NFPA Industrial Technology Roadmap

Meeting Report on Customer Drivers and Strategies

NFPA Industrial Technology Task Force

March 14, 2025

NFPA Industrial Technology Roadmap

The NFPA Industrial Technology Roadmap describes an industry-wide consensus regarding the pre-competitive research and development needs associated with improving the design, manufacture, and function of fluid power components and systems for industrial, or in-plant, applications.

The research and development agenda it describes is focused on advancements that will help the fluid power industry meet the future needs of its customers, expand into new markets, and attract the best and brightest students to the field.

It is used by the NFPA and its academic partners to guide their research efforts, by NFPA members and other industry players to inform decisions about research partnerships and product development, and by academic, government, and other organizations that wish to pursue research and development projects of importance to the fluid power industry.

It is also a key part of NFPA's fluid power technology promotion strategy, as it illuminates places both where fluid power is meeting the needs of its customers and where emerging technologies are being developed and deployed.

It is updated every four years under the guidance of NFPA's Industrial Technology Task Force.

Roadmap Elements

The NFPA Industrial Technology Roadmap is comprised of five primary elements, each connected to the next in an interdependent chain.

1. **Customer Drivers** are the top-level performance objectives of fluid power customers, the OEMs or machine builders that manufacture machines that often incorporate fluid power systems. Customer Drivers help these machine builders serve the needs of their own customers and are not necessarily connected to their use of fluid power.

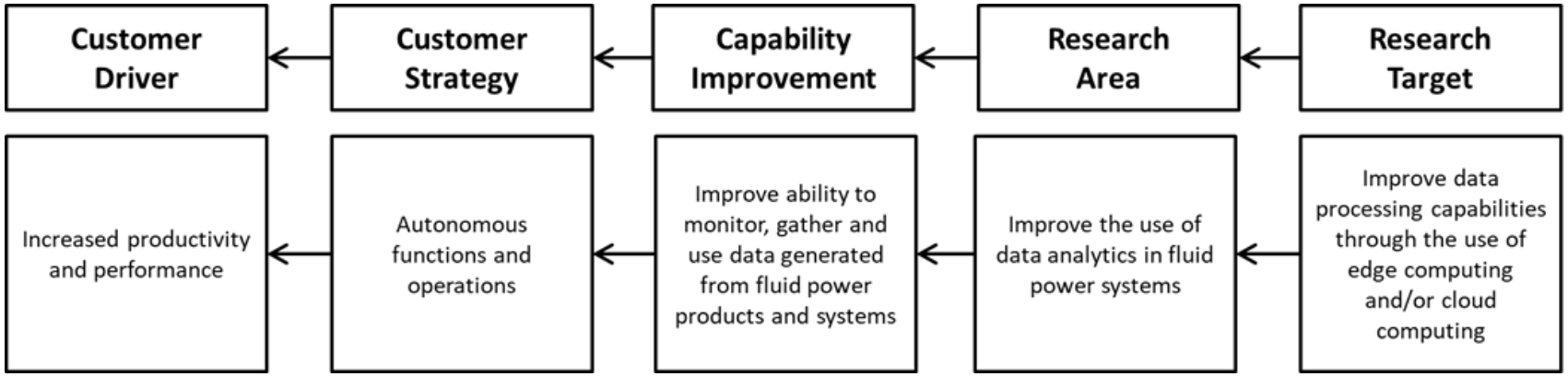
2. **Customer Strategies** are the machine-level objectives and technologies that the machine builders have set or are using to help them achieve the top-level performance objectives described by the Customer Drivers. Again, these Customer Strategies are not necessarily connected to their use of fluid power.

3. **Capability Improvements** describe the ways in which fluid power systems must improve if they are to participate or increase their participation in the technology trends described by the Customer Strategies.

4. **Research Areas** are the broad areas of pre-competitive investigation that could assist in bringing about the Capability Improvements.

5. **Research Targets** are the objectives that quantify or otherwise describe successful strategies for pursuing the Research Areas.

EXAMPLE:



2025 Project Process and Timeline

The NFPA Industrial Technology Task Force is following this process and timeline for the 2025 update to the NFPA Industrial Technology Roadmap. This is the report from its meeting on March 14, 2025 to discuss, define and prioritize Customer Drivers and Strategies.

Phase 1 – Planning and Development (4Q24)

Dec 2024 Task force meeting to review project plan and survey on Customer Drivers and Strategies

Phase 2 – Customer Drivers and Strategies (1Q25)

Jan 2025 Launch of survey on Customer Drivers and Strategies

Feb 2025 Deadline to respond to survey on Deadline to respond to survey on Customer Drivers and Strategies

Mar 2025 Task Force meeting to discuss, define and prioritize Customer Drivers and Strategies, and to review survey on Fluid Power Alignment and Capability Improvements

Meeting report published with prioritized Customer Drivers and Strategies

Phase 3 – Capability Improvements (2Q25)

Apr 2025 Launch of survey on Fluid Power Alignment and Capability Improvements

May 2025 Deadline to respond to survey on Fluid Power Alignment and Capability Improvements

Jun 2025 Task Force meeting to discuss, define and prioritize Capability Improvements, and to review survey on Research Areas and Targets

Meeting report published with prioritized Capability Improvements

Phase 4 – Research Areas and Targets (3Q25)

Jul 2025 Working Groups identified for each Capability Improvement

Launch of survey on Research Areas and Targets

Aug 2025 Deadline to respond to survey on Research Areas and Targets

Working Group meetings to discuss and prioritize Research Areas for each Capability Improvement

Sep 2025 Task Force meeting to review, harmonize and prioritized Research Areas and Targets

Meeting report published with prioritized Research Areas and Targets

Phase 5 – Final Roadmap Document (4Q25)

Oct 2025 Draft Roadmap written and circulated for review and comment

Nov 2025 Deadline to return comments on draft Roadmap

Final Roadmap published and presented

Meeting Participants

- Pete Alles, National Fluid Power Association
- Jeffrey Borchers, ROSS Controls
- Greg Broschka, Kepner Products Company
- Tom Carlson, Deltrol Fluid Products
- Linda Caron, Parker Hannifin Corp.
- Dave Coffee, EPCO Zero-Leak
- Andy Curriston, ACE Controls, Inc.
- Jon Frey, Bosch Rexroth Corporation
- Allison Forsythe, National Fluid Power Association
- Jonathan Gamble, Enfield Technologies
- Bernd Hunger, IC-Fluid Power, Inc.
- Denise Husenica, National Fluid Power Association
- Chul Jang, Moog Inc.
- Paul Johnson, Aggressive Hydraulics
- Keith Kushnir, Parker Hannifin Corp.
- Eric Lanke, National Fluid Power Association
- Denis Lenoble, Famic Technologies Inc.
- Adam Livesay, Elevat
- Andy McMichael, JWF Technologies
- Paul Michael, Milwaukee School of Engineering
- Michael Miles, KersTech, Inc.
- Bob Mosey, Moseys Production Machinists, Inc.
- Andrew Newman, Sun Hydraulics Corp.
- Katherine Quigley, Trelleborg Sealing Solutions
- S. Brian Simons, OEM Controls, Inc.
- Darshan Talagalage, GE Aerospace
- Dave Tetzlaff, Innovative Hydraulics
- Dan Worden, OEM Controls, Inc.

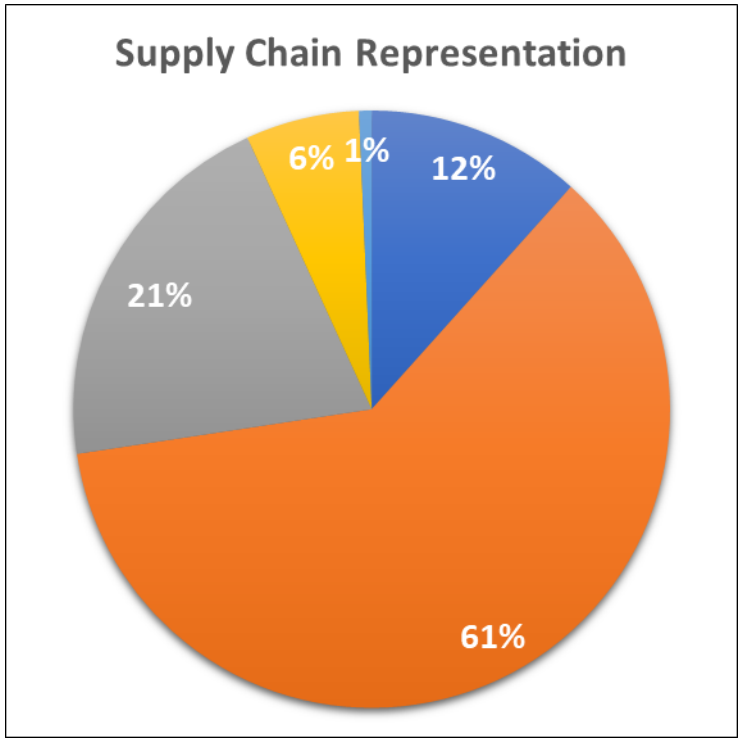
Fluid Power Industrial Markets

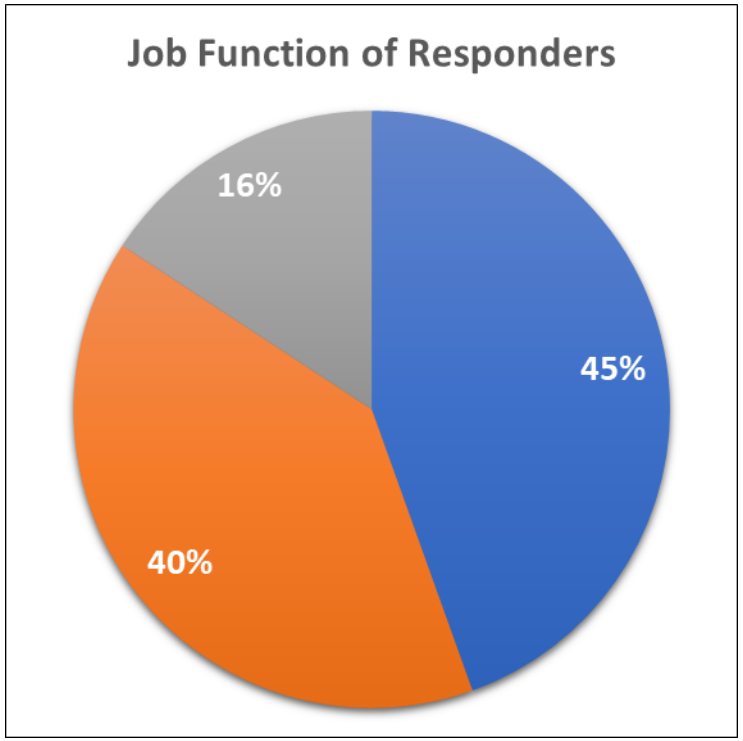
Fluid power technology is used in hundreds of applications in dozens of specific customer markets. The National Fluid Power Association (NFPA) groups fluid power's customer markets into two general areas: (1) Applications on different types of mobile or off-highway equipment; and (2) Applications on different types of industrial, stationary or in-plant equipment. The Task Force first reviewed the following fourteen large industrial customer markets defined by NFPA.

- **Aerospace Manufacturing.** In-plant machines and equipment used in the manufacture of aerospace products and parts.
- **Food Product Machinery.** In-plant machines and equipment that process raw ingredients into food products.
- **Medical Equipment Manufacturing.** Stationary equipment that creates tools, instruments and equipment that are used in healthcare.
- **Metalworking and Machine Tools.** Stationary equipment used to cut or shape metal or metal parts.
- **Oil and Gas Machinery.** Machinery used to extract oil and/or process it into gasoline.
- **Packaging Machinery.** In-plant machines and equipment used to pack products for storage, shipping, or sale.
- **Plastics and Rubber Machinery.** Stationary equipment used to process or make plastic or rubber products.
- **Power Generation.** Stationary equipment used to generate power, including through such clean energy technologies as solar, wind, and wave.
- **Primary Metals Manufacturing.** Stationary equipment used to extract, refine, and shape raw materials into metal products.
- **Recycling Equipment.** Stationary equipment that transform waste into reuseable resources.
- **Robotics, Assembly and Material Handling.** Stationary machines and equipment that move materials through a facility or perform assembly tasks.
- **Semiconductor Machinery.** In-plant machines used to fabricate semiconductor chips, test them, and support their manufacturing process.
- **Vehicle Manufacturing.** In-plant machines and equipment used in the manufacture of both on- and off-highway vehicles.
- **Wood and Paper Machinery.** Stationary equipment used to process wood or paper products.

Survey on Drivers and Strategies in Industrial Markets

The Task Force next reviewed the results of a January 2025 survey conducted by NFPA to determine the market drivers and technology strategies important to these fourteen industrial markets. The survey received responses from 146 individuals across the fluid power supply chain, including a large percentage from the NFPA Industrial Technology Task Force.





Customer Drivers

A Customer Driver is a top-level performance objective for the builder of machines that often incorporate fluid power systems. Based on the results of the 2023 NFPA Technology Roadmap and a subsequent discussion with the NFPA Industrial Technology Task Force, survey responders were asked to rank the importance of each of the following Customer Drivers for each of the Industrial Markets with which they were familiar.

Customer Drivers

Machine builders want to provide their customers with machines that offer:

1. **Increased availability and up-time**
2. **Increased productivity and performance**
3. **Lower total cost of ownership**
4. **Compliance with regulations**
5. **Sustainability**

Importance of Existing Customer Drivers

Some variations in importance emerged for individual markets. In the aggregate, 96% of the driver choices were rated as at least somewhat important. The color codes categorize the average scores into their quintiles – with dark green and light green representing averages in the upper 40% of the response range.

For all markets, and for the aggregate of all responses, “Increased availability and up time” and “Increased productivity and performance” were the two most important drivers. “Lower total cost of ownership” and “Compliance with regulations” rated as highly important for some individual markets.

		CUSTOMER DRIVERS				
INDUSTRIAL MARKETS	N	Increased availabilty and up time	Increased productivity and performance	Lower total cost of ownership	Compliance with regulations	Sustainability
Aerospace Manufacturing	26	4.462	4.462	3.500	4.462	3.308
Food Product Machinery	46	4.435	4.304	3.652	4.304	3.283
Medical Equipment Manufacturing	15	4.400	4.533	3.533	4.933	3.267
Metalworking and Machine Tools	57	4.386	4.544	3.842	3.491	2.842
Oil and Gas Machinery	37	4.622	4.378	3.405	4.189	3.162
Packaging Machinery	30	4.400	4.533	4.100	3.533	3.367
Plastics and Rubber Machinery	21	4.571	4.381	4.095	3.476	3.381
Power Generation	24	4.542	4.250	3.792	4.083	3.500
Primary Metals Manufacturing	17	4.529	4.706	3.882	3.471	2.824
Recycling Equipment	15	4.600	4.400	4.267	3.667	3.667
Robotics, Assembly and Material Handling	33	4.667	4.788	4.061	3.515	3.121
Semiconductor Machinery	4	5.000	5.000	3.500	4.250	3.000
Vehicle Manufacturing	34	4.647	4.706	4.118	3.971	3.382
Wood and Paper Machinery	21	4.381	4.524	3.810	3.238	2.905
Other*	7	4.286	4.286	4.286	4.143	3.571
All Respones	**387**	4.506	4.501	3.837	3.871	3.204

5	Extremely important
4	Very important
3	Somewhat important
2	Not so important
1	Not at all important
	5.000 - 4.566
	4.565 - 4.131
	4.130 - 3.695
	3.694 - 3.260
	3.259 - 2.824

*Seven responders suggested that other industrial markets be considered. These were described as: (1) Construction; (2) Department of Defense; (3) Marine, Ships, Oil Rigs, Windmills, Hydraulics and Enclosures; (4) Medical Devices; (5) Mining; (6) Mobile Machines; and (7) Testing.

Most Important Customer Driver

Respondents were also asked to identify the most important Customer Driver in each of the customer markets with which they were familiar. The color codes categorize the most popular responses – with dark green representing the driver most frequently chosen as the most important and light green representing the driver second most frequently chosen as the most important driver.

Several markets saw a broad distribution of drivers thought to be the most important. For almost all markets, "Increased availability and uptime" or "Increased productivity and performance" were selected as the most important driver by large majorities of responders.

		CUSTOMER DRIVERS					
INDUSTRIAL MARKETS	N	Increased availabilty and up time	Increased productivity and performance	Lower total cost of ownership	Compliance with regulations	Sustainability	Other*
Aerospace Manufacturing	26	19%	31%	8%	23%	4%	15%
Food Product Machinery	43	37%	30%	7%	23%	2%	0%
Medical Equipment Manufacturing	15	13%	13%	20%	53%	0%	0%
Metalworking and Machine Tools	55	20%	67%	7%	2%	0%	4%
Oil and Gas Machinery	36	53%	39%	6%	0%	0%	3%
Packaging Machinery	29	21%	59%	21%	0%	0%	0%
Plastics and Rubber Machinery	21	43%	29%	24%	0%	5%	0%
Power Generation	23	57%	26%	4%	4%	9%	0%
Primary Metals Manufacturing	17	29%	53%	18%	0%	0%	0%
Recycling Equipment	15	27%	47%	20%	0%	7%	0%
Robotics, Assembly and Material Handling	32	28%	63%	3%	6%	0%	0%
Semiconductor Machinery	3	67%	33%	0%	0%	0%	0%
Vehicle Manufacturing	32	28%	44%	19%	6%	3%	0%
Wood and Paper Machinery	21	29%	48%	24%	0%	0%	0%
Other	7	29%	29%	14%	14%	0%	14%
All Respones	375	31%	44%	12%	8%	2%	2%

Most popular choice
Second most popular choice
Third most popular choice

*Six responders suggested other drivers as the most important. These were described as: (1) Customer service; (2) Environmental and cost avoidance; (3) Initial purchase price; (4) Protect internal parts from corrosion and contamination; (5) Reliability; and (6) Technical support.

Suggestions for New Customer Drivers

In addition to ranking the importance of the existing Customer Drivers, respondents were asked to suggest any additional drivers that they would have ranked as “Extremely Important” or “Very Important” for the customer markets with which they were familiar. The following responses were received.

Aerospace Manufacturing
- Customer service.
- Documentation support.
- Electrification.
- Environmental and side benefits.
- Technical support.
- Reliability.
- Safety.

Food Product Machinery
- Availability of wash down capable, ingress protected products.
- Broad compatibility options with IoT-based controls and data demands.
- Delivery of products (impact from supply chain).
- Ease of maintenance, cleaning.
- Electrification.
- Environmental and side benefits.
- Food safety compliance such as stainless steel material requirements.
- Paint of the body stays clean after a few years of use.
- Parts availability.

Medical Equipment Manufacturing
- Cost avoidance.
- Electrification.
- Low noise and zero leak.

Metalworking and Machine Tools
- Cost avoidance.
- Electrification.
- Health and safety (noise).
- Initial purchase price.
- Leading edge technology, connection with business tools.
- On time delivery of parts.
- Quality and cleanliness.
- Repair lead time.

Oil and Gas Machinery
- Alternatives to historically established norms.
- Availability of new materials and designs.
- Carbon reduction - energy efficiency.
- On-time delivery or in stock products for immediate needs.
- Preference for local service support and good lead times for components.
- Reliability.
- Time between failure.

Packaging Machinery
- Electrification.

Plastics and Rubber Machinery
- Electrification.
- Initial purchase price.
- Material improvements and compatibility.

Power Generation
- Decarbonization.
- Environmental and cost avoidance.

Primary Metals Manufacturing
- Low cost / fast & simplified maintenance.
- Quality and cleanliness.

Robotics, Assembly and Material Handling
- Increased battery life through energy efficiency.
- Product lifetime, reliability.
- Safety.

Vehicle Manufacturing
- Abilities for data acquisition.

Customer Strategies

A Customer Strategy is a machine-level objective or technology that machine builders have set or are using to help them achieve the top-level performance objectives described by the Customer Drivers. Based on the results of the 2023 NFPA Technology Roadmap and a subsequent discussion with the NFPA Industrial Technology Task Force, survey responders were asked to rank the importance of each of the following Customer Strategies for each of the Industrial Markets with which they were familiar.

Customer Strategies

Machine builders are using these objectives or technologies to deliver the top-level performance objectives of their machines.

1. **Automation.** Either semi- or full-autonomous functions and/or operations.
2. **Compactness.** Increasing power density and/or reducing weight and/or size.
3. **Connectivity.** Expanding the use of data, such as intelligence for cloud-based condition monitoring, integration with site management systems, and/or communicating machine status for other value-added purposes.
4. **Energy Efficiency.** Increasing it; and including strategies to extend operational life, use less energy, and/or reduce emissions.
5. **Maintenance.** Making it easier; and including strategies to ease the serviceability of the machine and to increase the availability of repair or replacement parts.
6. **Materials.** Use of conflict and/or environmentally-friendly materials in strategic ways to better comply with regulations.
7. **Noise.** Reducing perceived noise levels and/or improving noise pulsation.
8. **Precision Control.** The ability to manage a system or process with high accuracy and minimal error.

Importance of Existing Customer Strategies

Some variations in importance emerged for individual markets. In the aggregate, 91% of the strategy choices were rated as at least somewhat important. The color codes categorize the average scores into their quintiles – with dark green and light green representing averages in the upper 40% of the response range.

For most markets, and for the aggregate of all responses, “Automation,” “Maintenance,” and “Precision Control” were the three most important strategies. “Connectivity” and “Energy Efficiency” rated as highly important for some individual markets.

		CUSTOMER STRATEGIES							
INDUSTRIAL MARKETS	N	Automation	Compactness	Connectivity	Energy Efficiency	Maintenance	Materials	Noise	Precision Control
Aerospace Manufacturing	25	3.720	3.480	3.720	3.680	4.160	3.640	3.480	4.520
Food Product Machinery	46	4.130	3.152	3.543	3.391	4.065	3.457	3.022	3.913
Medical Equipment Manufacturing	15	4.267	3.467	4.067	3.400	4.267	3.600	3.667	4.600
Metalworking and Machine Tools	56	4.196	3.036	3.571	3.411	4.143	2.875	3.196	4.304
Oil and Gas Machinery	37	3.432	3.054	3.216	3.459	4.378	3.108	2.622	3.622
Packaging Machinery	30	4.467	3.400	3.867	3.533	4.100	3.167	3.267	4.167
Plastics and Rubber Machinery	21	3.857	3.000	3.333	3.714	3.810	2.762	3.143	4.048
Power Generation	24	3.750	3.167	3.583	3.750	4.292	3.083	3.083	4.042
Primary Metals Manufacturing	17	4.059	2.765	3.706	3.706	4.353	2.824	2.941	4.176
Recycling Equipment	15	3.600	3.067	2.933	3.667	4.267	2.667	3.200	3.400
Robotics, Assembly and Material Handling	33	4.485	3.788	4.091	3.606	4.242	3.030	3.455	4.455
Semiconductor Machinery	4	4.500	3.250	3.750	4.000	4.250	3.750	3.250	4.750
Vehicle Manufacturing	34	4.118	3.294	3.912	3.706	4.059	3.206	3.500	4.235
Wood and Paper Machinery	21	3.762	2.714	3.238	3.238	3.952	2.762	2.762	3.952
Other*	7	3.714	3.571	3.429	3.429	4.000	3.429	3.286	4.286
All Respones	385	4.021	3.203	3.610	3.540	4.153	3.119	3.169	4.127

5	Extremely important
4	Very important
3	Somewhat important
2	Not so important
1	Not at all important
	4.750 - 4.325
	4.324 - 3.899
	3.898 - 3.473
	3.472 - 3.047
	3.046 - 2.622

*Seven responders suggested that other industrial markets be considered. These were described as: (1) Construction; (2) Department of Defense; (3) Marine, Ships, Oil Rigs, Windmills, Hydraulics and Enclosures; (4) Medical Devices; (5) Mining; (6) Mobile Machines; and (7) Testing.

Most Important Customer Strategy

Respondents were also asked to identify the most important Customer Strategy in each of the customer markets with which they were familiar. The color codes categorize the most popular responses – with dark green representing the strategy most frequently chosen as the most important and light green representing the strategy second most frequently chosen as the most important strategy.

Several markets saw a broad distribution of strategies thought to be the most important. For almost all markets, "Automation," "Precision Control," or "Maintenance" were selected as the most important strategy by large majorities of responders.

		CUSTOMER STRATEGIES								
INDUSTRIAL MARKETS	N	Automation	Compactness	Connectivity	Energy Efficiency	Maintenance	Materials	Noise	Precision Control	Other*
Aerospace Manufacturing	24	8%	4%	8%	4%	17%	8%	0%	46%	4%
Food Product Machinery	42	43%	0%	0%	2%	21%	12%	2%	14%	5%
Medical Equipment Manufacturing	15	20%	0%	20%	0%	13%	7%	7%	33%	0%
Metalworking and Machine Tools	54	35%	0%	0%	2%	19%	2%	0%	41%	2%
Oil and Gas Machinery	36	17%	0%	0%	8%	64%	0%	0%	8%	3%
Packaging Machinery	28	61%	7%	11%	7%	4%	0%	0%	11%	0%
Plastics and Rubber Machinery	21	24%	0%	5%	14%	24%	14%	0%	19%	0%
Power Generation	24	13%	4%	4%	29%	38%	0%	0%	13%	0%
Primary Metals Manufacturing	17	24%	0%	6%	12%	24%	0%	0%	35%	0%
Recycling Equipment	15	33%	0%	0%	20%	47%	0%	0%	0%	0%
Robotics, Assembly and Material Handling	32	41%	3%	6%	6%	3%	0%	6%	34%	0%
Semiconductor Machinery	3	0%	0%	0%	0%	0%	0%	0%	100%	0%
Vehicle Manufacturing	31	13%	0%	6%	29%	13%	0%	0%	39%	0%
Wood and Paper Machinery	20	20%	0%	0%	5%	45%	0%	0%	30%	0%
Other	7	29%	14%	14%	0%	14%	0%	0%	14%	14%
All Respones	369	28%	2%	4%	9%	24%	3%	1%	26%	2%

Most popular choice
Second most popular choice
Third most popular choice

*Six responders suggested other strategies as the most important. These were described as: (1) Availability of suitable parts at a reasonable price; (2) Electrification; (3) Manufacturing location (USA); (4) Proper surface treatment that keep components clean after years of use, cost, availability; (5) Safety; and (6) Specification and legal compliance.

Suggestions for New Customer Strategies

In addition to ranking the importance of the existing Customer Strategies, respondents were asked to suggest any additional strategies that they would have ranked as “Extremely Important” or “Very Important” for the customer markets with which they were familiar. The following responses were received.

Aerospace Manufacturing
- Electrification.
- Manufacturing location (USA).
- Side benefits.

Food Product Machinery
- Availability of clean design components.
- Cost and the lead time/availability.
- Cost avoidance.

Medical Equipment Manufacturing
- Cost avoidance.
- Electrification.

Metalworking and Machine Tools
- Aftermarket service.
- Cost avoidance.
- Electrification.
- Reduce price/cost.
- Reduction in labor costs.
- Safety in automation.

Oil and Gas Machinery
- Electrification.
- Safety.

Packaging Machinery
- Electrification.

Power Generation
- Environmental and side benefits.

Vehicle Manufacturing
- Battery electric vehicles.

Prioritized Customer Drivers and Strategies

The Task Force then engaged in a discussion to define and prioritize the Customer Drivers and Strategies to be used in the 2025 NFPA Industrial Technology Roadmap. Reviewing both the numerical scores and the open-ended comments from the survey, the following list of drivers and strategies were defined.

Customer Drivers. Machine builders want to provide their customers with industrial machines that offer:

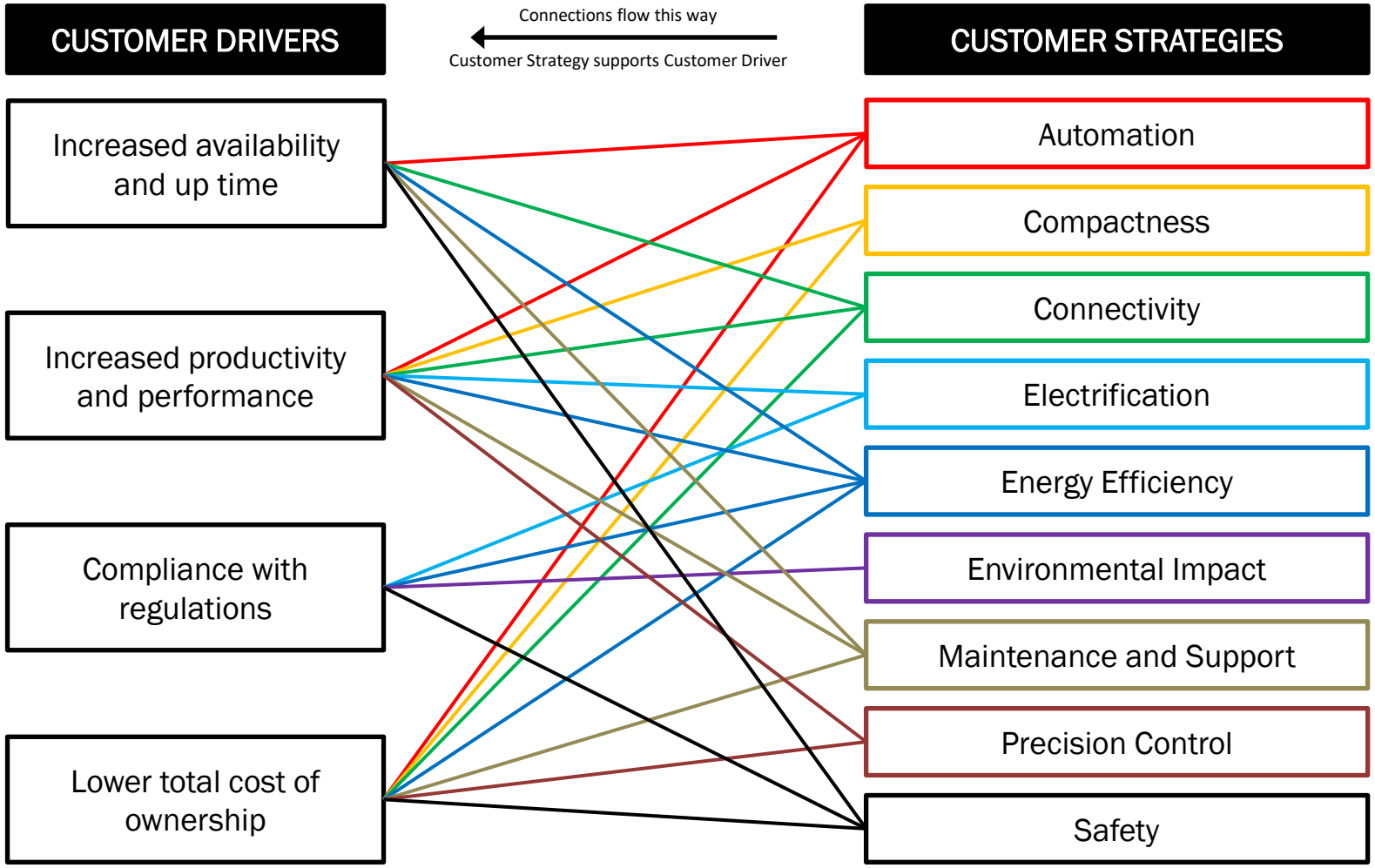
1. **Increased availability and up-time.** Generally defined as the robustness of the machine, its ability to work continuously.
2. **Increased productivity and performance.** Generally defined as the efficiency of the machine, its ability to do more work in less time.
3. **Compliance with regulations.** Such as those pertaining to environmental, safety, or other concerns.
4. **Lower total cost of ownership.** Includes capital and/or operating costs.

Customer Strategies. Machine builders are using these objectives or technologies to deliver the top-level performance objectives of their industrial machines:

1. **Automation.** Incorporating either semi- or fully-autonomous functions and/or operations on the machine.
2. **Compactness.** Increasing the power density of the machine without increasing its weight and/or size.
3. **Connectivity.** Expanding the use of data, such as intelligence for cloud-based condition monitoring, integration with site management systems, and/or communicating machine status for other value-added purposes.
4. **Electrification**. Moving towards electric actuation to improve efficiency or control on the machine.
5. **Energy Efficiency.** Increasing energy efficiency, including strategies to extend operational life, use less energy, and/or reduce emissions.
6. **Environmental Impact**. Reducing environmental impact, including strategies to lower noise, reduce leaks and/or use environmentally safe fluids.
7. **Maintenance and Support.** Making it easier to maintain the machine, including strategies to ease initial integration and implementation, to provide documentation support, to ease the serviceability of the machine, and to increase the availability of repair or replacement parts.
8. **Precision Control.** Improving the ability to manage systems or processes on the machine with high accuracy and minimal error, including through the use of sensors.
9. **Safety.** Improving the safe use of the machine.

Connecting Customer Strategies to Customer Drivers

The Task Force then discussed possible connections between the prioritized Customer Strategies and Customer Drivers, recognizing that each strategy could be used to help the machine builder achieve multiple drivers. A map of the proposed connections is shown below:



Fluid power is a modern and thriving technology.

Hydraulics and pneumatics can be found in hundreds of applications; the driving force for dozens of critical industries.

To learn more, contact:

Eric Lanke, President/CEO
National Fluid Power Association
elanke@nfpa.com

Or visit www.nfpa.com