth.

Table 3-18 presents the growth projection for each industry sector.

Table 3-18: Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 3-19 presents estimated number of new jobs overall by sector and for M&S-jobs in each scenario.

Table 3-19: Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	20.967	2.8714	20.967	2.8714	20.967	2.8714
Other commercial and service industry machinery manufacturing	3.042	0.4670	3.042	0.4670	3.042	0.4670
Ship building and repairing	944.472	125.3269	944.472	125.3269	944.472	125.3269
Software publishers	148.695	24.1857	210.426	34.2263	272.156	44.2669
Telecommunications	495.055	78.7062	495.055	78.7062	495.055	78.7062
Other information services	18.323	2.9941	18.323	2.9941	18.323	2.9941
Architectural, engineering, and related services	1307.226	177.7115	1307.226	177.7115	1307.226	177.7115
Custom computer programming services	1630.626	284.3098	2281.003	397.7071	2931.380	511.1043
Computer systems design services	3336.247	489.8336	4671.546	685.8844	6006.844	881.9352
Other computer related services, including facilities management	190.910	24.3550	190.910	24.3550	190.910	24.3550
Management, scientific, and technical consulting services	1622.117	255.4999	2305.811	363.1885	2989.504	470.8772
Scientific research and development services	1325.253	196.2199	1827.521	270.5870	2329.790	344.9541
All other miscellaneous professional, scientific, and technical services	405.235	60.3864	556.892	82.9857	708.550	105.5850
Other private educational services	576.415	89.9076	576.415	89.9076	576.415	89.9076
Private hospitals	1412.028	256.7390	1412.028	256.7390	1412.028	256.7390
Total	13436.612	2069.5141	16821.637	2593.6577	20206.662	3117.8014

Bold text represents core sectors

Table 3-20 presents the projected (2011-2020) M&S economic impact based on the labor projections in Table 3-19 (previous).

Table 3-20: Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	2,069.5	190,722,532.00	226,227,555.40	365,425,978.40
Indirect Effect	791.9	43,696,881.60	73,016,146.10	114,643,408.40
Induced Effect	1,254.1	53,739,529.90	99,708,925.50	161,973,552.40
Total Effect	4,115.5	288,158,943.50	398,952,626.90	642,042,939.20
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	2,593.7	245,835,677.60	283,824,087.00	448,858,609.00
Indirect Effect	959.9	52,575,785.50	87,641,523.50	137,148,371.80
Induced Effect	1,596.4	68,406,912.30	126,921,967.90	206,180,723.30
Total Effect	5,150.0	366,818,375.40	498,387,578.40	792,187,704.20
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	3,117.8	300,948,823.80	341,420,618.90	532,291,240.50
Indirect Effect	1,128.0	61,454,689.90	102,266,901.00	159,653,335.30
Induced Effect	1,938.8	83,074,294.90	154,135,010.70	250,387,895.00
Total Effect	6,184.6	445,477,808.70	597,822,530.60	942,332,470.80

* values in \$1000

Based on Total Effect, *Value Added* column, M&S will contribute an estimated \$399.0 billion (Scenario 1) to \$597.8 billion (Scenario 3) to the Virginia GRP from 2011 to 2020.

3.3.8 Growth Barrier Identification (M&S Economic Growth Barriers)

By all accounts, Virginia has a strong infrastructure and industrial base to support future M&S growth. The transition from a defense-based to a commercial-based business model was cited by study participants as a concern and a challenge for stakeholders. Successful transition to a more commercialized marketplace may depend on smaller more innovative and proactive companies.

To transition, Virginia's M&S industry will need to overcome the following growth barriers (as identified in this study, sections 3.1.4 and 3.2 all):

- Limited availability of R&D capital (bank and venture capital);
- Lack of capital funneled toward M&S
- Lack of entrepreneurship
- Lack of incubators
- Impediments to industry-academic partnerships
- Lack of information and communication (including about M&S stocks)
- Lack of industry standards (verification, validation, and accreditation of M&S tools)

Growth is dependent on cost-efficient access to materials and resources. Survey respondents were asked what type of M&S products and services they bought (see Figure 3-5 and Figure 3-6), and where their primary suppliers and vendors were located. National and international suppliers were identified most frequently (see Figure 3-7 on page 45). The data includes responses from all organizations; however, note that one-half of the survey respondents represent Commercial Businesses.

Figure 3-5: Types of Products Bought, All Organizations

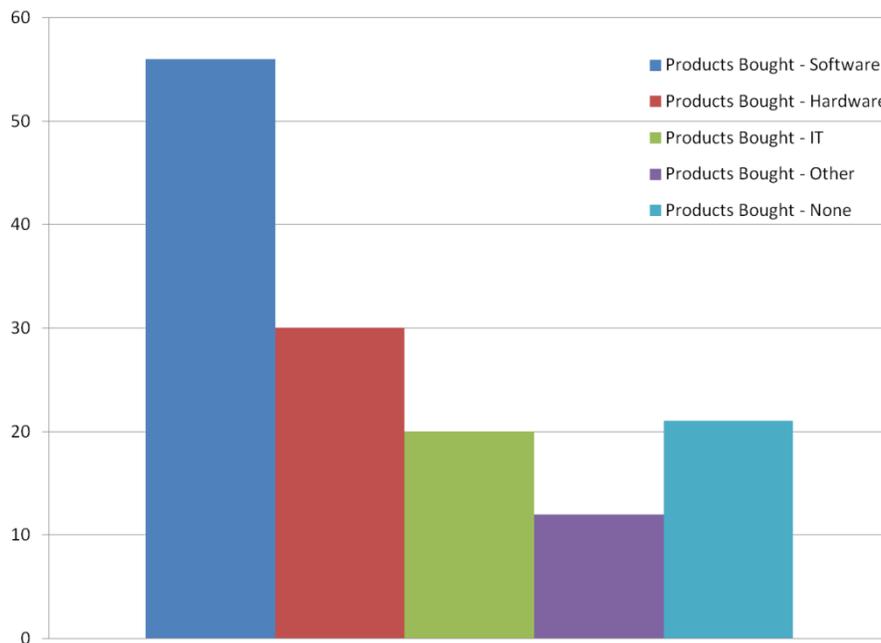


Figure 3-6: Services Bought, All Organizations

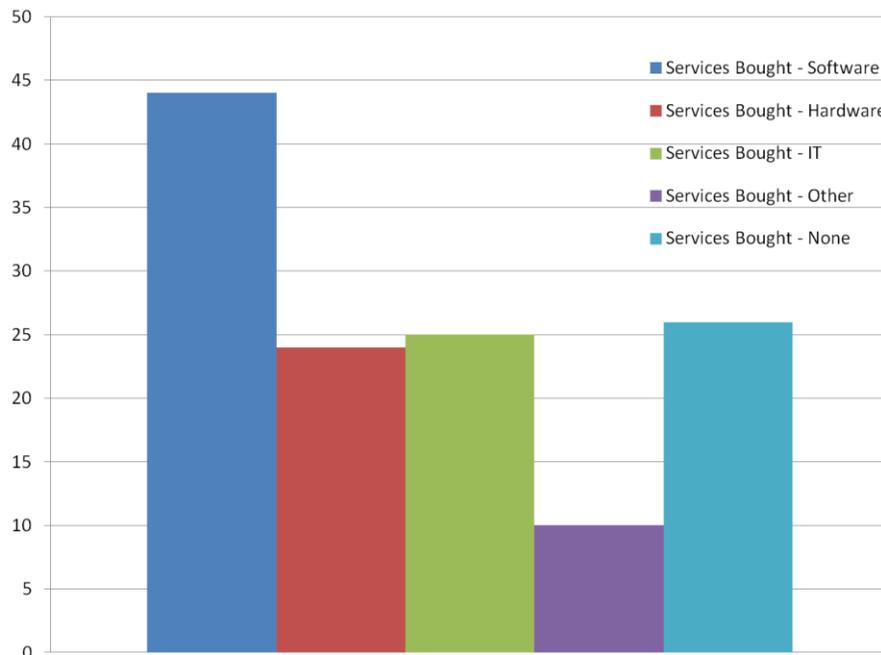
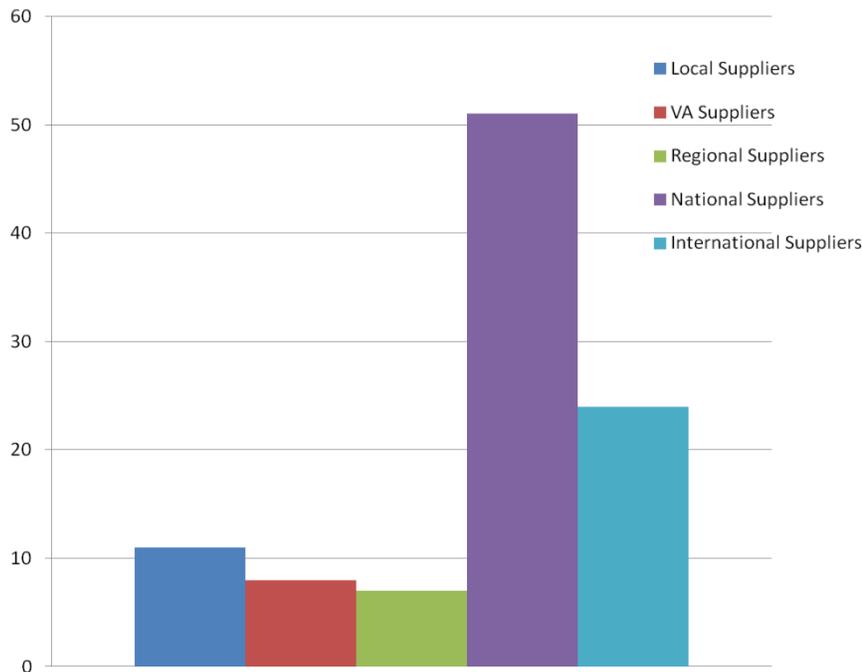


Figure 3-7: Suppliers & Vendors, Locale Distribution, All Organizations

The data suggests there are limited suppliers in the Commonwealth. In addition to benefitting Virginia directly through economic impact of new supplier business growth, second and third tier industrial growth would improve technical workforce availability, particularly in non-industrial regions, to support M&S growth. It would also improve partnership and networking, particularly in those regions with limited opportunities for collaboration.

Users of M&S who participated in focus groups reported that they identify potential vendors primarily through internet searches and word-of-mouth, based on industry reputation. They also noted that they consider Orlando first when they identify M&S resources, followed by Hampton Roads.

Although the growth environment is favorable for much of Virginia, there are common obstacles across multiple regions, particularly the rural or semi-rural regions. The availability of a technical workforce is a catch-22 for these regions – the local labor force may be sufficient for current needs, but growth is dependent upon a more extensive workforce. However, that workforce is not likely to be available without the business opportunity growth in M&S products and services to support it. Networking and partnership opportunities were also cited as obstacles to growth, particularly when potential collaboration with local universities is limited.

3.4 Virginia M&S: Market Opportunities

In the words of one focus group participant, future M&S market opportunities are “anything you can think of.” This reflects the general consensus of collected data – M&S can be used anywhere decisions need to be made regarding planning, design, production, logistics. The following information discusses market opportunities for export and asset utilization in the Commonwealth, as determined through analysis of survey responses and focus group interview data.

Table 3-21 presents the current and emerging markets for M&S as identified by survey respondents.

Survey respondents were allowed to select any number of markets, but only one time for each market. So, for *Health Medical*, 31 survey respondents identified it as emerging, while 26 identified it as a current market for M&S.

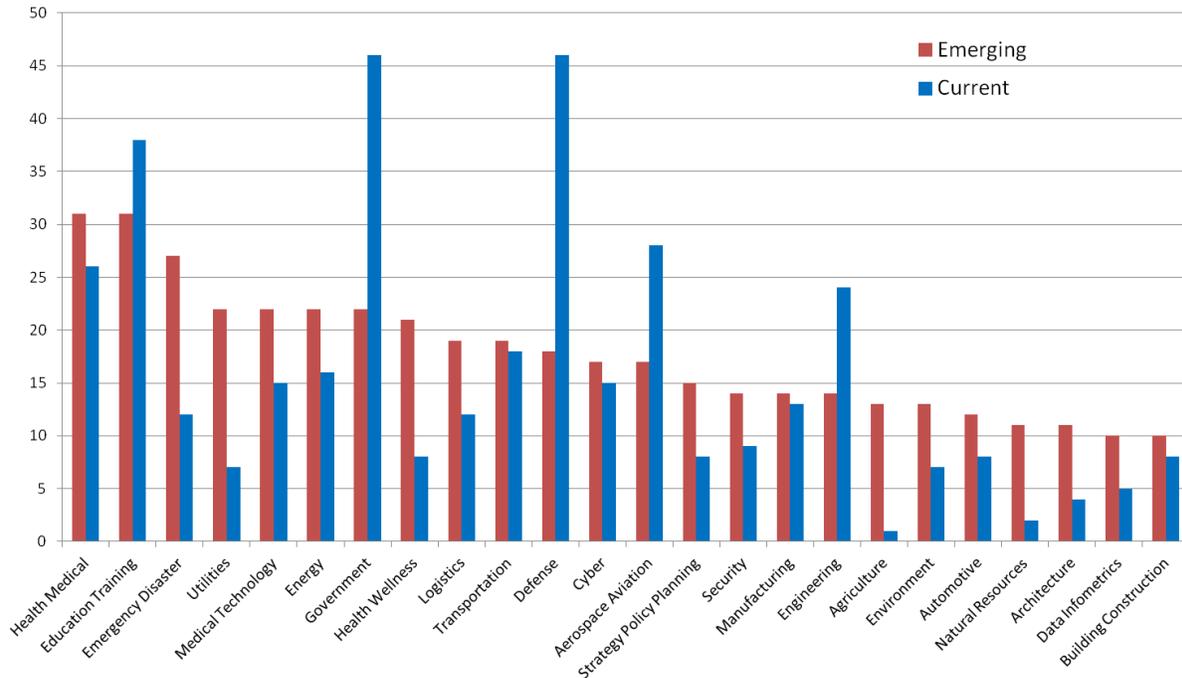
Table 3-21: Current and Emerging Markets Identified by Survey Respondents

Market	Emerging	Current	Market	Emerging	Current
Health Medical	31	26	Building Construction	10	8
Education Training	31	38	Agribusiness	9	5
Emergency Disaster	27	12	Information Assurance	9	11
Utilities	22	7	Mining Physical Resources	8	4
Medical Technology	22	15	Design	8	8
Energy	22	16	Software Programming	8	15
Government	22	46	Meteorology	7	2
Health Wellness	21	8	Tourism	7	3
Logistics	19	12	Development	7	11
Transportation	19	18	Entertainment	6	7
Defense	18	46	Electrical	5	0
Cyber	17	15	Administrative	5	3
Aerospace Aviation	17	28	Arts Creative Performing	5	3
Strategy Policy Planning	15	8	Quality Assurance	5	3
Security	14	9	Microelectronics	5	4
Manufacturing	14	13	Optics	5	4
Engineering	14	24	Communications	5	10
Agriculture	13	1	Retail	4	2
Environment	13	7	Hospitality	4	4
Automotive	12	8	Food Beverage	3	3
Natural Resources	11	2	Photonics	3	3
Architecture	11	4	Services	3	4
Data Infometrics	10	5			

These markets align closely with those highlighted during focus group discussions, particularly the markets in the left column of the table. Historically strong M&S markets, *Government*, *Defense*, *Aerospace Aviation*, and *Engineering*, are still viewed as emerging, though by significantly fewer respondents than those who report them as a current market for their organization. It is also note-worthy that two markets also identified as emerging by focus group participants, *Health/Medical* and *Education/ Training*, already have a strong presence among Virginia M&S organizations.

For those markets receiving more than ten “emerging” responses, this data is also presented graphically in Figure 3-8 on the following page.

Figure 3-8: Emerging & Current Markets, 10+ Stakeholder Responses



In Figure 3-8 above, note that the difference between those bars of emerging markets (red) which are significantly higher than current markets (blue). Predicted growth is shown for emergency disaster, utilities, health wellness, natural resources, agriculture, and architecture.

Focus group data provided more detailed perspectives on emerging markets. Logistics, in particular, maritime logistics applications will grow. Energy, particularly power design and operator training will be in demand. Training, particularly operator safety, commercial and pleasure boating, and simulation for healthcare (medical schools and nursing programs) is growing and will continue to do so. Epidemiology applications will grow. Manufacturing applications should target small to medium sized businesses because most large business already use M&S. Study participants predicted an increase in use of cloud-based simulation and agent-based modeling in simulations. The use of high-tech visualization systems is expected to increase as use of virtual worlds for collaboration and meetings become much commonplace. Simulation for healthcare training and processes improvement for patient management at both the hospital and health plan levels is also expected to grow (e.g., medical modeling of complex systems for delivery and risk mitigation). Participants cautioned that gaming, for pleasure or training, has higher margins than traditional DoD M&S uses, but requires significant R&D investment,

Study participants reported huge potential for M&S exports, particularly for applications in power generation and infrastructure in developing nations; yet they acknowledged that these potential customers often lack the financial resources to purchase M&S products or services, and that expansion into foreign developing markets might be impeded by cost of M&S products and services. There are numerous small businesses among Virginia’s M&S commercial business assets, and small business often lacks the resources to market to non-US customers. It is likely that Commonwealth M&S businesses, particularly small businesses, will need support to enable and promote M&S regional networking (be it funding, promotion, legislation) and/or partnership assistance to offset foreign marketing costs.

3.5 Virginia M&S: Workforce

The analysis of Virginia's M&S workforce examined the current state of employment, gaps, and projected needs of the Commonwealth's M&S workforce. This analysis was conducted for the Commonwealth as a whole and for each region.

3.5.1 Current State of the M&S-related workforce

Survey respondents were asked to identify labor categories in which their organization employs workers. They were also asked to identify those labor categories for which it is difficult to recruit or retain employees. Forty-three different labor categories were identified overall and 28 of those were identified as difficult to recruit or retain by at least one respondent.

The number of respondents who selected the labor categories as "employed" or "difficult to recruit or retain" is shown in Table 3-22 on page 49. Twenty respondents reported that they had difficulty neither recruiting nor retaining any specific labor category. The *Software Developers* and *Software Applications Developers* categories had significantly higher responses for "difficult to recruit or retain" than any other labor category.

3.5.2 Workforce Needs

Study participants agreed, in general, that there is a need for cross-training for M&S workers to meet the diverse M&S work requirements. Most new hires have a bachelor's degree and require significant on-the-job training. There was no consensus on whether M&S specific or general degrees are preferred. There is a perception that general computer science/engineering degrees provide a larger set of skills that is more applicable to a broad range of job requirements.

Regionally, workforce issues are varied, and in some cases no issues were reported. Current regional workforce states are summarized in the following bullets.

- The Southern Piedmont Region is waiting for business to use its newly trained M&S technical workforce and infrastructure. They seek ways to draw businesses to the area.
- While no issues were reported in the southern part of the Hampton Roads Region, work is outsourced in the north because software simulation knowledge is lacking among workers. Industry needs are growing faster than the graduates can be produced.
- The Lynchburg Region needs a trained technical operation, design, and final assembly workforce. Recruiting younger engineers to the areas has been difficult.
- In the Richmond Region, the focus is on finding and creating cross-disciplined workers.
- In the Charlottesville Region, retaining talented workers is difficult because the region cannot generate the necessary pull to attract technology-based businesses and workers.
- In the Roanoke-Blacksburg Region, the local market is specialized as far as the type of M&S work performed, so most graduates move to more populated areas to find work.
- In the Shenandoah Valley Region, students move to other regions because they do not see career opportunity in their region.
- The Southwestern Virginia Region needs help identifying alternatives to coal industry occupations, then training local workers in those alternatives.
- The Fredericksburg Region respondents reported that there was more M&S work to do than people available to perform it.
- No workforce issues are reported in the Northern Virginia Region where STEM education has helped grow the pool of qualified candidates.

Table 3-22: Labor Categories, Employed or Difficult to Recruit or Retain

Labor Category	Employ	Difficult
Software Developers, Applications	29	12
Software developers	28	11
Software Developers, Systems Software	16	7
Computer Programmers	29	4
Engineer	14	4
Programmer	19	4
Aerospace Engineers	16	3
Graphic Designers	14	3
Multimedia Artists and Animators	8	3
Analyst	20	2
Civil Engineers	2	2
Graphic Artist	13	2
Industrial Engineers	6	2
Mechanical Engineering Technicians	2	2
Mechanical Engineers	11	2
Network and Computer Systems Administrators	9	2
Operations Research Analysts	15	2
Researcher	22	2
Teacher	14	2
Biomedical Engineers	3	1
Database Administrators	15	1
Electrical Engineers	11	1
Industrial Engineering Technicians	1	1
Information Security Analysts, Web Developers, and Computer Network Architects	9	1
Instructional Coordinators	6	1
Materials Engineers	2	1
Materials Scientists	5	1
Nuclear Engineers	2	1
Biochemists and Biophysicists	4	0
Chemical Technicians	1	0
Chemists	4	0
Computer and Information Systems Managers	11	0
Computer Hardware Engineers	9	0
Computer Systems Analysts	11	0
Electrical and Electronic Engineering Technicians	4	0
Electronics Engineers, Except Computer	5	0
Environmental Engineering Technicians	1	0
Environmental Engineers	1	0
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	2	0
Marine Engineers and Naval Architects	1	0
Medical Records and Health Information Technicians	2	0
Medical Scientists, Except Epidemiologists	3	0
Microbiologists	3	0

3.5.2.1 Gap Identification (current and needed resources)

Qualified M&S workforce availability varied by region across the Commonwealth. Availability (or lack thereof) was attributed to the local job opportunities, production by higher education feeder systems, and perception of job opportunity in the area by workers. Salaries were reported as very competitive among private industry and nationwide. Stakeholders reported difficulty for government and academia in hiring and retaining experienced M&S workers, because public pay cannot match private sector pay.

Key questions stakeholders had included:

- What VA-based M&S assets can support our workforce training programs?
- How can we locate workers with specialized M&S skills to fill job vacancies?
- How can we develop a more cross-disciplined M&S workforce?
- How can we bridge education for labor (e.g., M&S and healthcare)?

3.5.2.1.1 Current Gaps

Experience gaps exist among M&S job candidates. Study participants reported a need for workers with more hands-on experience in their primary field. The M&S workforce needs training and education for work with the downstream applications of M&S. Recent graduates reportedly lack experience and expertise. Candidates for M&S positions are typically experienced in systems engineering and generally lack new product development experience. Younger job candidates lack M&S experience related to their primary field.

Recruitment gaps exist. Universities appear to lack key programs which impact workforce recruitment. For example, at present, the University of Virginia (UVA) curriculum does not include simulation, so many companies recruit from Virginia Tech. Study participants reported that they routinely hire workers from outside the US because they cannot find any locally.

Skill and knowledge gaps exist in the M&S workforce. The M&S workforce needs a better mix of bio-engineering, programming, and scientific skills. Workers with a combination of knowledge in one of the physical sciences and proficiency in scientific programming are needed, as are those with a solid logistics and sustainment background, STEM degrees and professional certifications. Candidates are reported to lack executable knowledge even though they know requirements and mental models. Of note, study participants reported that though international students have a much better foundation in STEM, they lack the business development skills necessary to productize, and seem less creative in problem solving than US counterparts..

Workers with the following skills were reported as difficult to recruit and retain: GIS specialists, 3-D modeling, graphic artists, videographers, digital editors, video programmers C++ based and Java skilled personnel. A lack of systems engineering oriented M&S practitioners was identified in some regions, as was a need for those with design skills.

3.5.2.1.2 Projected Gaps

Study participants reported future needs for the workforce. Future workforce will need to bridge the gap between defining requirements and creating solutions/products for clients. Study participants suggested that the adoption of a common M&S industry lexicon would help to bridge this gap. Workers must also be able to obtain and maintain security clearances as security concerns grow with greater digital advancements.

The skills and capabilities identified as needed in the future M&S workforce are in:

- Applied engineering
- Robotics/autonomy
- Game Design
- Programming
- Software development (C++, web programming)
- Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) software
- Software and solution architecture
- Software engineering and coding
- Performing multi-disciplinary analyses in M&S engineering
- Systems engineers and analysts with capability to construct high fidelity models in any system context or application
- UVS/robotics operational and behavioral simulation development and integration with groupware human factors assessment capabilities
- Hybrid Modeling, Simulation and Gaming application environment
- Capability to think in 3-D with physical world augmenting the virtual
- Skill to perform calibration of and elicitation from humans when data is sparse
- Decision analytic skills to understand what measurements are meaningful
- Stakeholder engagement and requirements elicitation

Study participants stressed that workers will need experience that is more hands-on vice theoretical application. Workers will need experience in the practical application of dynamic databases with reasoning logic, web services, constructive and virtual simulation integration with collaborative environments in a mobile end user environment. They will need a strong business background to help in commercialization and business development.

Experience needs for the future M&S workforce will be in areas including:

- Healthcare-related data management
- Animating models
- Application and server development
- Commercial language/platform Java, .NET, Windows).
- Mobile platform development
- Cloud integration
- Developing and using Big Data facilities
- Human factors applied for operational tests and to improve M&S platforms usability

In the future, study participants predict that the M&S will require greater support of:

- Subject matter experts
- Network engineers
- Network analysts
- Software and gaming/simulation programmers
- Information assurance specialists
- Quality control specialists
- Support technicians

3.5.3 Training Needs

Training (e.g., workshops or symposiums) will help the current workforce transition. As the M&S industry anticipates evolving from a Government-oriented market to a more diverse marketplace, executive, management, and business development approaches will need to change, and this may require training as well. There is a need for early career exposure to users and clients through training in the field and collaboration.

Study participants called for a cross-trained M&S workforce. That need is driven by the fact that the technical aspect of many M&S jobs is completely different from the artistic application and industry nuances. Study participants suggested that workers with M&S technical expertise should also have a background that matches customer requirements so they can communicate effectively. There was a reported current industry need for M&S healthcare sciences training, and geospatial modeling.

In order to address reported current gaps, study participants suggested pairing computer science/engineering academics with exposure to other academic disciplines, or alternatively formally combining other academic disciplines with study in computer science/engineering. For example, physics (physics-based modeling) and other sciences would provide a content background for modeling and simulation work; art or graphic design for visualization, etc.

To meet future M&S workforce demands, participants believed that education should focus on:

- Advanced physics
- Current computer technology
- Engineering
- Math and specific technical science capabilities
- Stronger math and science education to understand models
- Systems dynamics thinking

4 Regional Findings

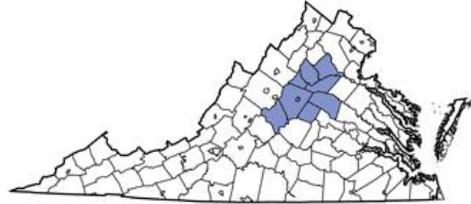
This report section presents the findings for each of the ten Commonwealth regions.

4.1 Charlottesville Region

This section presents information for the study region identified as the Charlottesville Region for this report.

This region is depicted in the figure shown at right.

Charlottesville Region M&S is focused on local engineering and architectural companies. Focus group participants reported that more external awareness about the Charlottesville producers, talent, and companies in the region was needed, and that retaining talented M&S workers was difficult because the small to medium-sized M&S companies were not shining in the region. They seek to generate more interest in area M&S capabilities and attract M&S technology.



Survey responses were evenly split regarding whether or not other market areas recognized the Charlottesville Region as a significant force in M&S. Responses regarding use of regional branding were mixed, with use reported “sometimes” by one respondent, and “never” by the other. The small market niche and crowded marketplace were identified as growth impediments; however, a lack of understanding about M&S was cited as the primary obstacle to growth. Participants noted that M&S networking and collaboration could be improved in the area.

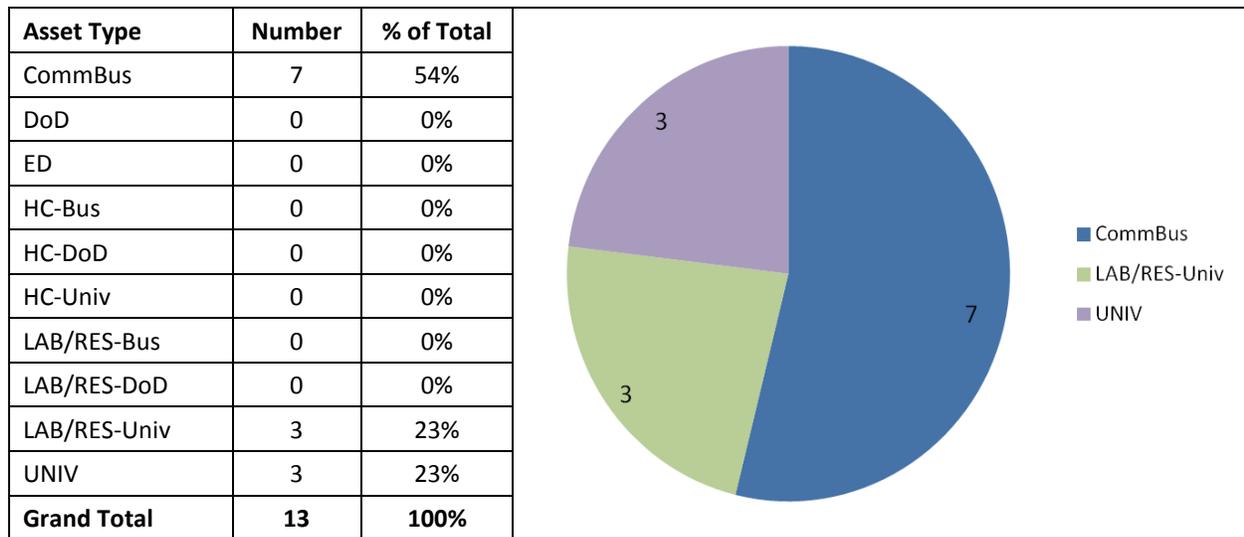
4.1.1 Number of Regional Study Participants

Information for the Charlottesville Region was provided by eight study participants. This data represents two survey respondents (both Commercial Business) and six focus group participants.

4.1.2 Asset Summary

Thirteen assets were identified for this region, including commercial businesses, universities, and university-based laboratory or research organizations. Table 4-1, presents the number of Charlottesville Region assets by category type and their percent of the total. For a detailed explanation of asset categories, see Table 3-4 on page 22.

Table 4-1: Charlottesville Region M&S Asset Distribution



4.1.3 Economic and Workforce Analyses

The definition of the M&S Industry is discussed in Section 2.6. Labor categories are discussed in Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6. Table 4-2 presents the current Charlottesville Region employment estimates for each industry sector.

Table 4-2: Charlottesville Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Charlottesville Region Employment, M&S Related Sectors	12,433.65
Pharmaceutical preparation manufacturing	7.57
Other commercial and service industry machinery manufacturing	0.63
Ship building and repairing	80.79
Software publishers	166.53
Telecommunications	511.75
Other information services	9.30
Architectural, engineering, and related services	1,550.50
Custom computer programming services	1,131.67
Computer systems design services	1,135.64
Other computer related services, including facilities management	627.95
Management, scientific, and technical consulting services	1,011.74
Scientific research and development services	2,013.01
All other miscellaneous professional, scientific, and technical services	342.85
Other private educational services	1,427.21
Private hospitals	2,416.50
Total Charlottesville Region Employment	183,947.61

Bold text represents core sectors

It is estimated that approximately seven percent of the Charlottesville Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Charlottesville Region are presented in Table 4-3.

Table 4-3: Charlottesville Region Economic and Workforce Analysis Scenarios

Scenario	Charlottesville Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-4 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-4: Charlottesville Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Charlottesville Region M&S Employment	124.337	153.344	182.351
Pharmaceutical preparation manufacturing	0.076	0.076	0.076
Other commercial and service industry machinery manufacturing	0.006	0.006	0.006
Ship building and repairing	0.808	0.808	0.808
Software publishers	1.665	2.498	3.331
Telecommunications	5.118	5.118	5.118
Other information services	0.093	0.093	0.093
Architectural, engineering, and related services	15.505	15.505	15.505
Custom computer programming services	11.317	16.975	22.633
Computer systems design services	11.356	17.035	22.713
Other computer related services, including facilities management	6.280	6.280	6.280
Management, scientific, and technical consulting services	10.117	15.176	20.235
Scientific research and development services	20.130	30.195	40.260
All other miscellaneous professional, scientific, and technical services	3.429	5.143	6.857
Other private educational services	14.272	14.272	14.272
Private hospitals	24.165	24.165	24.165

Bold text represents core sectors

Scenario 1 estimates that 0.07 percent of the Charlottesville Region total employment (183,947) is M&S specific, while Scenario 2 estimates 0.08 percent and the Scenario 3 estimate is 0.1 percent. Among the core sectors, *Scientific research and development services* represents the

greatest proportion of M&S employment. Although estimated at lower weights, the related sectors of *Architectural, engineering, and related services, Other private educational services,* and *Private hospitals* also have relatively high estimates for M&S employment. These high estimates may reflect, in part, the relatively high proportion of overall employment among these industries. The economic impact was calculated using the estimates presented in Table 4-4.

Table 4-5 presents the Charlottesville Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect, Indirect Effect, and Induced Effect*, and includes *Labor Income, Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-5: M&S Economic Impact, Charlottesville Region

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	2.5	157,503.5	220,272.9	380,225.5
Indirect Effect	0.9	36,194.3	69,190.0	111,190.2
Induced Effect	0.9	34,681.7	70,862.0	113,855.1
Total Effect	4.3	228,379.5	360,324.9	605,270.8
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	3.0	199,776.8	271,887.1	466,866.5
Indirect Effect	1.1	44,953.6	85,212.7	136,862.8
Induced Effect	1.2	43,824.3	89,541.0	143,867.4
Total Effect	5.4	288,554.6	446,640.7	747,596.8
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	3.6	242,047.7	323,495.7	553,498.5
Indirect Effect	1.4	53,711.9	101,233.6	162,532.7
Induced Effect	1.4	52,966.2	108,218.7	173,877.8
Total Effect	6.4	348,725.8	532,948.0	889,909.1

* values in \$1000

The M&S contribution to the Charlottesville GRP (value added, total effect) is estimated to be \$360.3 million (Scenario 1) to \$532.9 million (Scenario 3). The total economic impact of M&S on the Charlottesville regional economy is estimated to be \$605.2 million (Scenario 1) to \$889.9 million (Scenario 3).

4.1.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth. Table 4-6 presents the growth projection for each industry sector.

Table 4-6: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-7 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-7: Charlottesville Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	0.089	0.0122	0.089	0.0122	0.089	0.0122
Other commercial and service industry machinery manufacturing	0.007	0.0011	0.007	0.0011	0.007	0.0011
Ship building and repairing	0.964	0.1279	0.964	0.1279	0.964	0.1279
Software publishers	1.980	0.3221	2.971	0.4832	3.961	0.6442
Telecommunications	6.091	0.9683	6.091	0.9683	6.091	0.9683
Other information services	0.108	0.0177	0.108	0.0177	0.108	0.0177
Architectural, engineering, and related services	18.665	2.5375	18.665	2.5375	18.665	2.5375
Custom computer programming services	13.229	2.3066	19.844	3.4599	26.459	4.6133
Computer systems design services	13.073	1.9194	19.610	2.8791	26.146	3.8388
Other computer related services, including facilities management	7.441	0.9493	7.441	0.9493	7.441	0.9493
Management, scientific, and technical consulting services	11.880	1.8712	17.820	2.8068	23.760	3.7424
Scientific research and development services	23.683	3.5065	35.524	5.2598	47.366	7.0131
All other miscellaneous professional, scientific, and technical services	4.061	0.6051	6.091	0.9076	8.121	1.2102
Other private educational services	16.867	2.6309	16.867	2.6309	16.867	2.6309
Private hospitals	24.165	4.3937	24.165	4.3937	24.165	4.3937
Total	142.304	22.1696	176.257	27.4351	210.210	32.7006

Bold text represents core sectors

Table 4-8 presents the projected (2011-2020) M&S economic impact based on the labor projections in Table 4-7.

Table 4-8: Charlottesville Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	22.2	1,417,532.7	1,982,454.2	3,421,988.0
Indirect Effect	8.2	325,742.8	622,700.1	1,000,695.5
Induced Effect	8.4	312,134.6	637,756.3	1,024,692.7
Total Effect	38.8	2,055,410.0	3,242,910.6	5,447,376.3
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added	Output*
Direct Effect	27.4	1,797,985.3	2,446,960.9	4,201,730.0
Indirect Effect	10.3	404,574.5	766,901.3	1,231,744.5
Induced Effect	10.6	394,415.8	805,863.6	1,294,798.9
Total Effect	48.3	2,596,975.6	4,019,725.8	6,728,273.3
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	32.7	2,178,438.1	2,911,471.2	4,981,461.8
Indirect Effect	12.3	483,401.4	911,095.2	1,462,781.9
Induced Effect	12.8	476,696.2	973,969.1	1,564,902.0
Total Effect	57.8	3,138,535.7	4,796,535.5	8,009,145.8

* values in \$1000

Despite a rather limited current M&S presence, M&S has the potential to contribute \$3.2 billion (Scenario 1) to \$4.7 billion to the Charlottesville GRP from 2011 to 2020.

4.1.4 Regional Challenges Summarized

1. How can we establish an M&S anchor and ignite entrepreneurship regionally?
2. How can we inform the consumer base of application potential beyond typical M&S?
3. How can we network on a Commonwealth-wide basis?
4. How can we attract desirable businesses to the region?
5. How can we overcome the negative perception of the region impacting workforce?
6. How can we build public-private collaboration and partnerships?
7. How can we leverage workforce and market opportunities in healthcare regionally?

4.1.4.1 Marketplace

There are four marketplace challenges identified for Charlottesville:

- Lack of an anchor to start things up in the region;
- Lack of knowledge in the consumer base outside of typical M&S fields;

- Lack of mechanism to connect with other Commonwealth assets; and
- Lack of knowledge about how to attract desirable businesses to the region.

Though responses were few in number, the Charlottesville Region's commercial business survey data was valuable when aggregated with all regional data to provide a Commonwealth-wide perspective of the M&S industry.

Information on aspects of the business size of the Charlottesville Region's commercial business survey respondents is reported below, in Table 4-9.

Table 4-9: Charlottesville Region, Respondents' Commercial Business Size

Annual Revenue	# Responses	% of Responses	Total # of Employees	# Responses	% of Responses
<\$1M	1	50%	1-10	1	50%
\$1M-\$10M	0	0%	11-25	0	0%
\$11M-\$50M	1	50%	26-100	0	0%
\$51M-\$100M	0	0%	101-500	1	50%
\$100M+	0	0%	501-1000	0	0%
Unknown	0	0%	1001-2000	0	0%
			2001 +	0	0%

Among the commercial businesses, information about what percentage of the respondents' total revenue and what percentage of its employees are devoted to M&S was asked. This information is reported in Table 4-10 for the Charlottesville Region.

Table 4-10: Charlottesville Region, M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
0%	0	0%	0%	0	0%
1-10%	1	50%	1-10%	1	50%
11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	0	0%
51-75%	1	50%	51-75%	1	50%
76-100%	0	0%	76-100%	0	0%
DNR	0	0%	DNR	0	0%
Grand Total	2	100%	Grand Total	2	100%

Information about all of the Charlottesville Region survey respondents' M&S business activities is presented in Table 4-11, including percent of budget to production of M&S products, research of M&S, and training of M&S.

Table 4-11: Charlottesville Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses	Budget % – Research M&S	# of Responses	% of Responses	Budget % - Train M&S	# of Responses	% of Responses
0%	0	0%	0%	1	50%	0%	0	0%
1-10%	1	50%	1-10%	0	0%	1-10%	1	50%
11-25%	0	0%	11-25%	1	50%	11-25%	1	50%
26-50%	0	0%	26-50%	0	0%	26-50%	0	0%
51-75%	1	50%	51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	0	0%	76-100%	0	0%
DNR	0	0%	DNR	0	0%	DNR	0	0%
Total	2	100%	Total	2	100%	Total	2	100%

4.1.4.2 Workforce

Participants reported that workforce recruitment and retention are negatively affected by a perception of this region as one lacking initial and long-term career opportunities for M&S. Respondents and focus group participants felt that a lack of recognition of the region as an M&S player contributed to this perception. Charlottesville survey respondents reported no QOL factors that negatively impacted employee recruitment or retention.

Workforce needs identified by study participants in this region include a better mix of bio-engineering, programming, and scientific skills among workers. Other needs included more simulation in higher education curriculum and also more M&S hands-on experience.

Regional employment was examined regarding what types of labor categories respondents' M&S employees fitted into, and in which labor categories they experienced any M&S employee difficulty in recruitment and retention. Survey response information is presented in Table 4-12; note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-12: Labor Categories, Employed and Difficult to Recruit or Retain, Charlottesville Region, All Organizations

Labor Category	Employ	Difficult
Analyst	1	0
Biochemists and Biophysicists	1	0
Biomedical Engineers	1	0
Civil Engineers	0	1
Computer Programmers	1	0
Computer Systems Analysts	1	0
Engineer	0	1
Environmental Engineering Technicians	1	0
Information Security Analysts, Web Developers, and Computer Network Architects	1	0
Medical Scientists, Except Epidemiologists	1	0
Microbiologists	1	0
Researcher	2	0
Software developers	1	0
Software Developers, Applications	1	1
Teacher	1	0
NONE		1

Based on a combination of focus group input and survey data as presented in the above table, the following labor categories are needed in the Charlottesville region:

- Analytics
- Bioengineering
- Civil engineers
- Engineers
- Software
- Software developers, applications

4.1.4.3 Systems engineers (healthcare)Networking

Participants characterized the M&S entrepreneurial community and small business networking in this region as lacking. Employees rely on personal professional networks; consequently, there is little sense of M&S community. Survey respondents reported participating in regional business networking activities **2-4 TIMES** during the past twelve months. One respondent reported seeking assistance from the regional network **ONE TIME** during the past year, and the other respondent reported seeking assistance **2-4 TIMES**. (**THIS TEXT** indicates a survey response choice.)

4.1.4.4 Collaboration

Regionally, federal grant funding (e.g., National Institutes of Health (NIH), National Science Foundation (NSF)) and faculty incentive structures have resulted in limited university-corporate partnerships. Furthermore, collaboration is reportedly inhibited by university legal frameworks and difficulty in finding research funding for academics. The reliance on faculty to raise money was reported as counter-productive. There is also a reported lack of awareness between industry and academia regarding the talent, innovative products, and organizational capacity available.

4.1.5 Regional Opportunities

Healthcare, product commercialization, and multi-disciplinary programs present regional opportunities for M&S growth. Study participants reported a need for M&S in local healthcare agencies and medical centers. Healthcare systems engineering positions are available regionally.

According to study participants, engineering school curriculum mixed with academics from liberal arts might be the perfect union to create multi-disciplinary, M&S jobs. Both engineering and liberal arts schools are co-located in this region. Several products were identified for potential commercialization in this region. These are available in the IP inventory attachment.

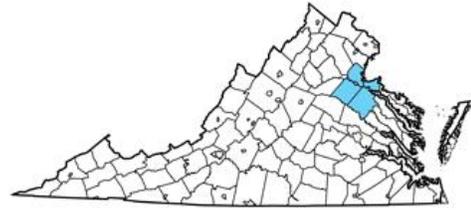
4.1.6 Proposed Actions and Investments

Study participants proposed the following actions and investments to grow M&S in this region:

- Plan around regional M&S of healthcare, engineering, and architecture. Incentivize the use of M&S. Emphasize medical/disease modeling as an aspect of strategic growth.
- Establish a technology/business incubator. Provide funding for startups. Form collaborative alliances with startups. Establish mutually beneficial partnerships.
- Provide internships to promote business - university partnerships and promote careers in the region.
- Create a tier 2 or 3 technology hotspot to drive innovation.

4.2 Fredericksburg Region

This section presents information for the study region identified as the Fredericksburg Region for this report. This region is depicted in the figure shown at right.



The Fredericksburg Region study participants reported that there was more M&S work to do than there were people available to perform it. Typically employee attrition is low in the region. There are difficulties with public-private collaboration, and regional M&S networking needs to be initiated. Survey responses indicated that that region is not recognized as a significant force in M&S, and that regional branding and marketing is never used.

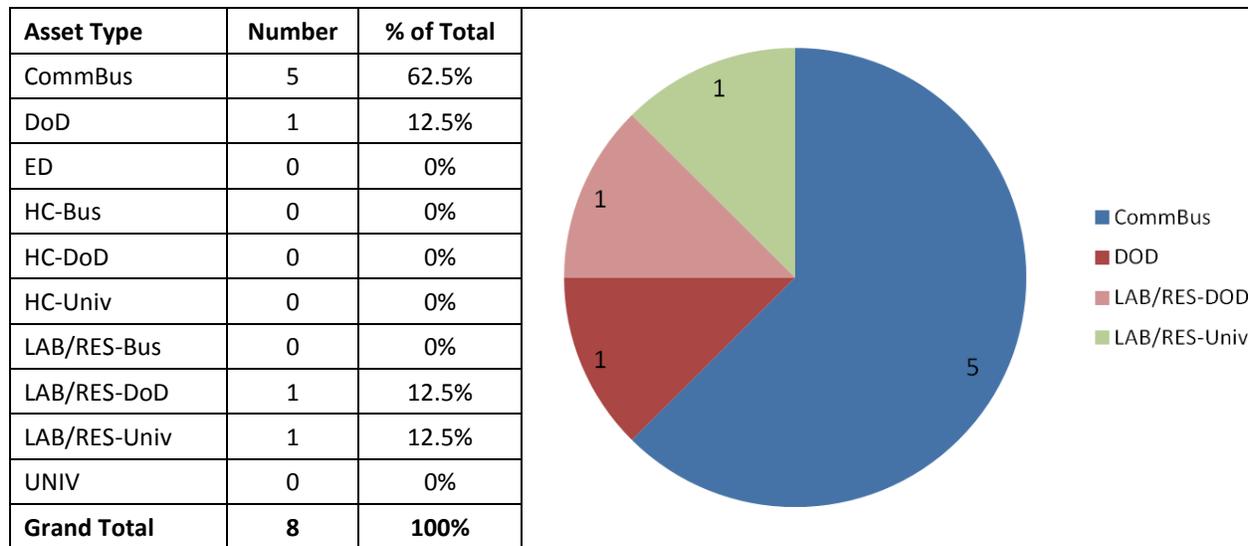
4.2.1 Number of Regional Study Participants

Information for the Fredericksburg Region came from eight study participants in total. This data represents two survey respondents, one College/University and one Commercial Business, and six focus group participants.

4.2.2 Asset Summary

Eight assets were identified for this region; mostly commercial businesses. Table 4-13 presents the number of assets by category type and percent of the total. For a detailed explanation of asset categories, see Table 3-4 page 22.

Table 4-13: Fredericksburg Region M&S Asset Distribution



4.2.3 Economic and Workforce Analyses

The definition of the M&S Industry is discussed in Section 2.6. Labor categories are discussed in Section 2.7 M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-14 presents the current Fredericksburg Region employment estimates for each industry sector.

Table 4-14: Fredericksburg Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Fredericksburg Region Employment, M&S Related Sectors	14,754.57
Pharmaceutical preparation manufacturing	0.00
Other commercial and service industry machinery manufacturing	4.75
Ship building and repairing	0.00
Software publishers	40.70
Telecommunications	322.72
Other information services	106.93
Architectural, engineering, and related services	2,314.98
Custom computer programming services	2,031.22
Computer systems design services	3,020.62
Other computer related services, including facilities management	310.64
Management, scientific, and technical consulting services	1,169.71
Scientific research and development services	447.37
All other miscellaneous professional, scientific, and technical services	511.30
Other private educational services	928.33
Private hospitals	3,545.31
Total Fredericksburg Region Employment	148,523.98

Bold text represents core sectors

It is estimated that approximately ten percent of the Fredericksburg Region total employment is employed in M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Fredericksburg Region are presented in Table 4-15.

Table 4-15: Fredericksburg Region Economic and Workforce Analysis Scenarios

Scenario	Fredericksburg Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-16 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-16: Fredericksburg Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Fredericksburg Region M&S Employment	147.546	183.650	219.755
Pharmaceutical preparation manufacturing	0.000	0.000	0.000
Other commercial and service industry machinery manufacturing	0.048	0.048	0.048
Ship building and repairing	0.000	0.000	0.000
Software publishers	0.407	0.611	0.814
Telecommunications	3.227	3.227	3.227
Other information services	1.069	1.069	1.069
Architectural, engineering, and related services	23.150	23.150	23.150
Custom computer programming services	20.312	30.468	40.624
Computer systems design services	30.206	45.309	60.412
Other computer related services, including facilities management	3.106	3.106	3.106
Management, scientific, and technical consulting services	11.697	17.546	23.394
Scientific research and development services	4.474	6.710	8.947
All other miscellaneous professional, scientific, and technical services	5.113	7.669	10.226
Other private educational services	9.283	9.283	9.283
Private hospitals	35.453	35.453	35.453

Bold text represents core sectors

Scenario 1 estimates that 0.1 percent of the Fredericksburg Region total employment (148,524) is M&S specific, while Scenario 2 estimates 0.12 percent and the Scenario 3 estimate is 0.15 percent. Among the core sectors, *Custom computer programming services* and *Computer systems design services* represent the greatest proportion of M&S employment. Although estimated at lower weights, the related sectors of *Architectural, engineering, and related services* and *Private hospitals* also have relatively high estimates for M&S employment. These high estimates may reflect, in part the relatively high proportion of overall employment among these industries. The economic impact was calculated using the estimates presented in Table 4-16.

Table 4-17 presents the Fredericksburg Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.

- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-17: Fredericksburg Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	2.9	198,084.6	237,914.2	395,381.1
Indirect Effect	0.7	28,870.8	56,323.7	90,041.3
Induced Effect	0.9	32,998.8	68,721.7	111,599.5
Total Effect	4.6	259,954.3	362,959.6	597,021.8
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	3.7	251,569.7	295,777.2	485,662.6
Indirect Effect	0.9	34,970.5	68,080.0	108,735.9
Induced Effect	1.2	41,678.2	86,796.8	140,952.7
Total Effect	5.8	328,218.4	450,654.0	735,351.1
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	4.4	305,007.5	353,557.4	575,625.9
Indirect Effect	1.1	41,052.2	79,804.4	127,377.8
Induced Effect	1.4	50,348.3	104,852.3	170,274.2
Total Effect	6.9	396,407.9	538,214.2	873,277.9

* values in \$1000

The M&S contribution to the Fredericksburg GRP (value added, total effect) is estimated to be \$362.9 million (Scenario 1) to \$538.2 million (Scenario 3). The total economic impact of M&S on the Charlottesville regional economy is estimated to be \$597 million (Scenario 1) to \$873.3 million (Scenario 3).

4.2.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth. Table 4-18 presents the growth projection for each industry sector.

Table 4-18: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-19 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-19: Fredericksburg Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Other commercial and service industry machinery manufacturing	0.055	0.0085	0.055	0.0085	0.055	0.0085
Ship building and repairing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Software publishers	0.484	0.0787	0.726	0.1181	0.968	0.1575
Telecommunications	3.841	0.6106	3.841	0.6106	3.841	0.6106
Other information services	1.244	0.2033	1.244	0.2033	1.244	0.2033
Architectural, engineering, and related services	27.868	3.7886	27.868	3.7886	27.868	3.7886
Custom computer programming services	23.745	4.1401	35.618	6.2102	47.491	8.2803
Computer systems design services	34.772	5.1054	52.159	7.6580	69.545	10.2107
Other computer related services, including facilities management	3.681	0.4696	3.681	0.4696	3.681	0.4696
Management, scientific, and technical consulting services	13.735	2.1633	20.602	3.2450	27.469	4.3267
Scientific research and development services	5.263	0.7793	7.895	1.1689	10.526	1.5586
All other miscellaneous professional, scientific, and technical services	6.055	0.9024	9.083	1.3535	12.111	1.8047
Other private educational services	10.971	1.7113	10.971	1.7113	10.971	1.7113
Private hospitals	35.453	6.4462	35.453	6.4462	35.453	6.4462
Total	167.169	26.4072	209.196	32.9918	251.224	39.5764

Bold text represents core sectors

Table 4-20 presents the projected (2011-2020) M&S economic impact for the Fredericksburg Region based on the labor projections in Table 4-19.

Table 4-20: Fredericksburg Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	26.4	1,783,189.2	2,141,976.6	3,561,290.7
Indirect Effect	6.6	259,995.6	507,194.9	810,837.3
Induced Effect	8.5	297,073.7	618,670.8	1,004,680.8
Total Effect	41.5	2,340,258.5	3,267,842.2	5,376,808.8
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added	Output*
Direct Effect	33.0	2,264,127.6	2,661,983.7	4,370,955.8
Indirect Effect	8.0	314,733.8	612,719.0	978,620.9
Induced Effect	10.7	375,104.2	781,171.3	1,268,574.9
Total Effect	51.8	2,953,965.6	4,055,873.9	6,618,151.5
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	39.6	2,745,086.2	3,182,025.3	5,180,671.2
Indirect Effect	9.5	369,475.3	718,248.7	1,146,413.6
Induced Effect	13.0	453,138.1	943,678.9	1,532,480.6
Total Effect	62.0	3,567,699.7	4,843,952.8	7,859,565.5

* values in \$1000

Analyses project M&S has the potential to contribute \$3.2 billion (Scenario 1) to \$4.8 billion (Scenario 3) to the Fredericksburg Region GRP from 2011-2020.

4.2.4 Regional Challenges Summarized

1. How can we locate workers with specialized M&S skills to fill job vacancies?
2. How can we establish M&S regional networking and provide networking opportunities?
3. How can we build public-private collaboration?

4.2.4.1 Marketplace

While producing only one commercial business survey response for the Fredericksburg Region, the entire set of survey data provided both a regional and Commonwealth-wide perspective of the M&S industry. Information on aspects of the business size of the region's commercial business survey respondent is reported in Table 4-21.

Table 4-21: Fredericksburg Region, Respondents' Commercial Business Size

Annual Revenue	# of Responses	% of Responses	# of Employees	# of Responses	% of Responses
<\$1M	0	0%	1-10	0	0%
\$1M-\$10M	0	0%	11-25	0	0%
\$11M-\$50M	1	100%	26-100	0	0%
\$51M-\$100M	0	0%	101-500	1	100%
\$100M+	0	0%	501-1000	0	0%
Unknown	0	0%	1001-2000	0	0%
Total	1	100%	2001 +	0	0%
			Total	1	100%

Among the commercial businesses surveyed, information about what percentage of the respondents’ total revenue and what percentage of its employees are devoted to M&S was asked. This information is reported in Table 4-22 for the Fredericksburg Region.

Table 4-22: Fredericksburg Region, M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
0%	0	0%	0%	0	0%
1-10%	1	100%	1-10%	1	100%
11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	0	0%
DNR	0	0%	DNR	0	0%
Total	1	100%	Total	1	100%

Information about the Fredericksburg Region survey respondents M&S organizational activities is presented in Table 4-23 on the following page, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-23: Fredericksburg Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses	Budget % – Research M&S	# of Responses	% of Responses	Budget % - Train M&S	# of Responses	% of Responses
0%	0	0%	0%	0	0%	0%	1	50%
1-10%	1	50%	1-10%	1	50%	1-10%	0	0%
11-25%	0	0%	11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	0	0%	76-100%	0	0%
DNR	1	50%	DNR	1	50%	DNR	1	50%
Total	2	100%	Total	2	100%	Total	2	100%

M&S in this region is focused on the DoD and survey and focus group data reflected this focus. Government customers reportedly want to buy a capability, rather than a product, and seek M&S toolkits, which can build a software framework with graphics, etc. This enables Government to use their own workforce in-house to adapt or contract out highly specialized skills. M&S product needs are identified as reusability, data transfer, and infrastructure. Issues with products cited by study participants included portability and compatibility.

4.2.4.2 Workforce

No QOL factors were reported to negatively affect employee recruitment or retention in this region, though difficulty in finding workers with specialized M&S skills was reported. Recent graduates from both Virginia and non-Virginia educational institutions provide the primary source of new hires in the area. According to study participants, there are few job candidates educated only in M&S. Candidates for M&S positions are typically experienced in systems engineering. Typically job candidates lack an M&S experience base along with a primary field.

Information regarding what types of labor categories survey respondents' M&S employees fit into, and also about which labor categories they experienced any M&S employee difficulty in recruitment and retention is presented in Table 4-24. Note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-24: Labor Categories, Employed and Difficult to Recruit or Retain, Fredericksburg Region, All Organizations

Labor Category	Employ	Difficult
Database Administrators	0	1
Graphic Designers	0	1
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	0	0
Software developers	1	0
Software Developers, Applications	1	1
Software Developers, Systems Software	0	1
NONE	0	0

Healthcare-related data management experience was seen as a necessary skill for the changing M&S workforce. Workforce needs identified included a lexicon for the M&S workforce.

4.2.4.3 Networking

M&S specific networking is minimal to non-existent regionally. Study participants reported use of the Simulation Interoperability Standards Organization (SISO) & Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) events for networking.

One survey respondent reported participating in regional business network activities **MORE THAN 10 TIMES** during the past year, and seeking assistance from the regional network **2-4 TIMES** in the same time period. (**THIS TEXT** indicates a survey response choice.)

4.2.4.4 Collaboration

Difficulties in collaboration were reported by regional participants who could identify no working relationships between themselves and any university, research organization or other company for M&S. These difficulties in collaboration were characterized by study participants as self-imposed and stemming from contracting issues. Study participants identified a potential model for regional collaboration as Penn State's applied research lab which has a process in place to enable collaboration. Study participants want both industry and academia to be more open to cross-pollination and exchange of skills and expertise.

4.2.5 Regional Opportunities

Respondents reported a need for greater numbers of qualified workers in this region. Products in the IP inventory identified for potential commercialization include a web-based M&S metadata management tool. In general, the government customer in this region is interested in industry tools that can be used as a base to create their own virtual M&S on top of them as a government effort. This could represent an opportunity for small to medium sized companies; big business is typically not as interested in these types of projects since they are done by the government and are therefore government IP.

4.2.6 Proposed Actions and Investments

Study participants proposed several Commonwealth actions and investments to grow the M&S industry in this region. They are organized by common study area:

Industry

- To encourage business growth, survey respondents advise the establishment of tax incentives for businesses operating and investing in M&S technology.
- Publish a statewide database of companies, government agencies, and educational institutions involved in M&S to encourage networking.

Workforce

- To meet changing M&S workforce needs in the region, encourage more M&S-related programs in Virginia universities and colleges.
- Tailor additional university programs to the M&S field, to include one upper-level science course, and an introduction to M&S where applicable. Provide sufficient funding to grow faculty to meet need.

Education

- Implement distributed networks to improve student learning, providing more opportunities, more resources, and more collaboration.
- Expose public school students to what M&S is early in their education, providing user interfaces that are easily operated and accessible for students.

Networking

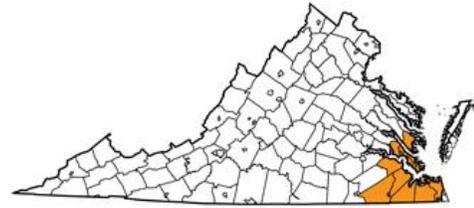
- Establish an annual conference that pulls together Virginia-based M&S stakeholders to network, share information, and collaborate. Participants reported willingness to support such a conference with time and resources.

Collaboration

- Employ laboratory faculty with past performance in working with M&S applications to provide businesses with more incentive and a feeling of trust in capability.

4.3 Hampton Roads Region

This section presents information for the study region identified as the Hampton Roads Region for this report. This region is depicted in the figure shown at right.



Hampton Roads is recognized nationally as a leading region for M&S industry, training, and research. The regional workforce was reported to be abundant with skilled M&S individuals. Two needs were identified for continued growth. The first is access to venture capital, because though the money is there, it’s not being directed toward M&S. The second is a leader to spearhead M&S industry networking and growth. The VA wine and film industry initiatives are looked to as growth models by study participants.

While Hampton Roads is recognized as a national M&S force, perception of its influence was mixed in the survey data. Nineteen respondents agreed that Hampton Roads was recognized as a significant force in M&S, while thirteen respondents disagreed. Ten survey respondents reported that they never used regional branding; fifteen sometimes used it and two always used it.

4.3.1 Number of Regional Study Participants

Information for the Hampton Roads Region was provided by 78 study participants in total. This data represents 48 survey respondents and thirty focus group participants. Survey respondents are reported by type in Table 4-25, below.

Table 4-25: Hampton Roads Region Survey Respondents, By Organization Type

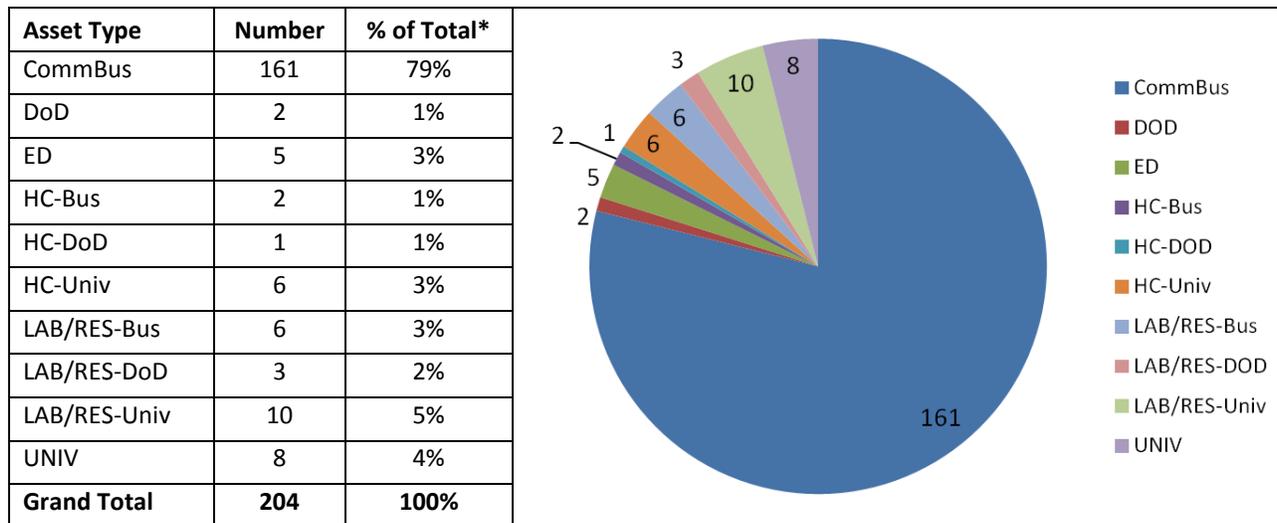
Hampton Roads Region	# of Responses	% of Responses*
College/University	9	19%
Commercial Business	30	63%
DoD	0	0%
Lab/Research	7	15%
Non-Profit	1	2%
Other	0	0%
Procurement	1	2%
Total	48	100%

*rounded to nearest whole number

4.3.2 Asset Summary

The majority of the 204 assets identified for this region are categorized as commercial businesses. Table 4-26, on the following page, presents the number of assets by category type and percent of the total. For an explanation of asset categories, see Table 3-4 page 22.

Table 4-26: Hampton Roads Region M&S Asset Distribution



*rounded to nearest whole number

4.3.3 Economic and Workforce Analyses

The definition of the M&S Industry is discussed in Section 2.6. Labor categories are discussed in Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6. Table 4-27 presents the Hampton Roads Region employment estimates for each industry sector included in the study.

Table 4-27: Hampton Roads Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Hampton Roads Region Employment, M&S Related Sectors	103,581.27
Pharmaceutical preparation manufacturing	65.46
Other commercial and service industry machinery manufacturing	53.04
Ship building and repairing	26,326.44
Software publishers	424.39
Telecommunications	3,646.41
Other information services	166.97
Architectural, engineering, and related services	16,636.77
Custom computer programming services	5,643.59
Computer systems design services	11,564.79
Other computer related services, including facilities management	746.07
Management, scientific, and technical consulting services	4,338.82
Scientific research and development services	5,452.09
All other miscellaneous professional, scientific, and technical services	1,721.15
Other private educational services	6,343.73
Private hospitals	65.46
Total Hampton Roads Region Employment	995,449.17

Bold text represents core sectors

It is estimated that approximately thirteen percent of the Hampton Roads Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Hampton Roads Region are presented in Table 4-28.

Table 4-28: Hampton Roads Region Economic and Workforce Analysis Scenarios

Scenario	Hampton Roads Region	
	Core Sectors	Related Sectors
Scenario 1	15%	3%
Scenario 2	20%	3%
Scenario 3	25%	3%

Table 4-29 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-29: Hampton Roads Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Hampton Roads Region M&S Employment	6604.818	8062.059	9519.301
Pharmaceutical preparation manufacturing	1.964	1.964	1.964
Other commercial and service industry machinery manufacturing	1.591	1.591	1.591
Ship building and repairing	789.793	789.793	789.793
Software publishers	63.658	84.878	106.097
Telecommunications	109.392	109.392	109.392
Other information services	5.009	5.009	5.009
Architectural, engineering, and related services	499.103	499.103	499.103
Custom computer programming services	846.539	1128.718	1410.898
Computer systems design services	1734.719	2312.959	2891.198
Other computer related services, including facilities management	22.382	22.382	22.382
Management, scientific, and technical consulting services	650.823	867.765	1084.706
Scientific research and development services	817.813	1090.417	1363.021
All other miscellaneous professional, scientific, and technical services	258.172	344.230	430.287
Other private educational services	190.312	190.312	190.312
Private hospitals	613.546	613.546	613.546

Bold text represents core sectors

Scenario 1 estimates that 0.66 percent of the Hampton Roads Region total employment (995,449) is M&S specific, while Scenario 2 estimates 0.81 percent and the Scenario 3 estimate is 0.96 percent. Among the core sectors, *Computer systems design services* represents the greatest proportion of M&S employment.

The economic impact was calculated using the estimates presented in Table 4-29.

The following table, Table 4-30, presents the Hampton Roads Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as Gross Regional Product (GRP).
- *Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-30: Hampton Roads Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	129.5	8,022,888.6	9,664,680.7	18,464,372.8
Indirect Effect	44.9	1,875,627.4	3,474,229.8	5,645,005.2
Induced Effect	48.9	1,815,318.0	3,567,760.9	5,847,793.1
Total Effect	223.3	11,713,834.1	16,706,671.3	29,957,171.2
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	158.6	9,944,830.0	11,785,731.6	22,025,292.8
Indirect Effect	53.8	2,232,053.1	4,132,316.9	6,702,832.5
Induced Effect	60.2	2,237,990.2	4,398,388.8	7,209,325.6
Total Effect	272.6	14,414,873.3	20,316,437.3	35,937,450.9
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	187.8	11,866,774.4	13,906,816.1	25,586,272.2
Indirect Effect	62.7	2,588,486.6	4,790,417.2	7,760,680.7
Induced Effect	71.6	2,660,664.4	5,229,020.9	8,570,864.9
Total Effect	322.0	17,115,925.4	23,926,254.1	41,917,817.8

* values in \$1000

The M&S contribution to the Hampton Roads GRP (value added, total effect) is estimated to be \$16.7 billion (Scenario 1) to \$23.9 billion (Scenario 3). The total economic impact of M&S on the Hampton Roads regional economy is estimated to be \$29.9 billion (Scenario 1) to \$41.9 billion (Scenario 3).

4.3.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data. Consequently, BLS projections were adjusted to project 2011-2020 growth.

Table 4-31 presents the growth projection for each industry sector.

Table 4-31: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

Table 4-32 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-32: Hampton Roads Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	2.313	0.3168	2.313	0.3168	2.313	0.3168
Other commercial and service industry machinery manufacturing	1.843	0.2830	1.843	0.2830	1.843	0.2830
Ship building and repairing	942.562	125.0735	942.562	125.0735	942.562	125.0735
Software publishers	75.704	12.3134	100.938	16.4178	126.173	20.5223
Telecommunications	130.193	20.6987	130.193	20.6987	130.193	20.6987
Other information services	5.829	0.9525	5.829	0.9525	5.829	0.9525
Architectural, engineering, and related services	600.833	81.6805	600.833	81.6805	600.833	81.6805
Custom computer programming services	989.618	172.5460	1319.490	230.0614	1649.363	287.5767
Computer systems design services	1996.953	293.1960	2662.604	390.9281	3328.254	488.6601
Other computer related services, including facilities management	26.522	3.3835	26.522	3.3835	26.522	3.3835
Management, scientific, and technical consulting services	764.192	120.3680	1018.923	160.4907	1273.654	200.6134
Scientific research and development services	962.144	142.4573	1282.859	189.9431	1603.574	237.4289
All other miscellaneous professional, scientific, and technical services	305.763	45.5635	407.684	60.7513	509.605	75.9392
Other private educational services	224.915	35.0816	224.915	35.0816	224.915	35.0816
Private hospitals	613.546	111.5567	613.546	111.5567	613.546	111.5567
Total	7642.930	1165.4710	9341.054	1427.6191	11039.179	1689.7672

Bold text represents core sectors

Table 4-33 presents the projected (2011-2020) M&S economic impact for the Hampton Roads Region based on the labor projections in Table 4-32.

Table 4-33: Hampton Roads Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1,165.5	72,206,028.3	86,982,053.8	166,179,169.9
Indirect Effect	404.1	16,880,605.0	31,267,990.8	50,804,917.6
Induced Effect	439.8	16,337,860.5	32,109,845.5	52,630,133.0
Total Effect	2,009.3	105,424,493.7	150,359,890.1	269,614,220.4
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1,427.6	89,503,474.4	106,071,600.1	198,227,617.2
Indirect Effect	484.0	20,088,461.5	37,190,817.5	60,325,430.4
Induced Effect	542.2	20,141,910.4	39,585,497.1	64,883,926.8
Total Effect	2,453.8	129,733,846.3	182,847,914.8	323,436,974.3
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1,689.8	106,800,918.0	125,161,171.0	230,276,109.4
Indirect Effect	563.9	23,296,324.6	43,113,654.2	69,845,959.5
Induced Effect	644.7	23,945,961.0	47,061,150.3	77,137,723.2
Total Effect	2,898.3	154,043,203.6	215,335,975.6	377,259,792.1

* values in \$1000

It is projected that M&S will contribute \$150.4 billion (Scenario 1) to \$215.3 billion (Scenario 3) to the Hampton Roads GRP from 2011 to 2020.

4.3.4 Regional Challenges Summarized

1. How can we get capital (either venture or Commonwealth dollars)?
2. Who will be the leader of the M&S industry growth effort?
3. How do we identify new customers?
4. How do we build public knowledge of M&S?
5. How do we cross over from one M&S market to another?

4.3.4.1 Marketplace

Regional study participants reported that the M&S industry requires a person to lead the growth effort. Participants asserted that small businesses needed a jumpstart in many regions, in addition to funding facilitation. Funding issues were actually a common theme among both focus group sessions and in survey data. Difficulties were cited in obtaining and identifying seed capital, locating commercial sources of funding, obtaining small business funding, and securing bank loans. Banks were characterized as lacking in understanding of the M&S market, and unwilling to loan to small businesses; thus, a gap exists between prototype software and final products.

In bringing new products or services to market, finding a buyer is also an issue. Identification of initial customer bases and gaining customer acceptance of new products are challenges. There is a lack of public understanding about the use, applications, and capability of M&S to increase efficiency, decrease costs, and standardize processes.

Insufficient internal staff resources present issues. This deficiency impacts finding funds for marketing, lack of a marketing organization, and marketing to new segments. Moreover, understanding the return on investment in a newly emerging market segment is difficult. Obtaining funding to employ M&S skilled people to use newly acquired products is also an issue cited by defense industry stakeholders. The DoD market cash flow model requires large stores of cash reserves or the ability to borrow payroll against (projected) receivables. This impacts hiring.

Modeling, simulation, and visualization hardware, software, and tools for analysis, research, development, training, and evaluation are used in the region. Specific examples included:

- Computational scientific modeling and visualization
- Computational fluids software and software for simulation framework
- Software tools for developing, hosting, and validating aircraft flight models
- UAS Intelligence, Surveillance, and Reconnaissance Research & Development
- Teaching tools for STEM related classrooms
- Authoring tools for games, video production, and high end work-station hardware
- CAD/CAM engineering design and analysis
- Discrete event simulation
- Grid generation
- Medical simulators
- Compilers
- Gaming engines
- Constructive (high/low resolution) simulations for communications
- Structural analysis, thermal analysis, satellite simulation

Issues cited with M&S products focused primarily on affordability, usability, licensing, and compatibility. In licensing, fees and requirements for third party indemnification (not possible for state agencies) and the need to articulate licensing agreements and product distribution agreements are impediments. Limited end-user involvement during design results in issues; a high degree of qualification to use products is required. Backward compatibility and traditional software currency and system integration are also issues.

Information on aspects of the business size of the Hampton Roads Region's commercial business survey respondents is reported in Table 4-34.

Table 4-34: Hampton Roads Region, Respondents' Commercial Business Size

Annual Revenue	# of Responses	% of Responses	# of Employees	# of Responses	% of Responses
<\$1M	11	36.67%	1-10	11	36.67%
\$1M-\$10M	8	26.67%	11-25	2	6.67%
\$11M-\$50M	2	6.67%	26-100	7	23.33%
\$51M-\$100M	4	13.33%	101-500	5	16.67%
\$100M+	5	16.67%	501-1000	1	3.33%
Unknown	0	0.00%	1001-2000	0	0.00%
Total	30	100%	2001 +	4	13.33%
			Total	30	100%

Among the commercial businesses, information about what percentage of the respondents’ total revenue and what percentage of its employees are devoted to M&S was asked. This information is presented in Table 4-35 for the Hampton Roads Region.

Table 4-35: Hampton Roads Region, M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
0%	4	13%	0%	4	13%
1-10%	10	33%	1-10%	9	30%
11-25%	6	20%	11-25%	2	7%
26-50%	1	3%	26-50%	2	7%
51-75%	1	3%	51-75%	1	3%
76-100%	8	27%	76-100%	6	20%
DNR	0	0%	DNR	6	20%
Total	30	100%	Total	30	100%

Information about all of the Hampton Roads Region survey respondents’ M&S business activities is presented in Table 4-36, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-36: Hampton Roads Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses	Budget % – Research M&S	# of Responses	% of Responses	Budget % - Train M&S	# of Responses	% of Responses
0%	7	14.58%	0%	14	29.17%	0%	16	33.33%
1-10%	12	25.00%	1-10%	20	41.67%	1-10%	17	35.42%
11-25%	8	16.67%	11-25%	6	12.50%	11-25%	4	8.33%
26-50%	3	6.25%	26-50%	1	2.08%	26-50%	0	0.00%
51-75%	2	4.17%	51-75%	0	0.00%	51-75%	0	0.00%
76-100%	8	16.67%	76-100%	3	6.25%	76-100%	1	2.08%
DNR	8	16.67%	DNR	4	8.33%	DNR	10	20.83%
Total	48	100%	Total	48	100%	Total	48	100%

4.3.4.2 Workforce

The southern part of the region produces a sufficient academically trained personnel. Strategies have been developed to grow and identify skilled workforce. For example, companies find interns from academic institutions all over the country, not just the Commonwealth. Companies also work with government organizations to fund internships or robotics and higher mathematics.

To the north, industry is moving faster than M&S skilled graduates can be produced. Software simulation knowledge is lacking in the quantity needed so work is typically outsourced. Often companies utilize regional education institutions to train software developers and analysts in M&S through an apprenticeship .Higher wages draw much young talent away from the area. In fact, Government assets reported difficulties in recruiting and retaining GIS specialists, 3-D modelers, video programmers, and C++ based and Java skilled personnel. Reportedly, between twenty and thirty percent leave for higher pay.

Employment was also examined regarding what types of labor categories respondents' M&S employees fit into, and also which labor categories they experienced any M&S employee difficulty in recruitment and retention. Survey response information is presented on the following page, in Table 4-37. Note that the numbers in this table are only indicative of responses, and not numbers of employees. While there were several types of employees reported, among the most difficult to recruit or retain were software developers.

Table 4-37: Labor Categories, Employed or Difficult to Recruit or Retain, Hampton Roads Region, All Organizations

Labor Category	Employ	Difficult
Aerospace Engineers	8	1
Analyst	9	1
Biochemists and Biophysicists	1	0
Biomedical Engineers	0	1
Chemical Technicians	1	0
Chemists	3	0
Civil Engineers	1	1
Computer and Information Systems Managers	6	0
Computer Hardware Engineers	5	0
Computer Programmers	16	2
Computer Systems Analysts	7	0
Database Administrators	8	0
Electrical and Electronic Engineering Technicians	1	0
Electrical Engineers	5	1
Electronics Engineers, Except Computer Engineer	2	0
Engineer	6	1
Graphic Artist	9	1
Graphic Designers	9	1
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	1	0
Industrial Engineers	2	1
Information Security Analysts, Web Developers, and Computer Network Architects	4	0
Instructional Coordinators	5	0
Materials Engineers	1	1
Materials Scientists	2	1
Mechanical Engineers	5	1
Medical Records and Health Information Technicians	1	0
Microbiologists	1	0
Multimedia Artists and Animators	5	1
Network and Computer Systems Administrators	6	1
Nuclear Engineers	0	1
Operations Research Analysts	9	2
Programmer	9	3
Researcher	7	0
Software developers	12	4
Software Developers, Applications	14	4
Software Developers, Systems Software	9	3
Teacher	7	0
NONE		13

Twenty-one Hampton Roads survey respondents reported that no QOL factors negatively impacted employee recruitment or retention; however, fifty respondents reported QOL factors that negatively impacted their ability to recruit or retain employees. Transportation (9 responses) was the most oft-cited factor followed by limited K-12 educational opportunities (1 response); healthcare access (2 responses); affordable housing (2 responses). Other factors impacting recruitment were, career stability and growth and pay not keeping up with the regional cost of living. A difficulty in bridging from traditional engineering to specific M&S fields was noted.

Factors impacting workforce retention included career stability and growth, competition for skilled employees from other national hubs, and lack of customer knowledge about M&S.

Respondents focused on the need for a multi-disciplined workforce. The workforce should be educated in advanced physics, engineering, math, technical sciences, and current computer technology. Capabilities in game design and multi-disciplinary engineering analysis are needed, as are software development, engineering, and coding skills. Experienced programmers gaming/simulation programmers are needed. Developers of robotics operational and behavioral simulations with groupware human factors assessment capabilities will be needed for the future.

Respondents also called for hands-on experience in M&S workforce. Specifically, employers want job candidates with practical application of dynamic databases with reasoning logic, web services, constructive and virtual simulation integration with collaborative environments, in a mobile end user environment. They want workers with the ability to adapt skills to a hybrid M&S and gaming application environment. A need for more multi-faceted Subject Matter Experts, support technicians, network engineers and analysts was reported, as was need for workers experienced in information assurance and quality control.

4.3.4.3 Networking

Survey responses and focus group discussions revealed the region has strong networks, including those that are M&S based. While 36 survey respondents report engaging in networking activities, less than half of those sought assistance from Commonwealth organizations to do so five times or more in the past year. MODSIM World was identified as a networking event; however, stakeholders asserted that it must reorient its focus around industry and issues other than those pertaining to DoD. Participants were concerned about an apparent decline in attendance to meetings and community events in terms of sustained interest in M&S regionally.

Table 4-38, on the following page, presents network activity survey responses.

Table 4-38: Hampton Roads Number of Networking Activities, Past Year

# of Networking Activities	# of Responses	# of Times Sought Assistance	# of Responses
Never	0	Never	9
1 Time	4	1 Time	3
2-4 Times	13	2-4 Times	11
5-10 Times	3	5-10 Times	2
More than 10 Times	12	More than 10 times	4
Unknown	4	Unknown	6
Total Responses	36	Total Responses	35

4.3.4.4 Collaboration

Collaboration with universities and research organizations occurs regionally, Commonwealth-wide, nationally, and internationally, however, participants were concerned that some institutions lacked interest in application specific R&D.

4.3.5 Regional Opportunities

Products identified for potential commercialization are listed in the IP inventory. These included tools for aerospace, authoring, healthcare, defense, education, emergency management, mapping, energy/power, games, life sciences, and training. Autonomous vehicles and mobile and cloud simulations were also identified. Specific examples included:

- Full Motion Video Intelligence, Surveillance and Reconnaissance (FMV ISR) software
- Ultrasound and blood simulation
- Inundation mapping
- Nuclear and thermal power plant simulation

4.3.6 Proposed Actions and Investments

Study participants proposed several actions and investments for industry and government in order to grow the M&S industry. Many were similar to recommendations already presented. Others are presented below, organized by common theme:

Business/industry general

- Provide seed funding like CRCF and Center for Innovative Technology (CIT).
- Interview companies that decide against locating in VA; their reasons will inform what obstacles the Commonwealth needs to overcome.
- Use California and Austin start ups as an example and invest in a lean start-up mentality.
- Help businesses create a plan for entering a new market.

Small business specific

- Require school systems to purchase hardware and software from VA small businesses.
- Work with banks to foster small business growth in high-tech fields.
- Establish M&S centers to incubate small businesses.

Center of Excellence (COEs)/incubators

- Develop a technology incubator.
- Establish a corridor of excellence similar to San Jose or Research Triangle Institute (RTI)
- propose pilot program to get a corridor of excellence for M&S off the ground to implement HR 487 to make US more competitive in a global economy.

Education

- Develop M&S apprenticeships.
- Implement hands-on certification programs instead of pure academic programs.
- Provide more educational entities producing gaming/simulation programmers.
- Encourage engineering at VA schools at the lowest level.
- Introduce entry level M&S degrees in associate colleges.
- Provide incentives and support for university spin-off companies to transition students into local work environments.

Infrastructure

- Expand UVS M&S and lab and field test environment capacities.
- Provide cloud based computing environment for M&S.
- Implement high throughput mobile communications networks.

Marketing

- “Buy Virginia First” when seeking M&S products & solutions for Commonwealth needs.
- Market VA as a National hub/hotspot both here and abroad.
- Encourage local and regional agencies to use M&S.

R&D

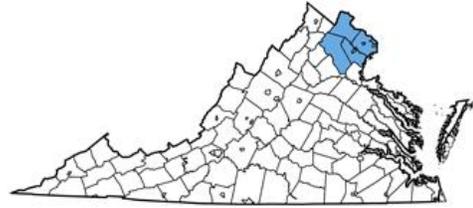
- Provide R&D grants to develop 'turn-key' M&S solutions because customers are hesitant to take on developmental costs.
- Conduct funded research studies open to commercial business competitors.
- Fund M&S in a university-based organization like the National Institute of Aerospace.

Taxation/Regulation

- Provide a tax credit to reward business collaboration for new products.
- Provide an incentive M&S implementation within new markets.
- Provide tax incentives for companies to locate here, or locate satellites here.

4.4 Northern Virginia Region

This section presents information for the study region identified as the Northern Virginia Region. This region is depicted in the figure shown at right.



The Northern Virginia Region has a wealth of focal areas, associations and networks; M&S is somewhat lost in this crowd. Access is important factor here for personal face-to-face networking and business deals, but in terms of workers, telecommuting presents no issues. Study participants reported no issue with the lack of an M&S NAICS code. The business environment is good and local schools draw in students of science and technology, which promotes workers with families to move and stay in this region.

Most participants here viewed M&S as an enabling tool, not an industry on its own, though input was mixed. Six Northern Virginia survey respondents thought the region was recognized as a significant force for M&S, while five did not agree. Four survey respondents reported use of regional branding in their marketing all the time, while four reported they never used it.

4.4.1 Number of Regional Study Participants

Information for the Northern Virginia Region was provided by 25 study participants in total. This data represents 22 survey respondents (see Table 4-39) and three focus group participants.

Table 4-39: Northern Virginia Survey Respondents Organization Distribution

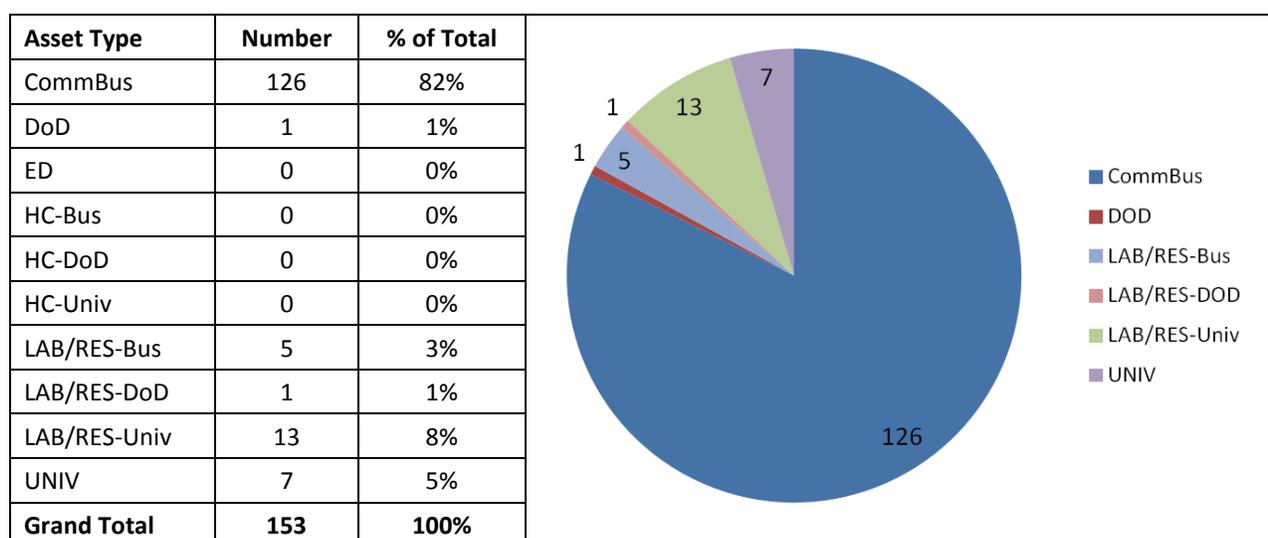
Organization Type	# of Responses	% of Responses*
College/University	5	23%
Commercial Business	10	45%
DoD	1	5%
Lab/Research	3	14%
Non-Profit	1	5%
Other	0	0%
Procurement	2	9%
Total	22	100%

*rounded to nearest whole number

4.4.2 Asset Summary

Commercial businesses, laboratory or research organizations, universities, and DoD assets comprise the 153 assets identified for this region. Their distribution by categories is shown in Table 4-40 on the following page. For an explanation of asset categories, see Table 3-4 page 22. Primarily, the assets are commercial businesses and laboratories/research organizations.

Table 4-40: Northern Virginia Region M&S Asset Distribution



4.4.3 Economic and Workforce Analyses

The definition of the M&S Industry and labor categories is discussed in Section 2.6 and Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-41 presents the Northern Virginia Region employment estimates for each industry sector.

Table 4-41: Northern Virginia Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Northern Virginia Region Employment, M&S Related Sectors	346,337.74
Pharmaceutical preparation manufacturing	185.48
Other commercial and service industry machinery manufacturing	31.58
Ship building and repairing	24.56
Software publishers	4,864.10
Telecommunications	19,888.03
Other information services	589.22
Architectural, engineering, and related services	37,131.73
Custom computer programming services	42,494.24
Computer systems design services	102,397.77
Other computer related services, including facilities management	8,283.68
Management, scientific, and technical consulting services	62,591.68
Scientific research and development services	23,112.42
All other miscellaneous professional, scientific, and technical services	5,191.70
Other private educational services	19,302.48
Private hospitals	20,249.06
Total Northern Virginia Region Employment	1,570,502.72

Bold text represents core sectors

It is estimated that approximately 22 percent of the Northern Virginia Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Northern Virginia Region are presented in Table 4-42.

Table 4-42: Northern Virginia Region Economic and Workforce Analysis Scenarios

Scenario	Northern Virginia Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-43 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-43: Northern Virginia Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total	3463.377	4666.637	5869.897
Pharmaceutical preparation manufacturing	1.855	1.855	1.855
Other commercial and service industry machinery manufacturing	0.316	0.316	0.316
Ship building and repairing	0.246	0.246	0.246
Software publishers	48.641	72.962	97.282
Telecommunications	198.880	198.880	198.880
Other information services	5.892	5.892	5.892
Architectural, engineering, and related services	371.317	371.317	371.317
Custom computer programming services	424.942	637.414	849.885
Computer systems design services	1023.978	1535.967	2047.955
Other computer related services, including facilities management	82.837	82.837	82.837
Management, scientific, and technical consulting services	625.917	938.875	1251.834
Scientific research and development services	231.124	346.686	462.248
All other miscellaneous professional, scientific, and technical services	51.917	77.876	103.834
Other private educational services	193.025	193.025	193.025
Private hospitals	202.491	202.491	202.491

Bold text represents core sectors

Scenario 1 estimates that .022 percent of the Northern Virginia Region total employment (1,570,502) is M&S specific, while Scenario 2 estimates 0.3 percent and the Scenario 3 estimate is 0.37 percent. Among the core sectors, *Computer systems design services* represents the greatest proportion of M&S employment.

The economic impact was calculated using the estimates presented in Table 4-43.

Table 4-44 presents the Northern Virginia Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-44: Northern Virginia Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	68.8	7,717,949.7	9,058,698.0	13,257,276.1
Indirect Effect	22.3	1,577,724.6	2,490,652.5	3,733,093.8
Induced Effect	31.1	1,596,505.2	2,761,151.2	4,241,307.9
Total Effect	122.2	10,892,179.6	14,310,501.7	21,231,677.8
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added	Output*
Direct Effect	92.9	10,547,170.2	11,903,073.6	17,249,698.0
Indirect Effect	28.8	2,017,438.1	3,166,917.6	4,726,394.0
Induced Effect	42.1	2,157,190.7	3,730,858.0	5,730,843.7
Total Effect	163.8	14,721,799.0	18,800,849.1	27,706,935.8
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	117.0	13,376,386.6	14,747,442.6	21,242,110.1
Indirect Effect	35.3	2,457,150.2	3,843,180.6	5,719,691.1
Induced Effect	53.0	2,717,875.3	4,700,563.2	7,220,377.2
Total Effect	205.3	18,551,412.0	23,291,186.4	34,182,178.4

* values in \$1000

The M&S contribution to the Northern Virginia GRP (value added, total effect) is estimated to be \$14.3 billion (Scenario 1) to \$23.3 billion (Scenario 3). The total economic impact of M&S on the Northern Virginia regional economy is estimated to be \$21.2 billion (Scenario 1) to \$34.2 billion (Scenario 3).

4.4.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth. Table 4-45 presents the growth projection for each industry sector.

Table 4-45: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors; * Source: US Bureau of Labor Statistics; ** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-46 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-46: Northern Virginia Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	2.185	0.2992	2.185	0.2992	2.185	0.2992
Other commercial and service industry machinery manufacturing	0.366	0.0562	0.366	0.0562	0.366	0.0562
Ship building and repairing	0.293	0.0389	0.293	0.0389	0.293	0.0389
Software publishers	57.845	9.4086	86.767	14.1129	115.689	18.8171
Telecommunications	236.697	37.6312	236.697	37.6312	236.697	37.6312
Other information services	6.856	1.1204	6.856	1.1204	6.856	1.1204
Architectural, engineering, and related services	447.001	60.7678	447.001	60.7678	447.001	60.7678
Custom computer programming services	496.765	86.6140	745.147	129.9210	993.529	173.2280
Computer systems design services	1178.770	173.0691	1768.155	259.6036	2357.540	346.1381
Other computer related services, including facilities management	98.157	12.5222	98.157	12.5222	98.157	12.5222
Management, scientific, and technical consulting services	734.947	115.7616	1102.421	173.6424	1469.894	231.5232
Scientific research and development services	271.914	40.2602	407.871	60.3903	543.828	80.5205
All other miscellaneous professional, scientific, and technical services	61.487	9.1626	92.231	13.7439	122.975	18.3251
Other private educational services	228.121	35.5817	228.121	35.5817	228.121	35.5817
Private hospitals	202.491	36.8174	202.491	36.8174	202.491	36.8174
Total	4023.895	619.1111	5424.759	836.2491	6825.623	1053.3871

Bold text represents core sectors

Table 4-47 presents the projected (2011-2020) M&S economic impact for the Northern Virginia Region based on the labor projections in Table 4-46.

Table 4-47: Northern Virginia Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	619.1	69,461,535.3	81,528,272.8	119,315,505.9
Indirect Effect	200.7	14,199,526.6	22,415,876.3	33,597,849.8
Induced Effect	280.1	14,368,546.6	24,850,359.7	38,171,769.2
Total Effect	1,099.9	98,029,608.5	128,794,508.8	191,085,124.8
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	910.5	100,058,140.7	112,783,415.6	165,711,920.0
Indirect Effect	282.6	19,541,887.5	30,988,264.1	46,123,631.5
Induced Effect	400.2	20,529,226.9	35,505,326.5	54,538,306.5
Total Effect	1,593.3	140,129,255.1	179,277,006.2	266,373,858.1
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1,053.4	120,387,459.0	132,726,944.3	191,178,977.5
Indirect Effect	317.6	22,114,354.8	34,588,626.1	51,477,220.8
Induced Effect	476.9	24,460,874.6	42,305,064.4	64,983,387.6
Total Effect	1,847.9	166,962,688.4	209,620,634.8	307,639,585.9

* values in \$1000

Based on the previous table, it is estimated that M&S will contribute \$128.8 billion (Scenario 1) to \$209.6 billion (Scenario 3) to the Northern Virginia GRP from 2011 to 2020.

4.4.4 Regional Challenges Summarized

1. How do we emphasize M&S in a sea of other industry?
2. How do we generate enthusiasm for an M&S network?

4.4.4.1 Marketplace

Products used include M&S training, communication, education, analysis and optimization tools such as:

- Tools to develop modeling software such as Matlab, etc
- Game Engines
- Software development tools, computer hardware
- Education and research support
- Small team communications

Issues identified with M&S products center on access, cost, and alignment of capability with requirements. Specifics are:

- IP protection and license management
- DoD controlled licensing and approval
- Proprietary scenarios and classified data scenarios and data
- Scalability
- Processing time and data storage for very large complex work

Obstacles cited to marketplace expansion included getting a foothold in the market. Locating the first customer in a sector is tough, and in general, customers must be educated about the potential of M&S. Study participants identified the need for more opportunities to meet potential customers and develop mutual understanding of needs and capabilities, and meeting the right person with the authority to fund purchases of the product or service. Lack of sufficient R&D funding, trained work force, as well as a lack of marketing support and resources were also cited.

Information on aspects of the business size of the Northern Virginia Region's commercial business survey respondents is reported in Table 4-48.

Table 4-48: Northern Virginia Region, Respondents' Commercial Business Size

Annual Revenue	#	%	# of Employees	#	%
<\$1M	3	30%	1-10	4	40%
\$1M-\$10M	3	30%	11-25	0	0%
\$11M-\$50M	2	20%	26-100	1	10%
\$51M-\$100M	0	0%	101-500	2	20%
\$100M+	2	20%	501-1000	2	20%
Unknown	0	0%	1001-2000	0	0%
Total	10	100%	2001 +	1	10%
			Total	10	100%

Among the commercial businesses, information about what percentage of the respondents' total revenue and what percentage of its employees are devoted to M&S was asked. This information is presented in Table 4-49 for the Northern Virginia Region.

Table 4-49: Northern Virginia Region, M&S Percentage, Commercial Businesses

Revenue – M&S%	#	%	Employees – M&S%	#	%
0%	1	10%	0%	0	0%
1-10%	0	0%	1-10%	1	10%
11-25%	2	20%	11-25%	0	0%
26-50%	2	20%	26-50%	1	10%
51-75%	2	20%	51-75%	1	10%
76-100%	3	30%	76-100%	4	40%
DNR	0	0%	DNR	3	30%
Total	10	100%	Total	10	100%

Information about all of the Northern Virginia Region survey respondents' M&S business activities is presented in Table 4-50, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-50: Northern Virginia Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses *	Budget % - Research M&S	# of Responses	% of Responses *	Budget % - Train M&S	# of Responses	% of Responses *
0%	0	0%	0%	1	5%	0%	2	9%
1-10%	7	32%	1-10%	8	36%	1-10%	7	32%
11-25%	2	9%	11-25%	2	9%	11-25%	4	18%
26-50%	3	14%	26-50%	4	18%	26-50%	1	5%
51-75%	0	0%	51-75%	1	5%	51-75%	0	0%
76-100%	5	23%	76-100%	2	9%	76-100%	0	0%
DNR	5	23%	DNR	4	18%	DNR	8	36%
Total	22	100%	Total	22	100%	Total	22	100%

*rounded to nearest whole number

4.4.4.2 Workforce

STEM education has helped the recruitment of M&S workforce in that the pool of qualified candidates has been strengthened. There were no reports of unqualified workers in this region. Survey respondents reported two QOL factors that negatively impacted employee recruitment or retention, affordable housing (8 responses) and transportation (4 responses). Four survey respondents reported that no QOL factors negatively impacted recruitment or retention.

Factors affecting workforce recruitment included cost of living, and competition for skilled workers with other national hubs. Factors affecting workforce retention included salary and cost of living.

Employment was examined regarding what types of labor categories respondents' M&S employees fit into, and also which labor categories they experienced any M&S employee difficulty in recruitment and retention. Survey response information is presented in Table 4-51. Note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-51: Labor Categories, Employed or Difficult to Recruit or Retain, Northern Virginia Region

Labor Category	Employ	Difficult
Aerospace Engineers	5	1
Analyst	7	0
Biochemists and Biophysicists	0	0
Biomedical Engineers	1	0
Computer and Information Systems Managers	4	0
Computer Hardware Engineers	2	0
Computer Programmers	10	1
Computer Systems Analysts	3	0
Database Administrators	4	0
Electrical and Electronic Engineering Technicians	2	0
Electrical Engineers	3	0
Electronics Engineers, Except Computer	1	0
Engineer	5	1
Graphic Artist	2	0
Graphic Designers	3	0
Industrial Engineers	2	0
Information Security Analysts, Web Developers, and Computer Network Architects	4	0

Labor Category	Employ	Difficult
Instructional Coordinators	1	0
Mechanical Engineers	2	0
Medical Scientists, Except Epidemiologists	1	0
Multimedia Artists and Animators	2	1
Network and Computer Systems Administrators	2	0
Operations Research Analysts	4	0
Programmer	8	1
Researcher	8	2
Software developers	10	4
Software Developers, Applications	10	4
Software Developers, Systems Software	5	1
Teacher	1	1
NONE		4

Workforce skills needed to expand Virginia's M&S industry capabilities were identified as stronger math and science education to understand models, multi-disciplined experience, and supported continued skill growth through certification. Respondents asserted that the M&S technology needs to be supplemented with a background that matches that of the customer, that a business background would help in productization and development, and that cyber security or IT backgrounds would also be helpful.

Experience needs were cited as:

- Animation of models for better understanding, greater impact.
- Commercial language/platform experience.
- Mobile platform development experience
- Cloud integration experience
- Skill to perform calibration of and elicitation from humans when data is sparse

4.4.4.3 Networking

Extensive networking takes place here, it is just not necessarily driven by common interests in M&S. During focus group discussions, National Defense Industrial Association (NDIA) and NTSA were identified as the only drivers of M&S networking in the Northern Virginia Region. Networking activity as reported by survey respondents is presented in Table 4-52.

Table 4-52: Northern Virginia Region Networking Activities

# of Networking Activities	# of Responses	# of Times Sought Assistance	# of Responses
Never	1	Never	2
1 Time	1	1 Time	2
2-4 Times	6	2-4 Times	5
5-10 Times	2	5-10 Times	0
More than 10 Times	1	More than 10 times	1
Unknown	2	Unknown	3
Total	13	Total	13

4.4.4.4 Collaboration

Collaboration and collaborative networks abound in the region, though not oriented around M&S. University-business collaboration sometimes hits a roadblock because classified materials work cannot be performed by interns.

4.4.5 Regional Opportunities

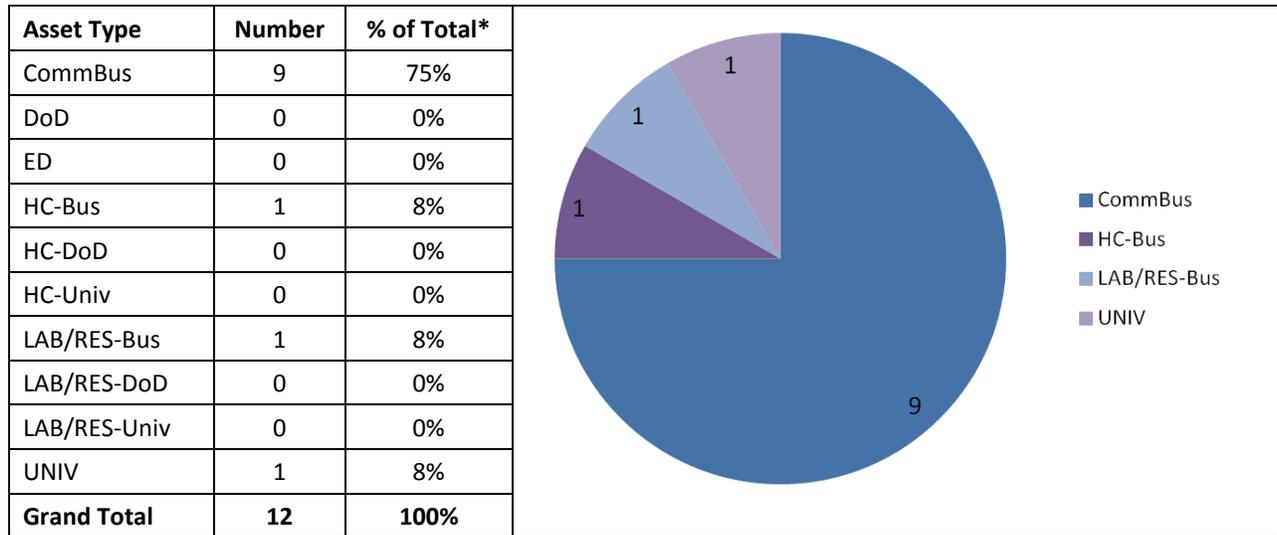
Several products that could be commercialized were identified. These are listed in the IP inventory. They include analytic, financial, automotive, and communications models, simulations, and tools.

4.4.6 Proposed Actions and Investments

Study participants proposed several Commonwealth actions and investments to grow the M&S industry in this region. Several have already been discussed in previous sections of this report. Others included establishing an M&S center at CIT and creating an industry exposition focused on transportation and energy. They suggested forming relationships with university and venture capital areas to explore sensors, data collection, calibration of human judgment. Education proposed actions included encouraging institutions that perform M&S development to support mentorship programs at the high school level and providing more emphasis on the organization and construction of models and simulations in academic programs.

Study participants would also like tax advantages for access to high-quality data that the Commonwealth could share in some formal/protected way. They suggested that the Commonwealth implement M&S in transportation decision making and seek to become a fiber hub, bring fiber to rural areas.

Table 4-53: Region 2000 M&S Asset Distribution



*rounded to the nearest whole number

4.5.3 Economic and Workforce Analyses

The definition of the M&S Industry and labor categories is discussed in Section 2.6 and Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-54 presents the Region 2000 employment estimates for each industry sector.

Table 4-54: Region 2000 Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Region 2000 Employment, M&S Related Sectors	9,546.56
Pharmaceutical preparation manufacturing	227.42
Other commercial and service industry machinery manufacturing	4.44
Ship building and repairing	0.00
Software publishers	3.52
Telecommunications	371.65
Other information services	7.18
Architectural, engineering, and related services	3,252.99
Custom computer programming services	519.36
Computer systems design services	234.93
Other computer related services, including facilities management	11.39
Management, scientific, and technical consulting services	347.39
Scientific research and development services	190.41
All other miscellaneous professional, scientific, and technical services	171.68
Other private educational services	506.74
Private hospitals	3,697.46
Total Region 2000 Employment	134,481.95

Bold text represents core sectors

It is estimated that approximately seven percent of the Region 2000 total employment is employed in M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for this region are presented in Table 4-55.

Table 4-55: Region 2000 Economic and Workforce Analysis Scenarios

Scenario	Region 2000	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-56 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-56: Region 2000 M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Region 2000 M&S Employment	95.466	102.802	110.139
Pharmaceutical preparation manufacturing	2.274	2.274	2.274
Other commercial and service industry machinery manufacturing	0.044	0.044	0.044
Ship building and repairing	0.000	0.000	0.000
Software publishers	0.035	0.053	0.070
Telecommunications	3.717	3.717	3.717
Other information services	0.072	0.072	0.072
Architectural, engineering, and related services	32.530	32.530	32.530
Custom computer programming services	5.194	7.790	10.387
Computer systems design services	2.349	3.524	4.699
Other computer related services, including facilities management	0.114	0.114	0.114
Management, scientific, and technical consulting services	3.474	5.211	6.948
Scientific research and development services	1.904	2.856	3.808
All other miscellaneous professional, scientific, and technical services	1.717	2.575	3.434
Other private educational services	5.067	5.067	5.067
Private hospitals	36.975	36.975	36.975

Bold text represents core sectors

Scenario 1 estimates that 0.07 percent of the Region 2000 total employment (134,482) is M&S specific, while Scenarios 2 and 3 estimate that 0.08 percent is M&S specific. Among the core sectors, *Custom computer programming services* and *Management, scientific, and technical consulting services* represent the greatest proportion of M&S employment. Although estimated at lower weights, the related sectors of *Architectural, engineering, and related services*, and *Private hospitals* have significantly higher estimates for M&S employment than any of the core sectors. These high estimates may be reflective, in part, of the relatively high proportion of overall employment among these industries, but it may also be reflective of the low proportional employment in recognized M&S core industries.

The economic impact was calculated using the estimates presented in Table 4-56.

Table 4-57 presents the Region 2000 economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- Labor Income reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-57: Region 2000 M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.9	126,563.7	169,342.3	316,178.6
Indirect Effect	0.7	22,168.9	43,280.1	72,012.9
Induced Effect	0.8	23,745.1	52,199.1	87,390.3
Total Effect	3.3	172,477.8	264,821.6	475,581.8
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	2.0	135,524.1	181,372.5	335,611.4
Indirect Effect	0.7	23,424.3	45,851.9	76,238.9
Induced Effect	0.8	25,376.2	55,785.1	93,394.0
Total Effect	3.5	184,324.6	283,009.6	505,244.3
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	2.2	144,484.9	193,403.0	355,046.4
Indirect Effect	0.7	24,680.1	48,424.5	80,466.1
Induced Effect	0.9	27,007.5	59,371.4	99,398.3
Total Effect	3.8	196,172.5	301,198.9	534,910.8

* values in \$1000

The M&S contribution to Region 2000's GRP (value added, total effect) is estimated to be \$264.8 million (Scenario 1) to \$301.2 million (Scenario 3). The total economic impact of M&S on the Region 2000 economy is estimated to be \$475.6 million (Scenario 1) to \$534.9 million (Scenario 3).

4.5.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth. Table 4-58 presents the growth projection for each industry sector.

Table 4-58: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-59 on the following page presents the estimated number of new jobs by sector and M&S-jobs for each scenario.

Table 4-59: Region 2000 Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	2.679	0.3668	2.679	0.3668	2.679	0.3668
Other commercial and service industry machinery manufacturing	0.051	0.0079	0.051	0.0079	0.051	0.0079
Ship building and repairing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Software publishers	0.042	0.0068	0.063	0.0102	0.084	0.0136
Telecommunications	4.423	0.7032	4.423	0.7032	4.423	0.7032
Other information services	0.084	0.0137	0.084	0.0137	0.084	0.0137
Architectural, engineering, and related services	39.160	5.3237	39.160	5.3237	39.160	5.3237
Custom computer programming services	6.071	1.0586	9.107	1.5879	12.143	2.1172
Computer systems design services	2.704	0.3971	4.057	0.5956	5.409	0.7941
Other computer related services, including facilities management	0.135	0.0172	0.135	0.0172	0.135	0.0172
Management, scientific, and technical consulting services	4.079	0.6425	6.119	0.9637	8.158	1.2850
Scientific research and development services	2.240	0.3317	3.360	0.4975	4.480	0.6634
All other miscellaneous professional, scientific, and technical services	2.033	0.3030	3.050	0.4545	4.066	0.6060
Other private educational services	5.989	0.9341	5.989	0.9341	5.989	0.9341
Private hospitals	36.975	6.7228	36.975	6.7228	36.975	6.7228
Total	106.666	16.8291	115.251	18.1989	123.836	19.5687

Bold text represents core sectors

Table 4-60 presents the projected (2011-2020) M&S economic impact for the Region 2000 based on the labor projections in Table 4-59 (previously). It is estimated that M&S will contribute \$2.4 million (Scenario 1) to \$2.7 million (Scenario 3) to the Region 2000 GRP from 2011 to 2020.

Table 4-60: Region 2000 Projected Economic Impact, 2011-2012

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	16.8	1,139,071.6	1,524,060.5	2,845,534.2
Indirect Effect	5.9	199,514.0	389,509.8	648,096.3
Induced Effect	6.8	213,704.7	469,789.0	786,507.4
Total Effect	29.6	1,552,290.4	2,383,359.2	4,280,137.9
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	18.2	1,219,709.6	1,632,327.0	3,020,431.3
Indirect Effect	6.3	210,814.4	412,659.2	686,135.1
Induced Effect	7.3	228,384.1	502,061.8	840,539.2
Total Effect	31.9	1,658,908.1	2,547,048.0	4,547,105.6
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	19.6	1,300,362.2	1,740,610.2	3,195,356.9
Indirect Effect	6.7	222,116.9	435,812.5	724,180.5
Induced Effect	7.8	243,066.0	534,340.5	894,580.9
Total Effect	34.1	1,765,545.2	2,710,763.2	4,814,118.3

* values in \$1000

4.5.4 Regional Challenges Summarized

1. How can we foster communication between businesses and higher education?
2. What focus areas of M&S should be concentrated on in this region?
3. How can we connect with and leverage other VA regions and assets?

4.5.4.1 Marketplace

Energy healthcare, and manufacturing M&S companies are strong here. There are also regional ties to international firms. Products used include Modular Modeling System (MMS), Motion Platforms, computers, and electronics.

R&D funding is the primary obstacle encountered when bringing new products or services to market. Finding businesses to support small business contract minimums is also an issue. A key obstacle to market expansion is recent DoD funding cutbacks.

Information regarding business size of among Region 2000's commercial business respondents is reported below, in Table 4-61.

Table 4-61: Region 2000, Respondents' Commercial Business Size

Annual Revenue	# of Responses	% of Responses	# of Employees	# of Responses	% of Responses
<\$1M	1	50%	1-10	1	50%
\$1M-\$10M	0	0%	11-25	0	0%
\$11M-\$50M	1	50%	26-100	1	50%
\$51M-\$100M	0	0%	101-500	0	0%
\$100M+	0	0%	501-1000	0	0%
Unknown	0	0%	1001-2000	0	0%
Total	2	100%	2001 +	0	0%
			Total	2	100%

Among the commercial businesses, information about what percentage of the respondents' total revenue, and about what percentage of its employees are devoted to M&S was asked. This information is presented in Table 4-62 for Region 2000.

Table 4-62: Region 2000 M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
0%	0	0%	0%	0	0%
1-10%	0	0%	1-10%	0	0%
11-25%	1	50%	11-25%	1	50%
26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%
76-100%	1	50%	76-100%	1	50%
DNR	0	0%	DNR	0	0%
Total	2	100%	Total	2	100%

Information about all of the Region 2000 survey respondents' M&S organizational activities is presented in Table 4-63, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-63: Region 2000 M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses *	Budget % - Research M&S	# of Responses	% of Responses*	Budget % - Train M&S	# of Responses	% of Responses *
0%	0	0%	0%	0	0%	0%	1	33%
1-10%	0	0%	1-10%	1	33%	1-10%	0	0%
11-25%	1	33%	11-25%	1	33%	11-25%	1	33%
26-50%	0	0%	26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	0	0%
76-100%	1	33%	76-100%	0	0%	76-100%	0	0%
DNR	1	33%	DNR	1	33%	DNR	1	33%
Total	3	100%	Total	3	100%	Total	3	100%

*rounded to nearest whole number

4.5.4.2 Workforce

The lack of an M&S qualified and trained workforce is seen as a key regional issue. Employers must train specific skills, particularly design skills. The local workforce is aging, and businesses are beginning to face younger workforce recruitment issues. Participants stated that recruiting younger engineers was difficult and employers must often retrain more experienced workers.

Employment was examined in relation to the types of labor categories respondents' M&S employees fit into, and also which labor categories they experienced any M&S employee difficulty in recruitment and retention. Region 2000 respondents reported no QOL factors negatively impacting employee recruitment or retention.

Survey response information regarding labor categories is presented in Table 4-64; note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-64: Labor Categories, Employed or Difficult to Recruit or Retain, Region 2000

Labor Category	Employ	Difficult
Aerospace Engineers	1	0
Computer Hardware Engineers	1	0
Computer Programmers	1	0
Database Administrators	1	0
Electrical and Electronic Engineering Technicians	1	0
Electrical Engineers	2	0
Electronics Engineers, Except Computer	1	0
Engineer	1	0
Graphic Artist	1	0
Graphic Designers	1	0
Industrial Engineering Technicians	1	0
Mechanical Engineering Technicians	1	0
Mechanical Engineers	2	0
Nuclear Engineers	1	0
Software developers	2	1
Software Developers, Applications	1	1
Software Developers, Systems Software	1	1
NONE		0

4.5.4.3 Networking

Networking in this region is prevalent state wide, nationally, and internationally; less so within the region. The M&S community relies on personal relationships among business leaders. One survey respondent reported **NEVER** participating in regional networking activities, and the other participated **ONE TIME** during the past year. Both reported they **NEVER** sought assistance from a regional network. (**THIS TEXT** indicates a survey response choice.)

4.5.4.4 Collaboration

Universities have had some success in collaboration with local companies, and have taken steps to align engineering programs with workforce needs. There are five colleges and universities in the area; one local university has a robust online program with 77,000 students. Local companies seemed to have limited awareness of this, or of its graduates as M&S workforce candidates.

4.5.5 Regional Opportunities

Products identified for potential commercialization included mobile truck, train, and automobile driving simulators. These are identified in the IP Inventory. Skilled machinists and assemblers are needed for final assembly of manufacturing products in this region. There is promising academic growth at a local community college STEM academy and through recently implemented mechatronics and biomedical engineering programs. Such effort will need to be continued and expanded to help address workforce needs.

4.5.6 Proposed Actions and Investments

Study participants proposed various Commonwealth actions and investments to grow the M&S industry in this region. They are organized by common study theme:

Industry

- Incorporate training simulators in colleges.

Workforce

- Fund a power plant operations or fundamentals course that includes simulation and interactive eBooks.
- Require simulation training for power plant operators.

Networking

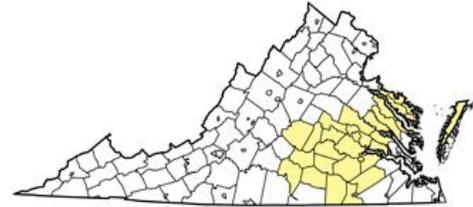
- Form an M&S Round Table through the Technology Council and Center for Advanced Engineering and Research (CAER) to provide information and a regional collaborative mechanism.
- Reach out to area companies beyond the current emphasis on energy.

Collaboration

- Facilitate communication between local company businesses and universities.

4.6 Richmond Region

This section presents information for the study region identified as the Richmond Region for this report. This region is depicted in the figure shown at right.



This region has a strong presence in healthcare using M&S applications. Seven Richmond respondents reported that they did not think the region was recognized as a significant M&S force. One respondent reported **SOMETIMES** using regional branding, while three respondents reported **NEVER** using regional branding. The region lacks a definitive M&S community.

4.6.1 Number of Regional Study Participants

Richmond Region information was provided by 22 study participants in total. This data represents ten survey respondents, the distribution by type of organization is presented in Table 4-65 below. Twelve focus group participants also provided data for the region.

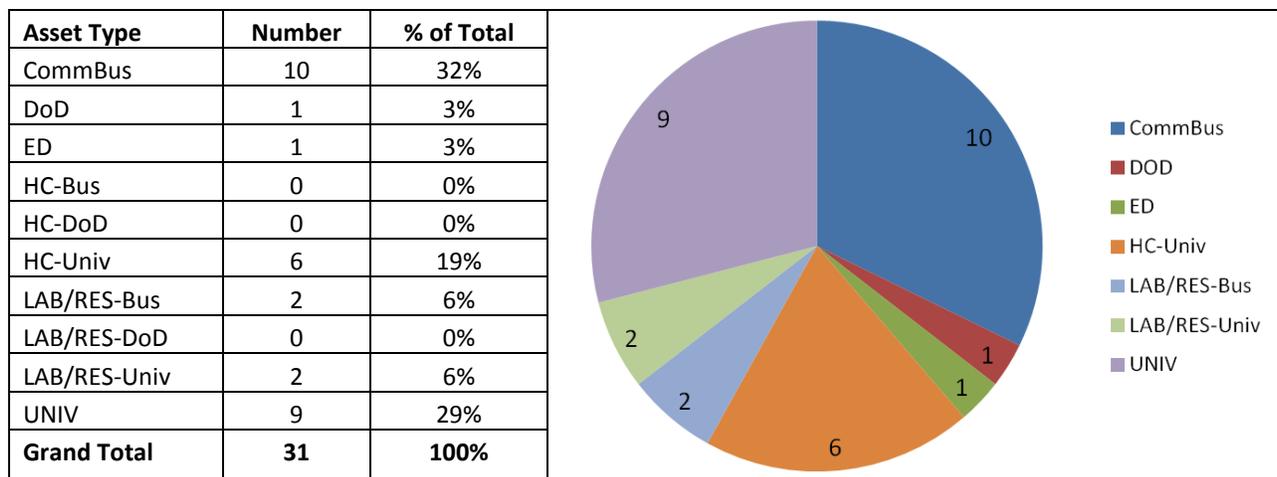
Table 4-65: Richmond Region Survey Organization Distribution

Organization Type	# of Responses	% of Responses
College/University	4	40%
Commercial Business	3	30%
DoD	1	10%
Lab/Research	1	10%
Non-Profit	0	0%
Other	1	10%
Procurement	0	0%
Total	10	100%

4.6.2 Asset Summary

Thirty-one M&S assets were identified within this region; consisting primarily of commercial businesses, universities, and university-based healthcare organizations. The distribution by type of asset category is presented in Table 4-66. For an explanation of asset categories, see Table 3-4 page 22.

Table 4-66: Richmond Region M&S Asset Distribution



4.6.3 Economic and Workforce Analyses

The definition of the M&S Industry and labor categories is discussed in Section 2.6 and Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-67 presents the Richmond Region employment estimates for each industry sector.

Table 4-67: Richmond Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Richmond Region Employment, M&S Related Sectors	70,138.52
Pharmaceutical preparation manufacturing	926.30
Other commercial and service industry machinery manufacturing	15.05
Ship building and repairing	54.70
Software publishers	335.85
Telecommunications	5,026.01
Other information services	146.36
Architectural, engineering, and related services	9,238.15
Custom computer programming services	5,617.80
Computer systems design services	7,248.16
Other computer related services, including facilities management	1,726.68
Management, scientific, and technical consulting services	5,904.47
Scientific research and development services	3,702.92
All other miscellaneous professional, scientific, and technical services	1,219.06
Other private educational services	5,034.50
Private hospitals	23,942.50
Total Richmond Region Employment	847,006.49

Bold text represents core sectors

It is estimated that approximately eight percent of the Richmond Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Richmond Region are presented in Table 4-68.

Table 4-68: Richmond Region Economic and Workforce Analysis Scenarios

Scenario	Richmond Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-69 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-69: Richmond Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Richmond Region M&S Employment	701.385	821.526	941.668
Pharmaceutical preparation manufacturing	9.263	9.263	9.263
Other commercial and service industry machinery manufacturing	0.150	0.150	0.150
Ship building and repairing	0.547	0.547	0.547
Software publishers	3.358	5.038	6.717
Telecommunications	50.260	50.260	50.260
Other information services	1.464	1.464	1.464
Architectural, engineering, and related services	92.381	92.381	92.381
Custom computer programming services	56.178	84.267	112.356
Computer systems design services	72.482	108.722	144.963
Other computer related services, including facilities management	17.267	17.267	17.267
Management, scientific, and technical consulting services	59.045	88.567	118.089
Scientific research and development services	37.029	55.544	74.058
All other miscellaneous professional, scientific, and technical services	12.191	18.286	24.381
Other private educational services	50.345	50.345	50.345
Private hospitals	239.425	239.425	239.425

Bold text represents core sectors

Scenario 1 estimates that .08 percent of the Richmond Region total employment (847,006) is M&S specific, while Scenario 2 estimates 0.10 percent, and Scenario 3 estimates 0.11 percent. Among the core sectors, *Computer systems design services*, *Management, scientific, and technical consulting services*, and *Custom computer programming services* represent the greatest proportion of M&S employment. Although estimated at lower weights, the related sectors of *Architectural, engineering, and related services*; *Other private educational services*; *Telecommunications*, and *Private hospitals*, also have relatively high estimates for M&S employment. These high estimates may reflect, in part the relatively high proportion of overall employment among these industries.

The economic impact was calculated using the estimates presented in Table 4-69.

Table 4-70, on the following page, presents the Richmond Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry, that will be incorporated into the production of another industry.

Table 4-70: Richmond Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	14.0	959,324.7	1,384,538.9	2,470,609.3
Indirect Effect	5.9	287,888.2	516,132.4	826,961.0
Induced Effect	7.4	302,153.7	565,765.6	922,516.2
Total Effect	27.3	1,549,366.6	2,466,437.0	4,220,086.5
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	16.4	1,154,175.0	1,599,359.5	2,805,900.5
Indirect Effect	6.7	323,924.4	578,649.6	925,400.6
Induced Effect	8.8	357,942.2	670,223.3	1,092,847.0
Total Effect	31.9	1,836,041.5	2,848,232.4	4,824,148.1
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	18.9	1,349,023.5	1,814,176.3	3,141,186.7
Indirect Effect	7.5	359,960.1	641,166.1	1,023,839.1
Induced Effect	10.1	413,730.2	774,680.0	1,263,176.1
Total Effect	36.5	2,122,713.7	3,230,022.4	5,428,201.9

* values in \$1000

The M&S contribution to the Richmond Region GRP (value added, total effect) is estimated to be \$2.5 billion (Scenario 1) to \$3.2 billion (Scenario 3). The total economic impact of M&S on the Richmond regional economy is estimated to be \$4.2 billion (Scenario 1) to \$5.4 billion (Scenario 3).

4.6.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth.

Table 4-71, on the following page, presents the growth projection for each industry sector.

Table 4-71: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-72 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-72: Richmond Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	10.911	1.4941	10.911	1.4941	10.911	1.4941
Other commercial and service industry machinery manufacturing	0.174	0.0268	0.174	0.0268	0.174	0.0268
Ship building and repairing	0.653	0.0866	0.653	0.0866	0.653	0.0866
Software publishers	3.994	0.6496	5.991	0.9744	7.988	1.2992
Telecommunications	59.817	9.5100	59.817	9.5100	59.817	9.5100
Other information services	1.703	0.2783	1.703	0.2783	1.703	0.2783
Architectural, engineering, and related services	111.211	15.1187	111.211	15.1187	111.211	15.1187
Custom computer programming services	65.673	11.4505	98.510	17.1757	131.346	22.9010
Computer systems design services	83.438	12.2506	125.158	18.3759	166.877	24.5012
Other computer related services, including facilities management	20.460	2.6102	20.460	2.6102	20.460	2.6102
Management, scientific, and technical consulting services	69.330	10.9202	103.995	16.3802	138.660	21.8403
Scientific research and development services	43.564	6.4502	65.346	9.6753	87.129	12.9005
All other miscellaneous professional, scientific, and technical services	14.438	2.1515	21.657	3.2272	28.876	4.3029
Other private educational services	59.499	9.2805	59.499	9.2805	59.499	9.2805
Private hospitals	239.425	43.5330	239.425	43.5330	239.425	43.5330
Total	784.291	125.8106	924.509	147.7469	1064.728	169.6832

Bold text represents core sectors

Table 4-73 presents the projected (2011-2020) M&S economic impact for the Richmond Region based on the labor projections in Table 4-72.

Table 4-73: Richmond Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	125.8	8,633,919.9	12,460,835.1	22,235,408.3
Indirect Effect	53.4	2,590,980.0	4,645,171.9	7,442,617.3
Induced Effect	66.6	2,719,378.4	5,091,882.4	8,302,632.4
Total Effect	245.8	13,944,278.3	22,197,889.4	37,980,658.0
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	147.7	10,387,554.9	14,394,186.7	25,252,981.2
Indirect Effect	60.6	2,915,300.4	5,207,818.6	8,328,560.8
Induced Effect	78.9	3,221,469.9	6,031,991.3	9,835,592.8
Total Effect	287.2	16,524,325.1	25,633,996.6	43,417,134.8
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	169.7	12,141,217.2	16,327,568.5	28,270,601.5
Indirect Effect	67.8	3,239,625.8	5,770,474.3	9,214,518.5
Induced Effect	91.2	3,723,569.2	6,972,114.8	11,368,577.1
Total Effect	328.7	19,104,412.2	29,070,157.6	48,853,697.2

* values in \$1000

It is estimated that M&S will contribute \$22.2 billion (Scenario 1) to \$29.1 billion (Scenario 3) to the Richmond Region GRP from 2011 to 2020.

4.6.4 Regional Challenges Summarized

1. How can we develop a more cross-disciplined M&S workforce?
2. How can we bridge M&S and healthcare?
3. How can we jumpstart the entrepreneurial community and help start-ups?
4. How can we enable small businesses?
5. How can we grow regional M&S networking?

4.6.4.1 Marketplace

Key sources reported that more *vision* is needed to jump start the M&S industry within the Richmond region, as are start up funds and venture capital. Expertise to develop a commercialization plan is also needed. Market obstacles to new product development and commercialization include a lack enthusiasm for novel technologies, and the likelihood of failure of new technology when pitted against more cost-effective, less risky technologies. Products reportedly used in the region include quantum chemistry simulations tools and audio/visual and programming services. Simulation is also used in academic coursework.

Information on aspects of the business size of the Charlottesville Region's commercial business survey respondents is reported on the following page, in Table 4-74.

Table 4-74: Richmond Region, Respondents' Commercial Business Size

Annual Revenue	# of Responses	% of Responses*	# of Employees	# of Responses	% of Responses
<\$1M	2	67%	1-10	3	100%
\$1M-\$10M	1	33%	11-25	0	0%
\$11M-\$50M	0	0%	26-100	0	0%
\$51M-\$100M	0	0%	101-500	0	0%
\$100M+	0	0%	501-1000	0	0%
Unknown	0	0%	1001-2000	0	0%
Total	3	100%	2001 +	0	0%
			Total	3	100%

*rounded to nearest whole number

Among the commercial businesses, information was asked about the percentage of the respondents' total revenue and the percentage of employees devoted to M&S. This information is presented in Table 4-75 for the Richmond Region.

Table 4-75: Richmond Region M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses*	Employees – M&S%	# of Responses	% of Responses*
0%	1	33%	0%	1	33%
1-10%	0	0%	1-10%	0	0%
11-25%	0	0%	11-25%	0	0%
26-50%	1	33%	26-50%	1	33%
51-75%	0	0%	51-75%	0	0%
76-100%	1	33%	76-100%	1	33%
DNR	0	0%	DNR	0	0%
Total	3	100%	Total	3	100%

*rounded to nearest whole number

Information about all of the Richmond Region survey respondents' M&S business activities is presented in Table 4-76, including the percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-76: Richmond Region M&S %, All Organizations

Budget % - Produce M&S	#	%	Budget % – Research M&S	#	%	Budget % - Train M&S	#	%
0%	5	50%	0%	4	40%	0%	7	70%
1-10%	0	0%	1-10%	1	10%	1-10%	0	0%
11-25%	0	0%	11-25%	2	20%	11-25%	1	10%
26-50%	2	20%	26-50%	2	20%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	1	10%
76-100%	1	10%	76-100%	0	0%	76-100%	0	0%
DNR	2	20%	DNR	1	10%	DNR	1	10%
Total	10	100%	Total	10	100%	Total	10	100%

4.6.4.2 Workforce

The focus in this region is on cross-disciplined workers. The region has been impacted by the DoD hiring freeze. Lack of innovation or new product development has impeded workforce recruitment and retention. No QOL factors, negatively affecting employee recruitment or retention, were reported for the Richmond Region.

Employment was examined regarding what types of labor categories respondents' M&S employees fit into, and also which labor categories they experienced any M&S employee difficulty in recruitment and retention. Survey response information is presented in Table 4-77; note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-77: Labor Categories, Employed or Difficult to Recruit or Retain, Richmond Region

Labor Category	Employ	Difficult
Aerospace Engineers	1	1
Analyst	3	1
Computer and Information Systems Managers	1	0
Computer Hardware Engineers	0	0
Computer Programmers	0	1
Database Administrators	2	0
Engineer	1	1
Graphic Artist	1	0
Industrial Engineers	1	0
Materials Scientists	1	0
Medical Records and Health Information Technicians	1	0
Network and Computer Systems Administrators	1	1
Operations Research Analysts	1	0
Programmer	1	0
Researcher	3	0
Software developers	2	1
Software Developers, Applications	2	1
Software Developers, Systems Software	1	1
Teacher	3	0
NONE		1

Workforce skills considered necessary to expand the M&S industry were identified as software development skills (C++, web programming). Participants reported a need for workers with a combination of knowledge in one of the physical sciences and proficiency in scientific programming. Those with STEM degrees and professional certifications are desired.

4.6.4.3 Networking

M&S-based networking was characterized by study participants as needing improvement. Four survey respondents reported participating in regional networking activities **2-4 TIMES** during the past year, one reported **5-10 TIMES**, and one reported **MORE THAN 10 TIMES**. Two respondents reported **NEVER** participating. Six respondents reported seeking assistance from their regional networks **2-4 TIMES** during the past year, and another respondent reports seeking assistance **MORE THAN 10 TIMES**. Most fairs and events are focused on M&S training and education which deters attendees focused on other M&S areas. (**THIS TEXT** indicates a survey response choice.)

4.6.4.4 Collaboration

As reported by study participants, university collaboration in this region takes place with institutions from several other states, particularly in the engineering, physics, and chemistry departments. Business study participants reported that they relied on university collaboration to produce proof-of-principle samples but lacked funding to support this.

4.6.5 Regional Opportunities

The use of simulations to produce a "designed" material, as an enabling technology for growing novel thin films on semiconductors, was reported as a potential product for commercialization.

4.6.6 Proposed Actions and Investments

Study participants proposed various actions and investments to grow the M&S industry. Some have already been discussed in previous sections of this report. Others are presented below, organized by common study theme:

Industry

- Establish a common nomenclature for simulation in healthcare, or provide examples so other industry can communicate with M&S.
- Enable logistics for small farmers.

Infrastructure/investment

- Provide resources to the nursing clinical simulation training center to help develop business case models to facilitate hospital use of their center.
- Create a computing center, friendly to small companies that require computing power.

Small business specific

- Provide a set of resources to small businesses without requiring an intermediary.

Education

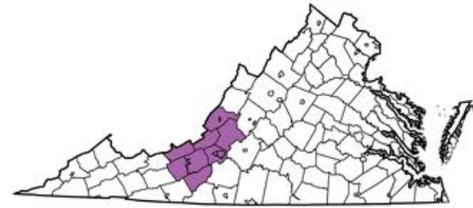
- Implement a business course for M&S application development and implementation.
- Support curriculum development at both community colleges and four-year universities.
- Increase focus on logistics and supply chain management programs.

Collaboration

- Streamline the procedure and overhead expenses for collaboration between academia and industry, particularly for small businesses.
- Enable industry to train students who will enter the workforce.

4.7 Roanoke-Blacksburg Region

This section presents information for the study region identified as the Roanoke-Blacksburg Region. This region is depicted in the figure shown at right.



The Roanoke-Blacksburg region reportedly has the critical mass to draw in M&S companies; however, more public-private collaboration is needed.

Impediments to start-up businesses must be removed and infrastructure issues should be addressed to facilitate growth. Transportation issues, a lack high speed internet access, a stifled entrepreneurial community, and limited access to Commonwealth databases and student project ideas were cited as impediments to growth.

Study participants did not see the Roanoke-Blacksburg Region as a significant force in M&S. They reported no use of regional branding.

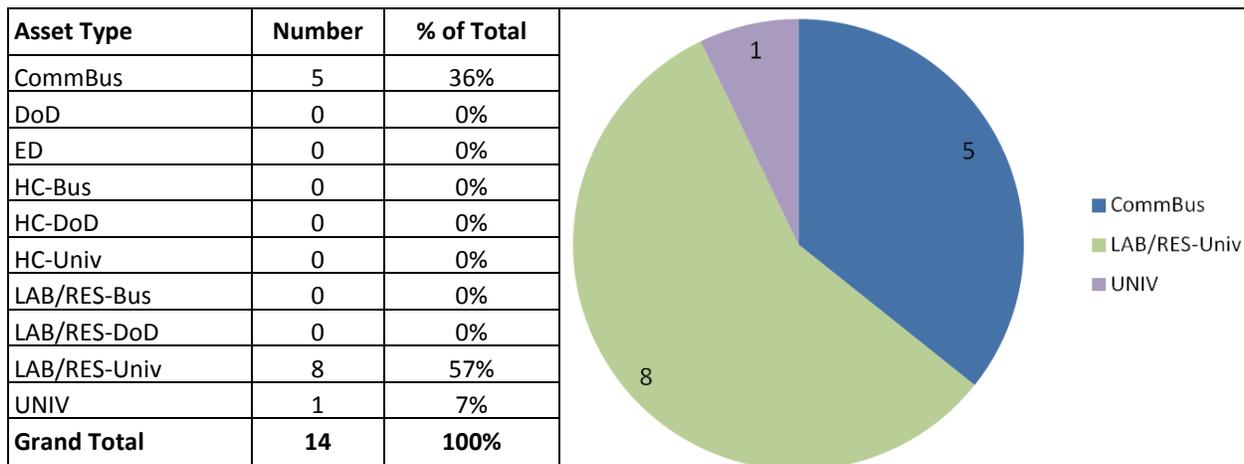
4.7.1 Number of Regional Study Participants

Information for the Roanoke-Blacksburg Region was provided by six study participants in total. This stakeholder data represents two survey respondents (both College/University) and four focus group participants.

4.7.2 Asset Summary

Fourteen M&S assets were identified in the region, including commercial businesses and university-based laboratory and research organizations. The distribution of asset categories is provided in Table 4-78. For an explanation of asset categories, see Table 3-4 page 22.

Table 4-78: Roanoke-Blacksburg Region M&S Asset Distribution



4.7.3 Economic and Workforce Analyses

The definition of the M&S Industry is discussed in Section 2.6. Labor categories are discussed in Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-79 presents the Roanoke-Blacksburg Region employment estimates for each industry sector.

Table 4-79: Roanoke-Blacksburg Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Roanoke-Blacksburg Region Employment, M&S Related Sectors	19,516.15
Pharmaceutical preparation manufacturing	59.03
Other commercial and service industry machinery manufacturing	26.98
Ship building and repairing	0.00
Software publishers	107.38
Telecommunications	980.98
Other information services	18.83
Architectural, engineering, and related services	2,099.96
Custom computer programming services	1,184.96
Computer systems design services	1,018.41
Other computer related services, including facilities management	2,655.14
Management, scientific, and technical consulting services	589.51
Scientific research and development services	910.25
All other miscellaneous professional, scientific, and technical services	306.82
Other private educational services	973.03
Private hospitals	8,584.88
Total Roanoke-Blacksburg Region Employment	259,012.30

Bold text represents core sectors

It is estimated that approximately 7.5 percent of the Roanoke-Blacksburg Region total employment is employed in M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Roanoke-Blacksburg Region are presented in Table 4-80.

Table 4-80: Roanoke-Blacksburg Region Economic and Workforce Analysis Scenarios

Scenario	Roanoke-Blacksburg Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-81 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-81: Roanoke-Blacksburg Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Roanoke-Blacksburg Region M&S Employment	195.161	215.748	236.335
Pharmaceutical preparation manufacturing	0.590	0.590	0.590
Other commercial and service industry machinery manufacturing	0.270	0.270	0.270
Ship building and repairing	0.000	0.000	0.000
Software publishers	1.074	1.611	2.148
Telecommunications	9.810	9.810	9.810
Other information services	0.188	0.188	0.188
Architectural, engineering, and related services	21.000	21.000	21.000
Custom computer programming services	11.850	17.774	23.699
Computer systems design services	10.184	15.276	20.368
Other computer related services, including facilities management	26.551	26.551	26.551
Management, scientific, and technical consulting services	5.895	8.843	11.790
Scientific research and development services	9.102	13.654	18.205
All other miscellaneous professional, scientific, and technical services	3.068	4.602	6.136
Other private educational services	9.730	9.730	9.730
Private hospitals	85.849	85.849	85.849

Bold text represents core sectors

Scenarios 1 and 2 estimate that 0.08 percent of the Roanoke-Blacksburg Region total employment (259,012) is M&S specific, while Scenario 3 estimates that 0.09 percent is M&S specific. Among the core sectors, *Custom computer programming services*, *Computer systems design service*, and *Scientific research and development services* represent the greatest proportion of M&S employment. Although estimated at lower weights, the related sectors of *Architectural, engineering, and related services*; *Other computer related services, including facilities management*; and *Private hospitals* have higher estimates for M&S employment. These high estimates may reflect, in part, the relatively high proportion of overall employment among these industries.

The economic impact was calculated using the estimates presented in Table 4-81 (above).

Table 4-82, on the following page, presents the Roanoke-Blacksburg Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-82: Roanoke-Blacksburg Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	3.8	262,045.3	376,864.7	651,323.1
Indirect Effect	1.3	49,422.6	99,879.7	160,858.2
Induced Effect	1.6	59,175.8	118,372.0	192,282.1
Total Effect	6.7	370,643.7	595,116.3	1,004,463.4
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	4.2	289,666.4	410,950.7	708,642.9
Indirect Effect	1.4	54,215.4	109,089.4	175,575.2
Induced Effect	1.8	65,329.4	130,681.0	212,276.3
Total Effect	7.4	409,211.2	650,721.1	1,096,494.5
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	4.7	317,287.2	445,033.8	765,957.6
Indirect Effect	1.6	59,007.7	118,298.2	190,290.8
Induced Effect	1.9	71,482.8	142,989.6	232,270.0
Total Effect	8.2	447,777.8	706,321.6	1,188,518.4

* values in \$1000

The M&S contribution to the Roanoke-Blacksburg Region GRP (value added, total effect) is estimated to be \$595.1 million (Scenario 1) to \$706.3 million (Scenario 3). The total economic impact of M&S on the Roanoke-Blacksburg regional economy is estimated to be \$1 billion (Scenario 1) to \$1.2 billion (Scenario 3).

4.7.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth. Table 4-83, on the following page, presents the growth projection for each industry sector.

Table 4-83: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-84 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-84: Roanoke-Blacksburg Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	0.695	0.0952	0.695	0.0952	0.695	0.0952
Other commercial and service industry machinery manufacturing	0.313	0.0480	0.313	0.0480	0.313	0.0480
Ship building and repairing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Software publishers	1.277	0.2077	1.915	0.3115	2.554	0.4154
Telecommunications	11.675	1.8562	11.675	1.8562	11.675	1.8562
Other information services	0.219	0.0358	0.219	0.0358	0.219	0.0358
Architectural, engineering, and related services	25.280	3.4367	25.280	3.4367	25.280	3.4367
Custom computer programming services	13.852	2.4152	20.779	3.6229	27.705	4.8305
Computer systems design services	11.724	1.7213	17.585	2.5819	23.447	3.4426
Other computer related services, including facilities management	31.462	4.0137	31.462	4.0137	31.462	4.0137
Management, scientific, and technical consulting services	6.922	1.0903	10.383	1.6354	13.844	2.1806
Scientific research and development services	10.709	1.5856	16.063	2.3784	21.418	3.1712
All other miscellaneous professional, scientific, and technical services	3.634	0.5415	5.451	0.8122	7.267	1.0830
Other private educational services	11.499	1.7937	11.499	1.7937	11.499	1.7937
Private hospitals	85.849	15.6093	85.849	15.6093	85.849	15.6093
Total	215.110	34.4501	239.168	38.2309	263.227	42.0117

Bold text represents core sectors

Table 4-85 presents the projected (2011-2020) M&S economic impact for the Roanoke-Blacksburg Region based on the labor projections in Table 4-84.

Table 4-85: Roanoke-Blacksburg Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	34.5	2,358,421.3	3,391,807.1	5,861,939.1
Indirect Effect	11.8	444,804.5	898,920.4	1,447,729.7
Induced Effect	14.3	532,584.6	1,065,353.9	1,730,548.0
Total Effect	60.5	3,335,810.4	5,356,081.5	9,040,216.7
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	38.2	2,607,006.1	3,698,555.2	6,377,778.0
Indirect Effect	13.0	487,936.6	981,802.6	1,580,174.2
Induced Effect	15.8	587,965.6	1,176,131.3	1,910,490.7
Total Effect	67.0	3,682,908.3	5,856,489.1	9,868,442.9
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	42.0	2,855,609.9	4,005,347.7	6,893,692.4
Indirect Effect	14.2	531,076.2	1,064,697.3	1,712,639.0
Induced Effect	17.3	643,351.7	1,286,919.0	2,090,450.0
Total Effect	73.5	4,030,037.8	6,356,964.0	10,696,781.4

* values in \$1000

It is estimated the M&S will contribute \$5.4 billion (Scenario 1) to \$6.4 billion (Scenario 3) to the Roanoke-Blacksburg Region GRP from 2011 to 2020.

4.7.4 Regional Challenges Summarized

1. How can we promote the area as technology rich, with many M&S opportunities?
2. How can we connect industry and academia to benefit IP and workforce development?

4.7.4.1 Marketplace

Study participants reported a need to jumpstart the entrepreneurial community in the region. This is a source of great frustration among participants. Many factors were cited as impediments, including significant start-up funding and fees associated with M&S. Both the front-end work and the invisible benefits of M&S were characterized as hard sells to the public because it is difficult for people to conceptualize M&S work. Study participants questioned whether sub-specialization of university faculty inhibited M&S growth.

Information on aspects of the business size of the region's study participants is not available.

Table 4-86: Roanoke-Blacksburg Region, Respondents’ Commercial Business Size

Annual Revenue	# of Responses	% of Responses	# of Employees	# of Responses	% of Responses
NO DATA AVAILABLE					

Information on commercial businesses respondents’ total revenue and percentage of employees are devoted to M&S is not available for the Roanoke-Blacksburg Region.

Table 4-87: Roanoke-Blacksburg Region M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
NO DATA AVAILABLE					

Information about all of the Roanoke-Blacksburg Region survey respondents’ M&S organizational activities is presented in Table 4-88, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-88: Roanoke-Blacksburg Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses	Budget % – Research M&S	# of Responses	% of Responses	Budget % - Train M&S	# of Responses	% of Responses
0%	0	0%	0%	0	0%	0%	0	0%
1-10%	1	50%	1-10%	1	50%	1-10%	1	50%
11-25%	0	0%	11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	0	0%	76-100%	0	0%
DNR	1	50%	DNR	1	50%	DNR	1	50%
Total	2	100%	Total	2	100%	Total	2	100%

4.7.4.2 Workforce

Participants asserted that while recent graduates were knowledgeable regarding requirements and mental models, they lacked more physical and executable knowledge. The local market was characterized as highly specialized in the type of M&S work performed. Due to market size, a majority of graduates reportedly move to more populated areas to find work.

Echoing previous study data, participants stated that in order to move forward, the M&S workforce will have to bridge the gap between defining requirements and creating solutions/products. A solid STEM foundation will continue to be required. International students are reported to have a much better foundation in STEM which troubles study participants. On the other hand, these international students were reported to lack the business development skills necessary to productize, and had less creativity than US students in problem solving.

Employment was examined regarding what types of labor categories survey respondents’ M&S employees fit into, and also, which M&S labor categories were the most difficult to recruit for and retain. No QOL factors were reported negatively affecting employee recruitment or retention, neither was labor difficulty reported to affect them.

Survey response information is presented in Table 4-89; note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-89: Labor Categories, Employed or Difficult to Recruit or Retain, Roanoke-Blacksburg Region

Labor Category	Employ	Difficult
Aerospace Engineers	1	0
Biochemists and Biophysicists	1	0
Biomedical Engineers	1	0
Chemists	1	0
Civil Engineers	1	0
Computer Hardware Engineers	1	0
Electrical Engineers	1	0
Electronics Engineers, Except Computer	1	0
Engineer	1	0
Environmental Engineers	1	0
Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	1	0
Industrial Engineers	1	0
Marine Engineers and Naval Architects	1	0
Materials Engineers	1	0
Materials Scientists	1	0
Mechanical Engineers	1	0
Medical Scientists, Except Epidemiologists	1	0
Microbiologists	1	0
Nuclear Engineers	1	0
Operations Research Analysts	1	0
Researcher	1	0
Teacher	1	0
NONE		1

4.7.4.3 Networking

Study participants reported a lack of networking among M&S companies. One survey respondent reported participating in regional networking activities **5-10 TIMES** during the past year, but **NEVER** asking for assistance from the network(s) during that period. (**THIS TEXT** indicates a survey response choice.)

4.7.4.4 Collaboration

The lack of networking and collaboration among higher education institutions and businesses is a growing concern for faculty. Universities require facilitation of networking and organizations to provide work for student projects. Various barriers block usage of data for project information.

4.7.5 Regional Opportunities

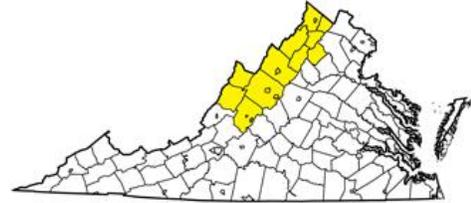
Study participants see opportunity for M&S growth in their region. They reported that university framework was available to promote connections for an accreditation center for new and donated software.

4.7.6 Proposed Actions and Investments

Study participants proposed that the Commonwealth provide university grants/funding to bring in more projects, build data nodes, and recycle student projects from other universities.

4.8 Shenandoah Valley Region

This section presents information for the study region identified as the Shenandoah Valley Region. This region is depicted in the figure shown at right.



The Shenandoah Valley Region needs initial adopters (e.g. users, producers, consumers) of M&S. City governments were characterized as responsive and progressive, and therefore, thought to be successful avenues for M&S networking and development initiatives. Study participants want an accessible person/organization to promote M&S locally.

The I-81 corridor has a good infrastructure, and stakeholders would like to see digital connectivity extended from the corridor out to rural areas. K-12, community college, and university undergraduate programs are healthy in STEM initiatives. Study participants want a regional state university to push for greater M&S investment. Survey respondents reported that they did not see the region as a significant force for M&S, nor did they use regional branding.

4.8.1 Number of Regional Study Participants

Information for the Shenandoah Valley Region was provided by six study participants in total. This stakeholder data represents two survey respondents (one commercial business and one non-project organizations) and four focus group participants.

4.8.2 Asset Summary

Seven assets were identified for this region; mostly universities. The distribution of asset categories is provided in Table 4-90. For an explanation of asset categories, see Table 3-4 page 22.

Table 4-90: Shenandoah Valley Region M&S Asset Distribution

Asset Type	Number	% of Total
CommBus	2	29%
DoD	0	0%
ED	0	0%
HC-Bus	0	0%
HC-DoD	0	0%
HC-Univ	0	0%
LAB/RES-Bus	0	0%
LAB/RES-DoD	0	0%
LAB/RES-Univ	1	14%
UNIV	4	57%
Grand Total	7	100%

4.8.3 Economic and Workforce Analyses

The definition of the M&S Industry is discussed in Section 2.6. Labor categories are discussed in Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-91 presents the Shenandoah Valley Region employment estimates for each industry sector.

Table 4-91: Shenandoah Valley Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Shenandoah Valley Region Employment, M&S Related Sectors	17,878.40
Pharmaceutical preparation manufacturing	41.62
Other commercial and service industry machinery manufacturing	14.78
Ship building and repairing	0.00
Software publishers	614.87
Telecommunications	2,046.48
Other information services	185.29
Architectural, engineering, and related services	1,491.45
Custom computer programming services	1,060.68
Computer systems design services	591.57
Other computer related services, including facilities management	128.46
Management, scientific, and technical consulting services	965.60
Scientific research and development services	289.17
All other miscellaneous professional, scientific, and technical services	350.44
Other private educational services	865.89
Private hospitals	9,232.11
Total Shenandoah Valley Region Employment	276,657.56

Bold text represents core sectors

It is estimated that approximately 6.5 percent of the Shenandoah Valley Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Shenandoah Valley Region are presented in Table 4-92.

Table 4-92: Shenandoah Valley Region Economic and Workforce Analysis Scenarios

Scenario	Shenandoah Valley Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-93 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-93: Shenandoah Valley Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Shenandoah Valley M&S Employment	178.784	198.146	217.507
Pharmaceutical preparation manufacturing	0.416	0.416	0.416
Other commercial and service industry machinery manufacturing	0.148	0.148	0.148
Ship building and repairing	0.000	0.000	0.000
Software publishers	6.149	9.223	12.297
Telecommunications	20.465	20.465	20.465
Other information services	1.853	1.853	1.853
Architectural, engineering, and related services	14.915	14.915	14.915
Custom computer programming services	10.607	15.910	21.214
Computer systems design services	5.916	8.874	11.831
Other computer related services, including facilities management	1.285	1.285	1.285
Management, scientific, and technical consulting services	9.656	14.484	19.312
Scientific research and development services	2.892	4.338	5.783
All other miscellaneous professional, scientific, and technical services	3.504	5.257	7.009
Other private educational services	8.659	8.659	8.659
Private hospitals	92.321	92.321	92.321

Bold text represents core sectors

Scenario 1 estimates that 0.06 percent of the Shenandoah Valley Region's total employment (276,657) is M&S specific. Scenario 2 estimates that 0.07 percent is M&S specific and Scenario 3 estimates that 0.08 percent is. Among the core sectors, *Custom computer programming services* and *Management, scientific, and technical consulting services* represent the greatest proportion of M&S employment. *Architectural, engineering, and related services*; *Telecommunications*; and *Private hospitals* have higher estimates than any core sector for M&S employment, this reflects the relatively low proportion of core sector industry activity in the region.

The economic impact was calculated using the estimates presented in Table 4-93 (above).

Table 4-94 on the following page presents the Shenandoah Valley Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-94: Shenandoah Valley Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	3.6	192,939.5	357,461.5	680,346.2
Indirect Effect	1.4	47,987.9	106,172.8	180,996.2
Induced Effect	1.1	38,087.4	81,741.4	137,077.5
Total Effect	6.1	279,014.8	545,375.7	998,419.9
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	4.0	211,528.7	390,496.8	744,737.3
Indirect Effect	1.5	53,874.9	117,295.6	199,360.8
Induced Effect	1.3	42,018.9	90,179.3	151,226.1
Total Effect	6.8	307,422.5	597,971.7	1,095,324.2
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	4.4	230,118.7	423,532.9	809,130.1
Indirect Effect	1.7	59,762.0	128,418.7	217,725.9
Induced Effect	1.4	45,950.4	98,617.5	165,375.2
Total Effect	7.5	335,831.1	650,569.1	1,192,231.1

* values in \$1000

The M&S contribution to the Shenandoah Valley Region GRP (value added, total effect) is estimated to be \$545.4 million (Scenario 1) to \$650.6 million (Scenario 3). The total economic impact of M&S on the Shenandoah Valley regional economy is estimated to be \$998.4 million (Scenario 1) to \$1.2 billion (Scenario 3).

4.8.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth.

Table 4-95 presents the growth projection for each industry sector.

Table 4-95: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors; * Source: US Bureau of Labor Statistics; ** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-96 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-96: Shenandoah Valley Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	0.490	0.0671	0.490	0.0671	0.490	0.0671
Other commercial and service industry machinery manufacturing	0.171	0.0263	0.171	0.0263	0.171	0.0263
Ship building and repairing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Software publishers	7.312	1.1893	10.968	1.7840	14.624	2.3787
Telecommunications	24.356	3.8723	24.356	3.8723	24.356	3.8723
Other information services	2.156	0.3523	2.156	0.3523	2.156	0.3523
Architectural, engineering, and related services	17.954	2.4408	17.954	2.4408	17.954	2.4408
Custom computer programming services	12.400	2.1619	18.599	3.2429	24.799	4.3239
Computer systems design services	6.810	0.9999	10.215	1.4998	13.620	1.9997
Other computer related services, including facilities management	1.522	0.1942	1.522	0.1942	1.522	0.1942
Management, scientific, and technical consulting services	11.338	1.7858	17.007	2.6788	22.676	3.5717
Scientific research and development services	3.402	0.5037	5.103	0.7556	6.804	1.0074
All other miscellaneous professional, scientific, and technical services	4.150	0.6185	6.226	0.9277	8.301	1.2369
Other private educational services	10.233	1.5962	10.233	1.5962	10.233	1.5962
Private hospitals	92.321	16.7861	92.321	16.7861	92.321	16.7861
Total	194.617	32.5944	217.323	36.2240	240.029	39.8535

Bold text refers to core sectors

Table 4-97 presents the projected (2011-2020) M&S economic impact for the Shenandoah Valley Region based on the labor projections in Table 4-96.

Table 4-97: Shenandoah Valley Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	32.6	1,736,452.1	3,217,146.4	6,123,081.2
Indirect Effect	12.3	431,887.3	955,551.7	1,628,959.9
Induced Effect	10.3	342,785.9	735,670.4	1,233,693.5
Total Effect	55.1	2,511,125.3	4,908,368.5	8,985,734.5
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	36.2	1,903,765.3	3,514,480.4	6,702,642.0
Indirect Effect	13.8	484,875.6	1,055,665.5	1,794,255.8
Induced Effect	11.3	378,171.2	811,616.8	1,361,039.8
Total Effect	61.3	2,766,812.0	5,381,762.8	9,857,937.7
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	39.9	2,071,066.2	3,811,799.9	7,282,176.5
Indirect Effect	15.3	537,861.7	1,155,775.6	1,959,545.3
Induced Effect	12.4	413,554.2	887,558.5	1,488,378.2
Total Effect	67.5	3,022,482.1	5,855,134.0	10,730,100.0

* values in \$1000

It is estimated that M&S will contribute \$4.9 billion (Scenario 1) to \$5.85 billion (Scenario 3) to the Shenandoah Valley Region GRP from 2011 to 2020.

4.8.4 Regional Challenges Summarized

1. How do we grow new businesses and existing capabilities of small businesses?
2. How do we get people to accept and use M&S applications to address local needs?
3. How can we get help to generate proposals and funding grants?
4. How can we change the perception of poor job opportunity in the region?
5. How can we overcome information access issues and create more student projects?
6. How can we build M&S networking on a regional level?

4.8.4.1 Marketplace

The marketplace would benefit from more regional entrepreneurship. Study participants host start-up weekends, which are local efforts to help potential entrepreneurs develop a business plans, etc. and navigate entrance into the marketplace. These events might be leveraged for M&S networking.

Information on aspects of the business size of the Shenandoah Region's commercial business survey respondent is reported on the following page, in Table 4-98.

Table 4-98: Shenandoah Valley Region, Respondents' Commercial Business Size

Annual Revenue	# of Responses	% of Responses	# of Employees	# of Responses	% of Responses
<\$1M	0	0%	1-10	0	0%
\$1M-\$10M	0	0%	11-25	0	0%
\$11M-\$50M	1	100%	26-100	0	0%
\$51M-\$100M	0	0%	101-500	1	100%
\$100M+	0	0%	501-1000	0	0%
Unknown	0	0%	1001-2000	0	0%
Total	1	100%	2001 +	0	0%
			Total	1	100%

Among the commercial businesses, information about what percentage of the respondents' total revenue and what percentage of its employees are devoted to M&S was asked. This information is presented Table 4-99 for the Shenandoah Valley Region.

Table 4-99: Shenandoah Valley Region M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
0%	0	0%	0%	0	0%
1-10%	0	0%	1-10%	0	0%
11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%
76-100%	1	100%	76-100%	0	0%
DNR	0	0%	DNR	1	100%
Total	1	100%	Total	1	100%

Information about the Shenandoah Valley Region survey respondents' M&S organizational activities is presented in Table 4-100, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-100: Shenandoah Valley Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses	Budget % – Research M&S	# of Responses	% of Responses	Budget % - Train M&S	# of Responses	% of Responses
0%	1	50%	0%	0	0%	0%	0	0%
1-10%	0	0%	1-10%	0	0%	1-10%	0	0%
11-25%	0	0%	11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	0	0%	76-100%	0	0%
DNR	1	50%	DNR	2	100%	DNR	2	100%
Total	2	100%	Total	2	100%	Total	2	100%

4.8.4.2 Workforce

Students reportedly choose to move to other regions after graduation, because they do not foresee sufficient career opportunities within this region. The perception of poor job opportunity impedes workforce retention and recruitment. The M&S workforce needs training and educating for the downstream applications.

Employment was examined regarding what types of labor categories survey respondents' M&S employees fit into, and also which M&S labor categories were the most difficult to recruit and retain. This information is not available for this region. No labor category responses were submitted by Shenandoah Valley Region survey respondents and no QOL factors were identified that negatively affect employee recruitment or retention.

Table 4-101: Labor Categories, Employed or Difficult to Recruit or Retain, Shenandoah Valley Region

Labor Category	Employ	Difficult
NO DATA AVAILABLE	-	-

To grow the M&S industry, study participants reported that the M&S workforce will need geospatial modeling students and faculty, GIS tools, and greater emphasis on dynamic, systems oriented thinking. There should be a push to cloud-based simulation, and agent-based modeling of actors in simulations, each with specific rules. Epidemiology applications will grow as well.

4.8.4.3 Networking

No networking activity was reported by survey respondents. Study participants asserted a need for representatives at a local, reachable level in order for M&S growth to take hold regionally.

4.8.4.4 Collaboration

Cooperation among educational institutions works well within the region. For K-12 education, cities promote STEM through several academies. There are GIS programs for high school seniors and two local Governor Schools. One city has seven robotics clubs. There is a need at the K-12 level to have someone who can write grants and pull schools together on various initiatives.

Community college programs depend on faculty interests. Regionally, JMU emphasizes quantitative biology, robotics, and some systems modeling. M&S transportation research and nuclear bomb modeling are also focus areas. Institutions could use assistance generating funded proposals and grants.

JMU has long history of community and business outreach, and has an established small business center. More Government and business partnerships are required for research at JMU. They need companies to provide small scale pilot projects and more student projects, and help overcoming data sharing/access issues.

4.8.5 Regional Opportunities

Local businesses listed in the asset inventory can be leveraged for industry growth. Additionally, the JMU small business center, SVTC, agriculture associations and cooperative extensions are all potential organizing forces that could energize the development of an M&S network.

Within this dispersed region, small business development will be the key, coupled with focusing on architecture and agriculture (poultry farming) M&S applications (e.g., managing the agricultural impact on the Chesapeake Bay Watershed.)

4.8.6 Proposed Actions and Investments

Study participants proposed actions and investments to grow the M&S industry within this region. They are organized by common study theme:

Industry

- Demonstrate state government successful use of M&S in specific task areas so that local government and businesses will feel comfortable following.

Small business specific

- Implement community volunteer and student projects to grow small business in the area.

Networking

- Establish a network and representatives at a technology council level.

Collaboration

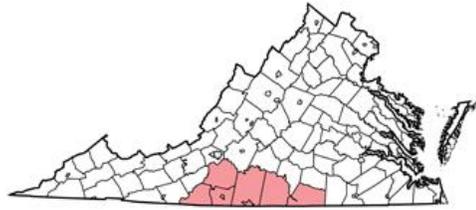
- Emphasize applied opportunities for M&S so that the University will be comfortable with greater investment in M&S programs.
- Provide capital investment, start-up money, and venture capital, possibly flowing funds through CIT.
- Provide seed money for local government initiatives to apply M&S to local/regional problems.
- Seed local activity through local government strategic investment.

Policy/Regulation

- Generate requirement (need) at the Commonwealth leadership level.

4.9 Southern Piedmont Region

This section presents information for the study region identified as the Southern Piedmont Region. This region is depicted in the figure shown at right.



The Southern Piedmont Region has several key pieces in place to create a strong M&S technical workforce and draw businesses to the area. On the forefront are the Southern Virginia Higher Education Center (SVHEC), focused on educating the workforce in the areas of advanced manufacturing, design, and nursing training programs; and the research capacity at the Riverstone Energy Center. Infrastructure includes Mid-Atlantic Broadband Cooperative (MBC) Broadband Infrastructure (400 Gbps), headquartered in Halifax.

Regional branding was reported as being **ALWAYS** used by one survey respondent, and **SOMETIMES** by the other two respondents. One respondent reported that the region was recognized as a significant force in M&S while the other two did not agree.

4.9.1 Number of Regional Study Participants

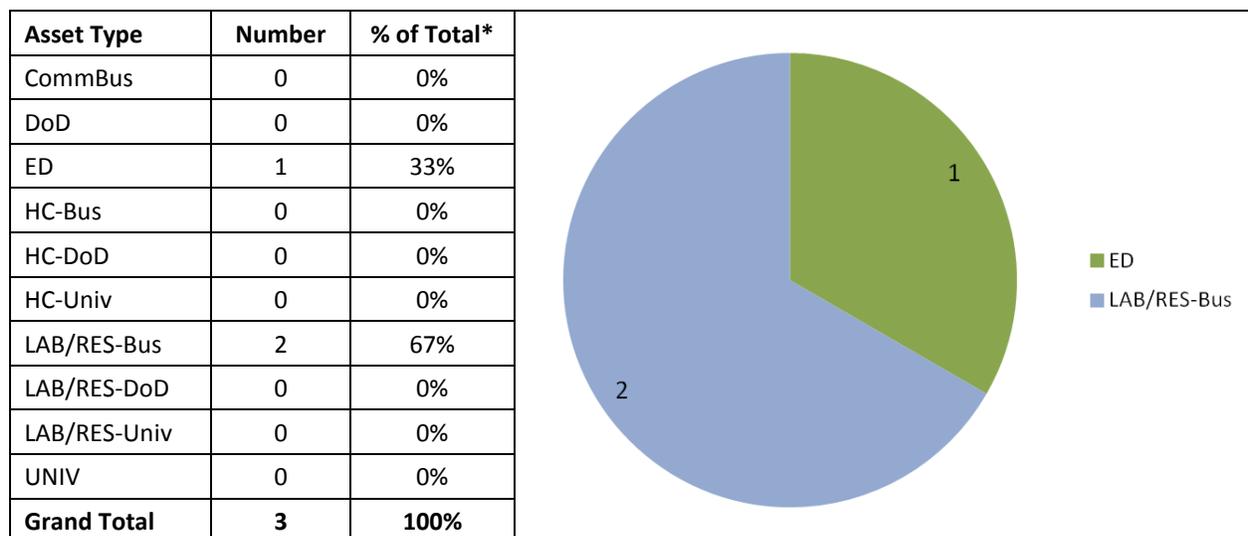
The Southern Piedmont Region was well-represented in the survey and focus group data. Regional stakeholder data represents three survey respondents (one College/University and two Lab/Research organizations) and three focus group participants. The visit to this region included tours of the SVHEC and Riverstone Energy Center. Tours included demonstrations of research and training technologies and tools used at both locations. Tour invitations were initiated by focus group participants.

4.9.2 Asset Summary

Three M&S assets were identified for this region. The distribution of assets by category for the Southern Piedmont Region is presented in

Table 4-102. For an explanation of asset categories, see Table 3-4 page 22.

Table 4-102: Southern Piedmont Region M&S Asset Distribution



*rounded to the nearest whole number

Riverstone Energy Center includes a Modeling and Simulation Center of Excellence which is oriented towards using M&S for training, education, and industry collaboration, to study products and applications through test and development. Riverstone Energy Center's facility includes a fully immersive 3D theater (CAVE) with visualization technology; a communication and marketing center to promote start-up business endeavors, and a National Coatings Laboratory which enables the research of product coatings for advanced manufacturing.

The SVHEC integrates M&S tools into its 125 training programs focusing on product design, nursing, and applied manufacturing research and workforce development training. It has significant M&S capabilities in the personnel, tools, and facilities that comprise its Research & Development Center for Advanced Manufacturing & Energy Efficiency (R&D CAMEE) Advanced Manufacturing Center, Center of Nursing Excellence, and studio production facilities. The nursing center possesses several high fidelity manikins, a nursing simulation laboratory, and classrooms. The Advanced Manufacturing Center houses a Computer Numerical Control (CNC) Machining Center, water laser jet, virtual welding trainer, two CAD/CAM computer labs, and a Product Lifecycle Management Training Lab.

4.9.3 Economic and Workforce Analyses

The definition of the M&S Industry and is discussed in Section 2.6. Labor categories are discussed in Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-103 presents the Southern Piedmont Region employment estimates for each industry sector.

Table 4-103: Southern Piedmont Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Southern Piedmont Region Employment, M&S Related Sectors	6,646.34
Pharmaceutical preparation manufacturing	86.03
Other commercial and service industry machinery manufacturing	5.25
Ship building and repairing	0.00
Software publishers	1.61
Telecommunications	438.72
Other information services	7.45
Architectural, engineering, and related services	482.11
Custom computer programming services	421.31
Computer systems design services	452.83
Other computer related services, including facilities management	50.95
Management, scientific, and technical consulting services	237.33
Scientific research and development services	46.66
All other miscellaneous professional, scientific, and technical services	131.55
Other private educational services	435.95
Private hospitals	3,848.60
Total Southern Piedmont Region Employment	138,875.34

Bold text represents core sectors

It is estimated that approximately 4.8 percent of the Southern Piedmont Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Southern Piedmont Region are presented in Table 4-104.

Table 4-104: Southern Piedmont Region Economic and Workforce Analysis Scenarios

Scenario	Southern Piedmont Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-105 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-105: Southern Piedmont Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Southern Piedmont M&S Employment	66.463	72.920	79.376
Pharmaceutical preparation manufacturing	0.860	0.860	0.860
Other commercial and service industry machinery manufacturing	0.053	0.053	0.053
Ship building and repairing	0.000	0.000	0.000
Software publishers	0.016	0.024	0.032
Telecommunications	4.387	4.387	4.387
Other information services	0.074	0.074	0.074
Architectural, engineering, and related services	4.821	4.821	4.821
Custom computer programming services	4.213	6.320	8.426
Computer systems design services	4.528	6.792	9.057
Other computer related services, including facilities management	0.510	0.510	0.510
Management, scientific, and technical consulting services	2.373	3.560	4.747
Scientific research and development services	0.467	0.700	0.933
All other miscellaneous professional, scientific, and technical services	1.315	1.973	2.631
Other private educational services	4.359	4.359	4.359
Private hospitals	38.486	38.486	38.486

Bold text represents core sectors

Scenario 1 estimates that 0.05 percent of the Southern Piedmont Region's total employment (138,875) is M&S specific, while Scenario 2 estimates 0.05 percent and Scenario 3 estimates 0.06 percent. Employment among all core sectors is low, and *Private hospitals* (related sector) account for one-half of the estimated employment.

The economic impact was calculated using the estimates presented in Table 4-105.

Table 4-106 presents the Southern Piedmont Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-106: Southern Piedmont Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.4	60,537.0	98,711.8	202,969.5
Indirect Effect	0.4	10,011.2	21,213.9	36,062.4
Induced Effect	0.3	7,837.0	18,255.7	30,564.2
Total Effect	2.0	78,385.3	138,181.5	269,596.1
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.5	64,742.6	104,456.0	214,324.5
Indirect Effect	0.4	10,678.0	22,606.4	38,402.3
Induced Effect	0.3	8,383.6	19,529.4	32,696.4
Total Effect	2.1	83,804.2	146,591.8	285,423.2
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.6	68,947.9	110,201.4	225,680.5
Indirect Effect	0.4	11,344.8	23,998.8	40,742.2
Induced Effect	0.3	8,930.1	20,802.9	34,828.5
Total Effect	2.3	89,222.8	155,003.0	301,251.1

* values in \$1000

The M&S contribution to the Southern Piedmont Region GRP (value added, total effect) is estimated to be \$138.1 million (Scenario 1) to \$155 million (Scenario 3). The total economic impact of M&S on the Southern Piedmont regional economy is estimated to be \$269.6 million (Scenario 1) to \$301.2 million (Scenario 3).

4.9.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth.

Table 4-107 presents the growth projection for each industry sector.

Table 4-107: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-108, on the following page, presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-109 presents the projected (2011-2020) M&S economic impact for the Southern Piedmont Region based on the labor projections in Table 4-108.

Based on the data presented in these tables, it is estimated that M&S will contribute \$1.2 billion (Scenario 1) to \$1.4 billion (Scenario 3) to the Southern Piedmont Region GRP from 2011 to 2020.

Table 4-108: Southern Piedmont Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	1.013	0.1388	1.013	0.1388	1.013	0.1388
Other commercial and service industry machinery manufacturing	0.061	0.0093	0.061	0.0093	0.061	0.0093
Ship building and repairing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Software publishers	0.019	0.0031	0.029	0.0047	0.038	0.0062
Telecommunications	5.221	0.8301	5.221	0.8301	5.221	0.8301
Other information services	0.087	0.0142	0.087	0.0142	0.087	0.0142
Architectural, engineering, and related services	5.804	0.7890	5.804	0.7890	5.804	0.7890
Custom computer programming services	4.925	0.8587	7.388	1.2881	9.850	1.7175
Computer systems design services	5.213	0.7654	7.819	1.1480	10.426	1.5307
Other computer related services, including facilities management	0.604	0.0770	0.604	0.0770	0.604	0.0770
Management, scientific, and technical consulting services	2.787	0.4389	4.180	0.6584	5.573	0.8779
Scientific research and development services	0.549	0.0813	0.823	0.1219	1.098	0.1626
All other miscellaneous professional, scientific, and technical services	1.558	0.2322	2.337	0.3482	3.116	0.4643
Other private educational services	5.152	0.8036	5.152	0.8036	5.152	0.8036
Private hospitals	38.486	6.9976	38.486	6.9976	38.486	6.9976
Total	71.479	12.0392	79.004	13.2290	86.529	14.4188

Bold text represents core sectors

Table 4-109: Southern Piedmont Region Projected Economic Impact, 2011-2012

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	12.0	544,819.5	888,370.9	1,826,654.3
Indirect Effect	3.2	90,097.2	190,916.8	324,546.9
Induced Effect	2.4	70,531.2	164,297.3	275,070.4
Total Effect	17.6	705,447.9	1,243,584.9	2,426,271.6
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	13.2	582,669.5	940,077.6	1,928,870.8
Indirect Effect	3.4	96,100.0	203,452.2	345,611.9
Induced Effect	2.6	75,450.6	175,760.5	294,261.1
Total Effect	19.2	754,220.2	1,319,290.3	2,568,743.7
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	14.4	620,525.2	991,791.4	2,031,085.8
Indirect Effect	3.7	102,101.3	215,985.0	366,672.6
Induced Effect	2.7	80,370.5	187,224.6	313,453.4
Total Effect	20.8	802,997.0	1,395,001.0	2,711,211.9

* values in \$1000

4.9.4 Regional Challenges Summarized

1. What VA-based M&S assets are in position to support our workforce training?
2. How do we increase our visibility now that we have capability?
3. How do we fund skilled personnel to maintain our training programs?

4.9.4.1 Marketplace

Regional products used include visualization technology, tracking technology, computer modeling, 3-D printing, CAD/CAM software, and high-fidelity manikins. Use of other advanced manufacturing, healthcare, and studio art and production products were observed by the study team and are detailed in the asset summary above.

Lack of funding, lengthy development time and limited availability of M&S engineers are obstacles to new product launch into the market. Also, high software licensing costs across a wide variety of required tools are cost prohibitive and inhibit M&S development. Obstacles to expansion include geographic isolation, lack of access to high performance computing power, and finding and retaining regional talent. Survey data on commercial business size, and M&S revenue and employees is not available for the Southern Piedmont Region.

Table 4-110: Southern Piedmont Region, Respondents’ Commercial Business Size

Annual Revenue	# of Responses	% of Responses	# of Employees	# of Responses	% of Responses
NO DATA AVAILABLE					

Among the commercial businesses, information about what percentage of the respondents’ total revenue and what percentage of its employees are devoted to M&S was asked. Unfortunately, this information is not available for the Southern Piedmont Region.

Table 4-111: Southern Piedmont Region M&S Percentage, Commercial Businesses

Revenue – M&S%	# of Responses	% of Responses	Employees – M&S%	# of Responses	% of Responses
NO DATA AVAILABLE					

Information about all of the Southern Piedmont Region survey respondents’ M&S organizational activities is presented in Table 4-112, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-112: Southern Piedmont Region M&S %, All Organizations

Budget % - Produce M&S	# of Responses	% of Responses *	Budget % – Research M&S	# of Responses	% of Responses *	Budget % - Train M&S	# of Responses	% of Responses *
0%	0	0%	0%	0	0%	0%	0	0%
1-10%	1	33%	1-10%	2	67%	1-10%	2	67%
11-25%	2	67%	11-25%	0	0%	11-25%	1	33%
26-50%	0	0%	26-50%	0	0%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	1	33%	76-100%	0	0%
DNR	0	0%	DNR	0	0%	DNR	0	0%
Total	3	100%	Total	3	100%	Total	3	100%

*rounded to the nearest whole number

4.9.4.2 Workforce

Technical workforce within the region is growing due to the well-positioned investments that support workforce training using technology. Worker recruitment and employee retention may have to overcome perception of the areas as economically depressed with transportation issues.

Employment was examined regarding what types of labor categories respondents' M&S employees fit into, and also which labor categories they experienced any M&S employee difficulty in recruitment and retention. Two survey respondents reported affordable housing and limited K-12 educational opportunities negatively impacted employee recruitment and retention. Survey response information is presented in Table 4-113; note that the numbers are only indicative of responses, and not numbers of employees.

Table 4-113: Labor Categories, Employed or Difficult to Recruit or Retain, Southern Piedmont Region

Labor Category	Employ	Difficult
Biochemists and Biophysicists	1	0
Computer Programmers	1	0
Graphic Artist	0	1
Graphic Designers	1	1
Industrial Engineering Technicians	0	1
Industrial Engineers	0	1
Information Security Analysts, Web Developers, and Computer Network Architects	0	1
Instructional Coordinators	0	1
Materials Scientists	1	0
Mechanical Engineering Technicians	1	2
Mechanical Engineers	1	1
Multimedia Artists and Animators	1	1
Programmer	1	0
Researcher	1	0
Software developers	0	1
Teacher	1	1
NONE		0

Participants reported that the skills necessary to expand Virginia's M&S industry capabilities included programming, math, science, physics, and engineering. In particular, workers need the capability to think in three dimensions with their knowledge of the physical world augmenting the virtual. Also needed are applied engineering skills and CAD/CAM software experience.

4.9.4.3 Networking

The region has networking in place, maintaining relationships with automotive and energy start-ups and tire companies. Community networking is emphasized and the network in place is robust among study participants. One survey respondent reported participating **2-4 TIMES** while a second respondent reported participating **MORE THAN 10 TIMES** in regional networking activities during the past year. These respondents also reported seeking assistance from the regional network **2-4 TIMES** and **5-10 TIMES** during the past year. (**THIS TEXT** indicates a survey response choice.)

4.9.4.4 Collaboration

Collaborative relationships are ongoing with The University of Virginia, Virginia Tech, ODU, Oak Ridge National Lab, and Riverstone Energy Center, Center of Innovation and Technology (grant recipient). The SVHEC partners with eleven higher education institutions including community colleges, universities both private and public, graduate and research institutions, and international institutions to serve sixteen counties in the region.

Issues with collaborative endeavors include cost relative to revenues and the ability to generate, in a higher educational setting, the financial support to maintain skilled personnel.

4.9.5 Regional Opportunities

The current assets provide a strong foundation for building technology-based workforce and industry.

4.9.6 Proposed Actions and Investments

Study participants proposed several actions and investments to grow the M&S industry. These are organized by common study theme:

Infrastructure/Investment

- Provide access to High Performance Computing Power for outlying regions.
- The Commonwealth should invest in the development of a digital manufacturing HUB that enables manufacturers to simulate product development, product performance, manufacturing processes, and VR work force training modules.

Education

- Promote statewide programs collectively.
- Development of a robust M&S educational program through the Virginia Community College System that is accessible via distance learning.
- Implement dedicated M&S training programs at the community college level.
- Engage students in middle school and high school through dedicated M&S training programs, similar to the Virtual Reality Educational Pathfinders (VREP) program that began in the public school system in Iowa.

Collaboration

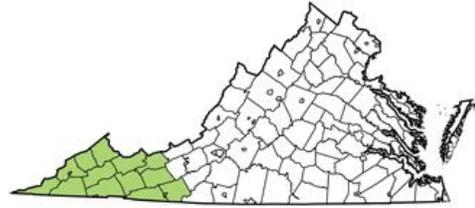
- Help companies hire and train workers.
- Implement a five-year program that would help the region afford to recruit and hire the numbers needed to build an M&S team.
- Align public school (K-12) curriculum with the technical skills demanded for the M&S workforce, similar to the way higher education institutions design their curriculum to match workforce needs.

Policy/Regulation/Taxation

- Provide tax credit or Work Force Investment Board Support to assist manufacturers and other companies with the cost of implementing M&S technologies.

4.10 Southwestern Virginia Region

This section presents information for the study region identified as the Southwestern Virginia Region. This region is depicted in the figure shown at right.



The Southwestern Virginia Region has M&S assets providing training in healthcare and emergency medical response. This training is used to expose students to critical care incidents. The nurse training program is characterized as robust, and has a brand new mobile training center. The M&S tools were purchased using Federal and VA grant money, with the initiative to apply spearheaded by a key individual rather than an organization. Regional branding is not used by survey respondents. Stakeholders in this region seek help identifying coal industry alternatives for the workforce and economy.

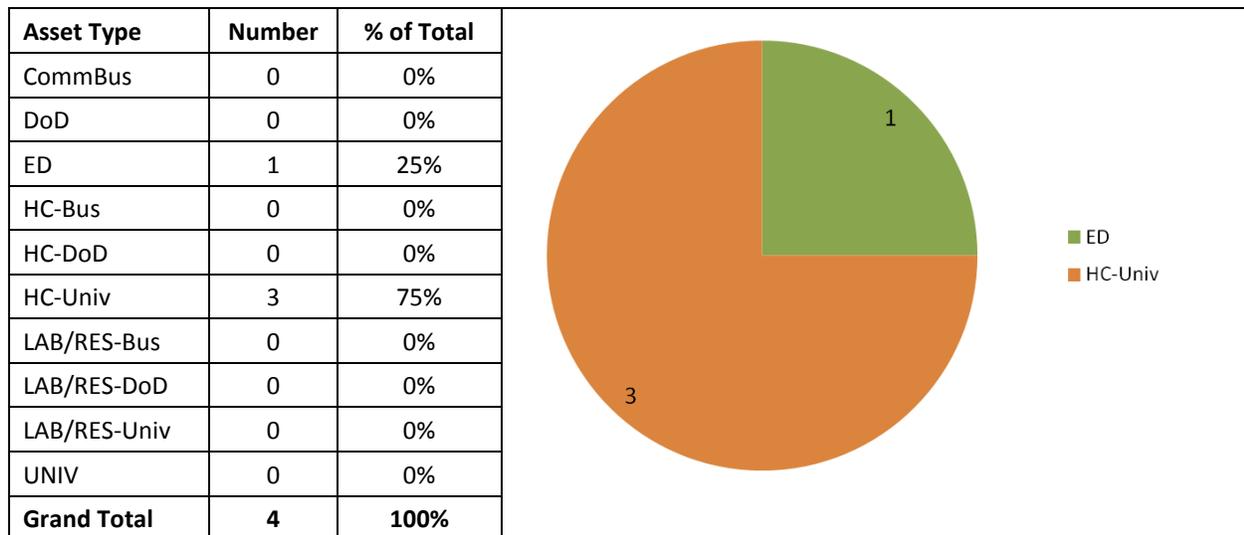
4.10.1 Number of Regional Study Participants

Information for the Southwestern Virginia Region was provided by five study participants in total. This data represents two respondents (one College/University and one Lab/Research organization) and three focus group participants.

4.10.2 Asset Summary

The distribution of assets for this region is presented in Table 4-114. For an explanation of asset categories, see Table 3-4 page 22.

Table 4-114: Southwestern Virginia Region M&S Asset Distribution



4.10.3 Economic and Workforce Analyses

The definition of the M&S Industry is discussed in Section 2.6. Labor categories are discussed in Section 2.7. M&S labor categories were aligned to each IMPLAN industry sector, as described in Section 2.6.

Table 4-115 presents the Southwestern Virginia Region employment estimates for each industry sector.

Table 4-115: Southwestern Virginia Region Employment in M&S Related Sectors

Industry Sector	Total Employment
Total Southwestern Virginia Region Employment, M&S Related Sectors	8,109.42
Pharmaceutical preparation manufacturing	50.28
Other commercial and service industry machinery manufacturing	0.00
Ship building and repairing	0.00
Software publishers	3.27
Telecommunications	1,070.53
Other information services	3.15
Architectural, engineering, and related services	1,117.18
Custom computer programming services	371.91
Computer systems design services	242.34
Other computer related services, including facilities management	78.12
Management, scientific, and technical consulting services	247.65
Scientific research and development services	151.60
All other miscellaneous professional, scientific, and technical services	173.60
Other private educational services	268.02
Private hospitals	4,331.77
Total Southwestern Virginia Region Employment	177,268.39

Bold text represents core sectors

It is estimated that approximately 4.6 percent of the Southwestern Virginia Region total employment is employed in the M&S-related sectors.

Three scenarios were developed to estimate the proportion of M&S activity within the core and related sectors. Scenarios were based upon literature findings, current study survey and asset findings, and expert opinion. Scenario weights used for the Southwestern Virginia Region are presented in Table 4-116.

Table 4-116: Southwestern Virginia Region Economic and Workforce Analysis Scenarios

Scenario	Southwestern Virginia Region	
	Core Sectors	Related Sectors
Scenario 1	1%	1%
Scenario 2	1.5%	1%
Scenario 3	2%	1%

Table 4-117 applies the scenario weights to the total employment in M&S-related sectors to estimate M&S-related employment for each industry sector.

Table 4-117: Southwestern Virginia Region M&S Employment, 3 Scenarios

Industry Sector	M&S Employment		
	Scenario 1	Scenario 2	Scenario 3
Total Southwestern Virginia Region M&S Employment	81.094	87.046	92.998
Pharmaceutical preparation manufacturing	0.503	0.503	0.503
Other commercial and service industry machinery manufacturing	0.000	0.000	0.000
Ship building and repairing	0.000	0.000	0.000
Software publishers	0.033	0.049	0.065
Telecommunications	10.705	10.705	10.705
Other information services	0.032	0.032	0.032
Architectural, engineering, and related services	11.172	11.172	11.172
Custom computer programming services	3.719	5.579	7.438
Computer systems design services	2.423	3.635	4.847
Other computer related services, including facilities management	0.781	0.781	0.781
Management, scientific, and technical consulting services	2.477	3.715	4.953
Scientific research and development services	1.516	2.274	3.032
All other miscellaneous professional, scientific, and technical services	1.736	2.604	3.472
Other private educational services	2.680	2.680	2.680
Private hospitals	43.318	43.318	43.318

Bold text represents core sectors

All three scenarios estimate that 0.05 percent of the Southwestern Virginia Region total employment (177,268) is M&S specific. M&S employment among all the core sectors is low, while the majority of M&S employment is accounted for in the *Architectural, engineering, and related services*; *Telecommunications*; and *Private hospitals* industry sectors.

The economic impact was calculated using the estimates presented in Table 4-117.

Table 4-118 (following page) presents the Southwestern Virginia Region economic impact of M&S based upon the three defined scenarios. Economic impact is reported as *Direct Effect*, *Indirect Effect*, and *Induced Effect*, and includes *Labor Income*, *Value Added* estimates, and *Total Output*.

Table Definitions:

- *Direct Effect* represents the portion of the regional economy accounted for by the M&S employment in the region.
- *Indirect Effect* captures all the iterations of regional industrial purchases (e.g., materials, services, etc.) accounted for by the Direct Effect.
- *Induced Effect* captures employee spending (e.g., groceries) for their personal use.
- *Labor Income* reflects the total value paid to local workers within the region.
- *Value Added* is comprised of Labor Income, Indirect Business Taxes, and Other Property Type Income. Value added is often referred to as GRP.
- *Total Output* represents the total value of an industry's production, comprised of the value of the Intermediate Inputs and Value Added. Intermediate inputs are the goods and services produced by one industry that will be incorporated in the production of another industry.

Table 4-118: Southwestern Virginia Region M&S Economic Impact

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.6	76,923.1	152,257.2	297,629.1
Indirect Effect	0.4	15,873.1	34,392.6	59,420.6
Induced Effect	0.3	10,760.4	24,777.2	41,430.5
Total Effect	2.4	103,556.6	211,427.0	398,480.1
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.7	81,878.4	160,023.7	311,238.8
Indirect Effect	0.5	16,584.5	35,827.2	61,842.2
Induced Effect	0.4	11,418.1	26,292.5	43,963.9
Total Effect	2.6	109,881.0	222,143.4	417,044.9
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	1.9	86,834.0	167,791.6	324,852.1
Indirect Effect	0.5	17,296.3	37,262.4	64,264.7
Induced Effect	0.4	12,075.9	27,808.0	46,497.7
Total Effect	2.7	116,206.1	232,861.9	435,614.5

* values in \$1000

The M&S contribution to the Southwestern Virginia Region GRP (value added, total effect) is estimated to be \$211.4 million (Scenario 1) to \$232.9 million (Scenario 3). The total economic impact of M&S on the Southwestern Virginia regional economy is estimated to be \$398.5 million (Scenario 1) to \$435.6 million (Scenario 3).

4.10.3.1 Growth Projections

Future Growth was estimated using BLS national growth projections, which are available for 2010-2020. IMPLAN data represents 2011 data; consequently, BLS projections were adjusted to project 2011-2020 growth. Table 4-119, on the following page, presents the growth projection for each industry sector.

Table 4-119: National Industry Growth Projections

Industry Sector	2010-2020*	2011-2020**
Pharmaceutical preparation manufacturing	17.92%	16.13%
Other commercial and service industry machinery manufacturing	19.76%	17.79%
Ship building and repairing	17.60%	15.84%
Software publishers	21.49%	19.34%
Telecommunications	21.02%	18.92%
Other information services	21.13%	19.01%
Architectural, engineering, and related services	18.18%	16.37%
Custom computer programming services	22.65%	20.38%
Computer systems design services	18.78%	16.90%
Other computer related services, including facilities management	16.80%	15.12%
Management, scientific, and technical consulting services	20.55%	18.49%
Scientific research and development services	19.35%	17.42%
All other miscellaneous professional, scientific, and technical services	19.61%	17.65%
Other private educational services	20.48%	18.43%
Private hospitals	20.20%	18.18%

Bold text represents core sectors

* Source: US Bureau of Labor Statistics

** Adjusted for 2011-2012

BLS projections were used to estimate 2011-2020 labor growth for each industry sector. Table 4-120 presents estimated number of new jobs overall by sector and M&S-jobs for each scenario.

Table 4-120: Southwestern Virginia Region Projected Employment, 2011-2020

Industry Sector	Scenario 1		Scenario 2		Scenario 3	
	Total Sector	M&S Portion	Total Sector	M&S Portion	Total Sector	M&S Portion
Pharmaceutical preparation manufacturing	0.592	0.0811	0.592	0.0811	0.592	0.0811
Other commercial and service industry machinery manufacturing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Ship building and repairing	0.000	0.0000	0.000	0.0000	0.000	0.0000
Software publishers	0.039	0.0063	0.058	0.0095	0.078	0.0127
Telecommunications	12.741	2.0256	12.741	2.0256	12.741	2.0256
Other information services	0.037	0.0060	0.037	0.0060	0.037	0.0060
Architectural, engineering, and related services	13.449	1.8283	13.449	1.8283	13.449	1.8283
Custom computer programming services	4.348	0.7580	6.521	1.1371	8.695	1.5161
Computer systems design services	2.790	0.4096	4.185	0.6144	5.579	0.8192
Other computer related services, including facilities management	0.926	0.1181	0.926	0.1181	0.926	0.1181
Management, scientific, and technical consulting services	2.908	0.4580	4.362	0.6870	5.816	0.9160
Scientific research and development services	1.784	0.2641	2.675	0.3961	3.567	0.5282
All other miscellaneous professional, scientific, and technical services	2.056	0.3064	3.084	0.4596	4.112	0.6128
Other private educational services	3.168	0.4941	3.168	0.4941	3.168	0.4941
Private hospitals	43.318	7.8761	43.318	7.8761	43.318	7.8761
Total	88.153	14.6318	95.115	15.7330	0.592	16.8342

Bold text represents core sectors

Table 4-121, below, presents the projected (2011-2020) M&S economic impact for the Southwestern Virginia Region based on the labor projections in Table 4-120 (previously).

Table 4-121: Southwestern Virginia Region Projected Economic Impact, 2011-2020

Scenario 1				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	14.6	692,300.6	1,370,306.4	2,678,647.1
Indirect Effect	3.9	142,856.8	309,530.2	534,779.7
Induced Effect	3.1	96,842.6	222,992.9	372,871.5
Total Effect	21.7	932,000.0	1,902,829.6	3,586,298.3
Scenario 2				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	15.7	736,904.0	1,440,219.3	2,801,164.3
Indirect Effect	4.1	149,261.6	322,445.6	556,580.8
Induced Effect	3.3	102,762.9	236,632.8	395,676.0
Total Effect	23.1	988,928.6	1,999,297.8	3,753,421.1
Scenario 3				
Impact Type	Employment	Labor Income*	Value Added*	Output*
Direct Effect	16.8	781,507.0	1,510,132.3	2,923,684.4
Indirect Effect	4.3	155,667.0	335,361.4	578,382.7
Induced Effect	3.5	108,683.1	250,272.7	418,480.5
Total Effect	24.6	1,045,857.1	2,095,766.4	3,920,547.6

* values in \$1000

It is estimated that M&S will contribute \$1.9 billion (Scenario 1) to \$2.1 billion (Scenario 3) to the Southern Virginia Region GRP from 2011 to 2020.

4.10.4 Regional Challenges Summarized

1. What are our industry alternatives now that coal production is restricted?
2. How should we retrain and refocus our workforce?
3. How can we begin to network and collaborate in the M&S industry?
4. How do we educate our region about the potential for M&S applications?

4.10.4.1 Marketplace

No data is available for this region regarding size commercial business survey respondents.

Table 4-122: Southwestern Virginia Region, Respondents' Commercial Business Size

Annual Revenue	# of responses	% of responses	# of Employees	# of responses	% of responses
NO DATA AVAILABLE					

Among the commercial businesses, information about what percentage of the respondents' total revenue and what percentage of its employees are devoted to M&S was asked. This information is not available for the Southwestern Virginia Region.

Table 4-123: Southwestern Virginia Region, M&S Percentage, Commercial Businesses

Revenue – M&S%	# of responses	% of responses	Employees – M&S%	# of responses	% of responses
NO DATA AVAILABLE					

Information about all of the Southwestern Virginia Region survey respondents’ M&S business activities is presented in Table 4-124, including percent of budget devoted to production of M&S products, research of M&S, and training of M&S.

Table 4-124: Southwestern Virginia Region M&S %, All Organizations

Budget % - Produce M&S	# of responses	% of responses	Budget % – Research M&S	# of responses	% of responses	Budget % - Train M&S	# of responses	% of responses
0%	0	0%	0%	1	50%	0%	0	0%
1-10%	2	100%	1-10%	0	0%	1-10%	2	100%
11-25%	0	0%	11-25%	0	0%	11-25%	0	0%
26-50%	0	0%	26-50%	1	50%	26-50%	0	0%
51-75%	0	0%	51-75%	0	0%	51-75%	0	0%
76-100%	0	0%	76-100%	0	0%	76-100%	0	0%
DNR	0	0%	DNR	0	0%	DNR	0	0%
Total	2	100%	Total	2	100%	Total	2	100%

Regional consumers use high fidelity simulation mannequins and software tools and hardware platforms. Specific products are mannequins for EMS and healthcare training. Cost of M&S commercial software product licensing and security for cloud based solutions were reported as obstacles to success. Obstacles in the marketplace were reported as a lack of knowledge about M&S applications, the lack of widespread advertising of the potential applications for simulation training, and insufficient funding for expansion of current healthcare programs.

Attracting and retaining an experienced workforce has been a challenge, particularly without a local university as part of the labor pipeline. Leveraging the existing assets, including a relevant high school curriculum and higher education center training opportunities was recommended. Higher education attainment coupled with applied experience among the regional workforce will be the key to M&S industry development initiatives.

4.10.4.2 Workforce

Employment was examined regarding what types of labor categories respondents’ M&S employees fit into, and also which labor categories they experienced any M&S employee difficulty in recruitment and retention. Responses about QOL factors negatively impacting workforce recruitment and employee retention in the Southwestern Virginia Region are detailed in Table 4-125.

Table 4-125: Southwestern Virginia QOL Factors Affecting Employment

QOL Factor	# of Responses	% of Responses
Limited K-12 educational opportunities	2	67%
Limited Health Care access	1	33%
Limited recreational opportunities	2	67%
Affordable housing	1	33%
Transportation	1	33%
None	0	0%
Survey Respondents	3	100%

No labor category data was provided by Southwestern Virginia Region survey respondents, so even though QOL issues were cited as affecting employee recruitment and retention, there is no information available regarding which labor categories are difficult to obtain and keep.

Table 4-126: Labor Categories, Employed or Difficult to Recruit or Retain, Southwestern Virginia Region

Labor Category	Employ	Difficult
NO DATA AVAILABLE	-	-

4.10.4.3 Networking

According to study participants, this region lacks any M&S community or networking. There is an existing healthcare business network, evidenced by survey respondents. There is no flagship university or other organization that could serve as an M&S network hub. The region needs an organization to step forward and begin to network for M&S growth.

One survey respondent reported participating in regional networking activities **2-4 TIMES** during the past year, and another reported participating **5-10 TIMES**. One respondent reported seeking assistance from a regional network **2-4 TIMES** during the past year. (**THIS TEXT** indicates a survey response choice.)

4.10.4.4 Collaboration

Collaboration is ongoing, with business-university working relationships existing with GMU, VMASC, ODU, GWU-Ashburn, Virginia Tech and Virginia.

4.10.5 Regional Opportunities

Clean energy investment is seen as a potential avenue, but the grant money available to promote the industry is contracting. Candidate products for commercialization include the a mobile simulation center, as identified in the IP inventory.

4.10.6 Proposed Actions and Investments

Study participants proposed the implementation of an M&S awareness initiative to grow the M&S industry in this region. Other recommended actions included:

- Facilitating discussion between the co-located National Center for Manufacturing Sciences (NCMS)/GMU and Grid Cell, to begin to energize the workforce and local industry. NCMS' 2nd Grid Cell has been established in partnership with George Mason

University in Fairfax and is (as reported by study participants) eager to expand its partnership with the Commonwealth.

- Implement Commonwealth policies that help to offset the costs of training current employees and leveraging student workers into M&S areas.
- Provide grant funding opportunities for expansion of simulation offerings.

5 Conclusions and Recommendations

MYMIC, LLC (MYMIC) and The ASTA Group, LCC (ASTA) are pleased to submit this report to the Commonwealth of Virginia (the Commonwealth) in fulfillment of contract number Request For Proposal (RFP) RFP-127-1-23-13, for the *Analysis of Modeling & Simulation in Virginia*. MYMIC has teamed with ASTA to perform this work. MYMIC and ASTA are referred to as the TEAM in this report.

This study provides the Commonwealth and its stakeholders with a state-wide and regional analyses of the M&S business sector in Virginia. Comprehensive data, analytic findings, and recommendations have been detailed throughout this report in the hopes that they will serve to inform future growth of M&S.

The Commonwealth's current M&S industry is comprised of commercial businesses, universities, defense agencies, and labs/research organizations. Four hundred and forty-nine M&S assets were identified across Virginia, including 325 businesses, 59 lab/research organizations, 41 educational organizations, 19 healthcare organizations (including both provider and training organizations), and 5 DoD organizations. Asset composition varied significantly by region, attesting to the breadth of M&S applications, products and services. M&S industry promotion and growth initiatives will likewise be multi-faceted and diverse in nature to address needs of this broad range of stakeholders.

A wealth of data was provided by 102 survey responses (a twenty percent response rate) and 68 focus group participants. Every region has been represented in the data. At least one focus group was held in each region, and at least two survey responses were provided for each region. Valid data input was inventoried and analyzed at both the Commonwealth (state-wide) and ten regional divisions. Information from the survey and focus groups was used to build the intellectual property (IP) inventory (Attachments 3).

Collaboration from study participants in the form of survey input and focus groups enabled the compilation of this information. Key findings resulting from the triangulation of the meta-analysis, survey and focus group data include the following:

- The recent emphasis on STEM education has improved the student pipeline (according to current study data) into technical education.
- Broadband infrastructure coverage has shown significant improvement but stakeholders would like it to continue to improve. They see this as key to M&S
- There remains a need to diversify and expand the M&S marketplace.
- An effective message to promote Virginia's M&S industry is needed.
- The facilitation of regional partnerships and M&S networking is vital for growth.
- There is a need for a consistent definition for the M&S Industry and a consistent set of labor and industry codes that can be used to inform subsequent M&S analysis, in order to plan for and track growth.
- There is a call for the creation of standards, accreditation, and certification for M&S tools.
- A de-emphasize of "big business – big customer" in business models is recommended.
- Stakeholders need better access to venture capital.
- Stakeholders want reachable M&S leadership, and a multi-disciplinary, multi-industry forum that appeals to many producers and consumers.

In the future, study participants predict that the M&S will require greater support of:

- Subject matter experts
- Network engineers
- Network analysts
- Software and gaming/simulation programmers
- Information assurance specialists
- Quality control specialists
- Support technicians

To meet future M&S workforce demands, study participants report that educational improvement and focus needs to be on:

- Advanced physics
- Current computer technology
- Engineering
- Math and specific technical science capabilities
- Stronger math and science education to understand models

5.1 Summary

The bright future of continued growth for the Commonwealth's M&S industry depends on a successful transition from the historic DoD focus roots to one that can meet the demands of a diverse marketplace. This transition will require a business model reorientation for some businesses and a continued stream of skilled M&S workers for all businesses. Increased collaboration among Virginia's M&S assets should leverage strengths across the Commonwealth and promote economic growth in each region. The TEAM has identified these strengths in this report.

Although the growth environment is favorable for much of Virginia, there are common obstacles across regions, particularly in rural or semi-rural regions. The availability of a technical workforce is a catch-22 for these regions – the local labor force may be sufficient for current needs, but growth is dependent upon a more extensive workforce. However, that workforce is not likely to be available without the business opportunity growth in M&S products and services to support it. Limited networking and lack of partnership opportunities were routinely cited as significant obstacles to growth, particularly when collaboration with local universities is limited.

Follow-on study of regional M&S strengths could produce an economic development plan. This plan would identify the right mix of areas the COV should focus on in the regions, so that strengths are leveraged and regional M&S activity is complementary, limiting competition with one another while promoting growth among the regions and for the Commonwealth as a whole. Following that, and along the same lines, an educational plan could be developed for M&S professionals by regions to complement each other, limit program duplication, and strengthen Commonwealth workforce development as a whole.

Comprehensive data, analytic findings, and recommendations were used in drafting a Strategic Plan (Attachment 1) to accelerate the growth of the Modeling, Simulation & Visualization cluster. The Strategic Plan identifies and guides the implementation of specific strategic goals, objectives, and steps to leverage existing M&S and promote growth and expansion of the M&S industry.

Table 5-1 summarizes study findings by each issue investigated for this report.

Table 5-1: Summary of Study Findings by SO2 Issues and Sub-Issues

Study Issues and Sub-Issues	Study Findings
Issue 1: What is the Current Marketplace for the Virginia M&S Industry?	Government, Defense, Aerospace Aviation, Engineering, Health/Medical and Education/ Training
Sub-issue 1.1: What capabilities for M&S development, production and research are present in the Commonwealth?	325 commercial business 59 labs/research – university 41 university/education 19 health care – business/DoD/university 6 DoD.
Sub-issue 1.2: What commercially accepted M&S products are available from Virginia sources? (IP)	Seventy-nine unique intellectual property items were identified via the Regional Business Survey and previously published reports. These include 21 Trademarks, eight Copyrights, and eight Patents, and 42 other items that were not categorized by the source.
Sub-issue 1.3: What are key markets represented by current customers of capabilities and/or products available within the Commonwealth?	Government, Defense, Education/Training, Aerospace Aviation, Health Medical, Engineering, Transportation, Energy, Medical Technology, Cyber
Sub-issue 1.4: What current business environment factors restrict growth?	<ul style="list-style-type: none"> • Access to venture capital; • Attracting new businesses (organic and relocated, both those who are potential customers for M&S and suppliers of M&S); • Technical workforce availability in non-urban areas; • Limited Academia-Industry collaboration; and • Obstacles to commercialization.
Issue 2: What are the opportunity markets for the VA M&S Industry?	Emergency Disaster, Utilities, Health Wellness, Logistics, Strategy Policy Planning, Security, Environment, Agriculture, Automotive, Architecture, Natural Resources, Data Infometrics
Sub-issue 2.1: What M&S consumer market segments are under served by current M&S products and services?	Primarily Emergency Disaster, Utilities, Health Wellness, Agriculture, Natural Resources, Medical Technology, Logistics, Strategy Policy Planning, Architecture
Sub-issue 2.2: What customer needs are M&S products or services not meeting?	<ul style="list-style-type: none"> • Cost – cost of services and products that meet requirements are high; • Flexibility – customers would like products that are adaptable to more than one project or requirement.
Sub-issue 2.3: What Virginia academic institution research products could be commercialized?	Fifty products (Intellectual Property or other products that could be commercialized) were identified among Virginia college and university assets.
Issue 3.0: What strategic actions should be made by the Commonwealth to meet Opportunities?	<ul style="list-style-type: none"> • Promote transition from government/defense to more commercial markets; • Support in development of vocational specialties needed for future opportunities – subject matter experts, network engineers and analysts, software and gaming/simulation programmers, information assurance specialist, quality control specialist, support technicians; • Focus educational improvement – advanced physics, current computer

	technology, engineering, mathematics and technical science (understand models)
Sub-issue 3.1: Should the Commonwealth expend more effort and/or funding into M&S industrial development?	<ul style="list-style-type: none"> • Attract new businesses to Virginia such as tax incentives, particularly potential customers, suppliers, and second and third tier manufacturing enterprises; • Support research and development through funding technology incubators and/or accelerators, commercialization support, and capital investments in virtual and field labs; • Improve access to high performance computing and data centers.
Sub-issue 3.2: What actions could the Commonwealth take to meet workforce requirements?	<ul style="list-style-type: none"> • Continued build-up of the workforce pipeline and focused regional economic development; • Invest in education at all levels from K-12 through technical colleges and universities; • Attract new businesses particularly in non-urban regions.
Sub-issue 3.3: What actions could the Commonwealth take to promote the use of M&S?	<ul style="list-style-type: none"> • Educate users and the public about model and simulation capabilities; • Advocate the use of modeling and simulation; • Facilitate inclusion in regulations the use of modeling and simulation for addressing safety issues; • Market Virginia as a whole, not just Hampton Roads, as a national hub for modeling and simulation.
Sub-issue 3.4: What actions could the Commonwealth take to overcome obstacles to growth?	<ul style="list-style-type: none"> • Provide for locally-based, accessible M&S leadership. • Apply equal emphasis on M&S capabilities and opportunities available across all of Commonwealth regions. • Lead by example using modeling and simulation in own projects where possible. • Facilitate academia-industry collaboration and effective regional networks and partnerships. • Provide access to venture capital to enable business start-up and innovation. • Provide tax incentives to attract new businesses and their material suppliers to Virginia.

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7 Appendix A – Region / County / City Alignment

Charlottesville Region

- Albemarle County
- Charlottesville City
- Culpeper County
- Fluvanna County
- Greene County
- Louisa County
- Madison County
- Nelson County
- Orange County

Fredericksburg Region

- Caroline County
- Fredericksburg City
- King George County
- Spotsylvania County
- Stafford County

Hampton Roads Region

- Chesapeake City
- Franklin City
- Gloucester County
- Hampton City
- Isle of Wight County
- James City
- James City County
- Newport News City
- Norfolk City
- Poquoson City
- Portsmouth City
- Southampton County
- Suffolk City
- Surry County
- Virginia Beach City
- Williamsburg City
- York County

Northern Virginia Region

- Alexandria City
- Arlington County
- Fairfax City
- Fairfax County
- Falls Church City
- Fauquier County
- Loudoun County
- Manassas City
- Manassas Park City
- Prince William County

Region 2000 Region

- Amherst County
- Appomattox County
- Bedford City
- Bedford County
- Campbell County
- Lynchburg City

Roanoke-Blacksburg Region

- Alleghany County
- Botetourt County
- Craig County
- Floyd County
- Giles County
- Montgomery County
- Pulaski County
- Radford City
- Roanoke City
- Roanoke County
- Salem City

Richmond Region

- Accomack County
- Amelia County
- Brunswick County
- Buckingham County
- Charles City
- Charles City County
- Charlotte County
- Chesterfield County
- Colonial Heights City
- Cumberland County
- Dinwiddie County
- Emporia City
- Essex County
- Goochland County
- Greenville County
- Hanover County
- Henrico County
- Hopewell City
- King and Queen County
- King William County
- Lancaster County
- Lunenburg County
- Mathews County
- Middlesex County
- New Kent County
- Northampton County
- Northumberland County
- Nottoway County
- Petersburg City
- Powhatan County
- Prince Edward County
- Prince George County
- Richmond City
- Richmond County
- Sussex County
- Westmoreland County

Southern Piedmont Region

- Danville City
- Franklin County
- Halifax County
- Henry County
- Martinsville City
- Mecklenburg County
- Patrick County
- Pittsylvania County

Shenandoah Valley Region

- Augusta County
- Bath County
- Buena Vista City
- Clarke County
- Frederick County
- Harrisonburg City
- Highland County
- Page County
- Rappahannock County
- Rockbridge County
- Rockingham County
- Shenandoah County
- Staunton City
- Warren County
- Waynesboro City
- Winchester City

Southwest Virginia Region

- Bland County
- Bristol City
- Buchanan County
- Carroll County
- Dickenson County
- Galax City
- Grayson County
- Lee County
- Norton City
- Russell County
- Scott County
- Smyth County
- Tazewell County
- Washington County
- Wise County
- Wythe County

8 Appendix B – Key Participating Organizations

The study thanks the following organizations for their participation in the focus groups and/or regional business survey.

- Advanced Training & Learning Technology, LLC
- Aerospace Corporation
- Alion Science and Technology
- AMSEC, LLC
- ArtisTech, Inc.
- Autodesk, Inc.
- AVID, LLC
- Avineon, Inc.
- Base Closure Partners, LLC
- Bihrl Applied Research Inc.
- Broad Axe Technology Partners
- CAE
- Capstone Corporation
- Carney Inc.
- Center for Advanced Engineering & Research (CAER)
- City of Hampton
- City of Virginia Beach Department of Economic Development
- Clearedge3D, Inc.
- Cole Engineering Services Incorporated
- College of William & Mary
- College of William & Mary - Virginia Institute of Marine Science
- Commander Operational Test and Evaluation Force
- Commonwealth Center for Advanced Logistics Systems (CCALS)
- Craig Technologies Inc.
- Deloitte Consulting LLP
- Designed Material Technologies LLC
- Eastern Virginia Medical School
- Engineering & Computer Simulations, Inc.
- Florida Institute of Technology
- George Mason University
- Georgia Tech Research Institute
- Halifax Industrial Development Authority
- Hampton Roads Military and Federal Facilities Alliance
- Hampton Roads Partnership
- Huntington Ingalls Industries - Newport News Shipbuilding
- Innovative Decisions, Inc.
- Interactive, Inc.
- IssueTrak, Inc
- James Madison University - College of Integrated Science and Engineering
- Joint Staff
- KaDSci, LLC
- Kaufman & Canoles Consulting
- KSI Video
- Liberty University, Center for Academic Support and Advising Services
- Liberty University, School of Engineering and Computational Studies
- Lisa Jean Bair Analytics
- LMI
- Lockheed Martin Center for Innovation
- Lockheed Martin Corporation
- Longwood University - Clinical Simulation Learning Center
- Longwood University - College of Education and Human Services
- Longwood University - Longwood Logistics Center
- Longwood University - Marketing and Information Systems
- Loyola Enterprises Inc.

- MITRE Corporation
- NASA Langley Research Center
- National Center for Manufacturing Sciences
- National Tire Research Center (VTT, LLC)
- Naval Surface Warfare Center Dahlgren
- Newport News Shipbuilding
- nHance Technologies, Inc.
- Norfolk State University
- Northrop Grumman Corporation
- NVIS, inc.
- Old Dominion University - Modeling, Simulation and Visualization Engineering Department
- Old Dominion University - Virginia Modeling, Analysis and Simulation Center
- On Course Solutions, LLC
- ProModel Corporation
- QinetiQ
- Reed Integration, Inc.
- Region 2000 Technology Council
- Richmond Technology Council
- Riverstone Energy Center
- Science & Technology Corp (STC)
- Science Applications International Corporation
- Shenandoah Valley Partnership
- Shenandoah Valley Technology Council
- SHINE Systems & Technologies
- SimIS Inc
- SimVentions Inc.
- Society for Simulation in Healthcare
- Southern Virginia Higher Education Center
- Steve Husak & Associates
- SWCC - Southwest Virginia Community College
- Tapestry Solutions
- Tatitlek Corporation
- Taurus teleSYS Inc
- Technology Commercialization Center
- Technology Venture Consulting
- The DDL Group
- The Epsilon Group Virginia, An Alere Company
- Thomas Jefferson National Accelerator Facility (Jefferson Lab)
- Thomas Nelson Community College
- TRAX International
- TREC, Inc.
- University of Mary Washington - Center for Spatial Analysis and Research
- University of Richmond
- University of Virginia - Applied Research Institute
- University of Virginia - Systems and Information Engineering
- URS
- US Army - Logistics Exercise and Simulation Directorate, National Simulation Center, U.S. Army
- US Army Training and Doctrine Command, Army Capabilities Integration Center
- US Army Training Brain Operations Center
- US Navy - NSW CDD CDSA DAM NECK, VA
- US Navy - Operational Test & Evaluation Force (US Navy)
- USMC - Marine Corps Systems Command
- Vectrona
- Vertex Solutions, Inc d/b/a Adayana Government Group
- ViGYAN, Inc
- Virginia Coalfield Economic Development Authority
- Virginia Commercial Space Flight Authority
- Virginia Commonwealth University

- Virginia Commonwealth University
Medical Center
- Virginia Commonwealth University
School of Allied Health Professions
- Virginia Economic Development
Partnership
- Virginia Small Business Financing
Authority
- Virginia State University
- Virginia Tech
- Virginia Tech - Center for
Geospatial IT
- Virginia Tech - Department of
Industrial and Systems Engineering
- Virginia Tech - Transportation
Research Center
- Vitech Corporation
- W. M. Jordan Company
- Wegmann USA, Inc

9 Appendix C – Focus Group Consent Form

Modeling & Simulation in Virginia Focus Group Information and Consent Form

Thank you for agreeing to participate in this focus group. This focus group is being conducted to inform a comprehensive study, the *Analysis of Modeling & Simulation in Virginia*. This study is being conducted on behalf of the Commonwealth of Virginia (COV) by Mymic, LLC and The ASTA Group, LLC (the Study Team).

The purpose of this study is to perform a comprehensive analysis of modeling and simulation in Virginia, and produce information and recommendations that will assist the COV in accelerating growth of the Modeling, Simulation & Visualization cluster. The focus group is expected to last 90 minutes. Topics discussed will focus on issues pertaining to conducting and growing Modeling and Simulation (M&S) business within the Commonwealth.

Data collected during this focus group and any included in the study will be non-attribution data. No comments or other aspect of the discussion will be attributed to specific individuals when findings are reported to the COV. Specific quotes, to illustrate the narrative, may be included in study reports – such quotes will not be attributed to a specific individual.

The Study Team does not expect you to benefit personally from your participation in this focus group. The Study Team does not expect any risk to you for your participation in the focus group. In line with these expectations, please read and agree to the following information and check and sign to indicate concurrence with the points below.

1. You, as the participant, agree to conform to the non-attribution nature of the discussion. It is expected that you, as a participant, will want to share your experience with colleagues; however, please respect the other participants by agreeing to not identify specific individuals with comments, discussion points, etc. during future discussions.
2. The study team would like to audio record the focus group, to ensure all data is captured and to facilitate subsequent analyses. This recording will only be available to the Study Team members present at this group, and will be destroyed following analysis.
3. It is customary to include participant lists in reports presenting focus group findings. Your name will only be listed as a participant—no specific comments or information will be attributed to your name.

- 1 I have read this form and agree to abide with non-attribution.
- 2 I agree that this focus group may be recorded, and consent to the recording.
- 3 I agree that my name may be included in participant lists reported to COV.

Printed Name

Date

I agree to participate in this focus group according to the conditions specified above. (Signature)

10 Appendix D – SO2 Framework and Questions

The TEAM derived a list of objectives, issues and sub-issues to drive study data collection, all analyses, and findings using the SO2 process. This list was developed through stakeholder input and vetted by the customer. This list became the framework which drove question formulation for the meta-analysis and focus groups. Questions were refined based on information from the meta-analysis and focus groups, and used to conduct the online survey. The complete SO2 framework, presented in, specifies the included study objectives (O), issues (I), and sub-issues (S), and the questions (Q) derived from them.

Table 10-1: SO2 Framework Including Questions

Type	ID	Text
O	0	Conduct analyses and identify actions to grow & evolve the M&S Industry in the Commonwealth
I	1.0	What is the Current Marketplace for the Virginia M&S Industry?
S	1.1	What capabilities for M&S development, production and research are present in the COV?
Q	1.1.1	What are the current assets?
Q	1.1.1.1	What is the name of your organization?
Q	1.1.1.2	What is your department or division within the organization?
Q	1.1.1.3	What is your job title?
Q	1.1.1.4	What is your office zip code?
Q	1.1.1.5	How many employees does your organization currently employ?
Q	1.1.1.6	What is your organization's annual revenue (estimate, past year)?
Q	1.1.1.7	How is your organization classified?
Q	1.1.1.8	How would you categorize your organization?
Q	1.1.1.9	What are the primary NAICS codes your organization to conduct M&S work?
Q	1.1.2	What is being produced?
Q	1.1.2.1	What types of M&S products does your organization sell?
Q	1.1.2.2	What types of M&S services does your organization sell?
Q	1.1.2.3	What proportion of your annual budget is devoted to the production of M&S-related products or services?
Q	1.1.3	What is being researched?
Q	1.1.3.1	What types of M&S-related research does your organization conduct?
Q	1.1.3.2	What proportion of your annual budget is devoted to M&S-related research?
Q	1.1.4	What is being trained?
Q	1.1.4.1	What areas of formal M&S-related training or teaching does your organization conduct?
Q	1.1.4.2	What proportion of your annual budget is devoted to formal M&S-related training?
Q	1.1.4.3	What M&S areas are being formally trained?
Q	1.1.4.4	What are the degree programs offered in the COV?
Q	1.1.5	What are asset workforce resources?
Q	1.1.5.1	What is the M&S employed work force?

Type	ID	Text
Q	1.1.5.2	What proportion of your organization's employees engage directly in M&S-related work (e.g., production, research, training)?
Q	1.1.5.3	Which primary occupations/labor categories do your employees fit in that produce your M&S-related product(s)/service(s)?
Q	1.1.5.4	How many M&S skilled employees has your organization hired in the past 12 months?
Q	1.1.5.5	Which (if any) M&S-related occupations/labor cats (or skill-sets) are difficult for your organization to recruit?
Q	1.1.5.6	How does your organization mitigate "hard to find" job candidates?
Q	1.1.6	What are assets' other resources?
Q	1.1.6.1	What is the approximate value of your organization's real estate holdings in Virginia? (Commercial Business Only)
Q	1.1.7	What are the vendors and suppliers?
Q	1.1.7.1	What types of industries/markets supply your production of M&S products?
Q	1.1.7.2	What industries/markets supply your org/firm with M&S service(s)?
Q	1.1.7.3	Where are key supplies/vendors located?
S	1.2	What commercially accepted M&S products are available from Virginia sources? (IP)
Q	1.2.1	What is the Intellectual Property (IP)?
Q	1.2.1.1	What Trademarks does your organization own?
Q	1.2.1.2	What Copyrights does your organization own?
Q	1.2.1.3	What Patents does your organization own?
S	1.3	What are key markets represented by current customers of capabilities and/or products available within the COV?
Q	1.3.1	Who are the current customers?
Q	1.3.2	What markets are represented by your current customers?
Q	1.3.2.1	What are current market \$ resources?
Q	1.3.2.2	How much \$\$ does M&S generate?
Q	1.3.2.3	What percentage of your business's revenue is generated by sales of M&S products and/or services?
S	1.4	What current business environment factors restrict growth?
Q	1.4.1	What regulations/laws inhibit growth?
Q	1.4.2	What Public policies inhibit growth?
Q	1.4.3	What Zoning practices inhibit growth?
Q	1.4.4	What infrastructure factors inhibit growth?
Q	1.4.5	What are issues pertaining to Workforce recruitment and/or retention?
Q	1.4.5.1	What factors affect your organization's ability to recruit employees with sufficient M&S-related skills?
Q	1.4.5.2	What factors affect your organization's ability to retain employees with sufficient M&S-related skills?
Q	1.4.5.3	What aspects of your region's Quality of Life may negatively impact workforce availability?
Q	1.4.6	How effective are regional business networks?

Type	ID	Text
Q	1.4.6.1	What regional networks or partnerships does your organization collaborate with for M&S-related business?
Q	1.4.6.2	What Regional Partnerships does your business belong to?
Q	1.4.6.3	How often, in the past year, has your organization been represented in Regional Partnership activities?
Q	1.4.6.4	How often, in the past year, did your organization seek assistance or information from your Regional Partnership?
Q	1.4.6.4.1	What type of assistance/information did your organization seek?
Q	1.4.6.4.2	How helpful was the assistance/information?
Q	1.4.6.5	Do you use your region's brand/logo or other mark of origination when marketing/packaging your products/services?
Q	1.4.6.6	In your experience, do other market areas recognize your region as a significant force in M&S?
Q	1.4.6.7	How does your region support your M&S business efforts?
Q	1.4.6.8	What more could be done regionally to promote your M&S business, products, or capabilities?
I	2.0	What are the opportunity markets for the VA M&S Industry?
S	2.1	What M&S consumer market segments are under served by current M&S products and services?
Q	2.1.1	What are opportunity market requirements?
Q	2.1.1.1	In your opinion, what untapped markets would benefit from M&S?
Q	2.1.1.2	What type of workforce requirements or capabilities do you foresee for the future?
Q	2.1.1.3	What types of products / services would benefit opportunity markets?
Q	2.1.1.4	What is the primary obstacle your organization faces in regards to expanding your M&S business into new markets?
Q	2.1.2	What are opportunity market \$ resources?
Q	2.1.2.1	What is the estimated value of untapped markets?
Q	2.1.2.2	What is the estimated value of projected growth markets?
Q	2.1.3	What are example customers within these markets?
S	2.2	What customer needs are M&S products or services not meeting?
Q	2.2.1	What types of M&S products do you purchase/use?
Q	2.2.2	In what ways have those products been insufficient?
Q	2.2.3	What other types of M&S products would be valuable to you in your work?
Q	2.2.4	What types of issues have you encountered getting M&S products?
S	2.3	What Virginia academic institution research products could be commercialized?
Q	2.3.1	What products has your organization developed that could be commercialized?
Q	2.3.2	What are existing academic-business relationships?
Q	2.3.2.1	What university or research organizations do you have a working relationship with?
Q	2.3.2.2	What businesses/companies does your organization have a working relationship with?
Q	2.3.3	What are commercialization obstacles?

Type	ID	Text
Q	2.3.3.1	What obstacles has your organization encountered bringing new products or services to market?
I	3.0	What strategic actions should be made by the Commonwealth to meet Opportunities?
S	3.1	Should the Commonwealth expend more effort and/or funding into M&S industrial development?
Q	3.1.1	What investments should the Commonwealth make to growth M&S business?
Q	3.1.1.1	What should be researched to close any gaps or solve issues with producing/selling M&S products and services?
Q	3.1.2	What investments should be Commonwealth priorities?
S	3.2	What actions could the Commonwealth take to meet workforce requirements?
Q	3.2.1	What workforce gaps are there?
Q	3.2.1.1	What M&S training/degree topics need to be implemented and focused on to solve your workforce issues today?
Q	3.2.1.2	Are there notable differences and interfaces between regional academic offerings and the pathways they offer for pursuing degrees and careers in M&S?
Q	3.2.1.3	What other Commonwealth or regional actions would meet changing M&S workforce needs?
S	3.3	What actions could the Commonwealth take to promote the use of M&S?
Q	3.3.1	What past/current Commonwealth actions have been effective promoting M&S?
Q	3.3.2	In what areas have Commonwealth M&S promotion actions been lacking?
Q	3.3.3	What actions could the Commonwealth take to further promote M&S?
S	3.4	What actions could the Commonwealth take to overcome obstacles to growth?
Q	3.4.1	What are strategies to overcome obstacles?
Q	3.4.1.1	What policy / regulatory actions could be done by the Commonwealth to encourage M&S business growth?
Q	3.4.1.2	What infrastructure-related actions could be done by the Commonwealth to reduce or eliminate obstacles to growth?
Q	3.4.1.3	What other actions could be done by the Commonwealth to reduce or eliminate obstacles to growth?