

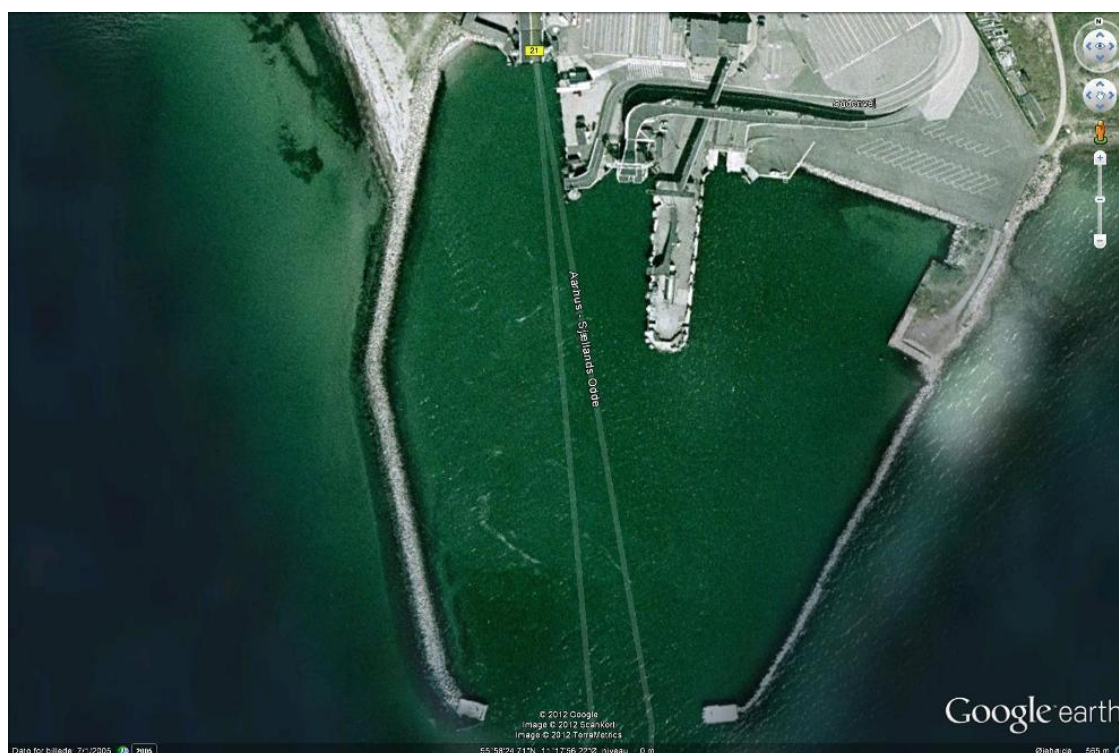
Operation with two ferry companies in the port of Odden

Time and safety study of fast ferry movements in and around the
port of Odden

Final report

FORCE Technology nr. 112-32072

Version 1.3



Source: Google earth



FORCE Technology

Project No. and Title of Report:

FORCE Technology no. 112-32072

Operation with two ferry companies in the Odden Ferry port

Time and safety study of fast ferries' movements in and around the Odden Ferry port.

Final report, version 1.3

Client:

Sund & Bælt A/S

Client's Ref.:

Mrs. Tine Kirk Pedersen
Mr. Søren Vikkelsø

Author(s):

Naval Architect, M.Sc. Jens Bay and
Master Mariner Erik Attrup

Date: 4th March 2013

Approved by:

1.3	Final	JCB/EAT	AFM	CMS	04-Mar-'13
1.2	Draft revised	JCB/EAT	AFM		20-Dec-'12
1.1	Draft revised	JCB/EAT	AFM		05-Nov-'12
1.0	Draft	JCB/EAT	AFM		29-Oct-'12
Revision	Description	By	Checked	Approved	Date

Keywords:

Sailing plans, manoeuvring safety, two fast ferries operation

Classification:

- Open
 Internal
 Confidential

LIST OF CONTENTS:

PAGE:

1 INTRODUCTION 1

1.1 PURPOSE OF THE STUDY 1

1.2 DEFINITIONS 2

2 BASIS OF THE STUDY 3

2.1 PORT LAYOUT 4

3 PRESENT OPERATION 5

3.1 PRESENT MANOEUVRING SITUATION 6

3.2 FUTURE OPERATION 6

3.3 OPERATION SAFETY ZONE 8

3.4 POSSIBLE SECOND OPERATOR 9

4 OPERATION WITH TWO OPERATORS 12

4.1 TWO FERRIES IN PORT SIMULTANEOUSLY 13

4.2 OPERATION WITH TWO FERRIES 21

5 SAFETY CONSIDERATIONS 22

6 CONCLUSIONS 23

7 RECOMMENDATIONS 23

APPENDICES:

- Appendix A: Photos from the port
- Appendix B: On-site inspection
- Appendix C: Drawings of port layout
- Appendix D: Danish sea chart no. 128
- Appendix E: Ship "Dolphin Jet"

1 Introduction

This report contains the description of the work carried out by "FORCE Technology, Division for Maritime Industry", (DMI), Lyngby, Denmark according to "Sund & Bælt A/S's" wish to have an independent investigation of the viability of having two fast ferry operators in the Odden Ferry port.

FORCE DMI was contacted via e-mail by Marketing Director Søren Vikkelsø, Sund & Bælt A/S on September 25th, 2012.

The Odden Ferry port is owned by Sund & Bælt, and Sund & Bælt is as such responsible for the port. At present, the Mols-Linien A/S is the sole operator of the port. Some of the land installations, e.g. the ramps etc. at berth A, are owned by Mols-Linien.

The Kattegatruten A/S is interested in operating a fast ferry between Odden and Aarhus. They have applied to Sund & Bælt for permission to do so. This is the background of this study.

FORCE Technology was asked to undertake a desk study of safety issues in connection with two ferry companies operating in the port based on existing sailing plans for Mols-Linien and a proposed sailing plan for Kattegatruten.

The study was undertaken from 1st to 29th October 2012 by FORCE Technology, and the following persons participated:

- Project Manager Jens Bay, FORCE Technology
- Captain Erik Attrup, FORCE Technology
- Captain Arne F. Mejer, FORCE Technology

The desk study included considerations of manoeuvring safety with two fast ferries as well as an on-site inspection of the port, a time study of manoeuvring times of Mols-Linien's two different fast ferries and a sailing with the fast ferry "Katexpress 1" from Odden Ferry port to Ebeltoft and back.

This final version contains comments and corrections etc. based on input from Kattegatruten A/S and Mols Linien in connection with the following meetings:

- Meeting with Kattegatruten A/S November 21st, 2012
- Meeting with Mols-Linien A/S January 29th, 2013

1.1 Purpose of the study

The purpose of the study was to:

- Investigate if it is safe to let the Kattegatruten fast ferry approach the port when the Mols-Linien ferries are not using the port.
- Investigate if it is possible in terms of safety to have one ferry moored while another is manoeuvring in the port.

1.2 Definitions

Definition of Safety

A satisfactory safety margin is defined as the situation where the tested berth and the environmental conditions provide sufficient under-keel clearance to avoid grounding, sufficient distance to shallow water areas and structures or moored vessels, and the ability to correct minor manoeuvring mistakes without compromising safety.

Definition of Under Keel Clearance

Under-keel clearance (UKC) is the distance between the seabed and the keel of the ship. It is dependent on the squat, heave, pitch and roll of the ship.

Definition of Operational Limits

Operational limits are defined as the environmental limits under which a vessel under its own power can be manoeuvred such that all available controls would at no stage be required to their full extent over a prolonged period of time. In other words, there should at all times be sufficient controlling options left to cope with unforeseen situations or to correct errors of judgement.

Definition of Standard Operating Procedures

A Standard Operating Procedure (SOP) is a document that describes the regularly recurring operations relevant to the quality of the task. The purpose of a SOP is to undertake operations correctly and in a consistent manner within agreed limits. A SOP should be readily available at the workplace.

Definition of arrival

A ship has arrived when it is alongside the berth, and the mooring lines/system has been made fast. The ship ramp does not necessarily need to be in contact with the shore ramp.

Definition of departure

A ship initiates its departure when the ship ramp is clear of any land installations, and the mooring lines/system is away.

2 Basis of the study

This section describes the basis and assumptions of the study.

Prior to commencement of this study, a number of basic documents were received from Sund & Bælt. Also information from the two ferry operators' web sites has been used as well as Danish sea charts of the area.

The documents received from Sund & Bælt include (see Appendices C and D):

- Port layout with water depth survey
- Drawing of the onshore port layout
- Port drawing showing Mols-Linien's 112 m Incat ferry at berths B and C
- General arrangement of Kattegatruten's Ferry "Dolphin Jet"
- Main particulars of the "Dolphin Jet"
- Letter from Delacour Dania dated 14 August 2012
- Letter from Kattegatruten A/S dated 18 September 2012
- Letter from Kattegatruten A/S: "Anløbemuligheder Kattegat-rutens Dolphin Jet Odden færgehavn"
- Proposed sailing plan of "Dolphin Jet"
- Time tables by Sund & Bælt: "Oversigt over Mols-Liniens anvendelse af Odden havn I efteråret 2012, samt Kattegatrutens ansøgte tidspunkter"

From Mols-Linien's webpage: www.mols-linien.dk

- Sailing plans for the fall season 2012

From Kattegatruten's webpage: www.kattegat-ruten.dk

- General information

Danish sea charts:

- No. 128: Samsø Bælt
- No 112: Århus Bugt

3 Present operation

At present, Mols-Linien is the sole operator of the port. They have two fast ferry berths in operation (berths A and B, see figure 4.1 for berth position). A third berth C similar to berth B is ready for operation. An aft ramp system has been operational December 2012. The port has a 4th potential berth area on the east side called berth D in this report. This potential berth is not developed at this point.

A bunker boat calls at the port regularly and uses berth C for unloading fuel.

The present sailing plan for the port is (source: www.mols-linien.dk):

Odden-Aarhus

22/10-11/11 2012

Afgang	Man-tor	Fre	Lør	Søn
07.30	▶			
08.30	▶▶	▶▶	▶	
10.30	▶	▶		
11.30			▶	▶
13.30	▶	▶		
14.30	▶▶	▶▶		
15.00			▶	▶
16.30	▶			▶▶
17.00		▶		
17.30	▶▶			
18.30			▶	▶
19.30	▶			
20.00		▶		▶▶
21.30				▶

Med hurtigfærge, overfartstid: Ca. 70 minutter

▶ = Afgang Max Mols

▶▶ = Afgang KatExpress 1

Med forbehold for trykfejl og ændringer uden varsel.

Odden-Ebeltoft

22/10-11/11 2012

Afgang	Man-tor	Fre	Lør	Søn
10.30			▶▶	▶▶
11.30	▶▶	▶▶		
13.30			▶▶	▶▶
16.30			▶▶	
18.30		▶▶		

Med hurtigfærge, overfartstid: Ca. 55 minutter

▶▶ = Afgang KatExpress 1

Med forbehold for trykfejl og ændringer uden varsel.

Figure 3.1 Mols-Linien's time schedule for operation in Odden port during 22nd October to 11th November 2012

The ferries from Aarhus arrive at minute 10 and leave at minute 30. Ferries from Ebeltoft arrive at minute 55 and leave at minute 30. According to info on the webpage, the travel time between Odden and Aarhus is about 70 minutes and between Odden and Ebeltoft 55 minutes.

3.1 Present manoeuvring situation

The ship manoeuvres of the existing Mols-Linien ferries are described in this section.

The fast ferries Mai and Mie Mols: Are at the moment laid up

When they are in operation, the arriving ferries always sail "straight in" as the ferry has a side ramp in the stern as well as a bow ramp. The ferry leaves the port by going astern passing the breakwaters and a few 100 m further south before swinging about 90 degrees to a westerly course.

In rough weather the ferries leave the berth going astern, and abeam of the centre pier head (B/C) they start to turn inside the basin and leave (bow first) on a southerly course.

The fast ferry Max Mols and Katexpress1

Arriving ferries enter the port, swing about 180 degrees and berth astern to berth B. The departing ferries leave "straight out". See pictures in Appendix A.

Manoeuvring times have been recorded to about 4 to 8 minutes for the arriving ferries and about 3 to 4 minutes for the departing ferries. For details, see Appendix B.

Two considerations have to be dealt with:

- 1) According to environment regulations Max Mols (the fastest) have to reduce like KatExpress1 on all arrivals from Ebeltoft. This means prolonged approach- and manoeuvring time.
- 2) Above manoeuvring times are for good weather situations. Manoeuvring time in wind speed above 12 m/s will normally be longer – up to 10 minutes for both arrival and departure situations. In winds exceeding 12-14 m/s the KatExpress1 will turn outside the port and reverse into the basin turning the aft end up towards the wind and slowly traverse to get contact with the pier head (B/C). From this point, the ship will be pivoted in towards the loading berth, either B or C, wind permitting. On departure the ship leaves the berth – pivots around the pier head and reverses out of the port and turns outside to a westerly course.

3.2 Future operation

Mols-Linien has informed that they intend to extend their summer schedule in 2013 to hourly operation from Aarhus and Odde. It is assumed that the schedule in terms of minutes will be the same as in figure 3.1.

According to time schedules, the ferries will arrive from Aarhus in minute 10 and ferries from Ebeltoft in minute 55, and ferries leave Odde in minute 30.

Delays can be expected in case of heavy winds and/or depending on the number of vehicles being unloaded and loaded.

In case of a second operator in the port, FORCE Technology suggests that a safety zone should be established.

From May 1st, 2013 the Mols-Linien plans to use the sailing schedule shown in table 3.2 below.

Mols-Linien sailing schedule after May 1st, 2013				
Dep. Aarhus	Dep. Ebeltoft	Arrive Odden	Departure Odden	Time in port (min)
06:00		07:15	07:45	30
07:00		08:15	08:45	30
	08:00	09:00	09:45	45
09:30		10:45	11:15	30
10:30		11:45	12:15	30
	11:30	12:30	13:15	45
13:00		14:15	14:45	30
14:00		15:15	15:45	30
15:00		16:15	16:45	30
16:30		17:45	18:15	30
17:30		18:45	19:15	30
18:30		19:45	20:15	30

Table 3.2. Planned sailing schedule from May 1st, 2013. The times indicated are for good weather conditions (below 12 m/s).

It should be noted that Kattegatruten will likely, like Mols-Linien, have environmental issues regarding the approach speed to the port. The approach speed from the cardinal buoy will likely be maximum 14 knots which means a more time consuming arrival than with no speed limits.

The distance from the cardinal buoy to the port entrance (inclusive the turn) is about 0.8 nm. With a speed profile as shown in table 3.2 the time it takes from the cardinal buoy to passage of the port entrance is 4 min. and 12 sec. This fits well with the on-site recordings (see table 3.3 in appendix B).

Leg #	Distance, nm	Comment	Start speed, Knots	End speed, knots	Average speed, knots	Sailing time (sec)
1	0,2	Cardinal buoy, start of leg	14	14	14	51
2	0,2		14	12	13	55
3	0,2	Turn, start of leg	12	10	11	65
4	0,2	Port entrance, end of leg	10	8	9	80
Total	0,8					252

Table 3.3 Speed profile of arriving fast ferry

3.3 Operation safety zone

With two operators or two ferries operating in and in the vicinity of the port of Odden, it is considered necessary to establish a safety zone where only one fast ferry or other ferries can sail/manoeuvre at a time. The purpose of this is to avoid or minimize the risk of a collision between two ferries. A suggestion to a safety zone is shown in the figure below.

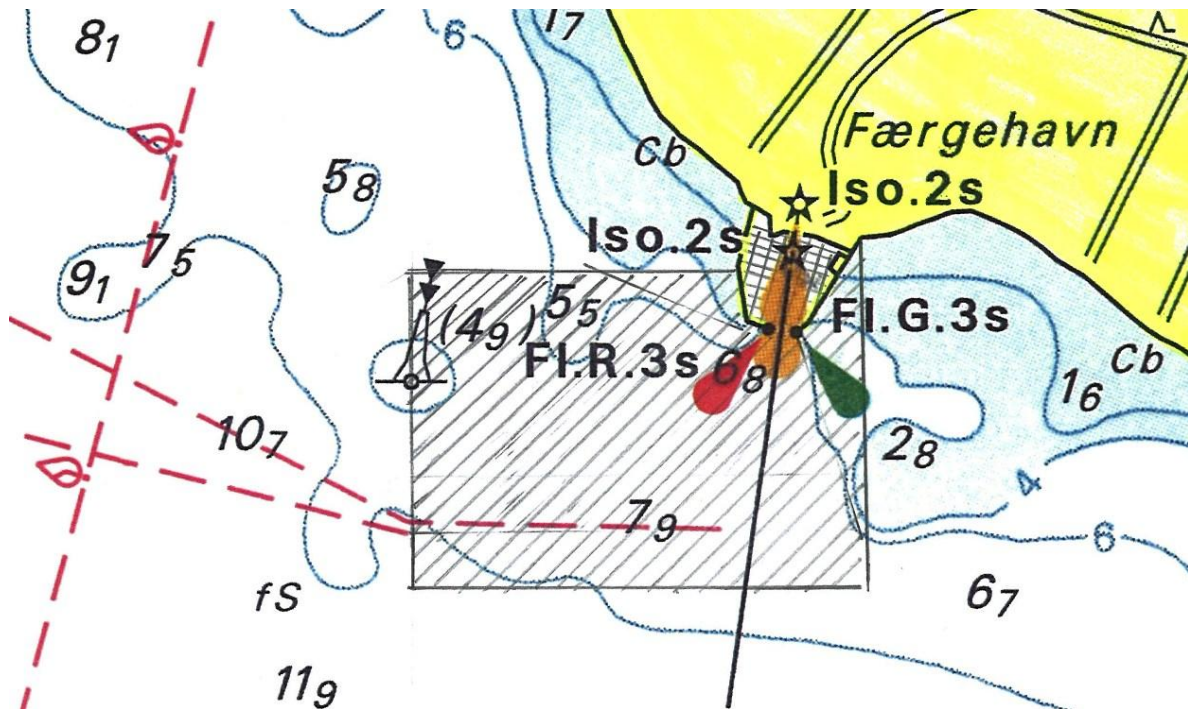


Figure 3.2 A proposed (by FORCE Technology) safety zone where only one ferry may operate at a time.

The proposed safety zone is based on the following assumptions:

1. The north boundary is established to avoid ferries entering the port from north. This is not considered likely as the leading line suggests an approach from the south, and the cardinal buoy marks a patch of shallow water of 4.9 m close to the north boundary.
2. The east boundary follows longitude $11^{\circ} 18' 200$ E. It is established to avoid ferries entering from the east.
3. The south boundary is established in such a way that it gives a departing or arriving ferry room to leave or to line up in a smooth turn. The line follows latitude $55^{\circ} 57' 850$ N.
4. The west boundary is a vertical line through the cardinal buoy west of the port. This has been chosen because it is a conspicuous indication, and its distance of about 0.65 nm west of the port entrance corresponds to about the distance a departing ferry travels in 3 to 4 minutes and similar for an arriving ferry. This is considered to be a safe time/distance separation between to ferries.

Apart from the safety zone described above, the entire port area is also included in the safety zone.

An outbound ferry should leave the safety zone on a WNW route when crossing the westerly boundary. An inbound ferry should enter from a more southerly route and can enter the safety zone by crossing the western or the southern boundary.

The suggested safety zone should be discussed and agreed upon with the Danish Maritime Authority, the port authority and the ferry operators.

3.4 Possible second operator

Kattegatruten wishes to operate between Aarhus and Odden with the fast ferry "Dolphin Jet" according to the following suggested schedule.

Mandag til torsdag:

Afgang Århus:	Ankomst Odden:	Afgang Odden:	Ankomst Århus:
06:20	07:35	08:05	09:20
11:20	12:35	13:05	14:20
16:20	17:35	18:05	19:20

Fredag:

06:20	07:35	08:05	09:20
11:20	12:35	13:05	14:20
17:20	18:35	19:05	20:20

Lørdag:

09:20	10:35	11:05	12:20
12:30	13:45	14:15	15:30
16:20	17:35	18:05	19:20

Søndag:

12:20	13:35	14:05	15:20
16:20	17:35	18:05	19:20

Figure 3.3 Kattegatruten's proposed time schedule.

The intention of this proposed schedule is to ensure that only one ferry occupies the port at a time.

Comparing the minutes for the Mols-Linien operation with the above schedule results in the following usage of the port in some hours of the day, e.g. between 07:00 and 8:00:

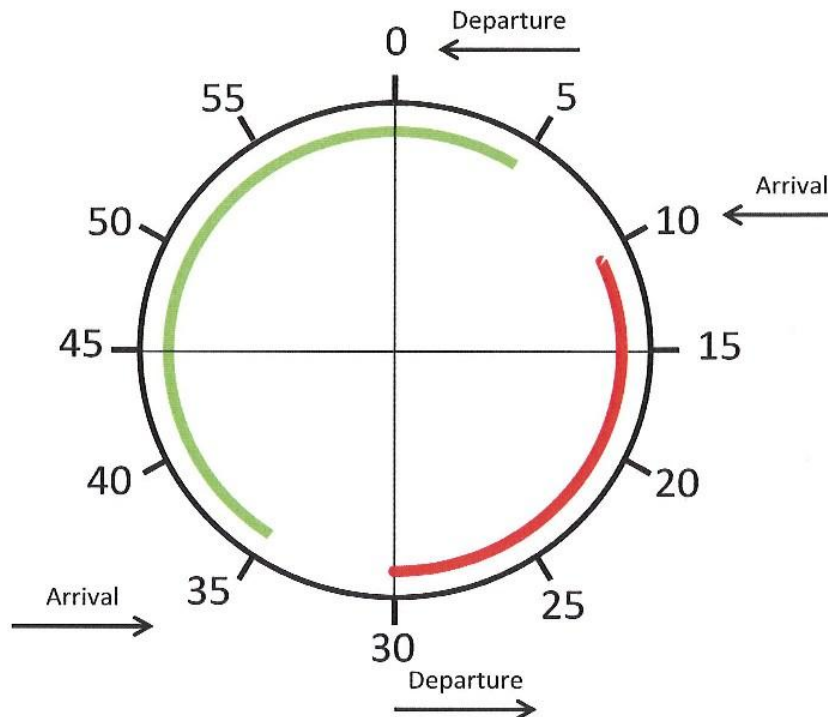


Figure 3.4 Mols-Linien's (red) and Kattegatruten's (green) proposed usage of Odden Ferry port.

Note: Kattegatruten does not intend to operate in those hours of the day when a ferry is arriving from Ebeltoft in minute 55.

If it is assumed that the ferries arrive and depart at the scheduled times, it can be seen from the illustration above that the consequence of the port usage would leave 5 minutes' manoeuvring time between the two operators from minute 05 to 10 and minute 30 to 35.

Time slot 05 to 10

During the 5-minute time period from 05 to 10, the Kattegatruten ferry will have to leave the berth and most likely go astern out of the port at a sufficient safety distance to let the Mols-Linien ferry enter the port. The Mols-Linien ferry will have to turn around in the port and berth astern.

It is estimated that the astern manoeuvre of the Kattegatruten ferry out of the safety area (see section 3.2) lasts about 3 to 5 minutes. The ferry is assumed to go astern all the way out of the southern safety zone boundary.

The Mols-Linien ferry manoeuvre has been recorded (see Appendix B, table 2) to take:

- From the cardinal buoy to berth: About 8 to 12 minutes
- From the port entrance to berth: About 4 to 6 minutes

The result is that the total time for both manoeuvres is about 11 to 17 minutes based on the assumption that there is only one ferry in the safety zone at a time.

If the safety zone is reduced in size corresponding to a distance of e.g. one minute sailing time from the port entrance the total manoeuvring time for the manoeuvres would be 7 (4+1+2) to 11 (6+1+4) minutes, as it is assumed that the astern manoeuvre for the Kattegatruten ferry could be reduced to about 2 to 4 minutes.

Time slot 30 to 35

During minutes 30 to 35, the Mols-Linien ferry will depart the port "straight out", and the Kattegatruten ferry will arrive "straight in".

It is estimated that the "straight in" manoeuvre of the Kattegatruten ferry from the cardinal buoy to the berth is about 6 to 8 minutes and from the port entrance to the berth about 3 to 5 minutes

The Mols-Linien ferry manoeuvre has been recorded (see Appendix B, table 2) to take:

- From the berth to the port entrance: About 1 to 2.5 minutes
- From the berth to the cardinal buoy: About 3 to 6 minutes

The result is that the total time for both manoeuvres is about 9 to 14 minutes. The basis of this is that there is only one ferry in the safety zone at a time. The time could be reduced by about 1 minute if the arriving ferry approaches from the southern boundary. See figure below.

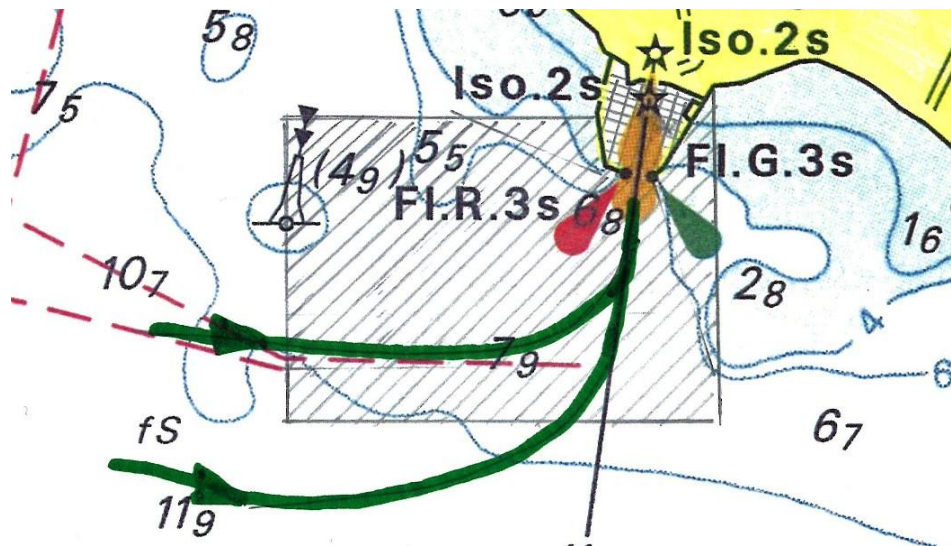


Figure 3.5 Example of two different arrival approaches to the safety zone.

If the safety zone is reduced in size corresponding to a distance of e.g. one minute sailing time from the port entrance the total manoeuvring time for the manoeuvres would be 6 (1+1+4) to 9.5 (2.5+1+6) minutes, as it is assumed that the astern manoeuvre for the Kattegatruten ferry could be reduced to about 2 to 4 minutes.

4 Operation with two operators

The application from Kattegatruten contains among other the following considerations:

There is a potential for four fast ferry berths as indicated with the rectangular boxes in the figure below. The Mols-Linien ferries (green) berth with the stern to the ramp and the Kattegatruten (red) with the bow to the ramp.

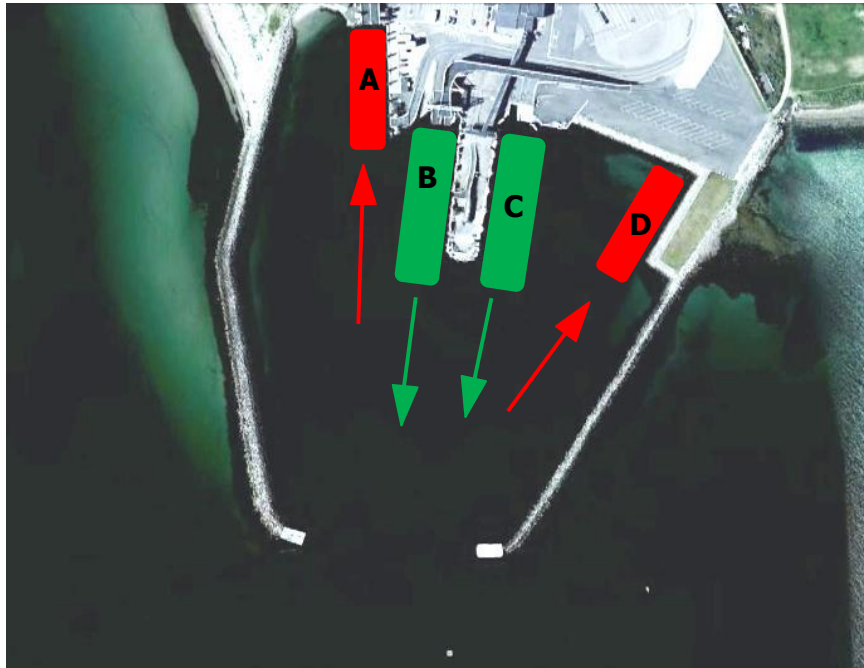


Figure 4.1 Berth concept and possible distribution between operators. Green boxes indicate Mols-Linien ferry berths (B and C), and red boxes indicate possible future Kattegatruten's ferry berths (A and D).

The potential berth D (east side of port) has not been developed at this point.

According to information from Sund & Bælt, it is Mols-Linien's intention to use berths B and C for their daily operation and only use berth A as a back-up for the smaller ferries Mai and Mie Mols.

4.1 Two ferries in port simultaneously

In this section, it is discussed if it is possible to have one ferry moored at one of the berths while another ferry enters or departs the port.

16 different cases are being discussed seen from a manoeuvring point of view with the following considerations:

- Safe distance between the ferries
- Safety during manoeuvre
- Berth availability
- Wake wash from the water jets

The table below gives an overview of the 16 cases. Each case is described in detail later in this section.

Legend to the two following table:

ML-FF1 = Mols-Linien fast ferry, no 1 is Max Mols and Katexpress 1

ML-FF2 = Mols-Linien fast ferry, no 2 is Mie Mols and Mai Mols

OO-FF = Other operator fast ferry

ML = Mols-Linien

Wake wash is the slipstream generated by the water jets. This can be very powerful.

Initial safety evaluation = preliminary evaluation based on a desk study and by applying common sense.







Situation no.	Mols Linien	Berth id.	Other operator	Berth id.	Initial safety evaluation	Manoeuvring considerations	Practical problems	Skematics of situation
1	ML-FF1 in port	B	OO-FF arrives bow in	A	Low, should be avoided	Inbound ship too close to berthed ship, especial risky in westerly winds	M-L has a 10 year contract on berth A, and may use it as a back-up	
2	ML-FF1 arrives and turn around	B	OO-FF in port	A	Medium to low	ML-FF1 stern could come close to OO-FF stern. Wake wash could be a problem	M-L has a 10 year contract on berth A, and may use it as a back-up	
3	ML-FF1 in port	C	OO-FF arrives bow in	A	Satisfactory	No real concern	M-L has a 10 year contract on berth A, and may use it as a back-up	
4	ML-FF1 arrives and turn around	C	OO-FF in port	A	Satisfactory	No real concern	M-L has a 10 year contract on berth A, and may use it as a back-up	
5	ML-FF1 in port	C	OO-FF arrives bow in	D	Medium to Low	OO-FF could come close to ML-FF1 in easterly winds. In about 10-15% wind speed exceeds 12 m/s	Berth D has to be developed.	
6	ML-FF1 arrives and turn around	C	OO-FF in port	D	Low, should be avoided	ML-FF1 stern could come close to OO-FF stern, wake wash is likely a problem.	Berth D has to be developed.	

Table 4.1: Cases 1 to 6







Situation no.	Mols Linien	Berth id.	Other operator	Berth id.	Initial safety evaluation	Manoeuvring considerations	Practical problems	Skematics of situation
7	ML-FF1 in port	B	OO-FF arrives bow in	D	Satisfactory	No real concern	Berth D has to be developed.	
8	ML-FF1 arrives and turn around	B	OO-FF in port	D	Satisfactory to medium	Small likelihood of ML-FF1's bow close to OO-FF's stern, except in strong westerly winds	Berth D has to be developed.	
9	ML-FF2 in port	A	OO-FF arrives bow in	B	Medium	No real concern	M-L has a 10 year contract on berth B and uses it for daily operation	
10	ML-FF2 depart going astern out of the port	A	OO-FF in port	B	Low, should be avoided	ML-FF2 could come close to OO-FF, especially in westerly winds	M-L has a 10 year contract on berth B and uses it for daily operation	
11	ML-FF2 in port	A	OO-FF arrives bow in	C	Satisfactory	No real concern	M-L has a 10 year contract on berth C, and intends to use it from 2013	
12	ML-FF2 depart going astern out of the port	A	OO-FF in port	C	Satisfactory to medium	No real concern, except in wind speeds above 12 m/s the outbound ferry turns in the port	M-L has a 10 year contract on berth C, and intends to use it from 2013	

Table 4.2: Cases 7 to 12





Situation no.	Mols Linien	Berth id.	Other operator	Berth id.	Initial safety evaluation	Manoeuvring considerations	Practical problems	Schematics of situation
13	ML-FF2 in port	A	OO-FF arrives bow in	D	Satisfactory	No real concern	Berth D has to be developed.	
14	ML-FF2 depart going astern out of the port	A	OO-FF in port	D	Satisfactory to medium	No real concern, except in wind speeds above 12 m/s the outbound ferry turns in the port	Berth D has to be developed.	
15	ML-FF1 in port	B	OO-FF arrives bow in	C	Satisfactory	No real concern	M-L has a 10 year contract on berth C, and intends to use it from 2013	
16	ML-FF1 arrives and turn around	B	OO-FF in port	D	Medium	ML-FF1 bow could come close to OO-FF stern, in strong easterly winds	M-L has a 10 year contract on berth C, and intends to use it from 2013	

Table 4.3: Cases 13 to 16

The result of the cases studied in tables 4.1, 4.2 and 4.3 is that the most promising solutions are case 3, 4, 7, 8, 11 and 12 where a new operator uses either berth A or berth D which is not developed at this point of time.

It should be noted that case 9 through 14 will likely not be relevant on a long term basis as the ferries Mai and Mie Mols are expected to be phased out over the coming year(s).

On the following pages all 16 cases are explained in details. Note: All case drawings are aligned north up!

Cases 1 and 2:

This combination where berths A and B are used should be avoided as it is considered that the ferries are too close to each other when the arriving ferry passes the moored ferry at berth B, this is especially critical in strong westerly winds. In case 2, the wake wash from the water jets from the astern berthing ferry could interfere with the moored ferry at berth A, this is especially critical in strong westerly winds. It should be noted that Mols Line has operated 2 ferries according to case 1, but with smaller ferries.



Figure 4.2: Case 1



Figure 4.3: Case 2

At present, there is a practical problem with using berth A as Mols-Linien has a 10-year contract on the use of this berth.

Cases 3 and 4:

This combination where berths A and C are used gives a good separation between the ferries. The wake wash from the manoeuvring ferry would most likely have little or no effect on the moored ferry. Seen from a manoeuvring and initial safety viewpoint, this combination does not create any major concerns. The safety level is initially evaluated to be acceptable.



Figure 4.4: Case 3



Figure 4.5: Case 4

At present there is a practical problem with using berth A as Mols-Linien owns ramp systems etc. installed in the berth. Also the existing ramp system needs to be rebuilt to fit the "Dolphin Jet".

Cases 5 and 6:

This combination where berths C and D are used should be avoided in general and especially in easterly winds exceeding 12 m/s as it is considered that the ferries are too close to each other when the arriving ferry (case 5) passes the moored ferry at berth C. The concern in easterly winds above 12 m/s is the risk that the arriving ferry at berth D could drift into the berthed ferry at berth B. As the arriving ferry (case 6) at berth C turns around, it is likely that the stern of the ferry gets too close to the moored ferry. In case 6, the wake wash from the water jets from the astern berthing ferry is likely to interfere with the moored ferry at berth D. Mols-Linien uses berth C in case of easterly winds in excess of 12 m/s.



Figure 4.6: Case 5



Figure 4.7: Case 6

At present there is a practical problem with using berth D as this has not been developed.

Cases 7 and 8:

This combination where berths B and D are used gives a good separation between the ferries. The wake wash from the manoeuvring ferry would most likely have little or no effect on the moored ferry. Seen from a manoeuvring and initial safety viewpoint, this combination does not create any major concerns. The safety level is initially evaluated to be acceptable. For case 8 however, there is a concern that the turning inbound ferry could get close to the stern of the moored ferry especially in strong westerly winds (above 12 m/s).



Figure 4.8: Case 7



Figure 4.9: Case 8

At present there is a practical problem with using berth D as this has not been developed.

Cases 9 and 10:

This combination where berths A and B are used should be avoided as it is considered that the ferries are too close to each other when the departing ferry (case 10) passes the moored ferry at berth B. The wake wash from the water jets from the departing ferry could interfere with the moored ferry at berth B in case 10. Case 9 is considered medium safe with no real navigational concerns. Case 10 should be avoided.



Figure 4.10: Case 9



Figure 4.11: Case 10

There is a practical problem with using berth B as Mols-Linien has a 10-year contract on the use of this berth.

Cases 11 and 12:

This combination where berths A and C are used gives a good separation between the ferries. The wake wash from the manoeuvring ferry would most likely have little or no effect on the moored ferry. Seen from a manoeuvring and initial safety viewpoint, this combination does not create any major concerns. The safety level is initially evaluated to be acceptable. However, for case 12 there could be a concern in strong winds (in excess of 12 m/s) as the departing ferry turns inside the port and could therefore get close to the moored ferry at berth C and the wake wash could affect the moored ferry.



Figure 4.12: Case 11



Figure 4.13: Case 12

At present there is a practical problem with using berth C as Mols-Linien has a 10-year contract on the use of this berth; also Mols-Linien's use of berth A is only relevant when sailing with Mai and Mie Mols. These ferries are expected to be phased out in future.

Cases 13 and 14:

This combination where berths A and D are used gives a good separation between the ferries. The wake wash from the manoeuvring ferry would most likely have little or no effect on the moored ferry. Seen from a manoeuvring and initial safety viewpoint, this combination does not create any major concerns. The safety level is initially evaluated to be acceptable. However, for case 14 there could be a concern in strong winds (in excess of 12 m/s) as the departing ferry turns inside the port and could therefore get close to the moored ferry at berth D and the wake wash could affect the moored ferry.



Figure 4.14: Case 13



Figure 4.15: Case 14

At present there is a practical problem with using berth D as this has not been developed. Also Mols-Linien's use of berth A is only relevant when sailing with Mai and Mie Mols. These ferries are expected to be phased out in future.

Cases 15 and 16:

This combination where berths B and C are used gives a satisfactory separation between the ferries. The wake wash from the manoeuvring ferry would most likely have little or no effect on the moored ferry. Seen from a manoeuvring and initial safety viewpoint, case 15 does not create any major concerns. The safety level is initially evaluated to be acceptable.

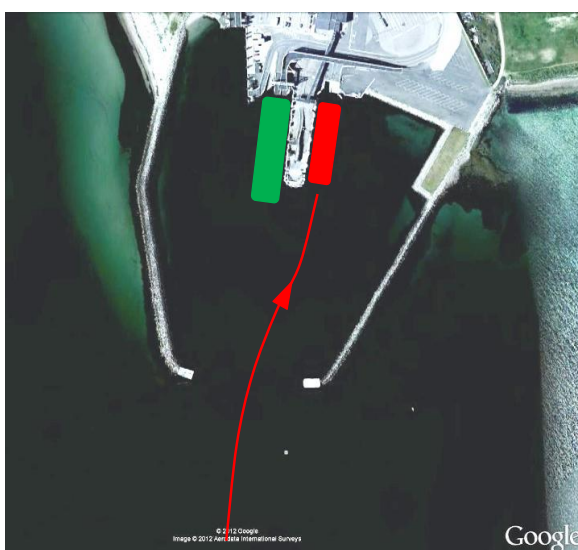


Figure 4.16: Case 15



Figure 4.17: Case 16

For case 16 it is a concern that in strong easterly (NE to SE) wind the M-L ferry has to position the bow on the end of the dolphin to get a mooring ashore to avoid drifting away from berth B when swinging around. In that case the bow of the M-L ferry could get close to the stern of the moored ferry at berth C.

In the strong easterly winds the M-L ferry most likely will use berth C by swinging to port and going astern with the starboard side alongside.

At present there is a practical problem with Kattegatruten using berth C as Mols-Linien has a 10-year contract on the use of this berth.

4.2 Operation with two ferries

The possible operation with two ferries in the port as described above results in a different time schedule for Kattegatruten than suggested in section 3.4. The time schedule has to take into consideration:

- A reasonable time separation between an arriving and a departing ferry (e.g. 2 minutes).
- An arriving ferry should arrive at least a few minutes before scheduled departure time for a departing ferry.
- A departing ferry should wait for an arriving ferry to be securely moored.
- Arrival and departure delays from either operator.

The work included in this report does not suggest a time schedule for a second operator. However, it is predicted that a set of port rules or regulations has to be made to deal with the day to day operation situations of delays. E.g. if an arriving ferry is more than x minutes delayed, it has to wait for the departing ferry to leave the safety zone.

In case of strong winds in which e.g. Kattegatruten has to cancel operations, this is not considered to have any negative influence on the operation of the Mols-Linien ferries. However, adverse weather with strong winds always makes manoeuvres more time consuming, difficult and risky.

5 Safety considerations

This section describes some safety aspects and outlines likely hazards and how to address them.

Hazard identification

The hazard identification is based on FORCE Technology's experience and also a specific "brain storming" among the FORCE Technology personnel that has contributed to this report.

- **Hazard 1:** An arrived ferry should be moored before a departing ferry casts off. This is essential to the basic safety. If a crew is in a hurry because of a delay, there is a potential danger that this rule is not fulfilled at all times.
- **Hazard 2:** Unpredictable weather situations can occur, and this could take the master on e.g. an arriving ferry by surprise with the risk of losing control or getting too close to another berth or a moored ferry.
- **Hazard 3:** The wake wash from the water jets can be significant, especially in weather with strong winds. It could set the whole or larger part of the water body in the port in movement and create additional forces and movements of a moored ferry loading or un-loading with the result of damage to the ferry, ramp and land installations.
- **Hazard 4:** Technical problems with the machinery or the jets on the arriving or departing ferry. This could increase the risk of losing control of the ferry or result in a need for larger (than normal) manoeuvring space. The moving ferry could come closer to a berthed ferry than normally with the risk of a collision.
- **Hazard 5:** Poor communication such as misunderstandings or unclear communication between ferries and/or the port master.

During the hearing process the following hazard were suggested:

- **Hazard 6:** Even with predicted wind/gales/storms where full control with the ferry is maintained there will be no room for other ship/ferries in the port.

Mols-Linien has often asked a fuel tanker to leave berth C for safe arrival to berth B.

As there is no practical experience with a ship berthed on a possible future berth D, hazard 6 needs to be confirmed.

6 Conclusions

The conclusions presented in this section are based on the facts presented in this report as well as discussions between the FORCE Technology personnel involved in the study.

1. The time schedule suggested by Kattegatruten is not viable as outlined. Even if they could reduce the ferries' port time to 20 minutes, it is still considered unrealistic that the manoeuvres for two ferries can be executed on average in 10 minutes. Also by experience, it often happens that the planned ferry schedule is not followed due to weather or due to the amount of vehicles loaded and unloaded.
2. It is likely that it is viable to have one ferry moored while another is arriving or departing, but this can only be done if there is an acceptable safety distance between the moored and the moving ferry.

The cases in section 4.1 indicate that numbers 3, 4, 7 and 8 are the most viable combinations for a second operator to make use of a new developed berth D at the east side of the port. However, there could be concern for case 8 in strong winds (in excess of 12 m/s).

3. The most realistic possibility for a second operator is to use case 7 and 8 for westerly winds and case 3 and 4 for easterly winds. This requires a development of Berth D and that Mols-linien vacate berth A.
4. A set of operating rules and regulations concerning use of the port needs to be developed to solve practical problems that e.g. would occur if the planned arrival or departure of a ferry is delayed.
5. The size, shape and use of the suggested safety zones have to be developed further and be discussed with the Maritime authorities, port authority and the ferry operators.

7 Recommendations

The recommendations are based on FORCE Technology's extensive experience with fast ferry operations and on the specific situations, observations and considerations described in this report.

1. Standard operation procedures (SOP) should be developed together with or as part of a set of port regulations. A port master might be needed to administer these regulations and also be responsible for communication with all ferries entering and leaving the port, if the ferry operators cannot demonstrate safe conduct of operations in the port and in the safety zone
2. In order to establish the actual safety margins and other considerations, it is recommended to perform full-mission marine simulation tests of the most relevant combinations of berth usage. See section 4.1.