



A National Workforce Development System for NAVSEA, the Maritime Industrial Base, and the Defense Industrial Base

Purpose

A standards-based, competency-driven national program to expand qualified welding, fitting, and brazing capacity; improve first-pass quality and production throughput; strengthen employee development and retention; and support Navy ship construction, repair, modernization, and sustainment.

Prepared for consideration by NAVSEA leadership, the Maritime Industrial Base Program, defense contractors, shipyards and suppliers, workforce agencies, community colleges, labor and apprenticeship partners, and state economic development organizations.

Author: Stephen RL Boergert
October 2026

Document Status and Use

This white paper presents a proposed national workforce-development framework. It is not a NAVSEA directive, qualification standard, contract requirement, or substitute for an approved welding procedure, technical publication, quality-assurance provision, or activity-specific authorization. All production work must be performed to the contractually invoked requirements and under the cognizance of the applicable technical authority.

Primary-source basis

This white paper uses the proprietary NAVSEA and Maritime overview and the Up-Skill Welder Program concept paper as the primary sources for defining the proposed educational system. Those documents describe the intended program architecture, engineering foundation, target populations, instructional philosophy, and maritime-specific content. Government reports, labor-market data, industry studies, technical standards, and educational research are used as corroborating and advisory evidence. This source hierarchy is intentional: the program concept defines the proposed solution, while external evidence establishes the scale of need and supports its design.

The NAVSEA and Maritime overview defines a broad engineering foundation that includes naval and maritime terminology, engineering administration, power systems, pumps, valves and piping, auxiliary machinery, instruments, electrical systems, environmental controls, ship maintenance, NAVSEA and maritime quality systems, documentation, communication, and Navy craftsmanship. It also identifies workplace ethics, safeguarding information, cybersecurity, and self-management as necessary supporting competencies (Welding & Joining Technology [WJT], n.d.-a).

The Up-Skill Welder Program concept identifies the shortage of entry-level and advanced maritime tradespeople, the decline of legacy Navy trade-training pipelines, and the limitations of fragmented training models. It proposes separate entry-level, up-skill, apprenticeship, and advanced-specialty pathways patterned after Navy systems of trade instruction and career development, supported by modern equipment and experienced Navy nuclear-component welders, brazers, and instructors (WJT, n.d.-b).

Proprietary-use notice

The two primary-source documents contain proprietary and confidential information belonging to Welding & Joining Technology. This white paper summarizes their program concepts for the intended planning and evaluation purpose. Detailed curriculum products, instructor materials, assessments, and implementation tools should remain subject to appropriate intellectual-property, nondisclosure, licensing, and data-rights arrangements.

Table of Contents

Document Status and Use.....	2
Primary-source basis.....	2
Proprietary-use notice	2
Table of Contents	3
Preface	6
1. Executive Summary	7
2. The National Workforce Challenge	9
2.1 Replacement Demand and Competition for Skilled Labor	9
2.2 Maritime-Specific Shortages	9
2.3 Historical Evolution of the Maritime Industrial Workforce.....	9
2.4 The Cost of Fragmented Training	9
3. Strategic Importance to National Security	10
4. Current Capability Gap	11
4.1 Skill Is Necessary but Not Sufficient.....	11
4.2 Training Completion, Qualification, and Authorization	11
4.3 Capacity Constraints in the Training System.....	11
4.4 Quality and Human-Performance Gaps	11
4.5 Why Existing Training Systems Cannot Fully Meet Maritime Requirements.....	11
Legacy Navy pipeline erosion	11
Regional vocational focus	11
Academic and institutional constraints.....	12
Contractor-specific acceleration.....	12
Local labor-market depletion	12
4.6 The Missing Middle: Experienced Welders Who Are Not Yet NAVSEA-Ready.....	12
4.7 Applied Science Must Match Occupational Decisions	12
4.8 Informal Knowledge, Authority Gradients, and Technical Misinformation.....	13
5. Educational Philosophy and Learning Model.....	14
5.1 Instructional Cycle.....	14
5.2 Assessment Philosophy	14
5.3 Integrated Learning Model.....	15
5.4 Instructional Ratio and Practice Design.....	15
6. Industry and Government Alignment	16
7. Program Architecture	16
7.1 National Core, Regional Delivery, Employer Qualification	16
7.2 Entry and Advancement Pathways	17

7.3 Governance.....	17
7.4 Three Primary Workforce Pathways.....	17
Pathway 1 - Entry-Level Maritime Trades Development	17
Pathway 2 - Commercial-to-NAVSEA Up-Skill Bridge	17
Pathway 3 - Advanced Specialty and Leadership Development	17
7.5 Five-Phase Educational Model.....	17
7.6 Delivery Modes	18
7.7 Scalability Across Maritime Trades	18
8. Curriculum Framework.....	19
8.1 Curriculum Differentiation	19
8.2 Instructor Development	19
8.3 Phase I - Naval and Maritime Engineering Foundation	20
Applied-science design standard.....	20
8.4 Phase II - Welding, Fitting, Cutting, and Brazing Fundamentals.....	20
8.5 Phase III - Maritime Systems Integration.....	20
8.6 Phase IV - NAVSEA Qualification Readiness	20
8.7 Phase V - Advanced Manufacturing and Continuous Improvement.....	21
8.8 Professional and Employability Competencies.....	21
Workmanship as an observable competency	21
8.9 Capstone and Transition to Employment	22
9. Technical Standards and Qualification	23
9.1 NAVSEA Requirements Govern Applicable Navy Work	23
9.2 Comparison with Commercial and International Standards	23
9.3 Qualification Readiness	23
9.4 Workmanship Requirements and Source Applicability.....	24
10. Workforce Development Strategy.....	24
10.1 Recruitment and Access	24
10.2 Supportive Services	24
10.3 Apprenticeship and Work-Based Learning.....	24
10.4 Retention and Advancement	24
10.5 Data and Accountability	25
11. Industry Partnerships	26
11.1 Employer and Supplier Role.....	26
11.2 Community College and CTE Role.....	26
11.3 Workforce and Economic Development Role.....	26
11.4 Staffing and Transitional Employment.....	26

11.5 Technical and Professional Organizations	27
12. Expected Outcomes	28
12.1 Workforce Outcomes	28
12.2 Quality and Production Outcomes	28
12.3 Cultural Outcomes	28
13. Return on Investment	28
13.1 Recommended Performance Measures	29
13.2 ROI Formula	29
14. Implementation Roadmap	29
14.1 Pilot Selection	30
14.2 Risk Management	30
14.3 Phase 0 - Mobilization and Design (0-6 Months)	30
14.4 Phase 1 - Curriculum Validation and Instructor Preparation (6-12 Months)	30
14.5 Phase 2 - Regional Pilots (12-24 Months)	30
14.6 Phase 3 - Expansion and Apprenticeship Integration (24-48 Months)	30
14.7 Phase 4 - National Network and Continuous Improvement (48-72 Months)	30
14.8 Decision Gates	31
15. Recommendations	32
15.1 Immediate Actions	33
16. Conclusion	34
17. References	35
Appendix A. Proposed National Competency Domains	37
Appendix B. Illustrative Regional Consortium Model	38
Appendix C. Curriculum Phase and Competency Matrix	39
Appendix D. Up-Skill Welder Diagnostic Model	40
Recommended diagnostic decision rules	40
Appendix E. Regional Pilot Charter	40
Appendix F. Performance Dashboard	40
Appendix G. Proposed Governance Structure	41
Appendix H. Strategic Communications Framework	41

Preface

America's maritime strength has always depended on the skill, professionalism, and dedication of its workforce. Ships, submarines, shipyards, and advanced manufacturing technologies are only as capable as the people who design, fabricate, maintain, inspect, and sustain them.

Throughout my career in welding engineering, maritime fabrication, workforce development, technical education, and support to the U.S. Navy and the defense industrial base, I have observed a steady erosion of the Nation's skilled maritime workforce. The challenges we face today are not the result of a single event, but the cumulative effect of decades of workforce attrition, retirement of experienced craftsmen, fragmentation of training systems, and reduced investment in developing future generations of maritime professionals.

This white paper presents a practical, scalable framework for rebuilding that capability. It is intended to encourage collaboration among NAVSEA, the Maritime Industrial Base Program, public and private shipyards, defense contractors, educational institutions, workforce agencies, labor organizations, and government leaders. Its purpose is not to replace existing technical authorities, standards, or qualification requirements, but to provide a coordinated workforce development strategy that complements them.

I believe the development of a National Maritime Workforce Development System represents a strategic investment in national security. By restoring institutional knowledge, strengthening apprenticeship pathways, developing instructors and technical leaders, and creating nationally aligned competency standards, the United States can rebuild the human capital necessary to sustain the Fleet for decades to come.

I respectfully submit this paper for consideration by senior leaders within the Department of the Navy, Congress, the Maritime Industrial Base Program, industry, academia, and workforce partners.

Stephen R. L. Boergert

NAVSEA/Maritime Workforce Development Consultant | Welding and Fabrication Expert

15 August 2026

1. Executive Summary

The United States faces a sustained shortage of welders, fitters, brazers, pipe trades, inspectors, supervisors, planners, instructors, and advanced-manufacturing technicians needed to build, repair, and modernize naval vessels. The challenge is not simply the number of open positions. It is the limited capacity of existing education and employer systems to produce workers who can perform safely and productively within NAVSEA-controlled environments, maintain qualification, understand quality-system responsibilities, and progress into senior craft and technical leadership roles.

The Bureau of Labor Statistics projects approximately 45,600 openings each year for welders, cutters, solderers, and brazers from 2024 through 2034, primarily because workers will transfer occupations or leave the labor force. Deloitte and The Manufacturing Institute estimate that U.S. manufacturers may need as many as 3.8 million additional workers between 2024 and 2033 and that 1.9 million positions could remain unfilled without major changes in workforce practices (Bureau of Labor Statistics [BLS], 2025; Deloitte & The Manufacturing Institute, 2024).

The maritime problem is more acute because Navy construction and repair require specialized qualifications, extensive documentation, controlled materials and consumables, high-reliability behaviors, and production experience that cannot be developed through short, generic welding courses. GAO has reported that workforce and infrastructure constraints contribute to persistent cost and schedule shortfalls in Navy shipbuilding and that submarine demand exceeds portions of the existing industrial base capacity (U.S. Government Accountability Office [GAO], 2025a, 2025b).

This white paper proposes a national, modular, competency-based program with regional delivery and employer-specific qualification. The program would prepare entry-level apprentices, experienced commercial welders transitioning to naval work, incumbent workers requiring advanced qualifications, and future instructors, inspectors, supervisors, planners, and manufacturing specialists. It would establish a common educational foundation while preserving the authority of NAVSEA technical requirements and individual employers to conduct procedure-specific qualification and authorize production work.

The workforce shortage confronting today's Maritime Industrial Base is not solely the result of increased shipbuilding demand. It is the cumulative consequence of post-Cold War restructuring, reductions in organic industrial capability, retirement of experienced personnel, and increasing reliance on private-sector maintenance. The proposed National Maritime Industrial Workforce Development System is therefore a strategic capability-restoration initiative.

The central finding is that the United States does not merely face a shortage of welders. It lacks a sufficiently coordinated national educational system for developing well-rounded maritime tradespeople who can progress from foundational engineering knowledge to NAVSEA-specific qualification and high-consequence production. Training capacity alone will not solve the problem where compensation is uncompetitive or working conditions cause avoidable attrition. The proposed system therefore combines a common national core, regional delivery, employer participation, procedure-specific qualification, and accountable job-quality commitments.

The program is intentionally broader than a test-preparation course. It develops workers who understand the ship, system, component, work package, quality framework, and mission consequences surrounding the project. This breadth is based on the primary-source NAVSEA and Maritime overview, which integrates engineering fundamentals and marine systems with technical trade education (WJT, n.d.-a).

Although welding and related fabrication trades provide the initial detailed model, the proposed system is designed as a scalable maritime trades-development architecture. Its common maritime core and regional operating system can be reused across occupations, while trade-specific standards, hazards, workmanship requirements, practical assessments, and employer qualifications are developed and controlled separately.

Three workforce pathways form the operating core: an entry-level pathway for new entrants; an accelerated up-skill pathway for experienced commercial and industrial welders who need NAVSEA-focused knowledge and refined skills; and an advanced-specialty pathway for nuclear, SUBSAFE, Level I, silver-brazing, and other controlled applications (WJT, n.d.-b).

Implementation should begin with regionally selected pilots where employer demand, facilities, instructors, candidate flow, and qualification support are already present. Pilots should be governed through performance agreements that measure time to competence, first-attempt qualification, first-pass acceptance, retention, rework, throughput, and advancement.

Central proposition

The nation should treat qualified maritime craft capacity as strategic infrastructure. Facilities, ships, materials, and advanced equipment cannot produce fleet capability without a sufficient number of competent people and a repeatable system for developing them.

- NAVSEA requirements remain the governing qualification and production authority for applicable Navy work.
- The curriculum exceeds typical entry-level industrial expectations by integrating welding skill, fitting, metallurgy, technical documentation, quality assurance, configuration control, inspection awareness, and high-reliability work practices.
- Competency-based education, mastery learning, deliberate practice, cognitive apprenticeship, experiential and project-based learning, adult learning, and situated learning provide the instructional foundation.
- Lean, Six Sigma, Theory of Constraints, Total Quality Management, Kaizen, Human Performance Improvement, Statistical Process Control, Root Cause Analysis, and FMEA provide the manufacturing-excellence framework.
- National core standards should be delivered through regional consortia of shipyards, suppliers, community colleges, apprenticeship programs, workforce agencies, and economic-development organizations.
- Program success should be measured through qualification, time to productive competence, first-pass acceptance, reduced rework, retention, advancement, supplier throughput, and schedule performance.

2. The National Workforce Challenge

2.1 Replacement Demand and Competition for Skilled Labor

National labor projections show continuing replacement demand even where net occupational growth is modest. BLS projects about 45,600 annual openings for welders, cutters, solderers, and brazers during 2024-2034. Maritime employers compete for many of the same workers sought by construction, energy, infrastructure, transportation, aerospace, and general manufacturing. This competition is intensified by retirements, geographic mismatch, housing and transportation constraints, and the length of time required to develop independent craft proficiency (BLS, 2025).

The broader manufacturing sector reports a similar structural problem. Deloitte and The Manufacturing Institute estimate a potential need for 3.8 million workers through 2033, with approximately half of those roles at risk of remaining unfilled. Sixty-five percent of surveyed manufacturers identified attracting and retaining talent as their primary business challenge, and most reported using external partnerships to strengthen their talent pipelines (Deloitte & The Manufacturing Institute, 2024).

2.2 Maritime-Specific Shortages

The shipbuilding workforce gap affects production trades and the occupations that support them. NSRP apprenticeship research identified difficulty filling entry- and mid-level positions including welders, pipefitters, supervisors, marine designers, estimators, and accuracy-control personnel. The same research documented the erosion of informal over-the-shoulder knowledge transfer as experienced employees retire or leave faster than new workers can be developed (National Shipbuilding Research Program [NSRP], 2023).

A shortage at the entry level becomes a future shortage of instructors, inspectors, planners, lead workers, and supervisors. Historically, many of these roles were filled by experienced craft personnel. When the deckplate pipeline contracts, the entire leadership and technical-support pipeline contracts several years later.

2.3 Historical Evolution of the Maritime Industrial Workforce

The workforce shortages confronting the Maritime Industrial Base today are the product of more than three decades of structural change rather than a sudden increase in shipbuilding demand. Following the end of the Cold War, the Navy reduced end strength, consolidated maintenance organizations, reduced portions of its organic industrial workforce, and increasingly relied on private industry for depot-level maintenance, modernization, engineering support, and ship repair. While these measures improved efficiency, they also eroded the national pipeline of experienced maritime tradespeople, instructors, mentors, inspectors, and technical leaders. Today's workforce shortage is therefore the predictable outcome of long-term structural decisions and requires rebuilding a coordinated national maritime workforce development system.

2.4 The Cost of Fragmented Training

Current training is often fragmented among high schools, community colleges, union programs, employer academies, workforce contractors, and private schools. Many programs provide valuable foundational skills but are not designed around NAVSEA requirements, naval materials, qualification ranges, documentation control, or production-system integration. Employers therefore repeat basic training, remediate inconsistent preparation, and bear substantial costs before a new worker reaches productive assignment.

A national framework would not eliminate employer training. It would reduce avoidable duplication by creating validated entry competencies, common terminology, reliable assessment, and documented learning outcomes that employers can trust.

Challenge	Operational effect	Program response
High retirement and turnover	Loss of capacity, mentors, and tacit knowledge	Continuous recruitment, knowledge capture, instructor development, structured mentoring
Inconsistent pre-employment training	Long onboarding and low first-attempt qualification	National core curriculum and validated performance assessments
Regional labor shortages	Production capacity concentrated in a few locations	Distributed delivery through regional training consortia
Supplier workforce constraints	Late components and concentration risk	Supplier-accessible training and shared qualification preparation
Modernization without workforce preparation	Underused capital equipment and poor technology adoption	Integrated digital, automated, and advanced-manufacturing instruction
Weak career visibility	Attrition and limited advancement	Stackable credentials and defined craft-to-leadership pathways

3. Strategic Importance to National Security

Naval shipbuilding and repair are sovereign industrial capabilities. Submarines, surface combatants, carriers, amphibious ships, auxiliaries, and their supporting systems require long-lead investments in facilities, suppliers, engineering knowledge, and skilled labor. Unlike commercial commodities, this capacity cannot be regenerated quickly after a crisis begins.

The Department of Defense National Defense Industrial Strategy identifies workforce readiness, resilient supply chains, flexible acquisition, and economic deterrence as core priorities. Workforce readiness is therefore a national-security requirement, not a local human-resources issue (Department of Defense, 2024).

GAO has repeatedly reported schedule and cost shortfalls across Navy shipbuilding programs and has connected industrial-base workforce and infrastructure challenges to those outcomes. Columbia-class schedule risk, Virginia-class production shortfalls, and maintenance delays reduce the availability of critical platforms and place additional pressure on ships already in service (GAO, 2024, 2025a, 2025b).

A qualified workforce contributes to deterrence in three ways. First, it increases the rate at which the nation can deliver and sustain vessels. Second, it reduces quality failures that consume scarce production and repair capacity. Third, it strengthens the supplier base and the ability to surge output when national requirements change.

National-security effect

Every month saved in construction or maintenance, every avoided repair cycle, and every additional qualified worker at a constrained operation increases the industrial base capacity available to the fleet.

4. Current Capability Gap

4.1 Skill Is Necessary but Not Sufficient

Many commercial welders enter the maritime sector with useful manipulation skill but limited exposure to naval technical publications, procedure restrictions, material control, inspection hold points, quality records, or configuration management. Conversely, an individual may understand classroom theory but lack the repeated performance necessary to produce acceptable welds in restricted access, multiple positions, and realistic assemblies. The current gap is the absence of a scalable system that develops both dimensions together.

4.2 Training Completion, Qualification, and Authorization

The program must clearly distinguish among education completion, personnel qualification, certification, and production authorization. Course completion demonstrates that a learner met educational outcomes. Qualification demonstrates performance within a defined range under an invoked standard or approved procedure. Certification may be issued by a recognized organization under its rules. Production authorization remains an employer and technical-authority decision based on the applicable contract, procedure, continuity, supervision, and work controls.

4.3 Capacity Constraints in the Training System

Training throughput can be limited by welding booths, instructors, coupon preparation, testing laboratories, qualification oversight, NDE capacity, consumables, and employer release time. Expanding enrollment without addressing these constraints can increase waiting, lower coaching quality, and reduce completion rates. Program planning must apply Theory of Constraints to the training system itself.

4.4 Quality and Human-Performance Gaps

Organizations frequently respond to defects by retraining individual welders without determining whether the actual causes include poor fit-up, inaccessible design, damaged equipment, unclear instructions, production pressure, inconsistent material control, or delayed feedback. The proposed program addresses this gap by integrating quality management and Human Performance Improvement into craft education.

4.5 Why Existing Training Systems Cannot Fully Meet Maritime Requirements

The program concept identifies structural limitations across the current training landscape. These observations should not be interpreted as dismissing vocational schools, community colleges, unions, or employer academies. Each performs a necessary role. The problem is that no single model consistently supplies the full combination of engineering foundation, trade breadth, naval standards, quality culture, advanced qualification readiness, and career progression required across the Maritime Industrial Base.

Legacy Navy pipeline erosion

The Up-Skill Welder Program concept reports that legacy Navy pipelines for Shipfitter, Pipefitter, Silver Brazier, and advanced nuclear-welding specialties were closed or substantially reduced beginning in the 1990s. As veterans trained through those systems retire, the industrial base loses both production capability and a source of instructors, mentors, supervisors, and technical leaders (WJT, n.d.-b).

Regional vocational focus

Secondary, adult and apprenticeship programs are commonly built around regional employer demand. That responsiveness is valuable, but it can produce narrow curricula that emphasize immediate production tasks without developing the broader engineering, quality, and maritime context needed for mobility across shipyards, suppliers, and advanced naval applications.

Academic and institutional constraints

Community-college programs provide important access, laboratories, credentials, and student services. However, they may be constrained by accreditation, credit-hour structures, academic calendars, and general-education requirements. The national framework should help colleges preserve academic quality while offering stackable, competency-based, noncredit, apprenticeship, and accelerated options aligned with employer qualification.

Contractor-specific acceleration

Employer academies are often optimized to place personnel into specific production assignments quickly. Their focus is necessarily local and contract-specific. A shared national foundation would allow contractor programs to concentrate on proprietary processes, facility practices, approved procedures, and qualification rather than repeatedly rebuilding foundational content.

Local labor-market depletion

Major shipyards and defense contractors often recruit from the same regional labor pools. Expanding national capacity therefore requires distributed training, interstate recruitment, relocation support, supplier pathways, and accelerated conversion of experienced industrial workers—not simply intensified local recruiting.

4.6 The Missing Middle: Experienced Welders Who Are Not Yet NAVSEA-Ready

The fastest available source of additional capacity may be experienced commercial welders who already possess basic process control, work discipline, and fabrication experience but lack NAVSEA-specific knowledge. Requiring these workers to repeat an entire entry-level program wastes prior learning; placing them directly into qualification preparation without a structured bridge risks failure and unsafe assumptions. The up-skill pathway addresses this middle ground through diagnostic assessment, targeted remediation, maritime engineering orientation, standards training, advanced practical exercises, and employer qualification readiness.

4.7 Applied Science Must Match Occupational Decisions

Trades programs can fail in two opposite directions: they can omit the science needed for sound technical judgment, or they can teach decontextualized mathematics and science at a depth that consumes time without improving craft performance. The correct standard is occupational relevance and transfer. Applied science should be rigorous enough for workers to understand heat input, electrical relationships, shielding, gas behavior, metallurgy, hydrogen control, distortion, corrosion, mechanical properties, tolerances, and cause-and-effect relationships in the processes they perform. It should not become an academic filter unrelated to the decisions, calculations, observations, and controls required on the job.

Mathematics and science requirements should therefore be derived from task analysis and failure consequence. Instruction should begin with the physical problem, use the equations and concepts needed to explain it, and return immediately to measurement, setup, troubleshooting, or verification. Advanced theory should remain available for technicians, inspectors, instructors, technologists, and engineering articulation, but entry and craft progression should not depend on mastering theory beyond the level required for safe, accurate, and adaptable performance.

4.8 Informal Knowledge, Authority Gradients, and Technical Misinformation

Tradespeople routinely learn from supervisors, senior workers, peers, and respected specialists. This social transmission is indispensable for preserving tacit knowledge, but it can also create durable local beliefs that are only partly correct, conditionally correct, or unsupported. When workers lack enough applied science, standards literacy, and confidence to test an explanation, status and repetition can substitute for evidence. Separate shops and crews can then develop incompatible explanations, workarounds, and traditions that persist despite changes in materials, processes, procedures, or equipment.

The program should treat this as a technical-control and human-performance issue, not as a defect in individual workers. Learners must be taught to distinguish requirement from preference, observation from inference, and verified cause from plausible explanation. Instructors and supervisors should model source checking, controlled experimentation, questioning attitude, and conservative decision-making. Disputed claims should be resolved through the invoked technical document, approved procedure, manufacturer data, qualified technical authority, or controlled test—not seniority alone. Assessments should require learners to explain why a control exists, identify the source of the requirement, state the limits of their knowledge, and escalate uncertainty before acting.

5. Educational Philosophy and Learning Model

The instructional methodology combines complementary learning theories because advanced trade competence includes knowledge, physical performance, judgment, communication, and participation in a controlled work system. No single theory is adequate by itself.

Learning methodology	Application in the program
Competency-Based Education	Progression is based on demonstrated knowledge, skill, safety, quality, and documentation performance rather than seat time alone.
Mastery Learning - Bloom	Learners receive formative assessment, corrective instruction, targeted practice, and reassessment before advancing.
Experiential Learning - Kolb	Practical work is followed by reflection, connection to theory, and controlled experimentation.
Cognitive Apprenticeship	Instructors model expert decisions, coach performance, provide scaffolds, require articulation, and gradually fade support.
Deliberate Practice - Ericsson	Practice targets specific weaknesses, uses immediate feedback, and requires repeated performance at the edge of current capability.
Project-Based Learning	Authentic assemblies integrate drawings, planning, fitting, welding, inspection, documentation, and teamwork.
Adult Learning - Knowles	Instruction recognizes prior experience, emphasizes occupational relevance, and provides accelerated progression when mastery is demonstrated.
Situated Learning - Lave and Wenger	Learners participate in realistic naval production and quality practices and progressively assume fuller responsibility.

5.1 Instructional Cycle

1. Define the required competency and applicable technical requirements.
2. Provide theory, safety instruction, and an expert demonstration that makes decision-making visible.
3. Use guided practice with checklists, fixtures, visual standards, and close coaching.
4. Assess performance formatively and diagnose specific errors.
5. Assign deliberate corrective practice and reassess to a mastery threshold.
6. Integrate the competency into a realistic fabrication project.
7. Verify sustained performance through written, oral, practical, and product-based assessment.
8. Transition the learner to employer- and procedure-specific qualification.

5.2 Assessment Philosophy

Assessment should evaluate the process used to produce the component as well as the finished product. A visually acceptable weld produced with an incorrect filler metal, unapproved parameter, lost traceability, or incomplete record is not acceptable naval workmanship. Assessment must include procedure interpretation, setup, fit-up, process execution, self-inspection, corrective reasoning, safety, and documentation.

5.3 Integrated Learning Model

The instructional model combines competency-based education, mastery learning, experiential learning, cognitive apprenticeship, deliberate practice, project-based learning, adult learning, and situated learning. These methods are applied as an integrated system rather than as competing theories.

Competencies define the required outcome. Mastery learning prevents unresolved gaps from carrying forward. Cognitive apprenticeship makes expert judgment visible. Deliberate practice targets specific deficiencies. Experiential learning connects action, reflection, theory, and correction. Project-based learning integrates separate competencies into complete fabrication work. Adult-learning principles recognize prior experience and occupational relevance. Situated learning develops participation in the language, roles, controls, and culture of naval production.

The primary-source program concept is consistent with this approach: it calls for a structured basic and advanced curriculum, active practical learning, incremental progression, merit-based advancement, modified outcome-based education, constructive learning, and focused pathways for entry-level, up-skill, and advanced students (WJT, n.d.-b).

5.4 Instructional Ratio and Practice Design

Delivery should be organized around short theory blocks followed by demonstration, coached practice, reflection, and reassessment. Practical time should be prescribed by demonstrated need rather than uniform seat time. Experienced learners may accelerate through mastered competencies; new learners may receive additional practice without being labeled unsuccessful. No learner should advance to high-consequence tasks until prerequisite behaviors are reliable.

Practice must be deliberate. Each session should specify the targeted variable—such as root opening control, torch angle, interpass cleaning, arc length, purge integrity, distortion sequence, documentation accuracy, or restart technique—and the evidence required for mastery. Undirected arc time should not be treated as equivalent to effective practice.

6. Industry and Government Alignment

The program should align education, apprenticeship, workforce funding, defense-industrial-base initiatives, and recognized manufacturing credentials. Alignment does not mean that every partner uses identical requirements. It means that each partner contributes to a coordinated pathway leading toward employer-defined productive competence.

Organization or framework	Program relevance
NAVSEA and Maritime Industrial Base Program	Technical authority, workforce priorities, supplier development, production capacity, and national coordination
U.S. Department of Labor Registered Apprenticeship	Structured on-the-job learning, related instruction, progressive skill development, and recognized completion
Employment and Training Administration / WIOA	Eligible training, supportive services, incumbent-worker training, dislocated-worker pathways, and regional workforce coordination
NCES and state education systems	Program classification, completion data, CTE alignment, and educational accountability
NIMS	Competency and performance-assessment concepts for advanced manufacturing occupations
Manufacturing USA and America Makes	Technology transition, additive manufacturing, automation, and regional innovation networks
JFF and National Skills Coalition	Career pathways, equitable access, job quality, stackable credentials, and middle-skill policy
BlueForge Alliance	Maritime workforce attraction, supplier engagement, regional initiatives, and advanced technology deployment
NSRP, SNAME, ABS, and ASSA	Shipbuilding research, technical modernization, supplier requirements, professional development, and commercial maritime perspectives

7. Program Architecture

7.1 National Core, Regional Delivery, Employer Qualification

The recommended architecture has three layers. A national core defines common outcomes and assessment requirements. Regional delivery partners provide instruction using validated facilities and instructors. Employers conduct procedure-, product-, and facility-specific qualification and authorize production work.

Layer	Primary responsibility	Representative outputs
National program office	Governance, standards, curriculum control, data, instructor criteria, continuous improvement	National competency framework; approved curriculum; assessment bank; data standards
Regional consortium	Recruitment, instruction, supportive services, apprenticeship alignment, employer coordination	Qualified instructors; labs; cohorts; student services; regional placement
Employer or activity	Procedure-specific training, qualification, continuity, supervision, production authorization	Welder qualification records; employer onboarding; production assignment; performance feedback

7.2 Entry and Advancement Pathways

- Exploration and pre-apprenticeship for high school students, adult learners, transitioning service members, and career changers.
- Entry-level naval manufacturing foundation for learners with limited welding experience.
- Commercial-to-NAVSEA bridge for experienced welders, fitters, and brazers.
- Registered Apprenticeship-aligned pathways combining related instruction and structured on-the-job learning.
- Advanced qualification pathways for specialized processes, materials, positions, and controlled applications.
- Incumbent-worker upskilling in automation, robotics, inspection, quality, planning, and leadership.
- Instructor, mentor, inspector, planner, supervisor, specialist, technologist, and engineering articulation pathways.

7.3 Governance

Governance should include NAVSEA technical representation, MIB workforce leadership, public and private shipyards, major and small suppliers, labor and apprenticeship partners, community colleges, workforce agencies, and state economic-development organizations. Technical decisions must remain separated from enrollment or placement pressures. A curriculum council should manage revisions, while an independent assessment and data group validates outcomes.

7.4 Three Primary Workforce Pathways

Pathway 1 - Entry-Level Maritime Trades Development

This pathway serves secondary students, adult learners, veterans, transitioning service members, displaced workers, and career changers. It begins with occupational orientation, safety, applied mathematics and science, tools, drawings, materials, engineering fundamentals, and maritime systems before progressing into welding, fitting, brazing, fabrication, inspection, and quality assurance.

Pathway 2 - Commercial-to-NAVSEA Up-Skill Bridge

This accelerated pathway serves experienced welders and fitters. Entry begins with diagnostic written and practical assessments mapped to program competencies. Individual learning plans identify what the learner can bypass, what must be refreshed, and what must be newly learned. The pathway emphasizes NAVSEA terminology, procedure limits, technical documentation, material and consumable control, marine systems, restricted-access technique, qualification preparation, and quality culture.

Pathway 3 - Advanced Specialty and Leadership Development

This pathway prepares qualified workers for advanced applications and future roles. Tracks may include silver brazing, nuclear-component welding, SUBSAFE and Level I work, advanced pipe systems, mechanized and robotic welding, welding inspection, instructor development, planning, supervision, and welding-technology articulation.

7.5 Five-Phase Educational Model

Phase I: Engineering fundamentals, safety, occupational orientation, ethics, safeguarding information, cybersecurity, documentation, communication, and Navy craftsmanship.

Phase II: Trade fundamentals in cutting, welding processes, metallurgy, blueprint reading, layout, shipfitting, pipefitting, brazing, inspection, and fabrication.

Phase III: Maritime systems, including power generation, steam and gas-turbine systems, pumps, valves, piping, auxiliary machinery, instruments, electrical systems, environmental controls, propulsion, and ship maintenance.

Phase IV: NAVSEA qualification readiness, including applicable technical publications, approved procedures, essential variables, material control, quality assurance, documentation, inspection, repair control, and employer-specific qualification.

Phase V: Advanced manufacturing and leadership, including Lean, Six Sigma, Theory of Constraints, quality management, automation, robotics, digital work instructions, data literacy, human performance, continuous improvement, mentoring, and supervision.

7.6 Delivery Modes

The system should support full-time academies, Registered Apprenticeship related instruction, incumbent-worker blocks, weekend and evening cohorts, mobile laboratories, hybrid theory delivery, employer-site instruction, co-op programs, and train-the-trainer models. Delivery flexibility is essential because the target populations include both new entrants and employed adults who cannot leave production for long periods.

7.7 Scalability Across Maritime Trades

The proposed architecture is transferable to other occupations required by the Maritime Industrial Base. Welding, brazing, fitting, and fabrication are the first detailed occupational applications; they are not the intended limit of the system. The same governance, regional-delivery, competency, apprenticeship, instructor-development, high-reliability, job-quality, data, and continuous-improvement structures can support shipfitters, pipefitters, marine electricians, machinists, millwrights, riggers, sheet-metal workers, insulators, coatings and preservation personnel, nondestructive-testing personnel, quality inspectors, dimensional-control specialists, HVAC and refrigeration technicians, instrumentation and controls technicians, shipboard systems technicians, planners, estimators, supervisors, and production-control personnel.

Scalability should use four controlled layers: (1) a common maritime core covering safety, ship systems, terminology, technical documents, configuration control, quality, high-reliability behaviors, communication, and Navy craftsmanship; (2) a trade-family foundation for related occupations; (3) occupation-specific technical instruction, workmanship criteria, tools, processes, and performance assessments; and (4) employer-, facility-, procedure-, and contract-specific qualification and production authorization. This structure permits shared infrastructure and mobility without falsely treating one trade's standards, hazards, or qualifications as interchangeable with another's.

Each additional occupation requires a formal occupational and task analysis, standards crosswalk, hazard analysis, equipment and facility specification, instructor criteria, practical assessment system, and determination of any licensing, certification, qualification, continuity, or supervised-experience requirements. Expansion should proceed by validated trade modules and trade families rather than by relabeling the welding curriculum. Common elements may be reused; technical authority and acceptance criteria must remain occupation-specific.

8. Curriculum Framework

The curriculum is modular so that learners can enter at an appropriate point, demonstrate prior learning, and accumulate stackable competencies. Recommended instructional hours should be established through pilot testing and employer validation rather than fixed nationally before performance data are available.

Curriculum domain	Core content
Safety and high-reliability work practices	OSHA principles; hot work; ventilation; PPE; confined spaces; fire prevention; FME; pre-job briefs; stop-work responsibility
Mathematics, measurement, and blueprint reading	Fractions and decimals; geometry; tolerances; weld symbols; drawings; revision control; model-based information
Materials and metallurgy	Carbon and alloy steels; stainless steels; aluminum; copper-nickel and other naval alloys; heat effects; cracking; corrosion; distortion
Oxyfuel and thermal cutting	Equipment, setup, cutting, beveling, heating, gouging, safety, and preparation quality
SMAW	Equipment, electrodes, parameters, positions, groove and fillet welds, restricted access, troubleshooting
GMAW and FCAW	Transfer modes, shielding, wire control, parameter relationships, productivity, mechanization, defect prevention
GTAW and brazing	Torch and filler control, purge practices, roots, thin materials, pipe applications, joint cleanliness, brazing variables
Fitting and fabrication	Layout, cutting, forming, alignment, tack welding, fixtures, sequence, dimensional control, pipe and structural assemblies
Inspection and testing awareness	Visual inspection, gauges, discontinuities, acceptance criteria, destructive and nondestructive test concepts
Quality systems and documentation	WPS/PQR/WPQ concepts; traceability; material and consumable control; records; nonconformance; corrective action
Manufacturing excellence	Lean, Six Sigma, TOC, TQM, Kaizen, SPC, RCA, FMEA, Human Performance Improvement
Digital and advanced manufacturing	Digital work instructions, electronic records, automation, robotics, sensors, additive manufacturing, extended reality
Professional and employability skills	Communication, teamwork, attendance, problem solving, financial literacy, career planning, leadership, mentoring
Capstone production simulation	Integrated planning, fabrication, inspection, documentation, presentation, and improvement project

8.1 Curriculum Differentiation

Entry-level learners require structured development of basic manipulation, measurement, safety, and work habits. Experienced welders should be assessed early and assigned a bridge curriculum focused on naval standards, qualification limitations, materials, documentation, and identified technical gaps. Incumbent workers should receive short, high-intensity modules tied to actual production problems and qualification needs.

8.2 Instructor Development

Instructor capacity is a critical constraint. The program should establish instructor qualification criteria, train-the-trainer academies, co-teaching arrangements between educators and experienced naval craft personnel, and release-time support for subject-matter experts. Instructor evaluation should include technical currency, teaching performance, learner outcomes, safety, and consistency of assessment.

8.3 Phase I - Naval and Maritime Engineering Foundation

The engineering foundation differentiates the proposed system from conventional welding instruction. Learners study the organization and language of naval and maritime work, basic engineering theory, safety and PPE, tools and equipment, applied science, engineering administration, documentation, quality systems, communication, craftsmanship, and workmanship. This phase also covers workplace ethics, safeguarding assets and confidential information, cybersecurity, relationship systems, and self-management (WJT, n.d.-a).

Marine-system content should include basic steam cycles, boilers, steam turbines, gas turbines, internal-combustion engines, propulsion systems, pumps, valves, piping, auxiliary machinery, instruments, marine electrical systems, environmental controls, and ship maintenance. The objective is not to qualify welders as marine engineers. It is to give tradespeople enough systems understanding to recognize component function, operating consequence, interface risk, and the importance of configuration and quality.

Applied-science design standard

Every mathematics or science outcome should map to a recognizable craft decision, observable failure mode, controlled variable, or progression pathway. Instruction should use representative materials, equipment, drawings, procedures, and production examples. Learners should calculate, predict, observe, measure, compare, and explain. Competence is demonstrated when they can apply the principle to an unfamiliar but related condition; recitation of theory alone is insufficient.

8.4 Phase II - Welding, Fitting, Cutting, and Brazing Fundamentals

Core trade modules should cover oxyfuel cutting and welding; shielded metal arc welding; gas metal arc welding; flux-cored arc welding; gas tungsten arc welding; plasma cutting; carbon-arc gouging; joint preparation; distortion control; metallurgy; filler-metal selection; shipfitting; pipefitting; silver brazing; blueprint and model interpretation; dimensional control; inspection; and fabrication planning.

Each module should contain instructor guides, learner materials, demonstrations, knowledge checks, practical exercises, performance rubrics, remediation plans, and evidence requirements. Skill progression should move from flat plate and simple joints to positional, restricted-access, pipe, and assembly work. The goal is reliable process control rather than isolated coupon success.

8.5 Phase III - Maritime Systems Integration

Learners apply trade skills to representative maritime systems. Projects may include pipe spools, valve assemblies, structural subassemblies, equipment foundations, tanks, supports, access-restricted joints, and repair scenarios. Every project should require planning, drawing review, material verification, fit-up, welding or brazing, dimensional control, inspection, documentation, and a post-job review.

8.6 Phase IV - NAVSEA Qualification Readiness

This phase teaches the learner to work within the qualification and quality framework governing applicable Navy work. Instruction should address NAVSEA S9074-AQ-GIB-010/248, relevant portions of NAVSEA S9086-CH-STM-010, MIL-STD-1689 where invoked, approved welding procedures, qualification ranges, essential variables, continuity, test-coupon preparation, acceptance methods, inspection interfaces, repair authorization, controlled documentation, and employer authority.

8.7 Phase V - Advanced Manufacturing and Continuous Improvement

Advanced modules develop digital and manufacturing-excellence capability. Topics include mechanized and robotic welding, digital work instructions, electronic quality records, data acquisition, additive manufacturing awareness, Lean flow, Six Sigma problem solving, Theory of Constraints, Statistical Process Control, Root Cause Analysis, FMEA, Human Performance Improvement, and quality-management systems.

8.8 Professional and Employability Competencies

The program should explicitly assess attendance, reliability, communication, teamwork, ethical conduct, documentation, self-management, respectful workplace behavior, safeguarding information, cybersecurity awareness, and response to feedback. These are production competencies, not optional soft skills. A technically capable worker who cannot follow controls, communicate conditions, or reliably report to work does not provide usable industrial capacity.

Highly Reliable Behaviors (HRBs) should be incorporated throughout the curriculum and organizational culture. The program should explicitly develop and assess the five core HRB principles commonly associated with high-consequence industries: (1) questioning attitude, (2) clear and effective communication, (3) procedural compliance and disciplined operations, (4) peer checking and verification of critical steps, and (5) conservative decision-making that defaults to the safest technically justified course of action. These behaviors should be reinforced through pre-job briefs, post-job reviews, human performance tools, stop-work authority, independent verification, error-likely situation recognition, and continuous learning from near misses and nonconformances. HRBs should be evaluated as measurable competencies alongside technical welding performance because they directly influence safety, quality, configuration control, and mission readiness.

Workmanship as an observable competency

Welder and brazer workmanship is the disciplined execution of approved work, not merely the visual appearance of the completed joint. It includes correct preparation and setup, compliance with the approved procedure, control of technique and process variables within permitted limits, protection of material and consumable identity, interoperation cleanliness, recognition and reporting of abnormal conditions, self-inspection, and accurate completion of required records. General workmanship extends beyond the individual arc or braze operation to fit-up, alignment, temporary attachments, access, sequencing, distortion control, protection of adjacent surfaces and systems, correction of deficiencies, housekeeping, and preservation of configuration and traceability.

Workmanship should be taught and assessed through direct observation in representative conditions. Rubrics must evaluate both the product and the behaviors that produced it, including whether the worker stopped when requirements were unclear or conditions moved outside authorized limits. A finished joint that appears acceptable does not demonstrate acceptable workmanship if an unapproved method, incorrect material, uncontrolled repair, missing verification, or inaccurate record was used. Conversely, workmanship training should explain the technical and mission basis of each control so that compliance is deliberate rather than ritualized.

8.9 Capstone and Transition to Employment

The capstone should simulate a controlled maritime production assignment. Teams receive a work package, drawings, material list, quality plan, hold points, and delivery requirement. They plan and fabricate a representative component, complete inspections and records, respond to a controlled discrepancy, and present a post-job review. Successful capstone performance demonstrates educational readiness; employer qualification and production authorization remain separate.

9. Technical Standards and Qualification

9.1 NAVSEA Requirements Govern Applicable Navy Work

NAVSEA standards, contract requirements, approved procedures, and activity-specific quality provisions govern qualification and production for applicable Navy work. Commercial and international standards provide useful educational and comparative benchmarks, but they do not replace NAVSEA qualification or employer authorization.

The curriculum should be designed around NAVSEA S9074-AQ-GIB-010/248, applicable portions of NAVSEA S9086-CH-STM-010, MIL-STD-1689, NAVEDTRA 14119, Level 1, SUBSAFE requirements where invoked, and other applicable NAVSEA technical publications. Because controlled documents and contract requirements change, training providers must maintain a formal document-control process and verify current revisions before instruction or qualification activity.

9.2 Comparison with Commercial and International Standards

Comparison with AWS, ASME, ISO, and IIW frameworks demonstrates that the proposed curriculum exceeds typical entry-level industrial welding expectations. The defensible claim is not that NAVSEA is categorically more demanding in every clause. It is that the complete naval curriculum is broader because it integrates high-consequence process control, technical-document discipline, material traceability, configuration awareness, inspection hold points, documentation integrity, and qualification to employer-approved procedures.

Reference	Primary purpose	Curriculum relationship
AWS D1.1	Structural steel welding code	Commercial structural code literacy; not a substitute for NAVSEA qualification
AWS B5.1	Qualification of welding inspectors	Inspection awareness and advanced career pathway
AWS QC10 and SENSE	Entry-level welder education and program standards	National educational baseline that the naval curriculum should meet or exceed
ASME BPVC Section IX	Procedure and performance qualification for pressure applications	Parallel qualification concepts; not interchangeable with NAVSEA
ISO 3834	Quality requirements for fusion welding	International process and quality-management benchmark
ISO 9606	Welder qualification testing	International comparison of variables and qualification ranges
IIW system	Harmonized education and certification of welding personnel	International career ladder and curriculum-quality benchmark

9.3 Qualification Readiness

Qualification preparation should not be reduced to repeated test coupons. Learners must understand the variables that bound qualification, the reason for each control, the difference between acceptable training practice and authorized production practice, and the continuity requirements needed to maintain qualification. Readiness decisions should consider repeated performance, process knowledge, safety, documentation, and professional conduct.

9.4 Workmanship Requirements and Source Applicability

Workmanship requirements must be derived from the documents invoked for the specific work. The program should teach a source hierarchy rather than combine every referenced document into a single generalized rule set. S9074-AQ-GIB-010/248 governs applicable welding and brazing procedure and performance qualification requirements. S9074-AR-GIB-010/278 addresses fabrication, welding, inspection, and workmanship for applicable machinery, piping, and pressure-vessel work. MIL-STD-1689A establishes fabrication, welding, inspection, and workmanship controls for ship structure, including applicable high-strength materials. TP 1688 provides submarine structural requirements for applicable HY and HSLA work when invoked. Electric Boat Specification 2678N Quality Control applies only where incorporated by the governing contract, purchase order, drawing, procedure, or other controlled requirement.

These documents differ in scope, applicability, technical authority, and revision control. Curriculum products should identify the governing source beside each workmanship criterion and should never present shipyard-specific or customer-specific requirements as universally applicable NAVSEA rules. Instructors must use the contractually invoked revision and approved local procedures. Where documents conflict or applicability is uncertain, work should stop and the issue should be referred to the responsible technical and quality authorities before instruction or production continues.

10. Workforce Development Strategy

10.1 Recruitment and Access

Recruitment should target high school CTE students, adult learners, veterans, underemployed workers, displaced workers, experienced tradespeople, and populations historically underrepresented in manufacturing. Outreach must present a realistic picture of the work, including physical requirements, schedules, safety expectations, advancement opportunities, wages, and the national-security mission.

10.2 Supportive Services

Training completion is affected by transportation, housing, childcare, tools, personal protective equipment, academic preparation, and income during training. WIOA and state workforce resources should be used to provide supportive services, while employers and economic-development organizations should coordinate transportation and housing solutions in high-demand regions.

10.3 Apprenticeship and Work-Based Learning

Registered Apprenticeship provides a durable structure for related instruction, paid on-the-job learning, progressive skill development, and recognized completion. Pre-apprenticeship should be connected to actual employer demand and include transparent entry criteria, credit for prior learning, and supportive services. NSRP research shows that structured pre-hire and apprenticeship partnerships can produce strong retention when employers, colleges, and mentors are aligned (NSRP, 2023).

10.4 Retention and Advancement

Recruitment without retention wastes public and private investment. Compensation and the work environment are operating conditions of workforce capability, not secondary benefits. Participating employers should provide market-competitive base pay; clearly defined shift, overtime, travel, per-diem, and high-skill differentials where applicable; affordable benefits; paid training and qualification time; and transparent wage progression tied to demonstrated competencies, qualifications, responsibility, and sustained performance. Compensation systems should not reward excessive overtime, unsafe production pressure, or qualification attainment without verified competence.

The work environment should support reliable performance through competent front-line supervision, adequate staffing, maintained tools and equipment, effective ventilation and environmental controls, accessible personal protective equipment, orderly material flow, reasonable break and fatigue-management practices, predictable scheduling, and credible stop-work authority without retaliation. Housing, transportation, childcare, travel, and security-processing delays should be addressed where they materially restrict labor-force participation. Worker feedback, near-miss reporting, grievances, absenteeism, overtime, injuries, rework, and voluntary turnover should be reviewed together because poor working conditions can appear as recruiting, training, quality, or productivity failures.

10.5 Data and Accountability

A shared data system should track enrollment, demographics, prior experience, completion, qualification attempts, placement, time to productive assignment, retention, advancement, starting and real wage progression, benefit access, schedule stability, overtime burden, safety climate, worker satisfaction, first-pass acceptance, rework, and employer satisfaction. Results should be disaggregated by employer, occupation, shift, employment arrangement, and workforce pathway where sample size permits, while protecting personally identifiable information. The program must demonstrate whether training investment creates durable industrial capacity rather than short-term placement followed by turnover.

11. Industry Partnerships

No single organization can build the required workforce alone. The partnership model should connect demand owners, technical authorities, employers, education providers, workforce agencies, suppliers, research organizations, and economic-development entities.

11.1 Employer and Supplier Role

Shipyards, repair activities, and suppliers should validate competencies, provide demand forecasts, support work-based learning, loan or donate equipment, assign mentors, provide defect and qualification feedback, and participate in governance. Participation agreements should also define employer commitments for compensation transparency, paid learning time, schedule practices, supervisory preparation, safe and serviceable facilities, anti-harassment and grievance processes, career progression, and reporting of retention and job-quality measures. Supplier participation is essential because production expansion increasingly distributes work beyond prime shipyards.

11.2 Community College and CTE Role

Education partners provide accessible facilities, instructors, student services, credit and noncredit delivery, dual enrollment, assessment, and academic articulation. They should be allowed to deliver a common national curriculum while retaining flexibility in scheduling, local recruitment, and student support.

11.3 Workforce and Economic Development Role

Workforce agencies can fund tuition, supportive services, transportation, childcare, tools, stipends, relocation, and incumbent-worker training. State economic-development organizations can align training investments with supplier recruitment, facility expansion, regional cluster strategies, and interstate workforce mobility.

11.4 Staffing and Transitional Employment

The Up-Skill Welder Program concept proposes partnerships with staffing organizations and industry partners, including transitional or leased-labor arrangements that allow employers to evaluate graduates at lower initial risk (WJT, n.d.-b). Such arrangements should protect worker rights, provide transparent conversion pathways, and be measured against retention, wage progression, qualification, and permanent placement.

Maritime-specialist staffing and contract-labor providers can serve as workforce intermediaries across recruitment, diagnostic assessment, training referral, qualification-readiness preparation, placement, mobility, continuity tracking, and redeployment between projects. Because they observe demand across multiple employers and regions, they can help identify transferable competencies, aggregate training demand that is too small for a single supplier and move experienced human capital toward constrained work. Their role should extend beyond filling vacancies to supporting the worker's development through the maritime career lifecycle.

Program participation should be governed by written standards covering accurate representation of qualifications, verification of records, wage and benefit transparency, travel and per-diem terms, paid training and testing, continuity and credential portability, safety reporting, grievance access, anti-retaliation, conversion terms, and responsibility for failed placements. Performance measures should distinguish temporary placement from durable capacity by tracking repeat placement, qualification maintenance, wage progression, permanent conversion, worker satisfaction, safety, rework, and retention. Staffing arrangements must not be used to evade employer training obligations, suppress compensation, fragment qualification records, or shift avoidable risk to workers.

11.5 Technical and Professional Organizations

BlueForge Alliance, the American Shipbuilding Suppliers Association, NSRP, SNAME, ABS, AWS, ASME, NIMS, Manufacturing USA institutes, America Makes, and other organizations can contribute research, technical review, modernization support, instructor development, supplier engagement, and dissemination. Their role should complement—not displace—NAVSEA technical authority and employer responsibility.

Partner	Recommended role
NAVSEA / MIB Program	Set strategic priorities, coordinate national demand, support technical alignment, and evaluate industrial-capacity outcomes
BlueForge Alliance	Support workforce attraction, supplier engagement, regional initiatives, technology adoption, and national messaging
Prime shipyards and repair activities	Define demand, provide subject-matter experts, equipment access, work-based learning, qualification, and production feedback
American Shipbuilding Suppliers Association and suppliers	Represent supplier needs, expand participation, identify regional demand, and support common foundational training
NSRP	Provide research, pilot projects, modernization methods, apprenticeship lessons, and technology-transfer mechanisms
SNAME	Connect craft education with naval architecture, marine engineering, ship production, and professional development
ABS	Provide commercial maritime, classification, risk, digitalization, and emerging-technology perspectives where applicable
Community and technical colleges	Deliver instruction, award academic credit, provide laboratories, remedial support, and faculty capacity
Workforce boards and state agencies	Provide recruitment, funding, supportive services, labor-market analysis, and regional coordination
Labor organizations and apprenticeship sponsors	Provide structured work-based learning, mentors, worker voice, and portable occupational progression
Manufacturing USA institutes	Support automation, additive manufacturing, digital systems, and advanced-manufacturing curriculum

BlueForge Alliance reports more than 160 active Maritime Industrial Base projects and engagement with more than 700 suppliers, illustrating the scale of current national coordination. NSRP projects demonstrate active modernization in apprenticeship, digital work instructions, welding process development, optimized weld records, tele-welding, and workforce productivity. These initiatives should feed directly into curriculum updates and instructor development (BlueForge Alliance, 2024; NSRP, 2025).

12. Expected Outcomes

12.1 Workforce Outcomes

- Increased number of workers prepared for employer-specific NAVSEA qualification.
- Higher first-attempt qualification and lower remediation demand.
- Reduced time from enrollment and hire to productive assignment.
- Improved retention at 90 days, one year, three years, and apprenticeship completion.
- Expanded pipeline of instructors, mentors, inspectors, supervisors, planners, and technical specialists.
- Greater mobility between regional employers based on documented foundational competencies.

12.2 Quality and Production Outcomes

- Higher first-pass weld acceptance and fewer repair hours.
- Improved fit-up, dimensional control, documentation, and material traceability.
- Lower variability in recurring processes and earlier detection of special causes.
- Increased throughput at constrained work centers.
- Better utilization of automation, robotics, digital tools, and capital equipment.
- Improved supplier on-time delivery and reduced concentration risk.

12.3 Cultural Outcomes

- Stronger questioning attitude, stop-work responsibility, and conservative decision-making.
- Greater understanding that quality is produced by capable processes rather than final inspection alone.
- Improved communication among craft, engineering, inspection, planning, and supervision.
- Employee participation in continuous improvement and root-cause problem solving.
- Clearer occupational identity and connection between individual workmanship and fleet readiness.

13. Return on Investment

The program should be evaluated as a workforce-capacity investment. The business case includes avoided cost, additional throughput, improved schedule reliability, supplier resilience, and national-security value. BLS replacement demand and manufacturing workforce studies show that employers will continue to compete for skilled labor. GAO findings show that industrial-base workforce constraints are already associated with shipbuilding and maintenance shortfalls (BLS, 2025; Deloitte & The Manufacturing Institute, 2024; GAO, 2025a, 2025b).

Benefit category	Illustrative calculation
Faster time to competence	Reduction in nonproductive onboarding time x number of hires x loaded labor and overhead cost
Higher first-attempt qualification	Avoided retests x total material, instructor, testing, and delay cost per retest
Reduced rework	Reduction in repair hours x loaded labor rate, plus avoided inspection, material, and schedule costs
Improved retention	Avoided separations x recruiting, onboarding, training, and lost-productivity cost per replacement
Constraint throughput	Additional accepted units or productive hours at the system constraint x contribution value
Supplier expansion	Avoided disruption, increased competition, and additional qualified capacity across the supply chain
Capital utilization	Increased productive use of facilities, robotics, digital systems, fixtures, and advanced equipment

13.1 Recommended Performance Measures

Measure	Purpose
Cost per enrolled participant, graduate, and qualified worker	Compare resource use with successful outcomes
Time to employment and productive assignment	Measure pipeline and onboarding efficiency
First-attempt qualification rate	Assess training alignment and avoid retest cost
First-pass weld acceptance and repair hours	Connect training to product quality and cost of nonquality
Retention at 90 days, 1 year, and 3 years	Measure durability of workforce investment
Advancement and wage progression	Evaluate career-pathway value and skill growth
Throughput at constrained operations	Link workforce capacity to production output
Supplier on-time delivery and quality	Measure supply-chain effect
Employee engagement and improvement submissions	Track culture, satisfaction, and continuous improvement
Schedule milestones and asset availability	Connect workforce outcomes to mission performance

13.2 ROI Formula

Return on workforce investment

(Quantified benefits - total program costs) / total program costs. Financial measures should be supplemented by mission measures because the value of reduced submarine delay, improved maintenance availability, and preserved industrial knowledge cannot always be fully expressed in dollars.

14. Implementation Roadmap

Phase	Time frame	Primary actions	Decision criteria
I. Design and governance	0-6 months	Establish charter and governance; validate demand; map standards; define competencies; select pilot regions; establish data and document control	Approved governance, competency framework, partner commitments, and pilot funding
II. Curriculum and instructor preparation	6-12 months	Develop modules, assessments, instructor guides, lab standards, train-the-trainer program, articulation, and apprenticeship alignment	Validated curriculum, qualified instructors, safe facilities, and employer-approved assessments
III. Pilot delivery	12-24 months	Launch cohorts in selected regions; test entry, bridge, and incumbent pathways; collect qualification, retention, and quality data	Demonstrated improvement over baseline and identified corrective actions
IV. Regional expansion	24-48 months	Scale to additional shipbuilding and supplier regions; add mobile capacity; expand instructor pipeline and advanced modules	Consistent outcomes across sites and sufficient employer demand
V. National sustainment	48 months and beyond	Institutionalize funding, annual technical review, data reporting, research integration, and continuous improvement	Stable governance, validated ROI, current curriculum, and measurable industrial-capacity gains

14.1 Pilot Selection

Pilot regions should represent different operating environments: a major submarine or surface-ship hub, a supplier-intensive inland region, a public shipyard or repair ecosystem, and a developing region with strong community-college and economic-development capacity. Selection should be based on documented demand, employer commitment, instructor and facility readiness, supportive-service capacity, and willingness to share performance data.

14.2 Risk Management

14.3 Phase 0 - Mobilization and Design (0-6 Months)

Establish the national steering group, confirm intellectual-property and data-rights arrangements, validate demand, select pilot occupations, define national competencies, identify technical authorities, conduct facility and instructor assessments, and create the initial performance-measurement plan.

14.4 Phase 1 - Curriculum Validation and Instructor Preparation (6-12 Months)

Convert the primary-source program concepts into controlled curriculum products. Complete employer reviews, map content to NAVSEA and industry references, prepare instructor guides and assessments, train and qualify instructors, establish safety and quality controls, and conduct small-scale curriculum trials.

14.5 Phase 2 - Regional Pilots (12-24 Months)

Launch pilots in two to four regions representing different industrial conditions: a major shipyard cluster, a supplier region, a community-college consortium, and an accelerated up-skill location. Enroll both entry-level and experienced-worker cohorts. Use common data definitions and independent evaluation.

14.6 Phase 3 - Expansion and Apprenticeship Integration (24-48 Months)

Scale successful modules into Registered Apprenticeship and pre-apprenticeship systems, develop interstate articulation, expand instructor capacity, add mobile and employer-site delivery, and establish advanced-specialty pathways. Continue to separate educational completion from employer qualification.

14.7 Phase 4 - National Network and Continuous Improvement (48-72 Months)

Establish a sustained national network with annual curriculum review, regional demand planning, instructor communities of practice, shared assessment standards, outcome dashboards, supplier access, and formal processes for incorporating changes in technology, standards, and production needs.

14.8 Decision Gates

Each phase should include a formal decision gate based on evidence. Expansion should depend on demonstrated employer demand, instructor readiness, safety performance, learner completion, qualification outcomes, retention, quality, cost, and throughput—not solely on enrollment or grant expenditure.

Implementation risk	Mitigation
Curriculum becomes outdated	Formal technical review, controlled revisions, and annual employer validation
Enrollment exceeds employer demand	Regional demand forecasting and cohort approval tied to actual openings
Inconsistent assessment among sites	Standard evaluator training, common rubrics, moderation, audits, and performance-data review
Instructor shortage	National instructor academy, co-teaching, retired-worker engagement, and employer release time
Qualification confused with course completion	Clear policy, communication, and separation of educational and employer qualification records
Partners protect data or duplicate efforts	Data-use agreements, common measures, and governance incentives
Technology displaces fundamentals	Require manual process competence while introducing appropriate automation and digital tools
Training used to mask system problems	Apply Human Performance Improvement and root-cause analysis before prescribing training

15. Recommendations

1. Establish a NAVSEA/MIB-sponsored national steering committee to develop and govern the workforce program while preserving NAVSEA technical authority.
2. Approve a national competency framework for welders, fitters, brazers, and related progression roles, with common performance assessments and stackable credentials.
3. Fund four to six regional pilots representing major shipyards, repair activities, suppliers, and emerging maritime-manufacturing regions.
4. Require each pilot to include employers, a community or technical college, a Registered Apprenticeship or work-based-learning partner, the regional workforce system, and a state economic-development organization.
5. Create a commercial-to-NAVSEA bridge pathway that recognizes prior skill while requiring mastery of naval standards, qualification limits, documentation, materials, quality assurance, and high-reliability behaviors.
6. Build instructor and mentor capacity as a parallel national initiative rather than waiting for learner enrollment to expose instructor shortages.
7. Integrate Lean, Six Sigma, Theory of Constraints, TQM, Kaizen, Human Performance Improvement, SPC, RCA, and FMEA throughout technical modules and production projects.
8. Establish a common data and ROI framework linking training to qualification, retention, first-pass quality, rework, throughput, supplier performance, and schedule outcomes.
9. Use WIOA, Registered Apprenticeship, state funding, employer investment, defense-industrial-base funding, and philanthropic resources as a coordinated financing stack.
10. Create an annual curriculum modernization process informed by NAVSEA changes, NSRP projects, BlueForge initiatives, SNAME and ABS technical developments, Manufacturing USA institutes, and employer performance data.
11. Provide supplier-accessible delivery, including mobile labs, shared facilities, short incumbent-worker modules, and regional qualification preparation.
12. Make competitive total compensation and a safe, respectful, sustainable work environment explicit conditions of publicly supported workforce pilots. Institutionalize worker feedback, transparent career and wage progression, predictable scheduling, supervisory development, fatigue controls, and corrective-action requirements to improve retention, safety, quality, and productivity.
13. Establish a National Maritime Industrial Skills Preservation Strategy to capture institutional knowledge, expand instructor development, standardize advanced curricula, and strengthen succession planning across the Maritime Industrial Base.
14. Require applied mathematics and science to be task-derived, occupationally relevant, and assessed through technical decisions and practical transfer, with advanced academic pathways available without imposing unnecessary barriers on craft entry.
15. Establish technical-knowledge controls that develop standards literacy, questioning attitude, source verification, and respectful challenge of unsupported shop practices, including mechanisms for resolving conflicts between tradition, supervision, and controlled technical requirements.
16. Include maritime-specialist staffing and contract labor providers in regional workforce consortia under measurable requirements for worker development, qualification-record integrity, transparent compensation, safe placement, retention, and conversion to durable employment.

17. Establish a controlled workmanship curriculum and assessment system that separates welder and brazer workmanship from general fabrication workmanship, maps every criterion to the invoked source, and evaluates both the completed product and the behaviors used to produce it.
18. Scale the system to additional maritime occupations through a common maritime core, validated trade-family foundations, occupation-specific standards and assessments, and employer-controlled qualification, beginning with trades at documented production constraints.

15.1 Immediate Actions

1. Recognize the NAVSEA and Maritime engineering foundation and the Up-Skill Welder Program concept as the baseline program model for formal validation and pilot design.
2. Establish an intellectual-property and technical-data framework that allows controlled government and partner review while protecting proprietary curriculum assets.
3. Convene NAVSEA, Maritime Industrial Base Program, shipyard, supplier, education, workforce, and state partners to validate the three-pathway and five-phase architecture.
4. Select pilot regions with documented demand for entry-level, up-skill, and advanced-specialty workers.
5. Fund instructor development, facilities, assessment, supportive services, and employer mentoring as integrated capacity requirements.
6. Create a national competency crosswalk connecting program outcomes to NAVSEA requirements, AWS SENSE, Registered Apprenticeship, WIOA, NIMS concepts, and appropriate college credit.
7. Require outcome reporting that links training investment to qualification, productive assignment, first-pass quality, rework, retention, advancement, and supplier throughput.
8. Develop a formal knowledge-capture initiative using experienced Navy and industry welders, brazers, fitters, inspectors, instructors, and supervisors before retirement further reduces the available expert base.
9. Create an accelerated diagnostic bridge for experienced commercial welders rather than forcing all candidates through a single entry-level sequence.
10. Integrate marine engineering, quality systems, ethics, information protection, and Navy craftsmanship into the technical curriculum so graduates understand the complete work system—not only the weld test.
11. Convene craft experts, instructors, engineers, and learning specialists to map every applied-science requirement to job tasks, failure modes, and progression roles; remove content that cannot demonstrate occupational value or a defined articulation purpose.
12. Add source-verification and technical-claim exercises to instructor guides, supervisor development, pre-job briefs, assessments, and post-job reviews so that informal knowledge is retained when valid and corrected when unsupported.
13. Develop a participation standard for maritime staffing and contract-labor providers covering training investment, qualification-record custody, compensation disclosure, worker protections, continuity, mobility, performance data, and permanent-placement pathways.
14. Develop controlled welder, brazer, and general-workmanship modules and observation rubrics cross-referenced to the applicable requirements of TP 248, TP 278, MIL-STD-1689A, TP 1688, approved procedures, and customer specifications such as Electric Boat Specification 2678N when contractually invoked.
15. Select the next two to four constrained maritime occupations for formal task analysis and develop a reusable common maritime core, trade-family modules, occupation-specific assessment packages, and employer-qualification interfaces.

16. Conclusion

The United States cannot meet long-term naval construction, repair, and modernization requirements through recruiting campaigns or isolated short courses. The maritime industrial base needs a repeatable national system that develops entry-level workers, accelerates experienced tradespeople into naval requirements, advances incumbent workers, and produces the instructors and leaders required to sustain growth.

The proposed program combines rigorous technical education with NAVSEA qualification readiness, recognized learning science, apprenticeship, quality management, and manufacturing excellence. It preserves the controlling authority of NAVSEA requirements while using AWS, ASME, ISO, IIW, ISO 9001, AS9100 concepts, and other industry frameworks as comparative and educational benchmarks.

Most importantly, the program is designed around process capability. Welding quality begins before the arc is struck: with correct engineering information, capable people (trained and qualified), controlled materials, suitable equipment, sound fit-up, approved procedures, effective supervision, and a culture that identifies abnormal conditions early. Inspection remains essential, but inspection alone cannot create quality after the process has failed.

A coordinated national initiative would convert education and workforce spending into measurable industrial capacity. It would reduce time to competence, qualification failure, repair, and turnover; improve throughput and supplier resilience; increase the return on facilities and advanced technology; and strengthen the Navy's ability to deliver and sustain the fleet. The strategic choice is not whether the nation will pay for workforce development. It is whether it will invest proactively in capability or continue to pay through delay, rework, lost knowledge, and constrained readiness.

17. References

- American Bureau of Shipping. (n.d.). Maritime training. <https://ww2.eagle.org/en/Products-and-Services/maritime-training.html>
- American Society for Quality. (n.d.). Continuous improvement. <https://asq.org/quality-resources/continuous-improvement>
- American Society for Quality. (n.d.). DMAIC process. <https://asq.org/quality-resources/dmaic>
- American Society for Quality. (n.d.). Six Sigma. <https://asq.org/quality-resources/six-sigma>
- American Society for Quality. (n.d.). Total quality management. <https://asq.org/quality-resources/total-quality-management>
- American Society of Mechanical Engineers. (2025). ASME Boiler and Pressure Vessel Code, Section IX: Qualification standard for welding, brazing, and fusing procedures; welders; brazers; and welding, brazing, and fusing operators. ASME.
- American Welding Society. (2025). AWS B5.1:2025, Specification for the qualification of welding inspectors.
- American Welding Society. (2025). AWS D1.1/D1.1M:2025, Structural welding code - Steel. AWS.
- American Welding Society. (n.d.). SENSE school programs. <https://www.aws.org/educators/sense/>
- BlueForge Alliance. (2024). FY2024 Maritime Industrial Base impact report. <https://www.blueforgealliance.us/>
- Bloom, B. S. (1968). Learning for mastery. *Evaluation Comment*, 1(2), 1-12.
- Bureau of Labor Statistics. (2025). Welders, cutters, solderers, and brazers. *Occupational Outlook Handbook*. <https://www.bls.gov/ooh/production/welders-cutters-solderers-and-brazers.htm>
- Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction* (pp. 453-494). Lawrence Erlbaum Associates.
- Deloitte & The Manufacturing Institute. (2024). Taking charge: Manufacturers support growth with active workforce strategies. <https://themanufacturinginstitute.org/research/digital-skills-report-2024/>
- Department of Defense. (2024). National defense industrial strategy. <https://www.businessdefense.gov/NDIS.html>
- Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3), 363-406. <https://doi.org/10.1037/0033-295X.100.3.363>
- International Institute of Welding. (n.d.). IIW qualification and certification of personnel. <https://iiwelding.org/iiw-qualification-and-certification-of-personnel/>
- International Organization for Standardization. (2021). ISO 3834-1:2021, Quality requirements for fusion welding of metallic materials - Part 1: Criteria for the selection of the appropriate level of quality requirements. ISO.
- International Organization for Standardization. (2012). ISO 9606-1:2012, Qualification testing of welders - Fusion welding - Part 1: Steels. ISO.
- International Organization for Standardization. (2015). ISO 9001:2015, Quality management systems - Requirements. ISO.
- International Society for Performance Improvement. (n.d.). What is human performance technology? <https://ispi.org/>

- Knowles, M. S., Holton, E. F., III, & Swanson, R. A. (2015). *The adult learner: The definitive classic in adult education and human resource development* (8th ed.). Routledge.
- Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.
- Lean Enterprise Institute. (n.d.). *Lean thinking and practice*. <https://www.lean.org/lexicon-terms/lean-thinking-and-practice/>
- National Shipbuilding Research Program. (2023). *Shipyard apprenticeship: A qualitative analysis*. https://www.nsrp.org/wp-content/uploads/2023/01/2018-447-017-Final-Report-Apprenticeship-Qualitative-Study_11-13-23.pdf
- National Shipbuilding Research Program. (2025). *NSRP all panel meeting: General session*. <https://www.nsrp.org/>
- Naval Education and Training Command. (1994). *NAVEDTRA 14119, Steelworker*. Department of the Navy.
- Naval Sea Systems Command. (n.d.). *NAVSEA S9074-AQ-GIB-010/248, Requirements for welding and brazing procedure and performance qualification*. Department of the Navy.
- Naval Sea Systems Command. (n.d.). *NAVSEA S9086-CH-STM-010, Naval Ships' Technical Manual, Chapter 074, Volume 1: Welding and allied processes*. Department of the Navy.
- Office of the Secretary of Defense. (n.d.). *Manufacturing USA institutes*. <https://www.manufacturingusa.com/>
- Society of Naval Architects and Marine Engineers. (n.d.). *Ship Production Committee*. <https://www.sname.org/>
- U.S. Department of Labor. (n.d.). *Registered Apprenticeship*. <https://www.apprenticeship.gov/>
- U.S. Department of Labor, Employment and Training Administration. (n.d.). *Workforce Innovation and Opportunity Act*. <https://www.dol.gov/agencies/eta/wioa>
- U.S. Government Accountability Office. (2024). *Columbia class submarine: Overcoming persistent challenges requires identifying and addressing risks* (GAO-24-107732). <https://www.gao.gov/products/gao-24-107732>
- U.S. Government Accountability Office. (2025a). *Shipbuilding and repair: Navy needs a strategic approach for private sector industrial base investments* (GAO-25-106286). <https://www.gao.gov/products/gao-25-106286>
- U.S. Government Accountability Office. (2025b). *Navy shipbuilding: Enduring challenges call for systemic change* (GAO-25-108136). <https://www.gao.gov/products/gao-25-108136>
- U.S. Military Standard. (1990). *MIL-STD-1689A, Fabrication, welding, and inspection of ships structure*. Department of Defense.
- Womack, J. P., & Jones, D. T. (2003). *Lean thinking: Banish waste and create wealth in your corporation* (Rev. ed.). Free Press.
- Welding & Joining Technology. (n.d.-a). *NAVSEA and maritime: Engineering fundamentals, safety, occupational orientation* [Proprietary curriculum overview].
- Welding & Joining Technology. (n.d.-b). *Workforce modernization - Shortage of skilled trades people: Up-skill welder program* [Proprietary program concept paper].

Appendix A. Proposed National Competency Domains

Domain	Example competency evidence
Safety and work control	Completes pre-use inspection, identifies hazards, follows hot-work controls, and applies stop-work responsibility
Technical-document use	Selects correct revision, interprets WPS and drawing requirements, identifies hold points and qualification limits
Material and consumable control	Verifies material identity, maintains traceability, controls storage and issue, prevents contamination
Fit-up and dimensional control	Prepares joints, measures root opening and alignment, uses fixtures and sequence, documents results
Process execution	Sets equipment, maintains variables, produces repeated acceptable welds, responds correctly to abnormal conditions
Inspection and self-verification	Uses gauges, identifies discontinuities, compares work with criteria, communicates nonconformance
Quality documentation	Completes records accurately, preserves traceability, records parameters and repairs, follows document control
Manufacturing improvement	Uses data, RCA, FMEA, Lean, and Human Performance methods to improve a controlled process
Professional performance	Demonstrates attendance, teamwork, communication, learning agility, accountability, and mentoring behavior
Welder, brazer, and general workmanship	Performs preparation, setup, fit-up, joining, cleaning, self-inspection, reporting, correction, and documentation to the invoked requirements; stops and escalates when conditions exceed authority.
Applied science and technical reasoning	Uses occupational mathematics and science to predict process effects, interpret measurements, troubleshoot within authority, and explain the technical basis of controls.
Knowledge verification and respectful challenge	Distinguishes requirements, preferences, observations, and inferences; checks authoritative sources; questions unsupported claims; states uncertainty; and escalates conflicts before work proceeds.

Appendix B. Illustrative Regional Consortium Model

Each consortium should be established through a written agreement identifying employer demand, participant roles, technical authority, facilities, instructor responsibilities, data sharing, supportive services, qualification boundaries, and funding. A lead institution should coordinate administration, but employers must remain directly engaged in curriculum validation, work-based learning, and performance feedback.

Function	Lead participant	Supporting participants
Demand forecast	Employers and MIB regional lead	Workforce board, state labor agency, economic-development organization
Curriculum delivery	Community or technical college / employer academy	Labor training center, subject-matter experts, suppliers
Work-based learning	Registered Apprenticeship sponsor and employers	College, workforce board, mentors
Supportive services	Workforce board and community partners	State agencies, philanthropy, employers
Qualification	Employer / authorized activity	NAVSEA technical and quality personnel as applicable
Data and evaluation	National program office and regional lead	All partners under data-use agreements
Continuous improvement	Regional steering committee	NSRP, BlueForge, SNAME, ABS, Manufacturing USA partners

Appendix C. Curriculum Phase and Competency Matrix

The following matrix provides an illustrative allocation of competencies. Final hours and sequencing should be validated through occupational analysis, employer demand, qualification requirements, and learner diagnostics.

Phase	Representative content	Primary evidence of mastery
I. Engineering foundation	Safety; maritime terminology; engineering fundamentals; steam and power systems; pumps, valves and piping; electrical and auxiliary systems; quality; documentation; ethics; cybersecurity	Written and oral assessments; equipment identification; system-function explanations; document-control exercises; safety demonstrations
II. Trade fundamentals	Cutting; SMAW; GMAW; FCAW; GTAW; fitting; brazing; metallurgy; drawings; dimensional control	Process-specific practical tests; joint preparation and fit-up; visual inspection; bend or other product tests; completed documentation
III. Maritime integration	Representative pipe, structural, equipment-foundation, support, and repair projects	Integrated fabrication project; dimensional acceptance; quality records; team review
IV. NAVSEA qualification readiness	Technical publications; WPS interpretation; qualification variables; material control; QA; inspection; repair control	Closed-book and open-reference examinations; mock qualification; work-package simulation; qualification-readiness board
V. Advanced manufacturing	Lean; Six Sigma; TOC; SPC; RCA; FMEA; HPI; robotics; digital work; leadership	Improvement project; process-capability analysis; digital record exercise; mentoring or leadership demonstration

Appendix D. Up-Skill Welder Diagnostic Model

The up-skill pathway begins with a structured diagnostic rather than assumptions based on years of experience or prior certifications. The diagnostic should include identity and credential verification, safety knowledge, process theory, drawing and WPS interpretation, material and consumable control, visual inspection, practical welding in relevant processes and positions, and an interview focused on work history and learning needs.

Results should be mapped to three categories: demonstrated and eligible for credit; requires refresher practice; and requires complete instruction. The individual learning plan then prescribes only the content necessary to reach the common standard. This approach respects adult experience while protecting against undocumented habits or qualification assumptions.

Recommended diagnostic decision rules

A learner may bypass instruction only when evidence is current, observable, and aligned with the competency. Prior employment alone is not evidence. A failed diagnostic is not punitive; it identifies the most efficient training sequence. High-consequence competencies—such as material traceability, controlled documentation, procedure limits, and stop-work expectations—should be verified for every learner regardless of prior skill.

Appendix E. Regional Pilot Charter

Each pilot should operate under a written charter defining sponsoring organizations, target occupations, projected hiring, learner populations, facilities, instructor requirements, qualification boundaries, supportive services, data ownership, intellectual-property protections, cost sharing, safety responsibilities, employer commitments, and evaluation methods.

Minimum pilot conditions include: documented employer demand; qualified instructors; suitable laboratories; access to testing and inspection; participant support; employer work-based learning; common assessments; data-sharing authority; and an identified pathway to qualification and employment.

Appendix F. Performance Dashboard

The national program should use a balanced dashboard. Enrollment and completion are necessary but insufficient. Measures should include participant demographics and access, diagnostic credit awarded, attendance, mastery attempts, time to completion, first-attempt qualification, time to productive assignment, first-pass acceptance, repair hours, retention, starting wage, real wage progression, benefit access, schedule stability, overtime burden, safety climate, worker satisfaction, advancement, employer satisfaction, instructor capacity, equipment utilization, and cost per qualified and retained worker. Turnover and vacancy data should be analyzed alongside compensation and work-environment indicators so that training deficiencies are not incorrectly blamed for employer-side retention failures.

Program leaders should review leading indicators monthly and outcome indicators quarterly. Data should be disaggregated by pathway, region, provider, employer, occupation, and learner population while protecting privacy. Results should drive corrective action, curriculum revision, and funding decisions.

Appendix G. Proposed Governance Structure

A national steering council should establish policy, approve competencies, manage intellectual-property and data-rights arrangements, coordinate technical review, and publish national outcome reports. Technical working groups should address welding and brazing, fitting and fabrication, marine engineering, quality and inspection, advanced manufacturing, instructional design, apprenticeship and credentials, and data and evaluation.

Regional consortia should remain responsible for recruitment, delivery, supportive services, employer coordination, facilities, work-based learning, and local continuous improvement. Employers retain responsibility for procedure-specific qualification, production authorization, supervision, and compliance with contractual requirements.

Appendix H. Strategic Communications Framework

The program should communicate different value propositions to different audiences. NAVSEA and the Maritime Industrial Base Program require evidence of capacity, quality, schedule, and national-security impact. Employers require qualified candidates, reduced time to competence, lower rework, and retention. Education partners require validated curriculum, instructor support, student outcomes, and sustainable funding. Workforce agencies require placement, wage, equity, and credential outcomes. States require job creation, supplier growth, and regional competitiveness. Learners require transparent career paths, respected instruction, safe workplaces, wages, and advancement.

A common message should connect these interests: the nation must rebuild a complete maritime trades-development system that produces technically capable, quality-focused, adaptable workers and provides visible pathways from entry to advanced responsibility.