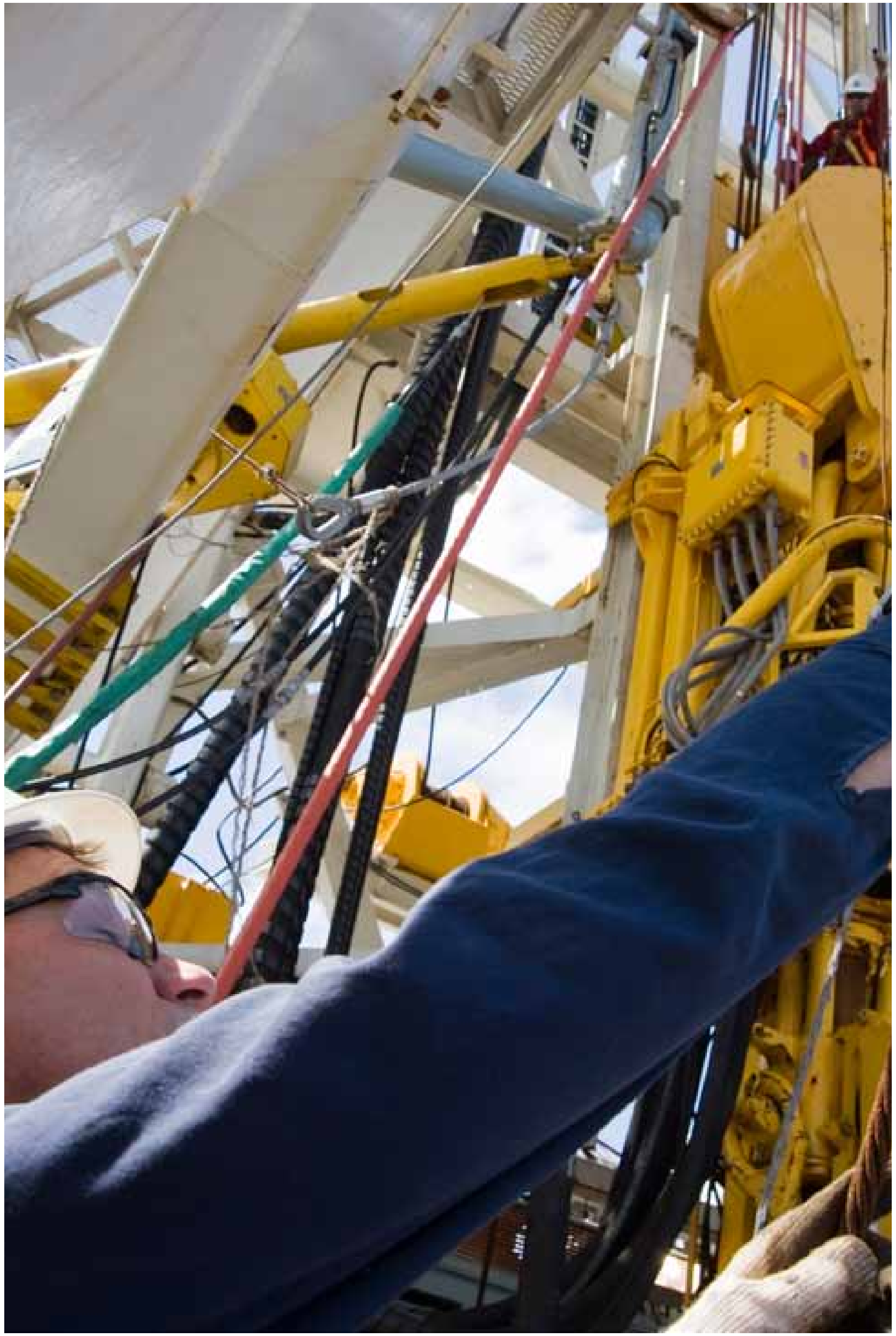
DEEPWATER



Perdido, Gulf of Mexico, USA


SHAPING DEVELOPMENTS IN DEEPWATER
EMPHASIS ON SAFETY
DRILLING INNOVATION
DEEPWATER CREDIBILITY
STATE-OF-THE-ART PROJECTS
LOOKING TO THE FUTURE

Continual investment in people, technology and project capabilities has enabled Shell to forge a prominent position in deepwater

Perdido Spar construction, Pori, Finland

Perdido Spar sail away from Kiewit Yard to the Gulf of Mexico, USA

Shaping developments in deepwater

Shell has been at the cutting edge of deepwater developments for more than 30 years. Innovative technology, world-class project management skills and a stable core of outstanding people are the platform for the success we have enjoyed in this arena, with all its challenges and opportunities.

Perdido Spar construction, Pori, Finland

COMBINED INNOVATION AND INTEGRATION

The Perdido development in the Gulf of Mexico is the latest and deepest in a series of Shell deepwater successes stretching back more than 30 years. The Perdido topsides rest on a buoyant spar, the combined structure being almost the height of the Eiffel tower in Paris. Moored in 2,450 metres of water, this is the deepest combined drilling and production platform in the world. The Perdido development also boasts the world's deepest subsea well. The well is in Tobago field, 2,934 metres down on the seabed. Tobago field broke the world water-depth record for subsea production, which was previously held by another field in the Perdido development: Silvertip field at 2,852 metres of water.

The Perdido development was only possible through a series of technology firsts across a range of disciplines. This combination of technology innovation and integration is paramount.

It is fundamental to the continuous progress that we have made since the beginning of the deepwater era, which can be traced back to the early 1980s.

Continual investment in people, technology and project capabilities has enabled Shell to forge a prominent position in deepwater. Our record now includes more than 20 successful deepwater projects, many of them groundbreaking. We have a strong presence in both established and emerging deepwater provinces around the world. Shell's 30+ years of deepwater operations in the Gulf of Mexico produce an average Shell-share of about 187 thousand barrels of oil equivalent per day. The Perdido facility sits over four oil and gas reservoirs. We expect it to ultimately connect 35 wells through a network of pipes on the seafloor. The facility is expected to produce about 100,000 barrels of oil equivalent per day.

Shell's 30+ years of deepwater operations in the Gulf of Mexico produce an average Shell-share of about 187 thousand barrels of oil equivalent per day

BEGINNING IN DEEPWATER

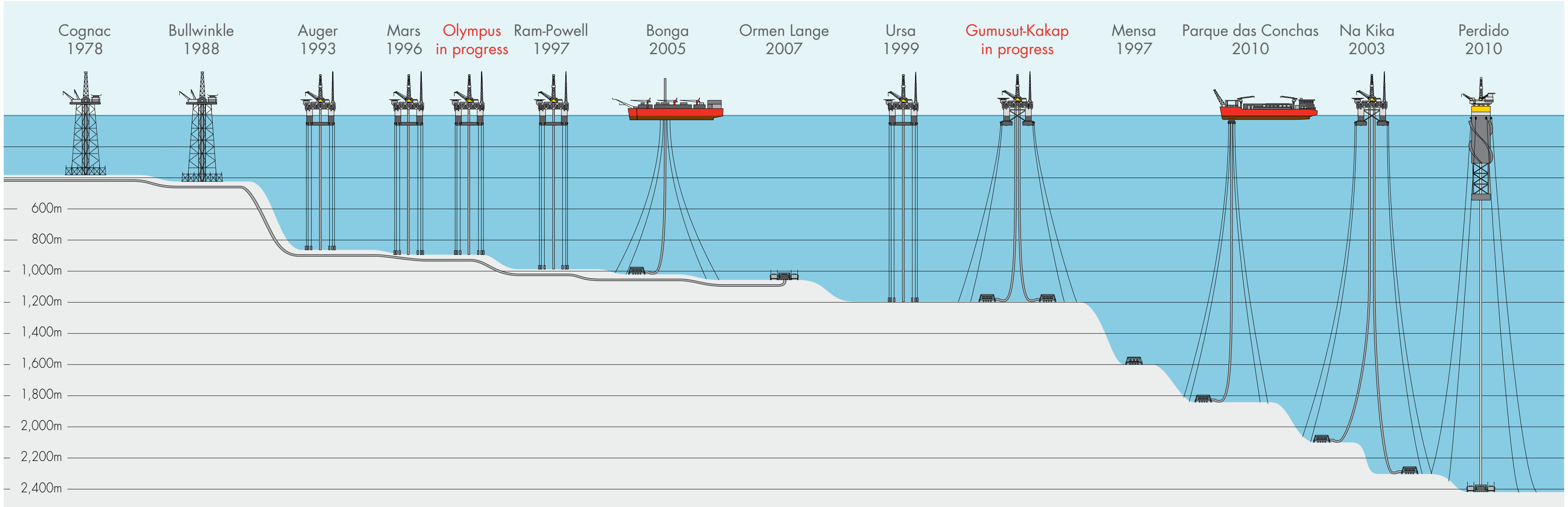
In 1978, Shell installed the Cognac platform in the Gulf of Mexico in three sections, excluding the deck. It sits on the seabed in 330 metres of water. The photo shows the Bullwinkle platform, which was installed 10 years later in 412 metres of water as a single section, excluding the deck module. This platform still holds the world record for the tallest fixed jacket structure ever placed in the sea: from the seafloor to the tip of the flare stack, the structure is about twice the height of the Eiffel tower in Paris. The Bullwinkle platform is significant because it marks the limit of what can be achieved using traditional offshore technology. It heralds the beginning of a period when Shell and others in the industry advanced the frontiers of oil and gas exploration and production as never before.

FACING UP TO THE CHALLENGES

Three words best summarise the challenges associated with deepwater development: scale, complexity and extremity. Challenges revolve around the installation of equipment, of access to the seabed and of bridging the distance between the seabed and the surface. The extended water column exerts huge pressures on oilfield equipment, which consequently has to be stronger than normal. As an example, the vital riser pipes used for drilling and production become heavier the deeper the water, which creates specific design challenges in terms of their fatigue life and the way they interface with surface and seabed facilities.

Platforms become bigger and more complicated to accommodate the hardware requirements and cope with the massive loads involved. Of course, the natural environment does not help. When working in deeper water, which is generally further offshore, the weather conditions, the wave forces and the currents can be extreme, which adds to the challenge of designing adequate facilities. Seabed temperatures also fall towards freezing, which raises the issue of hydrate formation and makes flow assurance a particularly important deepwater technology focus.

And the challenges do not end once production begins. Every aspect of oilfield operations and logistics, especially those involving well intervention, has to be viewed in a new and often costly light.



COMPREHENSIVE SKILLSET

Deepwater resources are vital to help meet the world's rising energy demand. Resources of over 80 billion barrels of oil equivalent are estimated in the Gulf of Mexico, Brazil and Nigeria deepwater regions alone.

Technology is the key to unlocking these massive resources of oil and gas, and the scale required should not be underestimated. The complexity of most deepwater projects and the unique challenges each presents call for an unusually comprehensive surface and subsurface technology skillset: one that spans the entire oilfield life-cycle.

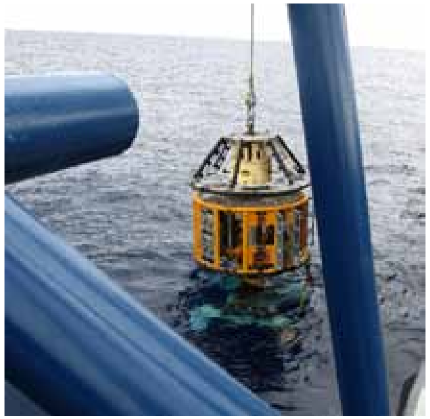
Ongoing investment in research and development over the years has underpinned Shell's ability to continuously extend the deepwater frontier. Our overall research and development expenditure was more than $1.1 billion in 2011, once again the highest among the international oil companies. Developing optimum technology solutions also requires us to look outwards. The ability to capitalise on the skills and abilities of other industry players and specialist oilfield services companies is vital to success.

PERSONAL OWNERSHIP AND ABIDING PRINCIPLES

All this innovation and integration would be impossible without the right people and the best minds within our organisation. The knowledge, experience and imagination of the people working at our Deepwater Centre of Excellence in Houston, USA, and at closely linked regional hubs in New Orleans, USA; Stavanger, Norway; Kuala Lumpur, Malaysia; and Lagos, Nigeria, provide us with a competitive edge. It is they who take ownership of the challenges we face and who embody Shell's abiding principle of providing for the world's energy needs in ways that are safe, affordable and environmentally sustainable, regardless of the practical challenges.

Continual investment in research and development coupled with the ability to capitalise on the skills and abilities of other industry players and specialist oilfield services companies is vital to success

We have a highly developed asset integrity management system covering all aspects of our operations



Troika splashing BOP assembly, USA

Ormen Lange, Norway

Emphasis on safety

We must constantly demonstrate our ability to understand and deal effectively with the safety and environmental hazards associated with deepwater development.

Shell has health, safety and environmental (HSE) standards that rank among the most robust in the world and maintains the necessary management procedures to ensure they are faithfully applied. We have a highly developed asset integrity management system covering all aspects of our operations. For well integrity, we have specific software tools, which are tried and tested in hydrocarbon provinces with ageing well stocks, to help us manage the operation, maintenance and workover of wells for their long-term reliability and safety.

WELLS MUST BE SAFE

Safe well operations demand highly competent people, strict safety procedures and rigorous design, construction and maintenance standards for all equipment. Shell applies a multilayered well control system designed to minimise risks, so that if any system or device fails it should not lead to loss of containment. As well as primarily focussing on prevention, we also work on secondary (cap-and-contain) well control tools and techniques to shut off subsea wells safely and quickly after an uncontrolled release of hydrocarbons.

The Deepwater Horizon disaster in the Macondo field, Gulf of Mexico, in 2010, had a profound impact on the industry, and instigated a thorough review of our approach to deepwater development, especially in terms of drilling and well construction. Despite our utmost confidence in Shell's standard well designs and construction procedures, we are focusing on a series of measures to further reduce the chance of a catastrophic well failure.

Blowout preventer

Our work has centred on blowout preventer (BOP) stacks that require less manual intervention and shut down problem wells automatically. We are developing explosive well severance systems to augment the hydraulic rams normally used in BOPs.

We are engaged in a range of initiatives and projects to develop improved well capping systems

Shell capping stack

MWCC capping stack (Courtesy: Marine Well Containment Company)

In addition, we are employing well designs that can survive complete loss of well control and then shut off the flow at the seabed.

In March 2011, Shell became the first oil and gas company to be awarded a permit to drill a new exploration well in the Gulf of Mexico following the Deepwater Horizon oil spill in April 2010. This demonstrated the credibility of our robust approach to safety and operating responsibly, which is based on rigorous global standards and practices.

READY TO RESPOND – CONTAINMENT INITIATIVES

However small the chance of a well suffering a blowout of the kind at Macondo, we have to accept that it cannot be completely ruled out. For that reason, we are engaged in a range of initiatives and projects to develop improved capping systems to suppress wells that are releasing oil and gas into the sea.

Shell has already designed a modular capping system for its own deepwater wells for easy transportation anywhere in the world. We are also working on an Arctic version dedicated to capping Shell wells in Alaska. Shell, along with ExxonMobil, Chevron and ConocoPhillips, formed the Marine Well Containment Company, a not-for-profit, independent company that provides well containment equipment and technology in the deepwater U.S. Gulf of Mexico. The company has developed an interim response system that will provide rapid containment response capabilities in the event of a potential future underwater well control incident in the deepwater Gulf of Mexico and is developing an expanded system. The majority of the expanded containment system will be complete in 2012 with the remaining equipment arriving in 2013.

Shell is also leading the International Subsea Well Response Project from its office in Stavanger, Norway. The project has nine oil company members and is initially assessing equipment and operating plans to accelerate and improve the industry's response to serious well failures. This is likely to lead to the design of new capping systems.

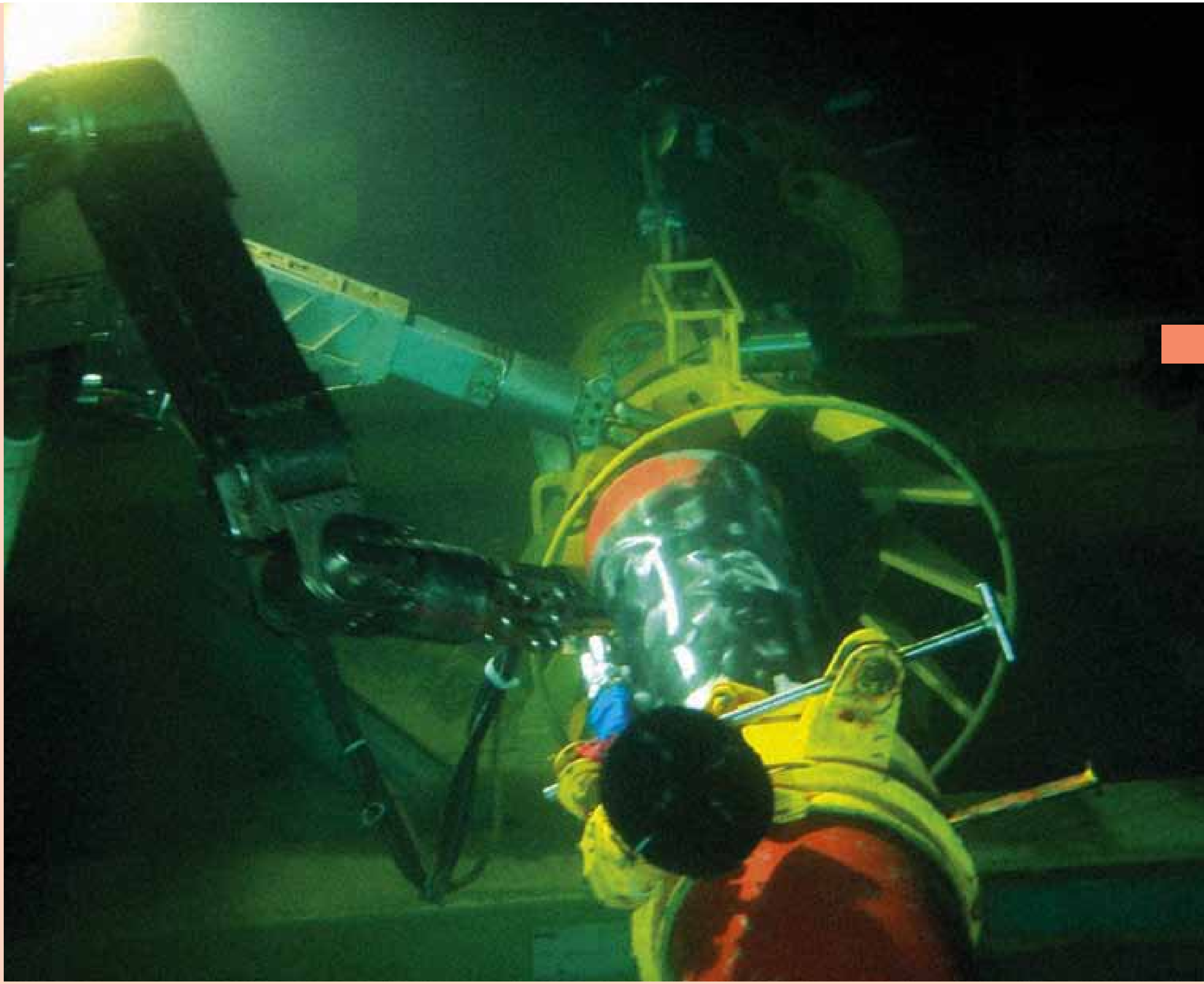
DEALING WITH ADVERSITY – SAFELY

Hurricane Katrina swept through the Gulf of Mexico in 2005 causing serious damage to oil and gas installations. Shell's Mars field tension-leg platform (TLP) and its wells survived the extreme weather conditions but the platform's drilling rig toppled and various production facilities were badly affected. The field's 18-inch oil and 14-inch gas export pipelines also suffered damage when an anchor belonging to a drifting semisubmersible drilling rig dragged across them during the storm.

The complex exercise to repair the platform facilities was planned in detail and meticulous preparations were made offshore before the 1,000-tonne drilling rig was lifted away from the platform in two pieces to be repaired onshore. Ultimately, achieving this lift without affecting a critical, high-pressure gas-treatment vessel underneath the rig was key to resuming production ahead of schedule.

The industry-first pipeline repair in 600 metres of water was accomplished using an emergency system Shell developed with this sort of event in mind. Subsea robots controlled from the surface cut out cracked sections and replaced them with jumpers.

This unprecedented project consumed more than one million work-hours, during which time there were no recordable injuries. The project received a National Ocean Industries Association award and an Energy Institute award for technology. Offshore Engineering also named it project of the year. In recognition of his personal contribution, the Shell project leader received a corporate leadership award from the U.S. Department of the Interior.



Repair works subsea robots

Over the past several years, Shell has made a series of important advances that promise to change the face of deepwater well operations

Noble Bully II

Drilling innovation


Noble Bully I

Shell has driven a series of innovations in deepwater drilling over a prolonged period. Reducing the environmental impact and cost of drilling in deepwater are constant objectives.

TAKING THE LEAD IN DRILLING – NOBLE BULLY I AND II

The highly innovative Noble Bully rig design is the result of a concerted development programme in collaboration with leading drilling contractor Noble Corporation. The rigs, which entered service in late 2011 and early 2012, are based on a revolutionary concept: a floating drilling rig with all the attributes and functionality of the latest fifth-generation drillships but with lower capital and operating costs and a reduced environmental footprint.

Working with Noble, we have achieved that. Noble Bully I and II are significantly lighter and shorter than comparable capacity drillships. Locating the pipe storage in the hull of the vessel and having a compact, box-type, multipurpose drilling tower rather than a conventional drilling derrick ensure its stability. The vessels can drill in water depths up to 3,000 metres deep.


Noble Clyde Boudreaux semisubmersible drilling rig
(Courtesy Noble Corporation)

DRILLING AND COMPLETION RECORDS

Shell was the driving force behind the deployment of world's first semisubmersible drilling rig, the Bluewater 1, in the Gulf of Mexico in 1961.
In 1993, our Auger TLP was the first floating deepwater platform in the Gulf of Mexico to have a full drilling rig. The Perdido platform is currently the world's deepest full drilling and production platform. We have achieved a series of drilling water depth records over the past 30 years.
We have also set and then broken our own records for the deepest subsea well completion in the Gulf of Mexico: West Cameron, the first subsea completion (1961); Tahoe, 460 metres (1994); Popeye, 610 metres (1995); Mensa, 1,650 metres (1997); and Perdido, 2,900 metres (2009).

Technology has a crucial role in providing the information to make sound deepwater exploration decisions

Perdido, USA

The vessels also boast the latest electronic engine controls and an advanced dynamic positioning system, which preserves fuel consumption and cost, and helps to reduce carbon dioxide emissions by over 100,000 tonnes per year compared with deepwater drillships with the same capabilities.

EXPLORING THE DEEP

Technology has a crucial role in providing the information with which to make sound deepwater exploration decisions. Given the complexity and high cost of drilling in deepwater, there is great value in being able to identify the best spots to drill exploration wells, to first place the bit. This skill hinges on our ability to generate an accurate and comprehensive picture of the Earth's subsurface. Seismic technology lies at the heart of this process and is a key research priority for Shell.

Working with various specialist technology entities, we have driven advances in wide-azimuth, ocean-bottom seismic surveying that have cast new light on deepwater reservoirs lying below thick salt formations, which were previously notoriously challenging to image. We have enjoyed spectacular success using this technique to explore the Deimos subsalt prospect in more than 1,000 metres of water depth in the Gulf of Mexico. At the site of a costly earlier dry hole, the prospect has yielded two new discoveries, the West Boreas and South Deimos fields. These have added significantly to the reserves figures for the already prolific Mars basin and we are currently developing them as part of the massive Mars B project. The new technology was also instrumental in a more recent discovery in the same region: the large Appomattox field.

If there is a downside to ocean-bottom seismic surveying, especially in deep water, it is the laborious and costly task of deploying the numerous sensors over the target area. In an imaginative attempt to simplify this task and to reduce the time and costs involved, Shell is working with GO Science to develop Flying Nodes. These self-propelled Nodes can be programmed to dive through the water to defined locations in the survey area up to 100 kilometres from the launch point. Once in position on the seabed, they will gather seismic data until commanded to return to the survey vessel for data downloading. A trial with 5 Flying Nodes is planned in the Gulf of Mexico for the summer of 2012. A larger trial with 50 is planned for 2013.

KEY ECONOMIC DRIVERS

The cost of hiring a deepwater drilling rig can be up to $1 million dollars per day.

The cost of a deepwater well splits roughly equally between drilling and completion work. The former is impossible without a drilling rig but, in the case of the latter, the situation is far less clear-cut. The ability to complete deepwater wells without a rig provides huge economic benefits.

Oil recovery rates from subsea wells are typically in the range 35 to 45%. Pushing these rates higher by intervention to work over or modify producing wells is often uneconomic owing to the cost of bringing in a drilling rig. Rigless well intervention has the potential to alter field production economics radically in deepwater.

COST-EFFECTIVE WELL INTERVENTION

For clear economic reasons, it makes sense to seek alternatives to using a drilling rig for completing deepwater wells and any subsequent intervention. Shell could not be more driven by this objective and, over the past several years, the organisation has made a series of important advances that promise to change the face of deepwater well operations.

For the past few years, we have been able to install oilfield trees on wires from a workboat equipped with a simple A-frame or a crane. We first did this in the Gulf of Mexico and since then at Ormen Lange field, Norway, and Bonga field, Nigeria.

We also now have initial well clean-up procedures that are possible via the host facility rather than a drilling rig, and we can perform acid stimulation work in deepwater wells from a boat. Most impressively, we can conduct open-water wireline work in water depths to about 2,000 metres. Many thought this would be impossible owing to vortex-induced vibration (VIV) instability issues. In 2009, we successfully replaced a valve in 850 metres of water in the Gulf of Mexico using this technique. At the beginning of 2011, we also used it in Bonga field offshore Nigeria in 1,155 metres of water and saved millions of dollars. In June 2011, we set a depth record in Brazil in 1,890 metres of water.

We have plans to build a system for interventions on caisson electrical submersible pumps without using a drilling rig. In 2010, we finished our first open-water completion in the multi-field Parque das Conchas project offshore Brazil: the first step in building technology and lessons learned for doing this from a boat.

Construction Olympus TLP hull, Mars B project, South Korea

DEEPWATER PROJECTS

AUGER – 1993

- Water depth record drill & produce platform
- ASCE civil engineering award
- Fully integrated drilling rig

MARS – 1996

- Water depth record dry tree platform
- Depressurisation/ blowdown philosophy

RAM-POWELL – 1997

- Water depth record TLP
- Replication of the Mars TLP
- Improved Mars design and construction processes to reduce cost & schedule

URSA – 1999

- Investment in flexibility
- Shallow water flow mitigation
- First TLP to use the upper column frame to isolate topsides from wave forces

SUBSEA ADVANCES 1994 – 2012+

- Start development of novel spar concepts
- Electrically heated flowlines
- Deployment on a wire
- Steel helically wound umbilicals
- Pipeline connection and repair

BRUTUS – 2001

- Hydrocarbon dewpoint control
- TLP schedule & cost improvements

NA KIKA – 2003

- 15,000 ton super lift
- Pipe-in-pipe electrical heating ready flowlines and risers
- Oil storage in hull
- Low motion SEMI in 2,000 metres water depth

DEEPWATER TECHNOLOGY DEVELOPMENT AND NEW

- Advanced integrated design/analysis tools/PDMS
- Coupled global response analysis
- Response based criteria
- State of the art model testing
- Multiphase flow and hydrate inhibitors

BONGA – 2005

PARQUE DAS CONCHAS 2010

PERDIDO – 2010

GUMUSUT-KAKAP IN PROGRESS

OLYMPUS – IN PROGRESS

Bonga – 2005

- First deepwater project offshore Nigeria
- Spread-moored FPSO
- First application of steel centenary risers for an FPSO
- Shell's largest FPSO to date with 225 kbbls/d net processing capacity

Parque das Conchas 2010

- Subsea separation and boosting
- Multiple subsea FPSO

Perdido – 2010

- Ultra deepwater spar
- Heavy oil
- Single lift topsides

Gumusut-Kakap in progress

- First Shell deepwater project in Malaysia
- Smart Fields technology

Olympus – in progress

- Extends life of prolific Mars field to 2060
- 1st GOM deepwater brownfield development
- 6th Shell GOM TLP - enhance value via concept replication
- 1st TLP utilisation of passive hull design
- Forefront of major GOM deep-water developments post Macondo
- Post-hurricane Katrina metocean design criteria

HORIZONS

- Continuous project execution improvement
- Advanced design visualisation, data integration and automation tools
- Standard systems implementation in projects

NEW CHALLENGES AND OPPORTUNITIES

- **Arctic**
- **Floating liquefied natural gas (FLNG)**
- **Subsea separation and boosting**
- **High pressure, high temperature applications**
- **Cost effective wells**
- **Deepwater waterflood and EOR**

Over an eight-year period, between 1993 and 2001, Shell installed five TLPs in the Gulf of Mexico

Brutus platform, Gulf of Mexico, USA

Tow-out of the Troll production platform

Deepwater credibility

Shell has established an enviable record in deepwater and has the credibility needed to lead demanding projects in ever more challenging environments.

You can be as imaginative as possible, you can drive innovation relentlessly, and you can develop world-class technology across the widest possible spectrum, as Shell patently has done. But nothing is achievable without the know-how and the skills to execute these enormous, complex deepwater projects.

Inevitably, they involve multiple partners and legions of contractors, specialist equipment manufacturers and service providers, all eager to play their part but requiring inspirational leadership and an integrating force to make it all happen. This is where experience counts, and where Shell excels.

CONCRETE GIANT

The Troll A platform is worthy of inclusion in any catalogue of deepwater achievements. It is the centrepiece of Troll field in the Norwegian North Sea, which contains 40% of Norway's gas reserves. Four enormous concrete legs that reach down to a concrete gravity base 303 metres below the sea's surface support the production topsides, which can process over 100 million cubic metres per day of natural gas. Installed in 1995 and weighing 700,000 tonnes without ballast, Troll A remains the biggest concrete platform in the deepest water anywhere

Auger production platform, Gulf of Mexico, USA

in the world. It is also the tallest structure ever moved over the surface of the Earth by human beings.

Equally notable about this development is the close co-operation between Shell, the field developer, and Statoil, the field's producing operator. This led to a seamless and highly effective handover as the giant platform came to life.

SHELL'S TLP PRODUCT LINE

Over the eight-year period between 1993 and 2001, Shell installed five TLPs in the Gulf of Mexico. The first, in Auger field in 870 metres of water, was then the world's only TLP to have full drilling and production capabilities. The Auger field flowlines were the first laid in deep water using the near-vertical J-lay

Shell has a new Gulf of Mexico TLP on the drawing board – the Olympus TLP. This TLP will form the heart of the Mars B field development project, the first serious deepwater brownfield project in the Gulf of Mexico

technique, which Shell had developed some years earlier. Auger field was also the first to employ steel catenary risers, which have since become the preferred riser technology for deepwater field developments worldwide. Shell is now planning to tie back the subsea Cardamom field to the Auger TLP.

Following Auger was the Mars TLP in 900 metres of water in 1996; then the Ram Powell TLP in 980 metres in 1997; the Ursa TLP in 1,160 metres in 1999; and finally the Brutus TLP in 910 metres of water in 2001.

The Brutus TLP's claim to fame is that it was the first purposely designed as a field hub, though various platforms were previously retrofitted for this role. More significantly, the Brutus TLP was completed seven months faster and 18% more cheaply than Ram Powell, the TLP before. When compared with the Auger TLP, the cost was down by 60% and the construction time was half.

This is a striking example of the economic benefits of the design one–build many standardisation concept. However, it can only happen in established and stable organisations such as Shell, where efforts are made to develop and retain people's skills and the process of identifying and applying best practices is deeply ingrained.

TEN YEARS LATER, A NEW TLP

Ten years after the Brutus TLP, Shell has a new Gulf of Mexico TLP on the drawing board. The Olympus TLP will form the heart of the Mars B field development project, the first serious deepwater brownfield project in the Gulf of Mexico. This will increase recovery from the Mars basin and tap into the West Boreas and South Deimos fields recently discovered nearby. The new TLP, at peak, will process approximately 100,000 barrels of oil equivalent per day, which puts it in the same class as the earlier five.

RISER TECHNOLOGY AND THE PROBLEM OF VORTICES

Shell has been at the forefront of deepwater riser technology since the 1970s and can claim a series of industry firsts in this area. The risers are critical elements of any deepwater development and particularly prone to vortex-induced vibration (VIV), which can reduce their fatigue life very quickly. Research at Shell aims to improve understanding of riser responses to VIV, formulate more effective riser monitoring measures and develop hardware solutions, such as strakes and fairings, to minimise the effects of VIV.

By exploiting the vast TLP operating experience within Shell, the Mars B project team aims to provide a model of HSE excellence for future deepwater projects. The whole project is being conducted within the framework of a full-cycle integrity management process. The latest hazard and effects management philosophy is being used to define the optimum facilities layout, the best protection for personnel from fire, blast and smoke or gas ingress, and the most ergonomic control room design. The TLP, to highlight just one of its process equipment features, will have riser isolation valves to minimise the impact of any serious incident. A similar approach to this is being taken to modifications on the West Delta 143C platform, to which the Mars B production will be transferred by pipeline.

AVOIDING THE NEED FOR SURFACE FACILITIES

In 1997, Shell claimed the record for the world's deepest subsea production development and the world's longest subsea tieback, when it developed the Gulf of Mexico Mensa gas field. Mensa field had three wells initially and now has four that feed

Centralised surveillance, the Bridge, New Orleans, USA into a manifold connected via a 12-inch pipeline to the West Delta 143C platform just over 100 kilometres away.

A few years later, the Ormen Lange project in Norway, a joint development by Shell and Statoil eclipsed the achievements of the Mensa team. Considered the country's first genuine deepwater development, Ormen Lange lies off the Norwegian coast in waters ranging from 850 to 1,100 metres. The development is relatively unusual in being completely subsea and connected directly to the shore 120 kilometres away. Production from 19 wells (each 9 5/8 inches in diameter) in four clusters is transported through two 30-inch pipelines to an onshore processing centre where the gas and condensate is separated and treated. The gas is then sent to the UK via the purpose-built Langeled pipeline. At 1,200 kilometres in length, this is one of the world's longest subsea pipelines.

The challenges facing the Ormen Lange partners were daunting. The natural environment is harsh, even by North Sea standards. There are sub-zero temperatures for large parts of the year, stormy seas, exceptionally strong underwater currents and a steep, uneven seabed close to a giant back wall formed by a submarine landslide thousands of years ago.

The seabed is extremely cold and this, combined with the high pressure in the flowlines, raised concerns about hydrate formation. Consequently, the two flowlines are constantly dosed with inhibitor, which is cycled between the shore facilities and the subsea production manifolds.

Ormen Lange field came on stream in the second half of 2007, three years after the field development plan was approved and only two years after drilling began. It was six months ahead of schedule and within budget. It reached plateau production in 2009 and now delivers 20% of the UK's total gas demand.

URSA Princess, Gulf of Mexico, USA

IMPROVED OIL RECOVERY AT URSA FIELD

The production lives of the deepwater Ursa field and the nearby Princess field, which is tied back to Ursa, have been extended by an expected 10 years by retrofitting waterflooding facilities on the Ursa TLP. The Ursa-Princess waterflood project was one of the largest projects ever carried out on an existing platform in the Gulf of Mexico and involved high levels of construction, maintenance, commissioning and well service work, all undertaken simultaneously. A key challenge for the project team was fitting the necessary water treatment facilities into the limited space on the TLP. The first injection of treated seawater was in July 2008; the volume enhancement capacity of the scheme is 30,000 barrels of oil equivalent per day.

ENHANCED OIL RECOVERY IN DEEPWATER

Lowering the salinity and controlling the ionic composition of the injection water can improve waterflooding efficiency. With this mind, Shell has developed low-salinity waterflooding. The water produced by low-salinity waterflooding can be used for straight waterflooding or to enhance a range of chemical enhanced oil recovery techniques. Its potential to help take enhanced oil recovery offshore and into deep water is very real. As such, it is a significant component of Shell's deepwater technology programme.

Bonga Floating Production Storage and Offloading vessel, Nigeria

Na Kika mooring, Gulf of Mexico, USA

FIELD HOST UNLOCKS DISPERSED FIELD ECONOMICS

The Na Kika development in the Gulf of Mexico (on stream since 2003) is notable for being the first deepwater development to use a central processing facility, a semisubmersible platform, to host production from several small, widely dispersed fields: Kepler, Ariel, Fourier, Herschel, East Anstey and Coulomb, which lie in water depths between 1,770 and 2,300 metres. Crucially, none of these fields was economically viable on its own.

Several technologies that emerged at the time, including smart wells and real-time multiphase flowmeters, enable the full production from the various fields to be isolated or commingled under remote control from the Na Kika host platform.

MILESTONES IN FLOATING PRODUCTION, STORAGE AND OFFLOADING (FPSO) FACILITY DEVELOPMENT

Shell has been at the forefront of FPSO facility technology since its earliest days. We installed the industry's first such vessel in Castellon field off the coast of Spain in 1977 and we have played a major role in taking this technology into deep water since then.

The Bonga FPSO facility, in more than 1,000 metres of water off the coast of Nigeria, stands out for several reasons, not least because it was Nigeria's first deepwater project. The vessel, which came on stream in 2005, set the benchmark for the industry. At the time, it was one of the largest FPSO facilities in the world, having the capacity to store 2 million barrels of oil. It was also the first vessel to utilise Inconel-clad steel catenary risers.

We made great efforts to maximise the local content of the Bonga project. Various processing modules and foundation equipment were designed and constructed in Nigeria, and there was a significant investment in training and developing local operations and production engineers. Consequently, 90% of Bonga field's workforce is now Nigerian.

Bonga field has 16 subsea wells: a mixture of producers and water injectors. We plan further drilling to develop reserves on the northwest fringe of the field, which we uncovered with our first 4D seismic surveys in Nigeria in 2008 and again in 2010.

PIPELINE TECHNOLOGY FIRSTS

Our pipeline project record speaks volumes for our commitment to technology in this area.
We pioneered the J-lay technique in the late 1960s and developed the articulated stinger for continuous pipelaying at about the same time.
We were behind the introduction of flexible flowlines in the 1970s. During the 1990s, we performed the first deepwater J-lay project (Auger field), installed the first helically wound, super-duplex steel umbilical (Popeye field) and established a water depth record for S-laying a pipeline (Mensa field). The year 1999 saw the first deepwater buried pipeline (Angus field), and a year later we set the depth record for a pipe-in-pipe flowline (Europa field). In 2003, we set the depth record for a subsea flowline (Coulomb field, 2,316 metres), and a couple of years later we performed a record-depth burial operation to improve this flowline's heat retention properties.

Coming right up to date, connecting the Perdido oil export pipeline to the Hoover offshore oil pipeline system involved us in one of the most ambitious hot taps ever attempted. The Perdido pipeline was connected into the live system in 1,370 metres of water during a 17-day window in 2010. The operation took more than two years to plan, work that involved 3D modelling, remotely operated vehicle simulation and precise metrology. Key to the exercise was the design of an unusual semi-buoyant truss structure that forms the foundation for the pipeline tee.

Final assembly of offshore pipeline construction system, Perdido, USA

The Parque das Conchas and Perdido projects demonstrate our constant innovation to ensure the success of deepwater ventures and change the game

Espirito Santo, Parque das Conchas, Brazil

State-of-the-art projects

Deepwater development provides the ultimate stage for world-class engineers at Shell seeking to use their skills and creativity to the maximum.

Despite the progress made, deepwater development still has the power to set pulses racing. Two recent projects, Parque das Conchas, offshore Brazil, and Perdido in the Gulf of Mexico demonstrate the requirement for constant innovation to ensure the success of deepwater ventures.

PARQUE DAS CONCHAS

In July 2009, Shell began production from the multi-field Parque das Conchas development in the Campos basin, 110 kilometres off the south-east coast of Brazil in approximately 1,800 metres of water.

Espirito Santo, Parque das Conchas field, Brazil

Oil and gas from three fields, Abalone, Ostra and Argonauta B-West, are pumped through risers to the Espirito Santo FPSO facility. There are few such facilities deployed in waters this deep and not many that are much bigger. The giant double-sided vessel is 330 metres long and can process up to 100,000 barrels of oil and 50 million standard cubic feet of gas per day and store up to 1.5 million barrels of oil.

Of the numerous technical innovations or advances associated with this project, too many to list here, four stand out as instrumental in ensuring its economic viability. The first concerns the drilling of the wells. Using a high-pressure drilling riser enabled Shell to go with a cost-effective, third-generation rig to drill and complete the nine production wells and one gas injector in the three fields. It was the first time this had been done. The Transocean Arctic is normally rated for drilling in waters no deeper than 945 metres; with a surface BOP, this rating was extended to 2,250 metres.
The second is that Parque das Conchas is the first full-field development in which the oil and gas are separated at the seabed and the oil is pumped to the surface. This is essential to the development, as there is insufficient energy in the reservoirs to lift the heavy oil (16–20 API) almost 2 kilometres to the FPSO facility. The power requirement is huge: the FPSO facility boasts

Espirito Santo, Parque das Conchas, Brazil

Perdido is a genuine game changer. When Shell took on the Perdido acreage, the industry was developing fields in water depths of about 1,000 metres maximum and the technology was at full stretch. Now, the Perdido facility is moored in 2,450 metres of water.

Perdido spar, Gulf of Mexico, USA

a 68-megawatt power plant to drive the subsea separation systems and the six 1,500-horsepower, high-pressure pumps that sit in specially designed artificial-lift modules on the seabed. The third, a consequence of the power needed at the seabed, is that the dynamic umbilicals linking the FPSO facility to the seabed facilities (total length 30 kilometres) are also highly unusual. They incorporate multiple high-voltage power transmission lines, steel tubes to convey hydraulic power and chemicals, and low-voltage electrical cables for control purposes and data transmission.

The fourth is that reducing the weight of the risers was critical in such deep water. Hence, the development uses buoyant steel risers that take on a lazy-wave form between the seabed and the vessel. This decouples the risers from the motion of the FPSO facility and preserves their fatigue life. This was the first use of such technology on a turreted FPSO facility.

Phase 2 of the Parque das Conchas development, in which the Argonauta O-North field will be developed using seven production and four injection wells, is under way. This second phase at peak will likely deliver an additional 35,000 barrels of oil per day in addition to the volume from the first phase of the project.

PERDIDO

Shell acquired the leases for the Perdido fields in the Gulf of Mexico in 1996. Water depths in the area range from 2,300 to nearly 3,000 metres. To add to the challenges, the seabed covers a part of the Perdido fold belt, which resembles a smaller version of the Grand Canyon and has near-vertical cliffs up to 300 metres tall. It is worth noting that when Shell took on the Perdido acreage, the industry was developing fields in water depths of about 1,000 metres maximum and the technology was at full stretch.

Ultimately, Shell discovered three fields in the area: Silvertip, Great White and Tobago, which together were judged to form a potentially economic development, as long as the right technology solution could be assembled.

Some of the Perdido reservoirs hold relatively heavy oil (17–20 API) and have low reservoir pressures. Some hold light oil. A wide variety of target zones means that the Perdido development needs many wells. There are 35 in the development plan: 22 of them clustered together. This would have been a massive, prohibitively costly host platform using conventional design concepts.

The solution was to use a buoyant spar, an established, lighter-weight, ultra-deepwater platform, in combination with direct-vertical-access wells fitted with subsea (wet) trees. This necessitated a high-pressure drilling and completion riser with a surface BOP. Also key to the whole concept was subsea separation and boosting, which is very similar to the system used first at Parque das Conchas. The produced fluids from the subsea wells are commingled on the seafloor and directed into an artificial lift module consisting of five identical separation and electric submersible pumping units. The net effect of all of this technology reduces the size and weight of the well bay, and so the platform topsides, which means the whole system can be supported on a reasonably sized spar.

The integration of these technology elements in such deep water represents one of the most remarkable achievements in the industry's history. It is an achievement that would have been impossible without the exemplary commitment, imagination, co-operation and openness displayed by Shell, its venture partners Chevron and BP, and some of the oilfield service sector's leading lights. What is particularly significant about the Perdido development is that it points the way for the development of smaller oil and gas reserves in ultra-deepwater all around the world – it is a genuine game changer.

SUBSEA PROCESSING – WORKING AT THE NEXT FRONTIER

Subsea processing arguably represents one of the oil industry's last major frontiers. It is an area of huge potential rewards and considerable technical challenges. Shell has been active in the area for many years and can take credit for world's first use of subsea multiphase pumping; this was in the Draugen field, Norway, in 1993.

The Parque das Conchas and Perdido developments were wholly reliant on subsea processing: the reservoirs in both cases have insufficient natural pressure to force the hydrocarbons to the surface and so require artificial lift. Shell engineers came up with the idea of caisson-contained electrical submersible pumps for Parque das Conchas: the first time this was tried in a continuous production environment. Parque das Conchas then replicated the design for Perdido.

Key to the development of the systems was the involvement of Shell scientists and engineers from a range of disciplines. Well, process, subsea facilities and power engineers, riser technologists and flow assurance specialists worked together and with leading equipment manufacturers to design systems that have performed remarkably well on these two iconic deepwater projects.

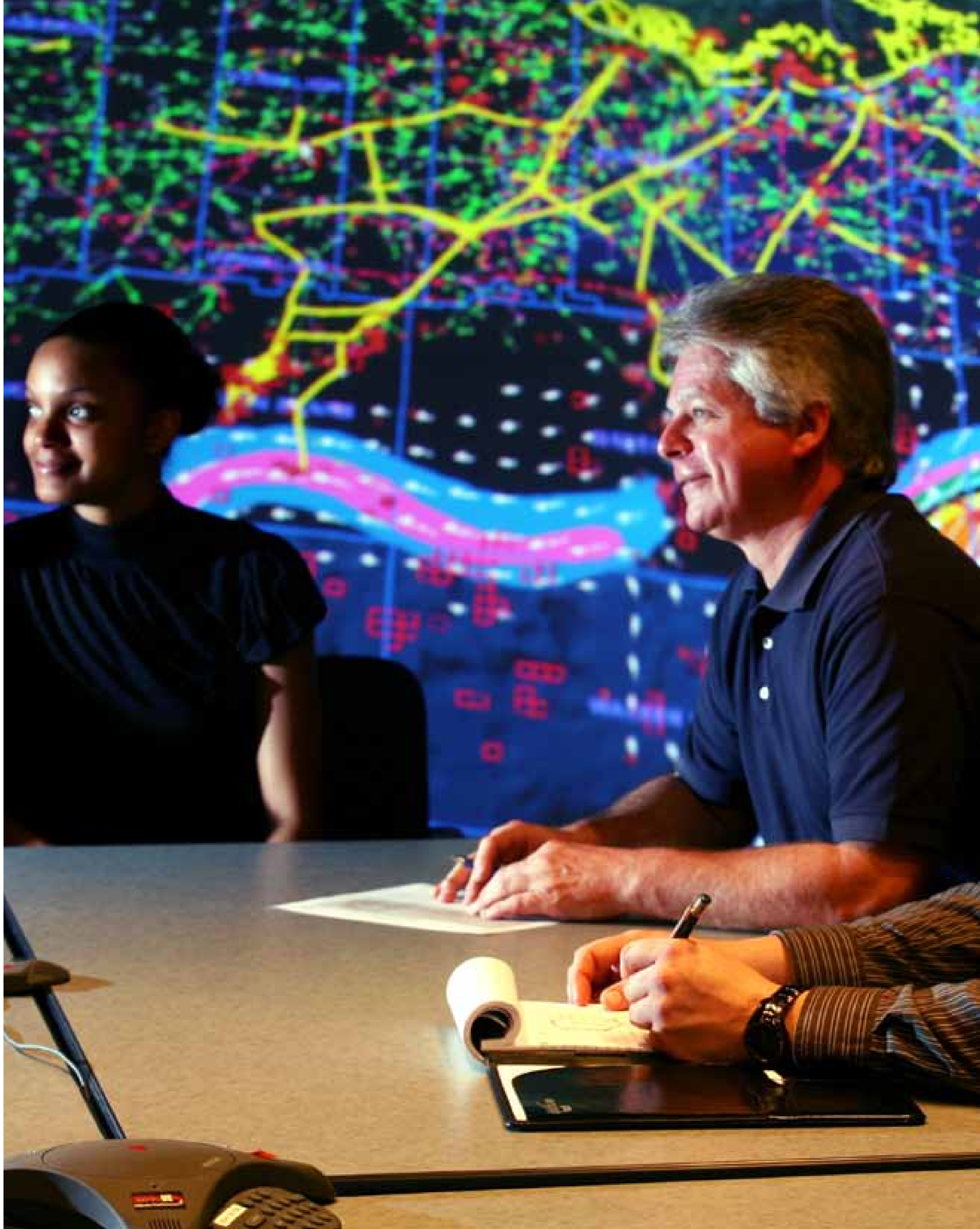
Research and technology development in this area is now targeting improved caisson designs and electrical submersible pump reliability; the qualification of downhole and seabed systems for high-pressure, high-temperature applications; fundamental understanding of new flow assurance phenomena; and measures to cope with the high salinity and scale levels commonly associated with subsalt reservoirs.

Cross section of typical umbilical

Installation of enhanced vertical deepwater tree, Perdido

We have reached the stage where water depth, per se, no longer represents quite the technical barrier it once did

Bonga Floating Production Storage and Offloading vessel, Nigeria



Looking to the future

There has been outstanding progress in deepwater, and yet new technical challenges keep on coming. At the same time, new deepwater provinces are being established and new players are entering the game. All of this promises to alter the dynamics of this exciting sector of the industry.

It is tempting to think that after so many years of deepwater oil and gas development, the challenges might have diminished. However, this is not the case.

We have reached the stage where water depth, per se, no longer represents quite the technical barrier it once did. However, increased safety and environmental challenges have come along with more complex reservoirs and fluid streams, more remote and smaller fields, and constant economic pressure. In combination, this makes life as challenging as ever for deepwater developers.

3D visualisation, New Orleans, USA

TECHNOLOGY AND INNOVATION COMMITMENT

Advances in a wide range of technologies will be necessary in the future to maintain the pace of progress. There never has been a single silver-bullet solution as far as deepwater development is concerned. For this reason, Shell remains committed to world-class research and development programmes in a variety of key areas.

Subsea compression pilot unit, Ormen Lange, Norway

We are looking to build additional capabilities in subsea processing: separation, compression, boosting and, further down the line, water injection. Flow assurance is a constant focus: our attention covers all the produced fluids from the reservoir to the point of export. Well design, containment systems and downhole sensor technology are high on our agenda for safety and production optimisation reasons.

Driving costs out of the facilities design and construction process is an important aim, so we are looking at lightweight materials and structures, greater standardisation, process automation and water management, a particularly key issue.

Over the years, we have made tremendous advances in improved and enhanced oil recovery technology, and we have several processes and techniques that we will seek to take offshore in the years ahead.

TECHNOLOGY FLOW INTO NEW EXCITING AREAS

It is generally believed that, regardless of the area in which you work, the best solutions are developed at times of greatest need. The technology solutions devised as we have moved into ever-deeper water bear this out. Deepwater has stimulated advances in oilfield technology rarely seen during any other period in the industry's history.

We now need to look at what we have gained in deep water and leverage this at other industry frontiers: floating liquefied natural gas technology is a particularly pertinent example as far as Shell is concerned. Much of what we have learned in deepwater will be immensely valuable during the next few years as we develop Prelude gas field off Australia's northwest coast using what is currently the biggest floating hydrocarbon processing facility ever built.

STANDARDISATION AND LEVERAGING GLOBALISATION

Having stressed the individual nature of deepwater projects, there are elements of these overall ventures that bear standardisation. There are elements we can replicate to reduce costs, accelerate project timescales and improve reliability. Not everything needs to be a one-off. We have shown this with the development of deepwater fields in the Gulf of Mexico using very similar TLPs. Our work to standardise tree designs is another good example, as is the recent development of the Parque das Conchas fields in Brazil and the Perdido complex in the Gulf of Mexico with almost the same subsea processing systems.

Standardisation will become even more important as the deepwater industry becomes more global. Transfer of the latest technology, development concepts and equipment designs in parallel with the application of best practices in project management, contracting, procurement and project execution will speed up deepwater projects in new provinces and help to raise their local content quickly.

LEADING THE WAY

The Deepwater Horizon disaster in the Gulf of Mexico in 2010 forced the industry to think again about safety. As well as developing technology measures to reduce the chances of such an incident recurring, we need to look at the structural relationships within the industry, to create even greater partnership and alignment between the field development community and the service sector. Strong leadership is required from all sides; at Shell, we are determined to show the way.

HELPING DEVELOP PEOPLE'S SKILLS

Projects like Gumusut-Kakap in Malaysia are valuable in many ways. They enable Shell to expand its deepwater portfolio. At the same time they help people to develop their deepwater project execution skills, and countries their deepwater capability and global competitiveness. In addition, these new projects will stimulate the formation of new supply chains which is a key focus area for the deepwater industry as more players enter the fray. Owing to high demand for key items of specialist subsea equipment, existing supply chains are coming under strain. This may ultimately impede the much needed high-pace of field development.

A stimulating and challenging working environment, plus the chance to work on projects of a remarkably diverse nature, have enabled Shell to build and retain a core of people with outstanding deepwater knowledge, experience and ability. To ensure continuous renewal at a time when there is so much competition for young talented people, Shell is partnering with universities and investing in programmes to help its senior staff become better teachers – to understand different learning processes, to communicate more effectively in various cultural settings and to coach and mentor young people on an individual basis.

We are working hard to attract the best and brightest people to join Shell Deepwater Project Centres around the world in the USA, Nigeria, Malaysia and Norway.

Developing talent worldwide is perhaps the biggest challenge we face if we are to continue to overcome the technology, project execution and safety challenges deepwater developments will inevitably present.

To maintain the pace of progress, advances in a wide range of technologies will be needed in the future

GUMUSUT-KAKAP POINTS THE WAY FOR DEEPWATER GLOBALISATION

The Gumusut-Kakap project offshore Malaysia is a great example of how deepwater expertise developed in the Atlantic basin, and especially the Gulf of Mexico, is delivering value around the world. The Gumusut and Kakap fields were combined into a single development: Shell and ConocoPhillips Sabah Ltd each hold 33% interest in the development, PETRONAS Carigali has 20% and Murphy 14%. Shell is the PETRONAS-appointed operator of the Gumusut-Kakap development.

The Gumusut-Kakap development offshore Sabah is Shell's first deepwater project in Malaysia. It will have 19 subsea wells linked to a semi-submersible Floating Production System (s-FPS) moored in 1,200 m of water. The oil will be exported by pipeline some 200 km to shore in Kimanis, Sabah. The associated produced gas from the field will be reinjected to improve oil production.

Shell Smart Fields® technology will optimise production at Gumusut-Kakap. Smart Fields technologies integrate digital information for real-time decision making by an integrated well and reservoir management team, and help to develop a comprehensive understanding of the entire production system from reservoir to sales point. This leads to a high standard in day-to-day production system surveillance and optimisation, and accurately targeted future development options. It keeps the system availability in the top quartile and ensures top quartile cost. An important enabler for this is the 'Smart Fields technology' exception based surveillance, whereby thousands of real-time data feeds are computer-monitored, and production system issues are flagged before they arise.

The Malaysian content of the project is high. The 40,000-tonnes FPS is owned by Malaysia International Shipping Corporation (MISC) and is being built at the Malaysia Marine and Heavy Engineering (MMHE) fabrication yard in Pasir Gudang, Johor. MISC will lease the s-FPS to Shell and it co-venturers.

The project is being led from Shell's deepwater major projects office in Kuala Lumpur, which is also serving as a training centre for Shell's Malaysian engineering staff. Malaysian contractors are also providing hundreds of local graduate engineers to the project, all of whom are accumulating valuable first-hand experience.

DISCLAIMER

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this brochure 'Shell', 'Shell Group' and 'Royal Dutch Shell' are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words 'we', 'us' and 'our' are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. 'Subsidiaries', 'Shell subsidiaries' and 'Shell companies' as used in this brochure refer to companies in which Royal Dutch Shell either directly or indirectly has control, by having either a majority of the voting rights or the right to exercise a controlling influence. The companies in which Shell has significant influence but not control are referred to as 'associated companies' or 'associates' and companies in which Shell has joint control are referred to as 'jointly controlled entities'. In this brochure, associates and jointly controlled entities are also referred to as 'equity-accounted investments'. The term 'Shell interest' is used for convenience to indicate the direct and/or indirect (for example, through our 34 percent shareholding in Woodside Petroleum Ltd.) ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest. This brochure contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as 'anticipate', 'believe', 'could', 'estimate', 'expect', 'intend', 'may', 'plan', 'objectives', 'outlook', 'probably', 'project', 'will', 'seek', 'target', 'risks', 'goals', 'should' and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this brochure, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for the Group's products; (c) currency fluctuations; (d) drilling and production results; (e) reserve estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments, including potential litigation and regulatory effects arising from recategorisation of reserves; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this brochure are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional factors that may affect future results are contained in Royal Dutch Shell's 20-F for the year ended December 31, 2011 (available at www.shell.com/investor and www.sec.gov). These factors also should be considered by the reader. Each forward-looking statement speaks only as of the date of this brochure, April 2012. Neither Royal Dutch Shell nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this brochure. The United States Securities and Exchange Commission (SEC) permits oil and gas companies, in their filings with the SEC, to disclose only proved reserves that a company has demonstrated by actual production or conclusive formation tests to be economically and legally producible under existing economic and operating conditions. We use certain terms in this brochure that SEC's guidelines strictly prohibit us from including in filings with the SEC. US investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330. Royal Dutch Shell plc, Carel van Bylandtlaan 30, 2596 HR The Hague, the Netherlands. Registered Office: Shell Centre, London, SE1 7NA.

Any supply of the technology is subject to agreement on a contract and compliance with all applicable export control regulations.

ECCN: Not subject to EAR – Publicly Available

For further information on Shell technologies, contact: technology-news@shell.com

Design and layout by Graphics, Media and Publishing Services Rijswijk/P06509