The combination of deeper water operations, working in areas of high ocean current and the use of heavier BOPs result in wellheads and risers experiencing greater fatigue. Due to the environmental and financial consequences of a fatigue induced wellhead failure, conservative assumptions have to be made during the preliminary analysis of wellhead integrity. These conservative assumptions can shorten drilling campaigns and reduce the actual operating window of drilling vessels.

**FUGRO SOLUTION**
The Wellhead and Riser Instrumentation Service (WARIS) accurately determines and tracks fatigue on wellheads, drilling risers and production risers against predictions. WARIS can also identify vortex induced vibration (VIV) events, estimate soil stiffness changes during a campaign and provide data for verification of riser models to help improve the efficiency and safety of well operations.

**BENEFITS**
- Enhances the understanding of wellhead integrity and riser behaviour
- Reduces environmental and financial risk
- Reduces drilling downtime
PROVEN TECHNOLOGY
WARIS is a valuable tool in understanding the real issues experienced by structures during well operations.

The system and data analysis tools used in WARIS are continually developed and refined and have a proven track record in a diversity of environments around the world, including areas such as the North Sea, Caspian Sea and Gulf of Mexico.

FEATURES
- Accurate wellhead and riser motion data
- Fatigue monitoring
- VIV monitoring
- Soil stiffness monitoring
- Self-logging or real-time monitoring
- Metocean data integration

FATIGUE MONITORING
The first stage of determining fatigue is to measure the motions of the BOP stack. Using subsea motion sensors (DeepData pods), WARIS collects motion data to determine the fatigue experienced by risers and wellheads.

This motion data can be used to calculate the stress cycles at the wellhead. A rainflow counting algorithm is applied to the data and the corresponding fatigue damage is calculated using an S-N Curve.

Often the measured fatigue is found to be less than the expected fatigue. The subsequent re-factoring of the wellhead and riser model can lead to an increase in the predicted fatigue life of the wellhead, increasing the number of well operations permitted.

VORTEX INDUCED VIBRATION MONITORING
In areas with high currents, risers can experience VIV which can cause significant riser displacement transverse to the direction of current flow.

VIV can therefore be a significant cause of fatigue for the riser and the wellhead. WARIS monitors the motion of the riser for VIV events and this allows the vibration modes of the riser to be identified through spectral analysis of the measured motion signals.

SOIL STIFFNESS MONITORING
Soil stiffness can change during well operations affecting assumptions made during modelling.

The fixity depth can be determined from the accelerometer and angular rate signals on the BOP stack. The determined motions of a wellhead can be used to refine the best estimate of dynamic soil stiffness, thereby improving the structural model of the riser and wellhead.
WARIS BASE SYSTEM
The standard WARIS configuration provides quality controlled motion data for the lower marine riser package (LMRP) and the first joint on the riser.

The motion data is recorded by DeepData subsea motion sensor pods that log motions to a memory card. These DeepData pods form the core of all WARIS configurations.

Each DeepData pod has high-performance linear accelerometers and angular rate sensors to measure motions. The sensor signals are filtered by a specially designed low-pass filter to prevent aliasing before acquisition by the data logger at a sample rate of 10Hz. The accelerometers are DC-coupled, which also allows them to read the static inclination derived from the component of Earth’s gravity.

For ROV deployment and recovery, receptacles or clamps can be added at the BOP stack and riser locations, allowing the pods to be ROV deployed and recovered as required. This enables regular updates of actual subsea motions rather than having to wait for DeepData pod recovery during riser running.

REAL-TIME MONITORING
Real-time monitoring of fatigue, VIV and other parameters can be a distinct advantage during operations in harsher metocean environments or where predicted fatigue life is low.

Historically, cabled solutions have been used for real-time monitoring, but this solution can cause delays in riser running operations. As an alternative, hydroacoustic modems can be deployed with DeepData pods to facilitate real-time communication to the surface.

In both cases, a data acquisition system is installed on the vessel to collect all WARIS data. The data can then be transferred automatically onshore via the internet for timely release of quality controlled data and reports. The data is also continuously logged within the DeepData pod to mitigate against any metocean generated data drop-outs.
METOCLEAN INTEGRATION

For the complete characterisation of VIV events and correlation of subsea structural motions with currents, it is essential to also measure the current profile through the water column at the vessel.

This can be achieved with one or more Acoustic Doppler Current Profilers (ADCP). A 38kHz ADCP deployed from the vessel can profile current speed and direction to a nominal range of 1000m. Additional ADCP systems can be deployed to monitor more of the water column as necessary.

Wave loading may be the dominant driver for fatigue in some locations. In this situation the data acquisition system can interface with the vessels Environmental Monitoring System (EMS) to collect the relevant wave data for later analysis with the subsea data.

A vessel Motion Reference Unit (MRU) can also be connected to the data acquisition system. Vessel motions can then be correlated with riser motions or help with heave compensation for the wave radar.

STRAIN MONITORING

WARIS is modular and scalable and other sensors and equipment can be integrated such as strain sensors.

Clamp-on strain sensors deployed on drilling risers provide a direct measurement of dynamic bending loads and fatigue cycles on the riser. Each DeepData pod can monitor up to 4 external strain signals.

DATA ANALYSIS

A quality report on motion data with checks on data availability, a general assessment of data validity and identification of any spurious data forms is issued as standard.

Data validity is carried out by plotting statistics data (standard deviation, maximum and minimum) and comparing it between DeepData pods. Spot checks are performed on power spectrum files to confirm evidence of expected spectral content (e.g. peak wave excitation and riser modes).

The content of extended reports is tailored to clients' individual requirements, but would typically include fatigue calculations, VIV assessment and soil stiffness calculations. Reports can also include full spectral and modal analysis of structural responses.