

# A Vision for the U.S. Metal Casting Industry 2002 and Beyond

May 2002



Cast Metals Coalition



# EXECUTIVE SUMMARY

## VISION

The U.S. metalcasting industry will exhibit increased strength, vitality and innovation, contributing to the nation's economy and security.

## MISSION

The metalcasting industry will communicate its essential value to the U.S economy, improve casting design methods to open new markets and applications, improve the understanding and control of metalcasting processes, and improve alloy and geometry performance, and attract employees and students to the industry.

Achieving the goals outlined below will have the added benefit of improving productivity, energy efficiency, and environmental performance in the U.S. metalcasting industry. Improvements in productivity and operating efficiencies will allow the metalcasting industry to maintain the nominal price of castings even as inflationary pressures increase the cost of labor, equipment and supplies. By 2020, the energy required to produce castings will be reduced by 20% compared to 1998 energy requirements. By 2020, non-recycled solid waste and toxic chemical releases to the environment will be reduced by 25% for a comparable amount of casting production.

## FULFILLING OUR MISSION

**Challenge:** To communicate the essential value of the metalcasting industry to the U.S economy.

**Situation:** Most Americans and many manufacturers are not aware of the importance of the metalcasting industry, and the components it produces, to the U.S. economy, national defense and everyday life.

**Goal:** *By 2020, society will recognize the metal caster as a desirable neighbor, a vital player in the U.S. economy, and a supplier of high-performance components. Metalcastings will solve challenging performance problems in high technology products and regularly demonstrate outstanding value in common applications.*

**Challenge:** To increase the rate and improve the methods of designing castings for new markets and applications while maintaining current markets.

**Situation:** Additional data and tools are needed to improve casting design methods. This includes alloy properties and performance data as well as the accurate simulation of casting performance based on alloy properties, stress levels, and solidification integrity. These improvements can increase the value of metal components, reduce component weight, reduce manufacturing lead-times, and assure product performance. They will assist manufacturers to build better products with less cost and less energy. Finally, they can help the casting industry to meet market demands in the global marketplace and respond to increasing foreign competition.

**Goal:** *Through improved casting design methods, geometry performance, alloy properties, alloy performance data, and casting performance simulation techniques, annual market growth rates for metalcasting shipments (based on value of shipments) will average 3% or more through 2020.*

**Challenge:** To improve metalcasting processes through increased understanding, accurate simulation, more finite real-time controls, and improved operating efficiencies.

**Situation:** Currently, there is a lack of understanding of the thermophysical behavior of alloys in melting, flow, and solidification and tools to accurately simulate these behaviors. There is a need to capture digital, analog, or computer vision signals from all levels of the metalcasting process to provide real time feedback about process status and to provide the ability to correct variances before they become product defects. An appropriate blend of statistical, shop floor layout, computer numerical control, and scheduling techniques is not currently used to optimize operating efficiencies. Effective application of these techniques could radically change the nature of Economic Order Quantities (EOQ's), production release sizes, inventory levels, and delivery performance in metalcasting plants..

**Goal:** *By 2020, the combination of alloy improvements and average melting and mold yield for each metalcasting alloy/process family will increase significantly so that, in aggregate, the metalcasting industry's yields will increase by 20% from current levels. Rejected casting rates will be cut by 40% from current industry averages. OnTime/Complete delivery performance for the full spectrum of order/release quantities will be sustained above 95% across the metalcasting industry while the combination of in-process and finished inventory in metalcasting plants will be slashed 50%.*

**Challenge:** To attract students to the metalcasting industry and retain the brightest, most productive employees.

**Situation:** A shortage of people entering the U.S. metalcasting industry and fewer schools offering related curricula and training threaten the competitiveness of the industry.

**Goal:** *By 2020, growth in the metalcasting markets and applications will strengthen the related curricula of at least 5 leading U.S. metalcasting R&D universities, add at least 3 new ones, and add at least 100 high school and/or vocational metalcasting programs across the U.S. Metalcasting related product design, process engineering, and production will be among the top 10 career choices of U.S. engineering and vocational graduates.*

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In 1988, the three leading technical societies of the U.S. metalcasting industry formed the Cast Metal Coalition (CMC) to foster the research and development needed by the industry. The member societies of the CMC are the American Foundry Society, North American Die Casting Association, and Steel Founders' Society of America. Through the CMC, the metalcasting industry came together in 1995 to identify common challenges, common goals, and pre-competitive research needs. They were outlined in a unified vision *Beyond 2000: A Vision for the American Metalcasting Industry*. Since that time, the Vision and a subsequent roadmap have guided research sponsored by the CMC. Revolutionary improvements are helping to increase productivity and energy efficiency. In performing this research, the CMC worked closely with the U.S. Department of Energy. That collaboration has since expanded to include the Environmental Protection Agency and the U.S. Department of Defense.

Recognizing the accomplishments of the partnership and the changes that have occurred in the industry, the CMC is updating its Vision. In October 2001, the CMC organized a two-day Vision Workshop where leaders from the metalcasting industry and government identified common goals and a unified vision for the future. This document represents the results of that workshop.

# INDUSTRY OVERVIEW

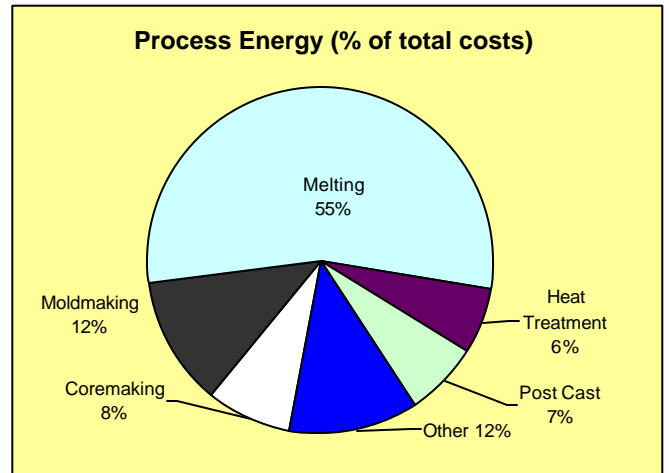
Metalcasting enables the production of simple and complex parts that meet a variety of needs. It is the most cost effective method to manufacture a shaped metal component. The process consists of pouring molten metal into a mold containing a cavity of the desired shape. Metalcasting is one of our Nation's oldest and most important industries. It was established in the U.S. in 1642. In 1776, seven foundry men signed the *Declaration of Independence*. Today, this small business industry is helping to fuel our Nation's prosperity into the 21<sup>st</sup> century. Metalcasting is vital to our economy and security. The industry helped the U.S. become the world benchmark in manufacturing, science, medicine, and aerospace and is helping it to sustain this position.

## Backbone of the U.S. Economy

In addition to transportation, aerospace, and defense cast metal products are found in virtually every sector of the economy including energy exploration and conversion, mining, construction, maritime, fluid power, instrumentation, computers, and myriads of household products. Cast metal components include: engine blocks; suspension parts for railcars, trucks, and autos; Fluid flow and power components, including valves, pumps, faucets, pipes, and fittings; mining, and oil field, and energy producing equipment; surgical equipment and prosthetic devices; and components for many of the household and electronic devices we all use everyday. Markets for products containing metalcastings are increasingly competitive and manufacturers are placing greater emphasis on high-quality, competitively priced castings, delivered in smaller quantities more frequently

The future holds great promise for the metalcasting industry. New advances have allowed the industry to employ materials such as aluminum, magnesium, titanium, zinc, advanced copper-based, and advanced ferrous alloys to produce thin wall, high-strength castings with higher precision castings and more complex shapes. But to remain competitive and maintain a viable domestic industry, challenges must be overcome in industry recognition, casting design, processing efficiency, and employment attractiveness.

Increasingly, the U.S. metalcasting industry will need to reduce its cost of production to remain competitive with global competitors. As long as non-U.S. manufacturers are able to benefit from low-cost labor and lax environmental constraints, U.S.



## Facts About Metalcasting

*90% of manufactured goods contain one or more metalcastings.*

*U.S. casting shipments totaled 14.3 million tons in 2000.*

*The U.S. is the world's leading casting producer with 21% of world casting markets.*

*The metalcasting industry consumes 328 trillion Btu annually.*

*Annual energy costs in metalcasting are over \$1 billion\*.*

*Energy used in casting is equivalent to residential energy consumed in New Hampshire, Rhode Island, New Mexico, Wyoming, and Hawaii combined.*

*There are approximately 2,950 metalcasting companies in the U.S.*

*The industry employs about 225,000 people.*

*Most metal casters are small businesses, of which 94% employ less than 250.*

*Leading metalcasting states include: Alabama, Indiana, Illinois, Michigan, Ohio, Pennsylvania, and Wisconsin.*

manufacturers will be at a disadvantage. Dramatic increases in U.S. metalcasting product and process technology are the economic answer to commodity castings produced outside the U.S.

### **Small Business Industry**

The majority of metal casters are small businesses. They are not positioned to perform the research necessary to remain competitive. Collaborative research partnerships such as the Cast Metal Coalition, which bring together industry, academia, and government, are proving vital to conducting the research needed to raise the technology of U.S. metalcasting products and processes.

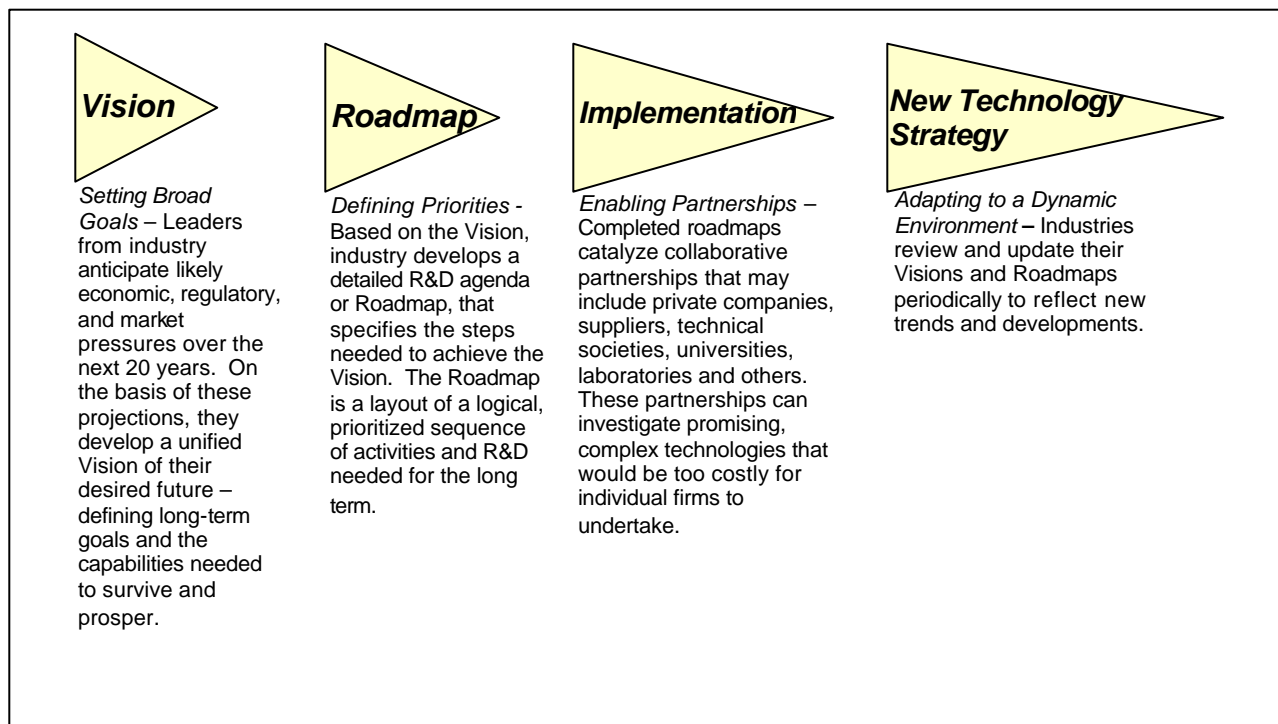
### **Energy-Intensive Industry**

Metalcasting is one of the most energy-intensive industries in the U.S. Approximately 55% of energy costs are consumed in melting. Mold making, core making, heat treatment and post-cast operations also use significant energy. Research to improve these operations and reduce melting requirements will help the industry save energy and improve competitiveness.

# A VISION FOR METALCASTING

In outlining a vision for the future, the metalcasting industry must communicate the important role that metalcastings play in our society. It must encourage the best students to study metalcasting and also encourage its brightest, most productive employees to remain in the industry. It must improve casting design methods and provide performance data and accurate performance simulation tools to the engineers designing metalcastings. Bold advances in casting production processes, including simulation and control technology, are needed to efficiently and consistently produce high-quality cast components.

The industry has set specific long-term goals to achieve its vision for the future. Achieving these goals will have the added benefit of improving productivity, energy efficiency, and environmental performance in the U.S. metalcasting industry. Improvements in productivity and operational efficiencies will allow the metalcasting industry to maintain the nominal price of castings even as inflationary pressures increase the cost of labor, equipment and supplies. By 2020, energy required to produce castings will be reduced by 20% compared to 1998 energy requirements. By 2020, non-recycled solid waste and toxic chemical releases to the environment will be reduced by 25% for a comparable amount of casting production.



# **COMMUNICATE THE VALUE OF METALCASTINGS**

## **Challenge**

To communicate the essential value of the metalcasting industry to the U.S economy.

## **Current Situation**

Metalcastings play a critical role in all sectors of the economy. Yet, many Americans are not aware of castings, the benefits they provide over alternative-manufactured components, and their role in everyday life. Further, some manufacturers, management and technical professionals do not understand the difference that metalcastings can make in their product compared to components made by other techniques. The result is missed market opportunities for metal casters. Many government decision makers and the public at large are not familiar with the casting industry and not aware of its importance to a healthy and vibrant U.S. economy as well as the nation's defense. This lack of awareness could result in poorly crafted regulation.

To remain profitable, maintain a viable number of producers, and expand into new markets, the industry must increase awareness on the part of manufacturers, defense contractors, and the public regarding the value of engineered cast components. Frequently the best performing metal component is a metalcasting, and the industry must make sure that designers and producers of manufactured products know it.

## **2020 Goal**

*By 2020, society will recognize the metal caster as a desirable neighbor, a vital player in the U.S. economy, and a supplier of high-performance components. Metalcastings will solve challenging performance problems in high technology products and regularly demonstrate outstanding value in common applications.*

## **Achieving our Goal**

To achieve this vision goal, the metalcasting industry will need to reach specific audiences -- addressing their unique needs and priorities. It will require well-documented industry facts and figures to validate and support these communication efforts. Specific audiences include:

- **Casting Customers** - Customers, from designers to those making the purchasing decisions, are unaware of the design flexibility and performance benefits of cast components. Domestic metal casters and mold makers are facing increased competition from off-shore producers. Targeted outreach is needed for both current and potential customers.
- **Expand Industry-Government Interaction** - The industry needs to expand industry-government interaction. It needs to improve its communication on the essential value of castings to government organizations responsible for trade, environmental, and other regulations as well as those supporting research and development.
- **Manufacturers, General Public and Special Interests** - The contribution of metalcasting to the U.S. economy should be communicated to the public and to organizations representing related interests. It should also be communicated to other manufacturers who may not be familiar with the quality and performance of cast metal components. Also to be communicated should be the fact that metalcasting is a major recycling industry and that it is responsible for



producing critical components used in transportation, energy production, national defense, and other areas.

- **Neighboring Communities** - Targeted outreach is needed to educate state and local officials and communities surrounding casting facilities about metalcasting and to improve their understanding of the industry. In 2020, neighboring communities will see metalcasting as a valued neighbor – a provider of safe, clean, quiet, and good jobs.

## ***DESIGN CASTINGS FOR NEW MARKETS***

### **Challenge**

*The U.S. metalcasting industry must design castings for new markets and applications while maintaining current markets.*

### **Current Situation**

Improving design capabilities in metalcasting is critical to the industry's ability to produce cast products that will be competitive in world markets. Improved design capabilities can enable U.S. metal casters to manufacture parts not currently possible with current design constraints, opening new markets for metal casters. Maintaining existing markets and opening new markets is critical to the financial viability of metalcasting companies. Improvements in casting design will reduce testing and tryout on the shop floor and replace it with computer-based design and analysis. This will significantly reduce energy and environmental impacts. Improved design capabilities will also reduce defects, post casting operations, and rejected castings – also saving energy and reducing environmental emissions. The casting industry already uses a number of strong design tools and employs basic design principles. However, design capabilities are not at the level necessary to remain competitive over the long term. The principles of casting design are still not well known and there is a lack of published data on tolerances as well as validated, widely available data on material properties and performance.

Additional data and tools are needed to improve casting design methods. This includes alloy properties and performance data as well as the accurate simulation of casting performance based on alloy properties, stress levels, and solidification integrity. These improvements can increase the value of metal components, reduce component weight, reduce manufacturing lead-times, and assure product performance. They will assist manufacturers to build better products with less cost and less energy.

Moreover, product designers are unaware of the flexibility and benefits of castings and therefore fail to consider castings in their design plans. Metal casters miss market opportunities by failing to pursue new and innovative designs.

### **2020 Goal**

*Through improved casting design methods, alloy properties, alloy performance data, and casting performance simulation techniques, annual market growth rates for metalcasting shipments (based on value of shipments) will average 3% or more through 2020.*

### **Achieving our Goals**

In 2020, the quality and performance of cast metal parts will be assured in the design stage. The metalcasting industry will design castings that reduce the time-to-part and improve manufacturing

efficiency and cost competitiveness. The result will be higher yield and productivity, reduced waste, and increased energy efficiency. Design technologies will enable real-time innovations in both the design and manufacturing stage. Design capabilities will enable castings to capture a greater share of total components designed. In order to achieve its vision for 2020, a number of enhancements to existing design capabilities will need to occur:

- **Improved Design Guidelines** – Metal casters will take a more active role in designing cast products and resources, and knowledge base available to casting designers must be improved. Improvements can be made in design guidelines and standards in areas such as geometric dimensioning and tolerancing, gating design, material/mechanical properties, and physics-based castability and structural design principles.
- **Improved Design Tools** – Broader application of existing design tools in the industry is needed. The industry also needs to expand the menu of available design tools.
- **Design Education and Training** – Metal casters must educate designers and customers on why metalcastings are the best option for components from a design perspective (i.e. improved structural design, ability to reduce weight while maintaining strength, unlimited choice of alloys, design for performance, design flexibility). Designers need to be trained on the latest design tools to increase current design capabilities. Students and decision makers can be educated on the design opportunities that castings can provide.
- **New Business Models** - New modes of doing business in the metalcasting industry should be investigated to better integrate the design function. This will lead to improved efficiency and productivity in the casting process and improved customer satisfaction.
- **New Materials** – Research and education in the design, use, and production of new alloys can create many new applications for metalcasting.

## IMPROVE METALCASTING PROCESSES

### Challenge

*The metalcasting industry must improve metalcasting processes by reducing scrap, reducing the cost of production, and improving product performance.*

### Current Situation

In order to remain competitive, the metalcasting industry must be able to cost-effectively and consistently produce high-quality, high-performance cast products. In the absence of the technical capability to achieve this level of performance, the industry will continue to see high scrap and low yield rates. A number of factors combine to inhibit the industry from making revolutionary process improvements. These include the lack of knowledge of, and control over, the actual casting process; the need to improve operating and equipment efficiencies in the manufacturing stage; the inability of companies to make financial investment due to overall cost in relation to company value and the lack of assurance of a reasonable return on investment; and the need to introduce advanced technologies which improve efficiency and performance in casting. Without significant improvements in metalcasting processes, metal casters will face increasingly difficult competition in both domestic and foreign markets. It can also lead to increased competition from alternative production techniques such as forgings, stampings, and powder metal as well as alternative materials such as plastics or ceramic composites.

## 2020 Goal

*By 2020, the combination of average melting and mold yield for each metalcasting alloy/process family will increase significantly so that, in aggregate, the metalcasting industry's yields will increase by 20% from current levels. Rejected casting rates will be cut by 40% from current industry averages. OnTime/Complete delivery performance for the full spectrum of order/release quantities will be sustained above 95% across the metalcasting industry while the combination of in-process and finished inventory in metalcasting plants will be slashed 50%.*

## Achieving our Goals

In 2020, metalcasting processes will be clean and efficient with significantly less waste generated. Advanced manufacturing technologies and process improvements will reduce the energy and labor content of each casting. Improved data on materials properties, mechanical performance and other areas will improve the industry's ability to reduce defects and scrap. The industry will focus on customer quality such that castings are benchmarked as the leader in their respective market sectors. The industry will produce and deliver high-quality, high-performance castings consistently, cost effectively and on schedule. Achieving vision goals will enable the industry to produce thinner-walled more efficient casting geometry, reduced casting rejections at all stages of production, reduced Economic Order Quantities (EOQ's), increased delivery performance at lower in-process and finished inventory levels, and overall lower cost of production through control, automation, and elimination of administrative waste

In order to achieve its 2020 goal of improved metalcasting processes in three interrelated areas: improved product performance, reduced production costs, and waste reduction. To the extent possible, models to achieve similar goals in other industries and in other countries should be investigated. Opportunities for advanced technologies, automation, and cleaner more efficient technologies must be pursued. Areas of focus include:

- **Reduce Production Costs** – Opportunities to reduce labor and energy content and make other efficiency improvements must be pursued. Lean manufacturing, six sigma and other concepts to improve operating efficiencies need to be pursued as do activity-based cost accounting approaches. Revolutionary technologies and process changes also should be investigated to achieve metalcasting without the use of tooling. The industry should investigate the application and blending of statistical, shop floor layout, computer numerical control, and scheduling technologies to radically change the nature of EOQ's, production release sizes, inventory levels, and delivery performance in metalcasting plants.
- **Reduce the Energy Content of Cast Products** - Energy content can be reduced by improving product quality - thereby reducing scrap and melting requirements. Improvements in equipment and process efficiencies will also save energy. The industry should develop a complete understanding of thermophysical behavior of alloys in melting, flow, and solidification as well as the ability to accurately simulate these behaviors.
- **Waste Management** – Process improvements are needed to enable increased reuse of foundry sand and other by-products and/or waste streams, more environmentally sound binders, and better emission treatment. Process improvements will also help to reduce scrap and thereby waste in casting processes.

- **Reduced Labor Content of Cast Products** - Current practices must be investigated to identify opportunities to reduce the number of process steps, develop and implement no-touch casting processes, and implement advanced information and control technologies.
- **High-Quality, High-Performance Engineered Cast Components** - Methods to improve quality, precision and performance will result in fewer customer returns. The industry must develop an understanding of all process variation that affects the performance of castings in their applications; and develop process controls to ensure that variation is within allowable limits. Better performing products will also open new markets for metalcastings. Tools are needed to capture digital, analog, or computer vision signals from all levels of the metalcasting process to provide real time feedback about process status and to provide the ability to correct variances before they become product defects.

## ATTRACT NEW WORK FORCE AND STUDENTS

### Challenge

*The industry must attract and retain skilled workers and a larger number of new students to the field of metalcasting.*

### Current Situation

To remain competitive, the metalcasting industry of the future will require a highly skilled, well-trained work force. However, there is a serious shortage of people entering the field of metalcasting. Fewer students are pursuing studies in curricula related to metalcasting. Fewer colleges are offering those curricula. The metalcasting industry is a source of challenging and rewarding careers and, in many cases, uses the latest in computer design, robotics, materials science, and other technological advances. The industry is safe and increasingly clean. However, the image of the industry among students is often at odds with reality. There is a need to identify and apply innovative outreach mechanisms to educate the future workforce about the industry

### 2020 Goal

*By 2020, growth in the metalcasting markets and applications will strengthen the related curricula of at least 5 leading U.S. metalcasting R&D universities, add at least 3 new ones, and add at least 100 high school and/or vocational metalcasting programs across the U.S. Metalcasting related product design, process engineering, and production will be among the top 10 career choices of U.S. engineering and vocational graduates.*

### Achieving our Goals

In 2020, metalcasting will be a respected career of choice in the U.S. To achieve this goal, the metalcasting industry will need to implement a multi-prong approach to achieve its vision for 2020. The industry must increase the number and quality of partnerships with educational institutions and improve outreach to future employees. Students must be introduced, at an early age, to the various types of career opportunities available in metalcasting. It will require educating students and instructors about metalcastings and the industry. It will require communicating the fact that in metalcasting careers, one can implement advanced science and innovative technologies in the areas such as computer-aided design, materials, and robotics. It also will require ensuring a clean and secure workplace. The industry must continue to emphasize workplace safety and reduce lost time

injury rates. The industry must also investigate the latest advances in workplace ergonomics and apply them in the casting industry.

The industry should develop new partnerships with educational institutions. Vocational schools provide the technical training needed for a large number of employees in the industry. Universities perform the materials, process and other research needed for the industry to maintain its technological edge. New partnerships between industry and these institutions will ensure a steady supply of high-quality labor for the industry. Internships, web-based outreach tools, virtual metalcasting facilities, and revitalized educational curricula can help to achieve this. Outreach messages should communicate the value of metalcastings and the industry to society and the fact that many companies in the industry are using the latest in technology to design and develop metalcastings. The industry must continue to improve the work environment in metalcasting. It should pursue measures to ensure a smokeless and fumeless work environment; and reduce “heavy labor” currently required in some operations.

# ACHIEVEMENTS

This Vision will build upon the many successes that have been achieved since the CMC was established:

- **Broad Participation is Expanding Outreach** – Hundreds of organizations from across the U.S. have participated in cost-shared metalcasting research including small-, medium-, and large businesses, universities, laboratories, and federal agencies.
- **Partnerships between Industry and Government are Leveraging R&D Resources** – Tens of millions of dollars have been leveraged for metalcasting research, including investment from industry and the federal government.
- **Research Consortia and Expanding Technology Transfer** - Multiple R&D consortia have been fostered, resulting in broad information sharing and technology transfer.
- **Research Partnerships are Contributing to the Future of the U.S. Casting Workforce** – University-based research has trained hundreds of students, the majority of whom have gone on to careers in metalcasting.
- **U.S. Engineering/Metallurgical Curriculum is being Enhanced** - Research results are being incorporated into the curriculum of U.S. colleges and universities, in some cases updating guidelines and instructional materials for the first time in decades.

Moreover, many technological advances have been made. New tools are now available to metal casters to improve casting design and testing capabilities and to improve equipment control. The industry has better data on material properties and mechanical performance. Process improvements are improving casting quality, reducing waste, and enabling the application of advanced casting methods. The metalcasting industry will build upon these lessons and achievements. It will continue to work in partnership with government and academia in achieving its vision for a vibrant and profitable future.