Support for the Manufacturing Universities Act of 2015

Recommendations for Leadership, Metrics and Execution

Position Paper

Support for the Manufacturing Universities Act of 2015 and Recommendations for Leadership, Metrics and Execution

A Position Paper
By the North American Manufacturing Research Institution of SME (NAMRI/SME)

1. Recommendations:

The NAMRI/SME Board of Directors recommends that:

1. **The Manufacturing Universities Act (MUA) of 2015 be passed without delay.**
2. **Fifty (50) awards, of up to $2.5 million per year for four years, should be made through the MUA of 2015.**
3. **A minimum of 1:1 matching funds should be required of universities supported by the MUA as a prerequisite of award.**
4. **Cash matching funds from industry for the MUA should be more highly valued than any other form of match.**
5. **New programs or expansion of underfunded manufacturing programs should be prioritized, but only if the university demonstrates a long-term commitment to manufacturing research and education.**
6. **Established programs with outdated resources should receive the second prioritization in evaluating proposals.**

2. Introduction

Recently introduced legislation in the U.S. Senate would designate up to 25 institutions of higher education as U.S. Manufacturing Universities (USMU), and would receive funding in the amount of $5 million per year for a four-year period. This bill is welcome, and is responsive to the Advanced Manufacturing Partnership Subcommittee of the President's Council of Advisors on Science and Technology's call for greater investment in manufacturing in higher education [1]. Some of the details of the proposed legislation are as follows:

1. The director of the National Institute for Standards and Technology, coordinating with the secretaries of defense and energy, and the director of the National Science Foundation, will select the USMUs.
2. An application by a university will require reporting of important metrics, such as the numbers of students studying manufacturing; the number of current industry-sponsored or joint projects; the numbers of students

obtaining engineering degrees; the percentage of master's or doctoral degrees awarded whose recipients pursued careers in manufacturing and so on.

3. Each application will also need a plan, describing a number of activities:
    a. How the engineering programs will be improved to emphasize manufacturing engineering and associated curricula.
    b. A description of a strategy to increase the number of joint industry projects related to engineering.
    c. A plan to increase the number of students participating in for-credit internships or cooperative education.
    d. How the institution will increase the number of students who are U.S. citizens, or permanent residents, in disciplines related to manufacturing.
    e. A description of how the university will cover the costs of equipment and facilities related to their plan, and how the university will increase funding from industry related to manufacturing.
    f. How the university will increase the number of students who launch a new manufacturing business.
    g. A plan for overseeing interdisciplinary programs related to advanced manufacturing.
    h. Identification of a "chief manufacturing officer" at the proposing university.
    i. The methods the university will use to positively impact local and regional economic development.
    j. A description of how the university will reward faculty for developing new means to interact with manufacturing companies.

The legislation aligns with the recommendations of the AMP 2.0, as outlined in the "Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing" [2]. Specifically, recommendation 11, which reads "The AMP Steering Committee recommends that universities bring new focus to advanced manufacturing through the development of educational modules and courses."

The legislation is also responsive to the detailed AMP subcommittee recommendations on expanding and modernizing the education and workforce development efforts [3].

The legislation calls on the director of NIST to establish and publish guidelines for the review and evaluation of applications.

This position paper is intended to examine the nature of manufacturing at institutions of higher learning, as well as make recommendations for consideration in the execution of this program.

3. Manufacturing in University Programs

3.1 Manufacturing Programs

There are 41 ABET-accredited programs that offer named bachelor's degrees in manufacturing and one master's degree program.[1] The number of named manufacturing engineering programs has been in decline since the 1980s (Figure 1), and of the top-rated universities in engineering listed by U.S. News and World Report, only the University of California at Berkeley; the University of Michigan; the University of California, Los Angeles; and the University of Wisconsin have named offerings specifically in manufacturing engineering, and of these, only UC-Berkeley and UCLA offer bachelor's degrees in manufacturing engineering. A number of other universities have strong manufacturing programs, which are often contained in mechanical or industrial engineering departments. Indeed, according to the U.S. Department of Labor, most engineering graduates have careers in manufacturing, but it is important to note that all engineers design, create and analyze things that are or will be made.

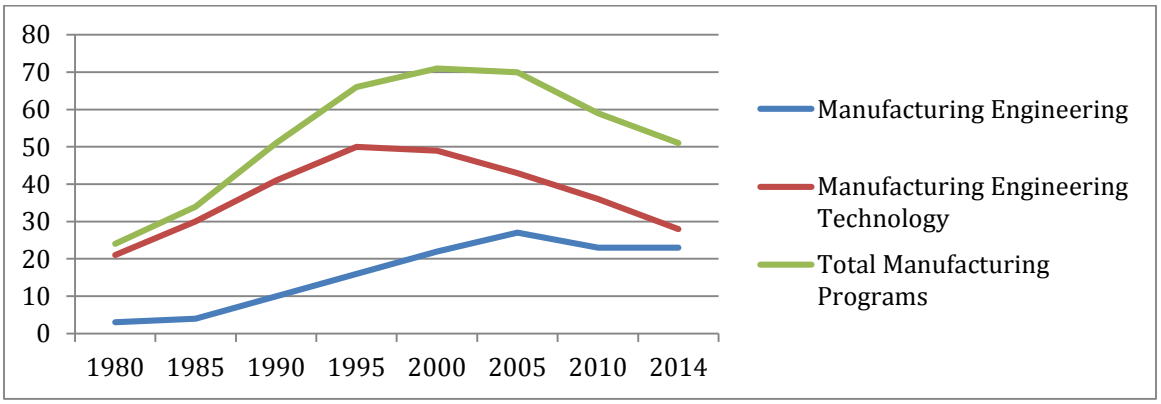

Figure 1: Historical trend of named manufacturing programs in higher education. Source: ABET

3.2 Mechanical Engineering Programs

There are currently 317 ABET-accredited mechanical engineering programs in the U.S., so it is useful to discuss the state of manufacturing education also with respect to mechanical engineering departments.

[1] http://main.abet.org/aps/Accreditedprogramsearch.aspx

Figure 2 shows the breakdown from a review completed by NAMRI/SME of self-reported faculty specialization in the top 20 mechanical engineering departments in the U.S. (based on U.S. News and World Report rankings). Mechanical engineering is a broad discipline, so it is proper that it have a broad representation of sub disciplines among the teaching and research faculty at universities. However, manufacturing is a superset that contains mechanical engineering, electrical engineering, industrial engineering and so on. It is interesting to note that the trends clearly show that manufacturing is less often cited as a specialty than fields such as fluid mechanics, solid mechanics, biomechanics, thermodynamics and control systems; although manufacturing is central to the engineering profession. In biomedical engineering departments, this trend would be reasonable and appropriate; however, the reason for higher emphasis on biomedical engineering as a specialty over manufacturing in mechanical engineering departments is not as clear. Certainly, the trends in faculty do not represent the career opportunities for mechanical engineers, where 41 percent of mechanical engineers work directly in manufacturing industries[2], and almost all are connected to manufacturing in their daily work.

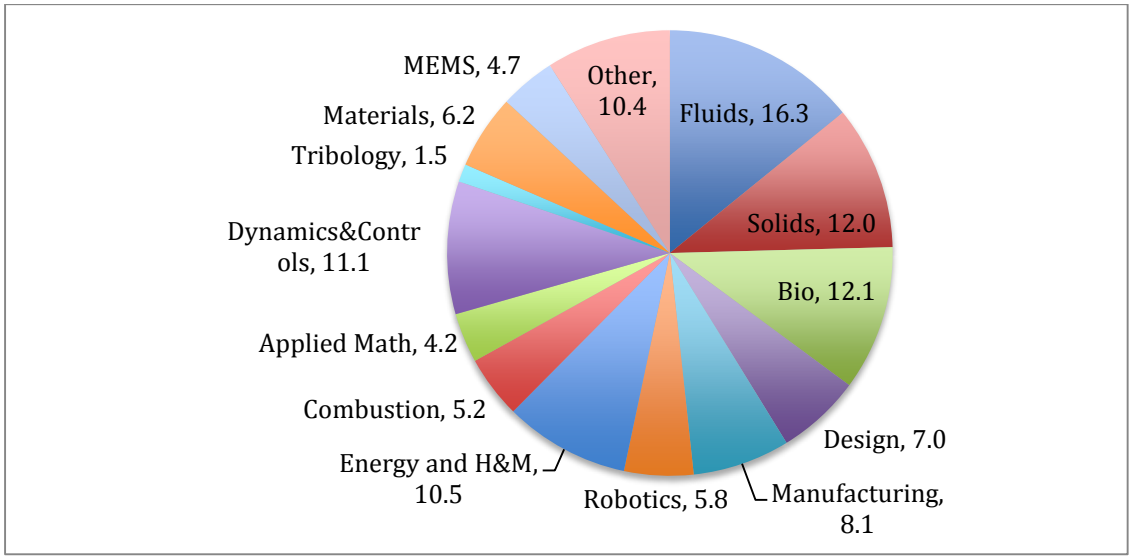

Figure 2: Percent of faculty citing different areas of specialization within mechanical engineering, considering only top 20 ranked mechanical engineering programs.

[2] http://www.bls.gov/ooh/architecture-and-engineering/mechanical-engineers.htm#tab-3

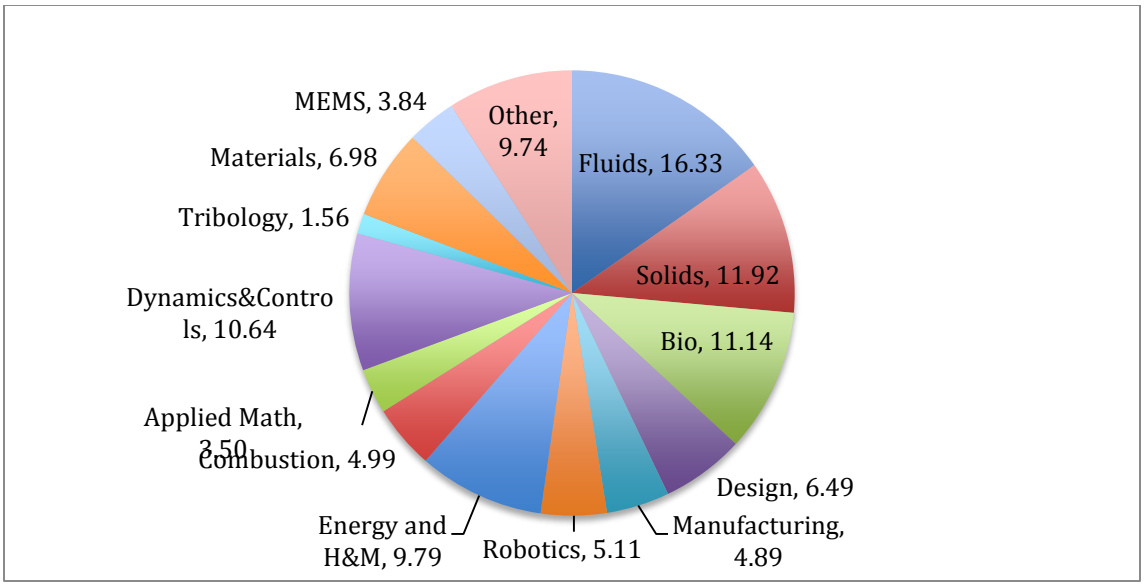

Figure 3: Percent of faculty citing different areas for top 20 ranked mechanical engineering programs, while eliminating the impact of the top five schools with named manufacturing degrees.

The under recognition of the importance of manufacturing found in NAMRI/SME's review of self-reported faculty specializations is of further of concern when one realizes that the faculty who cite manufacturing as a specialty are concentrated at a few locations and that the field is not broadly recognized within engineering curricula. If one excludes the University of Michigan, the University of Texas, the University of California and Carnegie-Mellon University, the distribution of engineering faculty naming manufacturing as a specialty is as shown in Figure 3. The underrepresentation of manufacturing as a cited specialty at the highest-ranked universities is alarming and representative of the lack of emphasis of manufacturing in mechanical engineering education. Certainly, the representation of faculty is not aligned with the skills needed and applied by practitioners of mechanical engineering. NAMRI/SME's research found three of the top 20 mechanical engineering departments have no faculty that reported specializing in manufacturing — a situation that is certainly cause for concern.

4. Discussion

Clearly, named manufacturing programs are very few in number, and a study of manufacturing education cannot be based on a study of just 41 named bachelor-level programs. Because manufacturing is generally taken as part of mechanical engineering, NAMRI/SME's review of the top-rated ME programs determined that manufacturing representation among faculty is much less than the number of graduates that pursue careers directly in manufacturing (8 percent versus 41 percent). Manufacturing is not universally valued; most schools in the top 20

mechanical engineering programs have significant underrepresentation in manufacturing faculty.

The motivation for the faculty ratios are understandable, and are the results of research funding policy enacted by the main sources of government funding: the National Institutes of Health, the Defense Advanced Research Projects Agency, the Advanced Research Projects Agency-Energy and the National Science Foundation. University metrics, especially national ranking, depend strongly on the ability to attract research funding. While the FY 2016 budget request of the NIH is $31.3 billion,[3] the FY 2016 budget request for the NSF is just $7.7 billion, of which only $222.7 million is planned for the Civil, Mechanical and Manufacturing Innovation program – not all of which goes to manufacturing specifically.[4] Under these conditions, it is astounding that any faculty specializing in manufacturing are retained at all. Tenure and promotion prospects are directly linked to external research funding.

The national imperative is demonstrable and pressing. Numerous studies, including Deloitte's 2015-25 manufacturing skills gap outlook,[5] have shown a prolonged shortfall of experienced manufacturing practitioners, even in a time of prolonged unemployment. PCAST [2] studied the university system and concluded that the size of universities was proper, but that a greater emphasis on manufacturing was warranted.

The MUA is therefore a welcome and essential legislation that can play a role in correcting the underrepresentation of manufacturing within engineering.

Therefore, the NAMRI/SME Board of Directors recommends that the MUA of 2015 be revised and passed without delay to offer 50 awards of up to $2.5 million per year for four years.

While there are many valid reasons for enacting the MUA of 2015, the most compelling is the reestablishment of manufacturing infrastructure in the U.S. to secure the crucial talent pipeline for advanced manufacturing. However, manufacturing occurs everywhere; it is taught at many kinds of universities, large and small, public and private. Manufacturing infrastructure is needed everywhere. The awards proposed in the MUA are of a size and duration that promote a significant investment in the manufacturing infrastructure; however, the awards are of limited impact because there are so few of them.

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[3] http://www.nih.gov/about/director/budgetrequest/fy2016testimony.htm

[4] http://www.nsf.gov/about/budget/fy2016/pdf/19_fy2016.pdf

[5] http://www2.deloitte.com/us/en/pages/manufacturing/articles/boiling-point-the-skills-gap-in-us-manufacturing.html

With manufacturing taking place everywhere; there is a danger that these awards will be concentrated in certain types of universities that do not have a real impact on the manufacturing infrastructure. Therefore, there needs to be more awards than the 25 suggested, supported by a reduction of funds to each recipient with additional offsetting matching funds being required to secure the award.

While this arrangement would provide one-half of the original award amount per institution from the MUA, there will be twice as many awards, of the same duration, without a reduction of funding thanks to the match requirement.

Some universities have thriving programs with preserved strengths and facilities that have long been nurtured; supporting such programs with MUA funds is proper. There are many others that have not maintained manufacturing strengths or that abandoned those activities for financial reasons. Naming them "Manufacturing Universities" could have a beneficial infrastructure effect, but only if such recognition catalyzes a long-term commitment of support for manufacturing at that university. The National Network for Manufacturing Innovation program has demonstrated the concept that matching funds are made available when a problem is deemed important. This program has proven to be extremely successful and has established that the federal investment can be leveraged using state, industry and private matching funds.

The NAMRI/SME Board of Directors recommends that a minimum of 1:1 matching funds be required of universities supported by the MUA as an award prerequisite.

Matching funds can be generated from state and local governments, industry partners and private sources. Matching can be in the form of cash, equipment, personnel and other resources.

The NAMRI/SME Board of Directors recommends that a cash match from industry for the MUA be more highly valued than any other form of match.

Among these sources, a cash match from industry sources is the strongest recognition of the value of a university's graduates to the U.S. industry.

5. Metrics

The MUA of 2015 gives considerable discretionary power to the director of NIST to establish guidelines for the evaluation of the universities. The metrics that need to be reported as part of a MUA proposal have been listed in Section 2. This section addresses the NAMRI/SME position on prioritization of metrics.

Proposals to be named a manufacturing university can be weighed using a variety of metrics, including those mentioned in Section 1 above. The characteristics of the universities can also vary from established manufacturing universities with long histories to universities starting new manufacturing programs to universities trying to revitalize neglected manufacturing infrastructure. All are worthy of support under this program. The NAMRI/SME Board of Directors suggests the following prioritization of metrics:

1. Amount of cash match from industrial partners. This is the strongest statement from industrial partners that the manufacturing university is already providing value to the industry through education, research, workforce development and so on.
2. Cash match from any other source. This indicates the level of support from the state, local government or other community partners for the program at the manufacturing university.
3. In-kind match from industrial partners. All manufacturing universities need up-to-date equipment, materials, supplies, space, meaningful interaction with industry personnel, software, training materials and so on. These items are valuable and an indication of industry support.
4. Identification of a "chief manufacturing officer" at the university to coordinate and develop the manufacturing activities at the university.
5. In-kind match from any other source. This would include commitments for new faculty positions in manufacturing areas, new buildings, laboratories, support staff, travel support and so on.
6. The level of industry-sponsored, manufacturing-related research funded at the university over the past decade.
7. The quality of the plan to improve the level of manufacturing-related funded research over the coming decade.
8. The level of manufacturing-specific content in the curriculum and the integration of a design-and-build philosophy throughout the curriculum.
9. The quality of the plan to improve the manufacturing and design-and-build philosophy throughout the curriculum.
10. The demonstrated and/or planned collaboration with NIST Hollings Manufacturing Extension Partnership programs.
11. The demonstrated and/or planned collaboration of community colleges and universities around manufacturing (e.g., sharing of equipment and facilities).
12. The demonstrated and/or planned emphasis on the interdisciplinary nature of manufacturing education through co-listed courses, co-taught courses and so on.
13. The demonstrated and/or planned inclusion of manufacturing-based capstone projects.
14. The number of faculty directly working in manufacturing-related areas.
15. The quality of the plan to increase the number of faculty directly working in manufacturing-related areas.

16. The number of U.S. citizen and/or permanent resident students participating in manufacturing-related cooperative education and/or internships.
17. The quality of the plan to increase the number of U.S. citizens and/or permanent resident students participating in manufacturing-related cooperative education and/or internships.
18. The number of all students participating in manufacturing-related cooperative education and/or internships.
19. The quality of the plan to increase the number of all students participating in manufacturing-related cooperative education and/or internships.
20. The number of manufacturing startup companies created based on university manufacturing research and development over the past decade.
21. The quality of the plan to increase the number of manufacturing startup companies based on university research and development.
22. The quality of the plan for other methods where the university will positively impact local and regional economic development
23. The quality of the reward structure for faculty that develop new means to interact with manufacturing companies.
24. The depth and breadth of the plan. For example, nurturing of manufacturing at multiple departments and at undergraduate and graduate levels should be recognized and rewarded; basing a plan on the broad field of manufacturing on an overly focused area should not take be permitted.

The NAMRI/SME Board of Directors recommends that new programs or expansion of underfunded manufacturing programs be prioritized, but only if the university demonstrates a long-term commitment to manufacturing research and education.

At the same time, established programs will have a difficult time expanding their manufacturing enrollment or course/degree offerings, but could have outdated laboratories and equipment that provide limited opportunities for relevant education.

The NAMRI/SME Board of Directors recommends that established programs with outdated resources receive the second prioritization in evaluating proposals.

6. Conclusion

The MUA of 2015 is a welcome and timely, if not late, initiative for rebuilding manufacturing education and research presence in US. institutions of higher education. The NAMRI/SME Board of Directors recommends it be passed without delay.

References

1. President's Council on Advisors on Science and Technology, "Report to the President: Accelerating U.S. Advanced Manufacturing." (AMP 2.0 Report), Office of the President, Oct. 2015.
2. PCAST, "Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing." (AMP 1.0 Report), Office of the President, July 2012.
3. PCAST, "Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing, Annex 3: Education and Workforce Development Workstream Report." Office of the President, July 2012.