

Photogrammetry, pushing the limits subsea

AUTHORS

Guillaume DELAETER, KAOMBO SURF Operations Manager, TOTAL E&P Angola

Frédéric AUGER, Chief Project Surveyor, TOTAL SA

Arnaud VIDAL, Survey & GIS Lead, TOTAL E&P Angola

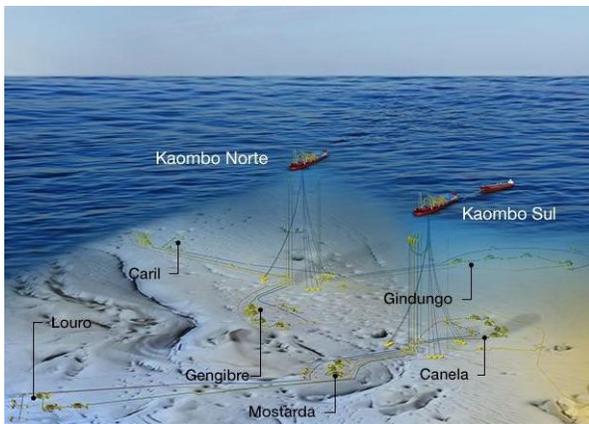
Régis MORTIER, Senior Survey Engineer, TechnipFMC

Vincent BRICOUT, Senior Project Surveyor, TechnipFMC

Bertrand CHAZALY, Digital and 3D Expert, FUGRO

ABSTRACT

Operated by TOTAL E&P Angola, KAOMBO is the first project on the ultra-deepwater offshore Block 32, located off the Angolan coast. As part of the project development phase, hundreds of kilometers of pipelines and tens of subsea structures were installed by TechnipFMC and its partner Heerema in 2017, in water depths ranging from 1,400 to 1,900 meters.



Some of these structures are installed separately and then require to be tied in using rigid spool pieces. In order to avoid excessive fatigue of the structures, the exact dimensions of the spools need to be determined with the highest achievable accuracy. FUGRO performed subsea measurements on metrology receptacles, allowing precise Hub to Hub 3D metrologies between two structures. However, the moment the integrity of a metrology receptacle is compromised, an accurate metrology cannot be guaranteed, meaning the spool may not fit at all or may fit but with impact on the spools' connectors integrity.

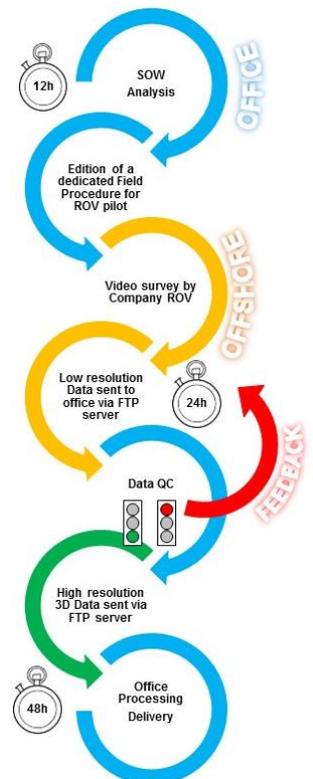
This situation was faced on KAOMBO when some receptacles fitted onto the structures were questioned, having several degrees of movements in yaw, far over the acceptable metrology tolerances. At this stage, performing a standard subsea metrology is no longer possible and there are no off the shelf technical solution.

How to perform a subsea millimetric dimensional control to reassess the integrity of the receptacles, without using any additional technologies, mobilizing any new equipment or staff, and spending too much time on it ?

TechnipFMC and FUGRO teams have solved the problem by implementing a short acquisition and processing chain using subsea photogrammetry. The idea was to use the ROV HD video cameras already mobilized on site.

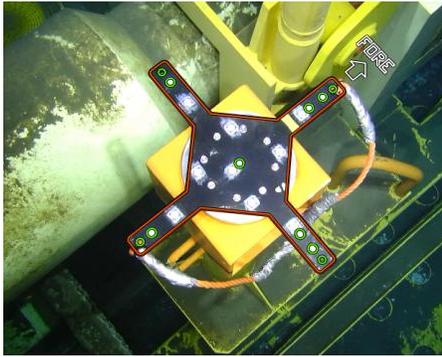
A dedicated acquisition strategy was planned in a few hours, with strict instructions delivered to the ROV pilot, concerning the trajectory of the ROV around the points of interest, speed, direction of shooting, lighting and camera settings.

Recorded HD videos were sent to the FUGRO office straight after data collection, to first QC and validate the images, prior to giving the green light for ROV demobilization. Then, the stereo photo coverage could be processed and merged with the terrestrial photogrammetric survey of the same structures, performed a few months earlier on construction yards.





The strategy allowed the post-calibration of the ROV cameras, and accurate recalculation of the positions and attitudes of the receptacles, with final errors relative to the structure better than 0.5 mm for position and 0.1° for angles.



Survey	X	Y	Z	Pitch	Roll	Heading	
Onshore - DC	0mm	0mm	0mm	-0.59°	-0.47°	-0.26°	
Offs. DC - (CW)	0mm	-0.5mm	1.1mm	-0.44°	-0.48°	1.39°	
Offs. DC - (CCW)	-0.7mm	-0.6mm	2.7mm	-0.50°	-0.50°	-0.31°	
Offshore Survey - Results Accuracy							
Receptacle (SWM)	Minimum Pixel Resolution	Min Residuals	Max Residuals	Position Error	Pitch Error	Roll Error	Heading Error
CW Position	0.9mm	0.2mm	0.3mm	0.3mm	0.04°	0.06°	0.05°
CCW Position	1.3mm	1.2mm	0.4mm	0.4mm	0.05°	0.06°	0.06°

Subsea photogrammetry survey has been proved to be an optimal, reliable and efficient technology for the subsea dimensional control surveys performed on KAOMBO Project. A very good performance has been observed using this methodology since all required dimensional surveys could be completed successfully and deliverables provided within 48h for metrology computation. It was also verified as efficient from an economical, logistical and operational point of view and therefore very suitable for offshore operations with the current industry constraints.

During the presentation, the acquisition, processing and QC methods will be developed, as well as the background of this operation, the current and potential future applications.