

# **FPSO offloading experience**

**FPSO FORUM October 3, 2001-LISBON**

- 1) Side-by-side mooring**
- 2) Tandem offloading**

by

**Dr. Johan Wichers-MARIN USA Inc.-Houston**

and

## **The industry view**

by

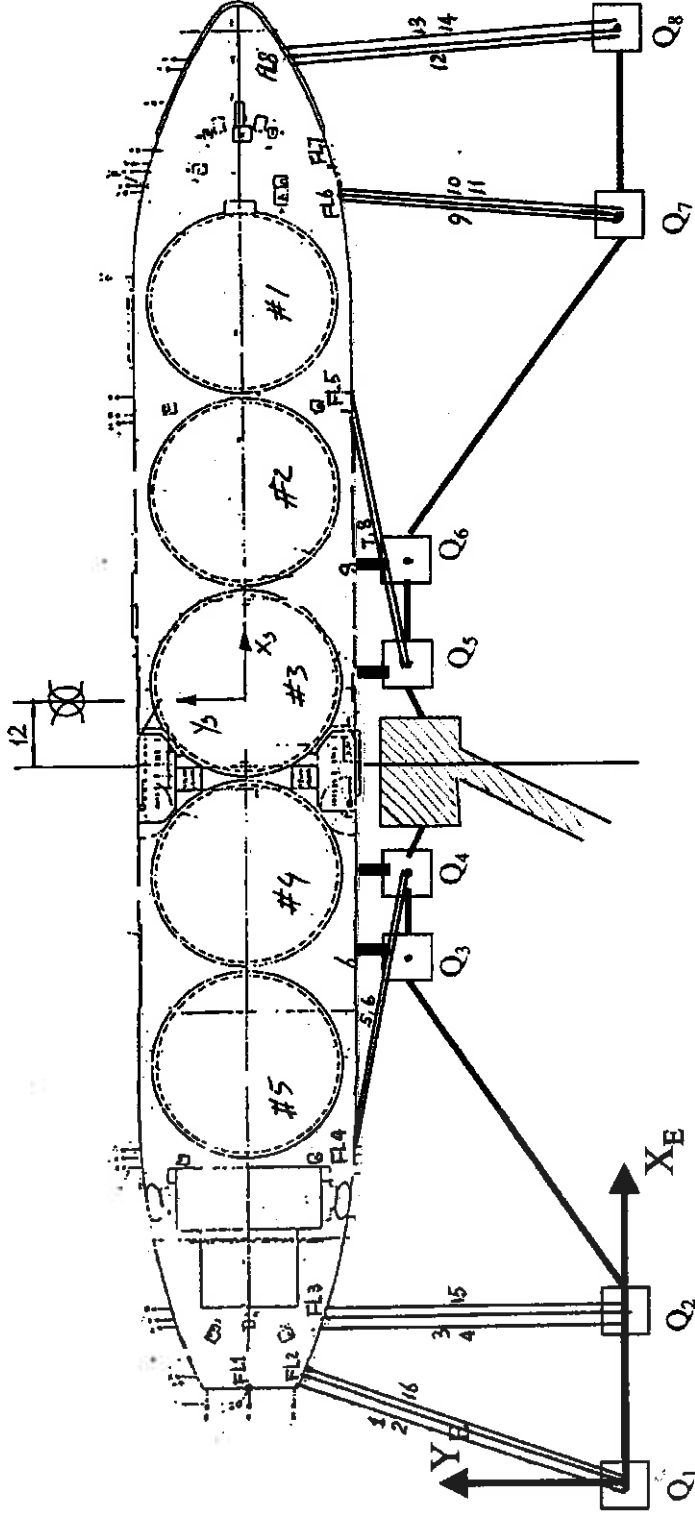
**Dr Arun Duggal- FMC/SOFEC-Houston**

Historical developments:

- Tankers/LNG carriers are offloaded moored to jetties
- Start F(P)SO-systems: offloaded side-by-side (examples : Afrika, Jepco North Jemen)
- 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

North

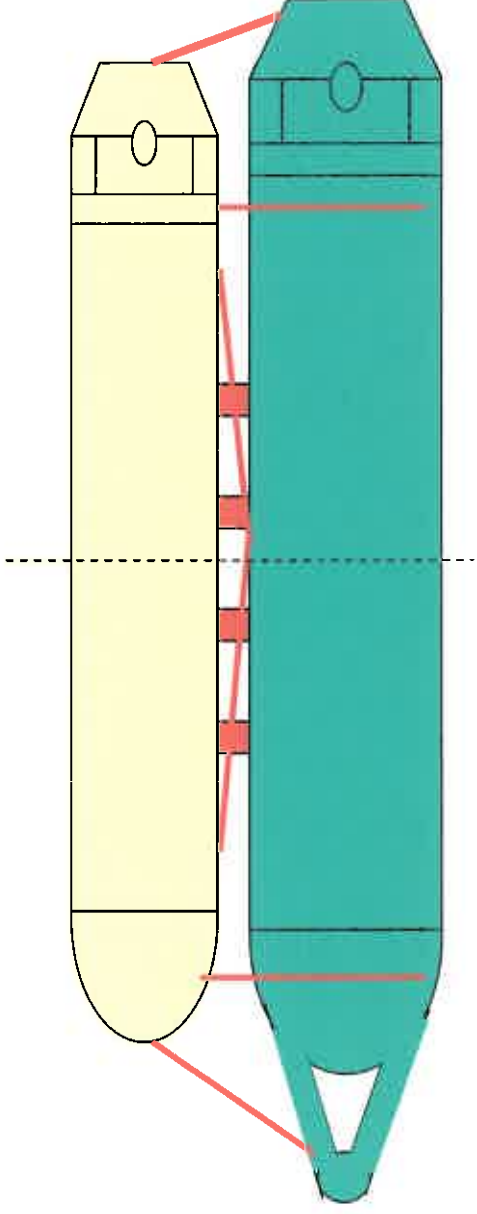


Offloading restrictions:

-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 weathervane:

- 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)



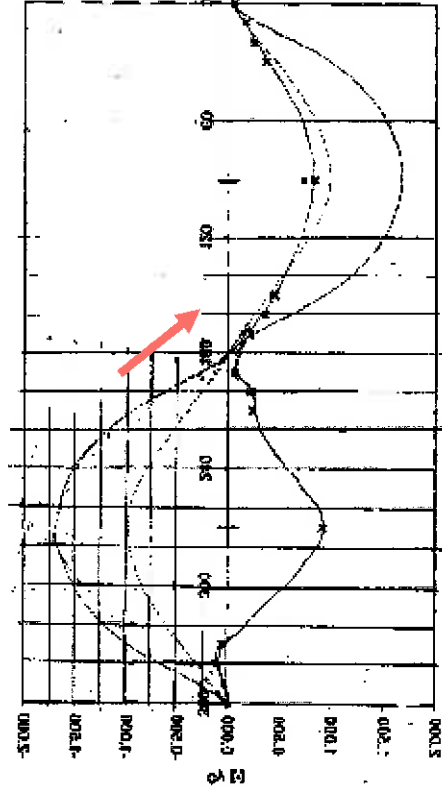
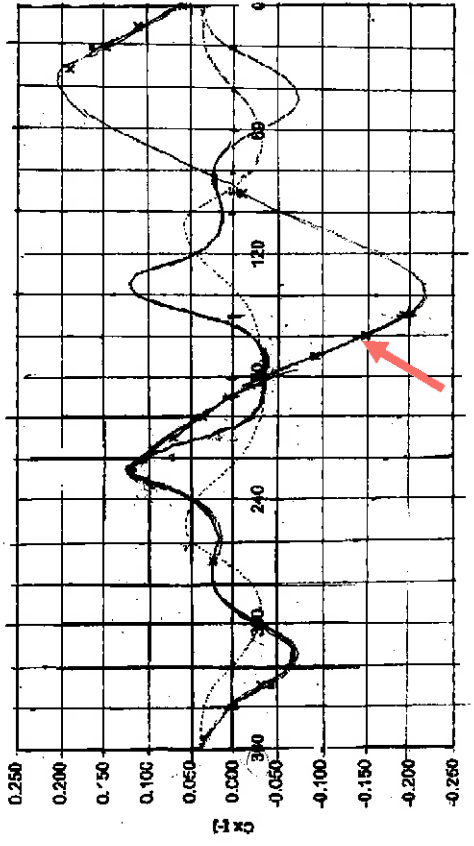
1986

Yepco-North Jemen - WD=31 m

# side-by-side current coefficients on offloading vessel

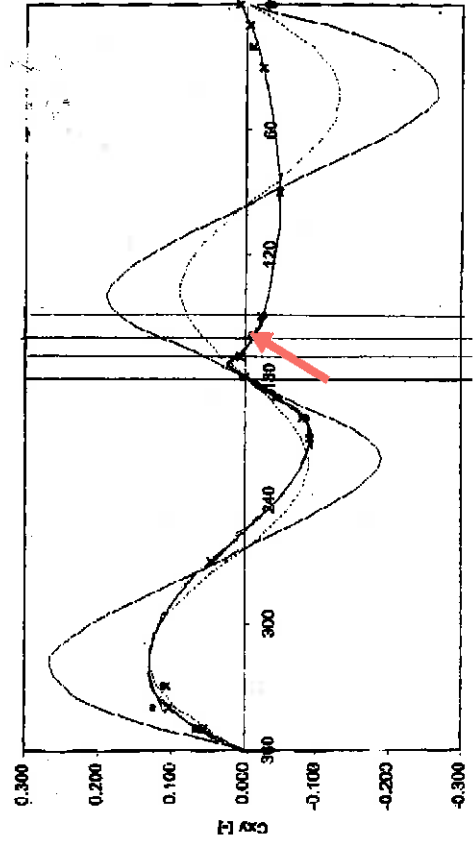
VLCC (WD/T=1.7)

coefficients side by side  
Cx LMGC, 20 m

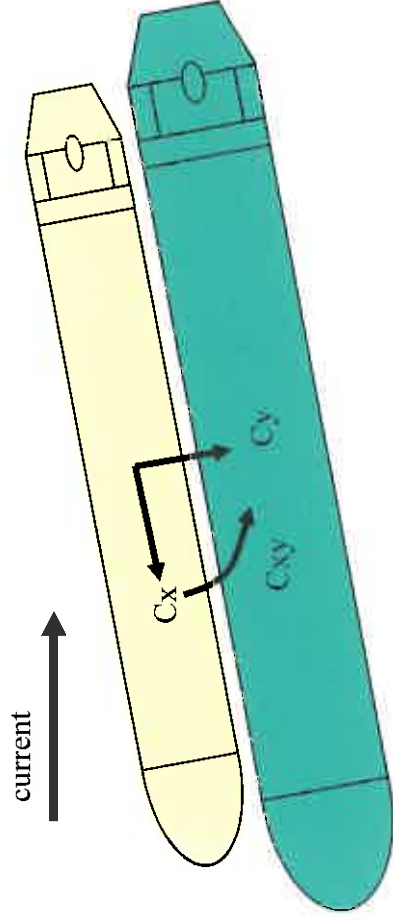


Heading [°]

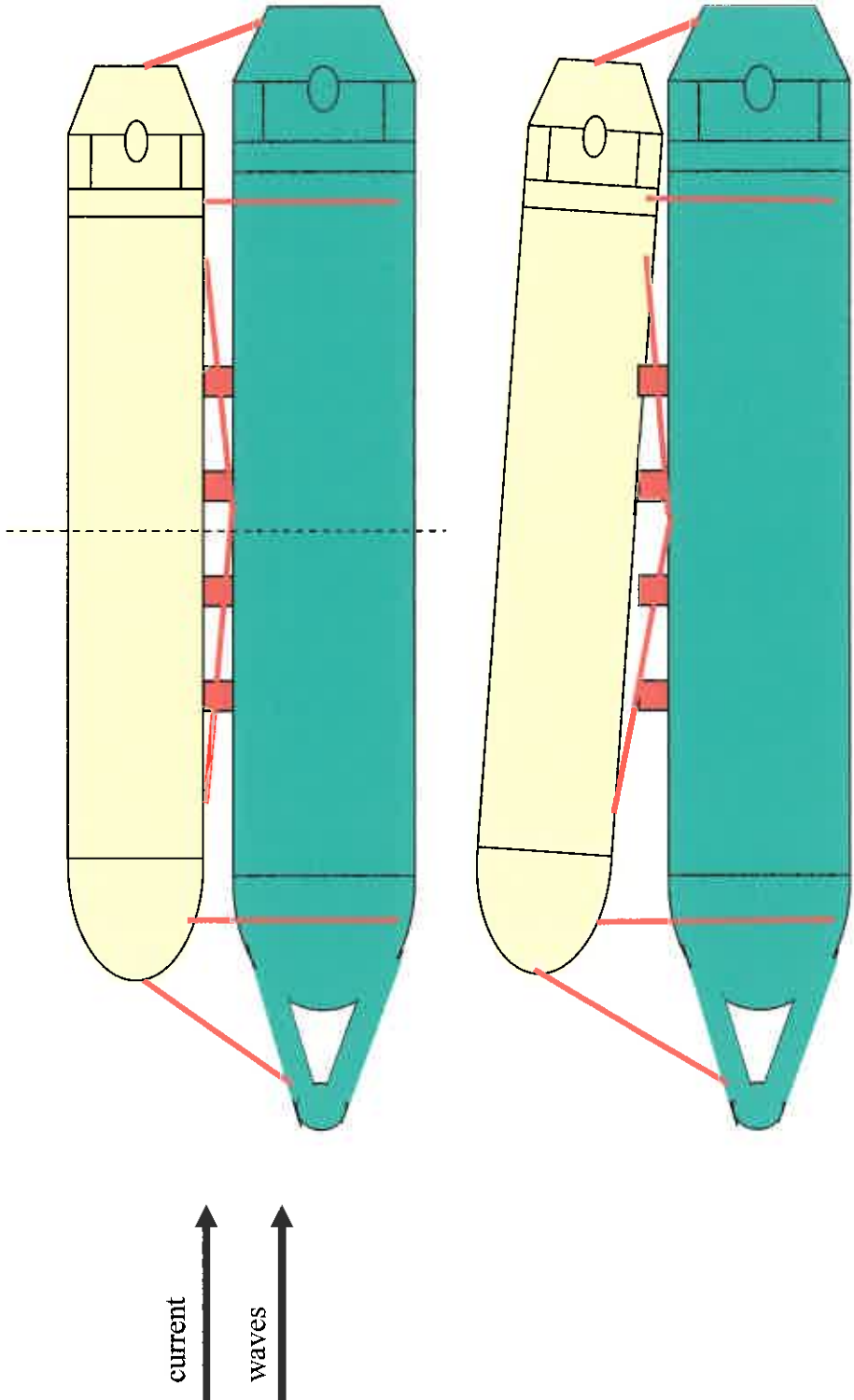
OCIMF 1.5 OCIMF 3.0



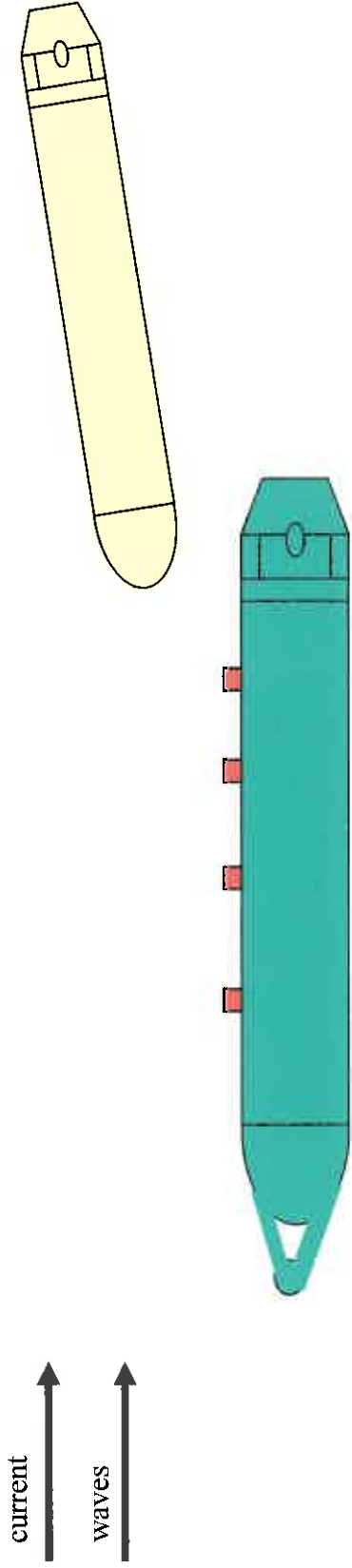
current





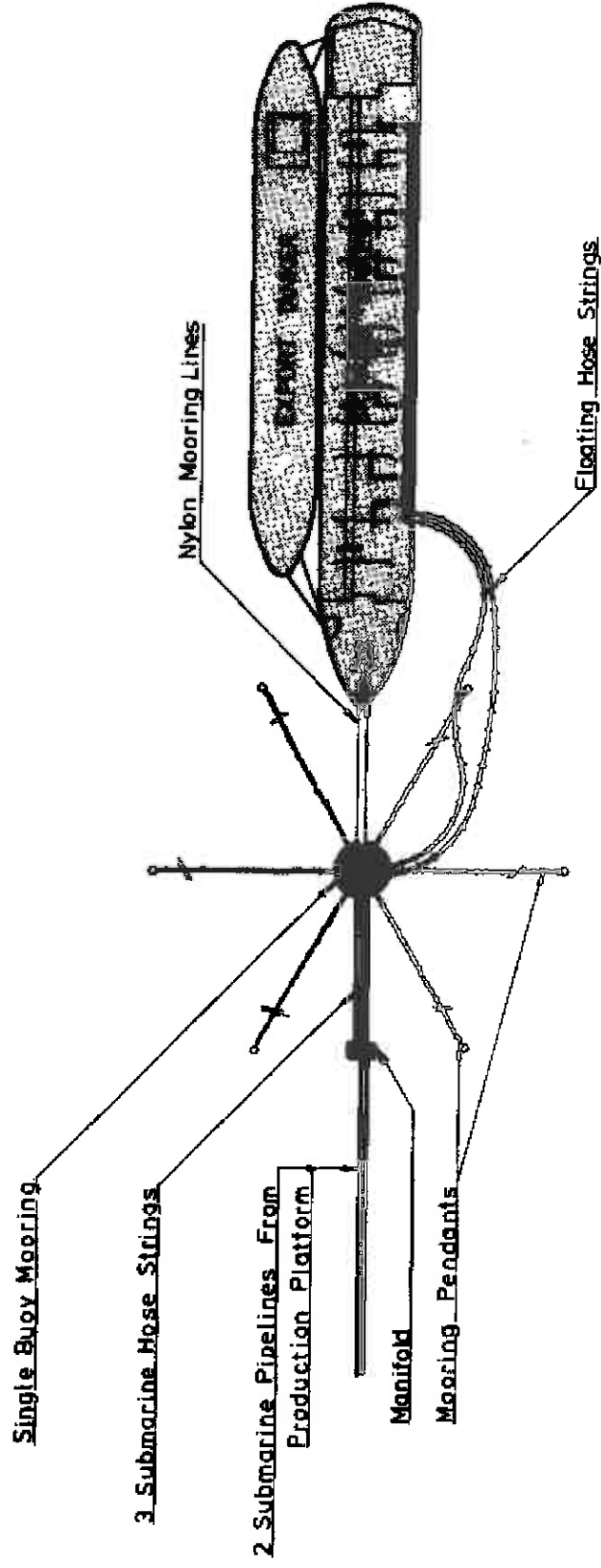


1) Jackknifing effects with high loads in bow breasting lines and in aft fender  
 Shallow water



## 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)

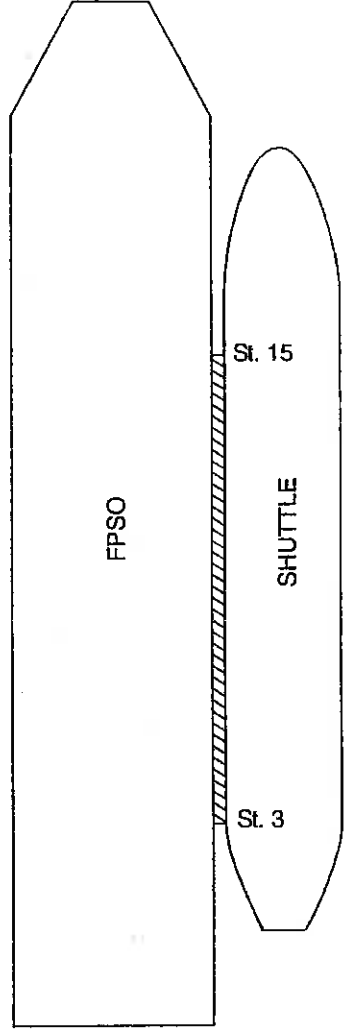
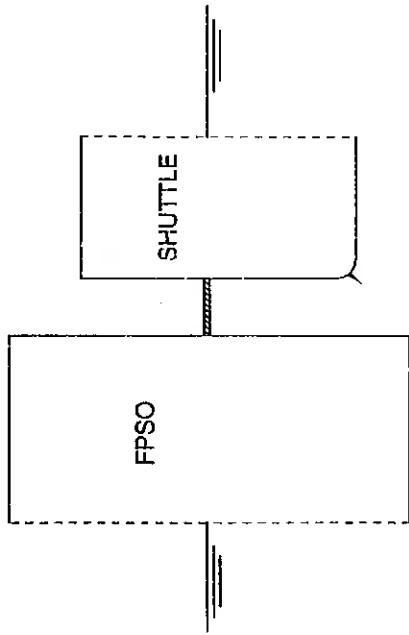
-offloading tanker side-by-side moored to turret moored tanker

-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

## **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**

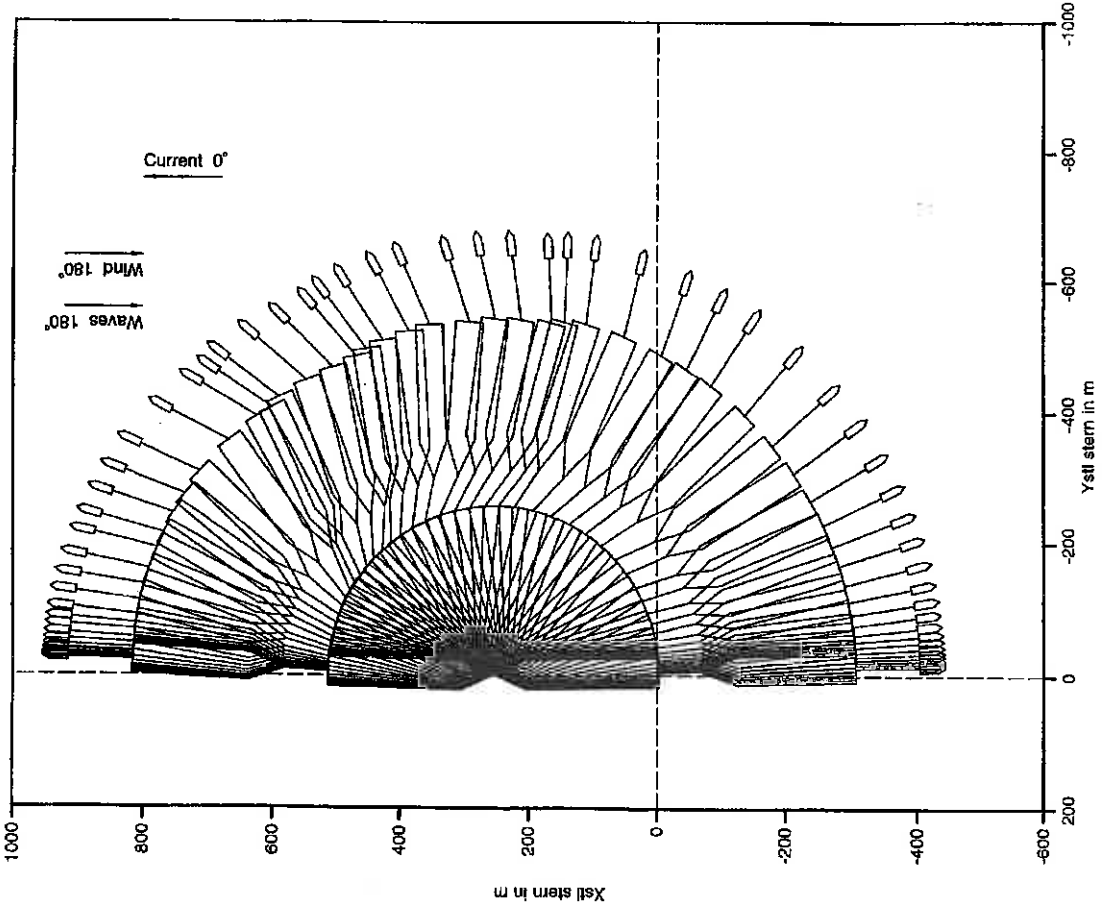
- Both tankers weathervane

## **Spread moored FPSO**

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

Benign weather conditions





# Maui-B



# Jabiru Venture



# Bohai Bay-23 and 31 m

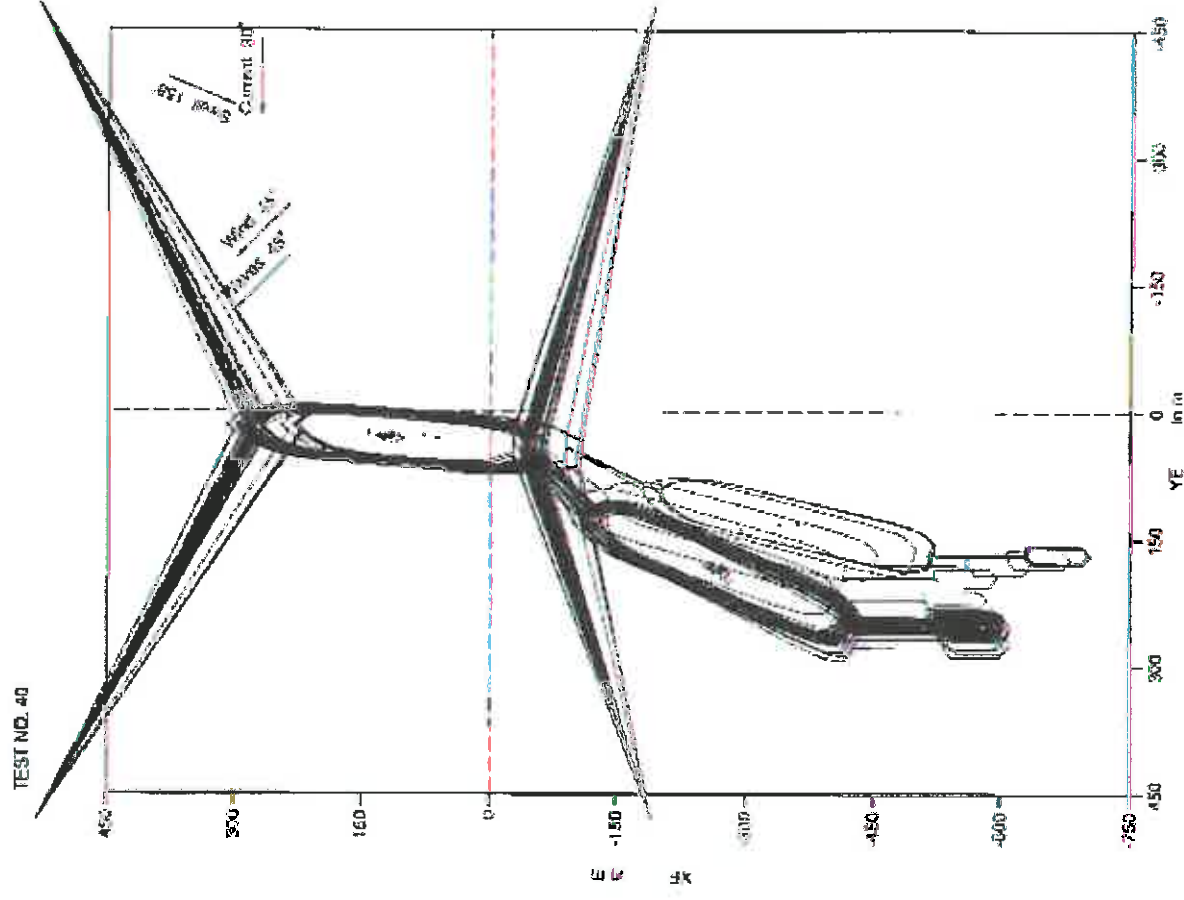


# Spread moored offloading

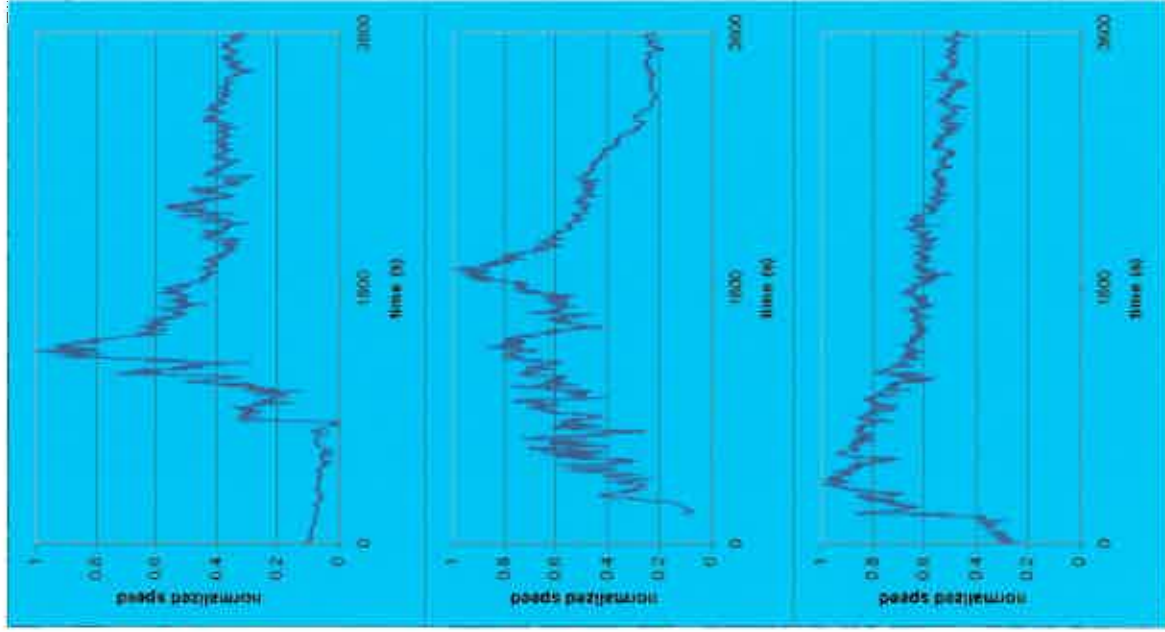
Simulation program in progress (interaction)



Interaction effects is now approximately computed with WINDOS



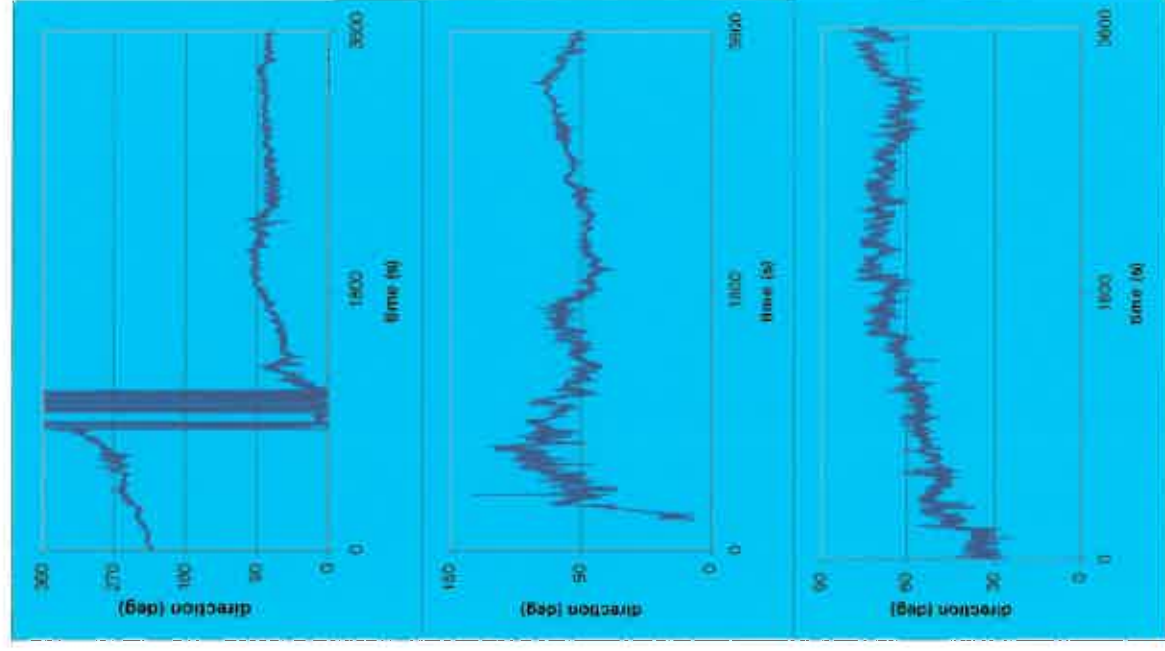
Benign weather condition; take into account squall winds



Jun  
97

Mar  
97

Oct  
97



**Maximum structure response can vary considerably for different squall records even if all squall records are scaled to the same peak wind speed.**

## Girassol Model tests



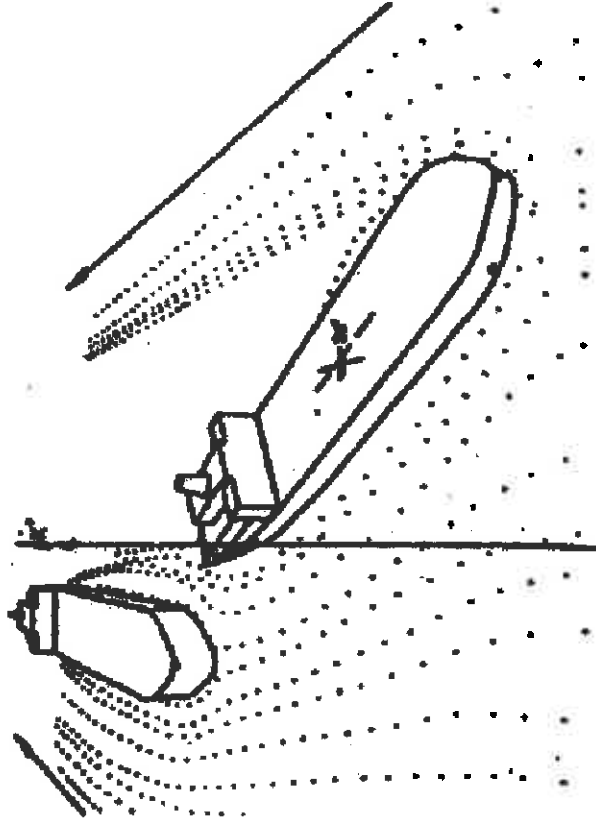
**in wind, waves and current**

**- RAO of two bodies 3-D linear potential theory**

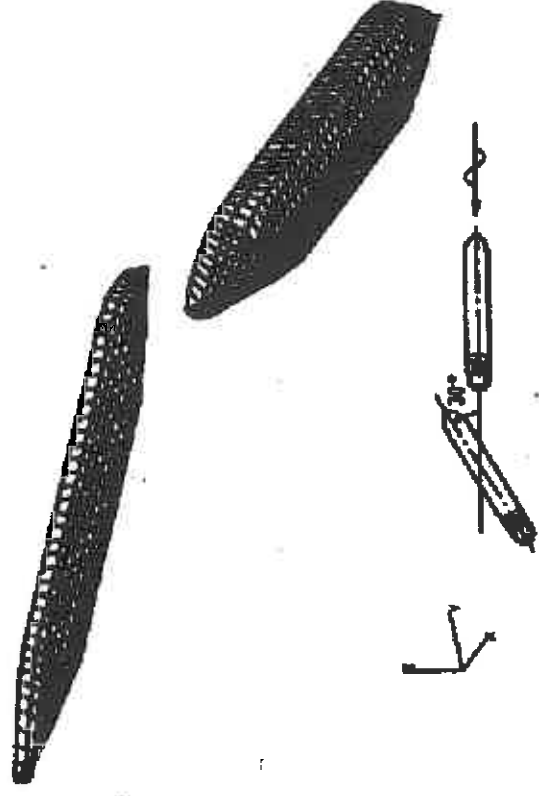
**- shielding effect wind and current**

**- wave drift forces of two bodies 3-D linear potential theory**

**SHIELDING EFFECTS  
(INTERACTION)**

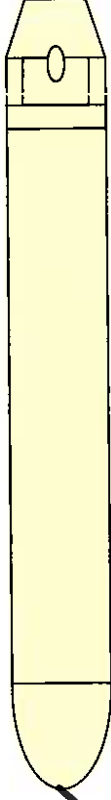


**INTERACTION WAVE DRIFT  
FORCES**

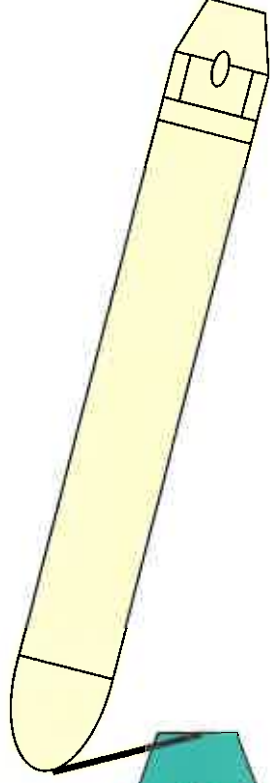
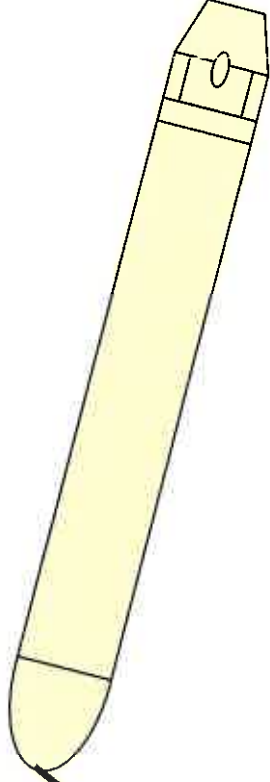




Wind and current shielding in wind tunnel



FPSO with process equipment



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

