Workshop: U.S.-Germany Collaborative Research in Advanced Manufacturing in Herndon, VA, USA
April 2 - 4, 2019

Final Report

Barbara Linke, Peter Groche, ZJ Pei, Petra Wiederkehr, Tobias Siebrecht
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EXECUTIVE SUMMARY

To utilize overlaps and synergies in advanced manufacturing research between the United States and Germany, two workshops were conducted to analyze challenges and opportunities for joint research between researchers of both nations. Following the first workshop in February 2016 in Darmstadt, Germany, five pilot projects have been funded by National Science Foundation (NSF) (through the Manufacturing Machines and Equipment program) and Deutsche Forschungsgemeinschaft (DFG) (through the Engineering Sciences 1 Program). The second workshop was held in April 2019 in Herndon, Virginia, USA and revised findings from the first workshop, identified best practices of collaborations, provided a forum for networking, and formulate recommendations. It connected 14 researchers from Germany, 19 researchers from the U.S., 4 representatives from DFG, and 6 representatives from NSF. Through presentations on the five pilot projects, input from NSF and DFG program directors, two keynote presentations, and several group work sessions, administrative aspects of joint projects, research needs, and broader impacts were worked out. Seven action items were formulated as stated in section 3.3 of the report.

1 Workshop Objectives

The United States and Germany rank among the world leaders for technological sophistication, high technology product development and advanced manufacturing activity. Both countries have strong support for scientific and engineering research, and there are significant overlaps and synergies between the funded research portfolios. Both National Science Foundation (NSF) and Deutsche Forschungsgemeinschaft (DFG) recognize the importance of advanced manufacturing to the future prosperity of their respective countries, and maintain healthy manufacturing research portfolios. Advanced manufacturing has the largest economic multiplier of any sectors in a modern economy, making this sector essential for economic prosperity. Further, manufactured products drive exports for both countries, and therefore infrastructural needs are similar. That is, a well-trained workforce, engineering sophistication, computer integration and advanced technologies are needed in both Germany and the US. However, there are few avenues where mutually beneficial research topics can be identified and jointly funded.

The first workshop was held in February 2016 in Darmstadt, Germany, funded by NSF and DFG. The workshop identified potential areas for collaboration, investigated challenges and proposed opportunities for joint research between researchers from the U.S. and Germany. As a result, five pilot projects have been funded by NSF (through the Manufacturing Machines and Equipment program) and the DFG (through the Engineering Sciences 1 Program).

This second workshop brought together advanced manufacturing researchers from the U.S. and Germany, with the following objectives:

(1) Revise and update research needs in advanced manufacturing as outcomes from the first workshop.
(2) Revise and update needs, gaps and challenges facing advanced manufacturing.
(3) Identify best practices of collaboration as well as administrative / organizational / structural challenges observed by researchers in both countries for U.S.-German collaboration, with a focus on collaboration in the past 4 years.
(4) Formulate recommendations for expanding and formalizing future joint research initiatives.
(5) Provide a forum for researchers from the U.S. and Germany to network and develop future collaborations.

2 Workshop Overview

The second workshop was held in Herndon, VA, USA from April 2 – 4, 2019 with 43 participants. The list of participants and detailed agenda can be found in the Annex. Different work sessions (with all participants and in break-out groups) reviewed the findings of the ongoing NSF/DFG pilot projects on advanced manufacturing, discussed administrative aspects of joint international research, highlighted research needs in keynote presentations, discussed research needs in advanced manufacturing and broader impacts of joint research.

2.1 Pilot projects

After the first workshop, both funding agencies agreed to handle the pilot proposals as follows: Proposals must be written in English; Proposals must be written according to the NSF proposal guidelines; Proposals must be submitted to NSF and DFG (with the proposal No. given by NSF); Additionally, the German applicants must submit an overview about the requested funding to DFG (according to the DFG proposal guidelines – chapter 4ff). Review of the proposals was conducted using the panel review procedure of NSF with the condition that at least one of the reviewers must be an elected member of the corresponding DFG scientific review committee.

By the time of the second workshop, five pilot projects on advanced manufacturing have been funded so far. Each project was introduced and discussed.

1. *Fundamental Study of Ultra-Precision Machining and Near Surface Damage Evolution in Single Crystal Fluorides for Advanced Optics*

Don Lucca, Oklahoma State University, NSF Award #1727244
Oltmann Riemer, Ekkard Brinksmeier, Laboratory for Precision Machining (LFM) at the University of Bremen, DFG Project Number 87318746
The central research goals are to develop new fundamental understanding of both the nature and extent of subsurface damage introduced into single crystal CaF2by ultra-precision (single point diamond) machining and establish a quantitative link between spectrally resolved optical performance and subsurface damage. Several PI visits have been performed and exchange lectures were given in both countries. Outreach activities have targeted at the International School of Bremen and resulted in programs aimed at 8^{th} grade students (Cubes in Space). Further videos developed are aimed at K-5 students (Professor Lichtstrahl).

2. *Understanding the Prime Factors Driving Distortion in Milled Aluminum Workpieces*

Barbara Linke, Michael Hill, University of California Davis, NSF Award #1663341
Jan Aurich, University of Kaiserslautern, DFG Project Number 351381681
The main research goal is to understand the main factors and mechanisms that drive machining distortion, and explore the use of models for prediction and control. It was stressed that the project has a beneficial integration of complementary partner expertise, where German and U.S. teams have unique strengths and

deep expertise. Monthly video conferences, face-to-face meetings and research visits are important for the project communication.

3. Interaction of Tool Wear and the Machining Affected Zone in Nickel-Based Superalloys

Laine Mears, Farbod Akhavan Niaki, Clemson University, NSF Award #1760809
Petra Wiederkehr, TU Dortmund, DFG Project Number 400845424
The objective of this research project is to decouple the variability in tool wear evolution models through a novel experimental procedure, and to relate wear and machining parameters to the plastic deformation layer (Machining Affected Zone, MAZ) depth in nickel-based superalloys. The project team set-up NAS data services for data exchange and storage and highlighted that the codes and data will change during the project and researchers need access to the latest version.

4. Laser Finishing of the Multi-Scale Surface Structure of Additive Manufactured Parts

Frank Pfefferkorn, University of Wisconsin-Madison, NSF Award #1727366
Frank Vollertsen, Bremer Institut fuer angewandte Strahltechnik, DFG Project Number 386371584
The goal of this research is to generate fundamental new knowledge that will improve surface finish and mechanical properties of additively manufactured metallic parts through the application of laser remelting. The positive aspects of collaborative international research were highlighted, such as learning foreign research culture, getting input from an outside perspective with inside knowledge, and having access to resources (people & equipment) available at other institutes. Students benefitted from learning to do things themselves in the U.S., whereas research in Germany is supported by technicians. There is a transition time when students travel which disrupts the work flow. Living arrangements for 3-month stays can be hard to make.

5. Next Generation Deep Drawing Using Smart Observers, Close-Loop Control, and 3D-Servo-Press

Brad Kinsey, University of New Hampshire, and Yannis Korkolis, Ohio State University, NSF Award #1727490
Peter Groche, Production Technology and Forming Machines (PtU) Institute at the Technische Universität Darmstadt, DFG Project Number 386415239
The objectives of this research are to (i) exploit the flexibility of a 3D servo-press to improve the formability of sheet metal components (ii) establish the scientific understanding to identify non-linear deformation trajectories for process improvement, (iii) investigate an acoustic emissions (AE) sensor to predict failure in sheet metal components, and (iv) create a framework for smart factory process implementation and benefits. It was highlighted that the benefits of collaborative research occur for several stakeholders: professors, who build international reputation, post-docs, who increase their international career opportunities, PhD students, who can access specialized equipment, and students, who get exposed to collaborative classes and exchange opportunities.

Conclusion

All projects showed that unique expertise and facilities at two (or more) partner institutions were utilized. There can be a misconception that the German partners are doing more experiments and the U.S. partners doing the analytical and basic research, which can come from the good availability of industrial equipment at the German partners. This is not confirmed with the five projects, since expertise is complimentary.

It was discussed that sometimes starting dates of DFG and NSF funding can be different up to 6 months. These misaligned project starting dates can complicate reporting and milestone completion.

Visa problems for international participants were highlighted. This includes getting visa initially processed for international students to come to the U.S. or problems or insecurities during re-entry into the U.S. Time to degree is different for students in both countries (obtaining a PhD after a MS degree, it takes 3 – 4 years in the U.S. versus five or more years in Germany).

It became evident that joint proposals are easier if the PIs know each other from conferences, keynote papers or scientific associations. Also exchange of researchers helps proposal writing.

2.2 Administrative aspects of joint projects

2.2.1 Comments from NSF and DFG

The NSF directors highlighted that the new Advanced Manufacturing (AM) program has open submission windows and is also open to 4 or 5 year proposals since collaborative research takes time. As always, the budget needs to be right-sized. NSF can also allow no cost-extensions for existing projects. DFG can only allow projects to last for up to 3 years; after that period a new or renewal proposal has to be written and approved. DFG can allow no cost-extensions for existing projects too.

It was emphasized that the DFG and NSF reviews of pilot project proposals were well aligned and proved that strong similarities exist in the intellectual merit and broader impacts definitions of both agencies and reviewers.

2.2.2 Group work

The "lessons learned" and "best practices" of collaboration as well as administrative challenges were discussed in five groups. The groups were set-up in advance to achieve highest diversity and ensure a mix of researchers, who do not work with each other in the pilot projects. Three questions were prompted and answered as follows.

A. What is the benefit of joint projects?

- The major benefit seems to be to have complementary people, skills, expertise and facilities. The different expertise and knowledge converge in the project, e.g. modeling approaches converge with experimental research. It is beneficial to have different views on the same topic and be able to reflect on one's own activities. Basically, the joint projects give more results (and potentially higher quality results) than two separate projects, in particular, multiple fundamental phenomena can be researched at the same time.
- The joint projects allow the use of unique equipment to the other researchers.
- The researchers experience immersion in the other culture (not only socially but as a research mentality) and learn about what is important on the other side. The cultural competency and understanding also increase.
- Students involved in joint projects gain international experience, expand their reference network, and have access to unique equipment and expertise. Postdocs or early career faculty can make contacts for new positions or tenure processes.

B. What are best practices of person and knowledge exchange?

- For a successful **proposal,** preliminary data, a detailed work plan and expected big leap in knowledge are beneficial. The proposal should be submitted on the same date with the full project budget, two-page CV and current and pending support (as requested by NSF).
  It has been found very effective if researcher exchange happens to develop the proposal.

- The **project start** should be synchronized. It should also be possible to delay project starts to prepare and recruit, because up to 6 months might be needed at the project start to hire a researcher or find a suitable student.
- **Exchange stays** seem to work very well for senior students without class obligations. Since travel can create potential timing concerns, such as with coursework, thesis completion, other travel, etc. Long-term travel generates sometimes hesitation. It is beneficial to not plan first research exchange until the second half of the first year. Furthermore, staggered exchanges of 3 months each seem to be beneficial.
  It is advised to have a good strategy for arranging visits (including visa/ ESTA, living arrangements, etc.). At some U.S. universities, international researchers need a J1 visa to use research facilities.
  If students take classes, they need to register and a Memorandum of Understanding (MOU) between the universities may be needed. In Germany, some engineering courses are also available in English. Benefits could come from sharing online training across partners.
  Language training (in particular German) has not been found necessary for research and is hard to fit into the student curriculum, but is good for social integration.
- During the project, regular **communication** in the form of monthly webinars and face to face meetings (needing international travel) are best practices.
- Challenges come from different constraints:
  - It has to be noted that the project duration is shorter than a PhD program in both countries, so the scope is shorter than a PhD thesis and the students have to include other research.
  - It can be challenging to synchronize research, since U.S. students have coursework and they might finish their PhD faster if they have already obtained an MS degree, whereas German PhD students are full time engineers with an MS degree. They usually take 5 or more years to finish the PhD.
  - Cultural misalignment can happen between researchers of both nations. For example, the direct German style can lead to misunderstandings. It might be a point of discussion how to co-author papers (e.g. with respect to leadership, list and order of authors).
  - The administration of international exchanges by admin staff can be time-consuming and should be documented, e.g. to arrange living, registration, visa.
- It is strongly desired that the NSF/DFG joint-project funding will persist within NSF and DFG.

C. What are urgent topics for joint research?

Some attendees pointed out that the topics should be not constrained, but open to all that need collaboration of U.S. and German researchers. An alphabetical list of urgent topics includes the following:

- Additive manufacturing
- Aging population, products, scale-up biomedical applications
- Artificial Intelligence (AI) / machine learning for manufacturing
- Climate change / energy efficiency
- Energy efficiency / (Efficiency) (manufacturing for everyone) (alternatives) (resources) (sustainability) / Climate change
- Future of work
- Get Computer Science (CS) /Machine Learning (ML) into manufacturing
- Industry 4.0, data science in manufacturing
- Manufacturing as a service
- Metamorphic manufacturing (see The Minerals, Metals &Materials Society (TMS) report), manufacturing on demand

- Mobility
- Physics based hybrid with AI / ML
- Quantum industry / technology
- Space / low gravity environment
- Urban / distributed manufacturing

Further comments were mentioned to include The International Academy for Production Engineering (CIRP), the Manufacturing USA network, and experts from non-manufacturing fields, such as computer science and engineering. More urgent topics will be discussed at workshops by NSF, DFG, and other agencies (such as the Air Force Research Laboratory (AFRL), the German Academic Association for Production Technology or the Academies of Science). Another idea was to build a task force for topic identification for the benefit of collaboration.

2.3 Keynote presentations

Two keynote presentations on *Advanced Manufacturing Initiatives in the U.S.* by Prof. S. Smith, Group Leader for Machining and Machine Tool Research at Oak Ridge National Laboratory, and *IoP - Internet of Production* by Prof. C. Brecher, Spokesperson of Cluster of Excellence EXC 2023, Laboratory for Machine Tools and Production Engineering, RWTH Aachen University, were given to further stimulate technical discussions. The PPT files of these two presentations are in the Annex.

2.4 Research Needs

The group work in Section 2.2 identified several topics for research in advanced manufacturing. Four groups around the following topics were generated: Additive Manufacturing (Group 1), machine learning (Group 2), Sustainability (Group 3), and manufacturing in new environments (Group 4). The workshop participants chose a group and discussed three questions: (a) What is the benefit of joint research for each topic? (b) Which disciplines should be involved? and (c) What are optimum models for collaboration? The results for questions (a) and (b) are summarized for each group, results for question (c) are bundled for all groups.

Group 1: Additive manufacturing / Metamorphic manufacturing, manufacturing on demand

Additive manufacturing (AM) and metamorphic manufacturing are defined as flexible and incremental manufacturing strategies. This area includes many disciplines, such as mechanical engineering, materials science, design, quality and statistics, control, machine learning, and computer science. Research needs and benefits include handling and post-processing of AM parts in the process chain, understanding of scale up and volume production, prediction and modeling of AM processes, in particular with regard to the sensitivity of process outcomes to process variables. Reducing support structures needs to be investigated. Machines need tobe developed as open architecture machines. Wireless microsensors are needed as well. Multi-material AM parts provide additional challenges. The Digital Thread of product information needs integrative software, high volume machine equipment, and quality control procedures. Voxel-based modeling is an appropriate research area. A need is there to have First Part Good production with high repeatability and reproducibility.

Group 2: Artifical Intelligence (AI) / machine learning for manufacturing, Physics based hybrid with AI / machine learning, Industry 4.0, data science in manufacturing

For the fields of AI and machine learning in manufacturing, several disciplines should be involved, in particular computer science, social sciences, educational sciences, law for safety concerns and unions, production engineering, electronics and mechatronics, as well as math and statistics. The fields need to engage computer science in the relatively small data of manufacturing, create data repositories, establish consistent frameworks for data like MT Connect, generate case studies to demonstrate benefits of AI in manufacturing, provide smart machine tools and human machine interactions, and provide clear explanation of what data will be used for what. Challenges are to convince companies to share data, make business models to sell and buy data, change the culture of the shop floor to motivate workers to use smart machines, and engage workers in data processing and process adjustments.

Specific benefits of joint research include again the shared and convergent expertise. Moreover, companies in the field are international and the interdisciplinary nature will help with acceptance and implementation of this emerging field.

Group 3: Energy eff. / (Efficiency) (manufacturing for everyone) (alternatives) (resources) (sustainability) / Climate change

The field of energy efficiency, critical resources and sustainability would include materials science and economics in addition to manufacturing engineering. Joint projects would result in better understanding and support of resource efficiency policies, sharing of best practices, more far-reaching educational impacts (for example global networks along the product life cycle (PLC)). International projects can tackle global challenges, find global answers and increase global talent mobility. Needs are in finding solutions for difference PLCs, finding substitutional resources and processes, and developing sustainable materials and material combinations.

Group 4: Manufacturing in new environments (Urban /Space / low gravity environment)

The vision for manufacturing in new environments, such as urban settings, space, lunar, martian or other low gravity environments, harsh environments such as underwater, is to enlarge manufacturing to become *ubiquitous production*. This type of manufacturing spans the disciplines of production systems, natural science (physics, chemistry, and more), law, economics, and social sciences. Challenges for manufacturing in new environments arise from the missing infrastructure including electricity, pressurized air, manufacturing equipment, operators, etc. Therefore, models are needed for modular machines and simple machines that can make complex parts. Urban manufacturing is highly dependent on infrastructure, which might age fast and need high maintenance. Therefore, new logistics and smart repair are paradigms to investigate. Important benefits of joint research are to be competitive with China and other upcoming international regions. Identical standards can be developed, risks are mitigated, expertise and costs are shared and bundled. Many of the applications are naturally global projects.

Results on best practice for collaboration

Good collaboration projects need common goals and complementary expertise (e.g. in the process chain). Good practices are data sharing, exchanges between labs with minimal institutional input (research only), inclusion of industrial partners and benchmark studies. Interdisciplinary research could focus on the application, such as aerospace or biomedicine.

Larger interdisciplinary teams with 4 – 8 Principal Investigators (PIs) would improve the scalability of the research. Projects could be conducted on a center level instead of individual PI projects, as it is done in the Priority Program of DFG.

To bring experts together, a joint workshop could be organized, resulting in white papers, which can be expanded to state-of-the-art papers. In this way, commonalities for basic research would be found and specific conferences could be organized after the congress.

Further ideas are to hold a Blue Sky competition (competition with revolutionary ideas) to stimulate international research. Also, international collaboration could be emphasized more in NSF CAREER proposals.

2.5 Broader Impacts

The workshop participants discussed broader impacts of international joint projects in the same predetermined groups as in Section 2.2. Four questions were prompted and discussed as follows.

A. How to extend joint projects?

The German-U.S. collaboration can be expanded beyond the five pilot joint projects currently funded. For example, it can be extended by a larger number of proposals and funded projects, by an extension of project durations, and by a higher number of PIs per project. The following opportunities were discussed:

- When all involved research groups present research results, they should briefly introduce the funding scheme. This can help increase the visibility of the funding opportunities.
- Communication of project results could be strengthened. The project teams could present to other research groups or hold joint workshops (focused on specific topics, at 2-4 universities, optionally industry would be invited). Formal visits of researchers at an U.S. institution is already supported by DFG. Also, supplemental funding of existing projects is possible through NSF. Presentations and lectures could be video recorded and shared.
- Collaborating teams can submit proposals based on ideas from the current projects. This can strengthen the established collaboration between U.S. and German research groups. It would be beneficial to bring forward new, aligned ideas from past projects.
- The transfer of results from basic research to application is of great importance to the participants. It was discussed that DFG has Transferprojekte (transfer projects) and NSF has the Partnership for Innovation program. Option 1 could be to combine an NSF GOALI proposal and a DFG Normalverfahren proposal (but the project will need to explore new ideas). Option 2 could be a DFG Transferprojekt, where an industry partner must cost share the research efforts. The project scope is a continuation of a previous project. Option 3 could be for the German or U.S. researchers to partner with a company with locations in Germany and the USA and to propose a DFG Transferprojekt and/or NSF GOALI project respectively.
- Bigger projects (even at a center level) with more collaborators would be appreciated. Larger projects would allow to add expertise and people. The DFG Priority Program provides a great model, where specific topics are investigated with coordinated multi-location funding.

B. How are the careers of people involved affected?

Joint projects can affect the career of people on all levels.

- In general, joint international publications, awareness of other communities and systems, deeper understanding of the international partners, their perspectives and way of working, research thinking and teaching, improved understanding of scale-up, research directions, opportunities, collaboration skills, learning best practices from other institutional models, a broadened mind-set toward future international collaboration, international visibility and benefits when applying for international jobs are important benefits of joint international projects.
- U.S. domestic and European students get valuable international experience.

- Due to the intrinsic international perspective joint U.S.-German projects offer unique selling points for junior faculty.
- PIs and senior personnel can expand their network of colleagues and work on projects that cannot be done at their home institution (e.g. due to missing facilities or specific expertise). By working with new people, new ideas can be generated and established ways of doing research and teaching can be scrutinized.
- The joint projects establish international and collaborative role models for students, faculty and society at large. All researchers involved (PIs, staff and students) become advocates for global collaboration.

C. How to transfer results to industry?

- Research results can be disseminated through workshops (e.g. subject focused), open houses, presentations, conferences, social media / online videos, presentational fairs, special information session at a conference, workshop or meeting with industrial participants, or articles in manufacturing magazines. Further dissemination and awareness could be facilitated through the Fraunhofer Gesellschaft and Manufacturing USA institutes.
- Start-ups (include business mind-set, NSF TTP, PFI) or transfer projects (GOALI / DFG transfer projects) would bring results into industrial practice.
- Industry should be involved in the research projects at different stages. Best practices include agreement on research prior to proposal submission and MOU between entities for technology transfer projects.

D. What are broader impacts?

- **Educational impacts** are evident, if findings of projects are included in student education. Moreover, international projects offer possibilities for global classrooms and lectures. An example for joint courses was given from Institute for Production Engineering and Forming (PtU) at TU Darmstadt and The University of New Hampshire. Also, high school students and teachers should be taught about new STEM related knowledge from the projects.
- The projects often result in **personal growth** for students, faculty, and the community. For example, both sides experience other side's scientific culture, get to know new research, institutions, and companies. Researchers build international relations and the personal growth is not just career-related.
- **Diversity and synergies** are important impacts. Joint research looks like the connected world we live in. Further broader impacts are related to including underrepresented groups in the research.
- **Technical and industrial impacts** include the research results, industrial awareness in both nations, and further outreach through open houses at the research labs or universities.

3 Conclusions

3.1 Comments from workshop participants

At the end of the workshop, every participant was asked to give some feedback. The response was very positive and several benefits were pointed out. Many participants said that it was helpful to see the results and ongoing work of the ongoing collaborative projects. This included their focus and structure, their content, and first results, but also the different kinds of practical problems and the different ways of handling them.

Several participants highlighted the great potential of the workshop for talking about future collaborations and identifying the research needs from a high-level perspective. The framework given by the DFG/NSF

was perceived as a good instrument for collaborating and writing common proposals. However, it was also emphasized that its success depends on the will of the participants to submit project proposals. There was a lot of positive feedback on seeing the support of the funding organizations. It was also mentioned that the workshop was a good opportunity to understand the different perspectives of NSF and DFG in more detail. It was pointed out that a lot of work and persistence was required by the organizations in order to make the collaborative projects possible and the funded projects show the good results of this effort. A strong need to continue this work was identified.
Beside the potential collaborations, the various opportunities for networking and meeting new people were beneficial for many participants. In this context, the similar mindsets between the U.S. and Germany was highlighted and many participants said that this is a valuable friendship and that both sides can profit from learning from each other. The NIST tour was received well and also the dinner was a good opportunity for discussions. One participant mentioned the wish to further involve industry.
In conclusion, the workshop was received very well and some significant process was seen by the participants.

3.2 Closing remarks from organizers and funding agencies

With the pilot projects a successful framework has been set in place. Clearly, a great friendship between the U.S. and German researchers can be experienced and a great commitment of the funding agencies is obvious. From the researchers' perspective, the new framework should be continued and enlarged with existing funding opportunities. Frequent workshops would be beneficial to allow continued exchange between researchers and funding agencies, to bring scientists together and to react to new tasks and initiatives in the scientific communities. With continuous changes in the agencies and in society, new colleagues have to be informed and potential changes for joint projects need to be continuously accommodated. The longevity of this program needs to be ensured and everyone has to stay engaged.

3.3 Action items

1. Information about the opportunity of U.S. – German joint projects should be distributed in both academic communities of advanced manufacturing technology (such as ASME Manufacturing Engineering Division, SME, WGP, VDI, CIRP). The joint proposal opportunity between NSF and DFG is appreciated.
2. Joint projects need some additional efforts to fully exploit the potential of international collaboration. This includes administrative work, physical exchange but also project communication and marketing and measures to activate the potentially significantly broader impacts on society and students. The necessary time requirements should be considered during the project planning and evaluation.
3. Joint workshops should be organized also in the future. They allow a wider bridging between different stakeholders in advanced manufacturing. Especially junior faculty should have the opportunity for matchmaking. Future workshops could be combined with conferences that are of high interest for many scientists in advanced manufacturing like MSEC/NAMRC.
4. Lessons learned and best practice examples from joint projects should be collected and distributed further. International researchers face similar problems with regard to visa, housing, matchmaking, etc. It would be appreciated to have streamlined strategies for those problems. Also technical training, e.g. from sharing online training across partners, can be streamlined for higher synergies.
5. The evaluation procedure for joint proposals as well as the administration of the projects is considered as very helpful and efficient. A continuation of the implemented procedures seems beneficial.
6. Opportunities for an extension of joint projects to a larger scale (like priority programs or collaborations of multiple U.S. and German groups) should be probed. In this case the review procedure has to be evaluated separately before by the funding agencies.

7. This program can benefit junior faculty. They do however need matchmaking opportunities with international experts. This could be provided through workshops, initiation/seed funding, more targeted information sessions e.g. at MSEC/NAMRC, IMECE. There should be more opportunities to work beyond established connections through CIRP or the NSF/DFG workshops.