The evening of the 12th of May saw SUT host an industry audience for an interesting presentation delivered by Cranfield MSc students on their MSc group research project. The students discussed the technical feasibility of undertaking an all-subsea field development - a much discussed concept within the industry which seeks to totally eliminate the use of any floating production facilities by transferring all production and processing underwater.

The Chairman, Alex Hunt, introduced the topic by referencing a recent DNV GL position paper which discussed various process steps to manage raw fluid streams for an all-subsea scenario. With the simplified process layout being limited in scope, Cranfield MSc students were given the task of expanding the work carried out by DNV GL, by adding as many process steps as possible and critically analysing each step based on technology readiness levels (TRLs) for each process module to in order to determine the maturity of the subsea factory concept.

The project goal was to “assess the technical feasibility and operational desirability of locating each sequential processing step of a full process-facility on the seabed to identify items that require further development and qualification”.

Full wellstream processing generally consists of 2 or 3 parallel streams (oil, gas and water). Depending on the field’s characteristics, each stream could consist of a number of processes such as compression, boosting, separation, heating, etc. (including storage). For each processing step in sequence, students were required to:

- Identify different possible technology solutions, the major equipment items and monitoring/control requirements.
- Assess the suitability for subsea deployment based on technical feasibility and operational desirability, providing recommendations on solution and location (i.e. subsea or onshore).
- Identify technology gaps and recommend areas for further development.

The students were given parameters based on a large volatile oil field scenario of 150,000 bpd oil processing, 250 MMSCFD gas processing, 120,000 bpd water processing, 180,000 bpd water injection, 5% CO₂, 0.5% H₂S, 2,200m water depth and 100 km from landfall. This was based on a Santos Basin "Replicant" FPSO, offshore Brazil.
The students argued the case for the subsea factory concept as it improves personnel safety and solves the problem of space on topside. It was also highlighted that proximity to wells provided by the subsea factory greatly increases hydrocarbon recovery. The students also assessed existing technologies based on ease of maintenance, flexibility and robustness. Examples were drawn from existing subsea processing developments such as the Statoil’s Åsgard subsea dry-gas compressor which scores high on safety but low on OPEX (high cost) due to high power consumption. Other field concepts such as the Gullfaks subsea wet-gas compressor (Statoil) and Ormen Lange subsea dry-gas compressor (Norske Shell) also score high on safety.

Conclusions
Oil stream: Analysis of the oil stream shows that the process chain breaks for subsea processes requiring desalting or mercury removal, as more work is required in technology qualification for subsea deployment. In such situations, the students recommended crude oil transport via single-phase pumps to onshore processing facility. The students also concluded that subsea oil storage may also be a suitable option for smaller fields and remote locations.

Gas stream: For the gas stream, cryogenic requirements cause the process chain to break at the NGL modules (NGL recovery, separation and storage modules). However, the removal of gas impurities is feasible with the use of semi-permeable membranes.

Water stream: Although the requirements for water polishing and seawater treatment are largely dependent on reservoir rock properties, the technologies for subsea water processing are fairly mature (moderate to high) as the only major challenge to full scale all-subsea field deployment is water handling for ultra-deepwater applications.

Commercial feasibility: Alex Hunt rounded up the presentation by discussing the major issues surrounding the commercial feasibility of the subsea factory concept. Subsea gas production would generally require a gas reception terminal to be constructed at shore. It would therefore be more practical to have the complicated production processes onshore rather than subsea due to ease of accessibility and lower OPEX. For the oil stream, desalting may not be required due to downstream refining processes carrying out this function. The Q&A session concluded a fascinating presentation, with guests being treated to fine refreshment of cheese and wine.

DNV-GL study scope (image © DNV GL)
Student’s adopted processing scope with recommendations (image © Cranfield University)