

## Mooring Analysis for Ships and Barges

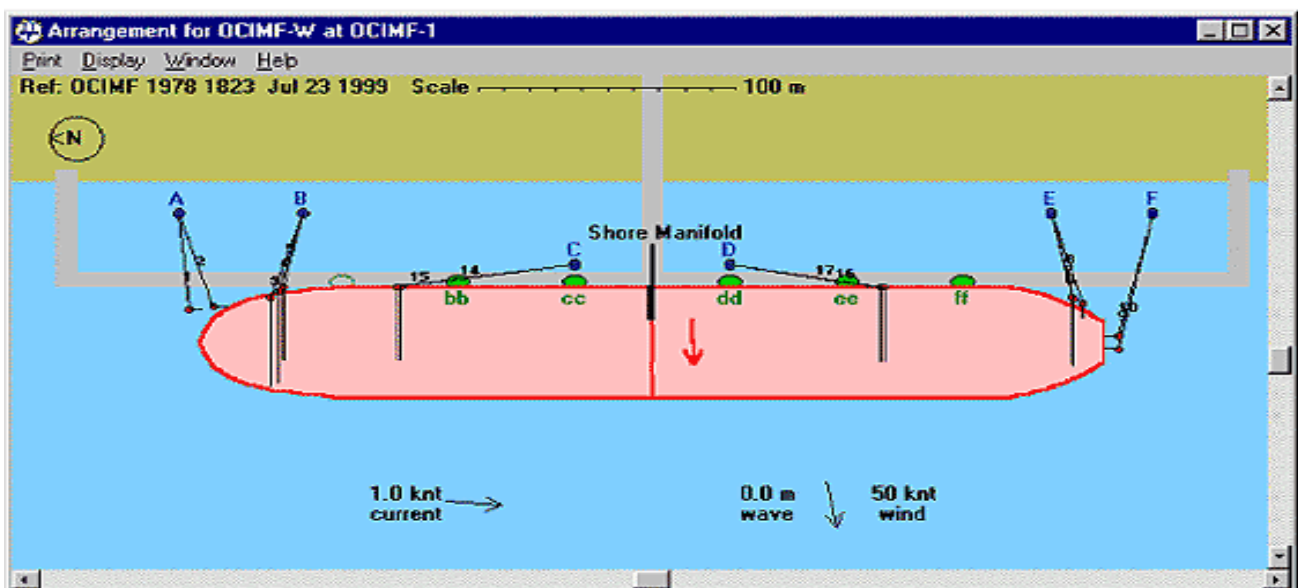
### OPTIMOOR (Program Suite)

OPTIMOOR is a unique program for the analysis of vessel moorings, and is proven as an essential tool for vessel and port operations personnel especially when assessments are required to be undertaken to meet requirements of the Oil Companies International Marine Forum (OCIMF) and satisfy the OPA-90 legislation. The program was originally written in the early 1980's by one of the TMC directors, naval architect Dr Alan Ractliffe, in collaboration with Noble Denton Associates and Newcastle University, now known as AMEC Ltd.

Figure 1: Tanker berthing



Figure 2: OPTIMOOR mooring arrangement (example)





**Optimoor Analyses (Levels)**

*Optimoor “Standard”* – for quayside moorings at piers, jetties and islands (does not allow for spread mooring and there is no allowance for buoys in pier-side, chains in lines or catenary effects);

*Optimoor “Plus”* – quayside plus spread moorings with buoys and catenary chains (catenary effects in chains included from both ship and anchor to buoy, catenary effects in wires included for CBM’s, buoys allowed in pier-side moorings);

*Optimoor “Dynamic”* – uses vessel hydrodynamics with time varying wind and current. Other time dependent forces such as wave drift can also be incorporated. The dynamic force and response of passing ships can also be calculated. OPTIMOOR dynamic can be run in continuous mode or in step mode to review data and vary input (e.g. line failure). This program generates plots of the time varying forces, vessel response, mooring line tensions and fender loads;

*Seakeeping “Option”* – this enhancement is available to all versions of OPTIMOOR. It calculates the vessel response to first-order wave effects taking shallow water and solid wall effects into account. The changing line load due to vessel motion is calculated at any fairlead.

**Data Required**

OPTIMOOR includes data on wire and synthetic fibre rope breaking strengths and elasticity values, which are automatically applied when a mooring line material and size is selected on the vessel data screen. Once the vessel lines and berthing details have then been entered, the mooring arrangement is then specified on the Mooring Screen by associating vessel lines with berth points. Winch tending is simulated to establish line preloads.

Figure 3: OPTIMOOR screen showing mooring lines data

Mooring Line No:	1	2	3	4	5	6	7	8	9	10	11
Midship to Fairlead	178.8	169.3	147.3	144.2	142.6	-162.0	-168.0	-166.0	-180.0	-180.0	
Centreline to Fairlead	15.3	16.8	21.1	24.3	25.9	21.4	20.2	18.4	3.1	-3.1	
Ht above Main Deck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Dist to Bitt/Winch	6.0	6.0	42.5	44.0	35.0	32.0	32.0	7.5	6.0	6.0	
Line Diameter (mm)	42	42	42	42	42	42	42	42	42	42	
Type of Line	SF	SF	SF	SF	SF	SF	SF	SF	SF	SF	
Strength of Line (t)	98	98	98	98	98	98	98	98	98	98	
Length of Tail											
Tail Diameter (mm)											
Type of Tail											
Strength of Tail (t)											
Winch Brake Limit											
Pre-Tension Aim	2	2	2	2	2	2	2	2	2	2	



Figure 4: OPTIMOOR berthing details

Berth File - H:\Optimoor.win\Study_Hok.ber								
Berth Data for OCIMF-1								
Top of Screen Site Plan Faces:	90° N							
Channel Width:	200 m							
Reference or Mean WL above Datum:	1.2 m							
Berth Height (Fixed) above Datum:	1.6 m							
Dredged Depth below Datum:	24.0 m							
Permissible Surge Excursion Fwd/Aft: ±	1.00 m							
Permissible Sway Excursion Port/Stbd: ±	1.00 m							
Wind Speed Specified at Height:	10.0 m							
				Tide Adjustments				
				High	Low			
				Time Lag (mins)	0 0			
				Height Factor	^ 0.00 0.00			
				Elevation Corr.	0.00 0.00			
				Tidal Current				
				Ebb	Flood			
				Time Lag (mins)	0 0			
				Knots per m Tide	0.0 0.0			
				Direction (°N)	0° 0°			
				Current Specified at Depth mean				
Bollard	A	B	C	D	E	F	G	H
X-Dist to Origin	-183.0	-135.0	-30.0	30.0	154.0	193.0		
Dist from Fenders	34.8	34.8	10.6	10.6	34.8	34.8		
Ht above Berth	0.0	0.0	0.0	0.0	0.0	0.0		
Fender	aa	bb	cc	dd	ee	ff	gg	hh
X-Dist to Origin	-120.0	-75.0	-30.0	30.0	75.0	120.0		
Compliance (mm/t)	20.0	20.0	20.0	20.0	20.0	20.0		

The program calculates mooring line and fender loads and vessel motions as soon as mooring arrangement or environment data are entered or changed. The mooring arrangement is then shown and can be altered on the mooring arrangement screen.

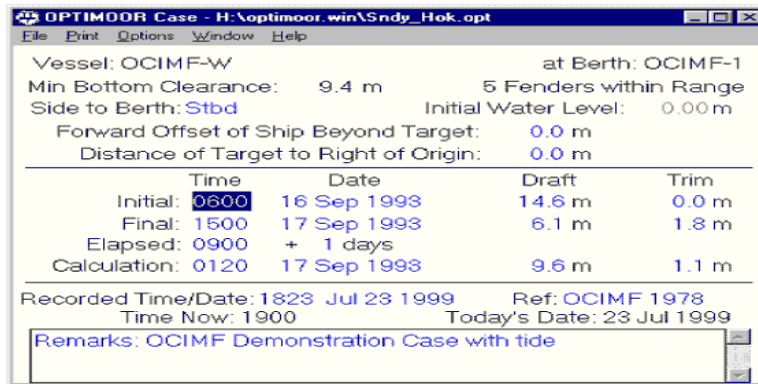
Figure 5: OPTIMOOR mooring data

Static Mooring Response for OCIMF-W at OCIMF-1														
Print Display Options Model Sweep Window Help														
Current:	1.0 knt	50 knt Wind	80° to Ship	Ret: OCIMF1978 1823 Jul 23 1999										
at	5° to Ship	Radius of Motion	0.00 m	Analysis for Time: 1600 16 Sep 1993										
Vessel Shifts:	0.0 fwd	0.4 inw	0.0° stbd	Water Level 0.61m rising Draft: 12.0m										
(at Manifold) Deck Level:	10.9 m	above Berth		Clearance under Keel: 12.3 m Trim: 0.6 m										
Line	1	2	3	4	5	6	7	8	9	10	14	15		
to Bollard/Hook	A	A	B	B	B	E	E	E	F	F	C	C		
Pull-in (m)	0.01	0.01	0.04	0.04	0.04	0.20	0.20	0.19	0.21	0.21	0.03	0.03		
Line Length	52.2	52.6	84.6	82.3	71.4	72.6	74.0	52.0	65.3	71.4	104.9	103.4		
Winch Slippage														
Inclination Down	14°	14°	15°	17°	18°	15°	15°	14°	10°	9°	9°	9°		
Tension (t)	22.6	23.6	21.5	26.3	32.7	34.3	32.3	42.1	24.6	19.9	20.8	21.4		
% of Strength	23%	24%	22%	27%	33%	35%	33%	43%	25%	20%	21%	22%		
Fender	bb	cc	dd	ee	ff	0.0 Disequilibrium after 49 iterations								
Thrust (t)	22	22	20	19	18									
Bollard/Hook	A	B	C	D	E	F								
X-Force (t)	8.9	-19.3	-41.2	41.9	24.7	-9.3								
Y-Force (t)	43.7	74.7	6.2	7.3	102.3	42.9								
Other X-Load														
Other Y-Load														
Total Horiz Force	44.6	77.1	41.7	42.5	105.2	43.9								
Direction in Plan	12°	-14°	-61°	60°	14°	-12°								
Uplift (t)	11.1	23.1	6.7	7.7	26.9	7.6								



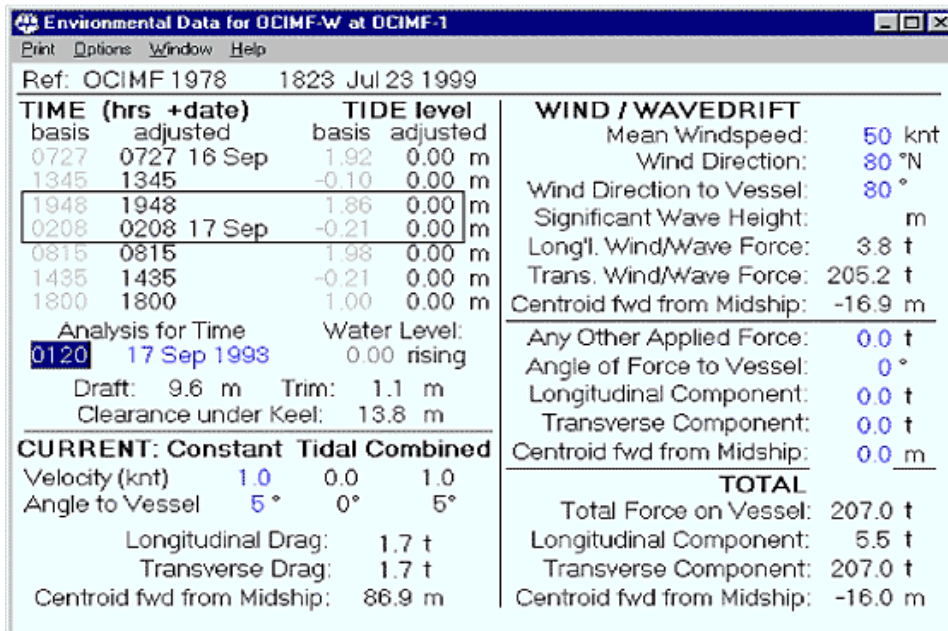
By entering the initial/final draft and trim on the Case Screen, the effects of change in freeboard are calculated.

Figure 6: OPTIMOOR vessel draughts and tidal data



If tide and tidal current data are entered, these are determined for the calculation time and adjusted for the mooring site if necessary. The results are displayed on the environment screen (see below). The tidal current is superimposed on the "constant" current, and the current forces and moments on the vessel are calculated and displayed. Wind forces and moment are also calculated and displayed. The OCIMF wind and current coefficients are licensed and included within OPTIMOOR. Other wind and current forces are also included. The user may provide other alternative data, and may choose which coefficients are to be used for a particular vessel in these calculations. The user may enter other applied force and moment data, for example from tugs, ice, or a passing tanker. The environment screen then displays the total force and moment on the vessel.

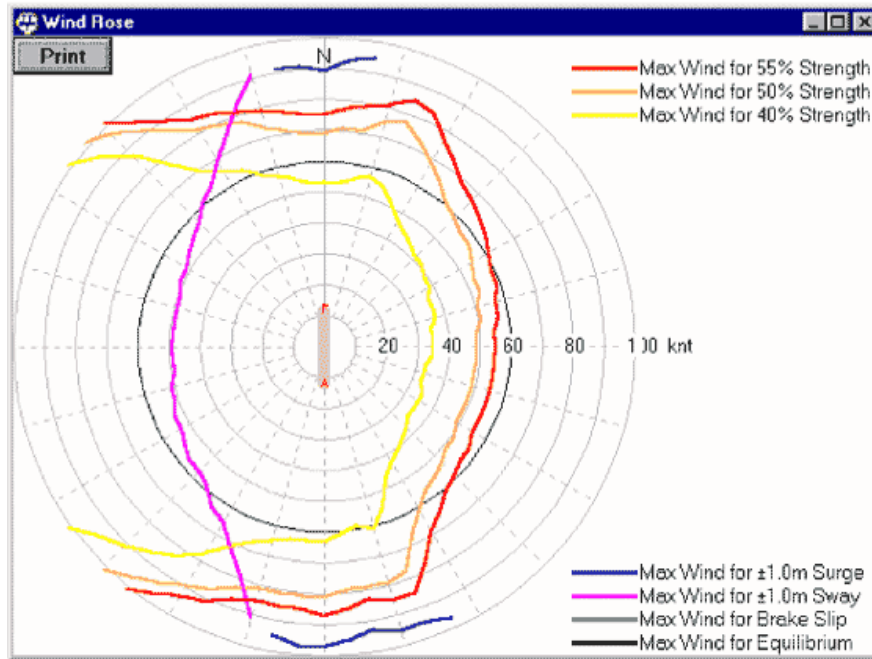
Figure 7: OPTIMOOR environmental screen



**Results Presentation**

A single command causes OPTIMOOR to calculate and display mooring line forces and vessel movements resulting from winds from various directions. These results can then be plotted as a "Wind Force Rose", showing the most severe wind directions.

Figure 8: OPTIMOOR polar diagram of mooring forces



When initial and final vessel draft and trim and/or tidal variation data are provided, OPTIMOOR calculates the change in mooring line loads with time. The following mooring screen shows the mooring loads at 5 hours after the time in the above Mooring Screen. Red shows that one line (8E) is overloaded. Orange and Yellow show that other lines are also highly loaded. The line tending feature of OPTIMOOR can then be used to plan how to let out winch lines to alleviate this problem.

Figure 9: OPTIMOOR static mooring response

Static Mooring Response for OCIMF-W at OCIMF-1												
Print Display Options Model Sweep Window Help												
Current:	1.0 knt	50 knt Wind	80° to Ship	Ref: OCIMF 1978		1823 Jul 23 1999						
at	5° to Ship	Radius of Motion	0.00 m	Analysis for Time:		2300 16 Sep 1993						
Vessel Shifts	0.1 fwd	0.8 inw	0.1° stbd	Water Level		0.61 m rising						
(at Manifold)	Deck Level: 12.7 m	above Berth		Clearance under Keel:		13.9 m						
				Trim:		0.9 m						
Line	1	2	3	4	5	6	7	8	9	10	14	15
to Bollard/Hook	A	A	B	B	B	E	E	E	F	F	C	C
Pull-in (m)	0.01	0.01	0.04	0.04	0.04	0.20	0.20	0.19	0.21	0.21	0.03	0.03
Line Length	52.2	52.6	84.6	82.3	71.4	72.6	74.0	52.0	65.3	71.4	104.9	103.4
Winch Slippage												
Inclination Down	17°	16°	18°	20°	21°	17°	17°	16°	12°	11°	11°	11°
Tension (t)	31.4	33.2	31.8	39.9	50.4	48.9	45.8	59.2	31.7	24.4	34.5	35.6
% of Strength	32%	34%	33%	41%	52%	50%	47%	61%	32%	25%	35%	36%
Fender	bb	cc	dd	ee	ff	0.0 Disequilibrium						