ADVANCING STANDARDS
TRANSFORMING MARKETS

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ADVANCED MANUFACTURING (REVISED FEBRUARY 2025)

CLEAN ENERGY AND DECARBONIZATION TECHNOLOGY

Standardization Impact Report

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Advanced Manufacturing

RELEVANT ASTM COMMITTEES

Committee B09 on Metal Powders and Metal Powder Products

Committee D20 on Plastics

Committee E07 on Nondestructive Testing

Committee E08 on Fatigue and Fracture

Committee F04 on Medical and Surgical Materials and Devices

Committee F07 on Aerospace and Aircraft

Committee F38 on Unmanned Aircraft Systems

Committee F39 on Aircraft Systems

Committee F42 on Additive Manufacturing Technologies

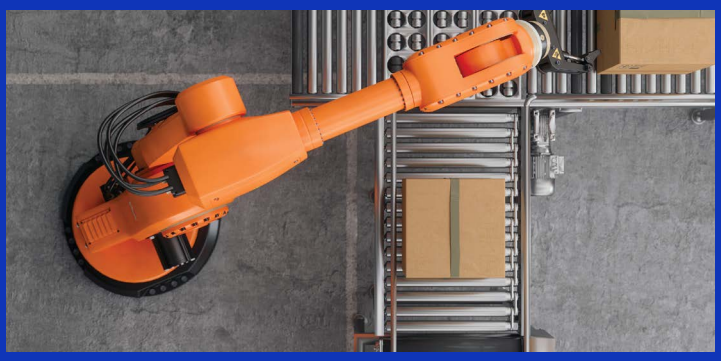
Committee F44 on General Aviation Aircraft

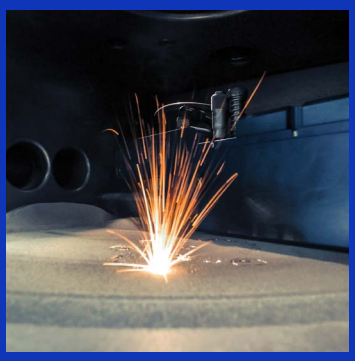
Committee F45 on Robotics, Automation, and Autonomous Systems

Committee F48 on Exoskeletons and Exosuits

As factories and production lines adopt advanced technologies such as automation, digital simulation, and self-monitoring, manufacturing is changing to become more efficient, customizable, and adaptive. Exoskeleton technology is another innovation within the industry, with the potential to reduce physical strain and enhance the safety of workers performing physically demanding tasks. Likewise, the development of additive manufacturing (AM) technology has expanded industry capabilities to include production of smaller lots, more complex structures, and the ability to transmit 3D designs across the globe.

These technologies are seeing significant growth that will reshape how work is done within the manufacturing industry and beyond, with the potential to create new jobs in diverse sectors including aviation, construction, shipping, and other heavy industries; military; and medical applications. As the opportunity grows, the affected industries are moving to keep up with education and training relevant to the evolving skill requirements. To ensure the successful adoption of these technologies, standards will be needed to improve communication and understanding, enable consistent testing methods for safety and performance, and support professional training.





Advanced Manufacturing
Additive Manufacturing

In contrast with traditional (subtractive) manufacturing predecessor technologies that remove parts of solid materials to create parts, additive manufacturing (AM) refers to the layer-by-layer deposition of materials to create 3D objects.[1] AM technology unlocks manufacturing opportunities that were previously not possible, such as creating of complex individual parts with minimal waste, cost-effectively producing small lots, and transmitting 3D printable designs across the globe and even to space, all of which have the potential to make manufacturing faster, more efficient, and more accessible to small businesses and remote geographies.[2]

FUTURE OF ADDITIVE MANUFACTURING

ASTM NEWS STORIES

- The 5 Most Important Standards in Additive Manufacturing
- The Future of Additive Manufacturing
- Additive Manufacturing of Concrete Addressed by Proposed Standards
- ASTM International Unveils Roadmap on Advanced Technologies for Digitalization of the Construction Industry
- Additively Manufactured Automotive Parts
- Data Crunch
- Austal USA, BlueForge Alliance Partner with ASTM International to Advance U.S. Navy AM Supply Chain

ADDITIONAL RESOURCES

- Smart and Sustainable Manufacturing Systems Journal
- AM CoE Annual Reports

U.N. Sustainable Development Goals Supported

MARKET GROWTH

According to Wohlers Report 2024, published by Wohlers Associates, the AM industry is expected to exceed 97.1 billion by 2033.[3]

ENABLER OF THE CIRCULAR ECONOMY

AM can facilitate the transition to a more circular economy through lightweighting of products, reduced resource consumption via low-waste production, reduced physical inventories, and lower carbon footprint due to supply chain localization. Further, AM technologies are well-suited for extending product life through repair and remanufacturing of broken products and may be an essential enabling technology for printing with more sustainable plant-based materials and recycled feedstocks.[4, 5]

ENABLER OF INDUSTRY 4.0

AM will become an important manufacturing technique and integrate with AI, robotics, and digital twins to accelerate the transition toward Industry 4.0 and meet growing trends toward mass customization, digital warehousing, on-demand production of spare parts, and fully automated end-to-end systems and technology solutions.[6, 7, 8]

AM SOFTWARE AND HARDWARE ADVANCES

Advances in AM software tools will improve quality control by enabling more accurate designs,[9] leading to fewer printing defects and less wasted material.[10, 11] Meanwhile, AM hardware improvements will enable greater levels of autonomy, more multi-material hybrid printing, more part consolidation, less human involvement, less material waste, and more degrees of freedom to build parts from all directions.[12, 13, 14]

EXPANDED MATERIALS PORTFOLIO

Standards will support the qualification of new AM materials including bio-based feedstocks, biodegradable materials options, and high-entropy alloys.[15, 16, 17, 18]

BROADER ADOPTION OF LARGE-AREA AM TECHNIQUES

The increased adoption and scale-up of large-area AM techniques—which were developed to overcome key technical limitations including part size, printing rates, and materials options—will help widen the supply chain as a cost-effective manufacturing approach for applications including building and construction,

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Additive Manufacturing

transportation infrastructure, packaging, automotive, marine, and other future applications.[19, 20]

SUSTAINABLE FEEDSTOCK MATERIALS FOR LARGE-SCALE ADDITIVE MANUFACTURING

Natural Fiber-Reinforced Composites (NFRCs). Decarbonization and energy reduction are driving the development of bio-based NFRCs. Compared with synthetic fiber, bio-based fibers provide advantages in biodegradability, weight, and mechanical performance.[21]

Global Support for Bio-Based AM. In the U.S., the Department of Energy (DOE) has funded a $20 million program between the University of Maine and Oak Ridge National Laboratory to advance large-scale 3D printing with cellulose nanofibrils, opening new opportunities for the forest products industry.[22, 23] In Europe, the €2 billion Circular Bio-based Europe Joint Undertaking (CBE JU) supports projects fostering competitive circular bio-based industries, including AM applications.[24] Meanwhile, regional analyses reveal significant potential for market expansion and product innovation in Japan's Polymers for Additive Manufacturing sector.

ASTM IMPACT ACTIVITY
ASTM International Additive Manufacturing Center of Excellence

Launched in 2018, ASTM International's Additive Manufacturing Center of Excellence (AM CoE) is a multistakeholder partnership that coordinates strategic R&D to advance AM standards and accelerate the development and adoption of AM technologies. Additionally, AM CoE concentrates on workforce enhancement through the provision of education and training, as well as the reinforcement of standards through the development of certification and proficiency testing programs. Learn more.

ASTM IMPACT ACTIVITY
Joint ASTM/ISO Additive Manufacturing Standards Development

ASTM International and International Organization for Standardization (ISO) partnered to jointly develop a framework for meeting the needs for new technical standards for AM.

This partnership supports the harmonization of global AM standards development workstreams among subject matter experts and standards development organizations; identification of standards-related gaps and needs in the AM industry; reduction in overlap and duplicative efforts in AM standards development; greater cohesion among AM standards; prioritization of AM standards development activities; and improved usability and acceptance among AM community stakeholders.

The Vienna Agreement between ISO and CEN (the European Committee for Standardization) ensures the adoption of joint EN ISO standards in the European Union.

Through those agreements ISO+CEN+ASTM are connected in the field of AM and develop joint standards, technical specifications (TS) and technical reports (TR) that are published in the EU with the three logos EN/ASTM/ISO. Learn more.

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ASTM IMPACT ACTIVITY E08 Subcommittee on Focus on Fatigue and Fracture Test Methods Specifically Applied to Additive Manufacturing	Subcommittee E08.01.02 is dedicated to developing and refining fatigue and fracture test methods tailored specifically to the unique characteristics of additive manufacturing (AM) materials and processes. The subcommittee's work addresses the challenges associated with AM's layer-by-layer fabrication techniques, which can lead to distinct material properties and microstructural features.
ASTM IMPACT ACTIVITY Proficiency Testing Program for Additive Manufacturing and Powder Metallurgy	ASTM Committees B09 on Metal Powders and Metal Powder Products and Committee F42 on Additive Manufacturing Technologies launched a new proficiency testing program to address new uses of metal powders. ASTM's Proficiency Testing Program for Additive Manufacturing and Powder Metallurgy provides laboratories with a statistical quality assurance (SQA) tool, enabling them to compare, improve, and maintain, a high level of performance in the use of ASTM methods with other laboratories worldwide. Learn more.
ASTM IMPACT ACTIVITY Additive Manufacturing In-Situ Monitoring Technology Readiness	The In-Situ Monitoring (ISM) report is a result of the second specialty workshop organized by ASTM AM CoE. The workshop, conducted in collaboration with The National Aeronautics & Space Administration (NASA) Marshall Space Flight Center (MSFC) and America Makes, aimed to explore the state-of-the-art monitoring technologies that facilitate rapid and cost-effective qualification and certification of AM parts in a production environment. The workshop covered key topics such as approaches to AM quality assurance using in-situ methods, integration of ISM systems in AM production, and correlation of ISM data to AM material characteristics and traditional ex-situ inspection techniques. Learn more.
ASTM IMPACT ACTIVITY Advanced Technologies for Digitalization of Construction Industry Roadmap	ASTM International has developed a roadmap on digitalization of the construction industry, sponsored by the NIST Advanced Manufacturing Technology Roadmap (MFGTech) Program. The roadmap identifies key technological/ technical challenges that, if solved, would encourage industry collaboration and transformative technology development to advance digitalization of the construction industry. The roadmap is based on input from the 3rd ASTM International Additive Manufacturing Center of Excellence (AM CoE) Specialty Workshop: Digitalization of the Construction Industry, held in January 2023, as well as a community survey and interviews with experts representing diverse perspectives across the construction community. Learn more.
ASTM IMPACT ACTIVITY ASTM International Conference on Advanced Manufacturing (ASTM ICAM)	This annual technical conference is hosted by the ASTM International Additive Manufacturing Center of Excellence (AM CoE) and is further supported by over a dozen ASTM technical committees. ICAM 2024 marks the ninth annual flagship event for ASTM, emphasizing standardization, qualification, and certification, with a particular focus on industry-specific requirements encompassing the entire advanced manufacturing processes and value chains. Learn more.

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ASTM IMPACT ACTIVITY Second Symposium on Fatigue and Fracture of Additively Manufactured Materials and Components		This symposium, sponsored by committee E08, provided a forum for the consideration and discussion surrounding the application of existing and potential development of new fatigue and fracture standards for AM materials, as they become more common in aerospace, ground vehicles, and medical devices. Learn more.
ASTM IMPACT ACTIVITY Consortium for Materials Data and Standardization (ASTM CMDS)		The AM CoE CMDS, in coordination with members and with input from regulatory agencies, enables companies of all sizes from across the entire additive manufacturing ecosystem to collaborate on standardizing the requirements and best practices for materials data generation and creating, curating, and managing the data needed to accelerate the industrialization and full adoption of AM technologies. Learn more.
ASTM IMPACT ACTIVITY Additive Manufacturing Certification Committee (ASTM AMCC)		ASTM constituted the Additive Manufacturing Certification Committee (AMCC) to create an industry accepted qualification program for the additive manufacturing supply chain that could complement industry standards and provide valuable service to Original Equipment Manufacturers (OEMs) and contract manufacturers. Learn more.
ASTM IMPACT ACTIVITY AM Innovation and Standards Summit at Formnext		One-day workshop held annualy at Formnext that is dedicated to discussing the standardization needs for additive manufacturing and enables engagement with experts to discuss standard practices and overcome implementation challenges to drive cost-effective AM. Learn more.
ASTM IMPACT ACTIVITY Additive Manufacturing Village		As part of an ongoing collaboration with the European Defense Agency on deployment of additive technologies for defense purposes, ASTM International participates in the workshop to provide tailored industrial AM solutions and will foster cooperation between industry and armed forces. Learn more.
ASTM IMPACT ACTIVITY Workshop on Metal Powder Characterization		This workshop, organized by ASTM Committee B09 on Metal Powders and Metal Powder Products, reviewed metal powder characterization techniques that are not yet standardized, with a focus on defining and explaining the parameters they measure. Topics include rotating drum testers, rotating blade rheometers, and the impact of laboratory conditions, such as relative humidity, on testing outcomes. Additionally, powder spreadability is examined, including methods for directly testing it or correlating rheological test results with spreading behavior. Learn more.
RELEVANT ASTM STANDARD Additive Manufacturing — General principles — Fundamentals and vocabulary	**ASTM ISO/ ASTM52900**	This standard establishes and defines terms used in additive manufacturing (AM) technology, which applies the additive shaping principle and thereby builds physical three-dimensional (3D) geometries by successive addition of material.

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Additive Manufacturing

RELEVANT ASTM STANDARD Standard Test Method for Apparent Density of Free-Flowing Metal Powders Using the Hall Flowmeter Funnel	**B212**	This test method describes a procedure for determining the apparent density of free-flowing metal powders, and mixed powders; and is suitable for only those powders that will flow unaided through the specified Hall Flowmeter funnel.
RELEVANT ASTM STANDARD Standard Test Methods for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel	**B213**	This test method covers the determination of a flow rate, by the use of the Hall Flowmeter funnel of metal powders and powder mixtures.
RELEVANT ASTM STANDARD Standard Test Method for Sieve Analysis of Metal Powders	**B214**	This test method covers the dry sieve analysis of metal powders, using sieves with openings ranging from 45 to 850 micrometres.
RELEVANT ASTM STANDARD Standard Practice for Additive Manufacturing – General Principles – Part Classifications for Additive Manufactured Parts Used in Aviation	**F3572**	The aviation industry has been slow to adopt the use of AM parts due to stringent requirements. This standard allows the cognizant engineering organization to assign a part classification based on consequence of failure. Many parts used in aviation have a low consequence of failure and proper identification will lead to higher adoption rates.
RELEVANT ASTM STANDARD Standard Practice for Additive Manufacturing — Powder Bed Fusion — Condition-Defined Maintenance for Optical Systems	**F3615**	This standard practice that provides guidelines for the maintenance of optical systems in AM, specifically focusing on powder bed fusion processes. This standard defines condition-based maintenance practices to ensure the optimal performance and longevity of optical components. It covers procedures for monitoring, inspecting, and maintaining the optical systems to prevent failures and maintain high-quality production.
RELEVANT ASTM STANDARD Standard Guide for Additive Manufacturing of Metals – Powder Bed Fusion – Measurement and Characterization of Surface Texture	**F3624**	This guide is designed to provide users of measurement technologies in both industry and academia with good practice for optimizing measurements of surfaces produced by metal powder bed fusion (PBF) manufacturing processes.
RELEVANT ASTM STANDARD Standard Guide for Additive Manufacturing of Metals — Data — File Structure for In-Process Monitoring of Powder Bed Fusion (PBF)	**F3605**	This guide provides standardized procedures and requirements for converting acquired in-process monitoring data into one file representing the printing process of powder bed fusion (PBF) for quality evaluation.
RELEVANT ASTM STANDARD Standard Guide for Additive Manufacturing — Test Artifacts — Accelerated Build Quality Assurance for Laser Beam Powder Bed Fusion (PBF-LB)	**F3626**	This guide illustrates a test specimen geometry and testing protocol that can be used to assess the quality of a metal powder bed fusion build cycle as it could be affected by major system errors severely affecting the quality of materials fabricated by laser beam powder bed fusion (PBF-LB).

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RELEVANT ASTM STANDARD Additive Manufacturing — Qualification Principles — Requirements for Industrial Additive Manufacturing Processes and Production Sites	**ASTM ISO/ ASTM52920**	This standard specifies criteria for AM relevant processes as well as quality-relevant characteristics and factors along the additive system operations and defines activities and sequences within an additive manufacturing production site.
RELEVANT ASTM STANDARD Additive Manufacturing for Construction — Qualification Principles — Structural and Infrastructure Elements	**ASTM ISO/ ASTM52939**	This standard specifies quality assurance requirements for additive construction (AC) concerning building and construction projects in which additive manufacturing techniques are used for construction.
RELEVANT ASTM STANDARD Standard Practice for Nondestructive Testing (NDT), Inspection Levels and Acceptance Criteria for Parts Manufactured with Laser Based Powder Fusion	**F3704**	This standard practice outlines nondestructive testing (NDT) inspection levels and acceptance criteria for parts produced using laser-based powder bed fusion (PBF-LB) additive manufacturing. It specifies two NDT inspection levels, detailing applicable methods and acceptance criteria based on the practical inspection capabilities of properly applied NDT techniques, rather than specific part-driven engineering criteria.
STANDARD IN PROGRESS New Specification for Additive Manufacturing – General Principles -- Metal Laser Beam Powder Bed Fusion Machines for Spaceflight Applications	**WK82605**	This proposed standard specification outlines the requirements for laser beam powder bed fusion (PBF-LB) machines used to produce metallic space flight parts. It establishes the minimum monitoring capabilities for PBF-LB machines used in space flight hardware production and mandates that machine manufacturers provide the machine owners with access to the raw data generated by the sensors.
STANDARD IN PROGRESS New Practice for Additive Manufacturing -- General Principles -- Design Process of Additively Manufactured Construction Elements	**WK81114**	This proposed practice is intended to define the design process of building components produced by additive manufacturing (AM) means and methods. It is focused on practical implementation of engineering design methods used in AM together with design methods commonly used in the construction industry.
STANDARD IN PROGRESS New Practice for - Additive Construction – General Principles – Standard Practice for the Evaluation of Structural Printed Elements	**WK84415**	This proposed standard practice is for evaluating structural printed elements in additive construction. It establishes general principles and guidelines for assessing the performance, quality, and safety of structural components produced through additive manufacturing techniques. This also aims to ensure that printed elements meet the necessary structural requirements and performance criteria for construction applications.
STANDARD IN PROGRESS New Test Method for Measurement of Particle Size and Shape of Additive Manufacturing Base Materials by Dynamic Imaging Analyzers	**WK78812**	This proposed standard method will cover the determination of particle size and shape distributions of metal and ceramic additive manufacturing base materials using dynamic imaging analyzers.

Advanced Manufacturing
Exoskeleton Technology

Exoskeletons are wearable devices that augment, enable, assist, and/or enhance physical activity through mechanical interaction with the body. Exoskeletons combine cutting-edge engineering design with emerging technologies (i.e., robotics, artificial intelligence, smart textiles) and other advanced materials that interface directly with individuals and may collaborate with machines and devices both directly and remotely. There are broad opportunities for their use, including in manufacturing, shipping, and other heavy industries; military; and medical applications. This technology has the potential to help people of all ages pursue a high-quality life and fully participate in work and society. From preventing injury and lessening the physical workload for industry workers, to making it possible for differentlyabled people to walk again – exoskeletons empower everyday lives.[25]

FUTURE OF EXOSKELETON TECHNOLOGY

ASTM NEWS STORIES

- The Future of Exoskeleton Standards
- Walking with Robots
- Use of Exoskeletons in Confined Places
- Exoskeletons Capture the Future
- Ergonomic Parameters for Exoskeletons
- Medical Exoskeletons, A Transformative Technology

ADDITIONAL RESOURCES

- ET CoE Annual Reports

U.N. Sustainable Development Goals Supported

MARKET GROWTH

The global exoskeleton market is expected to reach $2.1B by 2026: a more than threefold increase since 2020.[26] Another projection estimates this market will reach $12B by 2029, or more than 12 times the current market value over a 7-year period.[27] This growth will be fueled not only by the increased adoption of exoskeletons by electronics manufacturers, automakers, and logistics and shipping firms, but also by the medical industry to aid in gait treatment and rehabilitation.[28]

INDUSTRIAL EXOSKELETON PRODUCTION IS RAPIDLY INCREASING

The number of businesses producing or distributing exoskeletons has more than tripled between 2015 and 2020, from 16 to 56.[29]

EXOSKELETONS CAN SUPPORT AGING OR DISABLED WORKERS

Exoskeletons can foster a more diverse workplace by leveling the playing field—supporting articulations, preventing cumulative injuries, to retain the industry workforce by promoting career longevity.[30]

Enabling Aging Workers, Preventing Injury, and Supporting Disabled Workers. Exoskeletons could improve mobility for aging workers, allowing them to stay in the workforce longer by enhancing physical capabilities and reducing the strain of day-to-day job tasks. Additionally, exoskeletons can enhance the functionality of disabled individuals and prevent both healthy and disabled individuals from experiencing new injuries.[31,32]

EMERGENCE OF NEW EXOSKELETON CONCEPTS

Exosuits are a type of exoskeleton under continuous development and many users consider them lighter, more flexible, and less energy intensive.[33,34]

Measurement of Human Physiological Data. The integration of AI and sensors into exoskeletons could help analyze and interpret physiological data such as human posture and the physical demands of workers, including those returning to work after injury.[35]

Advanced Manufacturing
Exoskeleton Technology

ASTM IMPACT ACTIVITY ASTM International Exo Technology Center of Excellence		ASTM International's Exo Technology Center of Excellence (ET CoE) brings together industry, healthcare, academia, and government to accelerate safety and reliability standards for exoskeletons and their systems. Through research-to-standards, knowledge sharing, and education efforts, the ET CoE will ensure greater confidence in the baseline performance of exoskeletons and drive faster commercialization and adoption of the technology. Learn more.
ASTM IMPACT ACTIVITY ASTM International Exo Games		ASTM International's Exo Games initiative, which seeks to improve student involvement and education in the exo technologies industry, is a competition open to STEM degree university teams that connects students with exo industry professionals and provides hands-on experience with new exo standards. ASTM Exo Games were first held in 2023, hosted by the University of Lancashire, 2024 was held at ASTM Headquarters with support from NIST. Learn more.
ASTM IMPACT ACTIVITY ASTM Webinar Series: Exoskeletons		ET CoE hosted a series of webinars focused on PPE considerations, challenges and opportunities for PPE, and current state of exoskeleton applications. Learn more.
ASTM IMPACT ACTIVITY Global Survey of Healthcare Professionals Using Medical Exoskeletons		This report surveyed healthcare professionals to gather foundational information on their use of medical exoskeletons in clinical practice. The learnings from this project can be used to improve exoskeleton technology and develop standards, education, and outreach programs to help drive the growth of the exoskeleton industry. Learn more.
ASTM IMPACT ACTIVITY ASTM Excellent Exo Chat		Podcast hosted by ASTM that discusses exoskeletons, robotics, and emerging technology to increase the awareness of exo and emerging technologies in an informal manner. Guest speakers from industry, academia, and government have joined in the discussions to provide insight into the latest challenges and success of these technologies. Learn more.
ASTM IMPACT ACTIVITY The Following Seas Podcast		The Following Seas Podcast is part of a three-year grant awarded to the ASTM Exo Technology Center of Excellence, through the United States Navy's Office of Naval Research to help the Navy increase the STEM talent pool by reaching K-12 students across the world. The podcast features guests who have worked for the Navy, from scientists and engineers to military heroes. The podcast aims to help young people discover the science, engineering, and standards behind how the Navy operates worldwide from the seabed to space and how they can get involved. Learn more.
RELEVANT ASTM STANDARD Standard Terminology for Exoskeletons and Exosuits	**F3323**	The purpose of this terminology is to facilitate communication between individuals who may be involved in the research, design, deployment, and use of exoskeletons and exosuits in applications, including but not limited to industrial, military, emergency response, recreational, and medical areas.
RELEVANT ASTM STANDARD Standard Practice for Establishing Exoskeleton Functional Ergonomic Parameters and Test Metrics	**F3474**	This practice provides a recommended approach and a set of options for assessing one or more specific ergonomic parameters with respect to human users of exoskeletons.

Advanced Manufacturing
Exoskeleton Technology

RELEVANT ASTM STANDARD Standard Practice for Exoskeleton Wearing, Care, and Maintenance Instructions	F3392	This practice describes the minimum information to be provided by the manufacturer to the end user related to the wearing, care, and maintenance of an exoskeleton.
RELEVANT ASTM STANDARD Standard Practice for Movement Tests When Using an Exoskeleton	F3517	This practice guides the user through selection and documentation of movement tests and procedures for use in evaluating exoskeletons while worn by the user. The practice is designed to allow replication of movements and tests.
RELEVANT ASTM STANDARD Standard Practice for Considering and Deploying Exoskeletons for Return to Work	F3579	This standard offers guidance on the potential benefits and risks of using exoskeletons during the return-to-work (RTW) process. It also provides recommendations for those considering exoskeleton use during modified or transitional duty periods at work.
STANDARD IN PROGRESS New Guide for Maintenance of Exoskeletons	WK89778	This proposed guide will provide comprehensive guidance for the maintenance of exoskeletons, with a primary focus on informing both users and designers about essential maintenance practices.
STANDARD IN PROGRESS New Guide for Assessing Fit Accommodation of Exoskeletons for Manufacturers and Designers	WK78824	This proposed guide will assist manufacturers to effectively communicate information regarding the population for whom the exoskeletons is designed, including terminology or language to assist users in choosing the appropriate exoskeleton.

Advanced Manufacturing
Robotics & Automation

Robotics and automation are predominantly used in the automotive, electronics, logistics, and metals industries. These technologies are designed to augment, enhance, or emulate human physical capabilities to help manufacturers improve the productivity, flexibility, and workplace safety of their operations. Lower hardware costs and advances in speech recognition, computer vision, and sensor technologies are making robotics and automation technologies more accessible to the manufacturing sector and beyond.

FUTURE OF ROBOTICS & AUTOMATION

ASTM NEWS STORIES

- Robotic Training Systems
- Grasp Strength in Robotics
- Mobile Manipulator Performance
- Testing of Unmanned Ground Vehicles
- Big Data and Robotics/A-UGVs
- New Robotics Group on Grasping and Manipulation
- How Standards are Contributing to the Future of Robotics
- How Robots Could Change the Way We Work – Podcast
- ASTM Receives Award from ARM Institute to Develop Robotics Technology Roadmap

MARKET GROWTH

The global robotics market is projected to reach $74.1 billion by 2026, driven by advancements in AI, automation, and Industry 4.0 technologies. This represents a substantial growth from its value in previous years, reflecting the increasing adoption of robotics across various sectors.[36]

INCREASING JOB DEMAND

Robotics job postings have surged, with a 137% increase in demand for robotics technicians from 2019 to 2023. This reflects the growing need for skilled professionals as industries increasingly integrate automation and robotics into their operations.[37]

GROWING SKILLS DEMAND

A 2023 survey of manufacturers highlighted that skills in automation, robotics, and mechatronics are now critical for manufacturing engineers, with 89% of respondents ranking these as the top skills required over the next decade. This shift underscores the importance of education and training in emerging technologies.[38]

STANDARDS GUIDE AI INTEGRATION IN ROBOTICS

The integration of AI in robotics is essential for creating interoperable systems, driving market growth, and unlocking future economic opportunities. Standards play a crucial role in ensuring the safe and effective deployment of AI-powered robots across industries.[39]

CHANGES IN LABOR MARKET

42% of business tasks will be automated by 2027, as robotics and AI reshape the workforce. This transformation will require significant upskilling and reskilling efforts to prepare workers for new opportunities.[40]

Teleoperation vs. Autonomous Operations. The rise of 5G technology has enabled new use cases for robotics, where robots can switch between autonomous operation and remote control. This hybrid approach is especially useful in scenarios like remote forklift operation, highlighting the need for robust performance standards and signal reliability.[41]

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Advanced Manufacturing
Robotics & Automation

Robots Growing Popular Outside of Manufacturing.
Amazon now leads as the largest user of robotics globally, with over 750,000 robots across its logistics network. The trend of deploying robotics beyond traditional manufacturing is expanding rapidly, with industries like agriculture and logistics expected to surpass manufacturing in robot applications. New standards for safety and performance will be critical as these industries continue to grow their robotics use. [42]

ASTM IMPACT ACTIVITY Collaboration with the New England Robotics Validation and Experimentation (NERVE) Center at the University of Massachusetts Lowell		ASTM collaborated with the New England Robotics Validation and Experimentation (NERVE) Center at the University of Massachusetts Lowell to develop test methods for evaluating navigation and obstacle avoidance; results were incorporated as a revision to F3244.
ASTM IMPACT ACTIVITY 4th Specialty Workshop on Discovery and Market Analysis for Robotics in Manufacturing of Space and Hypersonic Components		Funded through a project call by ARM (Advanced Robotics for Manufacturing) Institute, this workshop aimed to ascertain the current state of the industry and help guide future technology road mapping sessions and investment strategies. Learn more.
ASTM IMPACT ACTIVITY New ASTM Subcommittee on Robotic Applications		The subcommittee is a response to the expanding use of robotics and automation throughout many industry sectors. The goal of the new subcommittee is to provide a place where a variety of industries can come to develop robotics standards that are specific to their sectors. Learn more.
RELEVANT ASTM STANDARD Standard Terminology for Robotics, Automation, and Autonomous Systems	**F3200**	This terminology covers terms associated with robotic, automation, and autonomous systems. By providing a common and consistent lexicon, the purpose of this terminology is to facilitate communication between individuals who may be involved in the research, design, deployment, and use of robotic, automation, and autonomous systems, including but not limited to, for manufacturing, distribution, security, healthcare, response, etc.
RELEVANT ASTM STANDARD Standard Test Method for Navigation: Defined Area	**F3244**	The purpose of this test method is to evaluate an automatic, automated, or autonomous-unmanned ground vehicle's (A-UGV) capability of traversing through a defined space with limited A-UGV clearance. This test method is intended for use by A-UGV manufacturers, installers, and users. This test method defines a set of generic 2D area shapes representative of user applications and for different A-UGV types.
RELEVANT ASTM STANDARD Standard Guide for A-UGV Capabilities	**F3470**	This guide is intended to be used by manufacturers and users of A-UGVs: (1) to fully define capabilities of their A-UGV(s) or (2) to allow the standard requestor to describe the A-UGV capabilities required for the requested A-UGV to align with assigned task(s).

Advanced Manufacturing
Robotics & Automation

STANDARD IN PROGRESS New Practice for Measuring Mobile Manipulator Performance: Non-continuous Tasks	WK83858	This practice describes an accepted procedure for measuring the static/indexed performance of mobile manipulators and is intended for use by mobile manipulator manufacturers, suppliers, integrators, and end-users to verify that mobile manipulator operations meet their specified performance requirements.
STANDARD IN PROGRESS New Test Method for Grasp-Type Robot End-Effectors: Grasp Strength Performance	WK83863	This test method will the grasp strength of a robot end-effector. This measure will yield information regarding a hand's payload capabilities for various object sizes as well as its limits in resisting pulling or pushing forces during a grasp operation.
STANDARD IN PROGRESS Standard Specification for Robotic Educational Standard	WK84838	This standard intends to develop specifications for robotic training systems and peripherals commonly used in educational and professional training environments.
STANDARD IN PROGRESS New Test Methods for Solar Panel Cleaning Robotic Test Methods	WK91653	This proposed standard that will evaluate robotic systems for cleaning solar panels to help to modernize solar panel cleaning systems, and address safety, asset protection, and water conservation.
STANDARD IN PROGRESS New Practice for Measuring Mobile Manipulator Performance: Recording the Workpiece Configuration	WK86116	This proposed standard practice focuses on the measurement of mobile manipulator performance and with respect to workpiece configurations, the identification of adjustable workpiece parameters, allowing comparison of performance across different workpieces and tests, and the replication of the mobile manipulators' performance testing.
STANDARD IN PROGRESS New Practice for Measuring Mobile Manipulator Performance: Inducing Workpiece Disturbance Impairment	WK92144	This proposed standard practice is intended for use by mobile manipulator manufacturers, suppliers, integrators, and end-users in either a laboratory or manufacturing environments to induce workpiece disturbances as a tested impairment while measuring the performance of mobile manipulators.

Advanced Manufacturing
End Notes/References

ADVANCED MANUFACTURING

1 https://unctad.org/webflyer/technology-and-innovation-report-2018
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