**Digital Oil Field Asset Management Webapp**

**Introduction**

The concept of the digital oil field has shaped digital innovations in the Oil and Gas sector for the past 40 years. Since the advent of the internet, and recent advances in data analysis, companies of all types are looking to optimize and increase efficiency through automation and digital solutions to real world problems. The main solution being worked towards in the Digital Oil Field initiatives involves real world asset management, the synthesis of a number of solutions into a centralized, continuously updated system which can be used to track and analyze product, storages, refineries and much more while implementing quick and efficient solutions to problems that arise. The minimizing of risk and loss while maximizing product return through digital means is the end goal of the initiative, and real time asset management has been pinpointed as the tool to bring this about. With the large influx of data in Oil and Gas, new ways to process, visualize and analyze this data are in need. With this project, a digital webmap is planned to route product most efficiently from well to pipeline, storage to refinery, or wherever else it may be going, based on user input of location and destination.

**Literature Review and Background**

The Oil and Gas Sector has been implementing digital solutions for increasing efficiency in both midstream and upstream processes, but still has issues with integrating and utilizing all of the data. As digital solutions for big data analysis become more efficient, the industry has increasingly invested in data collection and digital initiatives to integrate supply chain’s data and analyze it to streamline extraction and moving of assets in an effort to achieve real-time monitoring and analysis. This study will shed light on the most valuable methods for integrating and utilizing data from asset management systems, as well as some of the problems faced when doing so.

The article will include problems that the digital oil field is currently being implemented to rectify, and a study of the most popular solutions currently being used in the industry and the results they have yielded. Following this, some of the problems being faced by the digital oil field will be highlighted, as well as present some solutions to these. I conclude with a summary of the findings and issues still to be addresses, and how to move forward with my own project.

**Background**

Digital Oil Field Solutions

With the advent of the digital oil field it has been apparent that an increase in integration and analytical processes between business units in the supply chain is vital. In the past, digital solutions to address efficiency issues at separate stages along the production timeline which have yielded significant results for each stage. Gringarten et al. (1998) details innovations in Reservoir Management Processes to obtain and interpret data to model and predict reservoir levels and production possibilities to better visualize and predict production goals for development processes. However, it also highlights the issues plaguing the entire industry in its diagnosis that the separation of petroleum careers and lack of interdisciplinary education in both universities and carrying over to industry is drastically slowing innovation in the sector. In other words, lack of integration is hindering growth. Other projects, such as Virtual Asset Management of offshore assets have increased data collection and management of equipment and maintenance by huge leaps. These databases can help mitigate large cost overruns, project delays and lost productive time of workers by large margins, however they highlight the uncertainty of multi-firm cooperation in business projects which limits the integration and therefore efficiency of utilizing these huge datasets in the entirety of the Digital Oil Field (Leon et al. 2017).

Again, and again the issue of integration being needed comes as the main issue facing the supply chains in Oil and Gas management, with individual business units not sharing data and analytics across supply chains. Ossai (2012) describes the issue of corrosion on wells and drills due to oxidation and the types of chemicals being used in the formation and pipelines, and explains the use of subsurface in addition to surface sensors to mitigate the risks of equipment failure and help predict future issues this may present and circumvent them. While this is mostly a midstream issue, it costs the industry exorbitant amounts of money and should this data be shared in a multi-disciplinary approach, costs could be reduced, and risk mitigated. The article closes with “the effectiveness of the policy will therefore depend on the willing of the leadership and commitment of other personnel at all ranks.” Integration of digital processes seems to be the number one factor today in the utilization of big data in streamlining and improving of everyday processes along the supply chain. Individual units are utilizing new sensors and datasets to improve upstream and midstream business, but the major roadblock is the inability or unwillingness to utilize multidisciplinary solutions across the entire supply chain.

**Problems with Integration**

After the individual successes in the implementation of digital solutions in the oil field, it is logical to wonder why integration has taken so long. This is where new Digital Oil Field initiatives are focusing their attention for the future of Oil and Gas optimization, but there are roadblocks in the way of integration, slowing the process down. The industry has succeeded largely in establishing the infrastructure for large-scale data collection, with most components along the production cycle being recorded and monitored. However, this is a double-edged sword as there is so much data being collected that most of it goes untouched and discarded, with individual units containing as much as 20 petabytes of data in some cases. Utilizing this much data requires new approaches in big data and machine learning solutions, which the oil and gas industry has been slow to implement due to its fundamental view of data as a information, and not as an asset for value creation like it is in many other firms (Perrons et al. 2015). Better data processing solutions are necessary for processing these enormous datasets, but a fundamental viewpoint change by management is necessary to adopt these new, more expensive processes for data analysis and prediction. Steps are being made in this direction, despite the challenges being faced.

Optimum field management with Field Performance Models have begun development in companies such as Chevron, with the i-field program to accomplish real-time asset management. However, the major challenges they are facing are detailed by Unneland (2005) as the methods by which the data is stored and lack of standardization in established data collection infrastructure. Analysts spend 60-80% of their time locating and preparing data for analysis, negating any efficiency or value created by the implementation of digital solutions. The timeline of optimization has been decreased in certain portions of the supply chain; however, some processes can still take years to analyze and implement solutions, significantly slowing progress (Fig. 1, Unneland 2005). Standardization of data structures and inter-firm cooperation are necessary for the digital oil field moving forward. Slowly, through Value of Information (VOI) metrics and cooperation in data collection, steps are being made in the correct direction, however there is still a long way to go for many corporations.

**Solutions Addressing Integration**

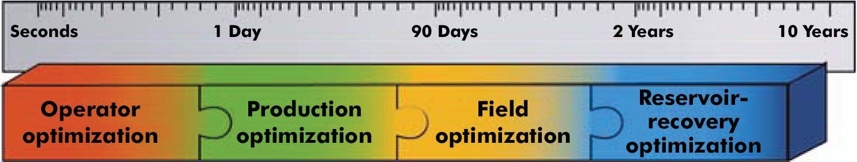
Moving forward, in the past 5 years many initiatives and models have been created for addressing the problems hindering integration of supply chain processes for increased efficiency in the Oil and Gas industry. Shuen et al. (2014) works to address these issues, developing a business framework, the Dynamic Capabilities Framework, to increase profits and mitigate loss in a dynamic way to account for volatility and address the need for reconfiguration and integration of existing process, a vital framework if the Digital Oil Field is to be realized. The three main strategies this framework are coordination/integration, learning, and reconfiguration. This is vital moving forward when data structures and processes will need to be reconfigured and relocated, centralized and processed in new ways without sacrificing profits from disorganization. BP has a success story involving the digital oil field, where standardization of data software and information services with suppliers has produced tremendous successes in utilizing data from multiple levels of the extraction lifecycle to increase efficiency and predict processes and problems in the future. Their Maximo system has decreased the lost efficiency in non-standardized data systems and made real time data sharing throughout multiple firms possible, yielding economic, strategic and behavioral benefits. This standardization of data information requires a level of influence over suppliers, however, and a willingness in firms to change existing processes to the standardized method (Holland et al. 2005).

**Conclusions**

The Digital Oil Field has made great progress in the collection and utilizing of data to streamline and manage processes in the Oil and Gas industry, such as the increase in sensors and analysis within business units and individual points along the supply chain to minimize loss from accidents and failures, and increase the efficiency of everyday processes. However, there are still challenges before the goal of real time asset management can be realized. Integration is the last important leap the Digital Oil Field must address. While data standardization and cooperation are the biggest obstacles, many are finding innovative ways to bring about this large undertaking.

My project involves the utilizing of up to date well data in Texas to create a web map visualization of wells and pipelines to most efficiently route transportation of oil and gas to its destination. This review has highlighted the importance of two key aspects in the project, namely the importance of real-time management as well as standardization of data storage. Due to this, I have decided to incorporate a real-time daily update of data, if possible, to incorporate closures of wells and pipelines for real-time analysis, as well as a standard database of the information to facilitate easy utilization across disciplines. Clean data structures and real-time updating will help create the digital oil field of the future and utilizing them in my project will only increase the utility of the application.

**Fig. 1** The timeline of Oil & Gas optimization



**Data and Methods**

**Data**

This study examines the quickest routes between production and pipeline for oil and gas wells, using data in Texas and finding the closest destinations for the resource available. To do this, large amounts of well and pipeline data needed to be collected. Unfortunately, many companies and organizations do not make their data freely available, with many being hidden behind paywalls or only offering historical data that is not up to date and does not accurately represent the current Oil and Gas Landscape. While, for at least a proof of concept for this web application this would be fine, the most up to date data for accurate routing as well as tracking closures and delays would be best for usefulness and utility reasons. Originally the project was planned to try to cover a larger geographical area, with the United States in mind, however due to the lack of easily accessible, extensive data for assets, and simple runtime issues, the scope was narrowed to Texas where a more focused, large scale webmap could be created. This still proved to be a difficult task as well, with many phone calls and emails leading nowhere, until the Texas Railroad Commission FTP server was found hidden behind many clicks and a webmap, which contains daily updated well and pipeline data of oil and natural gas shapefiles, which can easily be downloaded en masse. The file sizes are huge, however, so quite a bit of space must be available for these directories of numerous zipped shapefiles. On top of this, compressor stations layers had to be located as well as refineries and short-term storage locations in Texas, to better capture a larger part of the supply chain and increase the utility of the web application.

To begin, the Railroad commission FTP server Wells and Pipelines shapefile data was downloaded to get accurate data of status and locations of the assets. However, in the pursuit of real-time asset management which the Digital Oil Field is moving towards across the industry, a tool needed to be created to keep the data up to date with the daily updates to the data. The best solution for usability was determined to be a python script which can be set to run at whichever interval is most convenient was created to scrape the data and save to a local machine. This data contains comprehensive information on assets from IDs and locations to status. In addition to this, EIA refinery, plants, pipeline and storage locations were downloaded to incorporate processing locations for the destinations of the crude resources for use on the webmap (Fig. 2).

A close up of a piece of paper

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**Figure 2** EIA webmap data

This data is not updated nearly as often as the Railroad Commission, some data being up to three years old, so the Railroad commission data is preferable to this dataset when pipelines and wells are concerned. This dataset, while lacking in up-to-date information, is comprehensive and provides many processing plants and transportation facilities that are not included on the RR commission website. An advantage, however, is the relatively small size of the EIA dataset, making it much easier to use in fast webapps and use on ArcGIS server data hosting, as well as for implementing analytical processes. In addition, due to the time constraints and issues of storage capacity, the Texas RR data was sidelined in exchange for EIA and HILFD data, which was much more compactly wrapped. These datasets amounted to 8-10 layer files, in contrast to the Railroad Commissions 1000+ shapefiles. On top of the RR Commission’s extensive dataset and EIA’s comprehensive layers, the Homeland Infrastructure Foundation data of natural gas compressor stations along pipelines for processing to help get a solid destination for entrance into a pipeline along the supply chain (Fig. 3).

A close up of a map

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**Figure 3** HIFLD webmap for compressor locations

These three datasets conveniently come in zipped layer files, perfect for use in ArcGIS with minimum preprocessing, the only preprocessing necessary would be the trimming down of the data to save on memory, especially the RR Commission datasets and EIA US data.

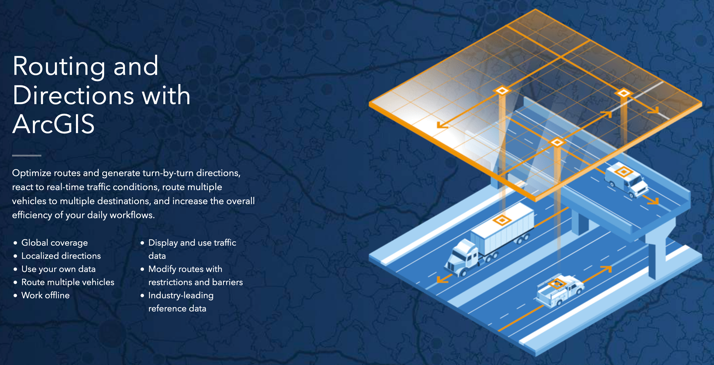
**Methods**

After this data collection the methods of analysis have to be addressed. Due to the data coming in shapefiles across the board, little to no preprocessing is required, with only the EIA data needing to be clipped to only include Texas data, which was done using ArcMap. The data must be uploaded to the ESRI servers, approximately 5GB worth, and hosted there for viewing on the webmap through their API. Luckily, the ArcGIS online portal allows for easy usability and configurability of layers without any programming required. Because of this; popups, data pre-processing, as well as symbology can be edited before the coding process ever begins to increase usability in the quickest and easiest way possible, with the minimal amount of programming, however, there is some javascript that must be implemented to finalize these style changes. The large majority of work in this study has been expedited due to ESRI software solutions. The data was clipped down and simplified using ESRI ArcMap, the Javascript API handles most of the styling and implementation of the layers, and a Routing and Networking ESRI Javascript API was utilized with developer permissions to integrate a seamless and extremely useful routing function between whichever two locations selected. The main objective of this study is the synthesis of disparate datasets for optimizing supply chains in an oil and gas webmap and working towards better utility in the digital oil field, as well as speeding up the process of problem identification to solutions, using backend and frontend programming as well as knowledge of ESRI software products. The frontend of the application is programmed in html, CSS and mostly javascript to help with rendering and the functionality of buttons and popups, as well as implementation of layers and routing analysis. The routing function was addressed last, because of the perceived necessity to be able to integrate data rendering as well as the analytical processes in the backend to route the data based on user input. Finally, the most important part of the equation, the routing of the asset from well to pipeline, refinery or storage via multiple methods was the most difficult part of the webapp due to the learning curve of implementing a finicky tool never used before. In the past, experience with static routes between a set, small number of locations have been used in routing webapps created, however, this map requires a real time, dynamic routing system between disparate coordinates and types of structures. To do this there must be a way to plug the closest located structure dictated by user input into a routing algorithm provided by ESRI. This serves to locate the type of structure that is chosen, and then plot a route to it via roads and provide some statistics on said route. This is where the ESRI Routing and Network Analysis shone, with its intuitive and easy click-to-choose start- and endpoint location provides the perfect interface for one trying to find efficient routing between not just the closest locations, but any location on the map desired. The distance, times and directions shown on the routing interface are intuitive, step by step, and in order making it an excellent tool for routing. This Routing and Network Analysis function was invaluable to the completion of the project and saved hours that would’ve been spent creating the buffer analysis or any of the other solutions considered when unaware of this function. After this, the route will be displayed, along with some statistics about the route and time estimation, on the interface on the righthand side of the field of view. The app calculates quickest distances and facilitates the most efficient asset management with the most accurate, up to date information available to the public. The integration of asset management processes is most important step in the digital oil field initiatives today, and this webapp utilizes and builds upon those principles.

**Results**

The webmap project changed a few times in execution as different challenges and solutions arose, as any project should, however the original ideal of fast asset management and routing on an easily accessible webmap utilizing ESRI APIs and programming was accomplished. The seamless routing between and visualization of pipelines, refineries, wells and stations are even more intuitive and functional than originally imagined. In figure 4 below you can see the service utilized to handle routing which necessitates the use of the streets basemap and a few functions of javascript to operate.

**Figure 4**



This service was extremely quick and information rich, providing all details of the trip that is selected and providing time to complete the trip, kilometers to destination and even step by step instructions on the roads to take to reach the destination, which can be seen in figure 5.

**Figure 5 Routing Functionality on Map**

A close up of a map

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This functionality, in addition with data provided, causes the webapp to be invaluable to multiple levels of the supply chain. It can be used from operators and suppliers tracking shipments, to drivers and buyers finding optimal locations to obtain their product. The density of information provided at each location, including ID numbers, capacities and rates of refining, which are not currently displayed in the map but present in the layer files could be utilized by regulators or from a large scale supply chain optimization effort, and displayed on the map at will by copying a few lines of Javascript within the code and inputting parameters. One of the greatest challenges, however, was the actual implementation of all of the data collected. Over 1000 layers of data in total was collected to be implemented in the application, however due to time and (digital) space constraints and lack of an efficient and automated processing system

with which to upload the layers to ArcGIS online servers, the data had to be cut down quite a bit to be implemented. While all of this data is available and in packaged zipped layers which can be easily implemented into the webmap, it was too time consuming and tedious a project for a single semester. Despite this, excellent data was collected and implemented into the map. Refineries, short term storage locations, pipelines and compressor stations were implemented with location, operator and company data, with Id’s and rates of processing data present but not displayed in the interactive popups on each asset. In addition, each asset has a unique icon to exemplify the type of location present there. These unique icons and interactive popups can be seen in the figure below.

**Figure 6**

A close up of a map

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These features combined with the reusability and potential to incorporate more data very quickly are some of the most exciting aspects of this project. The ability to quickly route from a webmap of all Texas Oil and Gas Assets to wherever the destination is was the original goal, and this application follows through on all functionality and abilities laid out at the start of the project, despite the incomplete data being visualized.

**Discussion**

The visualization and interactivity of the webmap were very exciting results of the mapping project. The intuitive layout of the routing feature overlaying the map is incredibly easy to use and the exact functionality sought out by the project. The fact that the routing service is utilized so easily with the ESRI developer account was a tremendous victory in the production of the application. ESRI’s built in services and applications provided the framework and tools to create the entire webapp, from preprocessing to hosting and implementation, it has provided the necessary tools to complete the job. Despite this, there are limitations, as previously mentioned, concerning the amount of data storage and time consumed slowly and manually preprocessing the data. It is important to remember these processes can be automated given the time, but the scale of a task such as this for this project was temporally prohibitive. In addition, the amount of space available for ArcGIS hosting is of concern, as only so many layers may be hosted and the time to upload each one and obtain the unique service URLs takes time, which are two other barriers which caused the amount of assets which were displayed to be trimmed from the original concept after data collection. In addition, because of the redirection toward EIA and HIFLD data from the Texas Railroad Commission data, the real-time aspect of the project had to be put on hold. Initially because of the way the daily-updated RR commission data is hosted on an FTP server there were high hopes of being able to write a script that pulled the data daily and updated locations based on their status, to lessen the need for any subsequent apps as this one updated automatically. This ideal is still very possible, however alternative layer hosting solutions would need to be established that addressed the storage and ease of uploading while still retaining the compatibility with the ESRI ArcGIS API. This could prove a challenge and require rewriting code, but this is the logical next step in for the application and one that will be continually improved. The implementation of more data is the final step and one weak point in the application where it was not all that it set out to be, in the daily updated data. Despite this, data from 2020 and only a maximum 1-2 years old was utilized and was a good substitute for the up to date counterpart when controlling for usability and compatibility. This app, if brought up to a daily updated dataset, could potentially be used across the entirety of the oil and natural gas production supply chain, in petroleum and pipeline management systems, transportation facilitators down to the drivers of the transportation operators as well. After the extra data is implemented, and each symbolically differentiated, an additional routing method for railroads may also be implemented, to fully cover the range of petroleum assets and production levels within the single application.

**Conclusions**

This project exemplifies the possibility of reaching the resolution of the Digital Oil Field initiatives today. For years there has been talk of real time asset management across the supply chain, however, by many who have been in the business for years this seems like a pipe dream. However, with this simple, easy-to-use application with the ability to keep relatively up to date information on assets and routing between them with extreme accuracy proves the fact that with slightly more resources and time, this multi-organizational asset management interface has endless possibilities for industry use and optimization. With the planned implementation of the remainder of the data collected, and some optimization of the quickness of the application, the webmap will only grow more functional and applicable to companies along the production lifecycle of oil and natural gas. The goal of extremely accurate routing between assets for product shipping has been achieved by this webmap, only falling short in the real-time aspect. In the future, however, the prospects of the application look very promising.

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