

## CSTI POLICY BRIEFING NOTE

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# Country Overview of Manufacturing Policy United States

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### Overview

Manufacturing accounts for roughly 12% of US GDP. With every \$1 spent in manufacturing generating \$1.35 in additional economic activity, a larger multiplier effect than any other sector of the economy, advanced manufacturing is recognised as an important component of domestic policy in the United States. US Government initiatives are motivated by the decline of high-technology manufacturing industries in terms of the US global share of total output, and also that of global high-technology exports. There is a belief that innovation is key to future economic performance, and that leadership in manufacturing is perceived to equate to innovation performance.

The US Government has [identified](#) manufacturing as the key means by which “inventions, research discoveries, and new ideas” are translated into “better or novel products or processes”. And it defines advanced manufacturing as involving both “new ways to manufacture existing products” and the “manufacture of new products emerging from new advanced technologies.”

Within the US Government, a number of key [agency partners](#) are concerned with formulating policies, creating synergies, and funding stakeholders. And there are several significant initiatives emerging now in place to advance this agenda, of which these are among the most significant:

- [Advanced Manufacturing National Program Office](#) (AMNPO)
- [Advanced Manufacturing Partnership](#) (AMP)
- [National Network for Manufacturing Innovation](#) (NNMI)
- [Manufacturing Extension Partnership](#) (MEP)
- DoD Manufacturing Technology ([ManTech](#)) program

### National Policy

US policy in advanced manufacturing is driven by a conviction that innovation drives U.S. economic growth and growth of U.S. productivity, and that manufacturing is an essential component of an innovation ecosystem. Several key [reports](#) commissioned by President Obama in recent years have made the case for the United States to support advanced manufacturing, believing it to be a keystone for future economic strength (and national security). Principle among these are the reports from the *President’s Council of Advisors on Science and Technology* (PCAST) in 2011 and 2012, which underpin the national strategic plan:

- [Ensuring American Leadership in Advanced Manufacturing](#)
- [Capturing Domestic Competitive Advantage in Advanced Manufacturing](#)
- [National Strategic Plan for Advanced Manufacturing](#)

Latest document from PCAST (October 2014)

- [Accelerating U.S. Advanced Manufacturing](#)

[Ensuring American Leadership in Advanced Manufacturing](#) starkly acknowledges the decline in American manufacturing leadership. It stresses the need for an “innovation policy” while explicitly rejecting the pursuit of an industrial policy. The reports key recommendations are the establishment of an Advanced Manufacturing Initiative, reform of tax policies, and improved support for research, education and workforce training.

[Capturing Domestic Competitive Advantage in Advanced Manufacturing](#) contains sixteen recommendations from the Advanced Manufacturing Partnership (AMP) Steering Committee. Those sixteen recommendations are developed around three pillars – enabling Innovation, securing the talent pipeline, and improving the business climate. Specific emphasis was given to energy policy in the promotion of domestic manufacturing, and the report recommends incentives and R&D policies towards enhancing energy efficiency and conservation, increasing and diversifying domestic supplies, speeding development of renewable sources and transitioning to a low carbon economy.

The 2012 [National Strategic Plan for Advanced Manufacturing](#) recommends meeting five objectives:

- Accelerate investment in advanced manufacturing technology, especially by small and medium-sized manufacturing enterprises, by fostering more effective use of Federal capabilities and facilities, including early procurement by Federal agencies of cutting-edge products.
- Expand the number of workers who have the skills needed by a growing advanced manufacturing sector and make the education and training system more responsive to the demand for skills.
- Create and support national and regional public-private, government-industry-academic partnerships to accelerate investment in and deployment of advanced manufacturing technologies.
- Optimize the Federal government’s advanced manufacturing investment by taking a portfolio perspective across agencies and adjusting accordingly.
- Increase total U.S. public and private investments in advanced manufacturing research and development (R&D).

Just published in October 2014, [Accelerating U.S. Advanced Manufacturing](#) follows up on the earlier reports, and reflects on the major actions taken by the Advanced Manufacturing Partnership, notably the public-private initiatives that have already been launched (the Manufacturing Innovation Institutes are described as a “cornerstone of the Nation’s investment”). Those actions, whose impact ranges from the creation of a national strategy to the launch of regional apprenticeship pilot programmes, were informed by those aforementioned three pillars – enabling Innovation, securing the talent pipeline, and improving the business climate – and for which further recommendations are made. The report also remarks on the “broad partnership required from across communities, educators, businesses, organized labor and government at all levels to accelerate U.S. advantage in advanced manufacturing”. PCAST also recommends that the Executive Office of the President speedily releases a plan for the implementation of the AMP2.0 report’s recommendations.

## Actors and Institutions

Within the US Government, there are now a number of [agency partners](#) that are concerned with formulating policies, creating synergies, and funding stakeholders. The Federal effort is coordinated by these recently created institutions.

- **Advanced Manufacturing National Program Office (AMNPO)**
- **Advanced Manufacturing Partnership (AMP)**

The [AMNPO](#), located within NIST, is staffed by representatives from federal agencies with manufacturing-related missions (DOD, DOE, NASA, and NSF) as well as by representatives from industry and academia.

Advanced manufacturing research is also pursued by several Federal agencies, each having its own particular focus.

#### Key Federal Departments and Agencies

- Department of Defense (DOD)
  - Defense Advanced Research Projects Agency (DARPA)
  - Manufacturing and Industrial Base Policy (MIPB)
- Department of Energy (DOE)
  - Office of Energy Efficiency and Renewable Energy (EERE)
  - Advanced Manufacturing Office (AMO)
- National Institute for Science and Technology (NIST)
- National Science Foundation (NSF)
- National Aeronautics and Space Administration (NASA)
- Department of Labor (DOL) / Department of Education (ED)

#### Central Government Policy Actor

##### US Advanced Manufacturing National Program Office (AMNPO)

Following a recommendation in a 2011 report by the *President's Council of Advisors on Science & Technology* (PCAST), the **Advanced Manufacturing National Program Office** was founded 2012.

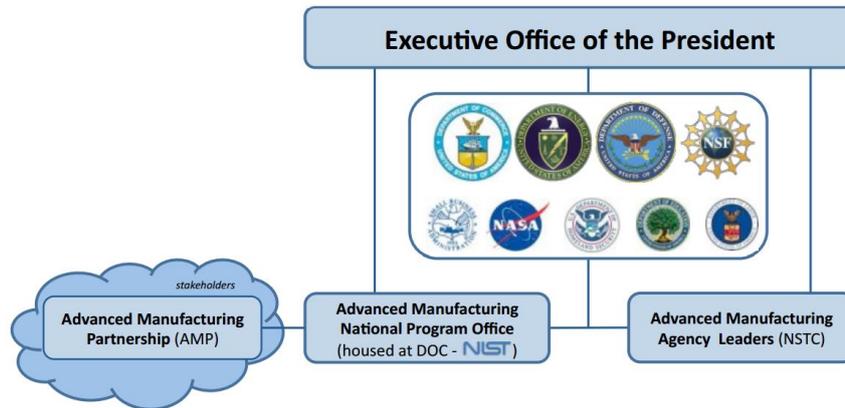
##### The AMNPO has two primary missions:

- To facilitate and link federal efforts to industry-led, private-public partnerships which also engage US universities, state and local governments, and other organisations.
- To design and implement advanced manufacturing initiatives that also promote collaboration and information-sharing across federal agencies.

In particular, the AMNPO aims to enhance advanced manufacturing-related technology transfer and to enable the scaling-up of production of new technologies.

##### AMNPO Structure and Governance

AMNPO is hosted by the Department of Commerce, within the National Institute of Standards and Technology (NIST). *The AMNPO engages with Federal Agencies through an Interagency Working Group of the National Science and Technology Council (NSTC)*. The AMNPO, whose current director is Mike Molnar, is also staffed by representatives from federal agencies involved in US manufacturing, including the Departments of Defense, Education and Energy, NASA, the National Science Foundation, as well as fellows from manufacturing companies and universities.



### Examples of AMNPO activities include:

- Responding to recommendations from **President’s Council of Advisors on Science & Technology** (PCAST), the **Advanced Manufacturing Partnership** (AMP) and the **Interagency Advanced Manufacturing** (IAM) interagency working group of the National Science and Technology Council (NSTC)
- Planning and coordinating federal **advanced manufacturing strategic planning**, including agency implementation of recommendations from the National Advanced Manufacturing Strategy (cf UK Future of Manufacturing Report and manufacturing sector strategies)
- Coordinating **advanced manufacturing planning and budget** activities with Executive Office of the President
- Producing the annual **advanced manufacturing supplements** to the President’s Budget
- Assembling **advanced manufacturing-related data and evidence** to support the briefing of senior government officials
- Supporting advanced manufacturing **public-private partnerships**, providing a linkage between manufacturers, government, and universities
- Coordinating multi-agency Federal activities supporting AMP, such as the Materials Genome Initiative (NIST, NSF, DOE, DOD ...), the National Robotics Initiative (NIST, NSF, NASA ...), etc.
- Supporting the development of advanced manufacturing-related **guidelines and metrics**, e.g. the key performance metrics and intellectual property frameworks of the new National Manufacturing Innovation Institutes (cf UK HVM Catapult)
- Establishing broad **engagement mechanisms among stakeholders** in government, industry, and academia, providing whole-of-government interface to stakeholders
- Convening **public workshops** throughout the US on initiatives and priorities (and disseminating workshop findings / outputs)
- Hosting the **manufacturing.gov** advanced manufacturing web portal – clearing house for information on US manufacturing policy and federal advanced manufacturing-related initiatives and programmes (cf IfM CSTI’s Manufacturing Policy Portal)

By coordinating federal resources and programs, the AMNPO will enhance technology transfer in U.S. manufacturing industries and help companies overcome technical obstacles to scaling up production of new technologies. It will work to build more effective collaborations in identifying and addressing challenges and opportunities that span technology areas and cut across agency missions.

A key AMNPO aim is to link federal efforts to the growing number of private-sector partnerships involving manufacturers, universities, state and local governments, and other organisations.

## Innovation Agencies and their Initiatives

There are many significant initiatives emerging to advance the government's advanced manufacturing agenda, of which these are among the most significant:

### Major AMNPO initiatives include:

- The Advanced Manufacturing Partnership (AMP)
- [National Network for Manufacturing Innovation](#) (NNMI)

### Department and agency programmes and initiatives include:

- **NIST**
  - [Manufacturing Extension Partnership](#) (MEP)
  - [Measurement Science for Advanced Manufacturing](#) (MSAM) Cooperative Agreement
  - [Advanced Manufacturing Technology Consortia](#) (AMTech)
  - [Engineering Laboratory Grant Program](#)
- **DOD**
  - Manufacturing Technology ([ManTech](#))
  - [Manufacturing Experimentation and Outreach Two](#) (MENTOR2)
- **DOE**
  - [Advanced Manufacturing Office](#) (AMO)
- **NSF**
  - [Advanced Manufacturing Cluster](#)
  - [Cyber-enabled Materials, Manufacturing, and Smart Systems](#) (CEMMSS)

### AMP

Another key grouping formed in recent years as a consequence of the US Government's renewed focus on advanced manufacturing is the [Advanced Manufacturing Partnership](#) (AMP). The inaugural Advanced Manufacturing Partnership Steering Committee was created in 2011 following the PCAST report of that year. And it was this committee that issued the 2012 PCAST report detailing 16 recommendations aimed at revitalising American manufacturing. Indeed, the committee is designed to function as a working group of PCAST. In 2013, President Obama [launched](#) the Advanced Manufacturing Partnership Steering Committee "2.0"<sup>1</sup> to continue the efforts of the first committee. Its composition demonstrates a belief that industry, academia, and government need to work in partnership "to identify the most pressing challenges and transformative opportunities to improve the technologies, processes and products across multiple manufacturing industries". The new committee works with the White House's National Economic Council and Office of Science and Technology Policy and the Department of Commerce, to fully implement the initial Steering Committee's previous recommendations, and also to identify new strategies for securing US

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<sup>1</sup> The 19 member Advanced Manufacturing Partnership Steering Committee 2.0 is co-chaired by Andrew Liveris, President, Chairman, and Chief Executive Officer of the Dow Chemical Company, and Rafael Reif, President of the Massachusetts Institute of Technology

advantage in emerging technologies, with a remit extending from technology innovation through to production. AMP 2.0 is also comprised of five Working Teams, with distinct briefs: Technologies, Workforce, NNMI, Scale-up Policy, and Manufacturing Image. Furthermore, the AMP Steering Committee 2.0 engages the wider manufacturing community through regional forums and working sessions.

## NNMI

One of the original AMP recommendations is the creation of the [National Network for Manufacturing Innovation](#) (NNMI), and a [report](#) by the NSTC has described an approach for implementing and managing such a network. This involves the creation of regional innovation hubs – public-private partnerships called [Institutes for Manufacturing Innovation](#) (IMIs) – intended to “accelerate development and adoption of cutting-edge manufacturing technologies for making new, globally competitive products”. Each institute is intended to bring together innovative manufacturers, university engineering schools, community colleges, federal agencies, non-profits, and regional and state organisations to invest in manufacturing technologies, with the idea being that [federal government seed money](#) is a catalyst for further private sector investment. In the budget for fiscal year 2014, the President [proposed](#) 15 IMIs to be funded by an investment of \$1 billion. The first four were initiated by executive order rather than congressional action, and while legislation is pending, the Obama Administration has carried on with building a manufacturing innovation network. Currently [five](#) have been established, and [more](#) are being planned. Furthermore, [funding](#) have been committed for the creation of Manufacturing Innovation Hubs and apprenticeships. However, it is [agreed](#) that long-term public financing will be necessary if these institutes are to become self-sustaining.

A pilot institute, the [National Additive Manufacturing Innovation Institute](#), was created in Youngstown, Ohio, in 2012, and has by now received \$50 million in federal funding. [More institutes](#) have since been revealed by President Obama in [separate](#) announcements, with funding on the order of \$70 million, investment which has been matched or exceeded in each case by the institutes’ industry partners. It is eventually envisaged that over the course of a decade there will be 45 IMIs around the country, which will likely necessitate investment from the federal government in excess of \$3 billion (as a point of comparison, the [National Science Foundation](#)’s fiscal year 2014 budget was \$7.172 billion, of which just over \$150 million was committed to advanced manufacturing).

## NNMI Metrics

[Draft performance metrics](#) have been proposed by the AMNPO to measure the success of the IMIs, which are both qualitative and quantitative, and give time frames over which the metric should be assessed. The metrics categories are:

1. Impact (e.g., manufacturing innovation, employment, and the regional manufacturing ecosystem)
2. Industry Value (the extent to which the industrial partners perceive that they are receiving value from the existence of the Institute)
3. Education and Workforce Development (increasing and improving the workforce prepared for advanced manufacturing jobs)
4. Portfolio (the breadth and depth of projects contained in the Institute portfolio)
5. Financial (Institutes need to establish stable revenue streams that will lead them to self-sufficiency after the initial NNMI funding expires)
6. Network Contribution (interaction of Institutes through the larger NNMI)

## Other Key Actors and Initiatives in US Manufacturing Policy System

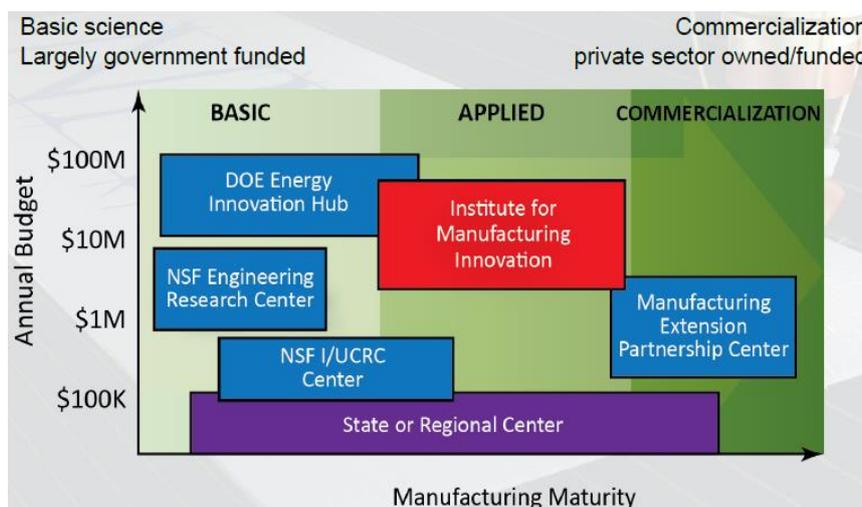
## National Institute for Science and Technology (NIST)

Founded in 1901 and now part of the US Department of Commerce, NIST is one of the nation's oldest physical science laboratories. It was established to support the US's industrial competitiveness, and that remains an important part of its brief today. One of NIST's [roles](#) is to provide technical support to manufacturing industries in the US. This it does via a range of programs, with varying degrees of scope.

In particular:

- [Engineering Laboratory](#)
  - [Smart Manufacturing](#)
  - [Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure](#)
  - [Projects of the Manufacturing Engineering Laboratory](#)
- [Manufacturing portal](#)
- Hosts AMNPO
- Manufacturing programmes (discussed in more detail in Programmes & Initiatives section below):
  - [Manufacturing Extension Partnership](#) (MEP)
  - [Measurement Science for Advanced Manufacturing](#) (MSAM) Cooperative Agreement
  - [Advanced Manufacturing Technology Consortia](#) (AMTech)
  - [Engineering Laboratory Grant Program](#)

One of NIST's initiatives is the Hollings [Manufacturing Extension Partnership](#) (MEP). The MEP, built around manufacturing extension centres, is a nationwide network of 1,200 technical experts serving as advisors to US manufacturers. They provide manufacturers with expertise and services, assisting them with expanding into new markets, creating new products, providing access to technology, workplace development, and improving processes and business practices. They also enable manufacturers to connect with government and trade associations, universities and research laboratories, etc. It is claimed that MEP generates nearly \$19 in new sales growth and \$21 in new client investment for every one dollar of federal investment, and that for every \$1,978 of federal investment, MEP creates or retains one manufacturing job.



Grants feature prominently in current initiatives. In autumn 2013, NIST, as part of its [Measurement Science for Advanced Manufacturing](#) (MSAM) Cooperative Agreement Program, [awarded two grants](#) totalling \$7.4 million to fund projects in additive manufacturing. In 2014, NIST [awarded](#) 19 advanced

manufacturing technology planning grants totalling \$9 million over two years to [universities and other non-profit organisations](#) as part of NIST's [Advanced Manufacturing Technology Consortia](#) (AMTech) program, which is aimed at creating partnerships between US industry, academia, and government. A further objective of AMTech is to identify and prioritise research projects that “reduce barriers to the growth of advanced manufacturing”. Project collaborations encompass a wide variety of industries and technologies. Technology roadmapping is an important element of all funded projects, which will also attempt to strengthen domestic supply chains and establish skill-set requirements for an advanced manufacturing workforce. New [competitions](#) for advanced manufacturing planning awards are ongoing.

The [Engineering Laboratory Grant Program](#) provides financial assistance consistent with the EL's mission to support research in numerous fields. Advanced manufacturing technologies, guidelines, and services form a significant component of this program's work.

## Other Federal Agency Actors

### Department of Defense (DOD)

The [Office of Manufacturing and Industrial Base Policy](#) (MIBP) supports the Office of the Secretary of Defense and Service Acquisition by providing analyses and understanding of the industrial supply chain supporting national defense. MIBP supports investment to advance industrial productivity through a variety of authorities and programs, including the Defense Production Act and Manufacturing Technology (ManTech). MIBP is also working to implement the two DOD pilot Institutes for Manufacturing Innovation (IMIs) announced in 2013.

The Department of Defense (DoD) oversees a Manufacturing Technology ([ManTech](#)) program, through the office of [Manufacturing and Industrial Base Policy](#), (MIBP), which will set up two manufacturing innovation institutes to serve the Obama Administration's national manufacturing agenda. Various branches of the armed forces, for example, the [Army](#), the [Navy](#), the [Air Force](#), have their [own particular ManTech programs](#), managed individually, some with budgets in excess of \$50 million. There are also ManTech programs run by the [Defense Logistics Agency](#) (DLA), the [Missile Defense Agency](#) (MDA). The office of the Secretary of Defense (OSD) also oversees the [Defense-Wide Manufacturing Science & Technology](#) (DMS&T) ManTech Program, which focuses on cross-cutting defense manufacturing needs that are beyond the ability of a single service to address. These various programs are coordinated through the auspices of the [Joint Defense Manufacturing Technology Panel](#) (JDMTP), which conducts joint program planning and develops joint strategies.

The DOD are also engaged in advanced manufacturing through the [Defense Advanced Research Projects Agency](#) (DARPA), who are involved in the development of disruptive manufacturing technologies with military impact. Prominent DARPA manufacturing programmes (e.g., [MENTOR2](#), [Open Manufacturing](#)) are run from the [Defense Sciences Office](#).

### ManTech

- [Army](#): “Army ManTech supports reduction in production risks and manufacturing costs throughout the weapons system life cycle. Investment portfolio areas include Ground Maneuver, Lethality, Air, Soldier/Squad, Command, Control, Communications & Intelligence, and Innovation Enablers”.
- [Navy](#): “Navy ManTech's mission is to develop enabling manufacturing technology – new processes and equipment – for implementation on DoN weapon system production lines. This is achieved through seven Centers of Excellence, which provide technological expertise and facilitate the transfer of manufacturing technology”.

- [Air Force](#): “Air Force ManTech develops agile manufacturing technologies with a focus on flexible, low-rate production. Their strategic thrusts are moving manufacturing to the left, cradle-to-cradle digital thread for manufacturing, a responsive, integrated supply base, and factories of the future”.
- [DMS&T](#): “Defense-wide Manufacturing Science & Technology ManTech focuses on crosscutting defense manufacturing needs that are beyond a single service’s ability. Its investment areas include Advanced Electronics and Optics Manufacturing, Advanced Materials Manufacturing, Enterprise and Emerging Manufacturing, the Industrial Base Innovation Fund, and Manufacturing Innovation Institutes. The Industrial Base Innovation Fund makes investments addressing shortfalls, especially surge production and diminishing sources.”

The Defense Advanced Research Projects Agency (DARPA) has its own [manufacturing programs](#). Furthermore, they have interests in developing technology, expertise and tools for in-theatre manufacturing as part of their [Manufacturing Experimentation and Outreach Two](#) (MENTOR2) program.

Other DARPA advanced manufacturing programs, including those pending:

- [Open Manufacturing](#)
- [Living Foundries](#)
- [Manufacturable Gradient Index Optics \(M-GRIN\)](#)
- [Atoms to Product \(A2P\) Nanoscale Manufacturing](#)

### **Department of Energy (DOE)**

The US Department of Energy (DoE) is also [engaged in advanced manufacturing](#), being heavily involved in the development of energy efficient technologies, as well as energy management solutions. The investments of the [Office of Energy Efficiency and Renewable Energy \(EERE\)](#) in advanced manufacturing include R&D projects, facilities for collaborative manufacturing communities, and technical assistance.

The DoE also contains the [Advanced Manufacturing Office \(AMO\)](#), which partners with industry, small business, universities, and other stakeholders to identify and invest in emerging technologies. The AMO, which oversees the department’s [R&D projects](#), also leads [participation](#) in the Advanced Manufacturing Partnership (AMP). The AMO performs three essential functions:

- Funds [Next Generation Manufacturing R&D Projects](#), focusing on the development of industry-specific and cross-cutting manufacturing technologies.
- Supports Advanced Manufacturing R&D Facilities that will enable the creation of Clean Energy Manufacturing Innovation Institutes consistent with the President’s vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI).
- Provides Industrial Technical Assistance that supports the deployment of energy-efficient manufacturing technologies and practices.

The AMO’s projects, which purport to fill the gap between lab-scale development and demonstration and scale-up, explore novel energy-efficient materials, innovative process technologies, and advanced energy technologies for a range of manufacturing industries. Those include:

- [Innovative Process and Materials Technologies](#)  
Development of advanced manufacturing process and materials technologies in order to transition scientific innovations into clean-energy manufacturing capabilities.
- [Next Generation Manufacturing Processes](#)

R&D in new manufacturing processes, simulation tools, and technologies with the goal of doubling net energy productivity, enabling rapid manufacture of energy-efficient, high-quality products at competitive cost. The process technology areas here are:

- Reactions and Separations
- High-Temperature Processing
- Waste Heat Minimization and Recovery
- Sustainable Manufacturing
- [Next Generation Materials](#)  
Innovative materials with increased functionality that can improve the energy productivity of U.S. manufacturing.
  - Thermal and Degradation Resistant Materials
  - Highly Functional, High-Performance Materials
  - Lower-Cost Materials for Energy Systems
- [Combined Heat and Power](#) (for industry)  
Combined heat and power (CHP)—sometimes called cogeneration—is an integrated set of technologies for the simultaneous, on-site production of electricity and heat.

Other DOE initiatives include:

- [Oak Ridge Manufacturing Demonstration Facility](#)  
“The Manufacturing Demonstration Facility (MDF) is a collaborative manufacturing community that provides affordable access to advanced physical and virtual tools for rapidly demonstrating new manufacturing technologies and optimising critical processes”.
- [Critical Materials Hub](#)
- [Clean Energy Manufacturing Innovation Institutes](#)  
“The Clean Energy Manufacturing Innovation Institutes are designed to focus on foundational technologies that are broadly applicable and pervasive in multiple industries and markets with potentially transformational technical and manufacturing productivity impact”.

### **National Science Foundation (NSF)**

The NSF is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..." The President has proposed \$7.255 billion in overall funding for NSF in FY2015. Over 75% of the NSF's budget supports university/third level research, approximately 90% of which is allocated as competitive awards. Lately the NSF has included advanced manufacturing among its specific [agency priorities](#). The NSF views its activity in this area as less a "refinement" of traditional manufacturing processes, but embracing new methodologies, systems, and processes, and it supports a diverse research portfolio.

- The [Civil, Mechanical and Manufacturing Innovation](#) (CMMI) Division is one of the four research divisions in the [Directorate for Engineering](#) (ENG) at the NSF. CMMI is organized into four program clusters:
  - [Advanced Manufacturing](#)
  - [Mechanics and Engineered Materials](#)
  - [Resilient and Sustainable Infrastructures](#)
  - [Systems Engineering and Design](#)
- Other NSF directorates and divisions also participate in NSF-wide manufacturing related programmes, such the [Directorate for Computer and Information Science and Engineering](#) (CISE) and the [Directorate for Mathematical and Physical Sciences](#) (MPS).
  - CEMMSS

- Robotics
- Nanotech

Much of the NSF's advanced manufacturing initiatives are run through its Directorate for Engineering, which is also an active participant in the Advanced Manufacturing Partnership and the National Nanotechnology Initiative.

- The [Civil, Mechanical and Manufacturing Innovation](#) (CMMI) Division is one of the four research divisions in the Directorate for Engineering at the NSF. CMMI is organized into four program clusters:
  - Advanced Manufacturing
  - Mechanics and Engineered Materials
  - Resilient and Sustainable Infrastructures
  - Systems Engineering and Design.

While the other programs also support some relevant manufacturing research, the [Advanced Manufacturing Cluster](#) accounts for the majority of CMMI manufacturing efforts. The cluster funds fundamental research to enable advances in manufacturing across a wide range of size scales, and has particular emphases on the following manufacturing themes:

- Design of Engineering Material Systems
- Manufacturing Enterprise Systems
- Manufacturing Machines and Equipment
- Materials Engineering and Processing
- NanoManufacturing

- [Cyber-enabled Materials, Manufacturing, and Smart Systems](#) (CEMMSS)  
In response to the Administration's [Materials Genome Initiative](#) (MGI), [Advanced Manufacturing Partnership](#) (AMP), and the [National Robotics Initiative](#) (NRI), the CEMMSS framework aims to integrate a number of science and engineering activities across the Foundation – breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems.  
CEMMSS is an NSF interdisciplinary program that includes investments by four NSF Directorates – Computer and Information Science and Engineering (CISE), which leads the project, Biological Sciences (BIO), Mathematics and Physical Sciences (MPS) and Engineering (ENG). The CEMMSS framework aims to integrate a number of activities across NSF – breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems (CPS). The goal is to discover, develop and produce new materials with unique properties and functionality, and to develop and deploy advanced manufacturing methods and strategies to turn static systems and processes into adaptive smart systems.
- **Engineering Research Centers (ERCs)**  
The National Science Foundation's [Engineering Research Centers](#) (ERCs) are interdisciplinary centers that join academia, industry, and government in partnership to produce advances in engineered systems that could radically transform the practices and processes of current industries. There are currently 5 advanced manufacturing-focused ERCs:
  - Nanosystems ERC for Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies (NASCENT)
  - ERC for Compact and Efficient Fluid Power (CCEFP)
  - Synthetic Biology ERC (SBERC)
  - ERC for Structured Organic Particulate Systems (C-SOPS)
  - Center for Biorenewable Chemicals (CBiRC)

- **Advanced Technological Education**

With an emphasis on two-year colleges, the Advanced Technological Education (ATE) program focuses on the education of technicians for high-tech fields, including on manufacturing.

### **National Aeronautics and Space Administration (NASA)**

NASA's advanced manufacturing brief largely entails finding manufacturing requirements for space transportation systems. Its initiatives are based on building the technology base for manufacturing next generation launch vehicle systems. There are some dedicated manufacturing divisions:

- Goddard Space Flight Center – [Advanced Manufacturing Branch](#)
- Glenn Research Center – Engineering Directorate, [Manufacturing Division](#)
- Ames Research Center – Engineering Directorate, [Applied Manufacturing Division](#)

Within NASA, the Johnson Space Center investigates [manufacturing technologies](#) from the perspective of spacecraft maintenance while in space.

NASA also has the [National Center for Advanced Manufacturing](#) (NCAM), located in New Orleans, Louisiana on NASA's Michoud Assembly Facility. NCAM is a partnership between NASA, the State of Louisiana, and The University of New Orleans, which leads a consortium of 7 Universities. The purpose of the partnership is to:

- Address NASA's needs in research and technology development,
- Build the technology base for manufacturing next generation launch vehicle systems.

Examples of other NASA projects/initiatives include:

- [Game Changing Development Program](#) – this programme seeks to “identify and rapidly mature innovative/high impact capabilities and technologies for infusion in a broad array of future NASA missions”, and there are several projects contained therein directly related to manufacturing
  - The [Manufacturing Innovation Project](#) (MIP) – rapid prototyping for low cost manufacturing
  - [Advanced Manufacturing Technologies](#) (AMT) – project to develop and mature innovative, low-cost manufacturing processes and products
- [Advanced Digital Materials and Manufacturing for Space](#) (ADMMS) – carried out at [NASA Ames Research Center](#)

### **Department of Labor (DOL) / Department of Education (ED)**

The DOL is tasked with providing innovative workforce solutions/training in order that all the various advanced manufacturing initiatives are propelled by people with the requisite skills. As such, it has [announced](#) a series of investments totalling more than \$105M to address the workforce needs of the advanced manufacturing industry. The grants are intended to provide genuine solutions, leadership, and models for partnerships that can be replicated across the country.

The U.S. Department of Labor has announced several investments, including the following:

- [Trade Adjustment Assistance Community College and Career Training Grant Fund](#) (TAACCCT) TAACCCT provides community colleges and other eligible institutions of higher education with funds to expand and improve their ability to deliver education and career training programs that can prepare program participants for employment in high-wage, high-skill occupations, while also meeting the needs of employers for skilled workers. The Department is implementing the TAACCCT program in partnership with the Department of Education. The FY2014 budget request has a FY2015 program as follow-on to TAACCCT, a proposed Community College to Career Fund.

- [Job Training for Employment in High Growth Industries](#)  
A strategic effort to prepare workers for high-growth, high-demand, and economically vital sectors of the American economy.
- Work Information, Electronic Tools, System Building  
Programs funded through the Workforce Information/E-Tools/System Building budget line item assist working-age individuals, employers, government entities, and non-profit organizations.

Beyond these key activities, there are other institutions engaged in advanced manufacturing initiatives. For example:

- The National Academy of Engineering (NAE) also launched a new [initiative](#) “to understand the role of manufacturing, design, and innovation in making value for America’s future”.
- The [SmartAmerica Challenge](#) is a [White House Presidential Innovation Fellow](#) project that is concerned with Cyber-Physical Systems, and combines activities from different sectors, one of which is [Smart Manufacturing](#). Smart Manufacturing is a concern of the [Smart Manufacturing Leadership Coalition](#), which is comprised of companies, universities, government agencies, etc.

## Manufacturing R&D

There are several notable documents addressing manufacturing R&D in the United States, both emanating from government and academia.

2012 – Executive Office of the President/PCAST

- [Capturing Domestic Competitive Advantage in Advanced Manufacturing](#)

2014 – Executive Office of the President/PCAST

- [Accelerating U.S. Advanced Manufacturing](#)

2013 – MIT/Production in the Innovation Economy (PIE)

- [Trends in Advanced Manufacturing Technology Innovation](#)

In the 2012 report “[Capturing Domestic Competitive Advantage in Advanced Manufacturing](#)”, the AMP Steering Committee recommends increasing R&D funding in eleven “top cross-cutting technologies”.

- Advancing Sensing, Measurement, and Process Control (including Cyber-Physical Systems)
- Advanced Materials Design, Synthesis, and Processing
- Visualization, Informatics, and Digital Manufacturing Technologies
- Sustainable Manufacturing
- Nanomanufacturing
- Flexible Electronics Manufacturing
- Biomanufacturing and Bioinformatics
- Additive Manufacturing
- Advanced Manufacturing and Testing Equipment
- Industrial Robotics
- Advanced Forming and Joining Technologies

While the technologies highlighted are not accompanied by detailed roadmaps, the list arises from consultations the committee had with key stakeholder groups, including the AMP Steering

Committee itself, AMP Steering Committee Regional Meeting participants, and members of MAPI, the National Center for Manufacturing Sciences (NCMS) and the Association of Public and Land-grant Universities (APLU).

The more recent document, [Accelerating U.S. Advanced Manufacturing](#), follows up on this call to increase R&D Funding in top cross-cutting technologies, noting that the Administration's proposed \$2.2 billion in advanced manufacturing R&D in FY13 Budget represents a nearly 20% increase over the prior year. The latest report also stresses the importance of coordinating R&D in advanced manufacturing as part of the national strategy, e.g., within manufacturing centres of excellence.

Published by the Massachusetts Institute of Technology as part of their Production in the Innovation Economy (PIE) study, [Trends in Advanced Manufacturing Technology Innovation](#) is a chapter summarising trends in technology R&D "that relate to the current and future state of advanced manufacturing". This work identifies seven key manufacturing technology categories.

- Nano-engineering of Materials and Surfaces
- Additive and Precision Manufacturing
- Robotics and Adaptive Automation
- Next Generation Electronics
- Continuous Manufacturing of Pharmaceuticals and Bio-Manufacturing
- Design and Management of Distributed Supply Chains
- Green Sustainable Manufacturing

This document expands further to compile a list of 24 technology areas related to manufacturing.

#### Manufacturing Process Innovation

- Rapid Prototyping
- Coatings
- Continuous Process Control
- Flexible Electronics
- Semiconductors
- Printed Electronics
- Manufacturing/refining of biofuels
- Pharmaceutical and Medical
- Optoelectronics and Photonics

#### New Materials and Multi-Scale Mfg

- Material Genomics
- Composite Materials
- Lightweight Material
- Meta-Materials

#### Automation and Precision Manufacturing

- Smart Automation
- Advanced Robotics
- Precision Manufacturing

#### Manufacturing Systems

- Supply Chain and Logistics
- IT for Manufacturing
- Adaptive and Flexible Manufacturing
- Mfg Simulation and Visualization

#### Sustainability in Manufacturing

- Mfg using recycled materials
- Energy efficient manufacturing

#### Measurement and Testing

- Advanced Sensing

- Advanced Metrology

It is noteworthy that within the US system, the government and its advisors set priorities that do not entirely align with academic studies of the manufacturing R&D landscape, though close scrutiny of the lists reveals a fair degree of commonality.

## Appendix 1

### Key Documents

#### 2009

Executive Office of the President

- [A Framework for Revitalizing American Manufacturing](#)

#### 2011

Executive Office of the President/PCAST

- [Ensuring American Leadership in Advanced Manufacturing](#)

National Economic Council/Council of Economic Advisers/OSTP

- [A Strategy for American Innovation: Securing our Economic Growth and Prosperity](#)

#### 2012

Executive Office of the President/NSTC

- [A National Strategic Plan for Advanced Manufacturing](#)

Executive Office of the President/PCAST

- [Capturing Domestic Competitive Advantage in Advanced Manufacturing](#)

#### 2013

Executive Office of the President/NSTC/AMNPS

- [National Network for Manufacturing Innovation: A Preliminary Design](#)

Gene Sperling – Director, National Economic Council

- [The Case for a Manufacturing Renaissance](#)

#### 2014

Executive Office of the President/PCAST

- [Accelerating U.S. Advanced Manufacturing](#)

### Key Federal Agencies

- Advanced Manufacturing National Program Office
- Department of Commerce
- Department of Defense
- Department of Energy
- Executive Office of the President
- National Aeronautics and Space Administration
- National Institute for Science and Technology
- National Science Foundation
- National Science and Technology Council
- Office of Science and Technology Policy
- President's Council of Advisors on Science and Technology

### Universities/Think Tanks

- [MIT](#)
  - [Technology Review](#)
  - [Industrial Liaison Program](#)
- [Georgia Tech](#)
  - [Georgia Tech Manufacturing Institute](#)
- [Carnegie Mellon University](#)

- [Research for Advanced Manufacturing in Pennsylvania](#)
- [Brookings Institution](#)

## Appendix 2

### NNMI – Manufacturing Innovation Institutes

Name	National Additive Manufacturing Innovation Institute (now known as <a href="#">America Makes</a> )
Established	August 2012
Lead	<a href="#">National Center for Defense Manufacturing and Machining (NCDMM)</a>
Location	<a href="#">Youngstown, Ohio</a> (part of “TechBelt” Cleveland to Pittsburgh Corridor)
Consortium	94 members (includes manufacturers, universities, community colleges, and non-profit organizations)
Activities	Additive manufacturing, 3D printing technologies. Hopes to foster collaboration in design, materials, technology, workforce and more.
Federal funding	\$50 million (matched by institute partners)
Name	<a href="#">Next Generation Power Electronics Manufacturing Innovation Institute</a>
Established	January 2014
Lead	DoE, <a href="#">North Carolina State University</a>
Location	Raleigh, North Carolina
Consortium	25 members
Activities	Energy-efficient, high-power electronic chips and devices; wide bandgap semiconductor technologies
Federal funding	\$70 million (matched by partners)
Name	<a href="#">Digital Manufacturing and Design Innovation Institute</a>
Established	February 2014
Lead	DoD, <a href="#">UI Labs</a>
Location	Chicago, Illinois
Consortium	73 members
Activities	Advanced design and manufacturing tools
Federal funding	\$70 million (more than matched by non-federal partners)
Name	<a href="#">Lightweight and Modern Metals Manufacturing Innovation Institute</a>
Established	February 2014
Lead	DoD, <a href="#">EWI</a>
Location	Detroit, Michigan
Consortium	60 members
Activities	Develop processes that accelerate scale-up of production of lightweight alloys
Federal funding	\$70 million (matched by non-federal partners)
Name	<a href="#">Institute for Advanced Composites Manufacturing Innovation</a>
Established	January, 2015
Lead	DoE, <a href="#">University of Tennessee-Knoxville</a>
Location	Knoxville, Tennessee
Consortium	122 companies, nonprofits, and universities
Activities	Develop new low-cost, high-speed, and efficient manufacturing and recycling process technologies that will promote widespread use of advanced fiber-reinforced polymer composites.
Federal funding	\$250 million - \$70 million in federal funds and more than \$180 million in non-federal funds

**Upcoming IMIs**

Name	Clean Energy Manufacturing Innovation Institute
Lead	DoE
Activities	Composites Materials and Structures
Federal funding	\$70 million
Name	Biomanufacturing innovation institute
Lead	Department of Agriculture
Activities	
Funding	