SECTION 2
HISTORICAL DEVELOPMENT OF DYNAMIC POSITIONING

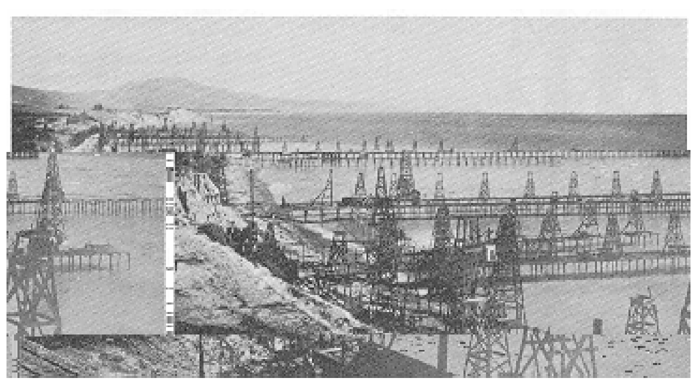
Background

Petroleum products play an important part in our modern civilisation, but even in Noah's time, tar was used to stop leaks in boats and ships. Later mankind has discovered more and more ways of taking advantage of these products.

Oil was first found near the Caspian Sea. The oil was discovered on land, but as time went on it was found that these oil fields extended into the sea. As early as the beginning of the 18th century a well was drilled about 30 m off the coast line near Baku. Even though this was not a success, it was still the start of an era. In 1925 the first oil producing well was drilled in the Caspian Sea.

Sicilian sailors "fishing" for oil -
Painting of Johannes Stradanus (1523-1605)

The oil fields in California were also found to be extending into the sea, so the oil wells were gradually moved into the sea here as well. These wells were connected to shore by piers, see picture below. At first these piers or platforms were built of tree, but soon steel took over. These piers could measure over 400 m.



Summerland, California 1902

It did not take long before the piers were replaced with free-standing oil platforms in the sea. The following shows the development from these piers to today's drilling platforms:

1869 The Americans, Thomas F. Rowland and Samuel Lewis respectively, took out a patent on a jack-up platform and developed a project for a jack-up vessel.

1897 Oil drilling from a wooden drill tower, connected to shore by a pier in Summerland, California.

1906 The coast of Summerland: 200 oil producing wells offshore.

1924 The first oil well in Lake Maracaibo, Northwest Venezuela.

1934 The first steel oil rig installed in the Caspian Sea, near Artem Island.

1947 Drilling in the Gulf of Mexico at a depth of 6 m. The platform could not be seen from shore (Louisana) except with binoculars.

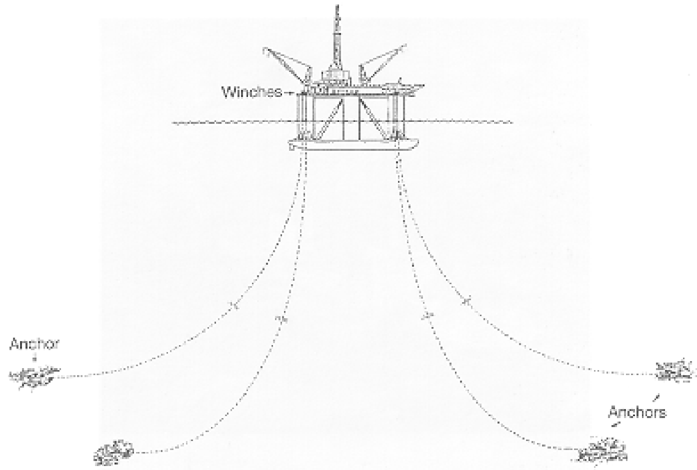
1963 The jack-up platform Le Tourneau was constructed for drilling at a depth of 75 m.

1976 The Hondo Field platform was installed off South California at a depth of 260 m.

1978 The Cognac Field platform was installed off Missisippi at a depth of 312 m. Weight around 59 000 ton steel.
A platform made of concrete was installed at the Ninian Field in the North Sea at a depth of 138 m.

1988 The Bullwinkle, a jack-up platform, was installed in the Gulf of Mexico at a depth of 411 m (world record). Weight around 77 000 ton.

The installation of these platforms was expensive and it was even more expensive to move them from place to place, so that test drilling for shorter periods was not interesting. The restrictions they had with respect to water depth (normally 300 m) made it necessary to look for other ways of extracting oil from the sea. The industry needed methods for drilling in deep water, and an easier and less expensive way of moving the drilling activity from place to place. This gradually led to the method of anchoring drilling vessels and portable platforms. Several anchors or weights were used to keep the vessel/rig in place, which at the same time minimised the movements.



Schematic drawing of a four point anchoring system.

The following is a list of some of the offshore operations where anchoring systems have been used:

1953 *SUBMAREX*, the first drilling vessel to use anchoring. This took place off the coast of California at a depth of 120 m.

1954 The first drilling vessel in the Gulf of Mexico.

1962 The first semi-submersible drilling platform, *C.P. BAKER*, constructed in the USA.

1970 Test drilling at a depth of 456 m from the drilling vessel *WODECO 4*.

1976 A world record in deep water drilling was set by the anchored vessel *DISCOVERER 534* at a depth of 1055 m off the coast of Thailand.

1987 New world record in deep water drilling set by *DISCOVERER 534* at a depth of 1985 m.

The anchoring systems have, however, their weak points. Elasticity in the anchoring system, poor hydrodynamic damping, etc., expose the vessel or the rig to movements made by waves, wind and current. In addition, drilling at such depths requires a lot of equipment (winches, anchors, wires, etc.) with the result that vessels using this type of system lose a great deal of their manoeuvring capability.

The Mohole Project

The very first dynamic positioning system was used in 1957 in connection with the American Mohole project. The purpose of this project was to drill into the so-called Moho layer, that is, through the outer shell of the earth. To succeed in this the drilling was to be done where this shell is at the thinnest, and that was where the great oceans are at the deepest. The depth was around 4 500 m, and that was far too deep for the usual anchoring systems.

The problem was solved by installing 4 manoeuvring propellers/thrusters onboard the barge, *CUSS 1*. The position in relation to the seabed was found by lowering a transmitter down to the seabed which transmitted signals up to the barge (some form of hydro acoustic reference system). The position in relation to the transmitter could be read on a display onboard the barge. In addition, 4 buoys anchored around the vessel were used. These transmitted radio signals to a radar onboard. By using different combinations of thrust and direction for the 4 propellers, it should be possible to keep the barge in position above the place of drilling. 9th March 1961 the *CUSS 1* was able to maintain position by the help of dynamic positioning at a depth of 948 m off La Jolla, California (picture below). Some time later the vessel did 5 drillings at a depth of 3 560 m, while maintaining position within a radius of 180 m.

CUSS 1,
the first vessel to be dynamically positioned in connection with the Mohole project in 1961

Automation of DP

The idea of developing an automatic control unit to take care of the DP function was born. Later that year (1961) the Shell Oil Company, USA, launched the drilling vessel *EUREKA*. Very soon equipment which automated the thruster commands was installed. In 1964 another vessel, *CALDRILL 1*, was delivered to Caldrill Offshore Company, USA, with similar equipment onboard. Both the *EUREKA* and *CALDRILL* projects were successful. *EUREKA* drilled at a depth of 1 300 m with 6 m high waves and a wind of up to 21 m/s. *CALDRILL* could drill at depths of maximum 2 000 m and was equipped with 4 manoeuvrable thrusters, each with 300 hp. The position was found using two taut wire reference systems.

French engineers watched the American projects closely. France had interests in companies laying pipelines in the Mediterranean, and dynamic positioning could make these operations safer and more efficient. In 1963 the first dynamically positioned French vessels, namely Salvor and Tèrèbel, were laying pipelines in the Mediterranean.

A few years later the oil adventure started in the North Sea, and Norway and the UK became interested in dynamic positioning. British GEC Electrical Projects Ltd equipped in 1974 *WIMPEY SEALAB*, an old cargo vessel converted to a drilling vessel, and in 1977 *UNCLE JOHN*, a semi-submersible platform, with equipment similar to that which the Americans and Frenchmen had named Dynamic Positioning (DP) System.

Norwegian ship owners wanted a DP system produced in Norway because of the problems connected with getting service in the North Sea from Honeywell, who had roughly the whole DP market in the early 1970's. Research was started up in Trondheim and a concept was presented. Kongsberg Våpenfabrikk (KV) was chosen to carry out the project and Stolt Nielsen ordered the first system. The first vessel to use a Norwegian DP system was the *SEAWAY EAGLE* on 17th May 1977.

Dynamic positioning has changed a lot since *CUSS 1* in 1961. From being designed for test drilling and laying of pipelines, DP is now being used for different types of operations, ranging from geological assignments, via military ones, to cruise ship manoeuvring in lagoons. The basic principles from 1961 are the same, but the explosive development within data has led to a similar development in DP systems, both when it comes to operating the equipment and the technology itself. In short, a DP system can be defined as:

a computer-based automatic positioning system for floating vessels

The DP system is used to keep a vessel in position, or to move a vessel from one position to another with low speed.

The History of Kongsberg DP System

The Norwegian DP adventure started in 1975 at the Kongsberg Våpenfabrikk (KV) with a small group of engineers called Dynpos, belonging to the Defence Division. The group was soon moved to the Oil Division, which was the Offshore Division in Kongsberg Våpenfabrikk.

Today, more than 30 years later, Kongsberg Maritime is the world's largest manufacturer of DP systems.

Kongsberg DP systems are divided into two main groups;

* KV technology with Kongsberg System 500 based systems, KS500, from the early years. This computer was developed by Forsvarets Forskningsinstitutt and Kongsberg Våpenfabrikk at the beginning of the 1970's and is built up around TTL logics.

* New technology with SBC based systems came from 1983 onwards. SBC, Single Board Computer, was developed by Kongsberg Simrad and uses Intel microprocessors 80186, 80286 and 80386 on respectively SBC1000, SBC2000 and SBC3000/SBC3003. The prototype of SBC1000 was the first computer in the world using Intel 80186 microprocessor.

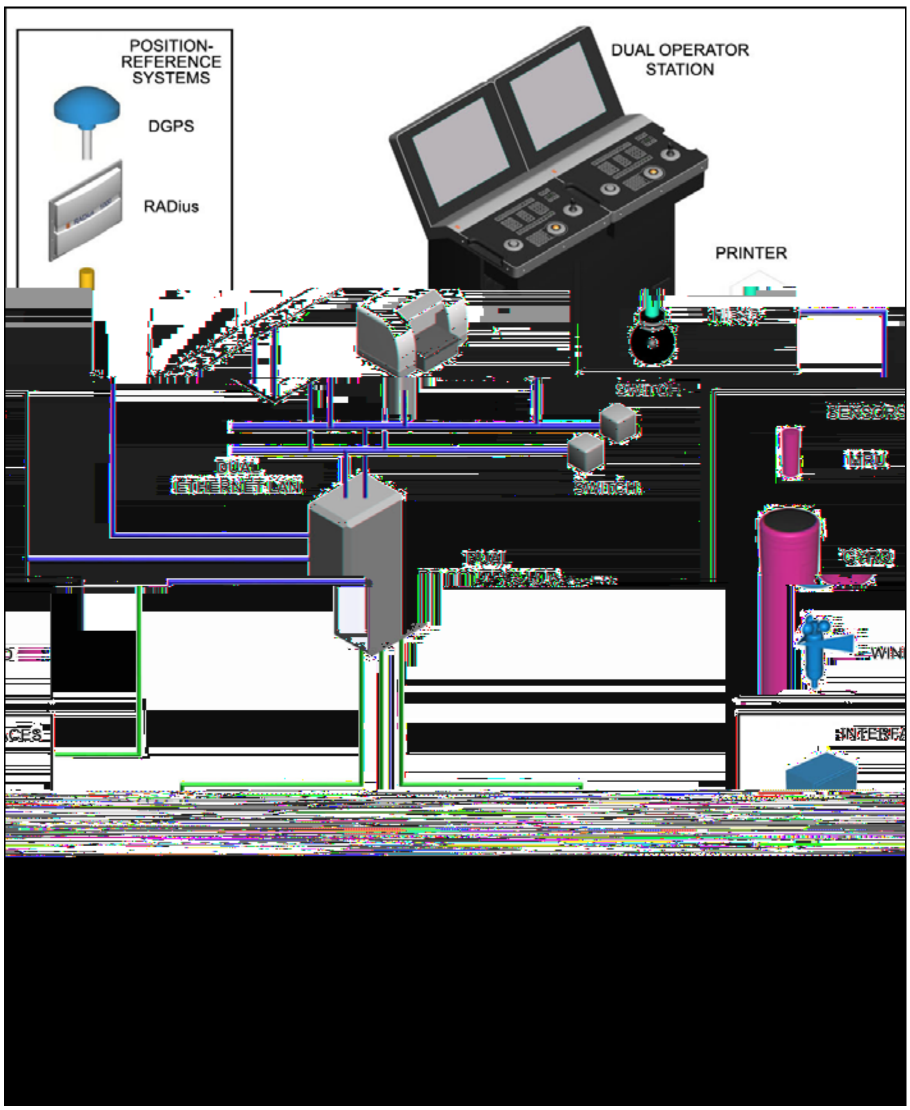
DP System Development

1977	ADP501 ADP502 ADP503	1 KS500 64k computer, HPR display 1 KS500 64k computer, display processor 3 KS500 64 k computers, 2 display processors
1979	ADP503 MkII ADP311	3 KS500 128k computers, 2 colour displays 1 KS500 128k computer, 1 colour display, 1 cabinet
1983	APM3000 ADP100	2 KS500 256k computers, 1 display 3 SBC1000, 1 display
1987	ADP703 rev. 0	9 SBC1000, voting, 2 displays
1990	ADP701 rev. 0 ADP700	2 SBC2000, 1 display 1 SBC2000 with joystick terminal
1992	ADP701 MkI & II ADP702 MkI & II ADP703 MkI & II STC	1 SBC3000, 1 display 2 SBC3000, 2 displays 3 SBC3000, 3 displays SBC3000 Thruster Control
1996	SDP11/12, 21/22, 31/32 SPM SJS01/SDP01 STC	SBC400 DP Controller and NT workstation SBC400 DP Controller and NT workstation Joystick/Compact DP (replace Robertson products) SBC400 Thruster Control and NT workstation
2001	SDP GreenDP (SDP11/12,21/22,31/32)	SBC500 DP Controller and NT workstation
2003	SDP/SDPM/SPM (SDP11/12,21/22,31/32)	SBC500 DP Controller and XP workstation
2004	SDP/SDPM/SPM (SDP11/12,21/22,31/32) cJoy cPos STC-400	RIO-based DP Controller and XP workstation RIO-based compact joystick system RIO-based compact DP system (equipment class 1) RIO-based Propulsion and Thruster Control System
2006	K-POS (DP11/12,21/22,31/32) K-Thrust	RIO-based DP Controller and XP workstation RIO-based Propulsion and Thruster Control System

The System

A modern dynamic positioning system consists of the following 7 main parts:

*	The control unit with the computer
*	Thrusters
*	Power supply
*	Position Reference systems
*	Sensors
*	Instruments/operator panels - MMI (Man-Machine interface)
*	Operator



The Control Unit with the Computer

The control unit receives signals from the sensors, position reference systems, thrusters and control panels, processes these signals and uses them to calculate how much thrust and in which vector direction this thrust has to be used for the vessel to maintain position and heading. These calculations are then converted into signals which are sent to the respective thrusters and the displays on the control panels.

Thrusters

These are propellers used to move the vessel. Usually the thrusters move the vessel in a fixed direction, but by combining several thrusters the vessel can be moved in all directions. The thrusters receive signals from the control unit. These signals contain information of how much thrust the thrusters shall use, and in which direction. The thrusters execute the commands given and give feedback to the control unit.

Power Supply

The computer, panels, sensors, reference systems and not the least, the electrically driven thrusters need power to function. This power is being produced and distributed by the power supply. The system includes generators, switchboards, cables, etc.

Position Reference Systems

Position reference systems can be based on, for example, radio signals (Artemis), satellite signals (DGPS) or mechanical signals (Taut Wire), which give the control unit information of position, either geographical or in relation to a given reference position (or movement from this). The control unit uses these positions for its calculations, which enables the control unit to put the vessel into a coordinating system with position, wanted position and wanted heading, direction and speed.

Sensors

The sensors give the control unit information about current, wind, waves, heading, draught, etc. The information is used in the calculations which give an overview over the vessel’s condition and movements, etc. Together with the position reference systems, the sensors provide all the data for the calculations done in the control unit.

Displays / Operator Panels

This is the link between the DP system and the people who is operating it. The display shows the status of the vessel and the DP system continually, and the operator is able to give new instructions and commands to the control unit continually by the operator panel. The operator is able to take over all, or more usual, parts of the control unit's tasks, for example manual control of the thrusters.

The Operator

This part of the DP system is the most important. The operator decides how the system is to work and what it has to do. His role has become more important over the years. Certification and regulations are continually under development and form the terms under which the operator works.

The DP System - Summary

Generally a DP system can do the following:

* Measure and calculate the forces acting on the vessel.
* Calculate how the vessel reacts to this information.
* Calculate the difference between wanted and real position and heading.
* Calculate how the vessel, by the help of the thrusters, can obtain wanted position and heading.
* Give commands to the thrusters according to the calculations.
* Control that the vessel reacts as expected, and adjust for possible errors.