FPSO offloading experience

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1) Side-by-side mooring

2) Tandem offloading

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and

The industry view

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Historical developments:

- Tankers/LNG carriers are offloaded moored to jetties
- Start F(P)SO-systems: offloaded side-by-side
  (examples: Afrikia, Jepco North Yemen)
- Later all F(P)SO-systems are offloaded in tandem
- Now FSRU-systems are again offloaded side-by-side
  (Floating Storage and Regasification Unit); using
  loading arm more easier than large offloading boom
  and
- what are the theoretical developments?
Tanker moored to jetty
Offloading restrictions:

- too high mooring line loads
- too large displacement of loading arms
Side-by-side mooring
Similar as tanker moored to jetty, but now both tankers are weather vane:
- two-body: wave frequency motions (interaction)
- two-body: wave drift forces (interaction)
- current loads on two bodies (interaction)
- low frequency damping on two bodies (interaction)
side-by-side current coefficients on offloading vessel

VLCC (WD/T=1.7)
1) Jacknifing effects with high loads in bow breasting lines and in aft fender

Shallow water
2) Possible ship handling problem-
Maneuvering approach to the FPSO: danger for collision
Benign weather conditions
Motions and fender/line forces can be computed for (see ISOPE paper 2001)

-offloading tanker side-by-side moored to turret moored tanker

-only irregular waves

first order motions and low frequency forces/moments of both vessels

Surface lid between both vessel to suppress numerical anomalies

Simple linear viscous terms (still water) between both vessels.
Surface lid between the shuttle and FPSO to suppress the numerical anomalies
Tandem:

- Approach FPSO similar as for SPM-buoy maneuver
- Tug to ensure stability and sufficient gap between moored offloading tanker and FPSO

Turret moored FPSO

- Both tankers weathervane

Spread moored FPSO

- tandem offloading in benign environment: only offloading tanker weather vanes

Benign weather conditions
Bohai Bay-23 and 31 m
Benign weather condition; take into account squall winds
Maximum structure response can vary considerably for different squall records even if all squall records are scaled to the same peak wind speed.
in wind, waves and current
- RAO of two bodies 3-D linear potential theory
- shielding effect wind and current
- wave drift forces of two bodies 3-D linear potential theory

Shielding Effects
(Interaction)

Interaction Wave Drift Forces
Wind and current shielding in wind tunnel

FPSO with process equipment

Data base different positions of shuttle w.r.t FPSO