



 **RESEARCH SPOTLIGHT**

The Chemical Industry:

On the Road to Remote Operations and the Autonomous Plant



In LNS Research's first two [Research Spotlights](#), we shared the results of our research into [autonomous plant](#) and remote operations based on our survey of 300 respondents across the process, hybrid/batch, and discrete industries. In this third Spotlight of our series, we drill down into one of these verticals, the chemical industry.

The Chemical Industry

The chemical industry is one of the most diverse industries with a massive global footprint. And, while we see that it has, in aggregate, much in common with its fellow process industries, there are unique differences.

LNS Research generally divides chemicals into three categories: petrochemicals, bulk & basic chemicals, and specialty chemicals. Petrochemical companies are usually large companies with multiple facilities with sizeable footprints. However, bulk & basic and specialty chemicals range from the very small toll manufacturers to large global firms whose operations may span multiple divisions and dozens of plants across 30+ countries. Thus, diversity is an understatement in describing the chemical industry. According to IHS Markit, there are worldwide:

- 14,000 chemical companies
- 20,000 chemical manufacturing sites
- 21,500 unique chemical products

The US has the largest concentration with approximately 13,500 chemical manufacturing facilities owned by more than 9,000 companies.

Let's drill in a bit deeper on the differences that we uncovered in our research. First, due to its diversity and global footprint, it is difficult to use aggregate scores to describe a particular sub-vertical, let alone any company-specific profile. However, as we expected, petrochemicals tended to mirror downstream oil & gas more closely. In many cases, refining and petrochemical plants are highly integrated complexes producing building-block chemicals and polymers. The more we move away from petrochemicals, the more variability we see. And in general, the smaller and independent companies are less sophisticated than the larger, more global firms.

Autonomy Defined



Watson & Scheidt (2005) define autonomy as: "Systems that – without manual (human) intervention – can change their behavior in response to unanticipated events during operation."

Key Characteristics:

- Self-controlling... more than automation, both controls and adapts.
- Self-managing... automates analysis, decisions, execution, and maintains itself.
- Self-learning... improves over time, self-optimizes.
- Incorporates system of systems architectural approach.



Second, chemicals stood out in a number of other areas:

- In their purer definition of autonomy.
- In their coordination with Industrial Transformation (IX) teams and programs as opposed to being integrated with them. We expect this to change as these programs mature.
- In the above-average way that they seek help from automation vendors, reinforced by their spend on technical and operational systems in pursuit of process excellence.
- Their leading focus on EHS and Quality.
- Their emphasis, especially in specialty chemicals, on the chemical process itself relative to their asset-intensive brethren, who are often more APM and reliability focused. And, it's not that the others are not process-focused, but in specialty chemicals, there is a large amount of organic product creation; i.e., process IP while refining, petrochem, and power tend to license third-party processes. Then, of course, some of the integrated oil majors and big chems are licensors themselves.

Some industries have long sought out their own version of autonomy. For example, CPG calls it “lights out manufacturing,” which is a common end-goal the industry has talked about for a long time – but perhaps too far out and based on the fact that packaging is still very labor-intensive. But chemicals are no stranger to packaging as not everything that leaves the plant is in pipelines, storage tanks, or rail cars.

As EHS category leaders, chemicals were perhaps the first to react and start to change their ways in the aftermath of the 1984 Bhopal disaster. Bhopal shocked the industry into becoming pioneers in a global industry improvement program called Responsible Care.

Third, in general, the chemical industry lags its process and discrete industry colleagues in next-generation technology spend, with pervasive sensing systems being the minor exception. They are well behind in the adoption of remote operations and autonomous operations. In chemicals' defense, they face considerable variability and complexity of operations, often within the same company and even in the same division. Thus, progress toward automation and autonomy is often uneven. This situation adds to the challenge of where to get started and how far to go.



Organizations in transition find it difficult to pursue IX, let alone remote operations and autonomous initiatives.

The range of complexity and scale of operations is particularly challenging for specialty chemicals.

– Joe Perino
Research Analyst



Nowhere is this truer than in specialty chemicals undergoing considerable rearrangement of its own molecules. Here, we are referring to the many spin-offs, mergers, and acquisitions in recent years; for example, the DuPont and Dow Chemical merger, a subsequent spin-off of Dow, and Dupont’s own spin-offs, like Chemours; or, Bayer’s spin-off of Covestro, followed by the subsequent merger with Monsanto’s agricultural chemicals division. Organizations in transition find it difficult to pursue Industrial Transformation (IX), let alone remote operations and autonomous initiatives. The range of complexity and scale of operations is particularly challenging for specialty chemicals. This goes a long way toward explaining why, thus far, Industrial Transformation (IX) ranks so low on the list of trends important to chemical companies.

Thus, it’s certainly no secret that one size doesn’t fit all, so let’s see:

- How chemical companies in aggregate stack up against their industry vertical peers,
- What special insights we can glean from the research, and
- What guidance we can provide to chemical companies embarking on the remote operations and autonomous journey.

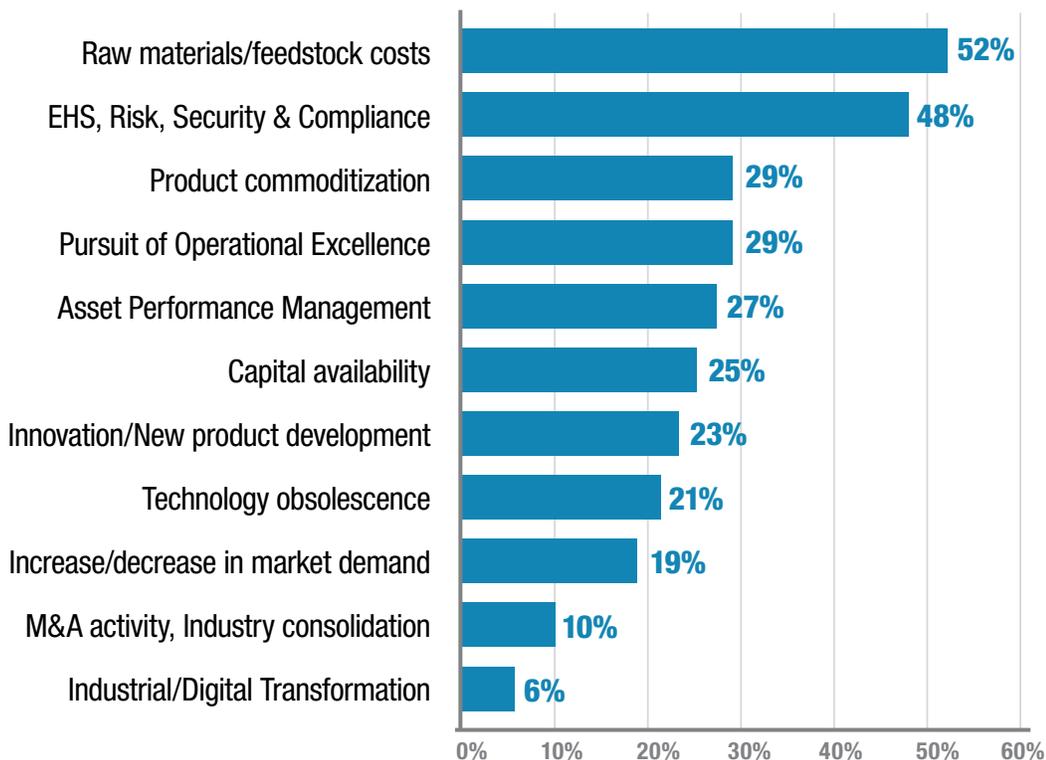


FIGURE 1 - Most Important Trends Impacting Chemical Companies

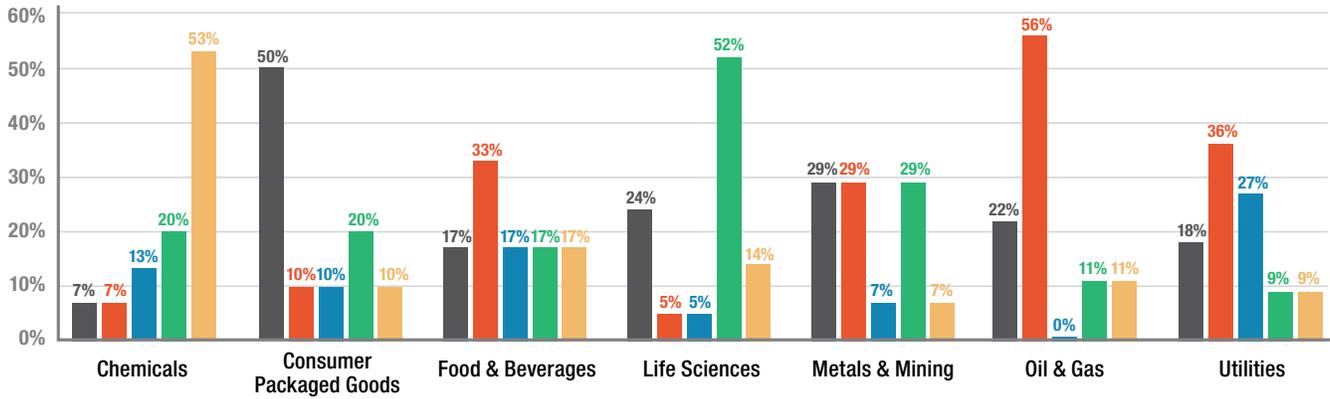
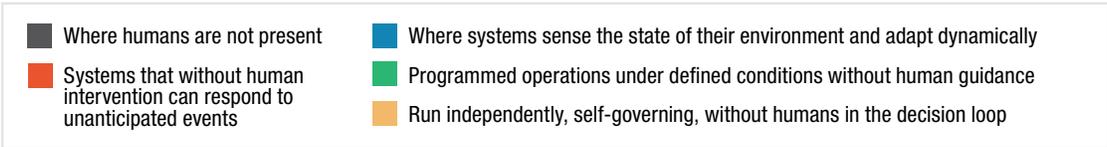


FIGURE 2 - Defining Autonomy

How the Chemical Industry Defines Autonomy

When we asked how companies define autonomy, we quickly saw chemicals jumping on the independent, self-governing, no-humans-in-the-loop definition relative to their peers. More striking is their embracement of an even more pure autonomy definition, differing from even IX leaders.

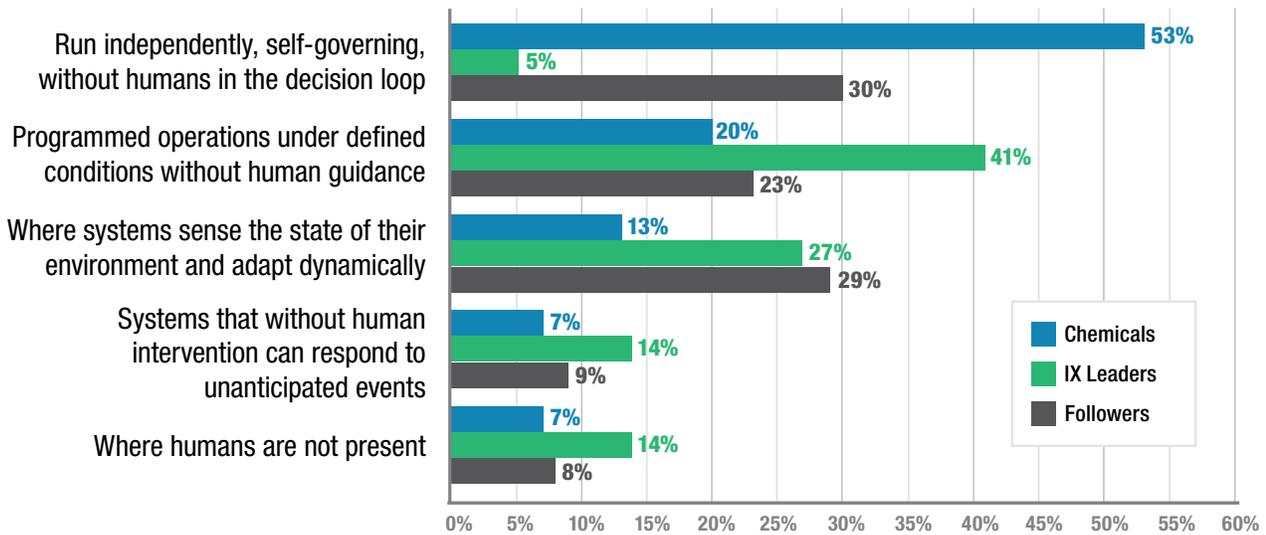


FIGURE 3 - Chemicals vs. IX Leaders and IX Followers



Business Objectives for Autonomy

In our first Spotlight, IX Leaders saw eight key motivators for autonomy. Figure 4 shows how chemicals stand out for focusing on Environmental, Health & Safety (EHS) and Process Safety Management (PSM), as well as lowering maintenance and inspection costs. EHS and PSM are traditional strengths for chemicals.

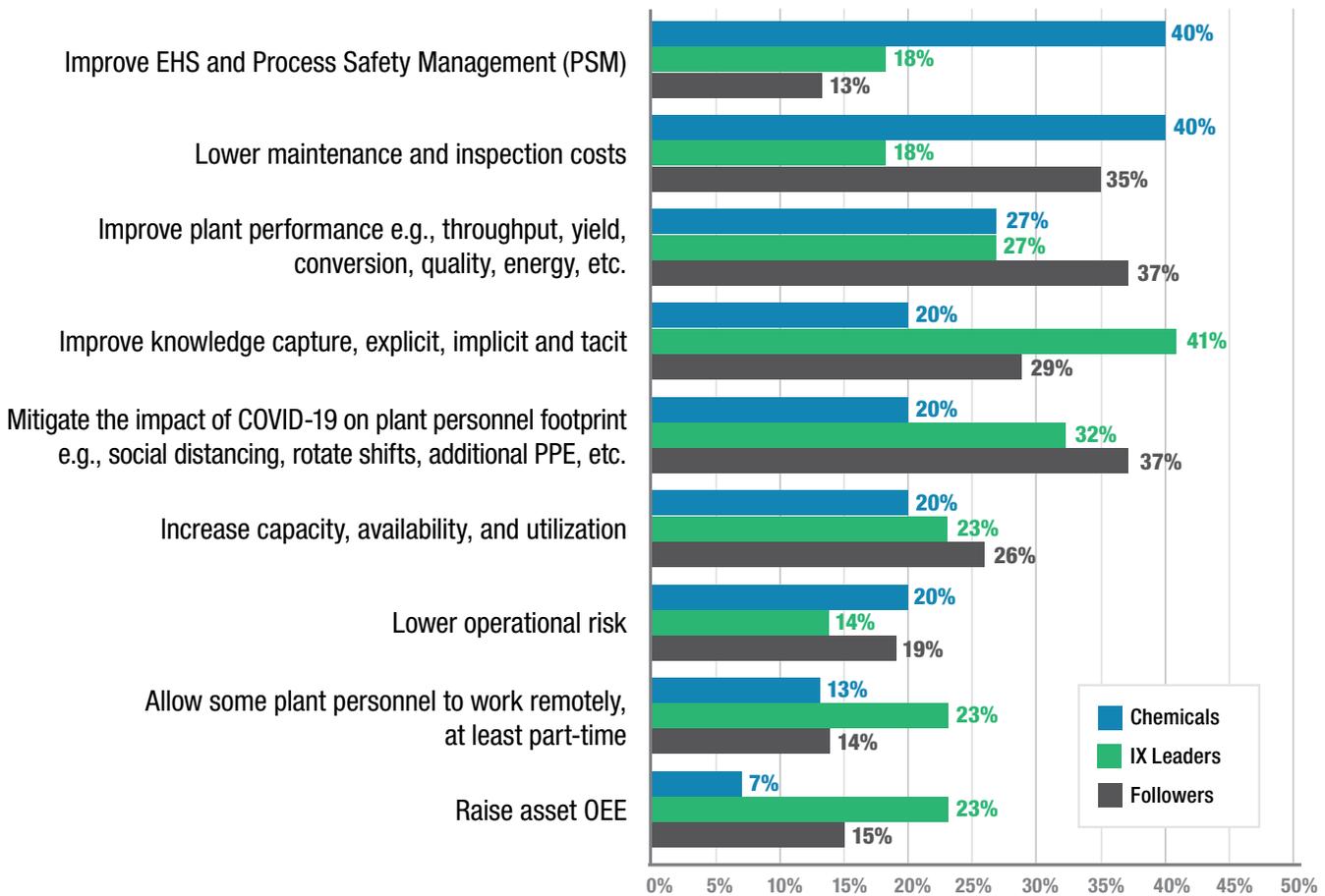


FIGURE 4 - Business Objectives Comparison



Challenges and Barriers

Lack of skills and trust in autonomous technologies and systems, which topped the overall aggregated list, were among the top four factors concerning chemicals. What differentiated chemicals was their concern about operational complexities. And like IX Leaders, they were far more concerned about business risk and regulatory compliance.

Autonomy, Leadership, and Culture

Our first Spotlight revealed insightful management policy and cultural differences in how autonomy is regarded by management, how they have organized to address it, where they seek help, from whom and why, and how they are involved in the initiatives and regarded by their employees. Let's see how chemicals stacked up.

First, we see a significant gap between IX Leaders who have converted their autonomous teams into IX teams and chemicals who have stayed the course in coordinating the two groups. LNS Research attributes this to the fact that the chemical industry generally lags IX Leaders when it comes to Industrial Transformation (IX).

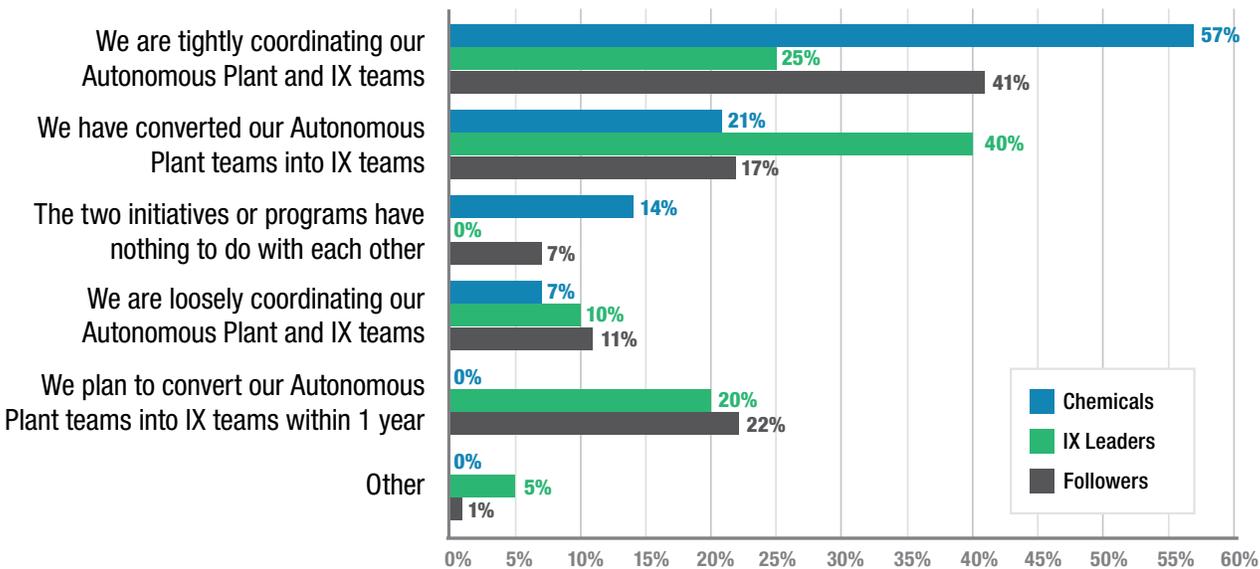


FIGURE 5 - Chemicals vs. IX Leaders and IX Followers, and Autonomous Teams



Chemicals also share a number of insights with IX Leaders. But unlike IX Leaders in general, chemical companies look to automation vendors for considerable assistance, second only to IT services firms. Why the big difference with IX Leaders? LNS Research sees that chemical firms highly value the automation firms' domain knowledge of complex and variable operations. In addition, the ability to safely control complex operations is an advantage for automation firms.

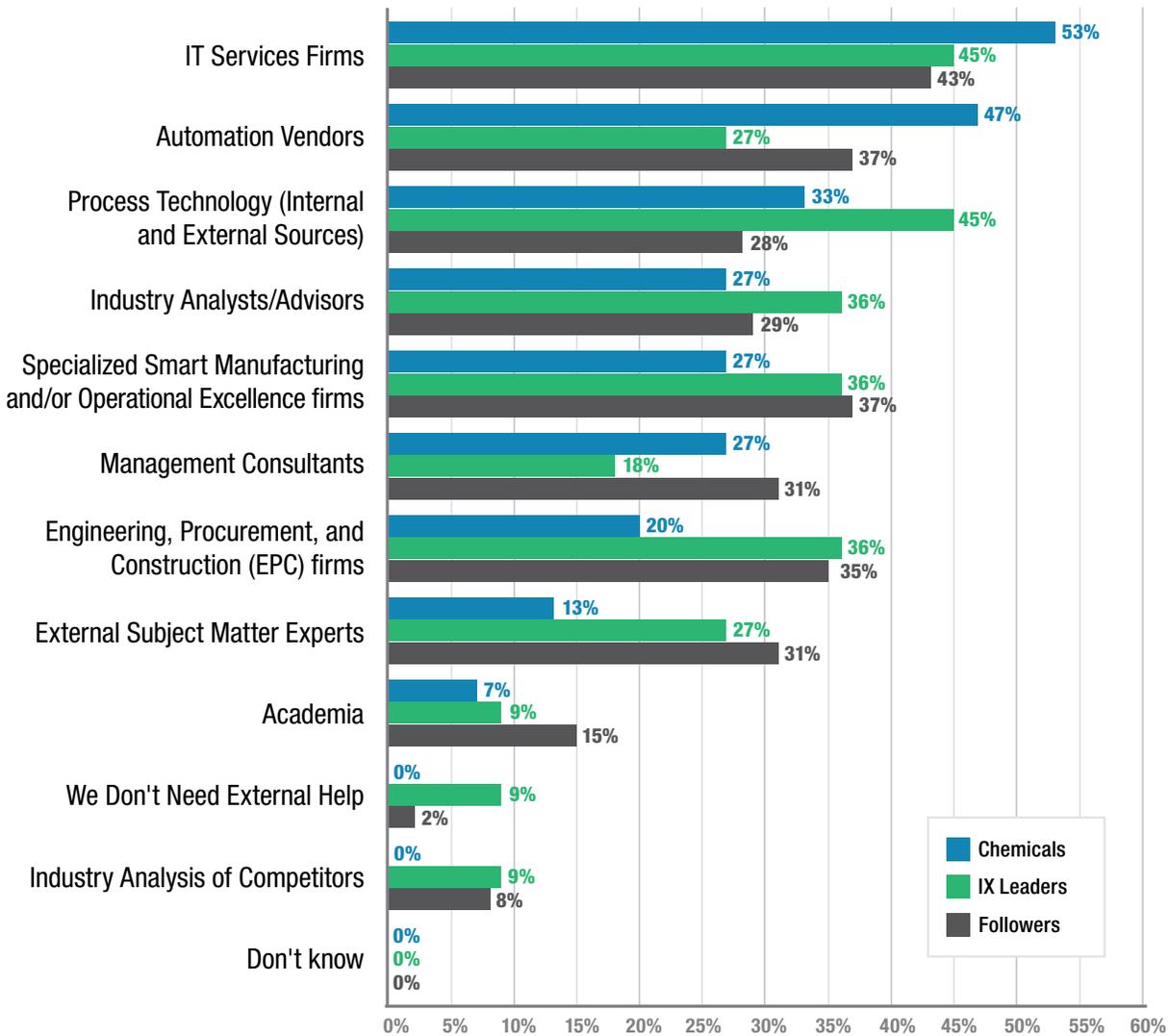


FIGURE 6 - Where Chemical Companies Seek Help for Autonomy



When LNS Research looked further into the data, we found that automation firms rank highly with operating companies only in the chemical industry. In fact, oil & gas, which we expected to parallel chemicals, looked to Engineering, Procurement, and Construction (EPC) firms for the most assistance and very little to automation firms. This difference showed up in two more areas, the first being in the nuanced differences in their definition of autonomy, and the second, in the type of help sought.

Why the apparent schism? Do oil companies take a stronger role in defining and selecting their automation systems while chemical companies rely more on automation vendors and systems integrators? While not the specific subject of this research, LNS Research believes that the answer has roots in the standardization of both technologies and work processes. As one moves from specialty chemicals to basic and bulk and to petrochem, where more and more similarities can be found among plants and producers, it becomes easier to standardize and template automation footprints. For example, ExxonMobil has long standardized on its downstream automation supplier, Honeywell. Even the control rooms in its refineries share common features and layouts, making them familiar to personnel who rotate through multiple plants as their careers progress.

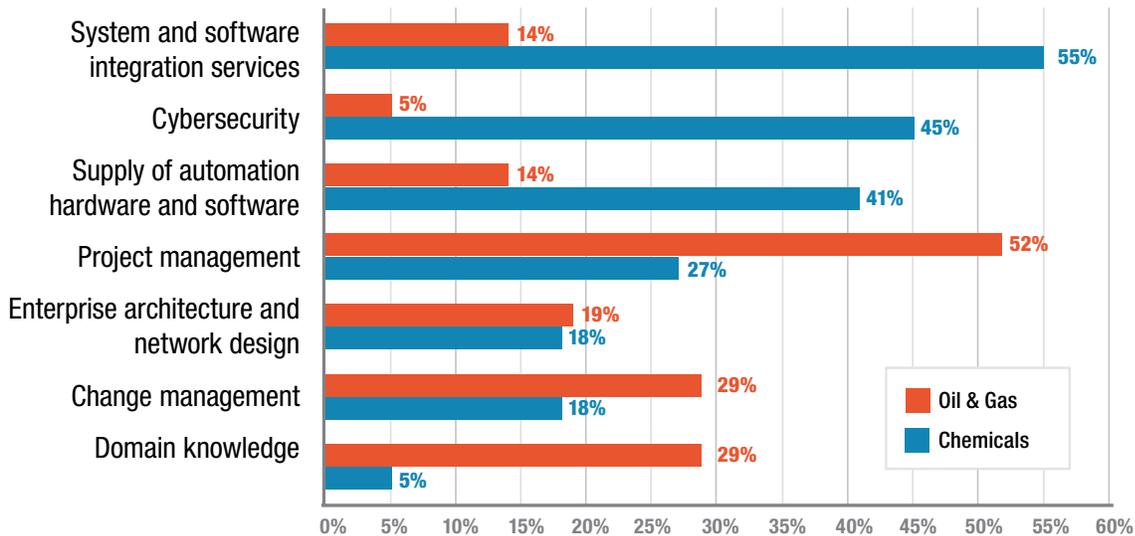


FIGURE 7 - Type of Help Sought



Status of Technology Adoption

Our survey also inquired about the level of take-up of both enterprise and Operational Technologies (OT).

- Environmental, Health & Safety (EHS) and Enterprise Quality Management Systems (EQMS) took first and second place at the enterprise level. EQMS displaced Supply Chain Management (SCM), which occupied the number two slot in the aggregate adoption rankings.
- Process Control Systems (PCS) and Production Planning and Scheduling (PPS) remain in the top slots at the OT level.

Next, we probed as to where the spending on next-generation technologies was going. Again, cloud, Edge, and the Operational Data Lake (ODL) topped the list. Still, more importantly, chemicals tend to lag the overall process industries groups in the other categories, especially in IIoT, Pervasive Sensing (PSS), and ICS cybersecurity.

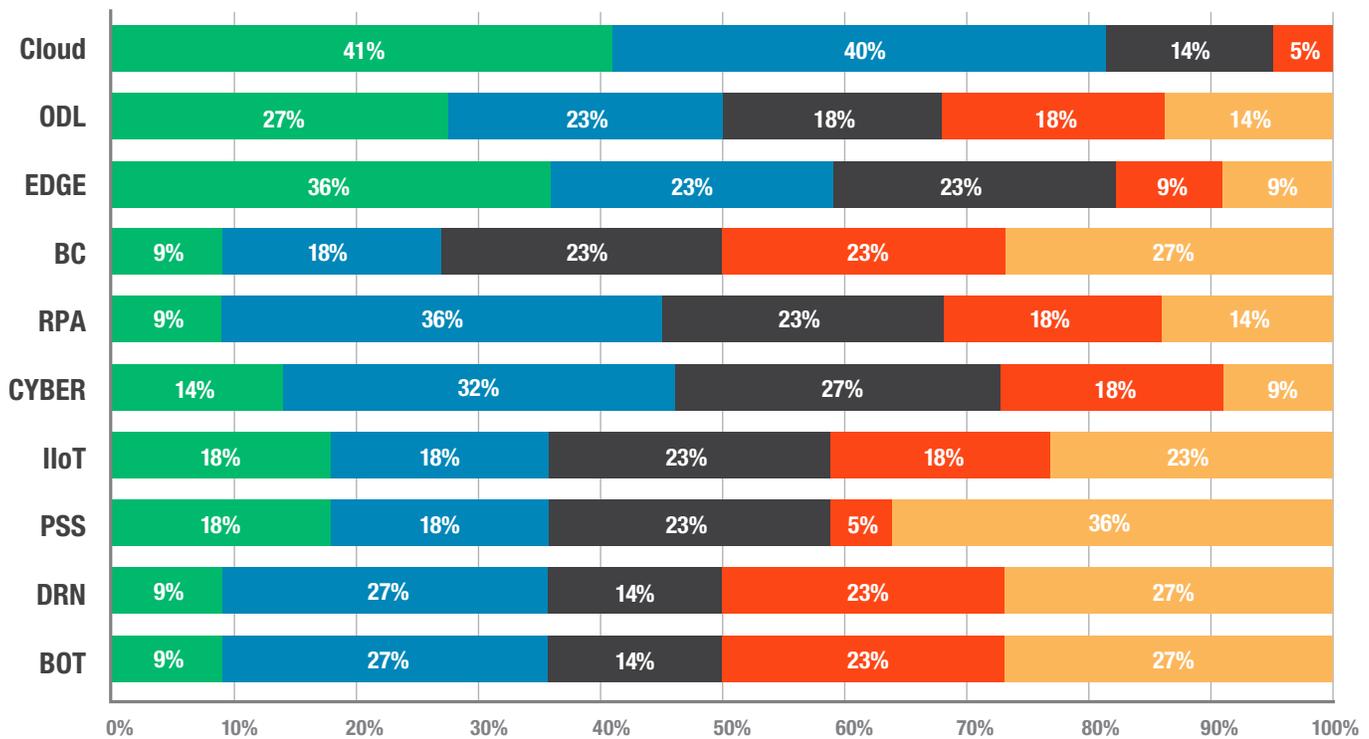
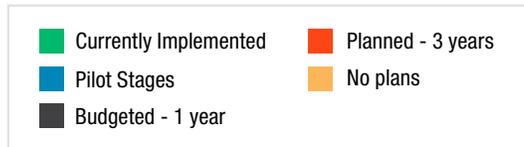


FIGURE 8 - NextGen Technology Adoption





Finally, we inquired into where the spending plans were for technology. We found that while business systems still command a healthy 30%, they slipped from first to third behind Operational Systems and Technical Systems. This is good news for both automation and modeling/simulation software providers. The chemical industry remains highly driven by chemistry and engineering.

Pervasive Sensing Systems (PSS) also showed double the spending of IX Leaders and IX Followers. LNS Research believes they have a scalability appeal to chemical operations, ranging from the very small to the very large. The former, with smaller equipment sizes, often means foregoing traditional full-sized, wired, more expensive instrumentation. In short, the wrap-and-extend capabilities of PSS allow the automated acquisition of data that heretofore has been collected manually or not at all.

Remote Operations

Turning to how many companies were implementing Remote Operations Centers (ROCs), our survey data found less than a quarter have done so but just over half should have them in place within the next one to two years, showing the upward swing in the trend. On the other hand, chemicals lagged IX Leaders considerably, and nearly one-third have no plans.

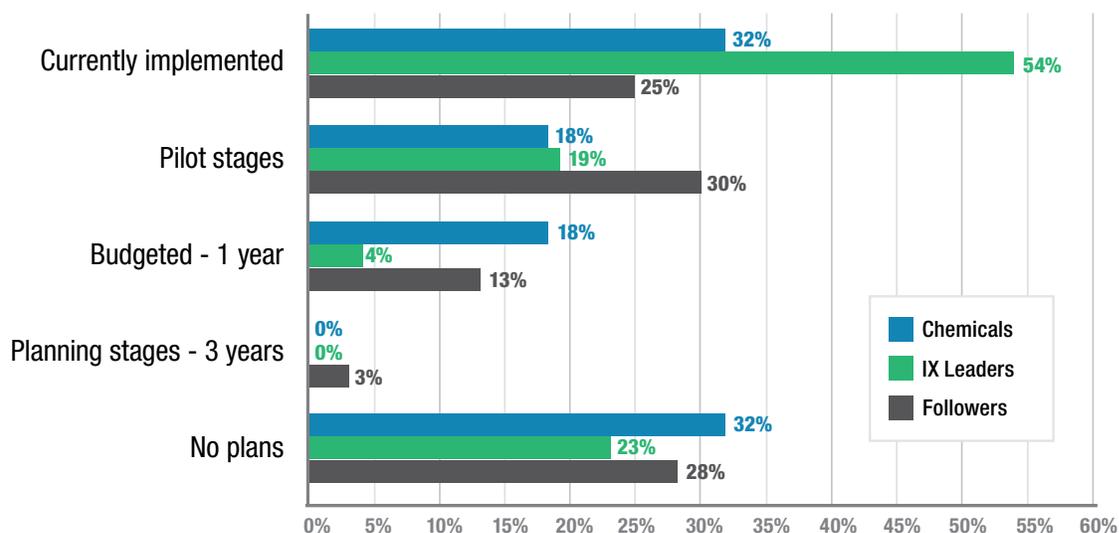


FIGURE 9 - Remote Operations Adoption



Status of Autonomous Adoption

Our first Research Spotlight discussed our survey focused on plant operations in the process industries. Specifically, LNS Research analyzed data from eight process and hybrid/batch industry verticals.

Based on their definition of autonomy, we asked how many organizations have implemented autonomous operations and to what degree. We did not impose an autonomous progression model nor a rigid scoring methodology on the respondents. Instead, we posed questions on the degree of functional autonomy across 11 plant functions and asked the respondents to choose the appropriate level, indicating where they stood today. The result was a range of answers showing where the most advanced and the average progress had been made.

Figure 10 shows just how far back the chemical industry lags IX Leaders and even IX Followers. They are conducting pilots and planning but no more than IX Followers. Nearly a third still do not have any plans for autonomy.

Process Verticals Surveyed:

1. Oil & Gas
2. Chemicals
3. Power Generation
4. Mining & Minerals
5. Pulp & Paper
6. Consumer Product Goods
7. Food & Beverage

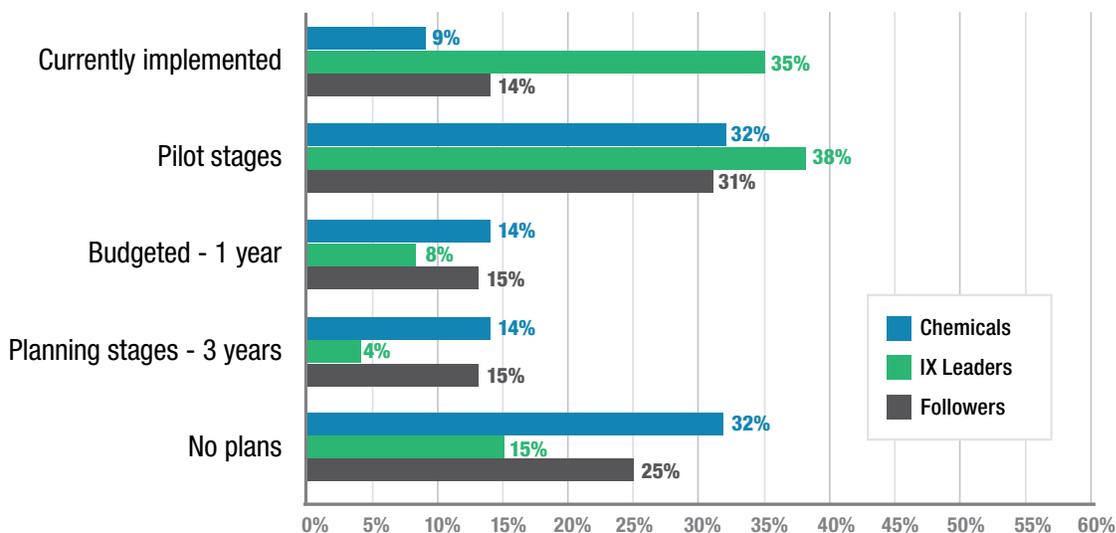


FIGURE 10 - Autonomous Implementation



Figure 11 below shows the progression across the 11 plant functions and the average progression. Keep in mind that:

- These represent a consolidation of the data across the eight verticals.
- Progression in one function is usually dependent on progression in other functions – that is, they are interdependent.
- This is an aggregate snapshot in time.
- Chemicals scores are layered on top of the aggregate scores.

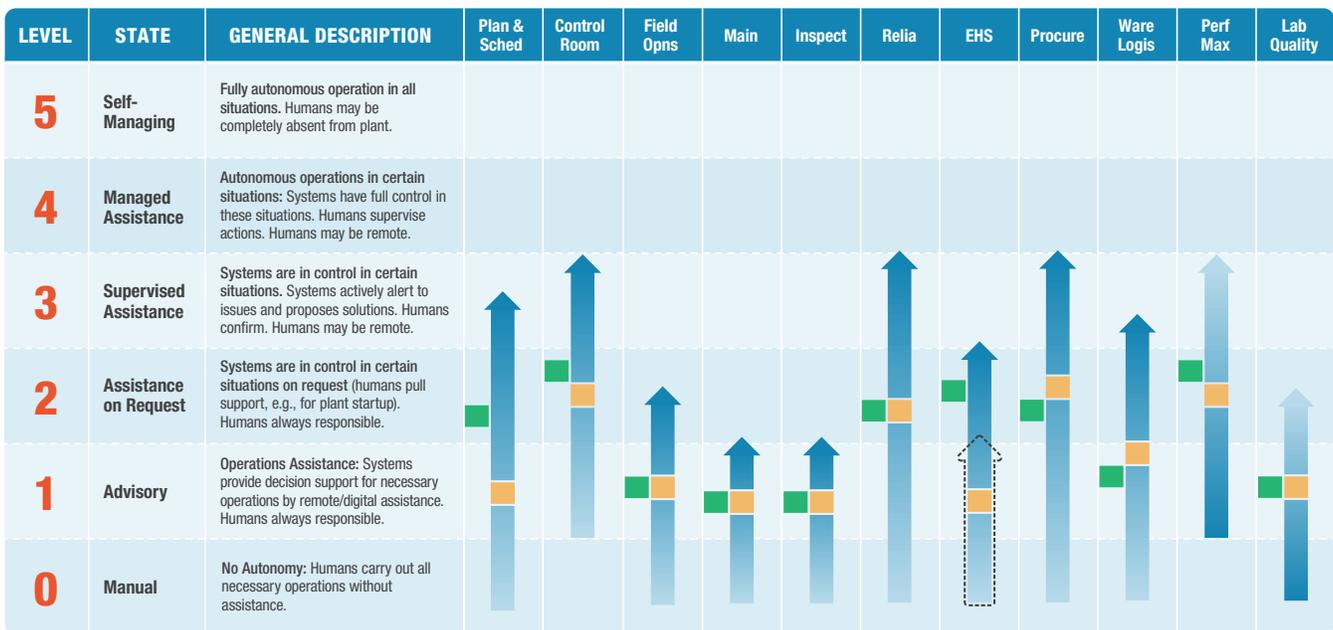


FIGURE 11 - Degree of Autonomous Progression Across the Plant Functions



While the averages are not surprising, the wide variation between those with no autonomy and those who have progressed the furthest indicates the significant potential for improvement for most companies. Chemicals are no exception.

While chemicals scored roughly at average in seven of 11 categories, four stand out. First, they are leaders in EHS and strong in production planning and scheduling. Second, chemical's performance in EHS matches their business focus on EHS. Third, they also do above average in control room operations and performance maximization.



Chemicals and IX Maturity

Our second report on IX Maturity and Autonomy assessed the IX maturity of the autonomous initiatives across nine elements. The data shows that the companies in aggregate have only adopted 32% of best practices on average and have a lot more room for improvement.

Chemicals generally lag in maturity, except for their focus on Operational Systems and Technical Systems, leading to planned spending. However, this is the one area where they are most progressive, as shown in Figure 13.

LNS Research sees a definite increase in the number of chemical companies with transformation initiatives. Some have extensive cross-divisional and cross-functional teams, often led by people with an operations background.

PEOPLE	Leadership Culture Competency
PROCESS	Management Systems Agility and Scalability Risk and Compliance
TECHNOLOGY	Connectivity Platforms & Applications Data & Analytics

FIGURE 12 - Elements of Maturity

	We are almost always early	We are usually early	We are usually mainstream	We are almost always mainstream	Don't Know
Chemicals	9%	41%	32%	14%	5%
Consumer Packaged Goods	21%	7%	50%	7%	14%
Food & Beverage	0%	29%	52%	14%	5%
Life Sciences	0%	39%	39%	24%	0%
Metals & Mining	9%	39%	38%	13%	9%
Oil & Gas	14%	24%	38%	19%	5%
Utilities	3%	17%	47%	23%	10%

FIGURE 13 - Technology Spend Across the Industry Verticals



How Chemicals Can Accelerate Progress

Chemical companies can take several steps to move ahead with Industrial Transformation (IX), remote operations, and autonomy.

- 1. Assess your current organizational readiness.** LNS Research has research that can show you how to deal with the inevitable issues, such as IT/OT convergence. It takes a cross-functional team. Don't leave plant personnel out of the equation.
- 2. Shape up your data access and quality, data architecture, and monument systems, especially at lower-performing plants.** Look to standardized Level 3 systems and leverage expertise across plants and divisions. Chemical processes may differ from plant to plant, but reliability strategies and fundamentals do not.
- 3. Make sure that you address capturing the knowledge of your senior and most experienced personnel before career-end.** Start by combining remote Subject Matter Experts (SMEs) supporting multiple plants and modern Connected Frontline Workforce (CFW) technologies.
- 4. Don't get caught up in the "lighthouse plant" movement.** These tend to be technology demonstrations that are not repeatable and do not scale. It is better to raise the lagging performers to the best performer's levels than to add marginal improvement to the best performers.
- 5. Leverage your strengths in EHS, PSM, and Integrity management.** The chemical industry practically invented Operational Excellence (OE) in the process industries. Look for opportunities to move toward OE 4.0, where EHS, Quality, and Asset Performance Management (APM) work closely together, automating work lows and data analysis to support operations.



- 6. Get the right help.** You emphasized trust in automation vendors, system integrators, and IT Services firms to help you control complex processes safely and efficiently. These vendors also can help wrap and extend newer technologies around existing systems to enable new capabilities. And, many automation vendors offer far more than automation. So, by all means, take advantage of what they can do for your company.

Remember that Industrial Transformation (IX) is a journey, so the sooner you get started, the sooner you will reap the benefits.





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