RAILROADS, ADAPTABILITY, COMPETITION AND THE SHUTTLE TRAIN (OR FOOD, CRUDE AND THE RAILROADS)

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The North American Great Plains is the breadbasket of the United States and Canada. Agriculture will always be a foundation industry of the region, but the recent oil boom is challenging that dominance. The problem of the Great Plains is the same spatial challenges it has always faced: great resources in vast areas far from population centers.

Business, especially business that specializes in transportation, likes to claim responsiveness to market demands. Most transportation industries can change and adapt in response to market demand. The railroad industry is clearly more limited in flexibility than other transportation industries. Once rails are down, it is expensive and difficult to change the path of the railroad. But this does not mean the industry does not change at all. In the last 20 years, two commodities, grain and oil, have driven a remarkable change in North American railroads particularly in the frequency and size of shipments. However, while the forces of grain shipment were phased in gradually in response to a slowly changing market, the forces of oil shipping are pushing the railroads to change rapidly and overtaxing an infrastructure that was not designed for optimal shipping of large volumes of oil.

History of Grain Shipping

Grain has been the backbone commodity of most North American railroads. Practically every town on the Great Plains once had an elevator or multiple elevators that shipped one, two, five, or 20 cars at a time, depending on need. An army of local trains trundled across the prairie, collecting the bounty of the harvest and bringing it to rail yards for classification into mainline trains. In Canada, the grain branchlines were often very light duty rail, which meant only lighter engines and cars could serve those areas. The result was that small elevators persisted longer, and unit trains came later. Even the boxcar had longevity as a grain car longer in the Canadian prairies, resulting in strings of “buffalo,” as the refurbished boxcars bearing Manitoba’s Buffalo logo were called.

The deregulation of the railroads in the United States in 1980 was a response to a simple fact; it was becoming too expensive to run that army of locals to collect the grain on those far-flung branch lines. As farms grew larger, towns and populations on the plains grew smaller. Grain alone could not support the railroad’s bottom line. Freedom to adapt was afforded the railroads by changes in regulations, and the railroads responded. The responses ranged from abandoning, selling, or tearing up branchlines, to changing service. Some of the largest service changes came from railroads encouraging shippers to move grain in larger lots. On one railroad, the discounted shipping price in the 1980s went first to 26-car units. By the 1990s, it had doubled to 52 cars, and then in the middle of the last decade it went to the scheduled, 110-car grain “shuttle.” From an operations standpoint, railroads love shuttles. These trains are loaded in 8 to 12 hours, run directly to their destination, unload in 8 to 12 hours, and run back to the plains. Most shuttles go to ports that handle export grain. The shuttles do not have to be yarded for classification, their locomotives are used very efficiently, and crews are scheduled efficiently, all major bonuses to the railroad.

Another result of the move to larger trains is that there are new “prairie skyscrapers” replacing traditional grain elevators. The shuttle elevators are usually huge; they must have offline space to hold the 110-car train when loading and they must have either storage or the means to get enough grain on hand to load a shuttle when it arrives. Efficient elevator operations results in profit, while delays result in penalties. Yet not all grain moves by shuttle or unit grain train. There are still millers and processors that use smaller quantities of grain or blended types of grain that do not use the shuttles/unit trains or the large elevators. They still provide a market and livelihood for some of the more adaptable, smaller elevators on the prairies.

New Challenges: The Boom in the Bakken

The geographical area of North America known as the Williston Basin covers most of western North Dakota, part of eastern Montana, and parts of Saskatchewan and Manitoba. Though oil was discovered and pumped as early as 1956 in the basin, petrologists always knew there was more oil trapped in formations that could not be reached by traditional oil drilling technology. One such formation is the Bakken Shale formation. Technological advances from gas drilling, mainly horizontal drilling and hydraulic fracturing, are now used to access previously inaccessible oil deposits.

So, with oil now needing to leave the states and provinces on the Bakken formation, a new problem arises, one very similar to that which faced the grain growing regions over 100 years ago. What infrastructure needs to be built or adapted for the purpose? The area has rail infrastructure designed mainly to move grain, or to route traffic over mainline routes that go mostly east-west through the area. Oil mainly needs to go south to the refineries or transfer points in Oklahoma, Louisiana, and Texas. What is the most economic method to move oil out of the region to refineries and to market? There are currently very few, perhaps one or two, refineries in the region, and they are mainly not 'set up' to take crude oil of the type produced in the Bakken, nor could they take more than a small fraction of the output. So, at least for now, the oil has to leave the area for processing and to get to market.

The most efficient way to move oil on land is by pipeline, but pipelines are expensive, slow to build, and complicated by environmental concerns. Only about a quarter of the Bakken production is accessed by a pipeline at this time. New pipelines are years in the future. This leaves the railroads as the best option to move large volumes of crude oil. But, there are serious questions about how the rails will adapt to serve this emerging industry.

There is a considerable difference in locational processes between building railroads to serve elevators and communities, building the grain shuttle system, and locating oil load terminals. Initial portions of this research began with studying the methods used to transition to and implement shuttle or multi-unit loading. Historical rail development and grain elevator placement were part of the background for that study. The spatial rationale for the placement of each type of loading, grain vs. oil, is as different as the products themselves. Shipping methodology is also quite different. Grain is bulky but not necessarily heavy and loses volume and weight in processing. Oil does not necessarily lose weight in processing since refining uses most of the product. Neither does the finished product, say gasoline or diesel fuel, necessarily cost more to ship than crude oil. So, it is very difficult to apply a traditional location theory such as Weber's location theory. The oil terminals are simply built where oil needs to be loaded with little concern for the factors that drove the spatial distribution of grain elevators.

Historic Grain Elevator Siting

It is fairly safe to say that agriculture built the networks of rails that crisscross the Midwest and the Great Plains. Railroads put down lines with the idea of capturing the agricultural shipping business from their rivals. With those lines came other services such as less-than-carload freight and passenger service. From the time of the last major railroad building projects in around 1915, the fortunes of these various branchlines went from boom to bust and everything in between. Railroad regulation, initially intended to curb the excesses of various powerful companies, had the added effect of preserving service on rural lines long after such operations ceased being profitable. Railroads began to feel the pressure of large amounts of infrastructure. The economics of upkeep versus slim profits dictated that rail companies must reduce or eliminate certain services and even remove tracks to stay competitive.

Most original prairie elevators are gone. The problem for the smaller elevators is one of limited storage and turnover. Most elevators used to turn over their stock only twice a year but larger ones turn over five or six times. When railroads wanted to run fewer trains, elevators were forced to load more cars at one fill. Small elevators simply do not store enough grain, do fewer turnovers, and are less competitive.

Modern Shuttle Elevator Siting

In contrast to the methods for placing historic elevators, the locations of modern shuttle elevators are driven not by the railroad industry, but by the needs of the corporate grain shippers such as Cenex Harvest States (CHS) and other exporters. Since most shuttle trains haul grains for export, it is the export companies that are the biggest influence on where the elevators are sited, built or modified to service shuttles. Railroads are quick to point out that they may have influenced the shift to grain shuttles with their pricing policies, but they work for the grain exporting companies to determine where the shuttle elevators are built.

Elevators capable of loading shuttle trains are usually located based on a few factors: Ease of loading, ease of assembling the large amount of grain to fill the train, and ease of access. A shuttle site must possess the first and second qualities, which are driven by the design of the facility itself. The quality of ease of access is driven by the configuration of the tracks. The third quality may have the single most important influence, as it will determine how the railroads are able to integrate shuttle trains into the traffic on their lines.

Elevators that load shuttles must load large trains; BNSF runs 110-car shuttles and CP runs what it calls "Power On" 112-car shuttles. With the tight schedule for a shuttle, speed is of the essence in loading, and most shuttle elevators are set up to load a train in 8 to 15 hours.

The rapid load times depend on having enough grain on hand to load, or getting it to the site quickly. One large, purpose-built shuttle elevator owned by Alton Grain Corporation has a capacity of 4.4 million bushels and is easily able to load a train with what is on hand. Another example owned by CHS is an elevator modified to shuttle load capability from an existing facility, and it has 'only' a 1.25 million bushel capacity and must rely on trucks to short haul grain from other elevators to fill a shuttle train. A purpose-built facility, like Alton Grain, could be located anywhere on the railroad's lines, where the modified elevators would be positioned centrally to the supplying facilities.

Ease of access to any shuttle load facility must allow loading without fouling the mainline traffic. There are three main track formats that shuttle elevators use to achieve this. Either they are loaded on a straight siding large enough to hold and do the loading operation of the entire train, or they are loaded on a balloon or loop track siding where the train runs in a large circle through the facility, or the facility is located on a branchline where there is little traffic other than the shuttle and the train can be parked without causing disruption.

It should be noted that unload sites have also had to be modified to be able to handle shuttle trains with similar time and access constraints. Most export shippers are also expanding their unload facilities in places like the ports of Seattle and Vancouver. It is noted by some who study port facilities that the numbers and efficiency of unload facilities have yet to catch up with the loading elevators. Large agribusiness shippers were the first to buy into the increases in size and capacity that would allow for running shuttles, but many other shippers have begun to consider it. The shuttle elevators are generally sited where there is the best confluence of the three factors. This has resulted in the map in Figure 1.

North Dakota is typical of grain growing areas in the U.S. and Canada where shuttle elevators are present. Because they have such large capacities, shuttle elevators generally have considerable distance between facilities, unlike the historic 15 to 20 miles between original elevator sites. The elevators that require input from satellite facilities are usually located centrally to those supplying elevators. Some shuttle loadouts have also been located on regional railroads. Regional carriers load and operate the trains, sometimes with the major carriers own locomotives, on their rails for the major carriers. This arrangement allows the major carriers to quite literally remove a shuttle from their traffic pattern while loading, a nearly ideal situation.

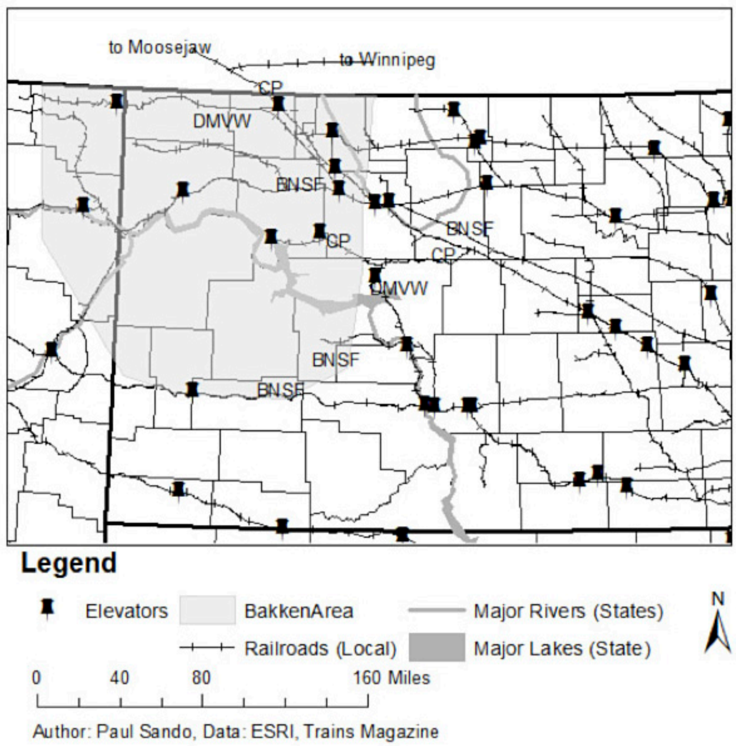

Figure 1. Shuttle elevators in or near the Bakken Formation

The railroads maintain they are not involved in any decisions on creating shuttle load elevator sites or unload sites, and that they have no ownership interest or capital involved in building terminals. The siting decisions rest with the agri-business firms doing the shipping. Choosing to use shuttles means commitment to both the cost of upgrades to facilities, and to a contract to run shuttles for one year with renewal for one or two years at a time. Within that year, a shipper may run as many shuttles as they can load and the railroad can handle. The main controls on the number per year hinge mostly on railroad crews and equipment turnaround times.

In the cross-border region of the Williston Basin/Bakken Shale play, the rail carriers BNSF, Canadian Pacific, and several regional railroads have been operators of shuttle trains for about 15 years. The new exploitation of oil with no clear way to get out of the region has forced the railroads into a new round of stress and adaptation.

The Addition of Oil

Large trains, like the shuttles and unit grain trains, have also created adaptations in the operational procedure of running trains. For example, railroads have used "helper engines" to supplement the road locomotives in certain circumstances for years. With the advent of long or heavy trains like the shuttles, the railroads developed methods of deploying locomotives maximizing the safety and train handling abilities of the crew. In recent times, computers have allowed railroads to perfect "distributed power" or remote operation. This allowed grain shuttles, for example, to have engines at both ends of the 110-car train, which made it much easier to start a train (pushing and pulling), and stop a train (setting the brakes from both ends). This was a considerable improvement in safety, as it reduced the occurrence of such things as breaking a train in two and it reduced the stopping distance of large trains in all situations.

Officials very quickly noted that the efficiencies gained in shipping of grain and other commodities by unit trains and shuttles could translate to the shipping of oil. Oil is a commodity that one might expect would lend itself to relatively easy loading and unloading, if the right infrastructure was available. Most railroads refer to the oil trains as unit trains, not shuttles, as they are not a scheduled as tightly as shuttles, nor are they captive to the operating railroad. Unit trains by nature can get passed off to other carriers in order to reach their destination. However, loading a unit train of oil, rather surprisingly, takes about double the time as does loading a grain shuttle. This is because oil does not generally sit in storage as grain does; oil needs to be brought to the terminals to fill the train. And, oil must be handled more carefully than grain from an environmental standpoint. A little grain on a siding is bird food; a little oil is a hazmat situation. Climate also plays a part in loading times too. Cold oil does not flow easily through loading pipes, but dried, stored grain can be loaded rapidly anytime.

Grain-hauling branchlines brought with them carload and passenger business; the oil terminals also bring other business. Carloads of sand for the hydraulic fracking process, diesel fuel, chemicals, heavy equipment, and other necessities of the oil business are trundling into the region. Many terminals have secondary equipment that enables them to unload other cargo when oil is not being loaded.

Oil and Terminal Siting

Oil terminals have sprung up rapidly in the region that overlays the Bakken Shale play. Oil terminals, like shuttle elevators, must have considerable off mainline track space to load trains. Oil terminals have also followed the similar track formats of the grain elevators; the straight siding or loop track. The oil trains themselves are operated as unit trains, but they do benefit from the same operational advances that were perfected by the shuttles. The oil terminals share some of the influence of the same three factors driving grain shuttle facility location: ease of loading, ease of assembling the large amount of commodity to fill the train, and ease of access. It seems, that the second, the assembling of loads, has become the dominant factor in where the oil loadouts are. In Figure 2, the oil loadouts are in the Bakken production area as expected, but are located much closer together than shuttle elevators, especially on BNSF's northern mainline through the area. Oil terminals are located with one purpose, to get the oil in railcars as soon as possible.

Once the oil is loaded, the trains can proceed to any number of destinations. But this too causes operational headaches. The railroads know, by contract, where a grain shuttle is going. But the oil unit trains can go to any of several destinations. Adjustments in how the railroad dispatch trains has had both oil and other freight taking some fairly roundabout routes to destinations in order to relieve congestion in the oil region. Some of CP's oil trains run north of the border to New York state and the east coast, and some run to Chicago and onto Union Pacific's lines to St. James, Louisiana. BNSF's oil trains head east until reaching Minnesota where they turn south to their destination in Cushing, Oklahoma, or St. James, Louisiana. No oil currently runs west out of the Bakken.

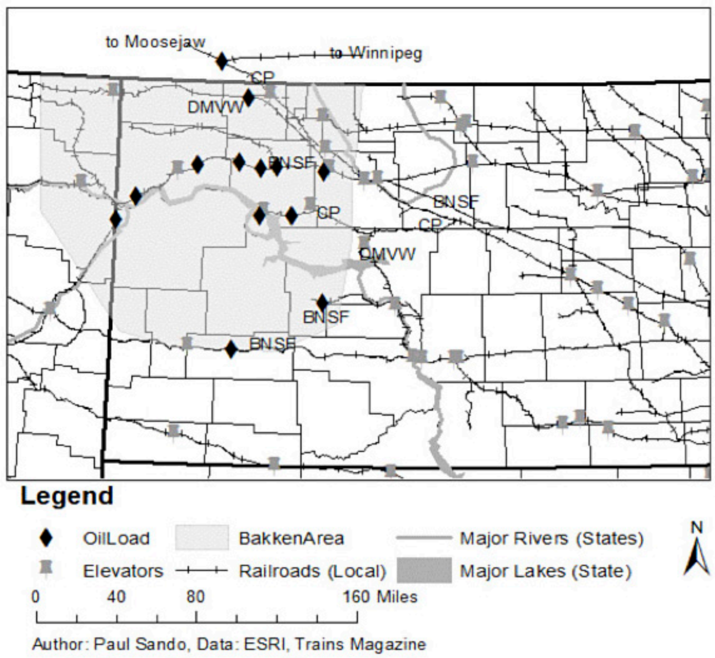

Figure 2. Oil loadouts in the Bakken Formation

Competition?

Is there competition between railroads to move the new commodity? To say the competition was vigorous during the evolution of grain shipping, siting elevators and shipping market dominance would be an understatement. Each railroad platted towns and laid out lines according to strict and secret internal guidelines to maximize their return. In his 1985 book, *Plains Country Towns*, author and geographer John C. Hudson detailed the guidelines used by the railroads, and discovered that all were very similar and were based solidly in economic principle. The result was a railroad map with towns located every 15 to 20 miles. This location allowed the elevators of the towns to capture the most grain business for the railroad, and the railroad had fuel and water services spaced uniformly along the lines.

Competition in moving grain is today more of a competition of efficiency rather than who controls the market share. Unit trains, including those filled with crude oil, can be and are handed off to other carriers. Oil movements are also a contest of efficiency, but the railroads are responding to the shippers demand rather than contesting each other for market share. One would expect the railroads to be competing with one another, but that has not been the case so far. One reason is that railroads do not enter the business of moving oil without serious consideration of benefits and consequences.

Benefits are fairly easy to see with shipping numbers and monetary bottom lines. Consequences are not as easily apparent. For example, integrating oil shipments into their systems represents a big logistical puzzle for the railroads. BNSF has two mainlines running through the Bakken region, with some double-tracking, and bi-directional operation. But, oil trains must be woven through the general traffic on those lines which includes all of the through trains such as container and manifest freights, locals, the grain shuttles, other unit trains, and Amtrak's Empire Builder passenger trains. Canadian Pacific has one mainline, not double-tracked, and a stub-end branchline, and two interchanges with regional carriers that handle oil traffic. Again, it is a challenge for CP to integrate the oil traffic as well.

Another consequence of oil traffic for the railroads is that their infrastructure is being strained by the weight and force of a train. An official with BNSF stated that their railroad spent $86 million, just in North Dakota, in 2012 on infrastructure and capacity improvements, including rail and tie replacements. CP spent $90 million in the past two years on its infrastructure in the Bakken area.[1] The increase traffic means that things wear out faster and cost more to replace.

An oil unit train is much heavier than a grain shuttle train. Even the railcars that are used reflect this. Grain was originally shipped in boxcars, which had capacity limited both by weight and cubic space of the cargo, and the fact that you couldn't really fill the car completely. Modern grain hoppers have been modified in efforts to push up their volume to more closely match their weight capacity. In the case of wheat, a full hopper car doesn't mean that it is at full capacity in terms of weight. Grain is bulky but not necessarily heavy. Current railcars have a capacity of 100 tons, but grain hoppers are rarely at that weight. When tank cars, especially crude oil tank cars, are full, they are full to cubic capacity AND nearly the full 100 ton weight limit.

Large and heavy trains also create adaptations in the operational procedure of running a train. For example, railroads have used extra "helper engines" to supplement the road locomotives in certain circumstances for years. With shuttles, the railroads developed methods of deploying locomotives that would maximize the safety and train handling abilities of the crew. Computers have allowed railroads to perfect "distributed power" or remote operation. This allowed the crews of shuttles, for example, to have engines at both ends of the 110-car train, which made it much easier to start a train (pushing and pulling), and stop a train (setting the brakes from both ends). This was a considerable improvement in safety, as it reduced the occurrence of such things as break-in-twos and it reduced the stopping distance of large trains in all situations. Of course, oil trains benefit from the same advances.

BNSF and CP together account for roughly three-quarters of all the oil leaving the region and most of the supplies coming in. Railroads have adapted to this huge demand on their services in a mere few years, just since about 2008. In 2008, there were 200,000 railcars of all types stored idle. Now, the four major car builders have a combined shortage of 27,000 orders, mostly for oil tank cars. Recent statistics show that U.S. railroads tripled their carloads of oil in 2012 to 233,811.[2] Canadian railroads increased their oil traffic by 30%.[3] Officials of both companies expect that when pipelines are built that the railroad share of outbound oil will drop to around 25% of the total. Would that mean competition? Not very likely, as officials for both railroads indicate that the adaptation to moving large amounts of oil is a temporary one, and they would likely retain a great deal of the traffic in other oilfield equipment and supplies. At this point it seems as though a decrease in the percentage of oil by rail would be a welcome relief for the railroads' taxed infrastructure and operations.

Conclusion

Crude Oil has only been a major cargo in the Midwest and Canadian Plains since 2008, but moving grain by rail is over 100 years old. The railroad infrastructure was built to haul grain; it continues to move grain, and is adapted for more efficiency. If anything, the historic competition for the grain market created a surplus of track and routes in the region that has aided the adaptation to hauling oil. The rail systems have had to quickly adapt for oil, and this causes problems and stresses for the railroads. As the Bakken formation reaches the point where it is fully exploited the railroads may have to adapt further. New refineries built in the region might have the railroads adjusting to shipping the finished product rather than crude oil. Pipelines may be built to take the strain off the rails, or not. For now, the weight of the cargo and length of trains has already resulted in increased maintenance cost to the railroads. If the railroads are unable to keep up with the situation may wind up looking a bit like the railroads did after World War II, where tired equipment and beat down rails were the norm rather than exception. The major differences now are that there are no war restrictions on material to put things right, and funds do not appear to be lacking on the part of the railroads serving the region.

Where historic competition between railroads was to create online economic opportunity, haul the largest share of the grain market, and build the rail system that is in place in the region, oil companies seek simply to use the existing infrastructure as an outlet for their product and transport to distant refineries. Competition does not seem to be between the railroads, but it is a contest to see if they can keep moving and responding to tremendous demand. Bakken oil production is years from being completely exploited, and oil pipelines are years from construction. Though the railroads are currently moving oil well, it may be a matter of time until outward stress begins to weigh on their operations. It remains to be seen how long the railroads and their infrastructure can keep it up.

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Endnotes

[1] Both infrastructure cost totals from *Trains Magazine*'s Newswire, referenced from BNSF and CP's annual reporting.

[2] Figure quoted from the AAR annual report.

[3] Figure quoted from the RAC annual report.