Market intelligence revolution:
AI, machine learning and satellite imagery offer an expansive new view

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CONVENTIONAL OILFIELD MARKET INTELLIGENCE — knowing where other companies are drilling and how much oil and gas they are producing — relies on downloading, processing and mapping various state regulatory filings, such as drilling permit submissions and production and completion reports. These regulatory data-driven processes are at least 20 years old and often more than 40 years old. About the only innovation in the upstream energy intelligence space in the past two decades has been to take the same old regulatory filings and put them on a map in a web portal, instead of on a CD-ROM loaded into a proprietary software package as they were prior to 2000. The technology world has lapped this segment of our industry by decades.

INDISPENSABLE, BUT INCOMPLETE

While reliance on regulatory filings is an essential component of oilfield market intelligence, regulatory sources have a number of shortcomings: They are slow, incomplete and often inaccurate. For example, of the 1,163,434 unique wellbores in the Texas Railroad Commission database, 472,931 (40.6%) have no matching drilling permit, and 193,317 (16.6%) have no associated location. Of 250,883 RRC wellbores in the Texas Permian, only 116,671 (46.5%) have an associated spud date. It also is highly likely that many wellbore records show locations, dates, depths and production that are inaccurate — but no one knows how many or by how much.

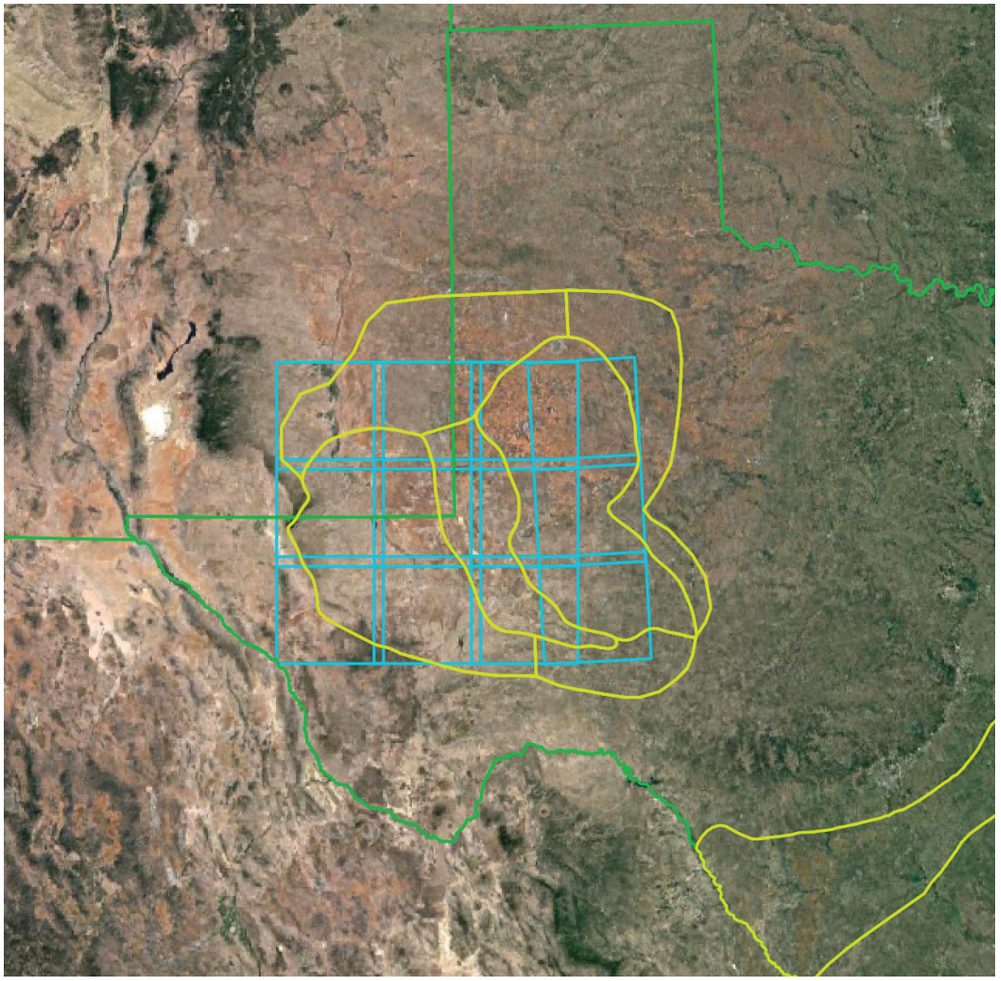
Reporting lag is another issue. While Texas drilling permit submissions and New Mexico drilling permit approvals are typically published online within a few days of their respective submission or approval, spud and completion reports lag the spud or completion event by up to 150 days in Texas and up to 190 days in New Mexico, creating uncertainty about current numbers of drilled but uncompleted wells, completions, production and other facts necessary for energy companies, investors and regulators to make well-informed, timely decisions.

Regulatory forms were never intended to capture all aspects of oilfield activity and have long been applied to intelligence purposes that they do not serve well. Many important oilfield activities are not subject to regulatory recordkeeping, while other data are submitted to or released by the regulator long after the relevant events on the ground have occurred. Moreover, much of the data submitted to regulators are self-reported by operators and unverified; errors, omissions and delays are common. Some of those errors, omissions and delays might be deliberate, to mislead competitors.

BIRD'S-EYE VIEW

New technologies for gleaning oilfield activity from independent, nonregulatory sources may enhance the timeliness, accuracy and completeness of market intelligence used for energy business decisions. One such independent source is satellite imagery. High cadence, high resolution satellite imagery has become commercially available from many competing sources in recent years, as have the software tools and processing power needed to analyze vast areas with high reliability on a near-daily basis.

One essential oilfield activity that is visible from the sky but not tracked in any regulatory record is the construction of well pads. A well pad is a clear, level area on the ground where heavy equipment such as a drilling rig can safely operate. It is a physical necessity that all oil and gas wells must have a well pad before they can be drilled. However, because there are no



The area inside the blue boxes was analyzed for Permian Basin activity, 2017-2020.

regulatory records of well pads, the time and probability relationships between well pad construction, drilling permit submission and drilling start date have never been measured — until now.

Sourcewater Inc. in Houston first started working with satellite imagery to identify and measure frac water impoundments. But then we started to notice that there were many other interesting activities visible on the ground that we could identify in satellite imagery using similar methods, so we further developed, applied and patented new machine learning and artificial intelligence technologies to detect and analyze additional kinds of energy activity, such as well pads, frac crews and lease roads.

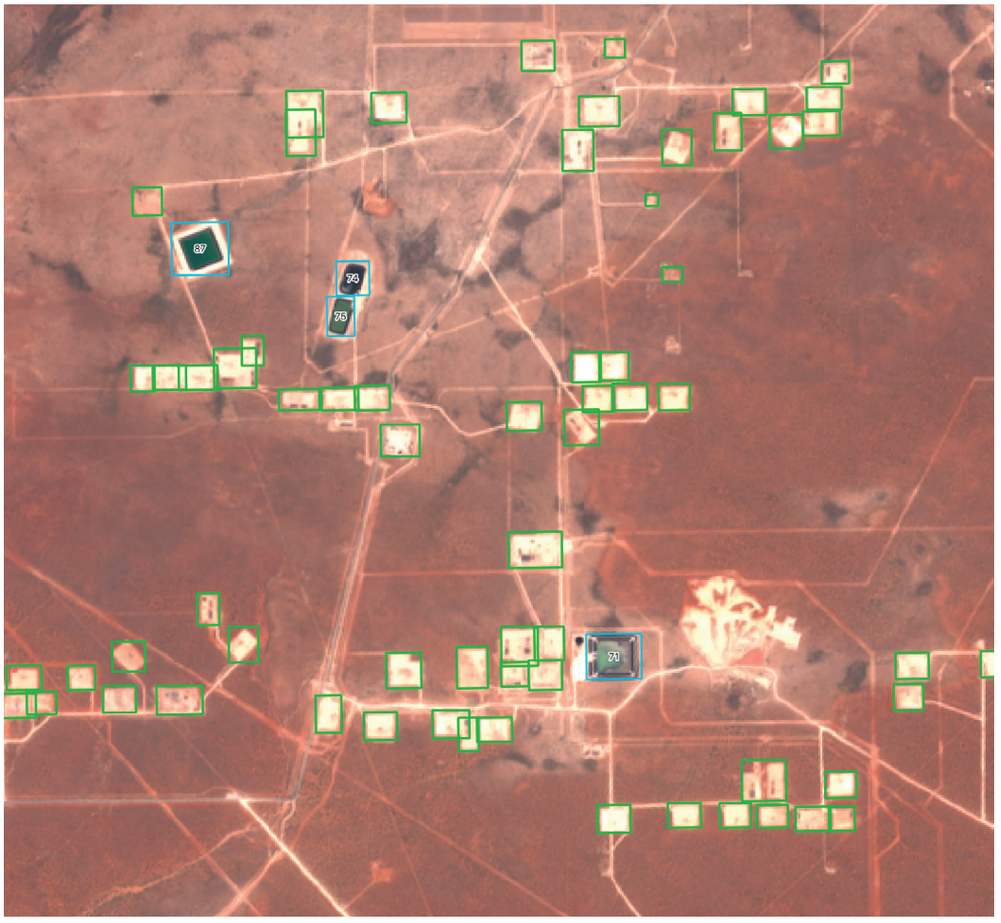
In mid-2020, we conducted a study using our DirtWork Alert satellite analytics service to detect every well pad constructed in the Permian Basin of Texas and New Mexico from 2017 through 2020 on a weekly basis. Detections were compared with RRC and New Mexico Oil Conservation Division drilling permit filings and completion reports for every drilling permit and spud reported during this same period to measure the time and probability relationships between these key oilfield indicators — and to see how satellite imagery might improve on conventional regulatory intelligence methods.

BY THE NUMBERS

We found several key takeaways:

- For 1 in 3 spuds in both Texas and New Mexico, a well pad was detected in advance of any drilling permit. In these cases, the pad appeared on median 76 days before the permit in Texas and 100 days before the permit in New Mexico.
- In Texas, 1 in 5 approved drilling permits was never drilled. In New Mexico, 1 in 2 approved drilling permits was never drilled.
- In both states, 2 of 3 satellite-detected well pads led to a spud.
- An additional 14% of presumed well pad detections led to undrilled permits in Texas and 25% in New Mexico, suggesting true well pad detection rates of at least 80% to 90% and possibly even higher, since many permits and wellbore records may have inaccurate location and date data and some true well pads are never permitted or drilled.
- In both states, about 95% of spuds had a collocated well pad detected, but in New Mexico, only 93% of spuds had a matching drilling permit.
- After a well pad appeared in the same location as an undrilled permit, a Texas permit was 14% more likely to be drilled and a New Mexico permit was 53% more likely to be drilled.
- A permit with a matching well pad was drilled on median 31 days sooner in Texas and 36 days sooner in New Mexico than a permit without a pad.

A mathematical index combining drilling permits and well pads predicted 75% of future drilling



Above is a typical satellite image with well pads and wellbores marked by Sourcewater AI.

activity, compared with only 46% predicted by drilling permits alone.

SCIENTIFIC APPROACH

Our study had four primary purposes.

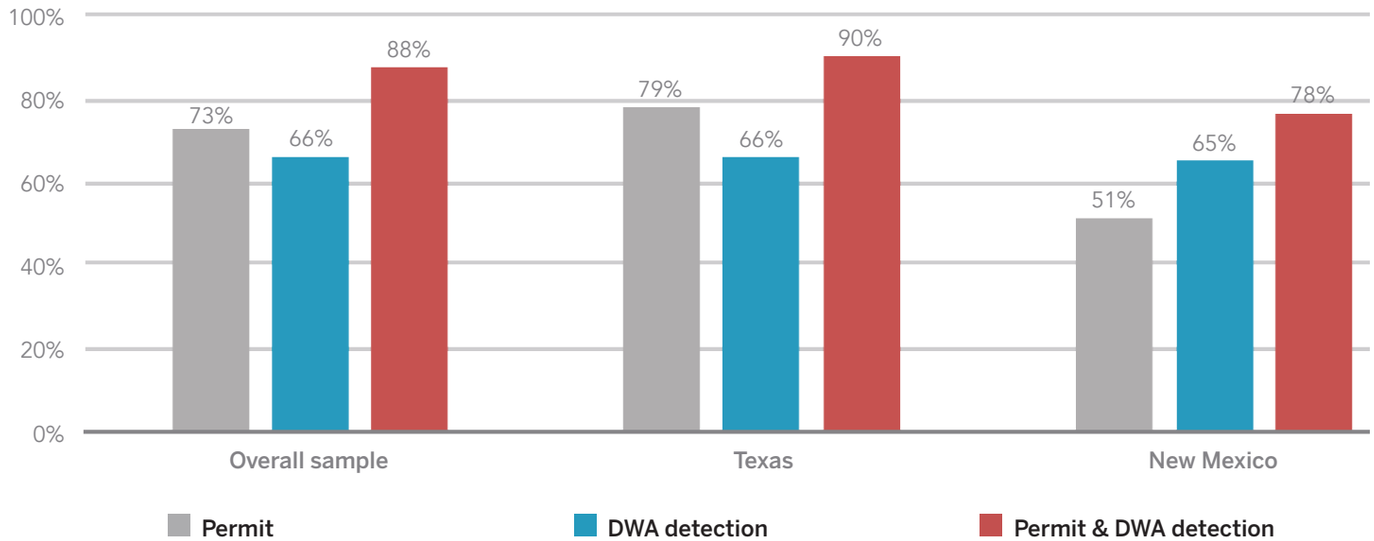
First, we wanted to rigorously quantify the time and probability relationships between drilling permit submissions and spuds in the Permian Basin, distinguishing Texas regulatory outcomes from New Mexico outcomes. Original new drilling permit submissions (Texas) and approvals (New Mexico) and spud dates from completion reports were matched by API number to measure false positive and false negative rates and time distributions from permit to spud. For study purposes, we only included 2018 permits for permit-to-spud false positive calculations and made Dec. 31, 2019, the outside date for matching a spud to a 2018 permit.

Our second and third purposes were to spatially associate presumed well pad detections (also called DirtWork Alerts or DWAs) with permit and spud locations in order to quantify the time and probability between well pads and spuds as well as gauge the performance of the evolving machine learning detection model. This challenge is far more complex than matching API numbers because the true time and probability between spuds and well pads on the ground is different from the evolving DWA model performance in detecting well pads.

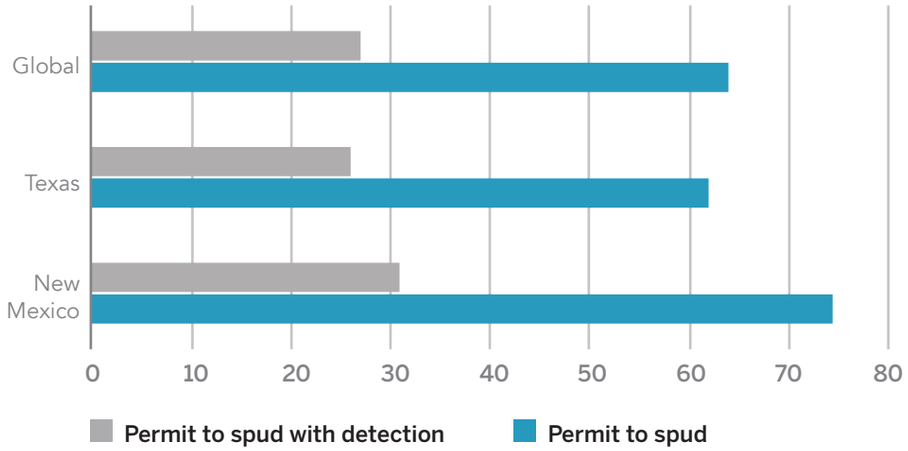
Cloud cover or occasional satellite imagery defects may delay or prevent detection of a new well pad, but that does not mean that the well pad does not yet exist. Also changes in light, weather, groundcover and erosion and new expansions can make it tricky to track the same well pad in many images over a long time. Moreover, the "ground truth" of regulatory data such as wellbore locations is shaky at best. Most regulatory information is self-reported by operators and is never independently verified. As noted earlier, 40.6% of all RRC wellbores appear to have no drilling permit, and 16.6% of wellbores have no recorded location. It seems likely that many other permit and wellbore records have recorded locations that are erroneous, and therefore a well pad detected in a satellite image might in fact be a true location for a wellbore, even though the wellbore record with the regulator shows a slightly different location.

A single missing or rounded thousandth place decimal in one GPS coordinate could move a wellbore about 50 feet off its true well pad. Likewise, many dates recorded on drilling permits and in completion reports may be missing or false. More than half — 53.5% — of all Texas Permian wellbores have no associated spud date. In such cases, however, the satellite imagery detection is always presumed wrong if it differs from the date or location on the permit or the completion report, even though your eyes can see that there is a real well pad in that location and the dot for the wellbore is in the middle of a road or off in

True positivity of spud



Median days to spud



the hills — or in China, which is what happens when the sign on a GPS coordinate gets switched.

Finally, it is difficult to quantify the detection performance for the machine learning model because even if all true well pads were observed — and even if all permit and wellbore records were correct — some true well pads are simply never permitted or drilled, just as some permits are never drilled. Just because something that looks like a well pad does not have a collocated permit or wellbore does not mean it is not a true well pad, built with a yet-unfulfilled intention of permitting and drilling a well on it.

The fourth purpose of the study was to compare the relative performance of drilling permits versus well pads in predicting spud events and to see if the combination of a well pad and a permit was a stronger predictor of drilling than either alone. DWA users always have access to current regulatory records in addition to the satellite intelligence, but conventional market intelligence sources do not provide the enhancement of satellite intelligence and rely on regulatory records alone. Does the addition of satellite intelligence to conventional intelligence provide an advantage to energy market decision-makers?

Our analysis found that false negatives for both permits and pads in Texas were negligible, but New Mexico permits had a significant false negative rate. False positive rates for permits leading to a spud or pads leading to a spud or permit were almost identical at 80% in Texas, but false positive rates for New Mexico permits were much higher than for DWA well pads detected. The appearance of a well pad predicted a spud earlier than a drilling permit in about a third of the cases in both states. A drilling permit collocated with a well pad indicated a 14% stronger intention to drill 31 days sooner on median than a permit alone in Texas and a 53% stronger intention to drill 36 days sooner on median in New Mexico. Overall, an index constructed from both well pad detections and drilling permits predicted a far greater portion of future drilling (75%) than drilling permits alone (46%).

This study of satellite-imagery well pad detection is just the first step for the oil and gas industry into a new world of remote sensing and machine learning based market intelligence insights both on the surface and in the subsurface. We are excited about all the possibilities for gaining a better understanding of our industry through the creative application of these new technologies and look forward to supporting our industry in the years ahead.

ABOUT THE AUTHOR

Josh Adler is CEO of Sourcewater Inc. (sourcewater.com), an energy market intelligence technology company based in Houston. He founded Sourcewater in 2014 based on ideas he developed as a Sloan Fellow for Innovation and Global Leadership in the Energy Ventures program at MIT in 2012. Sourcewater's data science innovations combining satellite imagery AI/ML, mobile GPS tracking and regulatory big data infrastructure have earned 10 U.S. patents with more pending.