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NATIONAL NETWORK FOR MANUFACTURING INNOVATION

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National Network for Manufacturing Innovation

1.0 Introduction

The business of America is business, and yet the backbone of American business, the manufacturing industry, has been in slow decline for many years. The National Network for Manufacturing Innovation (NNMI) was proposed with the vision of reinvigorating American manufacturing by reducing the cost and risk of commercializing new technologies, while addressing relevant manufacturing challenges on a production-level scale. Lockheed Martin believes a national network focused on manufacturing is critical to the strength of the defense industry and national economy. This response will outline the structure necessary to provide a robust, innovative platform for the rejuvenation of American manufacturing.

Several organizational models have shaped the Lockheed Martin vision, but by far the most influential is the Fraunhofer-Gesellschaft model. Fraunhofer-Gesellschaft is the largest research organization in Europe and, we believe, has the strongest model for sustainable development and use of innovative technology. The Department of Defense ManTech Program and the Networks of Centres of Excellence of Canada were also reviewed for best practices and lessons learned. The Lockheed Martin response combines the best elements from each of these organizations to create a powerful, yet agile manufacturing network for the United States.

2.0 Defining the Problem

Innovation has long been the foundation for growth and prosperity in the United States and Lockheed Martin believes that foundation is as strong as ever today. Instead of looking at the national advanced manufacturing deficit as a symptom of a lack of innovation, we believe the deficit is a symptom of poor business cases for performing commercial manufacturing in the United States. As companies look to reduce risks and costs, many find cost advantages in sending manufacturing work overseas. Of those that do keep manufacturing in the United States, few are willing to invest in unproven technology because of the challenges, risks, and cost associated with inserting new technology into products. Risk aversion is the primary cause of the Technology Readiness Level “Valley of Death” which prevents technological innovation from becoming a manufacturing product. The “Valley of Death” is blocking the pipeline of technological innovation that should be revitalizing American manufacturing.

The defense industry experiences risk aversion from program managers who are measured on acquisition costs and on-time delivery. They naturally want to meet requirements with as little risk as possible which typically prevents disruptive technologies from being incorporated into major platforms. Large programs often reveal the issues associated with incorporating unproven technology into a new platform in the form of cost overruns and schedule delays. As a result, very few program managers will use the technology before it is proven, however technology cannot be proven until it is used in a platform. This cycle of rejection repeats indefinitely until the need is strong enough to be worth the risk, but at that point there is rarely enough time to properly develop and insert the technology. Thus, the self-fulfilling prophecy repeats and resistance to new technology continues to grow.

Unfortunately, risk aversion is not limited to program managers; it permeates into the financial community. Obtaining the large amounts of capital required to start and sustain an advanced manufacturing business has become very difficult for many entrepreneurs because, in many cases, the financial community can easily find safer investments offering better returns. During a recent meeting of the National Defense Industrial Association's Manufacturing Division, a well respected venture capitalist clearly explained that venture capitalists were not interested in supporting manufacturing companies because the risks are too high and the returns are too low. His focus was on software because of the extremely high rate of growth possible for software companies. The commercial mindset is to make large, quick returns, and right now the United States does not provide a sufficiently profitable environment to entice large venture investments in manufacturing. Without financial support for advanced manufacturing, the trade deficit will continue to grow and more jobs will be sent overseas.

Finally, the advanced manufacturing companies that do exist are having a difficult time recruiting the right talent to work in manufacturing. Many students are unaware of the high salaries available in manufacturing and even more do not consider manufacturing because it is not perceived as a glamorous career. With the talent pipeline drying up, even those entrepreneurs with good ideas for manufacturing companies may not be able to find sufficient talent to sustain their new business. Education is just one more factor that is damaging the business case of advanced manufacturing in the United States.

Clearly there are large challenges facing the NNMI, but Lockheed Martin believes greater challenges reap greater rewards. Success in this initiative is vital to protecting the security of our nation and ensuring a strong economy into the future.

3.0 Designing the Solution

3.1 Introduction

Resolving the national advanced manufacturing deficit is no simple task, however with the right incentives and organizational structure in place, Lockheed Martin believes the NNMI can be the catalyst to initiate the advanced manufacturing revolution. The National Network for Manufacturing Innovation cannot resolve the national manufacturing problems while acting in isolation. Eliminating the deficit will take coordination and collaboration across industry, government, and academia.

Profitable businesses have driven the United States to the forefront of the global economy. With that in mind, the Lockheed Martin solution is aimed at improving the business case for keeping manufacturing in the United States. Once consistent profitability is established in advanced manufacturing, new companies will form with primary manufacturing operations in the United States and established corporations will return jobs to the United States. To improve the United States' business case, our solution addresses all of the barriers to success outlined in the previous section while creating an adaptable organization capable of overcoming unforeseen barriers as they arise.

Bridging the "Valley of Death," encouraging product commercialization, supporting new companies, reducing new technology insertion risks, and promoting manufacturing as a promising career are critical functions of the NNMI and support the ultimate goal of improving the manufacturing business case. However, success in each function will not be easy as the roots of the barriers to success are deeply

intertwined. All challenges must be worked and overcome simultaneously if any positive change is to take hold in the coming years.

To achieve success, a large yet flexible network is needed with the capability to teach, influence, and support advanced manufacturing companies throughout our nation. The Lockheed Martin response will guide the successful creation of the NNMI while establishing the best framework for sustaining the both the National Network and the individual Institutes for Manufacturing Innovation after the initial government support is removed.

3.2 Solution Overview

Since risk aversion drives most of the concerns associated with new technology in advanced manufacturing, the Institutes should be designed to prove technological viability in both commercial, civil, and defense applications. In the Lockheed Martin vision, the Institutes would meet annually to agree on large, medium and small scale prototype platforms that will be collaborative efforts between several, if not all Institutes to pilot and or demonstrate advanced technologies. Progress and results of the programs would be made public through participation in the Institutes. From the results, the Institutes would create manufacturing standards, qualifications, and certifications for each technology which would give further credibility to the technology. Through this process, the Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL) for each technology will be raised; making commercialization easier and investments in manufacturing more profitable.

In many instances, other federal support will be required to achieve the ambitious goals of the NNMI. Many nations have used tax credits and other incentives to help specific industries grow. Lockheed Martin envisions the NNMI making recommendations at the national and regional government levels which will help build the business case for keeping advanced manufacturing in America. Direct government funding for the Institutes will not be necessary after the initial three-year investment, however the country as a whole will benefit from incentives that reward companies for investing in manufacturing and creating jobs at home. As an example, Singapore and Ireland incentivized growth in biotechnology and are now considered two of the top locations in the world for biotechnology companies.

Throughout our response, the common thread across all sections is our vision for building the business case for manufacturing in the United States. Each section is designed to answer the questions presented in the Request for Information while expanding on our thought process and our operational vision for the NNMI Institutes. Despite our status as a large defense contractor, Lockheed Martin looked at the NNMI as national function that supports more than the defense industry and the specific interests of Lockheed Martin. Our company recognizes the importance of small businesses and we believe our response will support the goal of establishing regional clusters of technological innovation, which ultimately strengthens our nation and expands the capabilities of the defense industry.

4.0 Technologies with Broad Impact

4.1 Introduction

By properly scoping the technological focus of the Institutes, the NNMI will have the right mix of specific technical expertise and broad national applications. We have considered technologies that not

only support the defense industry, but those that will benefit society as a whole. Tissue growth and pharmaceutical manufacturing are two areas that we do not have an immediate interest, but we believe are critical manufacturing technologies that will support the greater good of our nation.

Our recommendations, listed in the response to question two, range from technologies that we have interest in internally to technologies we anticipate depending on suppliers to provide. In the defense industry we depend on trusted suppliers, preferably based in the United States, to provide us with low cost, high reliability products to integrate into our products. In many instances, it is becoming very difficult to find qualified suppliers at home to meet our technological needs. We believe the support provided by the NNMI will increase the number of startup advanced manufacturing companies which will strengthen our supply base and lower costs to the Warfighter.

Also keeping economic growth in mind, all of our recommendations have tremendous commercial potential as we believe they have the ability to reestablish U.S. companies in existing markets, while preparing the U.S. to be more competitive in emerging markets. The greatest measures of success for the National Network will be economic growth including reversing the national advanced manufacturing deficit; creation of new manufacturing companies and jobs; and growth of Science, Technology, Engineering, and Math educational fields. By choosing Institutes carefully, we believe the national will quickly begin to see positive trends in manufacturing.

4.2 Answers to RFI Questions

1. *What Criteria should be used to select technology focus areas?*

The goal of the NNMI is to revitalize American manufacturing and with this in mind, the technological focus areas should reestablish U.S. companies in existing markets while preparing the U.S. to be more competitive in emerging markets. The total portfolio of NNMI Institutes needs to encompass the economic and basic survival needs for the manufacturing industry which means materials, tooling, and processes need to be included. For example, if the nation has the best automated assembly capabilities in the world but does not have unfettered access to well machined parts and castings, the U.S. manufacturing industry will not thrive. Technologies should be rated based on their broad impact to national manufacturing and ability for small, medium, and large businesses and universities to benefit.

For Lockheed Martin, broad impact means cross-cutting with technology focus areas that have multiple applications on a single product or support common manufacturing needs across several products. In the national sense, broad means it has an impact in multiple industries and products with many opportunities for commercialization.

In order to meet the basic survival needs of the manufacturing industry, the agencies funding the NNMI also need to consider the total portfolio of Institutes when selecting technology focus areas. The advanced manufacturing industry requires advanced materials, tooling, processes, and manufacturing expertise to build advanced systems which means the portfolio of NNMI Institutes need to encompass all elements of advanced manufacturing. Advanced assembly techniques and supply chain logistics systems are not beneficial if they do not include

2. *What technology focus areas that meet these criteria would you be willing to co-invest in?*

Lockheed Martin's focus on affordability places emphasis on advanced manufacturing technologies that are vital to the defense industry in the future. However, the costs and risks are often too high for single a company to mature alone. The Institutes will lower scale-up and implementation costs of these products by spreading development across many companies and applications. The list below contains 13 Institutes we would be willing to co-invest in at this time.

- Forgings, Castings, and Joining
- Ultra Light Weight Materials
- Super Alloys
- Autonomy and Robotics
- Precision Machining
- Rapid Prototyping
- Organic Electronics
- Nano Composites
- Surface Engineering
- Electro-Optics
- Compact and Miniaturized Electronics
- Design Tools and Informatics
- Nano Electronics

LMCO acknowledges the importance of having an additive manufacturing in addition to the proposed 15 Institutes, which is why this is included in the notional NNMI structure in Figure 1. As explained during the Cleveland, Ohio NNMI Workshop, we did not consider the recently awarded National Additive Manufacturing Innovation Institute (NAMII) in our total recommended list of 15.

To complete the 15 NNMI Institutes, Lockheed Martin also recommends Institutes in Tissue Growth and Pharmaceutical Manufacturing. Although we would not co-invest in these Institutes at this time, both technologies are critically important to the well being of our nation's citizens and have tremendous opportunities for commercial growth in the future.

3. *What measures could demonstrate that Institute technology activities assist U.S. manufacturing?*

There are several direct metrics that the Institutes' activities should be measured against to determine effectiveness in assisting U.S. manufacturing. These should be set early, tracked regularly and progress displayed both in a physical manner and in media. The following list should be a starting point for these metrics and can be added to as the Institutes mature:

- Number of transitions to programs of record
- Cost savings to government programs and/or platforms
- Growth of existing manufacturing companies
- Formation of new manufacturing companies
- Introduction of new products produced by U.S. manufacturing companies
- Number of patents granted
- Number of active members in the NNMI Institutes
- Number of workforce members trained
- Number of manufacturing related internships and apprenticeships

4. *What measures could assess the performance and impact of Institutes?*

In addition to direct metrics listed in the previous question, there are indirect metrics that will measure the impact of the Institutes at a national level. These metrics are very different from the direct metrics in the previous question because they encompass more than just the NNMI to be successful, but the NNMI will be the catalyst to start the reaction of national improvement.

- Reversing the national advanced manufacturing deficit
- Creation of manufacturing curricula in schools and Universities
- Insourcing of previously outsourced manufacturing
- Reducing Veteran Unemployment

While key metrics will help advertise and document progression of the Institute at the national level, their ability to self sustain is going to be the most important metric of performance. If the Institute remains open, then there has been enough of a positive impact for businesses to continue to partner and invest with the Institute. The next section, structure and governance, provides guidance for Institutes that do not become profitable, and outlines the responsibilities of the Institute Directors to manage Institute performance.

5.0 Institute Structure and Governance

5.1 Introduction

The organizational structure recommended by Lockheed Martin was developed by studying the effectiveness of Fraunhofer-Gesellschaft in Europe, as well as the Department of Defense ManTech Program. These models provide a relatively flat organization for the Institutes to operate within while providing structure for coordination and collaboration across the network. Our vision is that the structure and governance be well suited to move and reshape Institutes based on emerging technological and manufacturing trends. Institutes must be allowed to fail if the technology is not relevant, but the overall structure of the NNMI needs to give each Institute the best possible chance of survival. The total network should be structured to provide the most value to the economy by improving the business case for performing advanced manufacturing in the United States. Although the initial number of Institutes may be limited to 15, the recommended organizational structure is well prepared to incorporate additional Institutes over time.

Regardless of the final form of the NNMI, we believe there are certain structure and governance requirements that are common to the national network and the individual Institutes. By meeting these requirements, the national network and individual Institutes will be well prepared to adapt to the changing needs of industry.

5.1.1 Structure Requirements

- Must be scalable
- Coordination between Institutes is simple, frequent, and beneficial
- Low bureaucracy and overhead costs
- Simple and frequent collaboration with technical community
- Simple and frequent collaboration with industry

- Clear leadership for promotion, strategy, and ownership
- Institute level financial responsibility

5.1.2 Governance Requirements

- Adaptable structure capable of incorporating and removing Institutes
- Industry has a voice in governance decisions
- Technical community has a voice in governance decisions
- Cannot be overly influenced by one group, company, or person

An organization that meets the above requirements will have the best chance at success because it will be scalable, adaptable, and will have active participation from industry.

5.2 National Network Structure & Governance

The Institutes are the ultimate focus of the NNMI, but without a proper structure connecting them, the network will fall apart and, we believe, the Institutes will quickly become inefficient and ineffective. This section is dedicated to the national structure which will govern all of the individual Institutes comprising the NNMI. Figure 1 visually depicts the notional vision for the NNMI organization.

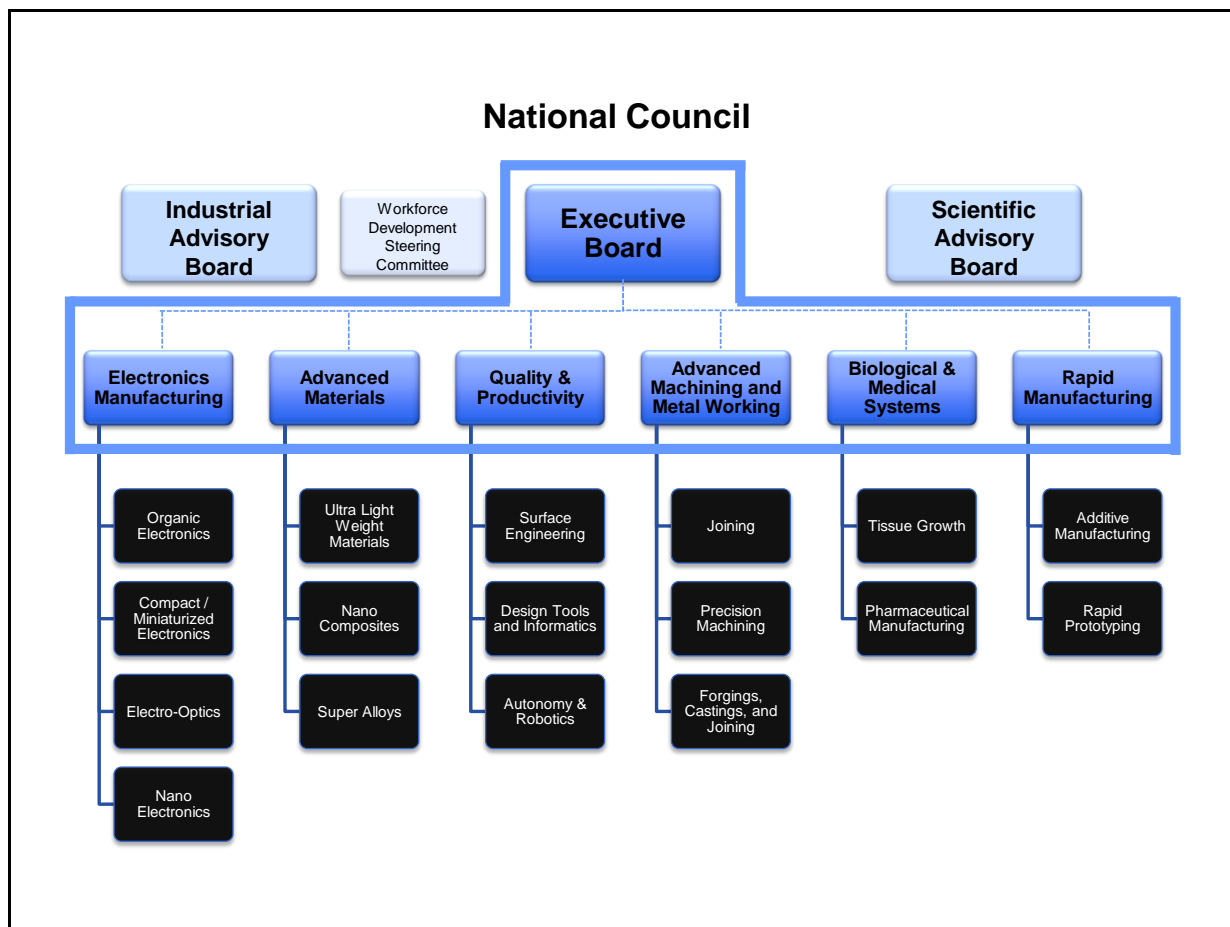


Figure 1 Notional NNMI Structure

In Figure 1, the black boxes depict Lockheed Martin's recommendations for Institutes while the higher-tiered blue boxes depict the proposed Subpanels. The Subpanels are grouped with the Executive Board to form the National Council. Outside of the National Council are an Industrial Advisory Board and a Technical Advisory Board. Each of these components is described in detail in the following section. The recommended model is designed to be customizable and scalable so if Institutes or Subpanels other than those depicted here are selected, the proposed organizational model will still be effective.

5.2.1 National Council

The National Council will serve as the strategic guiding element for the NNMI and will be comprised of the Chairmen from each of the proposed six subpanels, as well as the Executive Board members. The Executive Board will consist of the NNMI Executive Director and 3-4 Directors to help administrate and promote the NNMI. Together, the National Council will recommend, review and approve strategic directions for all of the Institutes; drive coordination between Institutes; promote the NNMI in public forums; and will have responsibility for adding Institutes as technological needs change or removing Institutes from NNMI that fail to become self-sustaining after three years of operation.

- a. *Executive Board* – 3-5 full-time administrative leaders for the national network with primary responsibilities to manage, promote, and govern the NNMI. One member will be the NNMI Executive Director and the other members will have various subordinate responsibilities.
- b. *Subpanel Chairmen* – comprised of the Chairmen from the six Subpanels of the NNMI. The Subpanel Chairmen will be responsible for coordinating the activities of the Institutes within their respective Subpanel. The Chairmen can develop major proposals, including adding and removing Institutes, and will be expected to provide strategic guidance to the rest of the National Council.

5.2.2 Subpanels

Institutes working in related subject areas cooperate within NNMI Subpanels and foster a joint presence in technical and industrial communities. They help to define the NNMI's business policy and act to implement the organizational and funding principles consistent with the NNMI model. The Subpanels will be responsible for coordination and collaboration across the Institutes within the Subpanel. Best practices and lessons learned will be shared within this group. The Subpanel will be lead by a Chairman who will be selected from the Directors of the Institutes within the subpanel and will rotate every two years. The Chairman will have responsibility for coordination across Institutes and will ensure the Subpanel is supporting the overall goals of the Institutes and National Network.

5.2.3 National Industrial Advisory Board

The National Industrial Advisory Board will be the national level connection between the NNMI and the manufacturing industry. The board will be formed from Presidents, Vice-Presidents, CEOs, and Chairmen from various companies and consortiums. Primarily, the National Industrial Advisory Board will advise the National Council on major manufacturing challenges facing industry which should include technical issues, cycle-time, cost drivers, quality, and any other factor of production that may be relevant. From this information, the National Council will create strategic guidance for the entire NNMI. Another function will be to propose and fund large cross-cutting demonstration projects that will help meet the collective goals of industry. Membership on the board will be limited to twelve and the National Council will have responsibility to ensure the mix properly represents the interests of all national industries.

5.2.4 National Technical Advisory Board

The National Technical Advisory Board will be the national level connection between the NNMI and the technical community. Members will be nationally recognized scientific experts as well as Presidents from top research universities and Chairmen from technical consortiums. The National Technical Advisory Board will be responsible for advising the NNMI on emerging technological trends as well as proposing new Institutes based on technical needs. The new Institutes will be verified by the National Industrial Advisory Board to ensure Institutes are not created without an interest from industry. Advice from this board will be used by the National Council to determine the annual strategic direction in conjunction with the information provided by the National Industrial Advisory Board. Membership will be limited to twelve and it will be the National Council's responsibility to ensure the members properly represent the technical community.

5.2.5 National Workforce Development Steering Committee

The National Workforce Development Steering Committee is tasked with creating national strategies for workforce development, ensuring educational coordination across Institutes, and disseminating best practices and lessons learned. The Steering Committee will consist of thirteen members and will be led by a member of the Executive Board who has full responsibility for the success of the Steering Committee. Each National Advisory Board will send six members as representatives to provide expertise and recommendations for workforce development based on the national strategy of the NNMI. More on workforce development and the roles of the National and Local Workforce Development Steering Committees is provided in Section 7.0.

5.3 Institute Structure & Governance

5.3.1 Overview

Institutes are the foundation of the NNMI. In these facilities, the real work will be completed through technical experts and collaborations across Institutes, organizations, consortiums, and companies. This section is dedicated to the structure and governance of individual Institutes. Each Institute will be an area of specific technical expertise and will be responsible for enhancing manufacturing in their designated field. Each Institute will be operated by a non-profit business entity selected by the Federal government department(s) providing funding for the Institute's initial three years of operation.

5.3.2 Institute Structure and Governance

Each Institute will be led by a director, appointed by the operating entity, to oversee all aspects of Institute management. The Institutes will be independent cost centers and each director will be responsible for bringing in sufficient funds to keep the Institute open without government intervention after a start-up period of three years. The director will have authority to choose his or her own team and organizational structure. It is predicted that each Institute will be large enough to warrant multiple managers responsible for leading specific aspects of the Institute. It will be up to the director to decide on the best staffing levels and leadership structure.

There will be several constitutional mandates that an Institute must oblige at all times. The most critical is organization and support for two local level advisory boards: Technical and Industrial. These boards will be established similar to those at the national level, with a distinction made at the requirements for participation. Senior and mid-level leaders, scientists, technologists, and other decision makers will sit on the two boards. The boards will serve the same purpose as the national level boards, but will be better

customized to meet the specific challenges facing each Institute. Each Institute will have the discretion of restricting membership on the Technical and Industrial Boards to representatives of entities that pay annual membership fees to participate. Payments may be in the form of cash and/or in-kind cost share.

Local Workforce Development Steering Committees can and should be formed based on recommendations from the National Workforce Development Steering Committee, however each Institute does not necessarily need a Steering Committee. Depending on the technological focus of the Institute and the local region, it may be beneficial for sister Institutes to develop a joint Workforce Development Steering Committee in order to better serve the community, industry, and, most importantly, the workforce. No matter the form, the Steering Committee will be responsible for coordinating all aspects of workforce development in the local region for Institute technologies. The Local Steering Committee will consist of members from the local advisory boards and will be led by an individual selected by the Institute Director(s).

5.3.3 Industry Project Participation

Aside from the Advisory Boards, the Institutes will depend on direct participation from industry. At the Institute level, industry participation will include collaborative manufacturing research, consulting, demonstration projects. The section “Strategies for Sustainable Operations” is dedicated to the details of Institute operations and features many different Industry interactions.

5.3.4 Intellectual Property

Intellectual Property (IP) is always a critical concern for companies participating in consortiums of any kind and the NNMI will be no exception. Lockheed Martin understands that the Institutes will not be able to achieve their goals of promoting manufacturing without holding some IP rights; however, without striking the right balance, the Institutes will not provide enough value to be worth industry participation and will ultimately fail. The IP policy will be set at the National Council level because of the need for a consistent policy across all Institutes; however IP will be held and protected by the Institutes. We envision three IP scenarios:

1. NNMI Institute Member IP
2. Company Protected IP
3. Public Domain, Open Source IP

In scenario 1, the NNMI Institute would hold IP for any project that is funded by government or through funding of multiple participating members. Only paying members of the NNMI Institute would have access to this IP and would be subject to royalty fee payments should they discontinue their paying membership. This scenario will be fairly common since we envision the government funding many projects through the NNMI Institutes. We also believe there will be one to two major industry projects each year that are worth collective industry participation because of the broad impact of the research.

Scenario 2 will also exist rather frequently as we anticipate many companies, especially small businesses, will need the technical expertise of an NNMI Institute to develop, demonstrate, or test a concept. The company will hire Institute experts to work on the project as a contractor. In this scenario, the company would hold all IP rights because they are paying for development of the IP. Institute may request to release non-technical papers regarding the project in order to promote the accomplishments of the Institute and the capabilities of the experts.

Scenario 3 involves IP created by the NNMI Institute but is released for public distribution with no rights held. This may be low level research information or may be designed to help promote the capabilities of the NNMI Institute in order to attract new members.

Fraunhofer-Gesellschaft uses an IP management tool that we believe will be effective for the NNMI. Each Institute will grant IP based on membership, and the Fraunhofer-Gesellschaft tool will be used to track who has used the IP and their current membership status. A company that has used NNMI IP but is no longer a member of the Institute will be subject to royalty payments to the Institute. The goal is to encourage companies to participate as active members in the NNMI because Lockheed Martin believes greater involvement will inspire innovative ideas which will lead to new projects, products, and manufacturing opportunities.

An IP policy at the National Network level is critical for the success of the Network and individual Institutes. Protection of IP is paramount to creating new companies and protecting those that already exist. We believe the simple IP structure as outlined here, enforced at the national and local level, is the best way to be consistent and clear throughout the entire network.

5.4 Summary

The goal of the NNMI is to encourage advanced manufacturing in the United States which will create new businesses, new jobs, and boost the economy. The NNMI needs to remain flexible and we believe the proposed organizational structure is flat enough to give Institutes control over their activities while ensuring all funds are spent as efficiently as possible. A solid structure will lead to investments from industry and continuous collaboration which will further strengthen the NNMI.

5.5 Answers to RFI Questions

1. *What business models would be effective for the Institutes to manage business decisions?*

Each Institute should be managed by a full-time Institute Director who will have ultimate responsibility for sustainment of the Institute. He or she will have responsibility for making staffing, strategic, and project decisions in the best interest of the Institute. Each Institute will have separate Industrial and Technical Advisory Boards which will help the director make business decisions. The industrial advisory board will keep the Institute relevant to industry while the technical advisory board will keep the director informed about basic research achievements which may prove relevant to the Institute.

2. *What governance models would be effective for the Institutes to manage governance decisions?*

Fraunhofer-Gesellschaft provides the best model to follow the NNMI to follow. Governance should be common across the Institutes and therefore must be coordinated at the national level by the National Council. Governing decisions will be proposed by the National Council and approved by the funding government agency during the three years of initial funding. During this time, the final rules of governance should be established and be made common across all Institutes. Beyond the initial government funding, decisions will be left to the National Council. Included in these governance responsibilities will be the decision to add or remove Institutes as necessary.

3. *What membership and participation structure would be effective for the Institutes, such as financial and intellectual property obligations, access and licensing?*

Each Institute should offer an annual membership at a fee set by the Institute Director. A National Network membership would not be effective because the Institutes need the ability to adjust membership fees as they see fit each year. Memberships will be an important source of revenue and generating revenue is the responsibility of the Institute Director.

Participation in the Institutes should be through the Industry Advisory Board and the Technical Advisory Board. These boards will provide business and technical guidance to the Institutes in order to keep the Institute relevant in the current market. The Institute advisory boards will consist of senior and mid-level leaders, scientists, technologists, and other decision makers.

National level participation should be from the National Industry Advisory Board and a National Technical Advisory Board. These boards will be formed from Company Presidents, Vice-Presidents, CEOs, Presidents from Top Universities, nationally recognized scientific experts and Chairmen from technical consortiums. This group will be responsible for addressing national issues and making recommendations to the overall NNMI National Council.

For IP concerns, we envision three scenarios:

1. NNMI Institute Member IP – this will be IP held by the Institute and provided to paying members of the Institute. It will be generated from internal research as well as the IP generated from leading industry and government sponsored projects.
2. Company Protected IP – When a company wants to use the technical experts at the NNMI, the company will pay the experts and maintain all IP generated from their efforts. More on this type of activity is included in the “Sustainable Institute Operations” section.
3. Public Domain, Open Source IP – Sometime the Institutes will have IP, but will decide it should be made public domain or it is not profitable enough to be worth protecting. In this case, the Institutes would release their IP publically. This could also be used to attract new companies to join the Institute once the companies understand the types of work the Institute performs.

4. *How should a network of Institutes optimally operate?*

They should coordinate, but operate independently just as the Joint Defense Manufacturing Technology Panel does for the DoD ManTech Program. The heads of each Institute should meet regularly to coordinate joint activities such as prototype demonstration programs and educational outreach programs. The Subpanel Chairman will be responsible for coordination and collaboration across the Institutes within a Subpanel, and the National Council will meet to coordinate across Subpanels. Each Institute should be financially secure on their own so there will not be provisions for sharing financials across Institutes.

5. *What measures could assess effectiveness of Network structure and governance?*

The effectiveness of the structure will be proven by the Network’s ability to coordinate prototype demonstration projects and share lessons learned across Institutes. If the Network is able to develop and execute on cross-technology demonstration projects, the structure is performing as it should. To

achieve this, the Subpanels will need quarterly meetings to discuss common issues and develop strategies for future projects.

The effectiveness of the Network's governance will be demonstrated when Institutes need to be added or removed, especially after the three-year initial government investment is completed. Adding or removing Institutes requires strong governance and agreement throughout the National Council and National Advisory Boards.

6.0 Strategies for Sustainable Institute Operations

6.1 Introduction

The Network's strategy for sustainable operations is based upon the stated goal to reduce the cost and risk of commercializing new technologies and to address relevant manufacturing challenges on a production-level scale. This goal can be broken into two major sections: Supporting New Technology Startup and Resolving Production-Level Issues. The Institutes will have the technical expertise to address both of these goals in profitable ways, as outlined in the next section.

6.2 Revenue Sources

Sustaining the Institutes will depend upon revenue streams from various sources and activities. The list below contains recommendations for generating revenue which will be explained in greater detail in the following sections.

- Lead prototype demonstration projects
- Technical and business consulting
- Prototype facilities for hire
- Technology and manufacturing business classes
- Membership fees
- Process certifications and creation of standards
- Royalties from IP

6.2.1 Support New Technology Commercialization

The use of new technology has always been a risky venture which can raise huge profits if successful while creating massive losses if unsuccessful. At the same time, many potential entrepreneurs never start a company because they do not know how or cannot find an investor. For these reasons, many new technologies sit in the "Valley of Death" for years because the initial risks were too high to be worth investment. Lockheed Martin believes the NNMI will not only bridge the "Valley of Death," but will prompt a manufacturing revolution which will result in many new manufacturing companies being created; boosting the US economy and improving the strength of the defense base.

Education is addressed more completely another section, however here it is important to acknowledge that education not only helps the NNMI achieve its goals, it can be a source of revenue. By partnering with Universities, general classes can be offered to teach innovators how to start their own business including incorporation, securing investor funding, and other business essentials. These could be offered for the cost of a class at a partner University, without having to go through admissions. The Institutes

should also offer technical training for the manufacturing workforce including operators and business leaders. Operator training should teach the workforce how to use advanced manufacturing equipment and give them new skills while business leader training should teach the fundamentals of the technology as well as potential applications. Education is vital to achieving the goals of the NNMI and is also a strong revenue generating activity for the Institutes.

Educating the general population is important, but in some matters it helps to have an expert. Each Institute should offer consulting services to help innovators launch businesses in their related fields. Activities would include equipment recommendations, concept evaluation, and support gaining investments, to name a few. Fraunhofer offers a similar program through Fraunhofer Venture. By providing a support system for new innovators, the Institutes would help create new businesses that push technology to market and into widespread use. As payment, Institutes could receive a future lump sum or hold an equity share of the newly created company.

Some innovators know business, but do not know if the product will work. To resolve this issue, the Institutes should offer manufacturing facilities and engineering support on an hourly basis for a fee. The cost of working in the Institute will be much cheaper than purchasing equipment in order to demonstrate a concept. This will also help innovators secure initial funding to start their business, since the designs can be proven and tested ahead of major investments.

Finally, to reduce the risk associated with first time use of new technology, the NNMI will lead large technical demonstration projects aimed at incorporating and proving the most advanced technology available. This will serve the dual purpose of proving the technology and will give the Institutes a clear manufacturing objective. These projects should be funded by both government and industry. In fact, instead of continuing provisions for the NNMI, Lockheed Martin envisions the government giving projects to the NNMI each year to be worked on and developed, much as Defense Advanced Research Projects Agency (DARPA) does for defense technology development. Companies large and small could bid to be a part of the project with the knowledge that their efforts will be made public as part of participation in the project and that they will be working with experts from the Institutes. We expect that these actions will support growth in the manufacturing industry as innovators find it much easier to take risks, secure investment funding, and start up their own manufacturing companies.

6.2.2 Resolve Production-Level Challenges

To resolve production-level challenges, Lockheed Martin envisions the Institutes offering technical support to any paying member of the Institute. It would be beyond the scope of the Institute to have full-scale production facilities, however the expertise of the Institute's team should be deployed to partner companies to help facilitate cost reductions and solve complex manufacturing challenges. As outlined in the Intellectual Property section, if the company wants to protect IP, they would have to pay the Institute for their services. The consultants would be bound by IP rules and regulations, however they would gain experience in solving problems and bring funding back into the Institute. If instead, the company is willing to release any IP generated from the effort to the Institute, the Institute's experts would perform their services for free or at a nominal price.

Another revenue stream would be the creation of manufacturing standards and associated certifications. These could be certifications similar to AS9100 standards. Technologies such as additive manufacturing may require new standards to prove the technology is safe for use on defense platforms, civil applications,

or commercial products. The Institute could offer a certification service for a small fee to paying members and a larger fee to non-members.

6.3 Answers to RFI Questions

1. ***How should initial funding co-investments of the Federal Government and others be organized by types and proportions?***

Initial government funding should be used to establish core capabilities and expertise within the Institute's technological thrust area. During the initial three years, the Institutes should focus on building an infrastructure capable of supporting the Institute once government funding is removed. Keeping sustainable operations in mind, we recommend using the majority of the initial funding to purchase equipment, materials, and technical experts to lead demonstration efforts. We expect the non-profit selected to operate Institute will already have facilities and some equipment to support the Institute. Below are the Lockheed Martin recommendations for dispersion of funds; however the Institute Director will ultimately be responsible for making final budget decisions. Since the Institute will all be self sustaining, the Institute Director needs to have flexibility to adjust funding allocations as necessary.

Administration – 10% (Director and other administrative costs)

Infrastructure – 10% (Buildings/facilities)

Equipment – 20% (Lab requirements, capital equipment)

Project Materials – 50% (Materials and Technical Experts)

Misc – 10% (Promotion, educational outreach, startup funding)

2. ***What arrangements for co-investment proportions and types could help an Institute become self-sustaining?***

Funding should come in from technological demonstration efforts funded by both industry and government. The various government departments should leverage the NNMI and industry partners to conduct prototype manufacturing efforts which will prove technology while working out the issues of first-time production. Industry may find value, in some cases, in pooling funding from multiple companies in order to create a project that would serve everyone in a pre-competitive effort.

Membership fees will also be a critical source of revenue. Companies will be incentivized to join the NNMI Institutes based on access to IP and other technical research conducted by the Institute.

3. ***What measures could assess progress of an Institute towards being self-sustaining***

The ultimate measure will be revenue against expenditures. If the Institute is bringing in more money that it is spending, then the Institute will become self-sustaining. Aside from bottom line financial numbers, projects awarded to the Institute, consortium fees, service contracts, certifications, and other sources of funding should be tracked and measured as they would be for a standard business. Costs need to be managed properly and investments need to be evaluated based on Return on Investment (ROI).

4. *What actions or conditions could improve how Institute operations support domestic manufacturing facilities while maintaining consistency with our international obligations?*

Supporting domestic manufacturing facilities has to be the top priority above the United States' immediate international obligations. By promoting manufacturing, we expect to see the U.S. economy strengthen which increases the country's ability to meet international obligations over time. Money for international aid, technology for international sales, government offsets, and other types of international obligations will all be better supported by a stronger U.S. economy. U.S. international allies will benefit in the long run from development of the NNMI and the improvement to the U.S. manufacturing base we expect it to bring.

5. *How should Institutes engage other manufacturing related programs and networks?*

Major consortiums should have members on the national and local advisory boards which will ensure the NNMI is connected to the activities of other major networks. The NNMI will be much more effective if it is intimately linked to the rest of industry, academia, government, and consortiums.

Current manufacturing related programs such as DARPA's Open Manufacturing or Vehicle Forge should be leveraged and supported by the appropriate Institutes. Engaging programs and networks that already exist allows for the Institutes to avoid some of the initial learning curves associated with startup. It also reduced duplicate research and development efforts throughout the country. We believe the open architecture of the NNMI will encourage other manufacturing related programs to join and support Institutes related to their own work.

6. *How should Institutes interact with state and local economic development authorities?*

Refinement of tax laws is needed to improve the business case for manufacturing in the United States. Incentives could be offered to companies doing advanced manufacturing in the U.S. or special economic zones could be created as was done in China to promote manufacturing growth. We envision the Institutes making recommendations to local and national government agencies to help promote manufacturing growth.

7. *What measures could assess Institute contributions to long-term national security and competitiveness?*

LMCO understands that the strength of the defense industry depends on the number of companies capable of meeting the current and potential surge needs of the armed services. Without a strong defense base, the nation will quickly lose wartime supremacy as other nations become more technologically advanced than the United States. The measures of impact to national security are the same as those for measuring the Institutes' impact on U.S. manufacturing. Any positive impact to U.S. based manufacturing will support national security and U.S. competitiveness.

- Number of transitions to programs of record
- Cost savings to government programs and/or platforms
- Growth of existing manufacturing companies
- Formation of new manufacturing companies
- Introduction of new products produced by U.S. manufacturing companies
- Number of patents granted
- Number of active members

- Number of workforce members trained

7.0 Education and Workforce Development

7.1 Introduction

People change the world. The greatest organizational structure in the world will fail without the right people in place to make key decisions and drive innovative solutions to the most difficult problems. With this in mind, Lockheed Martin believes education and workforce development is absolutely critical for the success of the NNMI and the nation as a whole. Science, Technology, Engineering, and Math (STEM) education is especially important for the manufacturing industry as new products depend on advances in all disciplines of science and math. We believe that through the National and Local Workforce Development Steering Committees outlined in Section 5, the NNMI National Network and Institutes can ensure that the United States has the most talented, capable, and productive advanced manufacturing workforce in the world.

Students need to be excited at a young age about STEM fields through innovative, exciting programs designed to capture imaginations and inspire dreams of the future. We believe National and Local Steering Committees should coordinate with existing programs in local regions and throughout the country to bring excitement about STEM to the youth. The response to the questions posed in the Request for Information provides examples of specific programs that have already been successful at encouraging STEM education. We believe the NNMI will be a strong partner to these successful organizations.

Learning does not stop with students so the Institutes will also be designed to teach the current and emerging workforce real skills and trades for careers in manufacturing. The Institutes should offer certifications in their specific technology fields and encourage participation from vocational programs and trade schools. The skills, trades, and certifications taught will be supported by the Industry and Technical Advisory Boards to ensure the training is relevant to the current and emerging needs of industry. The Institutes will also offer classes for business leaders to learn the basics of technology and how it can be applied. We believe that teaching business leaders about emerging technology will lead to new companies and technology commercialization faster because leaders and investors will have a better understanding of the capabilities and limits of emerging technology.

7.2 Answers to RFI Questions

1. How could Institutes support advanced manufacturing workforce development at all educational levels?

The Institutes should develop a comprehensive strategy that addresses engagement at traditional Science, Technology, Engineering, Math (STEM) K-12 and vocational programs, as well as trade schools at the high school, post-high school and college levels. A key to success is training teachers in the value of manufacturing and exposing them to the advanced manufacturing technologies that will be the foundation of future jobs for their students. Summer employment opportunities for both teachers and students would help develop their interest in manufacturing.

In the K-12 area, each Institute should develop a STEM engagement strategy that is relevant to its technology area. Some examples would be LEGO Mindstorm and *FIRST* Robotics for a Robotics

Institute, 3D Printers and associated CAD programs for an Additive Manufacturing Institute. The purpose would be to tailor a STEM outreach program at the Institute level and then work across the country at regional levels to roll out these programs. This strategy should exploit opportunities to engage with existing STEM programs such as *FIRST* Robotics, USA Science and Engineering Festival, and Science Olympiad to leverage existing networks, resources, and brand recognition that will be necessary for a rapid ramp up and adoption. Finally, with the successful launch of a National Manufacturing Day on October 5th 2012, the Institutes should develop content for this forum that focuses national interest on advanced manufacturing technologies, programs and careers.

At the high school levels for both vocational and technical programs as well as trade schools, the needs are slightly different. In particular, there is a strong need to build the ‘brand’ for manufacturing careers and engaging parents at this critical time in students’ lives is crucial. Lockheed Martin would like to see the creation of an Advanced Manufacturing Parent and Teacher Portal that focuses on parents and teachers with the intent of educating them on advanced manufacturing and connecting the Institute technology areas to jobs. This would include reference materials, case studies, and statistics to demonstrate connection between manufacturing-related studies and job placement. For the student focus, establish Institute ‘academies’ that bring high school and trade school students throughout the U.S. to the Institutes through Ambassador Programs. Selection into the program should be competitive and those chosen can study and learn through workshops at the Institutes and then take what they’ve learned back to their respective schools to share the information with others. This establishes leaders in advanced manufacturing at early ages.

At the post-High School or collegiate level, the Institutes should work with appropriate industry associations and organizations such as the Edison Welding Institute and American Welding Society, to develop certification programs. The educational focus at this level needs to be certification so that those interested in advanced manufacturing careers can demonstrate that they are capable of joining the advanced manufacturing workforce. The Industrial and Technical Advisory Boards would provide input into development of these curriculums in order to stay within the best interests of industry.

2. *How could Institutes ensure that advanced manufacturing workforce development activities address industry needs?*

The Institutes should setup a Workforce Development Steering Committee consisting of representatives from industry who develop and oversee the workforce programs described in the previous question. To be most effective, this Steering Committee should include representatives from educational institutions as well.

Additionally, the advisory boards should provide information on the types of skills required to support the needs of industry. The Industrial Advisory Board would likely focus on current issues while the Technical Advisory Board would be focused on upcoming manufacturing skills based on emerging technologies. The Institutes would then work with community colleges, universities, high schools, and trade schools to ensure appropriate curricula are in place to meet these needs.

Another key community that needs to be engaged is the veterans’ community. The Institute should partner with veterans programs to establish a veteran education program in manufacturing areas

addressed by NNMI Institutes. The goal would be to provide career education and training in advanced manufacturing that draws on technical and leadership skills obtained in the military, and provide a path to a manufacturing career upon re-entry to the civilian workforce.

3. *How could Institutes and the NNMI leverage and complement other education and workforce development programs?*

Similar to question two above, the Institutes should consider development of a workforce steering committee that pulls in representatives from academia and other educational institutions. This would be separate from the Industrial and Technical Advisory Boards and would be aimed specifically at education and workforce development. Also this strategy should exploit opportunities to engage with existing STEM programs such as *FIRST* Robotics, USA Science and Engineering Festival, and the Science Olympiad to leverage existing networks, resources, and brand recognition that will be necessary for a rapid ramp up and adoption. Finally, create a track or presence at national conferences and events such as Defense Manufacturing Conference that showcases all the latest developments coming out of the NNMI Institutes.

4. **What measures could assess Institute performance and impact on education and workforce development?**

Some measures in this area might include:

- Certification programs (number of people achieving certification through Institute-led initiatives vs. conventional certification programs)
- Job placement metrics (% of jobs filled in areas serviced by Institutes vs. those not currently covered by an NNMI Institute)
- Trends in number of new jobs created in Institute technology areas
- Number of veterans entering advanced manufacturing careers in areas addressed by NNMI Institutes.

5. **How might Institutes integrate research and development activities and education to best prepare the current and future workforce?**

The Institutes should partner with leading research universities and develop training programs and curricula that incorporate the latest research developments. These training programs should exist at the university, community college, trade school, and high school levels. Also, encourage teachers to participate in research and development efforts, document what they learned, then share and teach what they have learned back at their respective schools. Summer employment opportunities for teachers will directly involve the educators in the manufacturing research and development, accelerating the integration of new techniques and skills into the workforce training process.

8.0 Summary

Reestablishing a strong manufacturing industry in the United States is critical to the long term success of Lockheed Martin, the defense industry, and the national economy. We believe the National Network for Manufacturing Innovation can be a catalyst for the positive manufacturing revolution required to bring back the economic strength of the United States. The technologies and structure recommended in this response will establish the best framework for the Institutes to sustain operations and positively impact the national manufacturing industry. Lockheed Martin believes the National Network for Manufacturing Innovation is the right initiative at the right time and we look forward to working collaboratively with government, industry, and academia to rejuvenate American manufacturing.

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