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## A Vision for the Welding Industry in the USA

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# A Vision for the Welding Industry in the USA

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**Abstract**

Welding is a critical technique for the joining of materials in the nation's major manufacturing industries. Since 1998, leaders in welding industry have defined a vision of the issues and opportunities that it will face in 2020. In developing this vision document, more than 25 senior managers and respected experts from various segments of the welding community met to begin a dialog about the future of the welding industry. They were brought together to develop a long-range business plan for their industry that would identify how it would meet the needs of manufacturers, of the marketplace, and of society in 2020. In essence, these decision makers created an ideal vision of the state of their industry in 20 years, and the strategy to reach it.

Welding is a precise, reliable, and cost-effective, method for joining materials. No other technique is as widely used by manufacturers to join metals and alloys efficiently. Most of the familiar objects in modern society, from buildings and bridges, to vehicles, computers, and medical devices, could not be produced without the use of welding. Despite the importance of welding to the manufacturing industry, the leaders in this area felt that welding was not appreciated as much as it should be from the society. The welding industry consists of the "users" of welding techniques as well as the companies, universities and other organizations that provide the equipment, materials, processes and support service for welding. All branches of the industry look for improvements in their operations by 2020, and should find their interest addressed in this document.

A major economic impact study co sponsored by AWS and EWI and supported by US Navy, State of Ohio, US Department of Commerce, and major companies was kicked off. This two-year study will determine the economic impact of welding on the United States economy. The objective of this study is to break a paradigm about welding. - those of us who are heavily involved in welding, believe strongly that much of our gross domestic product is directly dependent on welding. Furthermore, continued advances in the field of welding are necessary to achieving further increases in productivity that makes our economy strong. Yet, despite intuition, anecdotal information, and fragmented analyses, the completing quantitative information that would proved the justification for strategic actions to further develop this critical field is not currently available.

## INTRODUCTION

Welding is a joining process that produces a local coalescence of materials by heating, by applying pressure, or both. In essence, the welding process fuses the surfaces of two distinct elements to form a single unit. It encompasses a broad range of joining techniques that include fusion welding, solid state welding, bonding, diffusion welding, brazing, and soldering.

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In June 1998 the U.S. welding industry took the first step in pursuing a research partnership with the U.S. Department of Energy (DOE) to demonstrate, evaluate, and accelerate new technologies and scientific insights that address the specific needs of the welding industry. That month, the industry held a workshop whose results were used to prepare the *Vision for Welding Industry*, a document that presents a unified, strategic vision of the future of the welding industry. This document, known as the "*Vision 2020,*" identifies the major challenges and barriers the industry is likely to face over the next several decades and sets broad performance targets for the following areas:

- Cost and productivity
- Technologies and processes
- Quality standards
- Materials performance
- Markets and applications
- Education and training
- Energy, environment, health and safety

The vision process is the first of a flexible, three step approach to technology development. Based on the performance targets identified in the vision, the industry will develop a detailed research agenda, known as a technology road map. Industry technology leaders began developing a "Road Map" for dealing with challenges and opportunities faced by our industry in an increasingly competitive global environment. Members who participated in developing the "Road Map" are shown in Table 1.

The vision describes the issues and opportunities facing the US welding industries through the next twenty years. The strategic goals outlined in the vision are ambitious and will require hard work and commitment by the industry. Virtually all manufacturing industries use some type of welding process. The group identified four major industry segments that rely heavily on welding. They are heavy industry, aerospace industry, petroleum/energy industry and automotive industry. Specific goals and action plans are proposed for the three industry segments based on several workshop by the industry technology leaders.

AWS and EWI announced a major economic impact that should benefit all sectors of the welding industry. The two-year, $500,000 study will determine the economic impact of welding on the United States economy. This project will be conducted through the support of key industrial companies; the US Navy, AWS, EWI and the State of Ohio, plus in-kind support from the US Department of Commerce.

Planning for this project has been underway for more than a year, and actual study beginning in May of 2000. It was said "those of us who are heavily involved in welding, believe strongly that much of our domestic product is directly dependent on welding. Furthermore, continued advances in the field of welding are necessary for achieving further increases in productivity that makes our economy strong. Yet, despite intuition, anecdotal information, and fragmented analyses, complete quantitative information that would proved the justification for strategic actions to further develop this critical field, is not currently available." Both EWI and AWS want to provide concrete support for the "Vision," and for the challenges and actions it will describe. Work toward a comprehensive study on the economic impact of welding on the US economy has already begun.

## THE VISION [1]

Vision for Welding Industry

" In 2020, welding continues to be the preferred method by which metals and other engineered materials are joined into world-class products. US industry will be the world's leading source of these cost-effective, superior-performing products by virtue of its leadership in joining technology, product design, and fabrication capabilities, and globally competitive workforce."

This vision clearly states that the society expects to maintain its superiority in joining technologies in the future. Technologically advanced welding and joining processes will be integrated into the design and manufacture of high quality products and structures. The research priorities contained in this technology road map should help guide the welding industry in accomplishing its vision.

Major challenges will be overcome by the welding industry by the year 2020:

- Integration of welding into the product life cycle:

Welding should be a part of integrated system. Welding should be integrated into design, manufacturing, and material selection. Traditionally, materials have been developed without considering if and how they can be welded. Weldability should be considered during the development of new materials. Integration of the weldment into the product life cycle, and accurate models of life-cycle costs will help customers better understand the relative cost and value of welding. Fatigue of welded structures is a good example for integration. Whereas, creep life assessment of welded joints have not been well integrated, despite the number of failures experienced at or near the weld.

- Quality of welded product:

While most welded products are produced to meet high standards of quality, the industry is moving toward "six-sigma quality". Improving weld quality lowers production costs and consumption of natural resources. Integrity assessment and standards play a role in determining weld quality. Effective integrity assessment should help eliminate unnecessary repair or replacement, thereby improving life-cycle costs.

- People – attracting and maintaining a skilled, educated workforce:

Like many other similar industries, welding has had difficulty attracting and keeping good workers. A skilled and educated workforce is critical to the survival and growth of welding. The perception of welding will continue to change as education and training increases the awareness of newly developed welding technologies. Public relations efforts may be one avenue for improving the image of welding. Education and training will be needed for all levels of the workforce. With the current trend toward down sizing and mergers, the welding industry should be able to provide more technology transfer both nationally and globally.

- Transition welding from art to science

Unfortunately, many of our existing welding practices are based on experience. It requires transition of welding from an empirical-based to a physical-based process. A major stumbling block is a lack of understanding of the fundamental physics of the materials used in welding and the welding process. The comprehensive physical-based model would cover the entire life cycle of the welded product. Welding processes based on engineering analysis, numerical modeling, and computer-based automated manufacturing will be widely used in 2020. The model will also facilitate the move to process-based quality for welding. Integrity assessment and lifetime prediction would be integral functions of the model.

## GOALS

Specific goals and research needs in the four industry segments ( Heavy Industry, Aerospace, Petroleum/Energy, and Automotive) were developed.

Heavy Industry
Heavy industry includes manufacture and maintenance of ships, off-shore platforms, train, farm vehicles, construction and mining equipment, bridges, buildings and similar structures utilizing welding. Advances of welding processes for these applications have not kept pace with other technological developments. Research to develop welding processes and integrated manufacturing systems will improve the cost effectiveness and cost of welding. Key R&D topics identified by the technical committee were as follows:

- New welding processes and filler metals
- Inclusion of weldability and manufacturability in new material development
- Concurrent product/process simulation and development
- Better forum to identify research needs

Aerospace
Aerospace industry includes manufacture of aerospace products such as aircraft, engines, missiles and rockets. This industry faces tough pressure for new products to be more affordable, both in initial production costs and overall lifecycle costs. Safety considerations, however, mandate that this cost-effectiveness be achieved without compromising quality. The integration of weldability into the development of new, lighter alloys will be a key component of this success. Key R&D topics identified by the group are as follows:

- More comprehensive scientific understanding and modeling of welding
- Process understanding will improve product quality to the six-sigma level.
- Capability to predict distortion and residual stress

Petrochemical /Energy
The extraction of oil and gas and the refining of petroleum rely on welded equipment ranging from pipes and tanks to offshore drilling structures. Increasing emphasis is on deep-water, applications. Safety of pressure equipment will require integrity assessment of aging equipment. The welding users in this industry must partner with metal producers on the development of new alloys to improve their weldability. Better data on weld performance, along with new integrity assessment techniques and updated integrity standards, will reduce maintenance requirements and improve the cost-effectiveness of welded structures. Key R&D topics identified by the group are as follows:

- Smarter welding equipment
- Weld process and product modeling
- Technologies for fitness-for-service, life extension and risk based inspection
- The ability to model residual stress and distortion in complex structures
- Weldable alloys that reduce pre – and post- weld heat treatment

Automotive
The automotive industry sector includes all on-road and light versions of off-road motor vehicles. Companies within this sector include the original equipment manufacturers (OEMs) and their

tiered supplier base. In the United States, several OEMs operate facilities (including "transplant") with thousands of companies supplying components to numerous OEMs or other suppliers. Outsourcing of components has been the trend with OEMs over the past decade. Key R&D topics identified by the group are as follows:

- Welding processes for lightweight alloys
- Predictive tools for welded structural integrity and distortion
- Processes to economically join coated materials
- Welding processes for tubular structures
- High confidence modeling tools

**Welding - Economic Impact Study [2]**

The objective of this study is to provide a clear understanding of the true scope and impact of the field of welding/materials joining on the nation's economic well-being. The goal of this study is to answer critical questions that include:

1. How much of the current US Gross Domestic Product is represented by the welding industry?
2. What has been the contribution of welding to improving the productivity of the US economy?
3. What industries could benefit most from further gains in welding quality and productivity?
4. How can the strategic objectives of key government bodies benefit from this knowledge?

The benefits arising from this study include:

- Compelling cases for future public and private investments in welding technology improvement by providing tools to estimate the impact of specific investments.
- Clear evidence of the importance and financial value of welding in their manufacturing operations to all levels of management.
- Tools to help strengthen the public's awareness of the importance of this field of manufacturing.
- Help in attracting high potential young people to the field as engineers, scientists, and as welders.
- A factual basis for the intuitive views of workers in the field regarding the importance of welding.
- This information will be useful to community and state education programs, economic development initiatives, and overall prioritization of investments by the scientific, technical, and industrial communities.
- Definite benchmarks for the future measurement of the progress field

**Modeling Technique [3]**

Over the years, tremendous efforts, mostly experimental, have been made to develop optimal welding procedures that would provide good mechanical properties and structural performance with or without postweld heat treatment. Experimental approach has its limits on timing and number of variables to tests. With the understanding of the fundamental physics of the materials used in the welding and welding process, a coupled thermo-mechnical model is developed to predict the microstructure evolution in a welding process. Welding processes based on engineering analysis and numerical modeling validated by experiment would provide users better understanding of welding physics.

**Structural Integrity Assessment (Fitness For Service) [4]**

When significant flaws are found in welded structures during in-service inspection, decisions about repair, replacement or continued operation need to be made in a relatively short time frame. In order to assure continued safe operation and to avoid an overly conservative solution, sufficient planning and engineering analysis need to be carried out. The fitness for service analysis method is a tool to assess integrity of equipment containing flaws.

A quantitative assessment of equipment reliability can be achieved by selecting proper inspection strategies and relevant fact-based assessment. Economic consideration and lifetime cost benefits as well as safety of the plant equipment should also be considered. Fitness for service technology, among other newly developed technologies, will help decision making in assurance of safe operation of pressure equipment and its cost effectiveness. This methohdology for fitness for service assessment is conducted by considering multi-disciplinary aspects, including metallurgical engineering, nondestructive examination, stress analysis, fracture mechanics and statistics.

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Table 1

| Name | Affiliation | Name | Affiliation |
|---|---|---|---|
| **Bill Myers** | Dresser-Rand, President of AWS | **Dong kim** | Shell/equilon |
| **Lee Kvidahl** | Ingalls Shipbuilding, ex-AWS president | **William King** | Pratt & Whittney |
| **Richard French** | AWS, executive Vice President | **Ernest levert** | Lockheed Martin Missles |
| **Karl Graf** | EWI, President & CEO | **Paul Murray** | Idaho EG&G |
| **Frank Armao** | Alcoa | **William Owczarski** | Mc Dermott |
| **Rick Arn** | RAMtech Industries, Inc | **Larry Perkins** | US Airforce |
| **Dean Dearing** | Caterpillar | **Tom Powers** | McDermott International |
| **Tom Doyle** | McDermott Technology | **Charles Robino** | Sandia National Lab. |
| **Glen Edward** | Colorado School of Mines | **Frits Saenger** | EWI |
| **Earl Helder** | GA Aircraft Engineering | **Mike Santella** | Oak Ridge |
| **Jim Jellison** | Sandia National Lab. | **James Snyder II** | Bethlehem Steel |
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| | | **Lee Sherman** | Case |