

WHITE PAPER

# Communicating in the Digital Oilfield

Part 2

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## EXECUTIVE SUMMARY

Despite falling revenues and rising costs, oil and gas companies continue to invest in high technology Digital Oil Field solutions. Initiated three decades ago, the Digital Oil Field uses advances in engineering, IT and high-speed communications to integrate and automate a wide range of company operations. The potential rewards are huge, but the complexity of industry processes and the diversity of technology options demand careful analysis before a company can identify the optimal solution. An essential first step is to get a better understanding of the communications requirements and possibilities.



## The Investment Dilemma

As crude oil prices plummet to new lows, there is a special urgency for oil companies to make changes that will drive down costs and improve productivity. The industry shows no expectation that oil prices will rebound quickly to comfortable \$90-\$100 USD barrel levels, or even to \$72 barrel break-even point. So oil companies and service providers will continue to lay off staff, decommission rigs, sell off rights to fields, and reduce their equipment spending for exploration and production.

Short term, they must weather the storm brought about by weakening US demand, a temporary glut fueled by shale oil production, the global economic slowdown, and more fuel-efficient vehicles dampening consumption. Longer term, they face:

- ▶ prospecting in increasingly-challenging locations (onshore desert, arctic, undersea) that are both remote and dangerous,
- ▶ a massive skills shortage due to a shrinking pool of qualified technical personnel,
- ▶ increasingly stringent environmental and safety regulations,
- ▶ urgent security upgrades to protect vital data against cyber attack.

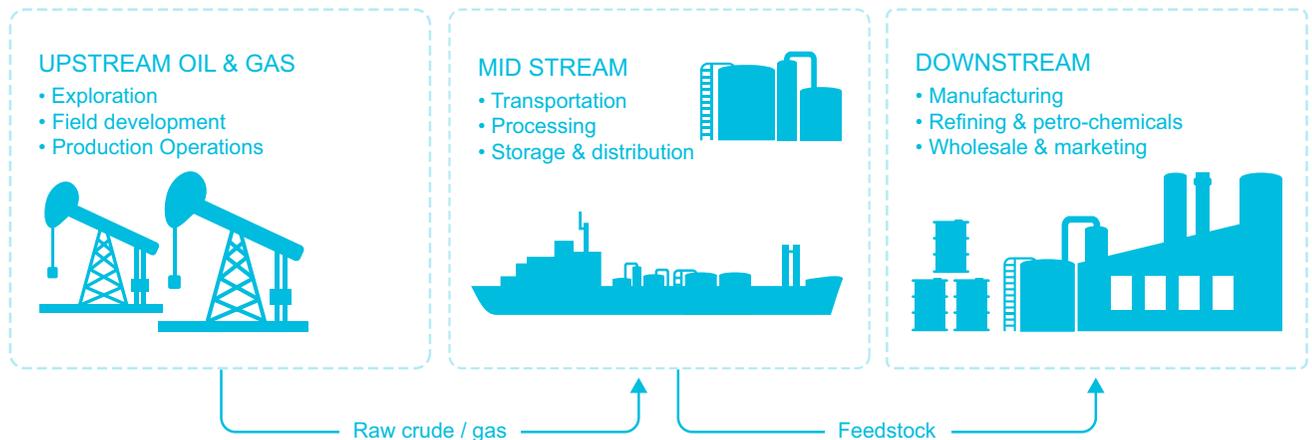
In short, costs spiral upwards while revenues dive, and the business outlook appears generally bleak.

So it would seem somewhat contradictory that 2015 surveys report that most oil executives intend to maintain or even increase spending on digital technologies over the next three to five years. How do they justify such apparent contradiction?

## THE DIGITAL OIL FIELD OFFERS A SOLUTION

Oil companies have been taking a longer view. For decades, they have attempted to rejig their entire value chain, harnessing technological advances in IT, communications (ICT), and engineering.

The 1960s' manual logging of offshore operational data eventually evolved into digitization of data and transmission via satellite. Now, oil companies must embark on a sophisticated and ambitious program to integrate (and increasingly automate) every stage of company operations.



## Why O&G companies need the DOF

Investment in the DOF is a necessity, not a luxury. Technology offers a lifeline to oil companies facing shrinking margins and rising costs by shortening project schedules and reducing manpower requirements. With the baseline cost of leasing a single deep water rig approaching US\$600k each day, minimizing project times alone can substantially bring down E&P costs.

Better communications and workflow automation can dramatically improve safety and avoid expensive disasters.

- ▶ In 1988 the Piper Alpha explosion on a North Sea production platform operated by Occidental Petroleum killed 167 workers and cost US\$3.4 billion. Failure to communicate between work shifts had led to a gas leak through pipework that should have been closed with a safety seal. A safety workflow generated out of the knowledge of each shift's work program could have corrected this oversight.
- ▶ In 2010 British Petroleum's Deepwater Horizon blowout killed 11 workers on a Gulf of Mexico platform, caused an ongoing environmental (and PR) catastrophe, and cost US\$18.7 billion. Analysis of the disaster concluded that had the blowout protection on the wellhead been fitted with remote-controlled or acoustically-triggered actuators, the well could have been cut off and disaster possibly avoided.

Lessons from these disasters tell us that automated and remote monitoring of production facilities and wellheads, together with distributed control systems prove their worth: they optimize production, reduce drilling time, and place scarce experienced personnel where they are most needed. New time-based models of

**“...automated and remote monitoring of production facilities and wellheads, together with distributed control systems prove their worth...”**

reservoirs highlight regions where revenue can be extracted from older fields, and predict where expensive problems (stuck pipes, lost circulation, wellbore instability) might lead to equipment failure and delays in exploratory drilling.

The communications investment that has brought extensive data on oil reservoirs has paid off over their lifetime, showing more accurately where resources should be deployed. Thus the DOF has demonstrated in pilots and a few fields how to deliver more revenue and minimize non-productive time.

However, the overall investment remains to be completed, industry-wide.

### **HOW THE DOF IS EVOLVING WITH TECHNOLOGY**

Implementing the Digital Oil Field program (also referred to as Smart Field, Intelligent Oil Field, or i-Field) began in the upstream Exploration and Production (E&P) sector. This is where costs and risks are highest, because prospecting is always something of a gamble.

DOF technology has evolved incrementally.

1. Prior to 1980, data from multiple wells and fields was digitized, collated and entered into spreadsheets, enabling basic but faster and more consistent production analyses for an entire field.
2. Adding instrumentation at wellheads, automatic data capture, and feeding the results into SCADA systems compelled companies to upgrade their communications systems. This not only improved the quality and delivery of data, but also reduced the on-site staff overhead.
3. In the 80s, the explosion of data generated by 3D seismic surveys demanded a further boost in communications capabilities. Now, databases store large amounts of drilling, production and other data, and applications quickly process the information and offer analyses on demand.
4. Engineering and embedded system developments took advantage of improved communications, using Digital Control Systems, where remotely-actuated equipment controls surface operations over great distances.
5. As field equipment intelligence increased, so did the potential to fully automate operations. Permanent gauges and automatic flow controls for continuous remote monitoring and automatic interaction combine with extensive downhole communication so wells become mostly self-managing.
6. As 'easy oil' opportunities ran dry in the 1990s, companies pursued unconventional drilling operations (e.g. horizontal drilling) in less-accessible locations under sea and on land.
7. Since 2004, time lapse (4D) seismic surveys have generated petabytes of data that must be transmitted over very high bandwidth connections, then processed and stored, creating considerably more accurate and dynamic monitoring of oil reservoirs.

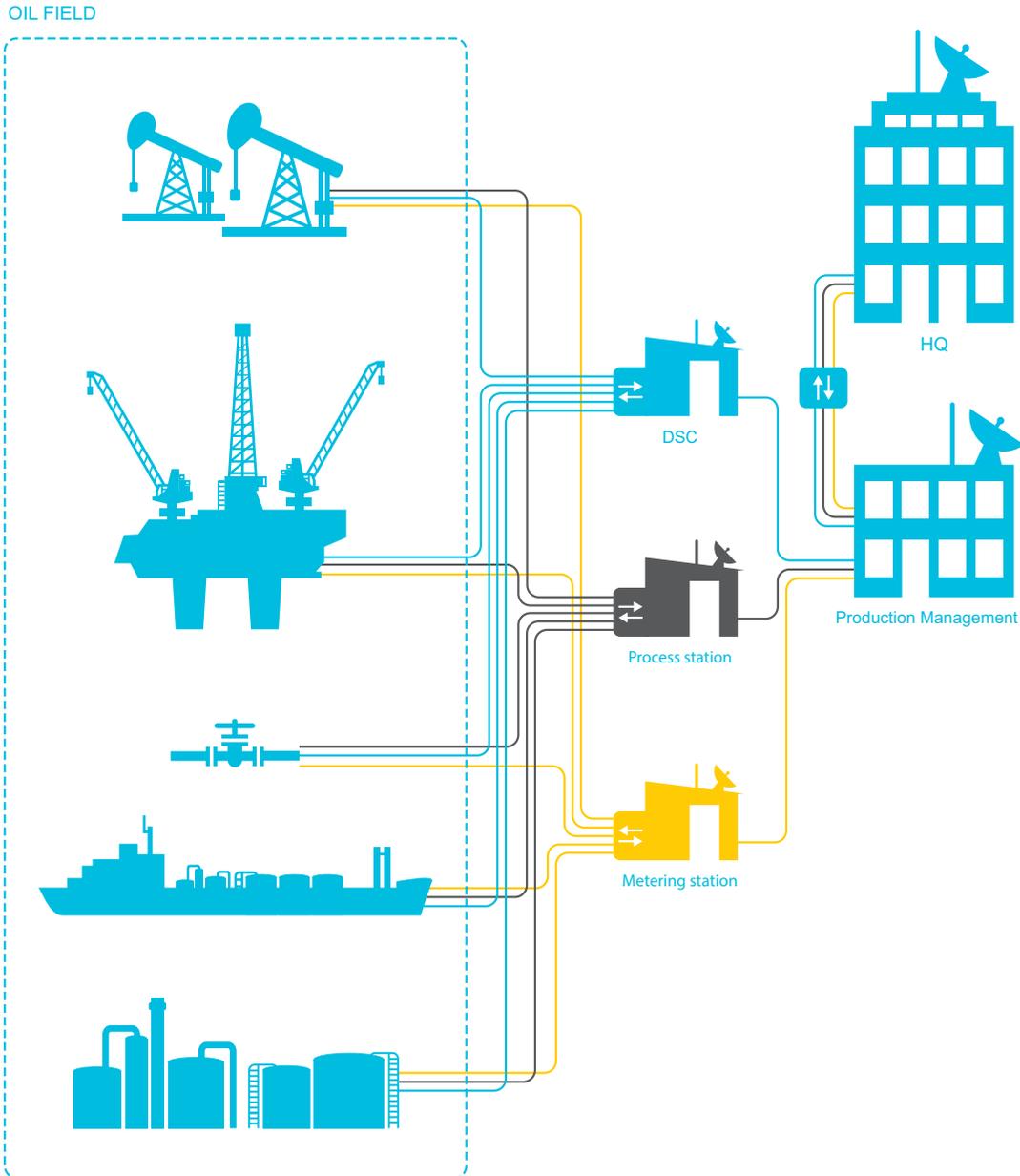
Although these new capabilities have undoubtedly added to the complexity of modern E&P operations, they offer huge benefits. With the possibility of real-time monitoring and control, vast quantities of data pouring in, and the big picture of the company's assets, operations, and market suddenly visible, it is possible to adjust business operations dynamically and interactively. Now there are tools to see that production is optimized, non-productive time is minimized, as much oil as possible is recovered from production fields, and the best possible financial outcome is obtained.

Web-based collaboration tools enable different functional groups to coordinate their work and respond cooperatively to operational issues as they arise. Workflow automation helps to automatically create up-to-date, repeatable, complex, and appropriately resourced workflows based on current business information. 'Drilling by (computer) mouse', dynamic monitoring of reservoirs and distributed production control, are today's realities rather than tomorrow's futuristic dreams. Sophisticated decision-support applications can rapidly digest the incoming data to display trends, performance plots, and produce on-demand analyses. And as machine-to-machine communication improves, more and more of the physical plant and facilities will run completely automatically, adjusting and repairing itself as necessary.

## Implementing a DOF

Communications – and data communications in particular – lie right at the heart of the DOF concept. While oil company communications design can get complicated very quickly, a basic starting point for the designer is to understand the data requirements of each operational unit. The overall communications architecture must then integrate each unit's requirements with the technical options for supporting them, to form the company's total communications system plan.

Although companies vary (since some companies are strictly midstream or strictly upstream), a generalized picture of a company that embraces all three sectors might look something like this:



The diagram highlights the challenging scale and complexity of a digitally-connected company. From a top level perspective, the most important areas to consider are:

- ▶ **corporate centers** – including corporate headquarters and regional offices – and possibly a separate production management center responsible for monitoring and optimizing production,
- ▶ **oil fields** – both exploratory wells and production fields – onshore and offshore and their associated pipeline systems,
- ▶ **refineries** – including nearby oil terminals (tank farms), port/rail facilities and pipeline systems.

Regardless of individual company variables, the ultimate aim is to use ICT to digitally unify the various business operations of an oil and gas company. While all three areas are addressed, we focus mainly on the oil fields, as this is where the DOF has demonstrated its most immediate impact.

### Corporate centers

Corporate HQ, regional offices, and the production management center will be connected by a secure, high-capacity IP enterprise network with global connections, and will house the company's main IT processing and databases. It will support big data applications such as reservoir simulations, advanced analytics, production planning and optimization, demand forecasting and other decision support tools that require powerful computing resources (e.g. grid computing) as they integrate data from across the company.

Video conferencing, voice services, and collaboration applications allow cross-functional teams to organize and work together quickly.

### Oil fields

From a communications perspective, onshore and offshore fields have a great deal in common:

Streams of sensor data from drilling and other equipment transmit to metering, processing, and control stations.

- ▶ Surveillance, video and camera feeds.
- ▶ Staff communicate via voice and data, usually via radio.
- ▶ Field and seismic data continuously transmit to an onshore network operations center (NOC).
- ▶ The onshore NOC remotely monitors and controls platform equipment.
- ▶ A broadband campus communications system for platform staff supports voice, PSTN access, Internet, email, video conferencing, IPTV, video surveillance, and security.

### Onshore fields

An onshore fields comprises a number of drilling rigs with instrumentation over each wellhead that includes sensors and triggered actuators for remote monitoring and control of valves, drill heads, and other equipment. Each rig feeds data – often wirelessly through a remote terminal unit (RTU) or programmable automation controller (PAC) – into either:

- ▶ a metering station,
- ▶ supervisory control and data acquisition (SCADA) system, or
- ▶ a distributed control system (DCS).

This can automatically log sensor data when monitoring oil and gas levels from the well. Rigs are also connected to a control panel so that valves can be closed or opened manually or remotely.

The metering station transmits production data and alarm notifications through a fast (e.g. fiber) connection to a process station which processes crude oil to remove gas, water, solids and other non-saleable components. IP video surveillance and instrumentation in the metering and process stations and pipelines can be transmitted to a central control room, which in turn, connects to the production management center.

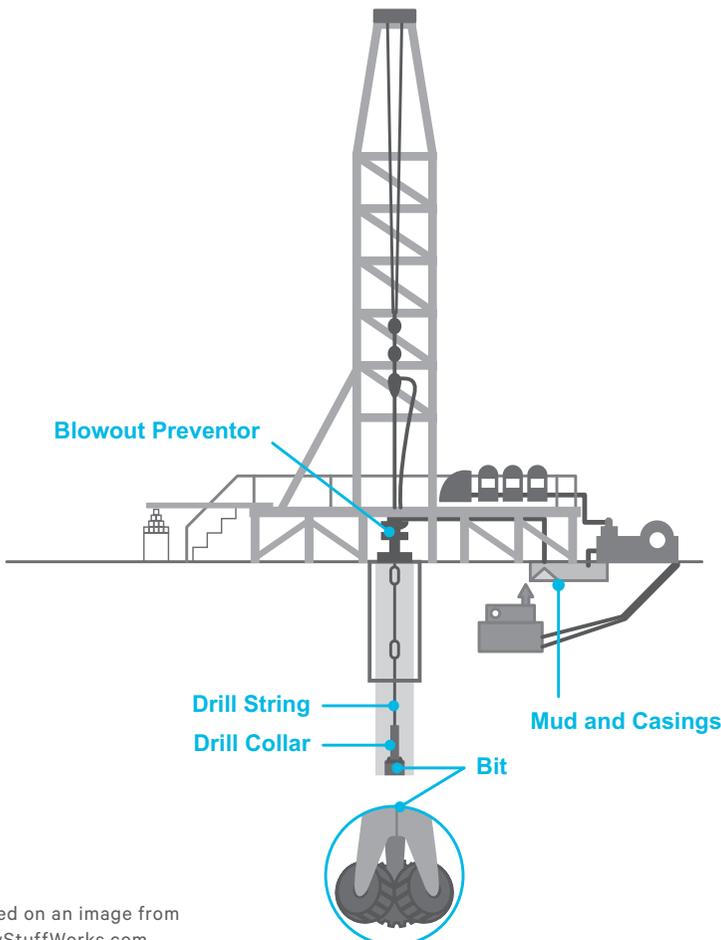
**“...ultimately the aim is to use ICT to digitally unify all of the business operations of an oil and gas company.”**

Through this data path geologists can “see” into the oil field reservoir, and engineers can use portable devices (e.g. laptops, tablets, and even smart phones) to remotely monitor, perform diagnostics, and control oilfield equipment. Integrating multiple DCSs, extends control across multiple oil fields from a single point.

However, this degree of automation does not eliminate the need for personnel at the sites. During exploration, work crews will construct, maintain, and move drilling sites. Drilling can be controlled remotely, but fixing faults generally requires human intervention.

A substantial proportion of E&P project costs is in non-productive time, (measured in lost rig days) while drilling is halted by equipment failures, stuck pipes, and loss of circulation. For example, drilling mud must circulate to lubricate and cool the drill bits, maintain formation pressure, keep the well bore stable, remove cuttings, and more. If the drilling mud is leaking underground, the drill pipe can seize up, shear off, and may need to be dug out before work can resume. A sensor array in the drilling equipment will detect this problem before it becomes critical, so the drill can be retracted normally.

Crews working in dangerous environments must resolve drilling issues quickly; so communications are essential for a speedy problem resolution and for enhancing worker safety.



Based on an image from  
HowStuffWorks.com

Sensor data from exploratory drilling and current video footage can be analyzed by experts (who may be hundreds – even thousands – of kilometres away) to identify the cause of failure and to recommend a corrective course of action. The field office (or ‘forward operations office’) is the communications contact between the field network which generates and transports the data, and the enterprise network which receives, stores and analyses field intelligence.

Field network workers typically use intrinsically-safe (C1D2) portable radios for voice communications. More powerful vehicular radios and vehicle area networks (VANETs) add range, flexibility and mobility to the portable coverage, and can include cab-mounted IP cameras and better mobile data.

Digital radio usually supports location services and man-down safety features. Location tracking is critical in field operations, for locating personnel during emergencies, and asset management, logistics, situating construction material, and establishing the position and status of monitored equipment. Technologies such as RFID can automate location tracking, streamlining workflows and improving situational awareness and safety.

Since oilfields tend to be in remote – even hostile – locations, robust and resilient communications act as a lifeline. Forward-operating campuses provide accommodation, security and communications for field staff. Data and communications that carry voice, PSTN access, Internet, email, video conferencing, IPTV, video surveillance, and security systems, must be set up from scratch.

### **Offshore fields**

Land-based oil fields are difficult enough to operate and maintain, but offshore fields add a new level of complexity and cost. Conditions are often harsh and unforgiving, they may be far from land and operating in depths up to 2000 meters. (Deepwater mobile offshore drilling units (MODU) – basically a submarine driller – can go to 3000 meters.)

The familiar image of an offshore platform is a self-contained man-made island, fixed or tethered in deep water, with everything needed to drill, extract and process hydrocarbons, and store them until they can be transported to shore by undersea pipeline. Where pipelines are not viable, specialized floating storage and offloading (FSO) vessels provide storage and processing. Manned platforms are also offshore hotels, with accommodation, cafeteria, office, medical, and recreational facilities for personnel who will live there for weeks at a time. Supply ships keep the platforms equipped and helicopters ferry staff to shore as required.

From a communications perspective, there are significant differences from the onshore oil field. An offshore platform is far more cramped, exposed, and dangerous than an onshore field. (Industry fatalities offshore far exceed those on land). Space limitations impose physical constraints on workers’ movements, where equipment can be located, work processes, and even on what equipment (communications or otherwise) can be accommodated.

Communication with supply ships and FSOs is critical for offshore platforms. A three-way dialog between platforms, FSOs, and onshore facilities is essential, to pass accurate production information. Even under the worst of conditions, contact with supply ships is vital for maintenance, and the safety and support of platform staff.

To transmit real-time field data onshore and to support remote monitoring and control of field equipment depends on a very fast, high capacity-link between platforms, and between platform and shore. The standard method has been to use VSAT (very small aperture terminal) satellite communications. However, real-time data acquisition, monitoring and control are not feasible via satellite, due to limited bandwidth, delay (latency) associated with transmitting to satellite and down to the destination, together with vulnerability to bad weather.

If the platforms are neither too far apart nor too distant from shore, submarine fiber optic cable is an attractive alternative. It offers much higher bandwidth, low latencies (20ms-50ms), and relative immunity from weather-related interference. If laying down fiber is not possible, then VSAT or microwave must be considered.

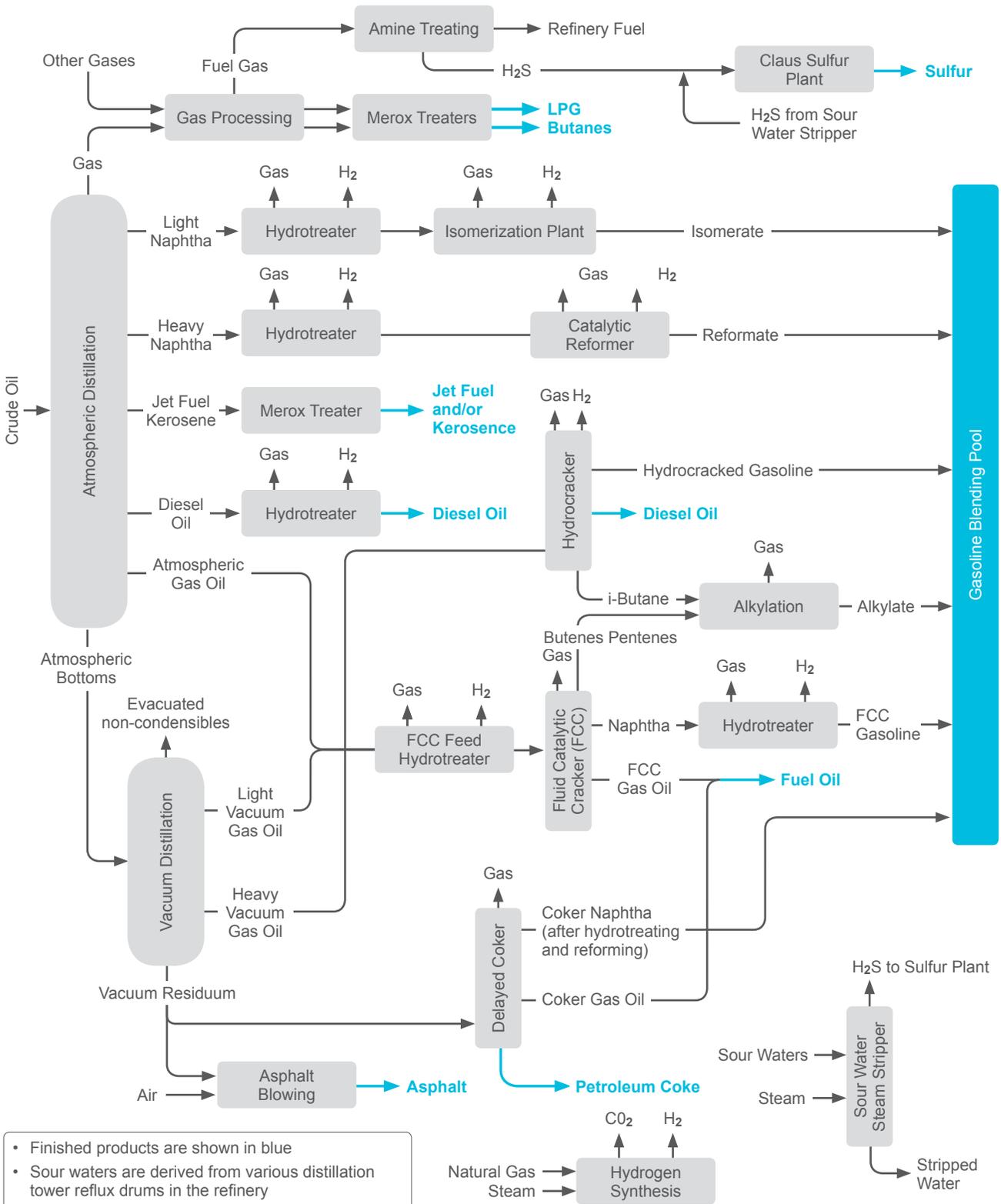
### **Refineries**

Oil refining applies physical and chemical processes to crude oil to remove impurities (e.g. salt, sulphur, mercaptans), and distils from it saleable products such as gasoline, diesel, kerosene, LPG, and tar. Often, a refinery has tank farms for storing incoming crude and outgoing refined products near an oil terminal or port.

The refining process is extremely involved, highly polluting and extremely dangerous as steam, chemical additives (acids and strong alkalis), high temperatures, and pressures create potentially-explosive mixtures of liquid and gas.

Each aspect of refinery operations – bringing in crude, storing it, piping it into refining units, transporting refined products to storage and distribution – generates a constant stream of interlocking data production data, sensor data, equipment status, work plans, maintenance schedules etc. Voice communications, usually over radio systems, keep refinery workers in touch.

To better manage this complexity, it makes sense to integrate communications with IT systems, thus automating processes and workflows as much as possible. Technologies such as RFID, intelligent sensors, and programmable automation controllers have already removed some less-responsive manual processes. Integrating these technologies more closely with workflows can reduce non-productive time, safety risks and environmental impact. At the same time, automated monitoring and control means that companies have a highly accurate picture of production, optimize refining operations, anticipate problems before they arise, and vitally, improve safety.



- Finished products are shown in blue
- Sour waters are derived from various distillation tower reflux drums in the refinery
- The "other gases" entering the gas processing unit includes all the gas streams from the various process units

Based on an image "RefineryFlow". Licensed under CC BY-SA 3.0 via Commons -

## Typing it All Together: Data Communications and Technologies

While on the face of it, the data communication requirements of oil and gas companies resemble the challenges other industries face, these are amplified by the scale of their global reach, complexity of operations and the immense commercial, human and environmental risk.

So for this industry, more than most, communications must be:

- ▶ totally reliable (must not lose service),
- ▶ resilient (must recover from failure quickly),
- ▶ robust (must work in harsh environments) and long lasting,
- ▶ secure (communications and data must be protected from loss, damage or intrusion),
- ▶ safe (may require intrinsic safety in some environments),
- ▶ integrated (must integrate many processes seamlessly).

The industry has already entered the era of Big Data where terabyte and petabyte volumes of data from numerous sources stream in daily. Faced with shrinking revenues and rising costs, the business value of using that data effectively is a matter of survival.

Faster, more accurate decision making is the key to making the oil and gas business work. The variety of communications technologies is enormous – more common options include:

- ▶ VSAT
- ▶ Radio (P25/DMR/TETRA)
- ▶ Wireless Sensor Networks
- ▶ Cellular
- ▶ 4G LTE/WiMax and (future) 5G
- ▶ WiFi (802-11 a/b/g/n)
- ▶ RFID
- ▶ Bluetooth
- ▶ Wireless Mesh Networks
- ▶ Vehicular Ad Hoc Networks (VANETs)
- ▶ Fiber optic
- ▶ Ethernet
- ▶ PLC, Power over Ethernet (PoE)
- ▶ Serial communications
- ▶ Fieldbus communications (Modbus, Profibus (wired & wireless) etc.)

No single technology can adequately serve all the communications needs of an oil and gas company. Each has its strengths and weaknesses. For example:

- ▶ VSAT satellite, a mainstay of O&G communications has excellent coverage, is fast and relatively inexpensive to set up but has limited bandwidth and latency problems. VSAT options offering higher bandwidth are available, but may be prohibitively costly. In rough seas, communication with ships can be disrupted as they struggle to keep aligned with the satellite.

- ▶ Radio – the standard for voice communications – has excellent coverage, lower latency than VSAT, but takes time and resource to deploy and offers limited data bandwidth.
- ▶ WiMax and LTE can provide both data and voice communications with very low latency and high bandwidth, but coverage, which is more limited than radio, dynamically depends on bandwidth usage.
- ▶ Fiber optic can supply very high bandwidth with extremely low latency, but is complex and expensive to install and maintain, so is not practical to install in remote or distant offshore locations.
- ▶ RFID delivers real-time object identification at short range. The range can be extended using antennae, and higher bandwidth models are available at a cost, but reliability, lack of security, and the need for intrinsic safety place constraints on its wider use.
- ▶ SCADA system equipment, traditionally deployed for managing oil and gas pipelines, can be vulnerable to cyber attacks. Newer versions replace proprietary network protocols with less-vulnerable, open standard protocols developed for the Internet of Things. Nevertheless, even modern SCADA equipment remains a target, and efforts to harden equipment security continue.

However, each technology has its place in oil and gas business operations. The key to making the digital oil field a reality is to integrate the relevant communications technologies with company IT capabilities. The variety of legacy and current technologies – both proprietary and open standard – and the need to embed security into the mix make this a truly ambitious task.

Typical high-level technical objectives for this exercise include:

- ▶ creating an IP-based architecture with built-in security at all levels,
- ▶ ensuring overall network design includes some degree of insulation between the networks. (Although the corporate enterprise network, the production networks, and the field campus networks must overlap, it would be catastrophic if problems in the enterprise network stopped the production network.)
- ▶ providing a high capacity, low latency linking backbone for the entire system,
- ▶ developing a consistent, effective, and integrated network management framework for the entire system,
- ▶ integrating company experience and real-time data with business and workplace processes that reflect industry best practices.

Few organizations have the capacity and expertise to carry out specialized projects on this scale, so clearly this mission calls for integration experts. It is little wonder then, that oil and gas service providers anticipate a bright future for investment in integration.

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