

Forging Industry Technology Roadmap

2016 Revision



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Forging Industry Educational and Research
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EXECUTIVE SUMMARY

The forging industry has achieved an essential place in the North American industrial economy by producing components with unique benefits that are difficult to duplicate. The strength, reliability, and durability of forged components have made them the preferred choice in a variety of industries for applications where fatigue life and fracture toughness are critical for human and equipment safety considerations. Despite the fact that these industries have come to depend on it as a key supplier, the North American forging industry faces an increasingly dynamic and challenging business landscape.

In order to maintain a strategic, proactive approach to positioning the forging industry for the future, the Forging Industry Education and Research Foundation (FIERF), under the auspices of the Forging Industry Association (FIA), sponsored a workshop in May 2008 to update the Forging Industry Technology Roadmap. The workshop brought together key members of the forging industry and academia to identify major challenges facing the industry and to determine research, education, and other development priorities that are needed to overcome them. The recast foundation of that workshop formed the basis for the *2008 Forging Industry Technology Roadmap Update and this 2016 Roadmap Revision*.

The 2016 Roadmap Revision redefines a growth and development strategy to ensure that the forging industry is positioned to move into a future in which forging firms not only survive, but thrive and grow. Figure 1 presents a high-level picture of the structure and content of the 2016 Roadmap Revision.

VISION

The forging industry first established its vision for the future in the original *1997 Forging Industry Technology Roadmap*, and reiterated the same vision in the 2003 and 2008 updates. In 2016, the industry's original vision remains: a future in which **the forging industry is a world leader in customer-focused, efficient, and cost-effective supply of high-quality components**.

MAJOR DRIVING FORCES

To achieve its vision, the forging industry must navigate a dynamic market and business landscape that has been and will continue to be shaped by a number of external driving forces. These forces create both obstacles and opportunities for the forging industry as it pursues its vision. They include:

- **Fluctuating economic & market conditions** – The forging business is sensitive to economic and market conditions that are notoriously unstable, such as energy costs, currency exchange rates, demand driven by financially vulnerable manufacturing sectors (automotive, aerospace, etc.), and metal supply. To cope with unpredictable changes, forging firms are pressured to be more lean, resilient, flexible, and adaptable.
- **Accelerated technological change** – Forging is a technology-dependent business that can be drastically affected by scientific breakthroughs and innovation. New advancements can present new threats or new opportunities, making the future less predictable. While this increases the risk attached to R&D investments, obsolescence or simply falling behind remains a constant threat. Forging firms are pressured to be innovative and technologically up-to-date with limited capital resources.
- **Intensified global competition** – For the forging industry, global competition means more than the competition from forging firms in other countries. It refers to all firms and industries, as well as supply chains, that seek to offer an alternative to domestic forged components, including component manufacturers who employ different value added strategies as well as different methods of metal processing (e.g., casting, high speed machining, additive manufacturing technologies, etc.) and different materials (e.g., plastics).

- **Increasing customer demand** – Increased customer demand puts a premium on both continuous improvement and continuous innovation. It pressures the industry to produce forged components that maintain the traditional benefits of strength, reliability, durability, and affordability, while offering new benefits.

STRATEGIC IMPERATIVES

Individual forging companies not only compete among themselves, but also as an industry against alternatives to forged metal components. To reach its vision, the forging industry must become stronger and more competitive *as an industry*. Four strategic imperatives have emerged to meet this competitive challenge.

- **Operational excellence** –Improving current practices, methods, techniques, and processes of forging. It asks, “What do we currently do and how can we do it better?” The continuous enhancement of operational excellence is the starting place and foundation for becoming more competitive.
- **Capability development** –Looking behind the activity to the skills, expertise, and know-how that enables the activity—from what we do to what we know. It asks, “What do we currently know and what else could we know in the future?” This is a critical next step in becoming more competitive, because it speaks to the industry’s ability to adapt and pursue new markets.
- **Collaborative partnerships** –Represents a shift from an inward to a more outward focus moving toward a vision which will require the coordinated participation of multiple stakeholders. It asks, “What could we know and do together?”
- **Product and market innovation** –Focusing on the relationship with customers. It asks, “How well do we serve our customers, how might we serve them better, and who else might we be able to serve?” This imperative represents a more deliberate and systematic customer focus at an industry level.

MAJOR CHALLENGES

Pursuing the strategic imperatives will require the industry to confront several major challenges. The challenges are organized into seven areas that provide a useful overview of the nature and scope of the issues facing the industry. Consistent with the previous roadmaps, the forging industry faces a number of research and technical challenges involving materials, energy, and forging technology. The industry also faces broader business issues involving labor, government, the environment, and market issues. The challenges in these areas require the industry to move beyond technical problems and deal with matters of education, perception, and influence.

ACTION PRIORITIES

The most critical part of the roadmap is the determination of specific activities that address the major challenges and move the industry along the path toward its vision. The activities identified distinct action agendas in the following areas:

- **Improve market positioning** – Pursue a closer connection to customers; look for ways to collaborate, rather than compete, with forging firms outside North America; Develop business tools that help individual firms deal with market instability.
- **Develop current and future workforce** – Continue building strong relationships with educational institutions; strengthen placement opportunities for graduates; develop better programs to train current and future workers; and execute a serious and sustained recruitment effort to attract and retain talent within all facets of a forging enterprise.

- **Advocate public policy agendas** – Improve the industry’s public image; implement targeted lobbying efforts; and build political influence.
- **Establish industry guidelines and best practices** – Implement a data-gathering effort to compile a library of best practices; and establish a common set of guidelines around forging operations and outputs.
- **Enhance material options and usage** – Develop better ways to minimize and process material waste in the forging process; and work collaboratively to enhance the range of material options available to the forging industry.
- **Reduce energy usage per unit of manufacture** – Find ways to reduce energy usage within the forging process.
- **Advance forging technology** – Pursue greater automation of the forging process; develop new lubricants that can improve die life; and generate innovations in the tools, equipment, and process of forging.

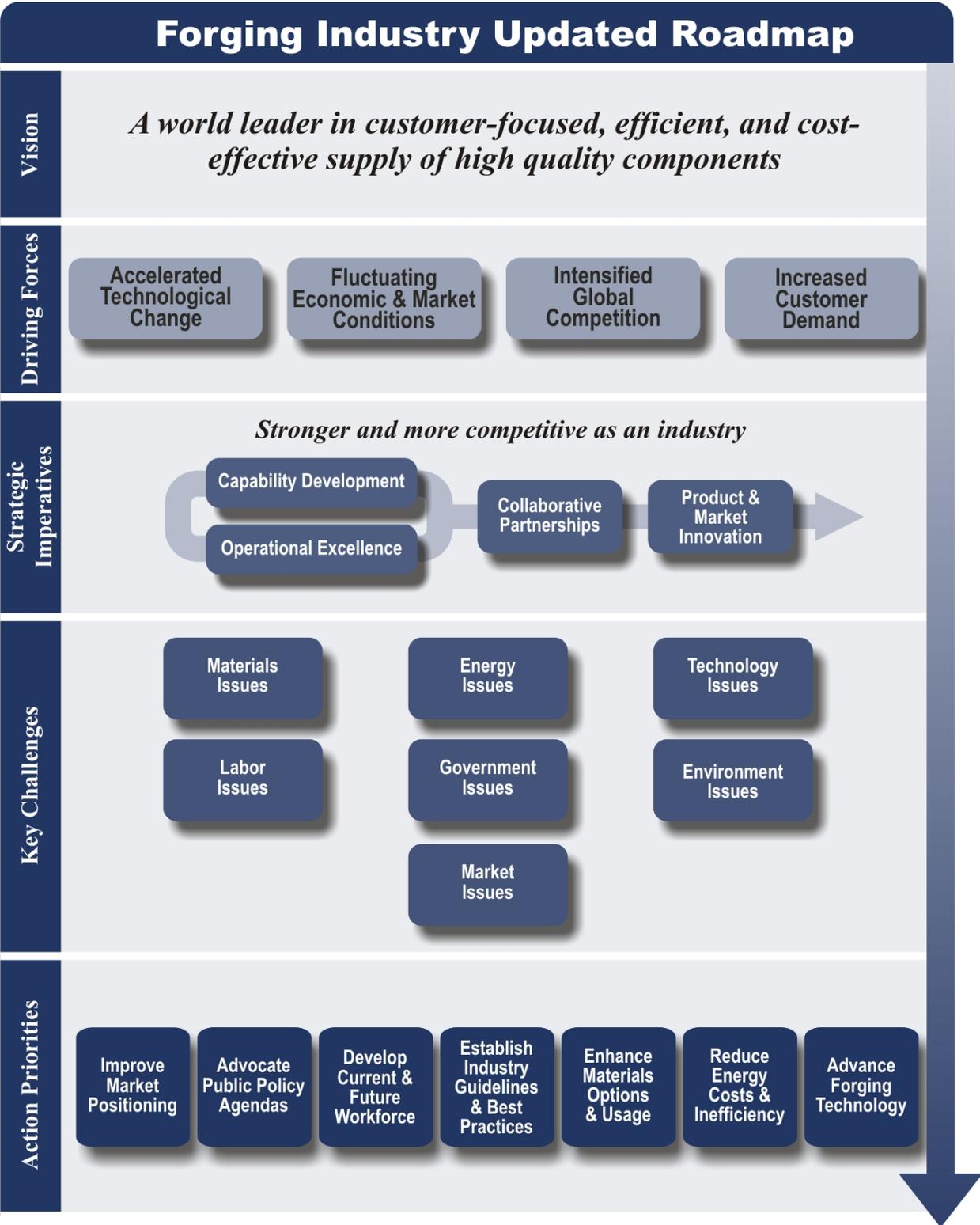
PATH FORWARD

The path to achieving the forging industry’s bold yet realistic vision is filled with competitive challenges as well as opportunities. Industry-level action that is decisive and strategic will enable the industry to move forward immediately and effectively. The industry has identified a diverse range of research, development, education, and other pursuits that could be undertaken as part of its strategic response. Five actionable items merit the highest priority in achieving the industry’s vision:

Highest Priority Activities

- Build real relationships with high schools, technical colleges, magnet schools and local communities to develop skilled workers for all facets of the forging enterprise
- Develop a low-cost, highly thermally efficient, environmentally friendly heating source
- Challenge equipment suppliers to bring new technology to industry and FIA/FIERF and encourage members to adopt new technology
- Benchmark the global industry and competing industries for best practices in enterprise and technological innovation
- Develop improved automation and process sensors

Figure 1: Roadmap Structure & Content



I. OVERVIEW

INTRODUCTION

In 1997, the Forging Industry Association (FIA) and FIERF worked with the U.S. Department of Energy's Office of Industrial Technologies (now the Industrial Technologies Program, or ITP) to create the *Forging Industry Technology Roadmap*. The Roadmap outlined a collaborative industry-wide vision of the future forging industry and presented R&D priorities needed to achieve that vision. In 2003, FIA/FIERF led an effort to update the Roadmap in light of new market realities and the progress that the industry had made toward its vision. To ensure that the industry maintains an up-to-date, proactive, and forward-looking strategy for the future, FIA/FIERF initiated a second update effort in May of 2008. This 2016 update to the Roadmap encompasses the changing environment due to global trade and technological advancement.

VISION

The 1997 roadmap was based on a vision of the future in which *the forging industry is a world leader in customer-focused, efficient, and cost-effective supply of high-quality components*. This vision was reiterated in the 2003/8 update of the *Forging Industry Technology Roadmap*. In 2016, this vision remains as compelling and relevant a destination as it was almost twenty years ago.

DRIVING FORCES

To achieve its vision, the forging industry must navigate a dynamic market and business landscape that has been, and will continue to be, shaped by a number of external driving forces. These driving forces create both obstacles and opportunities for the forging industry as it pursues its vision. They include:

- **Fluctuating economic & market conditions** – The forging business is sensitive to economic and market conditions that are notoriously unstable, such as energy costs, currency exchange rates, demand driven by financially vulnerable manufacturing sectors (automotive, aerospace, etc.), and metal supply. To cope with unpredictable changes and market instability, forging firms are pressured to be more resilient, flexible and adaptable, while maintaining their traditional qualities of reliability, unwavering quality, and cost efficiency.
- **Accelerated technological change** – Forging is a technology-dependent business that can be drastically affected by scientific breakthroughs and innovation. New advancements can present new threats or new opportunities, making the future less predictable. Technological change has a disruptive influence that increases the risk attached to R&D investments, and makes obsolescence or simply falling behind a constant threat. Forging firms are pressured to be innovative, and technologically up-to-date with limited capital resources.

Purpose of an Industry Roadmap

An industry roadmap is an organizing framework for strategic action at an industry level. Roadmaps are based on a logic that allows an industry's vision of the future to be linked to concrete action in the present.

Within the overall structure of a roadmap, the vision provides the destination. The driving forces describe the terrain, strategic imperatives, major challenges, and key activities mapping out the best path to the destination.



A roadmap is based on the input of experts and leaders, both inside and outside of the industry. A completed roadmap represents the industry's collective wisdom about how it should position itself for the future. An industry roadmap enables the future by inspiring participation, attracting external resources, and stimulating and focusing action.

- **Intensified global competition** – For the forging industry, global competition refers to more than the competition from foreign firms—it refers to all firms and industries that seek to offer an alternative to forged components. This includes component manufacturers who employ different methods of metal processing as well as those who use different materials (e.g., plastics).
- **Increasing customer demand** – The forging industry must deal with a customer who is more demanding, in terms of price and quality and of new functionalities and applications. Increased customer demand puts a premium on both continuous improvement and continuous innovation. Forgers are pressured to provide components that maintain the traditional benefits of strength, reliability, durability, and at the same time offer new benefits and new functionality.

STRATEGIC IMPERATIVES

Attaining the vision amid a landscape shaped by these driving forces is an undertaking that must be pursued by the forging industry as a strategic whole. In today's globalized business landscape, individual forging companies not only compete among themselves, but also as an industry against alternatives to forged metal components.

To reach its vision, the forging industry must become stronger and more competitive *as an industry*. Four strategic imperatives have emerged to meet this competitive challenge: **operational excellence, capability development, collaborative-public partnerships, and product and market innovation**. These imperatives provide an organizing framework for aligning and cross-leveraging separate action initiatives, and are the subject of Chapter 3.

II. CHALLENGES & ACTIVITIES

This Roadmap informs and facilitates the industry's path forward by identifying the particular challenges facing the forging industry and determining the range of research, education, and other activities needed to overcome those challenges.

CHALLENGES

Our membership has identified many challenges the forging industry faces today. A content analysis of these items revealed seven overall challenge areas that provide a useful overview of the nature and scope of the issues facing the industry. The challenge areas, along with the corresponding challenge items, are displayed in Appendix A. These results indicate that the forging industry is facing a broader range of challenges. Consistent with the results of previous roadmaps, the forging industry continues to face specific research and technical challenges involving materials, energy, and the forging process itself. However, the industry also faces broader business matters involving labor, government, and the environment, as well as critical customer and market issues. The challenges in these areas require the industry to move beyond technical problems and deal with matters of education, perception, and influence.

ACTIVITIES

The FIERF Trustees reviewed and updated the extensive list of activities needed to overcome the challenges and move the industry along the path toward its vision. These results are presented in Appendix B. Just as the challenge results show the broad range of issues facing the forging industry, the list of needed activities indicates the diverse range of research, development, education, and other pursuits that could be part of the industry's strategic response. In particular, the activities identify specific action agendas in the areas listed below. While all of the action agendas represent important priorities for action, six were indicated as having the highest priority. These six appear in italics.

- **Improve market positioning** – How well the forging industry is positioned in the marketplace affects its ability to adapt to changing market conditions and capitalize on new market opportunities. More importantly, market positioning is about expanding the depth and breadth of the demand for forged components. The activities to improve market positioning in the forging industry identify three key action agendas for the forging industry:
 - Pursue a closer connection to customers, including maintaining a better understanding of changing customer needs and actively managing/shaping customer perceptions and understanding of the benefit and role of forged components in the customer's business.
 - Pursue connections with forging firms in other countries and examine ways to maximize opportunities for collaboration and mutual learning while minimizing the occurrence of direct competitive battles.
 - Develop business tools that help individual firms deal with market instability.
- **Develop future workforce** – The development of the future workforce is an investment in the long-term future of the industry. It is directly related to the industry's ability to remain technologically current and ensures the capacity and capability to meet future customer demand. It also provides the foundation for developing new and more robust capabilities that enable the industry to expand its market by serving a wider range of customer needs, and determines the quality of technological and product innovation within the industry. The activities to develop the future workforce identify three key action agendas for the forging industry:

- Expand/personalize our collaborative relationships with educational institutions.
 - Implement sustained recruitment efforts (especially in schools and universities) designed to attract talent to the industry.
 - Work with universities to establish projects, internships and apprentice programs.
- **Develop current workforce** – The development of the current workforce is an investment in the near-term capacity and capability of the industry. It is directly related to the industry’s ability to remain competitive and technologically current over the near-term. It also ensures that the industry is able to maintain quality and productivity standards and meet shifting levels of demand. The activities to develop the current workforce identify two key action agendas for the forging industry:
 - Develop the programs and resources to retrain employees to use new technology and to support improved or redesigned manufacturing processes.
 - Find ways to better retain talented people and expand the labor pool for new hires.
 - **Advocate public policy agendas** – Advancement of the industry’s public policy agendas affects the degree to which public policy supports or inhibits the industry’s competitiveness and operational freedom. In particular, it influences the level of regulatory control and administrative bureaucracy with which forging firms must contend. It also affects the level of government support and funding directed to R&D efforts that could benefit the forging industry. The activities to advance public policy agendas identify two key action agendas for the forging industry:
 - Support our focused political strategy to build influence and direct targeted lobbying initiatives.
 - Implement a public relations effort to raise awareness and improve the industry’s public image. This effort should also support the effort to raise critical awareness of the manufacturing industry in general.
 - **Establish industry benchmarks and best practices** – Establishing industry benchmarking and best practices will enhance the industry’s overall level of performance, and in turn its reputation for both quality and efficiency. Established benchmarks and best practices also provide a basis for improving communication, collaboration, and trust with both suppliers and customers. Equally important, they are a necessary requisite for developing robust, world-class capabilities that can sustain a competitive advantage in the global marketplace. The activities to establish industry benchmarks and best practices identify two key action agendas for the forging industry:
 - Update our data gathering effort to benchmark best practices for the portfolio of issues or operations that affect our industry.
 - Update the Guidelines for Forging Process Tolerances and make available to all interested parties.
 - **Enhance material options and usage** – Materials represent the most significant cost factor in forging operations and have a direct link to the bottom line profitability of the forging industry. At the same time, materials are a significant factor in determining the properties and functionality of forged components. Material options and usage, therefore, also affect the industry’s potential for product innovation and its ability to provide new benefits to customers and pursue new markets. The activities to enhance material options and usage identify three key action agendas for the forging industry:
 - Develop better ways to optimize process material waste in the forging process.
 - Work within the supply chain to improve efficiency in material logistics.

- Work through partnerships and collaborative efforts to enhance the range of material options available to the forging industry.
- **Reduce Energy Costs & Inefficiencies** – Energy, particularly as it is used in heating material for forged components, is another cost factor in forging operations. Energy inefficiencies adversely affect bottom-line profitability and make the industry more vulnerable to unstable energy prices. Efficient energy usage could help reduce the industry’s environmental impact. The activities in this area expressed a single agenda:
 - Find ways to reduce costs and inefficiency around the use of energy within the forging process, including developing better heating systems, using alternative energy sources, maintaining better control, and improving energy management of forging operations themselves.
- **Advance Forging Technology** – The technological enhancement of the forging process itself continues to be an important part of the industry’s path into the future. On one hand, it is an avenue by which the industry may pursue continuous improvement in quality and productivity, and achieve cost reduction goals. On the other hand, technological enhancement of the forging process may also lead to new capabilities and the ability to meet new customer needs. The activities in this area identify key technology agendas for the forging industry:
 - Research/Analyze emerging technologies that impact forging process and product. (i.e. Additive Manufacturing/3D Model/Print)
 - Pursue innovations in all aspects of the forging process, as well as, the processes and logistics of the entire supply chain.
 - Develop new tool materials and invoke process modeling to reduce die cost. (i.e. Integrated Computational Material Engineering (ICME))
 - Develop new lubricants/application methods that can improve forging process control. (i. e. Robotics)

HIGHEST PRIORITIES

As stated above, each action agenda represents an important priority for action, although six were identified as having the highest priority. For each of these six action agendas, there is a single activity item that stands out as a more specific focus and starting place for implementation. The top priority action agendas with the corresponding activity items are shown below (see Appendix B for the complete list of activity items).

<u>Top Priority Action Agenda</u>		<u>Specific Activity Item</u>
<i>Pursue collaborative relationships with educational institutions</i>	➔	Build real relationships with high schools, technical colleges, magnet schools and local communities
<i>Develop a focused political strategy to build influence and execute targeted lobbying efforts</i>	➔	Seek government support for unique process improvement investments
<i>Find ways to reduce costs & inefficiency around the use of energy within the forging process</i>	➔	Develop a low-cost, thermally efficient, environmentally friendly heating source
<i>Pursue innovations in the tools, equipment, and process of forging</i>	➔	Challenge equipment suppliers to bring new technology to industry and to identify the most successful
<i>Implement a worldwide data gathering effort to compile a library of best practices</i>	➔	Benchmark the global industry and competing industries for best practices in enterprise and technological innovation
<i>Pursue greater control of the forging process</i>	➔	Develop improved automation and process sensors

III. STRATEGIC IMPERATIVES

Examination of the identified priority activities reveals four strategic imperatives that cut across the different categories. These imperatives provide an organizing structure that can guide action initiatives to directly aid in achieving the Roadmap vision. Together, the imperatives define a strategy to become *stronger and more competitive as an industry*.

FOUR STRATEGIC IMPERATIVES

- **Operational Excellence** – Action items show a push toward higher levels of operational excellence by improving productivity and efficiency, and reducing costs, waste, and environmental impact. Operational excellence reflects a strategic mindset in which the industry casts a critical eye on the current practices, methods, techniques, and processes of forging. It asks *“What do we currently do and how can we do it better?”* To meet the competitive challenge, operational excellence must be pursued at the industry level as well as the firm level. The continuous enhancement of operational excellence is the starting place and foundation for becoming stronger and more competitive.
- **Capability Development** – Action items also indicate a need to develop and expand capability, both at the industry and firm levels, through workforce development, best practices, technology development, and the pursuit of new markets. Capability development reflects a strategic mindset in which the industry looks behind the activity to the skills, expertise, and know-how that enable the activity. It asks *“What do we currently know and what else could we know in the future?”* This is a critical next step in becoming stronger and more competitive because it speaks to the industry’s ability to adapt and pursue new markets. New capabilities that are hard to imitate enable a sustainable competitive advantage.
- **Collaborative Partnerships** – Action items reveal a need to engage in more collaborative partnerships. Moving toward the vision will require the coordinated participation of multiple stakeholders, including government agencies, academic institutions, customers, suppliers, and even competitors. With both operational excellence and capability development, the focus tends to be inward, with the industry examining itself. Collaborative partnership, on the other hand, reflects a strategic mindset that is more outward looking. It asks *“What could we know and do together?”* This is another critical step toward becoming stronger and more competitive because it allows for more than a purely adversarial conception of business. Government is seen as a research partner rather than indifferent regulator. Foreign firms are seen as potential allies rather than just potential threats.
- **Product & Market Innovation** – Action items show a push toward developing a more deliberate and systematic customer focus at an industry level. Product and market innovation reflects a strategic mindset in which the industry casts a critical eye on the relationship with customers. It asks *“How well do we serve our customers, how might we serve them better, and who else might we be able to serve?”* This is the capstone of becoming stronger and more competitive. It recognizes that value is defined by the customer and that what customers’ desire is always subject to change. To understand and serve migrating customer needs, an industry must be able to reinvent both its product and the relationship it has with its customers.

SUMMARY

The four strategic imperatives provide a dynamic guide to align industry efforts. Operational excellence and capability development establish the competitive identity of the industry. This, in turn, provides the basis for building collaborative partnerships that leverage what the industry knows and can do.

Competence, capability, and partnerships are deployed with and through product and market innovation to enhance the strength and competitiveness of the forging industry in meeting the needs of current and future customers.

Stronger and more competitive as an industry



Together, these imperatives elaborate and clarify what it will take for the forging industry to become stronger and more competitive as an industry. They also provide an organizing framework that shows how different activities fit together.

IV. IMPLEMENTATION

INTRODUCTION

An industry roadmap is an organizing framework for strategic action at an industry level. It is designed to stimulate and focus industry action, enroll and engage stakeholders and potential partners, attract resources, and facilitate the recognition and realization of emergent opportunities. Good roadmaps are both practical and inspiring.

IMPLEMENTING THE CURRENT ROADMAP

There is no one right way to implement a roadmap and no two roadmaps are ever implemented in exactly the same way. Roadmaps are designed to be robust documents that offer a wide range of options for implementation. In fact, any activity, project, or event; any new learning, discovery, or innovation; and any new relationship, meeting of the minds, or deepening of mutual understanding, may be considered implementation if it moves the industry along the path toward the vision.

Below is a list of different ways in which this Roadmap may be used or implemented. It is not an exhaustive list, nor is it a to-do list. Effective implementation may involve any of these options, but certainly not all. This list is offered to stimulate ideas and facilitate the recognition of opportunity when it presents itself.

Reframing & refocusing industry – The results suggest that moving toward the industry vision will require new ideas, new ways of thinking, and new frames of reference. Such a change is likely to come against traditions, implicit assumptions, and entrenched ways of thinking that have developed over a long period of time. Create challenging dialogues—especially among industry leaders—that help the industry to question assumptions and discover new insights.

Building coalitions, relationships, etc., with stakeholders – Collaboration and partnerships are important to achieving a clear and practical picture of the industry’s vision and path forward. Establish common understanding and alignment of interests that are the basis for effective partnerships.

Communication & promotion of industry value and needs – Experience has shown that opportunities and support can come from unexpected sources. Beyond building relationships with specific stakeholders, the industry may also want to promote and market itself in a more general way in order to attract resources.

Implementing specific projects – This Roadmap is, first and foremost, an action planning tool. The activities, action priorities, and strategic imperatives provide an effective basis for designing individual projects, programs, or action initiatives.

It is important to keep in mind that steps forward can be the product of both intention and serendipity. Implementation should strike a balance between stimulating action via a prescriptive action plan and stimulating action via attracting resources and facilitating emergent opportunities.

CLOSING WORDS

The forging industry has a bold and promising vision of the future. Although the journey may currently seem particularly uncertain and difficult, this roadmap suggests that a “circling of the wagons” is not the path forward. Rather, the time is right for the industry to step up to the competitive challenge and move forward with decisive and strategic action.

APPENDIX A: COMPLETE SET OF CHALLENGES FACING THE FORGING INDUSTRY

MARKET ISSUES

- Increasing global competition; increasing gap on skilled labor (very lean technical staff relative to Japan/Germany); advancing worldwide technology; and loss of technology leadership (equipment, automation, maintenance)
- Eroding customer perceptions (e.g., perception of forgings as commodities, not solutions; industry lacks vision and solutions, especially for large forgings; perception of high cost; etc.)
- Slow down of market and potential over capacity (domestic and global)
- Increasing competition from other holistically designed product forms (e.g., casting, machining, additive manufacturing, machined parts from plate, etc.)
- Changes in strength of U.S. dollar
- Market instability and unpredictability due to market bubbles/booms
- Diminishing connection with customers and diminishing knowledge, understanding, experience regarding forging (e.g., perfect vs. practical quality); less appreciation/recognition of advantages of forging
- Increasing competition from other materials

LABOR ISSUES

- Lack of people wanting to work in manufacturing jobs
- Increasing shortage of experienced and technically skilled staff (e.g., engineering, technical and metallurgical talent, product/process designers)
- Technology advancing faster than education and training; lack of adequate technical training programs/materials needed to upgrade/maintain technical workforce; educational systems lack apprenticeships for skilled trades
- Attracting talent to metallurgy
- Marketing manufacturing as a worthwhile career
- Limited exposure to our industry in schools, starting in high school (schools/formal education is deficient in both exposure and skill development)
- Lack of support skills and good front-line supervisors with technical backgrounds
- Need for training to reduce work place injuries
- Increasing labor costs leading to higher overall manufacturing costs (both manual and technically experienced labor)
- Rising health care costs

TECHNOLOGY ISSUES

- Improving energy efficiency of heating
- Reducing costs through optimized material use
- Reducing labor costs through process control
- Forging die materials
- Availability of thermophysical property data
- Developing intelligent sensors for processes
- Need for improved sensor technology
- Ensuring forgers have the correct equipment for future requirements
- Designing safety systems into forging systems
- Driving innovation in the midst of global ownership and global competition
- Temperature measurement
- Cost efficient pre-heat strategies

MATERIALS ISSUES

- Limited availability of some materials
- Dependence on steel and lack of less expensive alternative materials
- Increasing demand for different alloys (rather than steel)
- Significant void in materials research that was done by suppliers in the past
- Process inefficiencies in use of materials; too much waste
- Logistics infrastructure

ENERGY ISSUES

- Rising energy costs
- Process/production inefficiencies in use of energy and lack of knowledge regarding efficient energy use

GOVERNMENT ISSUES

- Low U.S. government recognition/understanding of manufacturing needs and the importance and value of manufacturing; lack of U.S. government support and alignment with goals of industry
- Controlling intellectual property; too much U.S. technology going to Asia
- Government legislation, policies, regulations, trade agreements, etc. that have an adverse impact on forging industry (domestic investment, cost & efficiency, ability to compete globally)

ENVIRONMENTAL ISSUES

- Creating a "Green" working environment and reducing environmental impact inherent in current forging process
- Decreasing tolerance and increasing scrutiny by government, environmental groups, and general public (e.g., environmental and climate change legislation, limits in use of coal, etc.)
- Cost burden of reducing environmental impact inherent in current forging process

APPENDIX B: COMPLETE SET OF RESEARCH, EDUCATION, AND OTHER ACTIVITIES NEEDED TO OVERCOME THE CHALLENGES

(Note: highest priority activities are in bold)

IMPROVE MARKET POSITIONING

- Access technology roadmaps from other countries and identify opportunities to collaborate (versus compete)
- Educate customers about benefits of forging
- Develop and conduct ongoing forging awareness training (e.g., Magnet School projects; ASM Camps; etc.) to improve the "public's" forging perspective
- Keep in touch with customers
- Develop a method to track and forecast industry business cycles
- Re-position forgings as a part of the total product cost, not a commodity

DEVELOP FUTURE WORKFORCE

- **Build real relationships with high schools, technical colleges, Magnet Schools and local communities**
- Encourage high school to teach basic trade skills (e.g., "metal shop")
- Pursue industry/university joint development projects that put students in the field
- Establish partnerships between businesses and schools to create apprentice programs
- Create college and professional internships
- Work with universities and technical schools to improve education quality
- Explain career opportunities in forging industry to young people at younger age
- Sponsor scholarships and expand project opportunities for student engineers
- Create more defined technical engineering functions
- Cooperate with JVS to train/teach "forging"
- Take a forging "road show" to the high schools
- Promote our industry at JVS/high school

DEVELOP CURRENT WORKFORCE

- Evaluate present FIA education/training strategy
- Pursue ergonomic safety solutions to improve working conditions and enhance long-term retainment of labor
- Develop/enhance training for forging workforce, including virtual training (e.g., 3-D modeling), activity-specific training programs, training on tooling failure to reduce cost
- Collaborate with other technology societies on training (e.g., ASM)
- Pursue vendor/supplier partnering to secure technical training by the supplier

ADVOCATE PUBLIC POLICY AGENDAS

- **Seek government support for process improvement investments**
- Promote increased emphasis on math and science education as national priority
- Conduct research and develop publications explaining forging advantages
- Identify government officials that support manufacturing business and the forging industry and promote their election or re-election
- Develop & implement focused lobbying initiatives to eliminate unfair trade practices, update GAAP to be manufacturing favorable, reduce amount of "green" regulations and open available energy resources, reduce healthcare costs
- Educate elected officials

ESTABLISH INDUSTRY GUIDELINES & BEST PRACTICES

- **Benchmark the global industry and competing industries for best practices in enterprise and technological innovation**
- Learn from equipment/ automation practices in other countries.
- Form “strategic alliances” to identify & establish best practices from around the globe
- Identify pros and cons of hot, warm, and cold forging by application and share best practices
- Determine guidelines regarding optimum forging temperatures to ensure optimal energy use
- Consider creating forging standards (e.g., ISO standard, application protocol for product data, etc.)
- Ensure equipment manufacturers are aware of and meeting forging industry requirements/standards
- Build on recent safety survey to identify best practices
- Develop better understanding of overall cost of production and establish cost benchmarks
- Develop guidelines regarding the lowest-cost material for the application (balance alloys for carbon and cost)

ENHANCE MATERIAL OPTIONS & USAGE

- Optimize metal losses in die forging process
- Collaborate with customers to find alternative, lower alloy materials to reduce cost
- Work with American Iron and Steel Institute to determine true ultimate strength of materials to optimize use of expensive alloying elements
- Reduce material waste in the supply chain
- Integrate steel mills with forging processes
- Develop alternatives to higher alloys to reduce surcharge cost for both scrap and alloy
- Develop additional materials that allow forgers to eliminate heat treatment

REDUCE ENERGY COSTS & INEFFICIENCIES

- **Develop a low-cost, highly thermally efficient, environmentally friendly heating source**
- Optimize the heating of the material (process temperature and efficiency)
- Use alternative energy as a means to reduce energy costs
- Partner with energy suppliers to create more efficient heating
- Encourage capital investment in new technology, including technologies to reduce energy consumption
- Develop technologies to recover and utilize low-grade and high-grade waste heat
- Direct industry and government funds towards R&D in heating systems that can reduce energy costs
- Conduct energy audits

ADVANCE FORGING TECHNOLOGY

- Challenge equipment suppliers to bring new technology to industry and FIA/FIERF to identify the most successful
- Develop improved solutions in process sensors
- Reduce time from design to final forged product (“art to part”)
- Apply nano-coatings for die life improvement
- Improve burner design to lower emissions (CO/CO₂/NO_x)
- Improve robotics technologies and their application to forging processes
- Improve diagnostics to reduce maintenance
- Eliminate need for lubricants
- Develop longer-life die materials
- Develop direct quenching and controlled cooling treatment
- Develop affordable retrofit innovations to improve existing technology
- Develop new coating systems to improve die life
- Reduce die costs by using alternative die lubricants
- Pursue methods to reduce carbon footprint
- Improve environmental performance by automation of lubricant application
- Develop near net shape capability to reduce material and energy costs

APPENDIX C: LINKS

[TECHNICAL LIBRARY](#)

After the forging industry first established its vision for the future in the original *1997 Forging Industry Technology Roadmap*, and reiterated the same vision in the 2003, 2008 and current 2016 revision, the Forging Industry Educational and Research Foundation (FIERF) and Forging Industry Association (FIA) have funded, fostered and perused best practice industry research to share with FIA Members and partners. **The Foundation's Library of Technical Papers holds project reports and documents** produced by FIERF Magnet School Professors and Students, Government Labs, research partners and industry experts in pursuit of the vision and roadmap outlined by the industry. All can be found at www.forging.org/producers-and-suppliers/Technology.

[EDUCATION INITIATIVES](#)

The Forging Foundation's Technical Education Initiatives include

- Fostering forging curriculum and experiential training in university engineering departments;
- Providing scholarships to encourage careers in the forging and related industries; and
- Promoting industry awareness and career opportunities to students of all ages.

More information can be found at <https://www.forging.org/education-initiatives>.



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