Small Sats + Big Data Analytics = Insights on Chinese Economy

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ABSTRACT

Small satellite systems are now proliferating and creating huge amounts of data. However, there's still a large gap between the data being created and the actionable information that end customers need. In fact, most customers (commercial and government) don't want more data; they want better insights. This is even more critical for the newly emerging small satellites with synthetic aperture radar (SAR) capabilities. These radar satellites have tremendous remote sensing capabilities to see at night, through clouds, and in all-weather conditions and provide rich information. However, analytics are more vital for this data as radar imagery is less intuitive to the average user than optical satellite imagery. Ursa Space Systems Inc. (Ursa) is building advanced analytics and a user platform that are scalable to Big Data that can bridge the gap between the growing mountain of radar satellite data and the mountain of Big Data customer needs. These capabilities are currently being used by Ursa to analyze radar satellite imagery of China and provide insights on oil trading activity and the overall Chinese economy. This paper will explore the gap between satellite data and end user and provide a demonstration of how Ursa is using advanced analytics for the Chinese oil trading case which bridges this gap. Further, it will discuss the bright future of satellite-image based analytics which can solve complex customer problems and create continued growth for small satellite data sources.

INTRODUCTION

This paper will discuss the current gap that exists between satellite data capabilities and end customer needs, an example of closing this gap with analytics by Ursa Space Systems Inc. (Ursa) for insights on the Chinese economy by measuring oil storage, and the future of small sats and associated big data.

PROBLEM STATEMENT

In an increasingly complex and global economy, major regions of geopolitical and economic interest lack the data transparency required by financial markets, governments, and NGOs.

An example of this is shown in Figure 1 which shows member nations in the Organization for Economic Co-operation and Development (OECD). This organization promotes policies related to economic growth and international trade which include, among many things, sharing of economic data such as each participating countries' crude oil reserves and oil trade activity. These reserves and trade activity obviously have major global economic and geopolitical importance. Western nations are well represented in OECD, but many important nations or major emerging economies such as China, India, Russia, Brazil, and Middle Eastern nations are not included.

In a recent article in which Ursa's data on China's oil storage was quoted, the authors explain the need for this type of data: "OECD storage is only a slice of what investors are looking at. More than half of the world's oil refining capacity is now outside of the OECD, in countries like China and India, where accurate storage data is difficult to come by."[1]

Lack of data and insight on Chinese crude oil storage is particularly critical because China is now the world's 2nd largest consumer of crude oil after the U.S. and is rivaling the U.S. in crude oil imports. This demand is also expected to remain high for the foreseeable future.

Figure 1: Map of OECD Member Nations

A SOLUTION LOOKING FOR A PROBLEM

Note that the above end customer problem statement doesn't mention technologies such as satellites, machine learning, or big data analytics. It only mentions the need for better data and insight. These technologies can help solve this problem. However, focus needs to remain on the problem and applying the right solution to that problem and not the other way around. Founders and executives of satellite and analytics companies largely come from a technology background (traditional aerospace or Silicon Valley) which is often "world's away" from emerging commercial customers. These organizations and their leadership can also often focus on the technology with the dream of "Build it and they will come". Even if the technology is very capable or can significantly lower data cost, there can still be a large gap in meeting customer needs. Raw satellite imagery is difficult to obtain, can be quite complex with many different formats, and requires complex analytics and computing platforms to process. Machine learning and big data analytics are quickly becoming commoditized. Last, the raw data that comes out of these analytics may not be easily useable without fusion of other contextual data and provided in a format that fits in well with a customer's traditional workflow.

As a final word of caution, Mark Twain once said, "To a man with a hammer, everything looks like a nail."

On the upside, though, the ability and willingness to understand customer problems can unlock huge markets not traditionally addressed by satellite imaging and big data analytics.

CHINA OIL STORAGE DATA

China oil storage data is an example use case of solving a customer's problem utilizing satellites and big data analytics. Hopefully the reader can also see the parallels to numerous other problems that can be solved with this approach.

As discussed earlier, oil storage in China is of particular importance. The following sections will describe the customer requirements for this data and Ursa's solution to meet these requirements. Ursa's results and their impact are also shared.

Customer Requirements

Customer requirements for this product are shown in

Table 1 in prioritized order of importance.

Table 1: China Oil Storage Data Requirements

Requirement	Details
Access	Access to China required
Objective	Objective measurement is required
Current	Data should be current with weekly or better revisit rate
Accurate	Data must have sufficient accuracy for trading; typically 2% error or less
Reliable	Data must be provided reliability on a fixed delivery interval
Significant	Data should be statistically significant; typically 75% or greater survey size
Context	Context is needed for data
Useable	Data needs to be familiar and useable in the customer's workflow

Ursa Solution

The above requirements may seem simple in principle, but are quite challenging when it comes to implementation and truly fulfilling those requirements.

The heart of Ursa's business and solution to this customer problem is utilizing satellite synthetic aperture radar (SAR), image processing, and delivery in an easy-to-consume format. To simplify, Ursa calls this A^3 which is:

- **Access** - Exclusive, affordable, & scalable radar satellite data
- **Aggregation** - First unified data platform = reliable daily revisit today
- **Analytics** – Ursa-developed algorithms, unique training sets, and data networks

To start with, what is satellite radar and why is it important? The reader is likely very familiar with optical imaging satellites as this has been a major commercial application of small sats. These satellites are relatively inexpensive and produce a product that is fairly recognizable. However, optical imaging satellites have a dirty secret: clouds. Persistent cloud cover over many parts of the world prevents reliable, high frequency imaging required by many applications such as oil storage monitoring. Lower cost optical small sats and launch vehicles to allow you to launch more of them won't solve the cloud problem (unless you want a lot of pictures of clouds). Radar satellites can see through clouds, smog, and at night time. What these images look like and what this means can be seen in two images taken on the same day over the same location in Figure 2 and Figure 3.

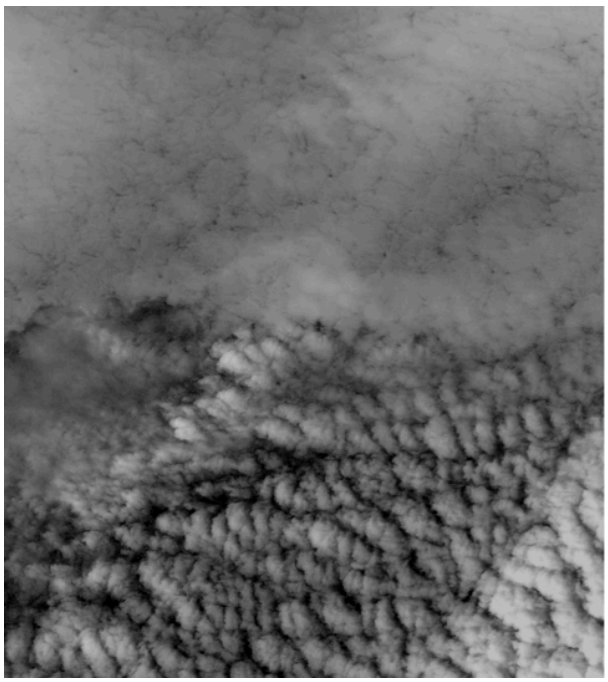

Figure 2: Optical Satellite Image of Ningbo, China Taken on 10/12/16 (courtesy of Digital Globe)

Figure 3: Radar Satellite Image of Ningbo, China Taken on 10/12/16 (courtesy of e-GEOS)

The way this kind of image can measure oil storage observing and measuring floating roof oil tanks in the image. These tanks have a roof or top that moves like a piston with the amount of oil in the tank (see Figure 4).

Figure 4: Floating Roof Oil Tanks

A secondary benefit of using radar imagery for this measurement is that it is, in many cases, more accurate than methods based on optical imagery. Utilization of optical imagery commonly involves observing the shadow cast on the floating roof by the sides of the tank and the shadow the tank casts on the ground. These shadows can be very slight depending on the time of year and latitude in which the tank is located. These small shadows reduce the accuracy of the measurement or require more high resolution optical satellite imagery which is typically more expensive and covers less observable area.

A summary of the Ursa solution built for the customer China oil storage requirements compared to other solutions is summarized in

Table 2

Table 2: Ursa Solution Summary

Requirement	Ursa Solution	Other Solutions
Access	Global access via satellites	Aircraft or ground measurement in China is difficult
Objective	Direct measurement is made	Some solutions involve self-reporting
Current	Satellites can provide daily access if needed which exceeds weekly requirement	Some competing solutions are monthly or quarterly reports
Accurate	2% error or better	Large errors due to self reporting or lesser errors from other aircraft/satellite solutions
Reliable	Radar satellites can provide reliable weekly access to 100% of desired locations	Optical satellites cannot provide reliable weekly access in this part of the world due to clouds and smog
Significant	75% survey coverage	Various
Context	Measurement is accompanied with other data such as tank owner, storage type, and material stored for context	In some cases, only raw measurement is provided
Useable	Product is provided in PDF or CSV formats which are familiar to customers and fit in their workflow	API or graphical solutions, although quite advanced, do not always add value or fit well in a customer's workflow

Ursa Data Results

Before providing results from Ursa data on China oil storage, some context is needed for what this means and how this is used.

The combination of global supply and global demand of oil determines oil prices; a constantly shifting value. To help customers better determine this balance of supply and demand, there is a "balance sheet" commonly used across the energy industry:

$$Production + Imports - Exports - Runs = Inventory\ Change$$

where *Production* is oil produced (i.e. pumped out of the ground) in that country, *Imports* are imported oil, *Exports* are exported oil, *Runs* are refinery runs which represents "implied demand", and *Inventory Change* represents the change in oil inventory which balances the equation.

By having reliable and consistent data on inventory change, someone can calibrate the other inputs with more confidence and find discrepancies. The Chinese government releases estimates on the additional four variables in the balance equation, while the inventory change is calculated based from them. This causes a lack of confidence and risk in the entire balance. If *Runs* information for China matters, then an inventory measurement will give a user more confidence in what that implied demand for oil is.

Ursa has been tracking Chinese crude inventories for many months and has seen large increases in Chinese inventories in late May and early June of 2017. Ursa is able to provide information before any other source, including the government data that comes out of China (1-2 months lagged). A comparison of the government (calculated) data published through the Joint Organizations Data Initiative (JODI) on inventory change versus Ursa's data is shown in Figure 5. This shows significant variation between current data sources (based on self-reporting) and Ursa's direct measurement. It also shows the effect of data latency.

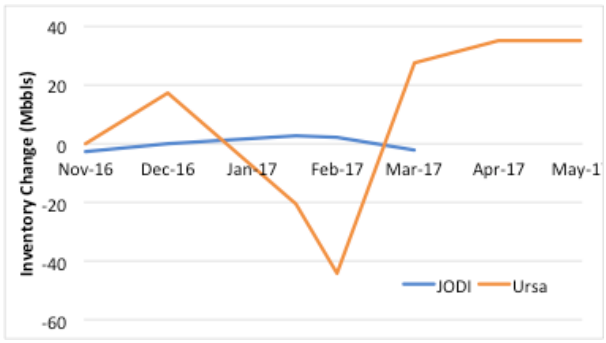

Figure 5: Ursa Measured Inventory Change vs. JODI Calculated Inventory Change (Mbbls)

In combination with Ursa's data, there are two details that could also indicate a decrease in oil prices happening now and in the future:

1. Moody's dropped China's credit rating for the first time in a while, showing that there is more risk to China's economy possibly slowing.

2. Chinese inventories are rising faster than the import rates of recent months would suggest. This implies a slowing in refinery runs, indicating a slowing in implied demand.

If one takes these things into account, then it appears that the Chinese economy may not be able to sustain the large amount of imports of crude oil that has been flowing into the country.

This is obviously of significant interest to those in the financial and energy sectors. What does this mean to

the general reader? The bad news is that this could be an indication of China's economy slowing down which could contribute to a global recession. The good news is that you may be spending less at the pumps soon.

FUTURE OF SMALL SATS

Ursa uses traditional radar satellites as there are no radar small sats yet in orbit. However, numerous radar small sats are now being developed with plans to launch in the next few years. Ursa has performed a survey of all current and planned radar satellites which is shown in Figure 6.

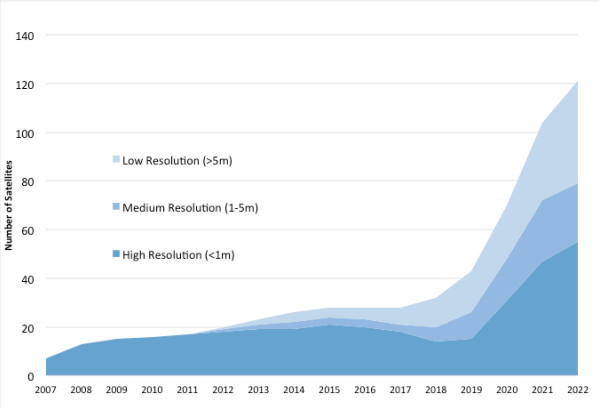

Figure 6: Ursa Radar Satellite Forecast

It's unlikely that this forecast will be fully realized or realized on this timeline, but it's clear that there will be significant growth in satellite quantity which is largely fueled by radar small sats. What's also interesting to note is that the relative percent of high resolution radar satellites is dropping significantly.

If this growth is realized (or even partially realized), this should enable new or expanded applications by leveraging lower data costs and increased revisit rates which come from low cost, radar small sat constellations. However, these small sats typically have lower resolution and signal-to-noise ratio (a critical parameter for radar) which limits end use applications. Lower cost alone for low resolution is not a significant differentiator as this begins to compete with low resolution imagery from the ESA Copernicus program which is free. However, the high revisit rate and task-ability of these low resolution radar small sat constellations can enable new or expanded maritime surveillance applications. This does leave a hole for a low cost, high resolution radar satellite which is an opportunity for this industry.

FUTURE OF BIG DATA ANALYTICS

Ursa believes there is a bright future for big data analytics which, in turn, creates a bright future for small sats which fuel these analytics.

The China oil storage use case is just one application for this technology and the same model and approach can be applied to many applications in the commercial and government markets including measurement of other commodity storage (coal, iron, copper), ship tracking, oil drilling activity, and many others.

As described in this paper, these products for new markets take a different approach where focus is needed on the problem and delivering value to these customers who may be unaccustomed to satellite imagery and big data analytics. However, the upside is considerable.

Satellite big data analytics based on traditional markets was estimated at $3-6B per year per NSR and Euroconsult in late 2016.[2,3] However, NSR has recently grew this estimate in early 2017 to $15.8B by including some of these new markets.[4] Even this recent update may be too conservative as not all commercial markets may have been considered. As an example, the oil and gas analytics market alone is predicted to grow to $36B by 2024 with a 19% CAGR.[5]

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