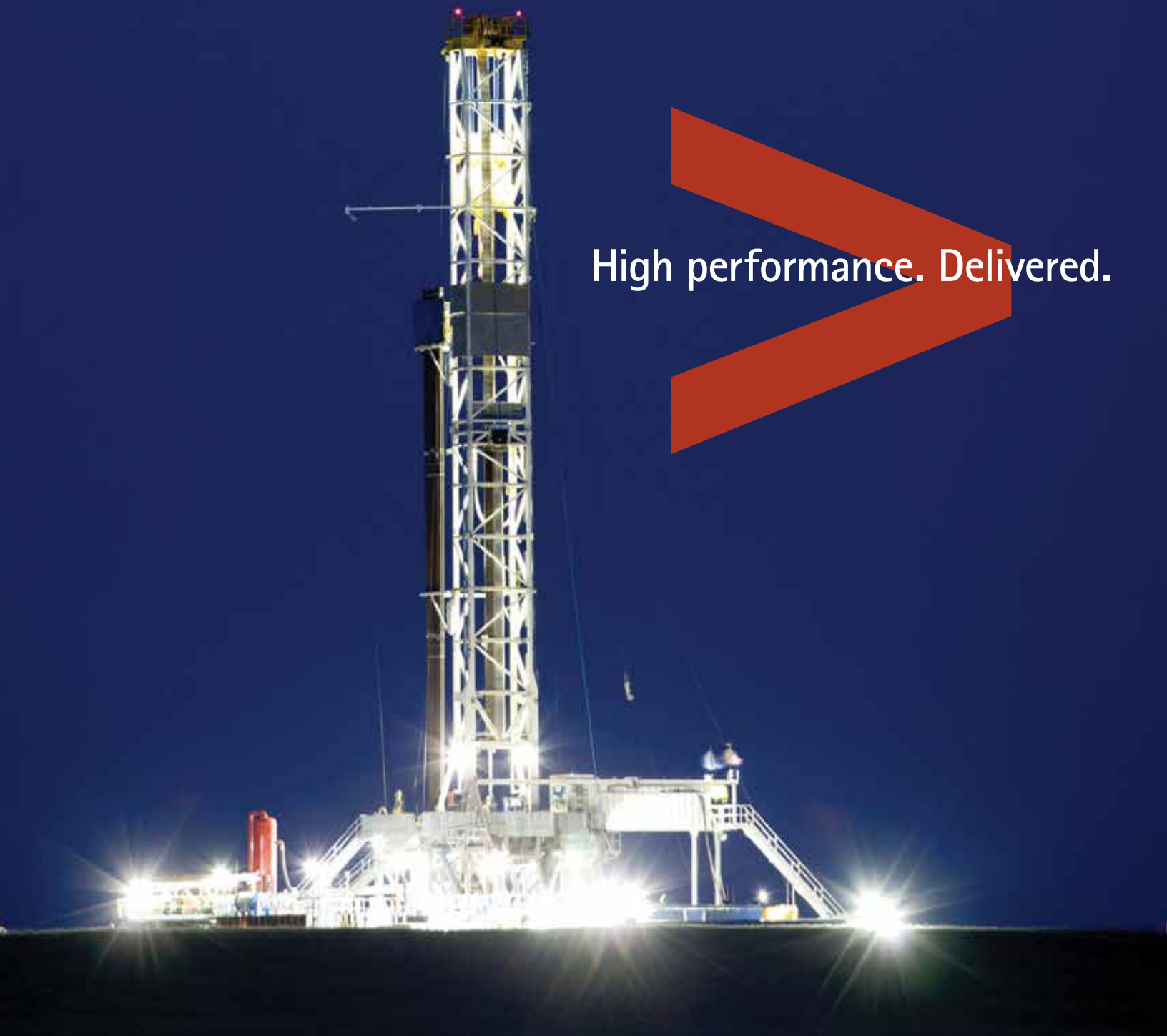
accenture

consulting | technology | outsourcing

Eight Leading Practices for the Proppant Supply Chain

By Pierre J. Mawet, Alex C. Fleming and John H. Nichols



Contents

Wild price fluctuations. Technology breakthroughs. Regulatory issues. Environmental controversies. Rarely is there a dull moment in the oil and gas business. And now there's hydraulic fracturing—not a brand new innovation, but still one of the most game-changing extraction approaches in a long time. North American response to this new method has been huge and interest in other parts of the world is rising almost as rapidly. For many companies, it's a whole new world, with field operators, services providers and material suppliers all learning as they go. And for those businesses that learn the fastest—and apply their new insights in savvy and productive ways—the opportunities are boundless.

This Accenture Point of View looks closely at one particular opportunity: using supply chain mastery to cost-effectively procure, move and store proppant: the commercial-grade silica (sand) and synthetic alternatives used to fracture subterranean rock and release oil and natural gas. More than 13 million tons of silica proppant are now being used for hydraulic fracturing in the United States alone. That's nearly ten times the total deployed by North American oil and gas companies ten years ago. Small wonder that masters of the proppant supply chain will have a significant edge over companies with lesser capabilities.

A Proppant Primer

By unlocking previously inaccessible hydrocarbons, hydraulic fracturing ("fracking") can greatly increase yields from shale formations with low permeability and porosity. High-pressure water and proppant—along with small amounts of specialty chemicals and acid—are pumped into the ground to break open the rock and allow hydrocarbons to flow out through the wellhead. Proppant plays a critical role in the process by keeping fractures "propped open" once pumping is complete and pressure reduced.

Commercial grade silica is the most common and economical form of proppant. As shown in Figures 1 and 2, oil and gas companies now use a significant percentage of all the proppant consumed in the United States.

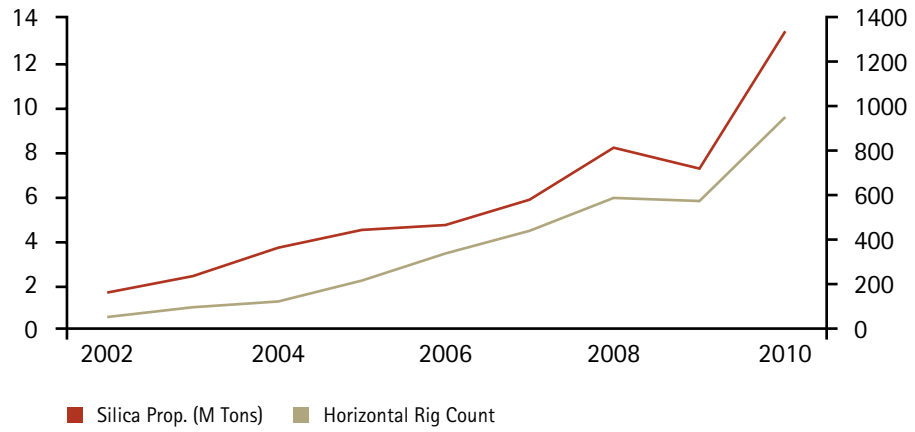
Commercial silica may not be as effective as costlier resin-coated silica and ceramic proppants. Resin-coated silica can reduce proppant flow-back by trapping fine grains that have been crushed under pressure. And ceramic proppants (manufactured from kaolin and sintered bauxite) do a better job of maintaining a uniform shape and size under high pressure (important for maintaining hydrocarbon flow paths in some formations and well designs). However, traditional silica-based proppant is significantly less expensive and, as illustrated in Figure 3, most companies consider this to be the determining factor.

Figure 1: The oil and gas industry consumes more than half the value (market share) of all commercial-grade silica mined in the United States.

End Market	Volume	Value
Oil & Gas Proppants	41%	54%
Glass	27%	19%
Building Products	7%	7%
Foundry	11%	6%
Other	14%	14%

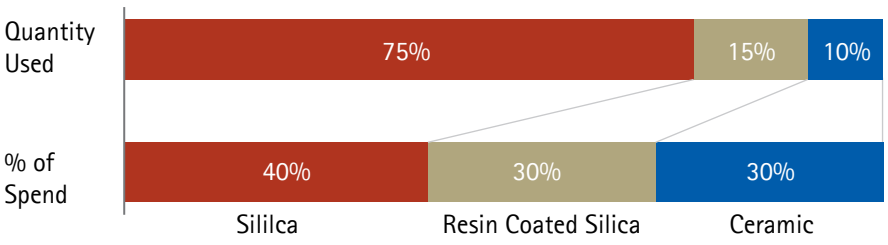
Source: US Geological Survey, USGS Minerals Yearbook, US Silica Holdings Inc., 2012 Form 10-K, pages 8-12.

Figure 2: As the number of horizontal wells increased across the United States, the silica proppant market grew significantly.



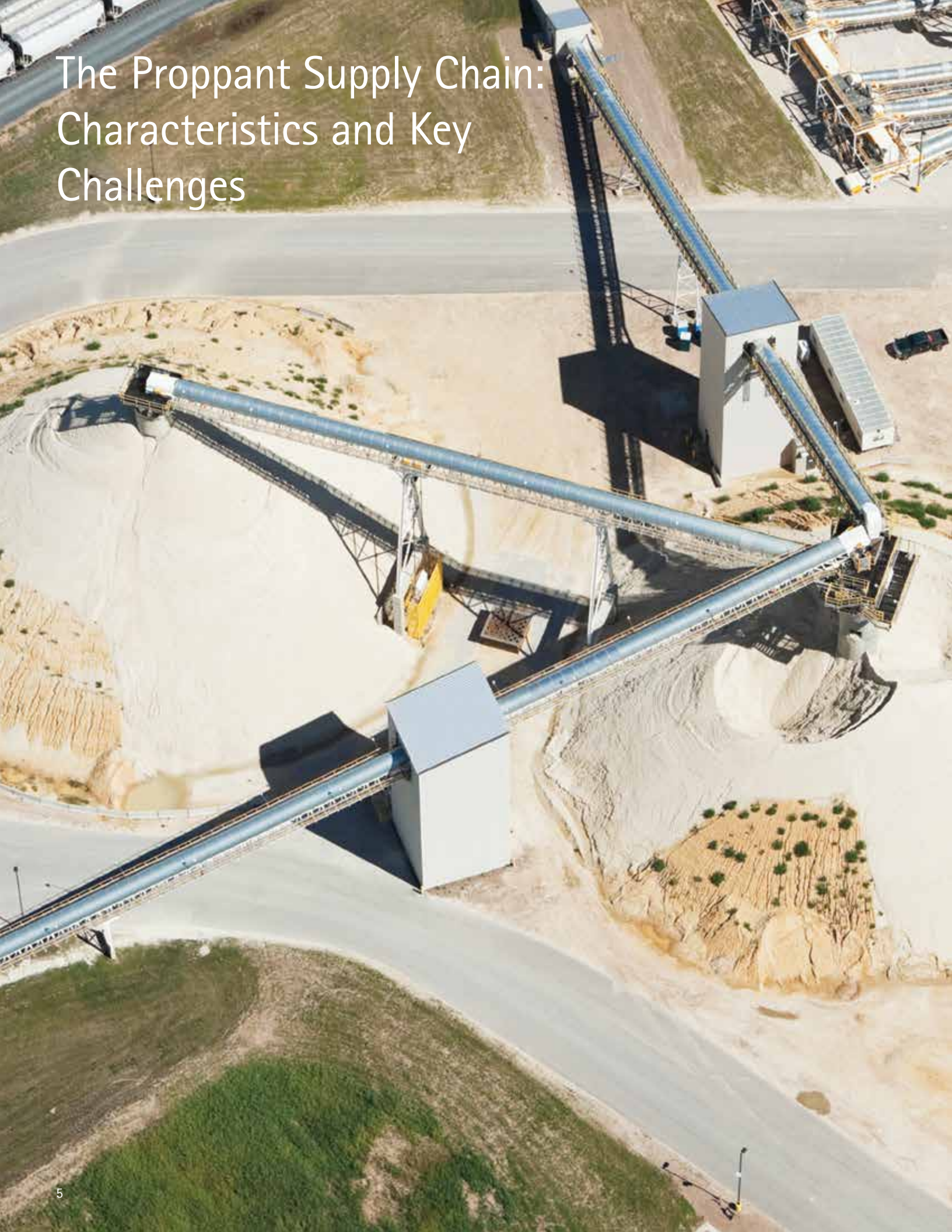
Source: USGS Minerals Yearbook, 2012 US Silica Form 10K.

Figure 3: Common example of proppant spend and quantities used by type.



Source: Accenture research.

The Proppant Supply Chain: Characteristics and Key Challenges



Transportation represents more than 60 percent of proppant's overall cost.

The proppant market has grown so fast that most field operators, services providers and material suppliers are struggling to keep up. Managing the proppant supply chain may be the biggest challenge of all. The typical proppant supply chain is hundreds, if not thousands, of miles long and involves myriad players and modes. The challenge is largely geographic: Most domestic silica mining happens in the Great Lakes region but smaller operations exist in Texas, Arkansas, Oklahoma, Arizona and other spots. Hydraulic fracturing operations are located from North Dakota to Louisiana and Pennsylvania to Wyoming (Figure 4).

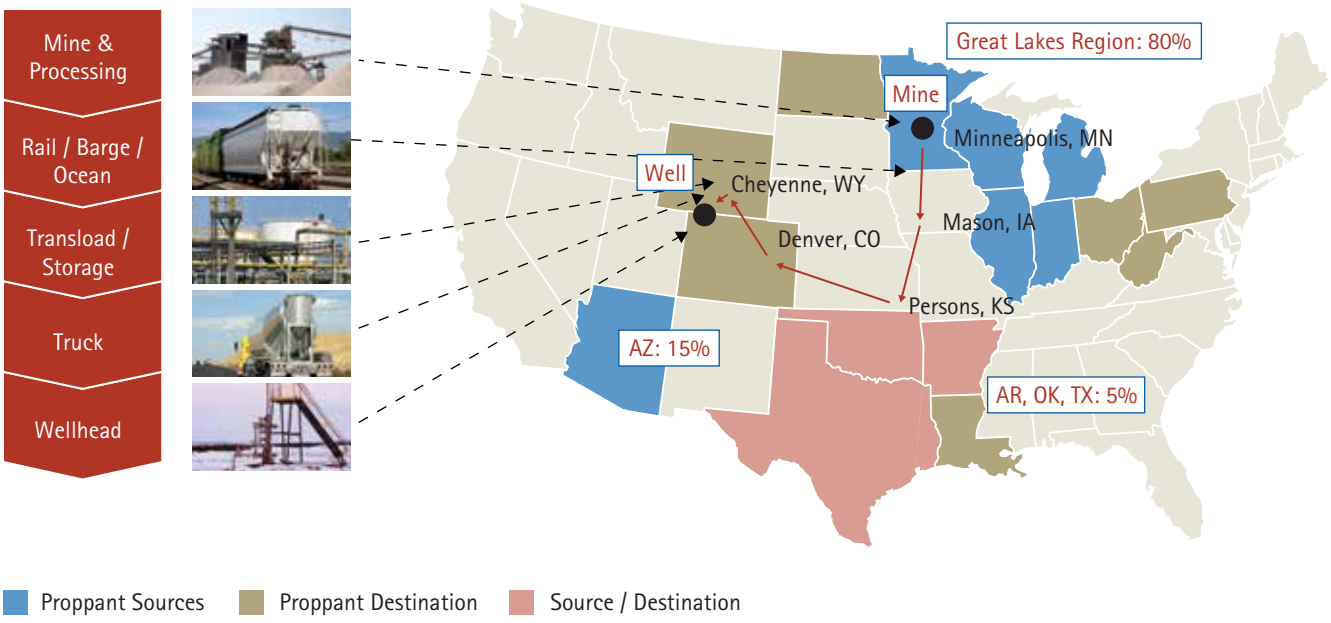
Given these widely disbursed operations, it shouldn't be surprising that transportation represents more than 60 percent of proppant's overall cost (Figure 5). On the transportation side, proppant's most salient characteristic is its high weight-to-value ratio and the fact that it must be mined or manufactured hundreds of miles from the well site. For these reasons, rail is the preferred transport mode. Oilfield services firms, proppant suppliers and railroads use a mix of owned, leased and rented hopper cars to transport proppant. The process is time consuming. Transit may comprise 10 to 15 days on manifest (multi-shipper) trains, with numerous stops to offload and take on cargo. Timetables are shorter on unit (single-shipper) trains, but 70 to 120 dedicated cars (roughly 7,000 to 12,000 tons) are typically required. Unit trains also need large amounts of track space to load and unload.

Distribution issues also are significant. Transload facilities must be available to store proppant and transfer it from rail cars to trucks for shipment to well sites. Significant storage costs are incurred when proppant is held at a transload facility or in railcars. Current rates for rail demurrage are about $80 per car per day and nearly double this figure for railroad-owned cars. In addition, high-volume storage facilities are capital intensive. A typical silo must be able to store 1,500 tons, which—in the case of the Bakken formation in North Dakota and Montana—is about the minimum amount of proppant needed to tap a single well. A large-scale storage facility might have capacity for 18,000 tons of proppant—enough for seven to twelve wells.

Proppant supply chain management also is complicated by a rapidly changing business mix. In recent years, the amount needed for one unconventional (shale-fracturing) well has grown from 150 tons to nearly 2,500 tons. To keep up with demand, the proppant industry has become highly fragmented. One major oilfield services firm currently buys proppant from at least 60 vendors.

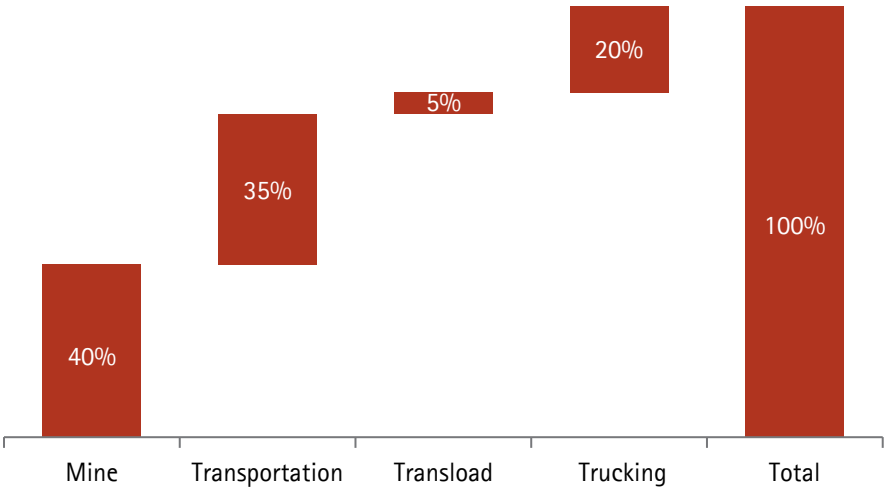
Lastly, oil and natural gas prices are particularly volatile, which complicates long-term supply chain planning. Consider the interaction between oil and gas prices: When gas prices are low, producers are more inclined to develop oil wells, which in turn alters the demand for various forms of proppant. Environmental regulations also vary from state to state.

Figure 4: Sample silica proppant supply chain from a mine located in Minnesota to a well site in Wyoming. Percentage values are estimates of the amount an oilfield services firm sources from a given region. Each rail stop adds one to two days to the total transit time from mine to well.



Source: Accenture research.

Figure 5: Approximate spend percentages for proppant components. Figures do not incorporate demurrage, storage or rail-lease costs.



Source: Accenture research.

Leading Practices in Proppant Supply Chain Management

Oil and gas extraction is certainly not new. Nor is the gathering and transport of silica. What is new is the epic expansion of volumes and destinations. This is what makes proppant supply chain management a largely new ballgame. Accenture has identified eight leading practices which, when implemented individually or in concert, can help field operators, services providers and material suppliers deal more cost effectively with their proppant supply chain challenges.

1.

Understand Total Cost of Operations

Analytics (along with improved-data capture mechanisms and standardized presentation formats) can help operators, services providers and material suppliers integrate field forecasting into supply/demand discussions on a real time and systematic basis.

Order-of-magnitude increases in venues and volume have forced the industry to add suppliers and alter logistical approaches; and for some, the ability to fully understand and control costs has been compromised as a result. In the new world of hydraulic fracturing, most companies are less able to calculate the relationship between efforts and outcomes—to quantify total delivered costs, understand each cost component, and assess the impact of changing modes or service. Simply put, companies have been so burdened trying to keep up with demand that many lack the information—and the ability—to correctly and fully calculate total cost of ownership (TCO).

To make better TCO decisions, companies need more advanced ways to collect, interpret and leverage data. Leading practices that help make this happen include the following:

- **Improve internal and external data-capture mechanisms.** Working through a centralized command center (with integrated systems and near-real-time feeds from partners) proppant supply chain leaders can keep a tight watch on sales figures, spending levels, and inventories (at rest and in motion). This gives them the data-mining muscle to make better, faster adjustments to changing business conditions.
- **Develop standardized presentation formats.** Consistent, accurate presentation of acquired data—parsed to meet the needs of specific decision makers—helps proppant leaders understand the complete operations picture, apply metrics more effectively, and achieve consensus on common goals and tactics.
- **Leverage analytics.** Analytics is about deriving actionable insights from data and using it to shape business decisions. In this area, the leading practice is "prescriptive analytics." Unlike descriptive analytics (which helps companies understand what already happened) prescriptive analytics looks forward—using statistical modeling, forecasting and optimization to predict potential outcomes, improve demand planning, "right price" products, accelerate innovation, evaluate the cost of risk and compare production-allocation scenarios based on product profitability. Analytics (along with improved-data capture mechanisms and standardized presentation formats) also can help integrate field forecasting into supply/demand discussions on a real time and systematic basis, and make it possible for companies to minimize their use of manual and paper-based processes.
- **Leverage exceptional people.** A worthy goal in proppant supply chain management is acquiring and leveraging human capital with the analytical knowledge to construct and conduct advanced analyses.

2.

Use Simulation to Gauge the Cost Implications of Changing Conditions

Companies need to know in advance 1) how total delivered costs are affected when material prices, transport profiles and drilling sites change and 2) what the potential cost and margin implications are of making tradeoffs in response to these changing events.

In addition to understanding the current total cost of moving and storing proppant, companies need to know in advance 1) how total delivered costs are affected when material prices, transport profiles and drilling sites change and 2) what the potential cost and margin implications are of making tradeoffs in response to these changing events. Like a good Boy Scout, it's about being prepared—minimizing TCO and risk.

Simulation (cost modeling) is how leading-practice companies deal with actual and anticipated changes—how they devise and assess tradeoffs among supply chain scenarios. From a technology standpoint, these proppant industry trendsetters excel in one or more of the following areas:

- **Statistical analysis**—rapidly recognizing and correcting statistical fallacies and data errors.
- **Linear programming and constraint theory**—calculating and demonstrating the impact of key drivers on the proppant cost structure (e.g., cost of dry bulk trucking or railcar transport) and drawing better conclusions about ideal values (rather than relying on tribal knowledge and personal experiences).
- **Monte Carlo simulation**—creating multi-variable simulations that demonstrate the financial impact of changing circumstances and shifting inputs.

Leading-practice companies also rely on highly skilled, specialized people to run these simulations. These are seldom the same folks who devise the scenarios and what-if questions. So the key is market- and supply-chain savvy people who collaborate with technology experts to anticipate potential shifts, quantify their impact and create suitable responses.

Lastly, it should be noted that most field operators, services providers and material suppliers understand the importance and mechanics of TCO and simulation. What is often lacking is the ability to apply these capabilities to hydraulic fracturing, where volumes, venues and number of parties are dramatically different from what most organizations are used to.

3.

Develop a Mobility Strategy

Leading-practice organizations are committed to formulating strategies that consider mobile-technology goals, platforms, operating systems, architectures, host application environments, data collection and tracking, security, integration with supply chain partners, and links to transportation/distribution and enterprise systems.

Paper is pokey, which is why leading-practice companies are diligently working to swear off paper. Helping to take paper's place are mobile devices that do a better job of capturing, storing, sharing, presenting and retrieving data. In short, smart phones, tablets and customized apps are making proppant supply chain information easier to manage. Wherever there's paper in the proppant supply chain, the process is slowed.

When it comes to mobility, leading-practice companies in the hydraulic fracturing field think first about strategy. They understand the risks of adopting new technologies without considering how those innovations will be used to make business better—how mobility can contribute to lower inventory carrying costs and fewer days of sale outstanding (e.g., with faster time-to-customer invoicing). These issues are particularly salient because mobile technology has already gained such a powerful foothold as a personal tool.

In short, leading-practice organizations are committed to formulating strategies that consider mobile-technology goals, platforms, operating systems, architectures, host application environments, data collection and tracking, security, integration with supply chain partners, and links to transportation/distribution and enterprise systems. From this list, three strategic considerations are particularly relevant to the proppant supply chain.

- **Collaborate with supply chain partners.** Proppant supply chain leaders are particularly adept at maximizing device and app compatibility; synchronizing associated processes; building mutually beneficial capabilities (e.g., applications and devices tailored for field usage and rough handling conditions); focusing on information sharing and expedited invoicing/payments; and ensuring that all devices are "factory hardened" for use in adverse conditions.
- **Leverage cloud-based data and open-source applications.** Companies are often inclined to build mobility strategies around an internal infrastructure. However, the IT management principles ingrained in many mainframe and ERP-centric organizations are rarely able to attain the speed and flexibility required for mobile development. The proppant business has too many rapidly shifting mobility issues that transcend internal parameters. Thus a leading practice is focusing on the cloud, and thereby maximizing flexibility and broadening accessibility while leaving infrastructure management tasks to qualified and approved third parties.
- **Ensure information security.** Protection strategies for client and internal data must closely consider information at risk and the nature of a reasonable worst-case threat scenario. Toward this end, leading practices in mobility include limiting data transmissions to an understood and manageable level of risk, performing validity checks on mobile inputs accessed via open-source applications, and making smart, realistic decisions about how to handle "organic" (personal) adoption of devices by the workforce.

4.

Use Analytics to Hone Sourcing and Purchasing Decisions

Non-material factors—transportation, distribution and inventory carrying charges—constitute a clear majority of overall proppant supply chain costs. The way to assess (and subsequently lower) these costs is with analytics.

It's always vital to know what your actual costs are—regardless of the function or process. An all-too-common example in the proppant supply chain is procurement: To make their purchasing decisions, companies frequently rely on factors that represent only a small percentage of a product, material or service's overall cost.

Leading-practice companies avoid this trap by considering all of the costs that affect a proppant-purchase decision. As noted in Section 6, this does not mean that creating captive sources of supply (vertical integration) is a panacea. From a sourcing perspective, the actual "stuff" represents only about 40 percent of the overall delivered cost. So by purchasing a mine or a proppant vendor, a company may be making a significant investment that doesn't radically reduce costs but does raise inventory levels, increase fixed costs and reduce flexibility. There's also the problem of inaccurate pricing to customers of the purchased companies: Poor costing capabilities make it difficult to understand what to charge as well as what to pay.

Non-material factors—transportation, distribution and inventory carrying charges—constitute a clear majority of overall proppant supply chain costs. The way to assess (and subsequently lower) these costs is with analytics: calculating current TCO, understanding spend priorities, and simulating the impact of alternative purchasing scenarios (e.g., what if the cost of hopper cars suddenly increases?). Procurement analytics also can reveal opportunities to more-strategically manage commodities and categories, work with competitors on contract swaps, and quantify the advisability of actually acquiring raw material and transportation resources.

Lastly, companies need to make sure that a variety of in-house organizations—sourcing, purchasing, logistics, marketing, planning—have access to the same data and analytical capabilities. When it comes to sourcing and procurement, intra-organizational coordination is vital.

5.

Explore Unconventional Collaborations to Improve Flexibility

There are ways that field operators, services providers and material suppliers can work together to raise flexibility and thereby make everyone's entire supply chain more agile and economical.

Flexibility is seldom top of mind when you're managing huge sand mines, slowly moving untold tons of sand via fixed-course rail systems, and storing material in gigantic silos. Changing plans at the last minute is inordinately cumbersome. Implementing rapid logistical shifts is rough. Postponement is generally unrealistic. However, there are ways that field operators, services providers and material suppliers can work together to raise flexibility and thereby make everyone's entire supply chain more agile and economical.

One solution is to establish secondary markets. Consider that, depending on the basin, decisions about what specific type of proppant to use must often be made very close to the time when a job actually starts. It isn't unusual for a customer to alter a well design after proppant has been ordered—leaving the oilfield services supplier little choice but to hold inventory in rail cars and often incur large demurrage charges. Possibly locked into a fixed contract, the company could be stuck with trainloads of the wrong type of sand (for example, 10 railcars of "20/40 white" instead of "40/70"). Despite the frequency of this problem, few organized attempts have been made to connect with secondary markets. Yet the buyers are out there.

A related issue is more extensive collaboration with traditional competitors. For example, hydraulic fracturing operators could do more in the trading arena by actively organizing contract and legal structures to conduct exchanges while still protecting proprietary information. There also are opportunities to pick up each other's delivered loads, although the best physical-exchange point may depend on rail companies and legal limitations. Increased collaboration might require that companies work collectively with one or several neutral third parties to protect proprietary information. Stronger connections with rail companies also may be needed, since the most common storage and transit location for proppant loads is railcar sidings. The bottom line, however, is that working together is a potential win-win.

Companies might further increase operational flexibility (thereby reducing excess inventory, lowering storage costs and increasing working capital) by working more closely with distributors. Compared to oilfield services customers, proppant distributors may sometimes have better visibility and a deeper understanding of the network. So rather than develop internal tools and systems, companies could use existing distributor information to improve tracking and make decisions.

6.

Avoid Capital Investments that Limit Agility

Leading companies have decision support mechanisms that use a variety of financial metrics to develop long-term lease-versus-buy business cases.

To help ensure proppant supply during the recent gas boom, many oilfield services companies increased their levels of vertical integration. Some purchased silica/sand-mining operations. Others acquired transportation assets such as rail cars—on the surface, a viable move since lease costs on the covered hopper cars that transport proppant have doubled in less than two years. Lastly, several firms built captive storage buildings adjacent to rail transload locations or are storing proppant in their own "rolling storage" facilities (hopper cars) at the rail yard.

The logic behind these vertical integration moves is obvious: the need for reliable, controllable access to raw materials and supply chain resources. However, the same drawbacks that vertical integration has always posed (higher fixed costs, lower flexibility and significant capital commitments) are still relevant. For example, proppant mine ownership typically does little to reduce transportation costs and can even increase expenses when new wells are opened at far-distant locations. And although railcar ownership and rolling storage may reduce demurrage expenses and help store proppant closer to the well site, they also raise inventory carrying costs. Lastly, vertical integration can bloat the balance sheet, making it harder to plan for (and respond to) changing market and supply conditions, and constraining the amount of funds available for other projects.

So does this mean that vertical integration isn't the best answer to companies' proppant supply chain management challenges? To some degree, the answer is yes. Consider the following leading-practice alternatives:

- **Minimize risk associated with market volatility.** By leasing from several vendors with varying lease periods, companies gain the flexibility to renew or not renew leases based on market conditions. Using leases of different lengths could allow firms to quickly scale the size of their operations to align with current demand.
- **Evaluate capital investments relative to other options, rather than making simple "go/no-go" decisions.** When making capital investments, leading firms look across a broad spectrum of possibilities and consider each investment's impact on the entire supply chain.
- **Build more robust what-if scenarios and implement forecast and decision gates for multi-year capital planning.** Both of these actions can help companies do a better job of analyzing tradeoffs between OPEX and CAPEX.
- **Formulate lease-versus-buy business cases for supply chain assets.** Leading companies have decision support mechanisms that use a variety of financial metrics to develop long-term lease-versus-buy business cases.

7.

Tighten Links with Key Customers

Comparatively little collaboration—especially when it comes to joint planning and information sharing—happens between proppant services providers and their customers. However, significant operational improvements (lower expenses, better margins, and faster time to production) are possible if more-open relationships could be established.

Most companies in the hydraulic fracturing business are not equipped to respond quickly and comprehensively to evolving customer requirements. This is somewhat understandable given the innate inflexibility of the product and the process: myriad tons of proppant moving along slow, fixed-path arteries. In addition, the entire concept of proppant supply chain management is quite new (with entire industries popping up in locations that were barren several years previous). This means that sophisticated collaboration strategies may not have had time to gel.

Yet the fact remains that comparatively little collaboration—especially when it comes to joint planning and information sharing—happens between proppant services providers and their customers, and that significant operational improvements (lower expenses, better margins, and faster time to production) are possible if more-open relationships could be established. In fact, better collaboration could be particularly valuable in proppant supply chain management because of the high volume of upfront and fixed investments.

So given the inborn constraints (cumbersome materials, new challenges, etc.), what can proppant supply chain managers do to collaborate more effectively with customers, and thereby reduce costs, increase flexibility and perform more synergistically? Two actions are particularly important:

- **Exchange planning information and conduct short-, medium- and long-term forecasting for individual sand types and geographic needs.** Shifting proppant mixes and demand levels are too frequent and significant to make assumptions.
- **Develop more sophisticated sales and operations planning (S&OP) processes and collaborative planning cadences.**

8.

Approach Proppant Supply Chain Management More Strategically

There are many ways for field operators, services providers and material suppliers to approach proppant supply chain management more strategically—to concurrently increase cost savings, synergies and competitive advantage.

Few companies in the proppant business have created a comprehensive, integrated supply chain strategy—particularly when it comes to distribution networks. Most are making it up as they go. Rail is a good example: Seeking to reduce costs, companies frequently ship proppant on manifest trains, two or three at a time from mine to transload facility. However, those few railcars are invariably coupled with scores of additional cars—a consolidation process that takes a lot of time. Plus, those few cars won't go directly from the mine to the transload facility; they'll head first to a switching terminal where cars are juggled around, resulting in additional lost time.

Thinking more strategically—particularly with respect to planning and collaboration—might produce a better scenario. For example, companies could deploy complete (unit) trainloads from the mine to a designated hub. From the hub, cars would be switched around, with various sand types forwarded to multiple transload facilities. The net effect could be faster transit times, lower inventory carrying costs and less-expensive drayage. Unit trains also tend to have priority over manifest trains, which can further accelerate transit time.

This approach may, or may not, involve vertical integration. Independently or with a partner, companies could purchase, develop or lease a hub, or share space with a competitor. They might also engage a third party to act as a broker. The most important thing is that you are strategically addressing the proppant supply chain's most significant cost driver, which is **transportation/distribution**, not the material itself.

Beyond railcar deployment, there are other ways for field operators, services providers and material suppliers to approach proppant supply chain management more strategically—to concurrently increase cost savings, synergies and competitive advantage. The overarching mission is to view proppant supply chain management as an integrated system, rather than a series of discrete jobs and decisions.

- **Use proppant planning information combined with actual tactical demand to build a distribution network focused on cost control.** These networks may abet the postponement of load breakage into truck-level quantities until the last leg of the supply chain, and help manage delays when loads are on the road.
- **Develop more sophisticated forecasting techniques to better anticipate demand and disruptions.**
- **Analyze assets within the supply chain to determine the optimal number of railcars and trucks to own, lease or rent.**
- **Deploy transportation management systems (TMSs) to help plan, manage and optimize the movement of proppant across various nodes and (ultimately) to the well site.** By using TMSs, companies can become more proficient at scheduling and tracking performance of internal and third party carriers—a traditionally manual and paper-driven process characterized by inconsistent performance and high demurrage charges. Moreover, companies that integrate TMSs with mobile technology often enjoy a more complete, real-time picture of the network, better control of their transportation costs, and the ability to more-effectively allocate material to a given job.

Making High Performance Happen

There is no single recipe for developing the perfect proppant supply chain. Yet there are a variety of leading practices with high levels of applicability to virtually all companies in the hydraulic fracturing business. In fact, some organizations have already implemented a number of these practices and made significant operational strides as a result.

Of course, not every leading practice applies to every company, nor is it necessary (or feasible) to pursue every one. But by embracing as many of the practices' underlying tenets as possible (developing integrated strategies; emphasizing total cost of ownership; leveraging analytics, simulation and mobile technologies), field operators, services providers and material suppliers will likely find new economies, leverage points and opportunities to achieve high performance.

About the Authors

Pierre J. Mawet is a Partner in Accenture's Management Consulting practice. Pierre has partnered with many of the largest oil field service providers and global energy companies to design and implement supply chain strategies and operational improvement initiatives. Based in Dallas, he can be reached at pierre.j.mawet@accenture.com.

Alex C. Fleming is a Manager in Accenture's Management Consulting Resources practice. Alex has worked with oilfield service providers, chemical providers, and transportation clients on supply chain strategy, manufacturing networks, logistics optimization, and field materials management. Based in Houston, he can be reached at alexander.fleming@accenture.com.

John H. Nichols is a Consultant in Accenture's Management Consulting Operations practice. John has worked with oil field service providers on supply chain strategy and field materials management. Based in Atlanta, he can be reached at john.h.nichols@accenture.com.

About Accenture

Accenture is a global management consulting, technology services and outsourcing company, with 257,000 people serving clients in more than 120 countries. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. The company generated net revenues of US$27.9 billion for the fiscal year ended Aug. 31, 2012. Its home page is www.accenture.com.

12-3341 / 02-5360