

Modeling, Simulation & Visualization Economic Impact and Cluster Analysis Study for Hampton Roads Virginia

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MS&V Economic Impact and Cluster Analysis Study

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EXECUTIVE SUMMARY

ANGLE Technology was selected by Old Dominion University Research Foundation, under the sponsorship of the Hampton Roads Planning District Commission, to conduct an economic impact survey and cluster model analysis into the computational modeling, simulation and visualization (MS&V) activity within the Hampton Roads region of Southeastern Virginia.

The economic impact data collected by ANGLE was input into the Regional Economic Models, Inc. (REMI) software, by the Hampton Roads Planning District Commission. Additionally, a cluster model, showing the inter-related network of organizations supporting MS&V, within the Hampton Roads region, was developed by ANGLE to describe the scope of MS&V activity and provided a framework for the impact assessment.

The MS&V definition, as defined in Appendix I, provided the underlying basis for the analysis. The overall intent of the study was to capture those companies and organizations primarily focused on and using MS&V, as defined in Appendix I, within Hampton Roads. Therefore, a conservative methodology was used to conduct the study that excluded MS&V activity associated with existing engineering analysis, product design and development.

KEY FINDINGS:

- The MS&V cluster contributed \$413 million annually to the region's output in 2004. This is projected to increase to \$764 million in 2009. The largest share of this increase will occur within the service sector.
- The MS&V cluster accounted for \$248 million in gross regional product (GRP) in 2004. This is projected to increase to \$482 million in 2009. GRP is the impact on gross regional product, or the net impact on the regional economy, after the removal of production costs from regional sales.
- The MS&V cluster generates slightly over four thousand (4,000) jobs in Hampton Roads each year. This is projected to increase to nearly seven thousand (7,000) new jobs in 2009.
- The largest fraction of the cluster generated jobs, twenty-seven hundred (2,700), are in the service sector. Other sectors experiencing a significant increase in employment include retail trade (628 jobs), construction (289 jobs) and finance, insurance, and real estate (134 jobs).
- The MS&V cluster contributed to a regional increase in population of 765 people in 2004. This is projected to increase to over 4,300 people in 2009.

KEY OBSERVATIONS:

- MS&V provides a significant contribution to the regional economy.
- Significant growth is projected across all reported impact measures.
- Potential exists to capture more defense activity and to diversify into other regional commercial markets over the next five (5) years.
- Challenges for the MS&V cluster include workforce training and development issues and the local availability of specialized MS&V training.
- There is a need to foster the participation of Small and Medium Size Enterprises (SME) across the overall MS&V cluster. Presently, they support specialized niches, i.e. focused on specific agencies such as NASA, etc.
- Proactive engagement and additional networking forums are needed to fully develop the cluster.
- Much of the current regional MS&V activity is a by-product of the requirements generated by the Joint Training, Analysis and Simulation Center (JTASC).
- JTASC was the catalyst that helped launch additional MS&V organizations that further leveraged the JTASC capabilities. Concurrently, the Joint Forces focus of the current MS&V activity tends to channel MS&V activity to key DoD organizations and contractors.
- There are significant growth opportunities in the areas of Joint Training, Experimentation and DoD Transformation, Homeland Defense, Intelligence, Medical M&S, and Environmental/Remote Sensing activities both within the US and worldwide.
- There is an opportunity for the Hampton Roads region to capture more of the M&S dollars that presently flow to other primary MS&V research areas such as Orlando, FL, & Huntsville, AL, as well as to other national laboratories and universities with similar and perhaps better established research capabilities.
- Development of new MS&V capabilities may require investment in the establishment of “Centers of Excellence” in emerging areas such as Homeland Security. Such an initiative will require a coordinated regional effort, at both the State and Federal levels, to be successful.

INTRODUCTION

The primary objective of the economic impact study was to assess the overall economic impact of activity related to computational modeling, simulation and visualization (MS&V) within the Hampton Roads region of southeastern Virginia. This investigation was intended to describe the scope of MS&V activity within the Hampton Roads region, and concurrently, to provide a framework within which the impact assessment can be undertaken.

The multiple purposes of this investigation were to:

- ♦ Assess the direct and indirect economic impact of MS&V on the Hampton Roads region.
- ♦ Develop and populate a MS&V mapping framework to show linkages between the key MS&V functions/groups and the pertinent vertical industries.
- ♦ Provide a framework within which the roles of different participants in the regional MS&V cluster can be identified and correlated.
- ♦ Identify future MS&V growth potential and opportunities for Hampton Roads region.

Modeling, simulation and visualization, as an enabling technology, has grown dramatically in the past seven years. The Virginia Modeling, Analysis and Simulation Center (VMASC) in Suffolk, Virginia, is reflective of that growth. From inception, in 1997, VMASC has grown from zero annual revenue to more than \$10M in annual revenue in calendar year 2004. Concurrent with VMASC's growth has been equally impressive growth within the MS&V industry and within DoD.

However, the depth and breadth of this regional growth has never been surveyed or analyzed. Therefore, VMASC, its industry partners, and the regional economic development community jointly initiated this analytical research study to determine and measure the economic impact of MS&V, within the Hampton Roads Region; define and analyze the depth and breadth of the regional MS&V industry/DoD cluster, and to forecast future MS&V trends and future demand.

This research study documents the growth of MS&V as an economic development engine within the region. It investigates all MS&V activities, including those companies, agencies and organizations that develop MS&V, provide MS&V services and support activities, or are MS&V end-users. The analysis assesses the impact of the primary job titles that work in or support MS&V functions, and links them across the regional military, industry and government sectors.

Study results provide the necessary information to create a comprehensive understanding of the depth of the infrastructure that supports the regional MS&V activity and will serve to establish MS&V as a significant regional economic cluster within

Hampton Roads. Additionally, the study identifies potential growth opportunities for MS&V within Hampton Roads.

In order to assist in the development of the study, a stakeholder-working group was convened, under the facilitation of VMASC , comprised of representatives from key regional companies and economic development organizations. The participants in this stakeholders working group are listed in Appendix II.

ECONOMIC ANALYSIS

The Hampton Roads Planning District Commission input the results of the survey conducted by ANGLE Technology, Inc., during the fall of 2004, into the REMI software model using the “employment mode.”

The REMI model is widely known for its ability to simulate changes to a regional economy dynamically, or for each of several years over a period of time. This investigation focused on the impact of M&S for 2004 and 2009. The 5-year average annual job growth rate was used in the REMI model to forecast the economic impacts in 2009.

Impact estimates for existing industries and companies are generally estimated by the use of a “counter factual” analysis. This sort of analysis is done by assuming that the industry or company is leaving the area so that all inputs are entered into REMI as negative values. The resulting simulation shows the regional economy with a “hole” in it left by the removal of the enterprise from the region.

The counter factual method was used in this study to generate the resultant impact. While the results appear in REMI as negative values (since negative values were entered into the model), they are shown in this report as positives, since the cluster produces positive economic impacts on the region.

The aggregated wage and employment data collected by the survey was allocated to three sectors, engineering and architectural services; research and testing; and computer and data processing services. The Hampton Roads Planning District Commission selected these sectors as the most appropriate for MS&V activities. The allocation of employment data, across the sectors, was estimated using the labor functional distribution for each organization.

However, in some specific instances, such as with the National Aeronautics and Space Agency (NASA), the activity focus of the organization, and/or specific group, was given greater weight in the allocation. Additionally, the wages/employment data was segregated by geography, i.e., Peninsula area and South Hampton Roads area.

The Peninsula area includes the cities of Hampton and Newport News, Poquoson, York County, Gloucester County, James City County and Williamsburg. South Hampton Roads area includes the cities of Norfolk, Portsmouth, Suffolk, and Virginia Beach, Isle of Wight County, Franklin, Surry County and Southampton County.

The final allocation of wages/employment data by sector and geography is provided in Appendix II.

Finally, it was also necessary, in a few cases to adjust the wage data to more closely match the peer data when “unburdened” data was not available. Concurrently, the HRPDC adjusted the unburdened data to include “benefits,” which was required to run the REMI model in the “employment” mode.

ECONOMIC IMPACTS

The REMI software estimates a wide variety of impacts and determines output by industry, gross regional product (GRP) by type, fiscal impacts on state and area local governments, employment by industry, and population.

As outlined in the following table, the Hampton Roads MS&V cluster contributed nearly \$413 million to the region’s output in 2004 and is projected to contribute \$764 million in 2009, where output can be thought of as the value of annual sales and/or production (see Table 1.). By a wide margin, the largest share of the projected increase in regional output occurs in the service sector, which is the sector containing the majority of the MS&V cluster. The MS&V cluster also produces large impacts upon the retail; finance, insurance and real estate; and construction sectors.

Perhaps more important is the impact of the MS&V cluster on gross regional product (GRP), or the net impact on the regional economy after the removal of production costs from regional sales. As outlined in the table, the cluster accounted for \$248 million in GRP in 2004 and is projected to account for \$482 million in GRP in 2009. The largest component of GRP is consumption, which is driven by the wages paid to workers in the MS&V cluster, as well as by others in the economy that owe their jobs and livelihood to the presence of the cluster.

The MS&V cluster also makes an important contribution to paying for the operations of state and local governments. The cluster is responsible for nearly \$24 million in state revenue and over \$9 million in local government revenue in 2004 and is projected to contribute \$54 million in state revenue and \$28 million in local government revenue in 2009. Even after subtracting for the projected increase in public expenditures made by state and local governments to accommodate the growth generated by the cluster, state and local governments experience a net positive fiscal impact at both levels of government.

The MS&V cluster also makes an important contribution to regional employment and overall population. The cluster currently generates slightly over four thousand (4,000) jobs within the region each year, with almost seven thousand (7,000) new jobs projected in 2009. The largest share of these new jobs will occur within the service sector, which accounts for over twenty-seven hundred (2700) current jobs due to the presence of the cluster. Other sectors experiencing a significant increase are retail

trade (628 jobs), construction (289 jobs), and finance, insurance, and real estate (134 jobs).

When an area experiences an increase in employment, an increase in population follows. This is the case for the MS&V cluster where the presence of more than 4,000 current jobs has led to an increase of 765 people in the region's population¹ in 2004, and a projected increase of over 4,300 people in 2009.

¹ This estimate is likely understated since the simulation was conducted for one year alone. Changes to population generally follow changes in employment with a lag so that conducting the simulation for just one year did not give the region's population enough time to fully adjust to the increase in economic activity created by the cluster.

**TABLE 1: The Economic Impact of Modeling and Simulation on Hampton Roads
2004 (Constant 2004 Dollars)**

	2004	2009
Output (millions of 2004\$s)		
Durable Goods Manufacturing	\$18.0	\$33.7
Non-Durable Goods Manufacturing	\$6.3	\$9.2
Mining	\$0.0	\$0.0
Construction	\$33.6	\$51.6
Transportation & Public Utilities	\$11.1	\$21.5
Finance, Insurance, and Real Estate	\$35.8	\$57.4
Retail Trade	\$34.9	\$62.3
Wholesale Trade	\$11.6	\$20.4
Services	\$260.7	\$506.0
Agriculture, Forestry, and Fishing Services	\$1.0	\$1.7
Government	NA	NA
Total	\$412.9	\$763.8
Gross Regional Product (millions of 2004\$s)		
Consumption	\$147.6	\$300.2
Fixed Investment	\$96.2	\$159.2
CBI net IVA + MISC	\$0.6	\$0.1
Government	\$3.6	\$22.3
Exports	\$204.5	\$364.9
Imports	\$204.5	\$382.0
Total	\$248.0	\$481.7
Fiscal (millions of 2004\$s)		
State Tax Revenue	\$23.8	\$53.9
State Public Expenditures	\$1.7	\$15.3
Net	\$22.0	\$38.6
Local Tax Revenue	\$9.5	\$28.4
Local Public Expenditures	\$2.4	\$17.3
Net	\$7.0	\$11.2
Employment		
Durable Goods Manufacturing	28	13
Non-Durable Goods Manufacturing	26	33
Mining	0	0
Construction	289	396
Transportation & Public Utilities	43	66
Finance, Insurance, and Real Estate	134	177
Retail Trade	628	1,004
Wholesale Trade	70	98
Services	2,729	4,737
Agriculture, Forestry, and Fishing Services	29	52
Government	47	276
Total	4,023	6,852
Population	765	4,386

Continuing the simulation for several years beyond 2004 would have produced an increase in population considerable higher than the increase shown here.

MS&V CLUSTER ANALYSIS

The concept of “clusters” has received extensive attention in economic development circles over the last two decades, and a detailed discussion and critique of the subject is beyond the scope of this study. However, as a basic concept, the idea of a cluster as an inter-related network of organizations serving a particular market is highly useful, particularly when considered in the context of industry-specific value chains. For the MS&V industry, value chains are key market functions, both vertical & horizontal (i.e. hardware vendors, software developers, database development), and assets (i.e. fiber optic networks, scientific laboratories) that are present in Hampton Roads and which create a competitive advantage and/or provide the catalyst for growth for the regional MS&V industry.

At the regional or national level, the extent to which any given component of the value chain, or the entire value chain can be captured, will be dependent on the extent and capabilities of the relevant “cluster” within the given geography. Focusing resources on the development of the appropriate supply chains and networks, which in effect constitute the cluster, can be a source of significant leverage for limited economic development resources.

It should be noted that a given company may operate at more than one point in the value chain, and some companies may be highly vertically integrated, fulfilling more than one function within the chain. Companies are often active in multiple value chains, fulfilling similar functions within each chain, but serving different markets. For example, research commercialization generally takes place within a given value chain; and for different value chains, different organizations may be involved in different steps such as invention, development and commercialization.

Fully implementing a cluster-based economic development strategy requires a detailed knowledge of the relevant value-chains within which regional companies function. The current study provides an initial analysis only of the cluster. It should be noted that to map and describe in detail all of the relevant value-chain components is a large scale exercise that needs to be maintained on an ongoing basis, with the understanding that the whole situation is dynamic, with participants entering or leaving the cluster, modifying their roles within the cluster etc., as the industry/market as a whole expands and contracts.

The required level of effort to develop and maintain a cluster can act as a deterrent to defining and understanding the dynamics of different clusters and their associated value chains, but the use of these models enables targeting of resources to specific activities that enhance the ability of a regional cluster to function within the relevant value chain. These models can also provide a means for identifying the opportunities where the greatest leverage of resources can be obtained e.g., a lack of capability in a specific part of the value chain may impair the ability of the cluster to service the value chain as a whole. This approach can also allow common needs to be identified that are applicable to multiple value chains, thereby achieving greater leverage from the deployment of resources.

Although there are clearly many market or industry-specific aspects, cluster development strategies generally incorporate one or more of the following elements:

- ◆ Seek to extend regional participation within one or more value chains to capture more of the activity of the value chain within the region.
- ◆ Improve the performance of the organizations participating in the cluster.
- ◆ Increase the number of organizations participating in the cluster.
- ◆ Develop more linkages between the participants.
- ◆ Improve the quality of the linkages between the participants.
- ◆ Create infrastructure that supports the regional participants in one or more elements of the value chain (such as research parks, incubation programs, shared facilities, etc.).
- ◆ Enhance the regional factor conditions (e.g. increasing the availability of capital and appropriate workforce skills, etc.).

These types of activities provide a valuable guide or framework within which planned economic development activities can be considered and implemented.

In this context, it is generally highly valuable for those driving economic development programs to understand, in detail, the relevant vertical markets and to undertake a clear assessment of their attractiveness and accessibility.

CLUSTER MAP

The Hampton Roads Planning District Commission developed an initial MS&V cluster mapping/linkages framework for review and consideration by the participating organizations. ANGLE Technology and the Stakeholder Working Group further refined the map/linkage framework. Key elements of the map/framework include:

- ◆ 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: IT hardware/software vendors and service providers
- ◆ Facilitators: VMASC, Academia, SMEs, Trade Associations
- ◆ Resources: Unique facilities, ODU, CC's, Retirees, IT labor force, other
- ◆ Infrastructure: Telecom, Power, Transportation, etc.

A main focus during the survey and analysis phase of the study was to further refine the different cluster tiers, including identification of the key End Users and the

Hardware/Software Vendors/IT providers in Tier 3, Enabling Technologies. The End Users and Tier 3 Enabling Technology Providers are identified by organization in Appendix VII

From the data collected by the survey, it was not possible to further delineate between Tier 1 Service Providers and Tier 2 M&S Developers. Clearly, the industry respondents, and some of the government respondents, constitute most of the Tier 1 and Tier 2 organizations.

Using the data collected, there was not sufficient information to identify which vendors and suppliers are located in Hampton Roads and which are outside the region. Identifying these vendors and suppliers is an important future action since potentially, key vendors and suppliers not located in the region could be recruited to establish a regional presence. Also, an effort was made to identify within the Cluster Map the key End Users located in the region. Other End Users, identified by the respondents, who are not located in the region, are included in the Appendices.

As a general observation, hardware vendors may have a small sales presence in the region while software vendors are typically outside the region. Also, many of the software applications are government developed and funded. However, the suppliers and contractors who provide IT support services are typically located within the region. As a result, hardware and software vendors could be selectively targeted for relocation and/or expansion within the Hampton Roads region to create additional high paying jobs.

It is also interesting to note that several organizations, including VMASC and key DoD contractors, perform at different levels within the cluster. These organizations perform a facilitating role, including potential technology transfer and networking across different vertical applications and industries. The impact of this activity is important to the cluster and helps enable it to achieve its full potential and realize emerging growth opportunities.

Clearly, the Government end users and supporting contractors/vendors are the major components of the Hampton Roads MS&V cluster. The Commercial sector is still evolving and there are excellent prospects for future growth. Some of the emerging growth areas are outlined in Section 7: Emerging Opportunities. Recommendations are offered in Section 9 to help the region realize the full potential of the MS&V cluster.

CLUSTER GAPS AND WEAKNESSES

Gaps and weaknesses and suggestions for improvement in the MS&V cluster were identified as part of the study analysis. Some of the key suggestions are outlined here. Under the scope of this survey/study, and the response detail provided, it was only possible to aggregate the gaps and suggestions and no attempt at quantitative

analysis was attempted. In addition to information received from survey respondents, the following summary includes information gleaned from the interview process.

Technology/Standards

- ◆ There is a need for a regional plug and play infrastructure that would support simulation driven training requirements for distributed participants.
- ◆ There is a need for more useable GIS databases and additional rapid database generators to support surge-training requirements.
- ◆ There is a need to foster the development of operations research practices within customer organizations to ensure the proper application of MS&V resources to meet customer business needs.
- ◆ There is a need to connect ODU, VMASC and other key Hampton Roads industry, government and academic entities to existing national high-speed university and technology computer networks.
- ◆ As the region experiences growth in the use of medical simulators for training, there is a need for standards development & validation of medical simulators.

Accreditation/Certification

- ◆ For MS&V to be recognized as a “discipline,” continued development and enhancement of formal higher-education curriculum and programs will need to occur.
- ◆ A visualization component should be integrated into existing MS&V education programs.
- ◆ A joint 3D modeling and computer graphics course should be developed to support realistic, real-time graphics modelling.
- ◆ The MS&V industry needs more certified professionals.
- ◆ MS&V courses should be introduced at the high school and community college level.
- ◆ There is a need for additional customized/specialized training to meet specific industry needs.
- ◆ The MS&V cluster needs fewer IT Network managers and more MS&V professionals with operational problem-solving experience.

Networking Opportunities

- ◆ MS&V vendors need help in marketing their unique capabilities to other vertical domain areas within the region.
- ◆ Hampton Roads has some excellent hardware development capability in small to medium businesses, but the electronic infrastructure and the

community relationships could be stronger. Cable company networks are slow and expensive for small businesses.

- ♦ The best source of technicians for MS&V is military operations personnel leaving military service. Advance identification of persons with these skills would be useful in retaining them within the regional MS&V cluster.

Other

- ♦ In the area of high performance visualization, there would be value in increasing the number of local vendors and support personnel.
- ♦ Local transportation infrastructure is a limiting factor to attracting and retaining qualified personnel for both Southside Hampton Roads and Peninsula-based companies.
- ♦ There is a need to develop R&D facilities to support private/public MS&V efforts.
- ♦ State and local government needs to make a stronger push for the integration of non-DoD activities into the regional MS&V cluster.
- ♦ There is a need to locally attract more mid-level operators and developers. Presently, mid-level analysts, engineers and architecture personnel tend to live elsewhere, because the industry has grown up elsewhere, e.g., Washington DC, Orlando, Huntsville.

EMERGING OPPORTUNITIES

A key element of the overall survey process was to identify emerging MS&V opportunities. Some of these are further discussed in the Interview Process – Section 4. The key areas identified by the respondents and interviewees are summarized here, broken out into logical M&S groupings.

Some of these observations build on current activities and programs, and some would leverage existing strengths and capabilities. Again, it was not possible under the Survey/Study scope, and on the level of detail provided in the survey responses, to develop a comprehensive quantitative analysis.

Clearly, there was significant interest in emerging Aerospace/DoD, Medical Simulation, Environment/Remote sensing, Homeland Defense, Education and other applications. The depth and breadth of the interest and the number of different domain areas, demonstrates there is significant potential to further explore and develop regional MS&V cluster activity.

Medical Simulation

- ◆ Medical MS&V, particularly as it relates to future physician training, trauma care, and mass casualty response.
- ◆ Simulation Based Training for military and civilian medical applications.
- ◆ Development of simulations to enhance a variety of current and future medical training, e.g., minimal invasive surgery.
- ◆ Development of M&S training simulators.

DOD/Aerospace

- ◆ Expanded F-22 training.
- ◆ Joint and Service Exercise Support.
- ◆ C2 Testing and Concept Analysis.
- ◆ NAVAIR Distributed Mission Training.
- ◆ Unmanned vehicle simulation development.
- ◆ Datalink simulation development.
- ◆ Air traffic simulation development.
- ◆ Multi-vehicle and environment simulation development.
- ◆ DoD- Joint and Service Experimentation, Mission Rehearsal and Training.
- ◆ Net-Centric Warfare and e-Battlefield simulation.
- ◆ Design and development of unmanned autonomous platform vehicles.
- ◆ Adding intelligence to MS&V tools.
- ◆ Human system integration.
- ◆ Synergistic opportunities between emerging sensor industry in HR and simulation industry.
- ◆ Modeling for analysis of system performance/value.
- ◆ Modernization of National Airspace System.
- ◆ Collaborative Virtual Environments and Training.

Homeland Defense/Security

- ◆ GIS centric simulation.
- ◆ Homeland Defense/Security and Counter terrorism.
- ◆ Port Security modeling and analysis.
- ◆ Disaster planning modeling and analysis.
- ◆ Transportation network M&S and decision support.

Environmental/Remote Sensing

- ◆ Environmental visualization such as visualization of ocean, water resources, agriculture, forestry, GIS system.
- ◆ Climate, weather and natural hazards modeling and simulation.
- ◆ Integration of remote sensing technologies into environmental simulation such as water resources management.
- ◆ Visualization of very large data collections from new generations of remote sensing equipment.

Urban Planning

- ◆ Urban Planning modeling and analysis.
- ◆ Modeling and Virtual Reality of proposed new buildings.
- ◆ Traffic Management modeling and analysis.

Education/Other

- ◆ Internet Education porting.
- ◆ Interactive Museum exhibits and information kiosks.
- ◆ M&S services and components in Service-Oriented Architectures.
- ◆ M&S services for Computer Grids.
- ◆ Low-cost COTS-based cluster visualization.
- ◆ Greater use of MS&V in learning situations.
- ◆ Education in Data Visualization.

SUMMARY AND CONCLUSIONS

The survey results clearly indicate that modeling, simulation and visualization activities, within the Hampton Roads region, are an important part of the economy.

Due to the conservative methodology employed in conducting the study, the overall economic impact is likely understated. The conservative methodology used eliminated any “double counting” in the wage/employment data. Also, non-relevant MS&V activities were excluded even though responses and data were provided. Relatedly and significantly, the MS&V definition, created by the stakeholders working group, did not allow for the inclusion of engineering analysis, and design and product development activities which would have significantly increased the MS&V regional economic impact.

The survey results indicate that the Hampton Roads MS&V cluster is poised for significant growth over the next five (5) years, based on near term and mid-term job growth projections. The principal driver for this growth is the increasing demand for military training and experimentation using tools that permit trainees to experience a wide variety of integrated live, virtual and constructive (LVC) training environments, at dramatically reduced costs compared with legacy in the field "live" training only.

The Hampton Roads MS&V cluster is continuing to rapidly evolve in response to market requirements. The current cluster map outlines what MS&V resources are present within the region. It may be relevant to further understand the cluster "tiers" as means to better understand the gaps and weaknesses. This may lead to activities aimed at attracting more MS&V organizations to the region to fill the identified gaps and weaknesses.

The Hampton Roads region is uniquely positioned for simulating command and control activities and applying this capability to training and experimentation activities across a wide variety of domains such as homeland security and transportation.

There seems to be ample opportunity to build on current programs and applications in the DoD, Aerospace and Communication sectors. Homeland Defense and Medical Simulation were cited as two significant areas with emerging MS&V opportunities. These are good examples where Hampton Roads could leverage already existing programs and technical strengths.

The Hampton Roads MS&V cluster has an adequate and growing supply of graduates with advanced degrees applicable to the MS&V field, a significant number of government contractors skilled in the field, and substantial and increasing demand for their skills from several military agencies. However, there is a need for expanded education opportunities at the graduate, undergraduate, community college and high school level. Concurrently, in addition to formal degreed education in MS&V, local specialized education and training courses should be developed to provide continuing education and training for the MS&V workforce.

There are opportunities to capture more of the local MS&V funding that presently leaves the region and is sent to specialized suppliers or government facilities outside the region. Doing so however, will require a concerted effort by the MS&V community to further understand why this "outsourcing" occurs, and to take appropriate actions to fill the gaps and weaknesses within the MS&V cluster, and to educate local customers to the advantages of keeping the funding within the region.

The survey participation rate by purely Commercial organization (non-DoD/Aerospace companies) was low, which validates the pre-study assessment that presently, DoD and Aerospace organizations dominate the MS&V cluster. However, some emerging opportunities were identified which could provide potential growth opportunities for more Commercial participation. Essentially, the commercial market remains an untapped market for MS&V.

RECOMMENDATIONS

The region can accelerate the growth of the MS&V cluster through implementation of the following five initiatives. Other, less compelling recommendations have been made throughout the study.

1. Increase regional MS&V networking by building on the leadership of VMASC, through its industry, government and academic members, and survey respondents, and supporting and developing the activities of the many regional economic development organizations.
2. Identify and implement a large, collaborative regional project to focus the group and develop network communications.
 - i. A proposed project was the development of a national training center for homeland security and disaster recovery. Many of the capabilities to initiate such a project are available among the stakeholders group or from other survey respondents. These include high-level contacts in the federal government, impressive training facilities, irreplaceable experience with developing communications skills between model developers and operations experts, and strong support from economic development agencies and their government sponsors.
 - ii. A second project was to study regional procurement patterns and outsourcing to identify the reasons that MS&V funding leaves the region. Such information would be of value to the MS&V cluster, and would help identify opportunities to capture and retain within the region a larger share of the funding and resultant MS&V activity.
3. Expand educational opportunities at the undergraduate, community college and high school level, as well as develop specialized training and certification courses to continually educate the existing MS&V workforce.
4. Market programs by the economic development organizations to attract more vendors & suppliers, with a goal of developing a central MS&V marketing focus and a coordinated marketing strategy that limits duplication and expands reach.

Appendix I: Hampton Roads MS&V Definition

The following statements serve to define Modeling, Simulation and Visualization (MS&V) as used in the context of this study.

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

Simulation. Simulation is a methodology for extracting information from a model by observing the behavior of the model as it is executed.

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

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

MS&V Applications. Modeling, simulation, and visualization is used for analysis, experimentation and training. Analysis refers to investigation of the behavior of a model under conditions within or at the design boundaries; experimentation refers to the investigation of the behavior of a model under conditions that exceed the design boundaries; training refers to the development of skills and/or knowledge required by individuals to operate or maintain the system represented by the model.

MS&V Organizations. Modeling, simulation, and visualization organizations are organizations that develop modeling, simulation, and visualization tools and technologies, provide modeling, simulation, and visualization services, or use modeling, simulation, and visualization services or products.

MS&V Labor Categories. Technology manager, systems engineering, software engineer, information technologists, database administrator, IT support, administrative support.

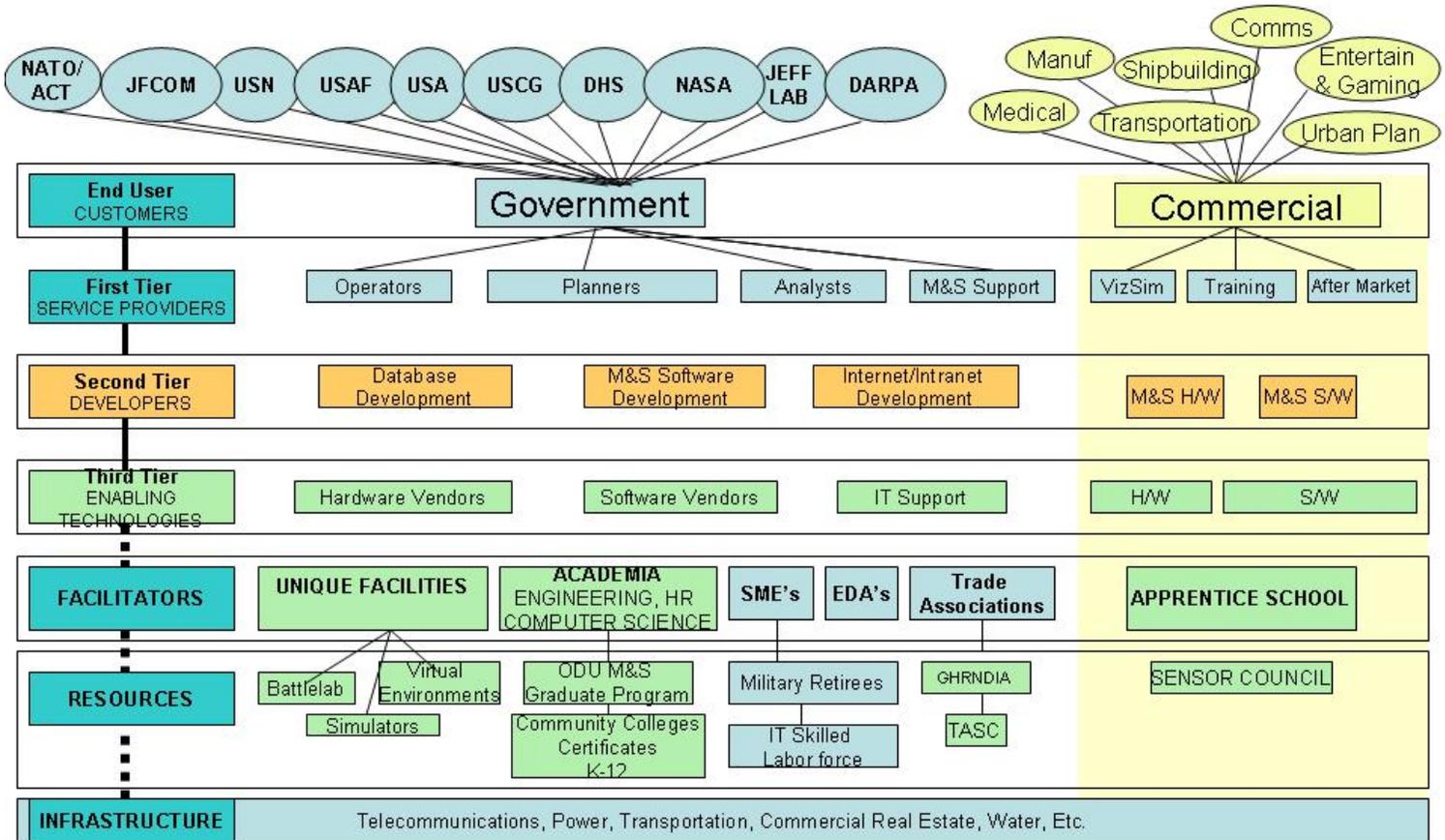
Appendix II: Stakeholder Representatives

Name	Organization
Bill Younger	VMASC
Kevin McCleskey	VMASC
Roland Mielke	VMASC
Bowen Loftin	VMASC
Steven Myer	Booz Allen Hamilton (BAH)
Daniel Snyder	BAH
Marland Parsons	DDL Omni
Tom Madson	General Dynamics- Advanced Information Systems
Bob Harper	Northrop Grumman Mission Systems
Matthew Lindfors	Northrop Grumman Mission Systems
Buck Marr	Lockheed Martin
Mike Kalaf	Lockheed Martin
Jerry Levesque	The Boeing Company
John Whaley	Hampton Roads Planning District Commission
Bob Sharak	Hampton Roads Partnership
Lee Beach	Hampton Roads Partnership
Charles Venerable	SAIC
Jack McGinn	BMH Associates
Peter Schrider	Hampton Roads Economic Development Alliance
Stephen Cook	Peninsula Alliance for Economic Development

Appendix III: MS&V Employment and Wage Summary

Harbor Side	Engineering and Architectural Services		Research and Test		Computer and Data Processing		Total Wages (\$)	Total Employment
	Wages (\$)	Employment	Wages (\$)	Employment	Wages (\$)	Employment		
Peninsula	31,760,000	546	11,680,000	152	14,505,000	287	57,945,000	985
Southside	27,203,600	453	930,879	34	12,998,000	187	41,132,479	674
TOTALS	58,963,600	999	12,610,879	186	27,503,000	474	99,077,479	1,659

Appendix IV: Hampton Roads MS&V Cluster Map



Appendix V: The Survey Methodology

A survey was conducted to determine the extent of MS&V activities in the region. The process is described below.

A survey of government and industry enterprises doing modeling and simulation work was constructed. Respondents reproduced the survey instruments in HTML form in order to allow for on-line submission. The versions were modified slightly in order to make it easier to follow visually on-screen, but all questions were identical in both the printed and electronic versions.

The final form of the questionnaires was reviewed by and agreed to by the stakeholders working group prior to publication.

The stakeholder group, drawn from their own internal records, provided an initial database of client contact information. During the survey process further additions were made to this database through the inclusion of the Hampton Roads National Defense Industry Association (NDIA) and Inside Virginia Business databases.

The database was reviewed by ANGLE Technology to identify and remove duplicate entries but preserved any entries that related to different individuals within the same company. This was done based on the assumption that there could be multiple groups within any given company or organization conducting MS&V activities.

The survey questionnaire(s) were mailed to all individuals identified on the final revised database lists. Concurrently, the survey was also published electronically via a dedicated web site. Government organizations received the government survey form and the Contractors and Commercial organizations received the Industry survey form.

The web site address was included on the printed survey, and all recipients were given the option of completing the survey on-line. Respondents were also given the option of returning the survey by fax, or by mail to a dedicated Post Office Box.

The web site was designed so that the completed survey could be submitted directly by pressing a single 'Submit' button. This system allowed for any duplicate submissions to be identified in cases where the respondent may have accidentally clicked on the 'Submit' button multiple times.

During the data collection process, the details of additional companies were provided for inclusion in the survey process, and in each case, the printed version of the survey was mailed out to the relevant contact as per the original mailing.

Mailings were made to a total of 514 separate organizations and/or groups during the survey process. In some cases, separate mailings were made to individuals in the same group/code to ensure a high response rate. Where this occurred, these mailing are not included in the total.

Selected non-respondent organizations were called and/or emailed during the follow-up process. Follow-up activity was mainly targeted based on size and economic

impact. It was not possible or productive to call all organizations on the Commercial list. Many of the Government and Contractor organizations were called since these would most likely represent a higher rate of MS&V activity with potential economic impact. The organizations that were contacted through follow-up calls and emails are highlighted in the Commercial list. A majority of the Contractors and Government agencies were contacted.

Appendix VI: Economic Impact Study Findings

SURVEY

The final statistics from data collected and collated into a master spreadsheet through the survey process were as follows:

Group	Number of Organizations	Number of Responses	Percentage
Government	92	17	18.5%
Contractors	137	31	22.5%
Commercial	285	12	4.2%
TOTAL	514	60	11.7%

INDUSTRY RESPONDENT PROFILE

Forty-three (43) industry organizations responded to the survey. Of these, 34% have other business units operating within the Hampton Roads area, and 61% have other business units supporting MS&V outside of the Hampton Roads area. The overall industry results are presented in the following tables.

Table 3.1: Current Number of Employees in Hampton Roads

No. of Employees	Percentage
1-10	12.2%
11-25	19.5%
26-100	21.9%
101-500	31.7%
501-1000	0.0%
1001-2000	2.4%
Over 2000	12.2%

Table 3.2: Current Annual Sales

Current Annual Sales	Percentage
Less than \$1M	12.2%
\$1M-\$10M	34.1%
\$11M-\$50M	26.8%
\$51M-\$100M	2.4%
More than \$100M	24.4%

Table 3.3: Number of years in operation in Hampton Roads

Years in Hampton Roads	Percentage
Less than 3 years	7.3%
3-5 years	12.2%
6-10 years	19.5%
More than 10 years	60.9%

Table 3.4: Industry Sectors represented by the respondents

Industry Sector	Percentage
Aerospace	16.6%
Communications	11.1%
Defense	33.3%
Entertainment/Gaming	1.4%
Financial Services	4.2%
Manufacturing/Distribution	1.4%
Medical	4.2%
Other	20.8%
Port Operations	1.4%
Retail (Fast Food/Hotels)	1.4%
Ship Construction	2.8%
Tourism	0
Transportation	1.4%
Urban Planning	0

INDUSTRY MS&V ACTIVITY

Respondents were asked to describe the role of their organization regarding their MS&V activities. The possible roles included end-user, developer, service provider, support or other activity. Respondents were allowed to identify more than one role.

Table 3.5: MS&V Role in Hampton Roads

MS&V Role in Hampton Roads	Percentage
End User	18.7%
Developer	28%
Service Provider	28%
Support	22.7%
Other	2.7%

Figures demonstrate an approximately equal distribution of activity across the different roles defined with an emphasis on the Developer and Service Provider roles.

INDUSTRY MS&V WAGES

To conduct the REMI Economic Analysis, the wages were then “burdened” to include benefits. In order to be consistent with the REMI model it is also necessary to assign the wages to standard categories. It was determined that of the categories available in the REMI model, the following three were most appropriate for MS&V:

- ♦ Engineering and Architectural Services
- ♦ Research and Test Services
- ♦ Computer and Data Processing Services

The information for the key labor functional areas and the percentage allocation of time was used to allocate wage and employment totals across the three industry sectors resulting in the following tables.

Table 3.6: Total Industry MS&V Wages and Employment (Unburdened)

Industry Sector	Wages	Employment
Engineering and Architectural Services	\$53,533,600	898
Research and Test Services	\$1,280,000	22
Computer and Data Processing Services	\$24,433,000	414
TOTAL	\$79,246,600	1334

The overall average salary for the private sector was \$59,405. The average industry salary for Engineering and Architectural Services was \$59,614; while Research and Test Services was \$58,180; and Computer and Data Process Services was \$59,017.

INDUSTRY LABOR FUNCTIONS

Information on labor function acquired from this survey is shown below.

Table 3.7: Distribution of labor functions across the MS&V workforce

Labor Functional Areas	Percentage of Total
Technology Manager	15.8%
Systems Engineer	28.5%
Software Engineer	20.3%
Information Technologist	22.2%
Database Administrator	7.5%
Administrative Support	12.5%
Other	16.7%

INDUSTRY PROJECTED GROWTH RATES

The annual change in the number of MS&V jobs expected over the next 2 years is approximately 18% per year indicating very strong job growth over the near term.

The annual change in the number of MS&V jobs expected over the next 5 years approximately 12% per year indicating solid job growth over the mid term.

INDUSTRY MS&V PROBLEMS/ISSUES/WEAKNESSES

The following statements were posed to further understand issues and problem areas in the Hampton Roads region.

Table 3.8: Responses to question positing, "There is a lack of trained MS&V labor force in Hampton Roads"

Lack of trained MS&V Labor Force	Percentage
Strongly Agree	13.1%
Moderately Agree	36.8%
No Opinion	28.9%
Moderately Disagree	18.4%
Strongly Disagree	2.6%

Approximately 50% of industry respondents moderately or strongly agree that there is a lack of trained MS&V labor force in Hampton Roads. Table 3.9: Responses

to question posing “There is a lack of trained support staff for MS&V in Hampton Roads”

Lack of trained support staff for MS&V	Percentage
Strongly Agree	5.3%
Moderately Agree	34.2%
No Opinion	26.3%
Moderately Disagree	31.6%
Strongly Disagree	2.6%

A somewhat higher percentage felt there was a lack of trained support staff versus others who did not agree there is a lack of trained support staff.

Table 3.10: Responses to question posing, “There is a lack of infrastructure in Hampton Roads to support MS&V”

Lack of Infrastructure	Percentage
Strongly Agree	5.3%
Moderately Agree	18.4%
No Opinion	36.8%
Moderately Disagree	39.5%
Strongly Disagree	0%

Most industry respondents did not have an opinion or did not agree that there is a lack of infrastructure to support MS&V activities in Hampton Roads.

GAPS, WEAKNESSES or NEEDS

Respondents were asked to identify any of the following gaps, weaknesses or needs that were applicable to their organization. Respondents were allowed to identify more than one weakness area.

Table 3.11: Gaps, Weaknesses or Needs Identified by Respondents

Gaps, Weaknesses or Needs	Percentage
Technology	13.8%
Standards	13.8%
Accreditation	13.8%
Certification	20.7%
Networking Opportunities	24.1%
Other	13.8%

GOVERNMENT RESPONDENT PROFILE

It is possible to characterize certain characteristics of the typical government MS&V organization based on characteristics, such as the number of employees, annual sales, years in operation and industry sectors in which the organization operates. Seventeen (17) government and public sector organizations responded to the survey. Forty-one percent (41%) have other business units operating within the Hampton Roads area. Also, 35% have other business units supporting MS&V outside of the Hampton Roads area.

The overall industry results are presented in the following tables.

Table 3.12 Current Number of Employees in Hampton Roads

No. of Employees	Percentage
1-10	5.9%
11-25	11.7%
26-100	5.9%
101-500	41.1%
501-1000	5.9%
1001-2000	17.6%
Over 2000	11.8%

Approximately 65% of the government respondents have less than 500 employees.

Table 3.13: Number of years in operation in Hampton Roads

Years in Hampton Roads	Percentage
Less than 3 years	5.9%
3-5 years	0
6-10 years	17.6%
More than 10 years	76.5%

Over 75% of the government respondents have been in operation more than 10 years in Hampton Roads indicating many long established operations.

GOVERNMENT MS&V ACTIVITY

These questions are intended to provide insight into the focus and role of the organization regarding their MS&V activities. Respondents were allowed to identify more than one focus and role.

Table 3.14: MS&V Focus

MS&V Focus	Percentage
Analysis	37%
Training	28.5%
Experimentation	34.3%

These results indicate a relative balance of focus across the three areas identified. This also shows that training is not necessarily the largest focus area for the Government organizations. Clearly, the Analysis and Experimentation areas have grown over the years based on the needs and influence of the Joint Forces Command (see Section 4: Interview Process).

Table 3.15: MS&V Role in Hampton Roads

MS&V Role in Hampton Roads	Percentage
End User	36.1%
Developer	27.8%
Service Provider	16.7%
Support	19.5%
Other	0

This is not surprising that a significant percentage of the Government/Public Sector respondents are end users and/or developers. The high percentage of Developers is probably due to the significant participation of ODU in the government/public sector survey.

GOVERNMENT MS&V RESOURCES

The objective of this question was to aggregate the total “unburdened” MS&V wages for full-time and part-time employees for respondent organizations who provided this data. The number of employees is based on “Full-Time Equivalent” (FTE) employees as estimated by the respondent organizations.

To conduct the REMI Economic Analysis, the wages were then “burdened”, by the Hampton Roads Planning District Commission, to include benefits. The Planning District Commission also requested the wages be allocated to the following three sectors: Engineering and Architectural Services; Research and Test Services; and Computer and Data Processing Services. The information gleaned regarding key labor functional areas and the percentage allocation of time was used to help allocate the wage and employment totals across the three industry sectors. The government results are provided in the following tables.

Table 3.16: Total Government MS&V Wages and Employment

Sector	Wages	Employment
Engineering and Architectural Services	\$5,430,000	101
Research and Test Services	\$11,330,880	164
Computer and Data Processing	\$3,070,000	60
TOTAL	\$19,830,880	325

The overall average public sector salary was \$61,018. The average public sector salary for Engineering and Architectural Services was \$53,726; while the average salary for Research and Test Services was \$69,090; and the average salary for Computer and Data Process Services was \$51,167.

Table 3.17: Distribution of labor functions across the MS&V workforce

Labor Functional Areas	Percentage of Total
Technology Manager	9.5%
Systems Engineer	7.9%
Software Engineer	6.6%
Information Technologist	13.8%
Database Administrator	4.8%
Administrative Support	9.5%
Other	28.4%

The other labor functions included research assistants and faculty, operators, designers, applied researchers and Operations Research and Support Analysis (ORSA). This was clearly impacted by the no. of ODU organizations participating in the public sector survey.

GOVERNMENT PROJECTED GROWTH RATE

The annual change in the number of MS&V jobs expected over the next two years is approximately 13% per year indicating strong job growth over the near term.

The annual change in the number of MS&V jobs expected over the next five years is approximately 7% per year indicating solid long-term job growth over the mid term

GOVERNMENT MS&V PROBLEMS/ISSUES/WEAKNESSES

The following statements were posed to further understand issues and problem areas in the Hampton Roads region.

Table 3.18: Responses to the question positing, “There is a lack of trained MS&V labor force in Hampton Roads”

Lack of Trained MS&V Labor Force	Percentage
Strongly Agree	6.2%
Moderately Agree	75%
No Opinion	12.5%
Moderately Disagree	6.2%
Strongly Disagree	0

Over 80% of government respondents moderately or strongly agree that there is a lack of trained MS&V labor force in Hampton Roads.

Table 3.19: Responses to the question positing “There is a lack of trained support staff for MS&V in Hampton Roads

Lack of Trained Support Staff for MS&V	Percentage
Strongly Agree	18.8%
Moderately Agree	62.5%
No Opinion	6.2%
Moderately Disagree	12.5%
Strongly Disagree	0

Again, over 80% of government respondents strongly or moderately agree there was a lack of trained support staff.

Table 3.20: Responses to question positing, “There is a lack of infrastructure in Hampton Roads to support MS&V”

Lack of Infrastructure	Percentage
Strongly Agree	18.7%
Moderately Agree	25%
No Opinion	6.2%
Moderately Disagree	50%
Strongly Disagree	0

Government respondents were basically split on the issue of whether there is a lack of infrastructure to support MS&V activities in Hampton Roads.

GOVERNMENT GAPS, WEAKNESSES OR NEEDS

Respondents were asked to identify any of the following gaps, weaknesses or needs that were applicable to their organization. Respondents were allowed to identify more than one weakness area.

Gaps, Weaknesses or Needs	Percentage
Technology	20%
Standards	20%
Accreditation	15%
Certification	20%
Networking Opportunities	20%
Other	10%

Further discussion of gaps/weaknesses and suggestions that would help address any of these issues are outlined in Section 6: Cluster Analysis.

INTERVIEWS

In conjunction with the survey process, interviews were undertaken to augment and further understand the information received from the survey process. Organizations interviewed are identified below. Key “themes” and insights gleaned from the interview process are also provided in this section.

Organization	Contact	Group/Role
Joint Forces Command	Eugene Newman	Consultant
Joint Forces Command	Steve Moore	Technical Director
Joint National Training Capability	Ken Goad	Technical Director
SAIC	Joan Conover	Joint Warfighting Center
Aerotech	Paul Robinson	President
NASA	Doug Dwoyer	Operations
NASA	Dr. Ajay Kumar	Systems Analysis And Concepts
Old Dominion	Dr. Ahmed Noor	Center for Advanced Engineering Environments
COTF	Alex Hoover	Engineering
Bihrl Aerospace	Bill Bihrl	President
TEA	Jim DeLucia Dr. Nickmeyer	Systems Engineering
Malcolm Pirnie	Jim Noonan	Engineering
AMA	Scott Angster	Engineering
SYColeman	Wally Bransford	Engineering

M&S ACTIVITIES ACT LIKE A CATALYST AND CREATE RELATED ORGANIZATIONS

M&S activities include tool development, model building, simulation operations and training. Tool development activities produce products that can be applied in a wide variety of contexts. As model builders use these tools to create simulations based on customer-defined requirements, they develop a thorough understanding of customer operations. As customers realize the benefits of the simulation, they invest in simulation operations more heavily. As knowledge of the benefits spreads, related organizations invest in new model builders, and the cluster grows.

Feeding this process are the universities that create a pipeline of skilled tool developers and model builders with functional skills that, when combined with new customers with operating experience, support continuous growth. The survey results demonstrate that this process is working well in Hampton Roads.

Relatedly, it is interesting to track the growth of MS&V activity through the growth of the Joint Warfighting Center (JWFC) (originally the Joint Training, Analysis and Simulation Center- JTASC) in Suffolk, VA and its related military agencies. The JWFC is the key MS&V catalyst within the Joint Forces Command (JFCOM) and also supports related work force development. It is interesting to note that the original Joint Training, Analysis and Simulation Center (JTASC) were a catalyst for the Joint Battle Center (JBC), which leveraged capabilities of the JTASC.

This growth in MS&V activity can also be tied to the annual budgets of the key agencies:

Joint Training, Analysis and Simulation Center (Start in '94)	\$40M
Joint Battle Center (Start in '96)	\$10M
Joint Warfighting Center (Start in '98)	\$30M

HOMELAND SECURITY IS AN IMPORTANT GROWTH AREA

The only economically feasible way to train emergency response workers in a variety of scenarios is with computer-based simulation. Although physical simulations are useful, they are very limiting in the number and types of disaster and terrorism situations that can be created. However, much work need to be done to define the processes, procedures and critical information requirements needed to create effective simulations. Hampton Roads is the logical place to educate homeland security staff members and local emergency response personnel on these requirements by demonstrating how they are applied to military situations. Further, Hampton Roads is the only location with a command-and-control simulation capability that is essential for effective emergency response operations.

M&S DEVELOPERS SHOULD BE TEAMS WITH BOTH ACADEMIC AND OPERATIONAL EXPERIENCE

Developing effective simulations requires close communications between model builders and customers with operating experience. Model builders must be flexible and creative to work with the limitations of their tools, and customers must understand these limitations as well as the potential benefits. Academic institutions need to prepare their graduates with communications skills and realistic expectations of customer knowledge of M&S activities.

THE DEMAND FOR M&S WORKERS IS EXCEEDING THE SUPPLY

Very few academic institutions presently offer degree programs in M&S (Old Dominion University is one of the few). Students must piece together interdisciplinary programs from different departments with no faculty mentors skilled in their integration.

Those institutions that do offer such degrees are severely limited in their ability to produce graduates at a rate that matches the demand.

M&S Funding Organizations Send Most of Their Money Outside of the Hampton Roads Region

The growth of the M&S cluster could be significantly accelerated if new organizations were formed capable of capturing more of the funds that leave the region. Although several large government contractors have set up local operations, numerous niches remain to be exploited by entrepreneurs.

EXTENSIVE NETWORKING WILL BE NEEDED

Growth of the cluster will be severely constrained if M&S organizations focus solely on their own problems. Venues are needed for sharing knowledge of new tools and new markets as well as addressing all of the themes listed above.

Appendix VII: Government – End Users

Army

Army Training Support Center (ATSC)
Headquarters, Dept. of the Army (HQDA)
Army MACOM
Missile Defense Agency
Transportation Command (TRANSCOM)

Navy/Marines

US 2nd Fleet
Strike Force Training Atlantic
Amphibious Group 2
Marine Forces Atlantic
2nd Marine Expeditionary Force
22 Marine Expeditionary Unit (MEU)
24 MEU
26 MEU
East Coast Expeditionary Strike Groups
Commander UK Amphibious Forces
Office of Naval Research

Joint Forces

Combatant Commanders
Training Commands

Civilian Agencies

NASA
Federal Aviation Administration (FAA)
Environmental Protection Agency (EPA)
National Intelligence Agency
Federal Emergency Management Agency (FEMA)
Department of Homeland Security (DHS)
National Science Foundation (NSF)
National Institutes of Health (NIH)

Other

Old Dominion University

VMASC

Medical Simulation Researchers

Aerospace Companies

Eastern Virginia Medical School (EVMS)

Appendix VIII: Industry - End Users

Army

Ft. Eustis
Training and Doctrine Command (TRADOC)
Army Research Institute

Air Force

Langley AFB
ACC (Langley AFB)
Air Force Research Laboratory

Navy

Naval Warfare Development Command (NWDC)
NAVAIR (PMA205)
NAVSEA (BFTT)
Office of Naval Research (ONR)
US Marine Corps
Fleet Forces Command

Joint Forces

J9
J8
J7 JNTC
J3
J4
CENTCOM
EUCOM
PACOM

Civilian Agencies

NASA

EPA

National Oceanic and Atmospheric Agency (NOAA)

US Geographical Survey (USGS)

US Coast Guard

FAA

State Department

Companies

Lockheed Martin

Boeing

Northrop Grumman

Avionics industry

Health Care

Architects

Villa, Inc.

CHI Systems

Honeywell

General Dynamics

Financial industry

Other

Universities

Defense Advanced Research Projects Agency (DARPA)

SUGS

EVMS

Academic R&D

Physicians

Appendix IX: Government - Hardware Vendors

Dell

SGI

SensAble Technologies

Sun

Toshiba

NVidia

Polhemus

ReachIn

HP

Barco

Christie Digital

Evans & Sutherland

Elumens

Intersense

Immersion

Ascension Technologies

Fakespace

NVidia

Appendix X: Industry - Hardware Vendors

Dell
SGI
Sun Microsystems
Compaq
Apple
Hewlett Packard
CDW
Norfolk Wire
CompUSA
Office Max
Novastore
Tandberg
Cisco
Sun
Siemens
Avaya
Verizon

Appendix XI: Government - Software Vendors/Programs

Linux

METI

Immersion Medical

Simulab

Limbs and Things

MacNeil Schwindler

ANSYS

Rational Rose

First Virtual Communications

Red Hat

Bio/Graphic Technologies

Renderware

ModelBuilder

Alias-Wavefront

Side Effects Software

Multigen Paradigm

Derivative

Microsoft

Calytrix

OpenGL

Open Scene Graph

Adobe

Mathworks

RTI

VRCO

Terrex

Right Hemisphere

Nvis

Autodesk

Appendix XII: Industry - Software Vendors/Programs

AP Labs
Wind River
Microsoft
Linux
MATLAB/Simulink (Mathworks, Inc.)
ACT Management
PC Doctor
Primavera
Popkin
Netvis
SLATE
VRCO (VGON)
VRCO (vGeo)
IBM (Data Explorer)
Onyx
Mathworks
Unigraphics
Trolltech
AGI's STK
Flight control software
3D Studio Max
Photoshop
AutoCad
CBS
VPC/Titan System
World Tool Kit
GIZMO 3-D
MSC Nastran
RSI, Inc (IDL)
Red Hat
Black Box
Adobe
Borlund
Fedora
Dame Ware
Norton
Macromedia

Novastore
Lavasoft
Terrex
Rational Rose
JAVA
MTWS
RESA
TACSIM
JIS/AIS
SAOC
GEM
SQL
Peoplesoft
Frizetto
Get You Started, Inc (GUS)
CSSTSS
JQUAD
JCATS
ProModel
FlexSim
Eclipse
C++
SABER (Synopsis)
Simplorer (Ansoft)
EDSA

Appendix XIII: Government - IT Suppliers/Programs

SAIC

Lockheed Martin

BMH Associates

Purdue

Alion

Argonne National Lab

Raytheon

Computer Sciences Corporation

Northrop Grumman

Lawrence Livermore National Lab

CACI

Aegis Research

JDLM Owners

Research Triangle Institute (RTI)

Appendix XIV: Industry - IT Suppliers/Programs

F-22 and Apache training devices

F-15 ground training for pilots

Lockheed Martin STS

CSC

VMASC/ODU

Applied Research Associates (ARA)

Lawrence Livermore National Lab

GIAC

SBS Technologies

SAIC

MITRE

RTI

Prosoft

AMSEC

Remtech

TDL

NSC

CACI

Roland and Associates

Siemens