PRELIMINARY INVESTIGATION REPORT ON THE SINKING OF M/V AL SALAM BOCCACCIO 98

August 17, 2006

PANAMA, REPUBLIC OF PANAMA

Panama Maritime Authority
General Directorate of Merchant Marine
Casualty Investigation Branch

INTRODUCTION

The Investigation committee, composed of The Arab Republic of Egypt as a Lead State and the Republic of Panama as the Flag State, decided to merge resources in order to carry out the casualty investigation of the M/V AL SALAM BOCCACCIO 98.

The Committee agreed to work within the International framework and terms of reference as established by the IMO CODE FOR THE INVESTIGATION OF MARINE CASUALTIES AND INCIDENTS, Resolution A.849(20), as amended, and the International conventions to which each State is Party.

Several factors while conducting the investigation, and while discussing a preliminary draft report resulted in the issuance of separate reports by each State.

The present report is based fully on the United Nations Convention on the Law of the Sea (UNCLOS), the International Conventions to which Panama is Party, Panamanian National law and the IMO resolution A.849(20), as amended.

Note: The original version of the preliminary report is presented in the Spanish language; however, for matters of cross reference, the present report has been made available in English.

OBJETIVE

The sole objective of the investigation of the sinking of M/V AL SALAM BOCCACCIO 98 is to determine its cause(s), in order to prevent future accidents of the same nature, taking as a reference the IMO Code for the Investigation of Marine Casualties and Incidents, Resolution A. 849(20), as amended.

This investigation is not for the purpose of determining liability, or to apportion blame; however, the investigating authorities have not refrained from fully reporting the cause(s) because fault or liability may be inferred from the findings.

This is a preliminary report stating the facts and conclusions achieved at this stage. Additional information may be provided in due course as a result of further investigation, if found necessary, which will be addressed in the final report.

We reiterate that the intent of this report is not to adopt a position of pointing out fault or blame. Nonetheless, we need to identify errors, whether technical or human, in order to correct them, and to avoid recurrence of accidents of this nature.

SYNOPSIS

The M/V AL SALAM BOCCACCIO 98, was a Panama registered RO-RO passenger vessel, which sank on February 03, 2006, at approximately 0133 hours Egypt local time (2333 hours UTC on February 02, 2006), during her journey across the Red Sea, a short international voyage where she departed from the Port of Duba, Saudi Arabia, with destination to Safaga, Egypt.

The vessel departed from the Port of Duba at 1651 hours UTC, with a total of 1418 persons on board, including crew members, and their luggage, and fully loaded with cars and some trucks.

The voyage started as usual, while the vessel was on routine normal trading between the above-mentioned ports.

Approximately 2 hours and 20 minutes after departure, at about 1909 hours UTC, the auto-pilot alarm sounded on the bridge and few seconds later, the fire-alarm sounded.

The crew members started fighting the fire with different means on board and as a result of the fire mitigation, the scuppers were blocked, and the accumulation of a large amount of water, coupled with the weather conditions, finally caused an excessive list of the vessel to starboard.

With the intention of correcting the list of the vessel, the master began ordering ballast water operations leading to a further increase of the list of the vessel. As a result of the list, sea water ingressed into the vessel eventually causing the sinking.

No orders of evacuation were given to the crew members or the passengers at any time.

This accident was due to a sequence of events, and caused the loss of 1,031 persons, including some crew members, the total loss of the cargo and the vessel.

With the outcome of this investigation several recommendations have been made to the IMO, the Flag State, the Coastal State and the Management Companies of RO-RO passengers vessels, as a matter of urgent attention.

APPOINTMENTS

The following appointments were designated by the Panama Maritime Authority:

Reynaldo Garibaldi
Marine Engineer
Chief of the Technical Department and the Casualties investigation Branch
Panama Maritime Authority

Napoleon Smith
Marine Engineer
New York Technical Office
Panama Maritime Authority

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CHAPTER "A"

FACTUAL

INFORMATIO

1. Glossary and Abbreviations

AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
CCTV	Close Circuit Television
CEC	Certificate of Equivalent Competency
COC	Certificate of Competency
CPA	Close Point of Approach
DOC	Document of Compliance
E/R	Engine Room
GMDSS	Global Maritime Distress and Safety System
GPS	Global Position System
GT	Gross Tons
IMO	International Maritime Organization
ISM	International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention
ISSC	International Ship Security Certificate
KW	Kilowatts
LBP	Length between Perpendiculars
LT	Local Time
NM	Nautical Miles
PSC	Port State Control
PMA	Panama Maritime Authority
PSR	Panama Shipping Registrar
PSSC	Passenger Ship Safety Certificate
OOW	Officer On Watch
RINA	Registro Italiano Navale
C/E	Chief Engineer
C/O	Chief Officer
1/E	First Engineer
2/O	Second Officer
2/E	Second Engineer
3/O	Third Officer
3/E	Third Engineer
A/B	Able Seaman
OS	Ordinary Seaman
MDO	Marine Diesel Oil
HFO	Heavy Fuel Oil
LO	Lube Oil
FW	Fresh Water
SW	Sea Water
ROV	Remotely Operated Vehicle
RPM	Revolution Per Minute

SMC	Safety Management Certificate
SMS	Safety Management System
SOLAS	Safety of Life at Sea Convention 1974
STCW	International Convention on Standards of Training And Watch keeping for Seafarers
UTC	Universal Coordinate Time
VDR	Voyage Data Recorder
VHF	Very High Frequency (radio)
VTS	Vessel Traffic System

2. Accident summary

2.1	Name of the vessel:	M/V AL SALAM BOCCACCIO 98
2.2	Flag:	PANAMA
2.3	Date of Sinking:	FEBRUARY 02, 2006
2.4	Time of Sinking:	23:33 UTC (0133 Egyptian local time)
2.5	Position:	27º 08.0' N, 034º 59.1' E
2.6	Total on board:	1,418
2.7	Total Loss of Life:	1,031 (710 missing and 321 bodies recovered)
2.8	Rescued alive:	387
2.9	Owners:	Pacific Sunlight Marine Inc.
2.10	Management Company:	El Salam Maritime Transport Co.
2.11	Classification Society:	RINA
2.12	Other RO:	Panama Shipping Registrar (PSR)
2.13	Pollution:	None reported
2.14		

3. Ship details

3.1	RINA Number :	46913
3.2	IMO Number :	6921282
3.3	Former Names :	Boccaccio
3.4	Service :	Ro-Ro Passenger Ship
3.5	Owner :	Pacific Sunlight Marine Inc.
3.6	Flag :	Panama

3.7	Call Sign :	3FIH9
3.8	Port Nº register :	Panama- 28066 Pext
3.9	Characteristic of Service:	Unrestricted Navigation
3.10	Class Period:	5 : 0 : 0
3.11	Class Starting date :	March 31, 2003
3.12	First Entry date :	June 1, 1970
3.13	Special notations :	None
3.14	Equip Nº :	1898
3.15	Gross Tonnage:	11779
3.16	Net Tonnage:	5555
3.17	Overall length:	130.98 m
3.18	LBP:	118.00 m
3.19	Molded breath:	23.60 m With Sponsons
3.20	Tonnage height:	12 m Upper Deck
3.21	Free board:	1312 mm
3.22	Draught:	5900 mm
3.23	Hull information:	Steel/ordinary-SD-BuB-Mer-18Dk
3.24	Derricks and cranes:	1 crane
3.25	Electrical plant Gen:	4x750kVA 1x187.5kVA x 1x1162.5kVA 440 V 60 Hz AC.
3.26	Speed:	22 Knots
3.27	Power, in kw-r.p.m:	12180
3.28	Numbers of cars: 22	
3.29	Numbers of trucks:	14 Truck with head
3.30	Number of trailers:	6 of 40 feet, and 1 of 20 feet

4. Hull

4.1	Builder:	Italcantieri s.p.s.-stab. Castellammare Di Stabia
4.2	Building Year :	1970

4.3	Building place :	Castellammare Di Stabia
4.4	Number of building :	4237

5. Machinery

5.1	Number – type – Designer :	2 Diesel Fiat
5.2	Year built:	1970
5.3	Manufacturer and place of build:	Cantieri Riuniti Dell`Adriatico (Fabbrica Motori S. Andrea.)
5.4	Power (k-W) and rpm:	12180 (2x6090) kw at 220 rpm
5.5	Characteristics:	2s 9cyl-line 600x800 Chp DR.

6. Bridge Equipment

6.1 Standard and spare magnetic compass
6.2 Gyro compass and heading/bearing reference
6.3 Autopilot
6.4 Echo sounder
6.5 GPS
6.6 Radars 9 GHz and 3GHz
6.7 Automatic radar plotting aid (ARPA)
6.8 Automatic identification system (AIS)
6.9 Speed and distance measuring device (through the water)
6.10 GMDSS equipment for area A1, A2, A3:
6.11 VHF radio installation
6.12 MF/HF radio installation
6.13 Secondary means of alerting
6.14 NAVTEX
6.15 EGC receiver
6.16 Satellite EPIRB – COSPAS – SARSAT
6.17 IMMARSAT SAT – A telex/voice/fax

6.18 IMMARSAT SAT – C (two).

6.19 VDR

6.20 Rudder indicator

6.21 Telephone to emergency steering position

6.22 Signaling lamp

7. Relevant safety equipment

7.1	Total number of Lifeboats:	10 (5 on each side)
7.2	Total persons accommodated by them:	890
7.3	Number of motor lifeboats:	2
7.4	Number of Lifeboats with search lights:	2
7.5	Number of Fast rescue boats:	1
7.6	Life rafts:	88
7.7	Number of persons accommodated by them:	2,200
7.8	Number of life buoys	18
7.9	Number of buoyant apparatus	6
7.10	Number of Life Jackets:	3,070
7.11	Immersion Suits:	36
7.12	Number of radar transponders:	2
7.13	Number of two way VHF radios:	3

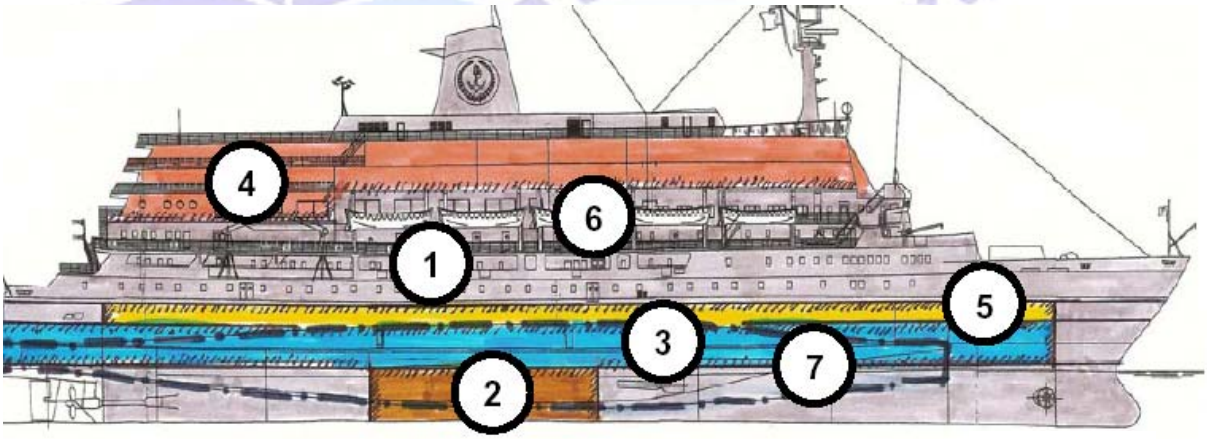


Figure 1

Notes.

1. Accommodation spaces as part of the original construction and fitted with sprinklers as per SOLAS 60.
2. Machinery spaces fitted with CO^2 in the M/E, auxiliary engine, stabilizer room, and electrical installation.
3. Main RO-RO cargo space (car deck) fitted with high pressure water spray fire extinguishing system.
4. Superstructure decks added to the vessel in 1990 and 1991 duly calculated and fitted with sprinkler system.
5. Upper Ro-Ro deck replaced with accommodation spaces
6. Survival crafts
7. Sponsons fitted on each side of the hull in 1990 and 1991.

8. Certifications and inspections

8.1 Registration certificate: Issued on **27/Nov/2002** and valid until **26/Nov/2006**
8.2 Radio Station License: Issued by PMA **07/Nov/2003** valid until **07/Oct/2007**
8.3 PSSC: Issued by PSR, issued on: **18/Oct/2005**, valid until **14/Sep/2006**
8.4 PSSC: Issued by the Egyptian Authority on **1/Feb/2006**, and expired **20/Feb/2006**
8.5 Class Certificates: Issued by RINA on **13/Nov/2003** and valid until **31/Mar/2008**
8.6 IOPP Certificate: Issued by RINA on **13/Jun/2003** valid until **31/Mar/2008**
8.7 LL Certificate: Issued BY RINA on **13/Nov/2003** valid until **31/Mar/2008**
8.8 SMC issued by RINA on **27/Oct/2005** valid until **26/Apr/2006** (Interim)
8.9 DOC issued by RINA on **12/Oct/2005** valid until **11/Oct/2006** (Interim)
8.10 MSMC: Issued by PMA on **04/Apr/1999**
8.11 ITC: Issued by RINA on **13/Jun/2003**
8.12 ISSC: Issued by RINA on **27/Oct/2005** valid until **26/Apr/2006** (Interim)
8.13 Last Dry dock: Issued by RINA on **13/Jun/2004**
8.14 Last Underwater Survey **Apr/2005**
8.15 Last ASI inspection **2003**
8.16 Exemption Certificate for oil water Separator valid until **31/Mar/2008**
8.17 Fixed CO^2 Certificate issued by Ultra Tec **4/Apr/2005**
8.18 CO^2 High Pressure tested by Ultra Tec **4/Apr/2005**
8.19 Breathing Apparatus tested by Ultra Tec **4/Apr/2005**
8.20 History of class and statutory surveys carried out by RINA (as from the last class renewal survey)

Date	Port	Class surveys	Statutory surveys
16-19/Mar/2003	Suez	• Renewal (commencement)	

26-31/Mar/2003	Suez	• Renewal (continued) • Annual • Continuous Machinery	• ILL Renewal
22-29/Jun/2003	Suez	• Renewal (completion) • Dry-dock • Tail shaft	• IOPP Renewal • SMC Intermediate
29/Oct/2003	Suez		• Inclining Test (Safety Passenger)
4-13/Jun/2004	Suez	• Annual • Dry-dock • Continuous Machinery • Hull Occasional	• ILL Annual, • IOPP Annual, • Safety Passenger Renewal
10/Jun/2004	Suez		• ISSC pre-verification
19/Jul-4/Ago/2004	Ancona	• Machinery Occasional	
2-5/Oct/2004	Suez		• SMC Renewal
26/Feb-3/Apr/2005	Suez	• Continuous Machinery	
25/Jun/2005	Suez	• Annual (commencement)	
30/Jun/2005	Suez	• Annual (completion) • Continuous Machinery	• ILL Annual • IOPP Intermediate
27/Oct/2005	Safaga		• ISSC pre-verification • SMC Interim Audit

Table 1

General arrangement view of the ship

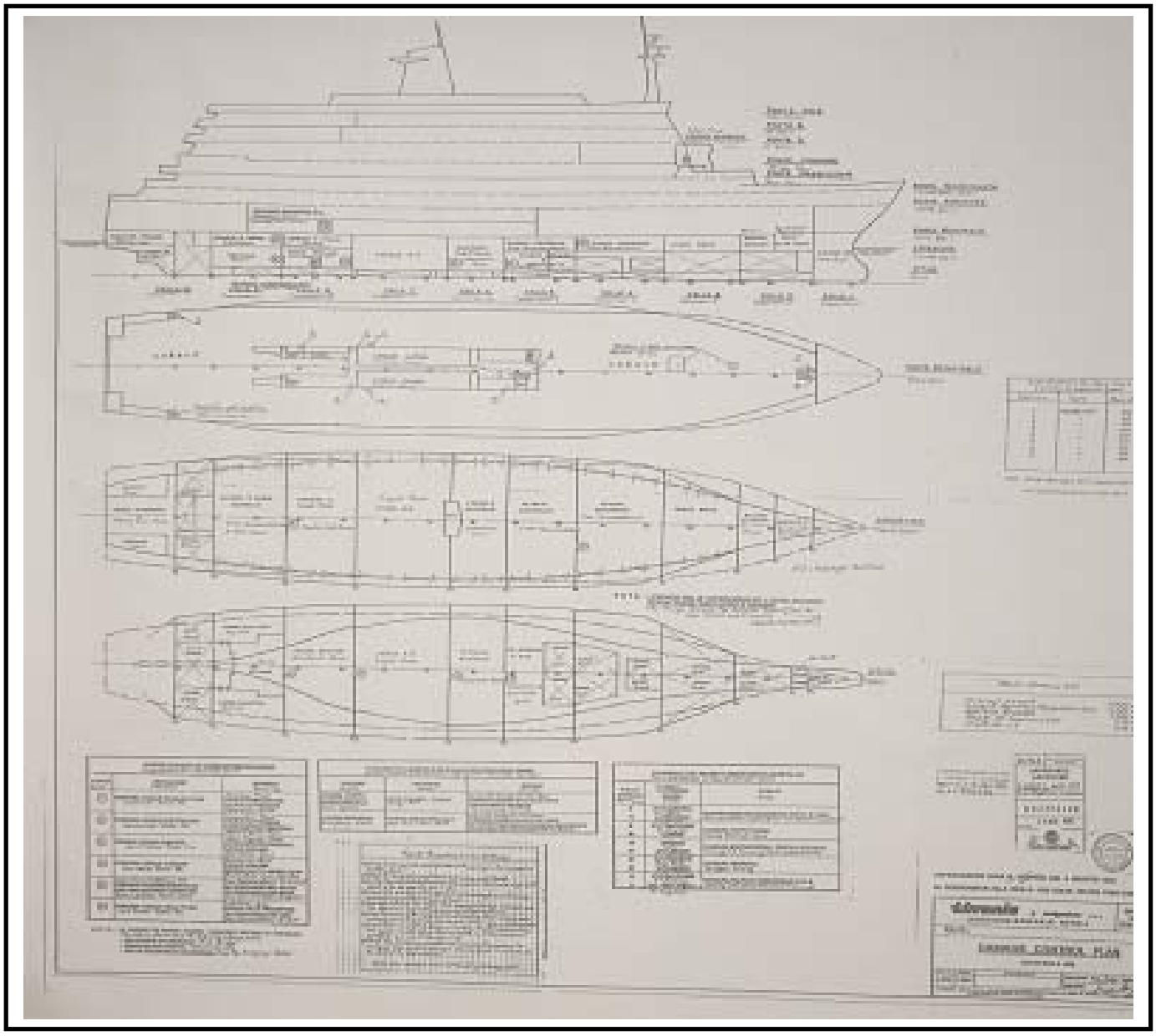


Figure 2

9. Working Language

The entire crew of the M/V AL SALAM BOCCACCIO 98 was of Egyptian nationality, and their working language was Arabic. All communications and orders during the final voyage between the master, officers and ratings were conducted in their native language; therefore the information recorded in the VDR was in Arabic and after recovery it was translated into English[1].

10. Background

10.1 The ship

The M/V AL SALAM BOCCACCIO 98 was built in 1970 in CASTELLAMMARE DI STABIA, Naples, Italy, and owned by TIRRENIA DI NAVIGAZIONE; and operated in the Mediterranean waters for 28 years.

In 1990, the ship underwent modifications at SEBM Shipyard in Naples, Italy, in order to fit car decks at the mid height in the main car deck, between frames # 26 and 160.

Moreover, in 1991 she was modified at the same yard with the addition of 3 superstructure accommodation decks, and sponsons were fitted on each side of the hull.

Also a fixed CO^2 fire-extinguisher system was fitted in the machinery spaces in lieu of high expansion foam system.

All modifications and calculations were carried out in accordance with the International Conventions and RINA rules.

After all modifications, RINA approved the new stability book in accordance with SOLAS 74 stability standards, as amended.The car decks previously fitted in 1990 on the main car deck were removed at Suez in 1999.

[1] Translation and transcription of the VDR from Arabic to English was made by a translator of the Committee.

The ship changed flag from Italy to Panama in the year 1999.

In the year 2000, the ship was modified with new accommodation areas fitted in lieu of the upper car-deck, and the work was carried out at Suez, Egypt.

RINA carried out the plans approval and also the supervision during the modifications work according to RINA classification rules and SOLAS requirements.

M/V AL SALAM BOCCACCIO 98

Figure 3

10.2 Management Company

From 1970 to 1999, the ship was operated by TIRRENIA DI NAVIGAZIONE trading between Civitiavecchia and Cagliari, Genova and Olbia.

In 1999 the vessel changed management company to EL SALAM SHIPPING AND TRADING. This company was already certified with an ISM Document of Compliance issued by RINA on behalf of the Panamanian Administration since 1997.

Ever since the company acquired the vessel, she had been trading in the Mediterranean Sea and the Red Sea, depending of her commercial obligations.

In October 2005, the management of the M/V AL SALAM BOCCACCIO 98 was changed to EL SALAM MARITIME TRANSPORT COMPANY.

This new managing company was certified by RINA in 2005, according to the ISM Code Part B, section 14 for Interim certification.

The EL SALAM MARITIME TRANSPORT Company currently operates 15 vessels in the Red and the Mediterranean Seas.

The M/V AL SALAM BOCCACCIO 98, ex BOCCACCIO, had 3 sister ships: AL SALAM MANZONI 94, AL SALAM PASCOLI 96, and AL SALAM CARDUCCI 92. All these vessels have undergone the same modifications as the M/V AL SALAM BOCCACCIO 98.

10.3. Maintenance

The maintenance of the M/V AL SALAM BOCCACCIO 98, according to records and interviews, was carried out at proper intervals with no significant or related outstanding remarks.

A maintenance plan was in place for the fleet, and the company carried out the last inspection of the vessel on January 26, 2006.

The Vessel's Superintendent informed us that, as a matter of policy, the company carries out monthly inspections on their vessels.

12. Source of Information and interviews

The information contained in this report has been extracted from the VDR recording, interviews of the crew members rescued, authorities, and company personnel, as well as documentation from the Flag State, the Port States and Recognized Organizations, accordingly.
However, it was not possible to carry out the interviews of the SAR Coordination Center or to the Saudi Arabia Authorities.

11.1 Persons interviewed

- Crew members.
- Egypt Port State Control officers who carried out the last Port State Control inspection.
- A previous master of the M/V AL SALAM BOCCACCIO 98.
- A previous chief engineer of the M/V AL SALAM BOCCACCIO 98.
- Superintendent of the Company.
- Designated Person ashore.
- A Red Sea Port Authority member.
- The Safaga agent on duty at the time of the accident.
- The Safaga Agency manager.
- Radio Qusseir personnel on duty at the time of the accident.
- General Manager of the Company.
- Flag State surveyor.
- PSR surveyor and RINA surveyor.
- Fleet Manager of the Company.
- Human Resources manager of the company.

Detailed list of persons interviewed by name and job title

S.N	Name	Job
1	Medhat Abbas Mahmoud Abdel-Meguid	O/S
2	Ahmed Essayed Fath-Allah Mohamed Amin	Cabin - supervisor
3	Mostafa Mohamed Essayed Metwalli	Cabin - supervisor
4	Abu-Bakr Gaber Abdel-Rahman Abú-Bakr	Cabin - supervisor
5	Mohamed Hamed Mohamed Hamed	Market head
6	Ahmed Mohamed Ahmed Ateya Abdel-Hadi	A/B
7	Rani Kamal-Eddin Mohamed Mounir	3rd officer
8	Ahmed Nasr-Eddin Mahmoud Suleiman	3rd officer
9	Mamdouh Mohamed Abdel Kader	Fleet Manager
10	Salah Eddin Mahmoud Gomaa	St. Catherine master
11	Essayed Abdel Moniem Essayed	2nd officer
12	Nabil Essayed Ibrahim Shalabi	Al Salam Safaga manager
13	Omar Fathi Abdel-Rahman Ahmed	Cabin - supervisor
14	Mohamed Tawfeek Abdel-Meguid El-Tayeb	Cabin - supervisor
15	Tamer Fikri Hakim Slouanas	Cabin - supervisor
16	Rani Kamal-Eddin Mohamed Mounir	3rd officer
17	Ahmed Nasr-Eddin Mahmoud Suleiman	3rd officer
18	Ali Youssef Mahmoud Selim	Welder man
19	Mohamed Bayoumi Hashem Abdel-Rahman	Baker
20	Essam Fouad Mahmoud Hashem	Trainee Cabin - supervisor
21	Mohamed Abdel-Mohsen Mahmoud Hanafi	Trainee Cabin - supervisor
22	Mohamed Saleh Abdel-Wahed	Wiper
23	Ahmed Essayed Kasem Suleiman	A/B
24	Yaseen Mohamed Waziri Ismael	Mechanic
25	Waleed Fawzi Ismael Ibrahim	Storekeeper
26	Waleed Helmi Zaki Ibrahim	Asst. Steward

27	Ali Ibrahim Ali Eldehna	Cabin - supervisor
28	Maher Saed Mahmoud Reda (1/2)	Inspection Expert
29	Mohamed Emad-Eddin M. Abu Taleb (+ hand written statement)	Vice-Chairman High-seas master
30	Magdy Saady_1-2	Q & S Controller
31	Medhat Abbas	O/S
32	Ahmed Helmi 1-2-3	Fleet Manager
33	Hossam-eddin Ismael	Recruitment manager
34	Ashraf Nazmi Ibrahim	Marine inspector
35	Ihsan Shagar Badawi	PSC officer
36	Ahmed M. Youssef Oleiba	Inspection and auditing GM
37	AlModdather M. Youssef	Safaga Deputy Manager
38	Ahmed Helmi_2	Fleet Manager
39	Shehab Al Matbouli+ Keith Java	RINA
40	Fathi Abbas	Previous chief engineer aboard Al Salam Boccaccio 98
41	Basem M. M. Al-Amir	Previous chief engineer
42	Ahmed Ateya	Radio Quseir
43	Ibrahim Sayyed M. Ahmed	Al-Salam, Safaga
44	Salah Gomaa	St. Catherine master
45	Nabil Shalabi	Al Salam Safaga Manager
46	Hayder Abdel-Aleim	Central Marine Inspection manager
47	A. El-Shal	Marine Inspector
48	A. ElHousini	Ex – Hurghada manager
49	A. Abdel-Karim	Hurghada Marine Inspection manager
50	Adm. Hussein Gamil El Hermeel	Ex – EAFMS Chairman

Table 2

12. Narrative

12.1 The previous voyage

The M/V Al SALAM BOCCACCIO 98 arrived at the Port of Duba in Saudi Arabia at about 0945 hours local time on February 2, 2006, with the following conditions:
FO 90 MT
DO 75 MT
FW 200 MT
1400 persons
14 Cars
12 Trucks
7 luggage Trailers (six 40 feet and one 20 feet)

12.2 The voyage of the accident

While the vessel was at the Port of Duba she was loaded with 14 trucks, 6 trailers of 40 feet and one trailer of 20 feet, all of them open top type, containing the passenger luggage, and 22 privately owned cars.
The total cargo declared was 76.32 tons not including the passengers' luggage.
According to the master's arrival and departure condition, the vessel departed from Port of Duba with approximately 90 tons of HFO, 99.8 tons of MDO, and 187.86 tons of FW.
There were 1,321 passengers and 97 crew members for a total of 1,418 persons onboard. She sailed from the Port of Duba at 1651 hours UTC, and reported a draught of 5.7 meters.
At 0133 hours Egypt local time, on February 3, 2006 (2333 hours UTC February 2, 2006) according to the VDR information, the 11,779 GT Panama registered RO-

RO Passenger vessel, M/V AL SALAM BOCCACCIO 98, sank approximately 57 miles from its port of destination, the Egyptian Port of Safaga, and 41 nautical miles from her port of departure, the Saudi Arabian Port of Duba.

As a result of this accident, there were 1,031 lives lost, of which 387 persons, including 24 crew members, were rescued and 710 are missing and presumed dead.

Route of the vessel from the Port of Duba heading to the Port of Safaga

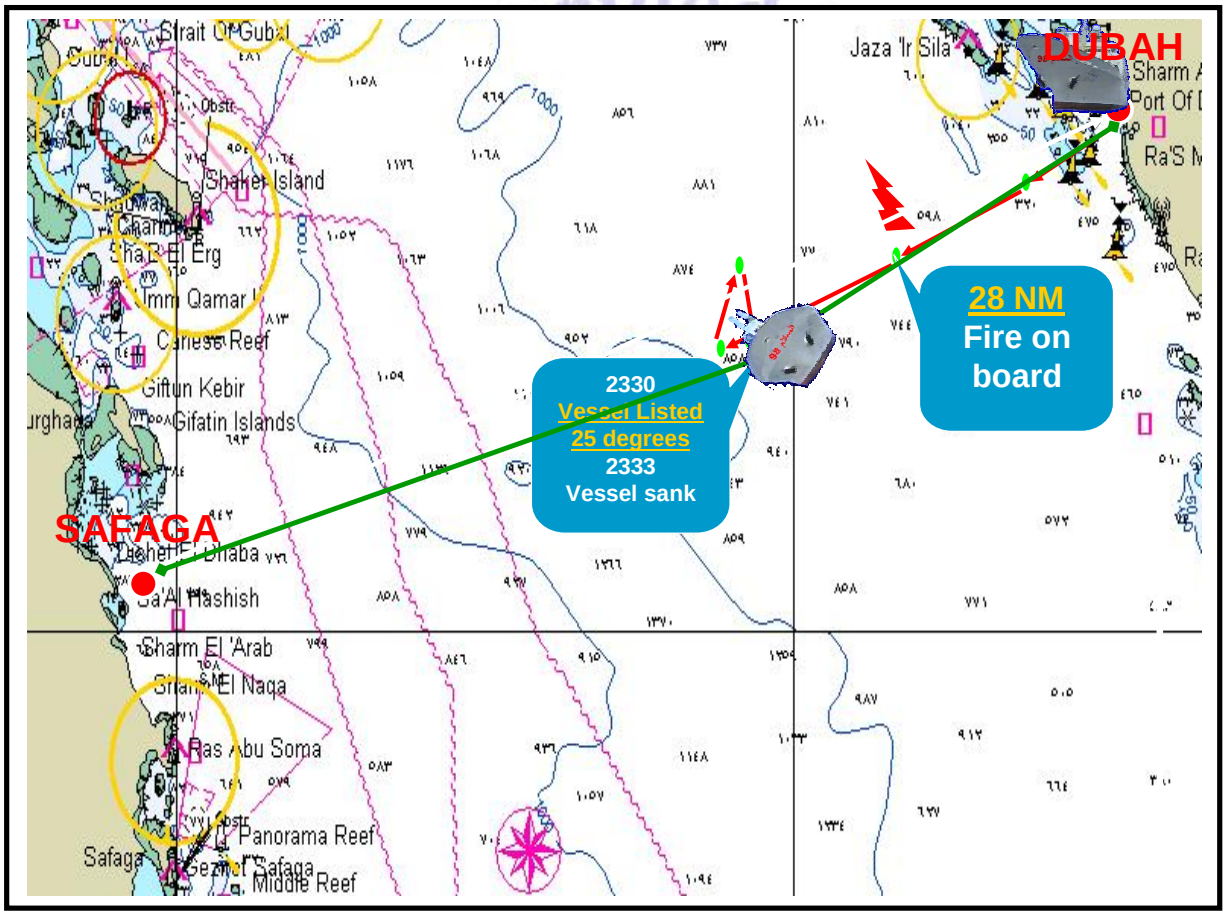


Figure 4

12.3 Weather conditions

The weather conditions, according to the departure information reported by the master, were approximately 6 to 7 on the BEAUFORT SCALE, but according to the VDR information, weather conditions were 7 to 8 on the BEAUFORT SCALE, moderate gale, with a southeasterly wind.

According to the information collected from the survivors, vessels in the vicinity and other authorities, the weather conditions were not the usual for that area.

This was also confirmed by the statement and subsequent interview with the master of the M/V SAINT CATHERINE, who declared that the weather was bad with an 8 BEAUFORT SCALE, and wind speed gusting up to 60 knots WNW based in the positions of his vessel.

12.4 Departing condition of the ship

Before departure, the operations were carried out as usual by the ship's crew. Loading cars and passengers on board the vessel followed normal procedures.

While she was at port, a Port State Control inspection was conducted with no significant remarks, and the crew members were present at the time of the inspection.

According to the interviews, prior to departure, the ship's crew started verifying the securing and lashing of the cargo as per the ISM manual. The ramps and doors were closed and secured before departing; the vessel sailed with her cargo, plus the 1,418 persons.

Additionally, all of the vessel's statutory certificates were valid, as required for the intended voyage.

12.5 Scuppers design and details

The M/V AL SALAM BOCCACCIO 98 was fitted with 13 scuppers on each side of the ship, and each scupper had a diameter of 125 mm. The scuppers were fixed with two non-return valves, one high up and the other at the lower part of the scupper, near to where it discharged, below sea level. The scuppers had a design capacity to evacuate the water coming from the fire-fighting system.

It is important to underline that immediately after the accident, several inspections and evaluations were carried out on the sister ships in order to obtain a similar view of the drainage system, but especially regarding the stability, fire-fighting systems, and behavior of the crew, as well as the scuppers performance.

Scuppers testing with the sprinklers

Figure 5

Note: As per the evaluation carried out on board one sister ship, in ideal conditions, it is clear that in a short period of time (10 minutes in this case), the accumulated amount of water can rapidly increase in the car deck.

As a matter of consideration, RINA, the RO acting on behalf of the Flag State, carried out an analysis of the design and performance of the scuppers in different scenarios; therefore we considered it important to have the design and engineering calculations of the scuppers as factual important information. These details and the analysis of the results are in the Chapter B.

The above mentioned details are specified as follows:

The simplified mathematical model is based on the following:

1. Calculation of the drainage flow rate that a single scupper is able to maintain as a function of the positive (driving) head.
2. Calculation, as function of the time, of the water mass accumulation on the freeboard deck, taking into account an input flow rate from the drencher system and fire-fighting hoses as well as an output flow rate from the scuppers.

The aim of this head loss calculation is to quantify the flow rate that a piping is able to discharge, given a certain hydrostatic head.

Definitions of Scuppers details and calculations.

H: total hydrostatic head (driving head) in [m]

h_f: head loss due to distributed friction in pipes in [m]

A: internal area of the pipe in [m^2]

Q: Volumetric flow rate in [m^3/s]

B: Average speed of fluid in the pipe in [m/s]

Diam: Internal diameter of the pipe [m]

h_c: Concentrated head losses in [m].

K: Concentrated head loss factor, depends on each fitting, adimensional.

f: friction coefficient in Darcy-Weisbach equation, adimensional.

Equation that relates the total driving head to the sum of all the head losses present in the piping system, both distributed and concentrated:

$$heads\_equation := H = h\_f + 2\ Check\_Valve + Elbow + Inlet + Outlet$$

Equation that expresses the internal area of a circular pipe given the internal diameter

$$A := \frac{1}{4}\pi\ Diam^2$$

Equation that expresses the volumetric flow rate, given the internal area and the average speed of the fluid

$$Q := \frac{1}{4}\pi\ Diam^2\ V$$

Concentrated head loss in [m], general formula.

$$h\_c := \frac{K\ V^2}{2\ g}$$

Head loss of each swing check valve from Frank M. White "Fluid Mechanics" 5th edition Chapter 6 Table 6.5. "Resistance Coefficients for Open Valves, Elbows and Tees" thus K = 2.

$$Check\_Valve := \frac{1.000000000\ V^2}{g}$$

Head loss of each tee from Frank M. White "Fluid Mechanics" 5th edition Chapter 6 Table 6.5. "Resistance Coefficients for Open Valves, Elbows and Tees" taken as K = 0.8 (on the safe side)

$$Elbow := \frac{0.4000000000\ V^2}{g}$$

Sharp edge inlet, from Frank M. White "Mechanics of Fluids" 5th edition Chapter 6 Figure 6.21 taken as K = 0.5

$$Inlet := \frac{0.2500000000\ V^2}{g}$$

Sharp edge outlet, from Frank M. White "Mechanics of Fluids" 5th edition Chapter 6 Figure 6.22 taken as K = 1.0

$$Outlet := \frac{0.5000000000\ V^2}{g}$$

Distribuited head loss Darcy-Weisbach equation, from Frank M. White "Fluid Mechanics" 5th edition Chapter 6 Eq 6.30

$$h\_f := \frac{f\ L\ V^2}{2\ g\ Diam}$$

Colebrook equation, from Frank M. White "Fluid Mechanics" 5th edition Chapter 6 Eq 6.64

$$Colebrook\_equation := \frac{1}{\sqrt{f}} = -\frac{2.\ln\left(\frac{0.2702702703\ rough}{Diam} + \frac{2.51}{Reynolds\ \sqrt{f}}\right)}{\ln(10)}$$

Reynolds Number definition:

$$Reynolds := \frac{\rho\ |V|\ Diam}{\mu}$$

Resulting system of equations in V and f:

$$H = \frac{f\ L\ V^2}{2\ g\ Diam} + \frac{3.150000000\ V^2}{g}$$

$$\frac{1}{\sqrt{f}} = -\frac{2.\ln\left(\frac{0.2702702703\ rough}{Diam} + \frac{2.51\ \mu}{\rho\ |V|\ Diam\ \sqrt{f}}\right)}{\ln(10)}$$

Density of sea water, in [kg/m^3]

$$\rho := 1025$$

(Dynamic) viscosity of sea water, in [kg/m*s]. The fluid is considered to be Newtonian.

$$\mu := 0.00089$$

Internal diameter of the considered pipe, in [m]

$$Diam := 0.125$$

Total length of considered pipe, including the length of swing check valves and elbow, in [m]

$$L := 5.5$$

Absolute roughness in [m], from Frank M. White "Fluid Mechanics" 5th edition Chapter 6, Table 6.1 "Recommended roughness values for commercial ducts" for rusted steel pipes with full 50% uncertainty on the safe side.

$$rough := 0.003$$

Gravity acceleration, in [m/s^2]

$$g := 9.81$$

Total hydrostatic head (driving head) in [m]

$$H := 1.3$$

Q_out_s: volumetric flow rate, in [m^3/s]

Q_out_h: volumetric flow rate, in [m^3/h]

$$\left\{1.3 = 2.242609582\, f\, V^2 + 0.3211009175\, V^2,\ \frac{1}{\sqrt{f}} = -\frac{2.\ln\left(0.006486486487 + \frac{0.00001743531707}{|V|\ \sqrt{f}}\right)}{\ln(10)}\right\}$$

$$\{V = 1.721757556, f = 0.05236271714\}$$

$$Q\_out\_s := 0.02112914410$$

$$Q\_out\_h := 76.06491876$$

$$Reynolds := 2.478653786\ 10^5$$

Note: See Chapter B for the results.

12.6 Lashing of cargo in the car-deck

The lashings in the car deck were secured properly using the chain blocks and lashing instruments accordingly.

The car deck was constructed with 2 angle stiffeners as well as fixed deck eyes in which the portable shoes could be slid. It is important to bear in mind that there are no bulkheads for lashing points.

The vessel was normally operated with a three step lashing system for different weather conditions.

The lashing step 1 comprises wheel chocking wedges and chains for lorries and trailers, and the number of lashing depended on the size of the vehicles.

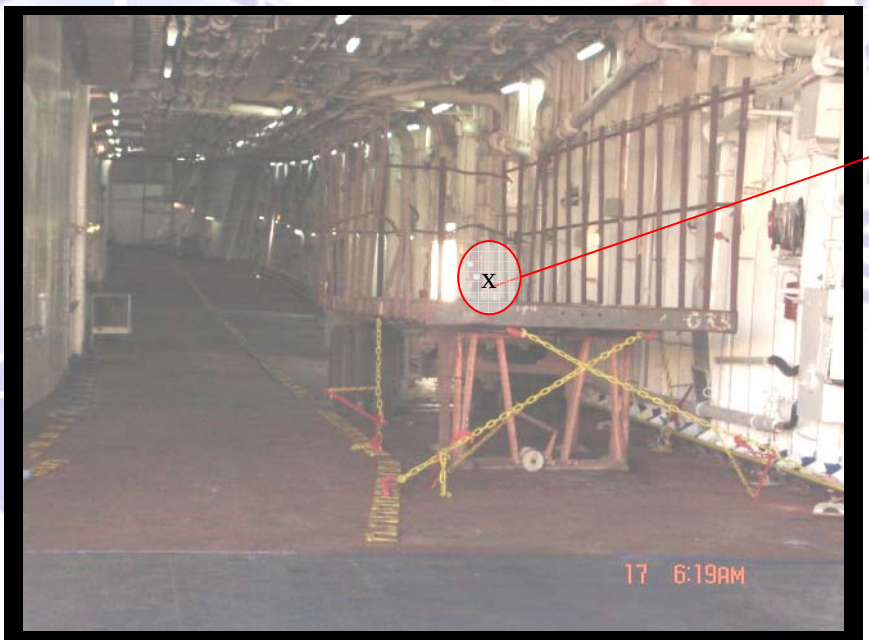
Also the information collected indicates that the lashings of the cars and wheels were done with straps.

The lashing system 2 is very similar to the lashing system 1, but with additional belts with ratchets for tightening. According to our investigations, this system has only been used for the vessels of the fleet in the Mediterranean Sea during the winter time.

The lashing system 3 is in addition to systems 1 and 2 mentioned above, and they involve the use of heavy lashing chains, but we could not obtain any indications that they had been used during the vessel operations.

According to the records, it appears that she was operating normally with lashing system 1 only.

Picture of a trailer for luggage and cargo lashing, looking from starboard aft to fwd.



Normal place for the stowage of luggage.

Figure 6

12.7 Fire-detection system in the car-deck

The car-deck fire detection system was composed as follows:

12.7.1 Fitted with automatic heat detectors, model NIFE ITALIA MODEL SWM-1KL, distributed through out the cargo space, and the system was connected to the fire alarm control panel located in the bridge.

12.7.2 The heat detectors were capable of being activated at a temperature of 57º C.

12.7.3 The alarm panel system indicated the trouble zone in which a heat detector had been activated.

12.7.4 The ship was provided as per SOLAS 74, Chapter II-2 regulations 41-2.6.4 (SOLAS 92 as amended) as follows: “The activation of any detector should initiate a visual and audible alarm in the control panel and indicating units. If the signal has not been acknowledged within 2 minutes, an audible alarm shall be automatically turned on through the crew accommodation, service spaces, control station and machinery spaces of category “A”.”

12.7.5 The fire detection system was divided into 5 zones and, as an additional measure a watchman was on duty in the car-deck, during the entire navigation period.

12.8 Fire-fighting pumps and hoses

The car-deck was provided with 9 fire hydrants connected to the fire main system, which was fed by three main fire pumps, with an approximate capacity of 90 M^3/h each one, and a head of 7 Bars.

One of the three main fire pumps was an emergency fire pump.

Additionally the vessel was provided with three fire pumps as follows:

- One pump dedicated to the ballast system.
- One pump dedicated to the sprinkler system.
- One pump dedicated to the water spraying system in the garage.

12.9 Fixed fire-extinguisher system

The vessel was fitted in the car deck, with a fixed fire extinguishing system (water spray type) reach to protect 5 distinct zones, with the capability of delivering 430 M^3/h through the nozzles.

Each section can be manually operated independently from the two different control stations.

12.10 Qualification of crew

The crew members of the vessel were of Egyptian nationality, properly certified according to the STCW 78 Convention, as amended, and the vessel was manned according to the Minimum Safe Manning Certificate.

Must of the senior officers were holding certificates of higher ranks than their current positions, and an important issue observed was that there were extra officers on board to help the principals in their duties.

12.11 Training

All crew members, including officers, had successfully completed courses and training to obtain the required certificates for seamanship at the Arab Academy for Science & Technology and Maritime Transport at Alexandria, Egypt.

The persons interviewed showed clear knowledge of their duties in case of emergencies, as per their instruction manuals.

Drills were carried out in accordance to SOLAS 74 requirements, and records of drills and training were verified during the visit to the management company. However, many of the checklists of familiarization are not available, due to the fact that they were maintained on board.

12.12 The master

Captain Sayed Ahmed Sayed Ahmed Omar was the master of the M/V AL SALAM BOCCACCIO 98 at the time the vessel sank. He was of Egyptian nationality, 60 years old, and had been working at sea for about 28 years and for the company for about 8 years.

He also served as master on the same vessel in the Mediterranean Sea for approximately 2 years.

The master rejoined M/V AL SALAM BOCCACCIO 98 on January 26, 2006 with all required documents up to date.

12.13 The VDR recovery

On February 19, 2006 at 1300 hours a team of experts departed onboard M/V Skandi Bergen to the area where, apparently, the wreck was. The operation was divided in two phases: the location of the wreck, and the retrieval of the VDR, which was carried out by experts Mike Travis from MAIB, and Adrian Borrows from the AAIB, as well as Mr. Reynaldo Garibaldi as the principal investigator for the Flag State, together with the specialized crew of the vessel.

The VDR was manufactured by Broadgate who was tasked with downloading the data at the UK Marine Accident Investigation Branch in Southampton.

The VDR capsule was found at the following position: 27º 08.0' N, 034º 59.1' E

Around 97 percent of the data was recovered by the technician of Broadgate, and was very useful in clarifying most of the aspects of the investigation.

At the time of the recovery of the VDR, the wreck was found at a depth of 912 meters lying on her starboard side. The ROV carried out a survey where we were able to observe that the ramp of the vessel was still closed.

ROV used to recovery of the VDR

The vessel for the recovery

Figure 7

UK Experts looking for the VDR beacon signal.

Figure 8

The AL SALAM BOACCIO 98 VDR

Figure 9

Figure 10

12.14 The role of PSR

Panama Shipping Registrar (PSR) is a Recognized Organization (RO) authorized by the Panama Maritime Administration to issue statutory certifications since 1987; PSR has been issuing different statutory certificates for the M/V AL SALAM BOCCACCIO 98 since the year 2000.

The most significant role of PSR in relation to the accident is the relative inspections and calculations regarding the issuance of the PSSC.

12.15 The role of RINA

RINA is also an RO duly authorized by the Panama Maritime Administration, to issue statutory certification on their behalf.

RINA has been involved with the M/V AL SALAM BOCCACIO 98 since her construction as a classification society and an RO.

RINA rules were applied to the design, details and performance of the ship during her entire life, therefore, RINA rules and criteria played a significant role in the analysis of the accident.

The certificates issued by RINA, as mentioned above, were valid at the time of the accident.

12.16 The ISM

We had noted that an ISM audit for interim certification was carried out by RINA according to Part B section 14 of the ISM code, in October 12, 2005. This audit has resulted in no recommendations or non-conformities.

Therefore, in accordance with the ISM Code, RINA had issued an interim DOC on behalf of the Panamanian Administration to El Salam Maritime Transport, valid until October 11, 2006; and an interim SMC on behalf of the Panamanian Administration to the M/V AL SALAM BOCCACCIO 98, valid until April 27, 2006.

The records pertaining to the M/V AL SALAM BOCCACCIO 98 were reviewed at the company and found satisfactory. Moreover, a review of the management system for the entire fleet was also accomplished while visiting the company and the sister vessels.

The ISM implemented on these vessels addressed actions to be taken in case of fire, abandon ship, many other emergency procedures, and preparedness. In all

cases, the manual indicated that the master should take actions to notify the authorities and the company in emergency situations.

CHAPTER "B"

ANALYSIS

Note: For clarity, it was decided to separate the main events of the accident that led to the sinking of the vessel.

It is important to remember that one event led to the other, and sometimes there were parallel events and scenarios taking place at the same time; however, we believe it is important to separate these events while analyzing each circumstance**.**

13. The fire

At 1909 hours the fire alarm of the M/V AL SALAM BOCCACCIO 98 had activated giving a visual and audible alert signal on the control panel at the bridge. The auto pilot alarm had sounded just seconds prior to the fire alarm being activated at the bridge. A minute later, the 3/O (Ahmed Nassar) on watch reported by phone to the master, who was in his cabin, the alarms activations that were registered at the bridge. At about 1910 hours, the A/B on watch in the car- deck arrived at the bridge and reported to the 3/O on duty that the car-deck was full of black smoke.

The 3/O ordered the A/B reporting the fire, who was on watch in the car-deck, to take the control of the helm, due to the fact that the A/B on duty on the bridge was not present. The A/B who was supposed to be on duty at the bridge was called on the public address system.

The master arrived at the bridge at 1910.36 hours and asked for the C/O (Captain Masoud).

As soon as the master arrived at the bridge, he enquired if the fire was visible and what type of smoke was coming from the car-deck; the A/B replied that it was black smoke.

Comment: It is probable that the fire started minutes before it was identified, since the presence of black smoke filling the entire garage would have taken some time after the ignition.

The master requested the A/B to provide more information regarding the fire. The A/B reported that he thought the fire was coming from the E/R, and he had reported this fact to the 3/O.

The master then tried to contact the E/R in an attempt to talk with the C/E, but was not clear if he actually got in contact with him.

At 1910.40 hours, the master ordered the C/O to investigate the car-deck area.

By 1911 hours, it was confirmed by the A/B that the smoke was filling the car-deck area.

At 1912 hours, the master ordered to send fire hoses to the car-deck, to quickly check and tackle the fire, and instructed the electrician to activate the water spray in the car- deck.

At about 1916 hours a passenger informed the master that something was on fire. The master reply was: “do not disturb us, lets us work”.

Many passengers knocked at the bridge giving reports of the ongoing fire conditions.

At 1918 hours a communication between the master, the 1/E and the 2/O revealed that the 2/O was confirming to the master, as per his request, that the sprinklers in the car- deck were already operating since the beginning of the fire. This communication was recorded at 1918 hours.

Since the first fire alarm, several other notifications of fire in the garage were verbally given to the master.

Comment: Despite the amount of notifications and alarms received, there was no indication that a general fire alarm was sounded to alert the passengers and crew of the ongoing fire conditions on board.

The relevance and importance of the amount of smoke present, together with the amount of alarms received, should have justified immediately sounding the general alarm.

Failure to sound the general alarm may have reduced the time to prepare the passengers for abandoning ship and the crew to perform their duties to assist in mitigating efforts.

By 1921 hours, there was still uncertainty by the bridge team, as to whether the fixed fire-fighting extinguisher system was actually in operation, due to the lack of communication with the E/R. The crew could not identify the source of the fire due to the thick smoke in the car deck.

At that time, the master ordered to turn off the lights of the bridge to prevent other vessels in the vicinity from seeing them and avoid persons finding out about their situation.

At 1923 hours, the master ordered to double check and make sure that the fixed water extinguisher system (spray) was operating in zones 2,3, and 4.

Comment: It may be possible that these instructions were given because the alarm panel had indicated that the fire was present in the above mentioned zones, and also due to all the notifications received by the master.

Until 1925 hours, the crew was under the impression that the fire was in the caterpillar generator located in the forward midship section of the ship, right under the cabins.

The 1/E confirmed to the master that there was not any sign of fire in the caterpillar generator, but the 2/O insisted that the fire was starting to catch the floor of the slipway. At 1926 hours, the situation had intensified for the “400” series cabins, which had begun to fill up with smoke, but reports of that being under control, were fed back to the master, and confirmed by the 1/E who stated that there was only smoke and no signs of fire in the garage area beneath these cabins. The master instructed the 1/E to “operate water” in order to mitigate the smoke.

The location of the fire was identified by the 2/O at the forward port side of the ship in a trailer containing luggage at about 1936 hours.

Comment: It was not until 28 minutes later that the master was convinced that the main fire situation was in the car-deck, somewhere near the port bow, below the 200 series cabins, located over the car-deck.

The fire conditions prevailed despite the fact that the sprinklers, the fire pumps and hoses were ongoing.

Mitigation efforts were in progress, and the crew's response consisted of three teams, composed of six persons each. One team began to fight the fire in the car deck, and the others were depending on the orders of the master and the presence of fire.

Due to heavy smoke, the crew could not identify, at the beginning, where the source of the fire was.

According to the VDR information, the spray was fully operating since the onset, along with the fire hoses. This was confirmed by the conversation recorded at 1918 hours.

The 2/O (Captain Sheriff), together with the hotel crew, were cooling down the suspected areas in the accommodation with fire hoses as per master's orders, and it was always reported that there was no fire, that it was only smoke; the fire teams were trying to find and extinguish the fire moving from one location to the other.

Comment: The interviews confirmed that some of the crew were acting on their own without instructions, as to when, how, and where to proceed.

The crew members could not control the fire, and the large quantity of water used for the fire fighting operation was increasing. The wind was coming from the port side of the vessel.

Comment: Constantly, wherever smoke was detected, the master interpreted a fire condition, and ordered to spray water or sent a team or an individual with a hose line to apply water.

It is not certain if serious consideration was given to the effects that deploying all this water on board would have.

By virtue of how smoke was filling up the vessel's compartments, it was taken as a given that a fire situation was evident and water was to be applied.

The tendency of smoke and gases is to seek the path of least resistance in order to top vent themselves. Smoke tends to fill up an area faster than heat would transfer from one location to another.

At approximately at 1939 hours, consideration was given to start coordinating the pumping of water out of the car deck. The 3/O had reported that the pumps were in operation, but the discharged water was accumulating on the starboard side due to the fact that the water taken from the starboard side was pumped to the port side and because of the list, the water was returning back to the starboard side.

The master during the first minutes of confusion in fighting the fire, gave instructions to the helmsman to maintain the actual course 220º, while the vessel was not really responding to the orders, and she actually made a complete round turn of about 358 degrees, in approximately 10 minutes; then the master realized that the vessel was not going in the desired heading, and later on, the master regained control of the heading of the vessel going to the Port of Safaga.

At this stage the list was of approximately 5 to 7 degrees to starboard.

The fire was never extinguished and it expanded to several places and decks. The crew was confused while the fire appeared in different zones.

The fire was fought by the crew for approximately 4.5 hours and the use of water to extinguish the fire was never successful.

14. The list of the ship and related events

The 2/O informed the bridge at 1938 hours, that there was an increasing level of water in the car deck.

At 1940 hours, the master asked to use a portable pump to discharge the water from the car deck.

Initially, it was noticed that there were complications in the use of the portable pump to discharge the water from the car-deck. The pump did not have fixed

arrangements to pump the water out. The operation was not satisfactory and the water was suctioned from the starboard side and pumped to the port side. Then the water returned back to the original position due to the list of the vessel.

At 1941 hours, a communication between the 1/E, R/O and master revealed that the 1/E recommended to open the 2 pilot doors to drain the water from the car-deck, the master accepted the suggestion but the R/O advised the master not to open the pilot door because it may ventilate and increase the fire.

The 1/E insisted that he would open the pilot door if he felt obligated, and the master replied “if obligates do it”.

Comment: It was never confirmed whether or not the pilot door was opened. Our assumption is that it was never opened at any time, and it could be possible that if the pilot door was opened only in the starboard side it could reduce the accumulation of water in the car-deck; however, due to that amount of water, the positions of the cars, the heavy smoke and high temperatures, it may be difficult to open or close it at a later stage.

The 2/O reported that the fire was ongoing under the slipway on the port side. The master’s reaction was to apply salt water to cool it.

At around 1943 hours, communications between the 1/E and the master led to understand that they were uncertain as to the vessels accurate position because of the equipment’s irregular function.

Comment: This may be caused due to the wiring being damaged by the fire.

The master was concentrating on the fire situation and expressed that he felt that they were in a clear zone and the risk was minimal, based on the R/O stating that the radar screen was clearly showing no vessels or other objects in the vicinity.

The master returned his attention to the fire and the accumulated water on board. He instructed the fire teams that cooling was still essential, but consideration for pumping the water out of the vessel was also necessary.

At about 2016 hours, the 3/O asked the master if they could contact the vessels in the area to request assistance. The master did not reply to this suggestion.

Comment: If communication was made to the authorities or the vessels in the vicinity informing of the situation on board the M/V AL SALAM BOCCACCIO 98, and assistance had been requested, it may have minimized the danger and advanced the possibilities to abandon the ship and save lives.

A decision to abandon the ship at an early stage would have been appropriate, considering that the water used in the fire-fighting operation could have caused and excessive list and, subsequently, the sinking of the vessel.

Approximately one hour had passed and the fire and uncertain situations were still ongoing.

At 2104 hours, the master discussed with the C/O if they could stop spraying the car- deck because the list had increased to approximately 7 degrees to starboard.

Between 2141 hours to 2227 hours, the list further increased to 11 degrees to starboard. Meanwhile, confusion in fighting the fire was still taking place in several areas.

At 2222 hours, once again, the vessel started making a turn, and at that time the master did not have a clear view of where the vessel was heading, while the crew was still fighting the fire and spraying more water in the car-deck.

At 2227.40 hours the master asked about the course and the 3/O replied that the course was 345º.

At 2227.47 hours the list was reported by the 3/O to have further increased to 15º to starboard.

Immediately things started to fall apart in the bridge, and an alarm sounded.

At 2228 hours the master ordered: “ALL THE WHEEL TO THE RIGHT”.

After that, the master asked again if somebody can deballast tank number 18 in the starboard side while filling the tank number 25, which had a capacity of 131.62 tons.

At 2229 hours the master asked the C/O if there was a possibility to deballast tank number 18 located on the starboard side. The ship was listing 15 degrees to starboard.

The C/O asked the master, through the R/O, if they could pump water to fill tank number 25 located on the port side.

According to the interviews, it was clear that the scuppers were blocked due to garbage generated during the fire-fighting operation and the movement of water containing these residuals.

At 2231 hours the 3/O informed that there was nobody responding in the E/R.

At approximately 2233 hours, the cargo was reported having shifted to the starboard side. At the same time, it was reported by the 3/O in the bridge that the vessel was listing 11 degrees to starboard. The speed was about 6 knots, and the course was 090 degrees. The master ordered again, 5 minutes later, to fill tank number 25 on the port side (heeling tank).

At 2240 hours, the 3/O informed the master that the vessel was heading back and that the course was 241 degrees. He stated that the wind was blowing before from the port side and the master replied, “now its from the right side”. Then the 3/O agreed and said that the course was 090 degrees and possibly this was the reason why the list decreased a little.

At 2242 hours, the heading was 090 degrees and the 3/O informed the master that the list had increased considerably; and the 3/O asked the master if he wanted to change the course. ***Comment: At this stage, an abandon ship order would have been the correct decision.***

The master, showing signs of indecision, asked the C/O what could be the solution for this situation.

At 2307 hours, the list continued at 15 degrees to starboard and the master ordered to ballast down more tanks, due to fact that he thought that the capacity of tank number 25 on the port side was very small. Also taking into account the quantity of water accumulated on the car-deck, and that the sprinklers were still working, it would not be a significant ballast operation to correct the list.

At that time, the master started to realize that the quantity of water was more dangerous than the fire. At 2312 hours, he ordered to stop the use of hoses to an unknown person in the accommodation area who was cooling down the cabin floors which were over the car-deck.

Comment: Since the ballasting operation started, the list had increased. It is still not clear if the longitudinal free surface of the water in the tanks caused an irreversible increase of the list; or if there was a mistake from the engineers and crew in opening valves, following orders from the master to correct the list.

The master concentrating on correcting the list, ordered to turn the ship to port, and reassume the heading of 240 degrees by ordering 20 degrees to port.

The bridge team was still confused about the heading, the wind, the course and correct decisions to take, and things were starting to fall apart in the bridge.

The recording showed that after starting the ballast operation, the list increased to 18 degrees to starboard at around 2324 hours, and the master was still asking why, if the port side tanks were being filled, the ship was continue to list more and more to starboard.

While ordering to pump ballast water into the port side tanks, the vessel's list increased to 20 degrees at about 2326 hours. Soon after, at 2328 hours, the vessel had continued to increase its list to starboard to 22 degrees.

The bridge team was still confused about the direction of the wind. After that, the 3/0 ordered the helmsman: all the wheel to the starboard, and the R/O asked the master twice "what was the wheel order, hard to starboard or hard to port ?".

The master confirmed the order to put the rudder all to starboard, and he was reminded that the list was 20 degrees to starboard, but the master requested to be patient.

Few minutes before the sinking, the master was advised by the 3/O to abandon the ship and the master's reply was: "just wait".

At that time the master ordered to turn the wheel all to the port.

The list was now 25 degrees to starboard and someone asked the master, around 2330.28 hours, if they should send the "May-Day" distress signal, and the master's reply was: "send a may day send may day"

The ship sank at 2333 hours.

15. Scuppers RINA analysis results

The resulting Reynolds number (around 2.5*10^5) tells us that the flow is within the region of complete turbulence. For rough pipes (as is our case) this means that the friction factor is almost constant with the Reynolds number, being thus function only of the relative roughness (see Frank M. White "Fluid Mechanics" 5th edition, Chapter 6, this result means that the system of equations is only slightly non-linear and can be made linear with a negligible mistake).

As a practical effect, the volumetric flow rate calculated for a driving head H = 1.3 [m] may be used to predict the flow rates for bigger and smaller driving hydrostatic heads H.

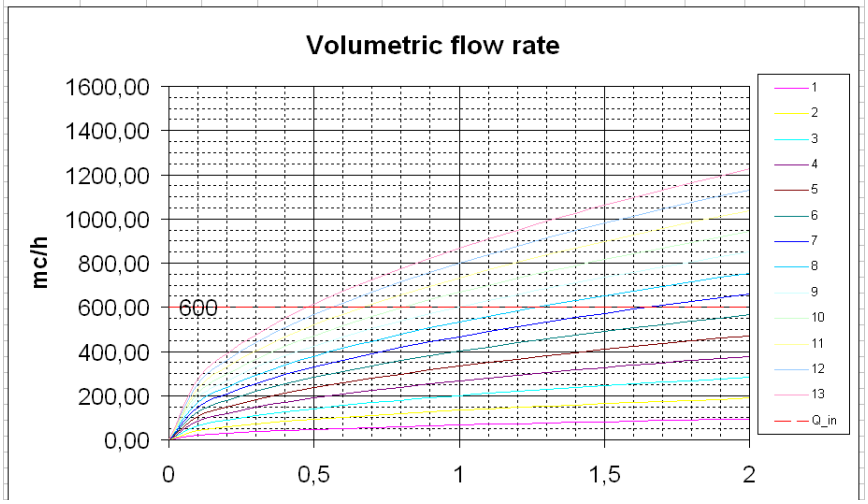
The final result is a linearised equation that gives the volumetric flow rate for one scupper as a function of the total hydrostatic head H.

$$Q\_out\_h(H) = 66.70903296\ \sqrt{H}$$

The results are summarized in the following Table, where the output flow rate is calculated for a finite set of total hydrostatic head values (in columns) and number of scuppers (in rows). A value of input flow rate of 600 [m^3/h] is assumed. The combinations H / number of scuppers that are sufficient to discharge the input flow rate are printed in green while those that are not sufficient are printed in red. The same results are shown in a graphical form with the volumetric flow rate as a function of the total hydrostatic head and the number of active scuppers as a parameter.

H [m]	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,1	21,10	42,19	63,29	84,38	105,48	126,57	147,67	168,76	189,86	210,95	232,05	253,14	274,24
0,2	29,83	59,67	89,50	119,33	149,17	179,00	208,83	238,67	268,50	298,33	328,17	358,00	387,83
0,3	36,54	73,08	109,61	146,15	182,69	219,23	255,77	292,30	328,84	365,38	401,92	438,46	474,99
0,4	42,19	84,38	126,57	168,76	210,95	253,14	295,33	337,52	379,71	421,90	464,10	506,29	548,48
0,5	47,17	94,34	141,51	188,68	235,85	283,02	330,19	377,36	424,53	471,70	518,87	566,04	613,22
0,6	51,67	103,35	155,02	206,69	258,36	310,04	361,71	413,38	465,05	516,73	568,40	620,07	671,74
0,7	55,81	111,63	167,44	223,25	279,06	334,88	390,69	446,50	502,32	558,13	613,94	669,75	725,57
0,8	59,67	119,33	179,00	238,67	298,33	358,00	417,66	477,33	537,00	596,66	656,33	716,00	775,66
0,9	63,29	126,57	189,86	253,14	316,43	379,71	443,00	506,29	569,57	632,86	696,14	759,43	822,71
1	66,71	133,42	200,13	266,84	333,55	400,25	466,96	533,67	600,38	667,09	733,80	800,51	867,22
1,1	69,97	139,93	209,90	279,86	349,83	419,79	489,76	559,72	629,69	699,65	769,62	839,58	909,55
1,2	73,08	146,15	219,23	292,30	365,38	438,46	511,53	584,61	657,68	730,76	803,84	876,91	949,99
1,3	76,06	152,12	228,18	304,24	380,30	456,36	532,42	608,48	684,54	760,60	836,66	912,72	988,78
1,4	78,93	157,86	236,79	315,72	394,66	473,59	552,52	631,45	710,38	789,31	868,24	947,17	1026,11
1,5	81,70	163,40	245,10	326,81	408,51	490,21	571,91	653,61	735,31	817,02	898,72	980,42	1062,12
1,6	84,38	168,76	253,14	337,52	421,90	506,29	590,67	675,05	759,43	843,81	928,19	1012,57	1096,95
1,7	86,98	173,96	260,93	347,91	434,89	521,87	608,85	695,82	782,80	869,78	956,76	1043,74	1130,71
1,8	89,50	179,00	268,50	358,00	447,50	537,00	626,50	716,00	805,50	895,00	984,50	1073,99	1163,49
1,9	91,95	183,90	275,86	367,81	459,76	551,71	643,66	735,62	827,57	919,52	1011,47	1103,42	1195,38
2	94,34	188,68	283,02	377,36	471,70	566,04	660,39	754,73	849,07	943,41	1037,75	1132,09	1226,43

Input Volumetric Flow Rat	600	[mc/h]		Nom. Output Vol. Flow Rate	988,78	[mc/h]



15.1 Calculation of water mass accumulation

15.1.1 Purpose:

The purpose of this calculation is to predict the evolution in the time domain of the stagnancy of water on the freeboard deck as a function of the input flow rate (from the drencher system and fire-fighting hoses) and output flow rate (from a variable number of scuppers) until a certain amount of water is accumulated.

15.1.2 Procedure:

A mathematical model is established. The equation that governs the system in the time domain is considered to be a non-linear first order differential equation as described below:

$$\frac{d}{dt} M(t) = \rho \, (Q\_in(t) + Q\_out(n, H))$$

$$H(M) = h(M) + f(M)$$

Where (see also Figure **B1** and Figure **B2** of this analysis specifically):

M(t): accumulated mass of water on the deck as a function of time in [kg]Q_in(t): volumetric flow rate in input as a function of time, in [m^3/s]

Q_out(n, H): volumetric flow rate in output as a function of the number of active scuppers and of the total hydrostatic head, in [m^3/s]

n: number of active scuppers

h(M): hydrostatic head on the deck as function of the accumulated mass M, in [m]

f(M): remaining freeboard as function of M, in [m]

H(M): total hydrostatic head as a function of M in m

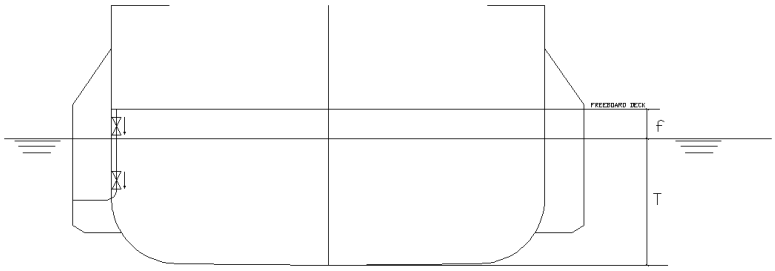


Fig B.1

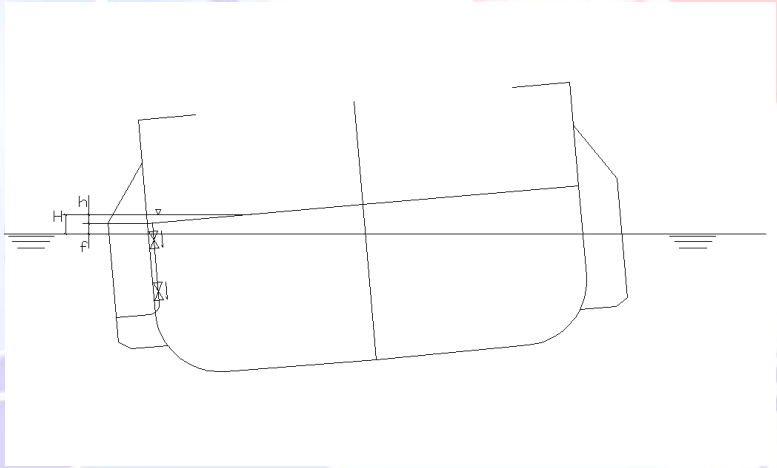


Fig B.2

In this differential equation, the difficult term to evaluate is the one that expresses the total hydrostatic head (H) as a function of the accumulated water on the deck. H depends directly from the current draught, heel angle of the ship, and internal head of water on the deck (h). All these parameters are related to the accumulated mass M. The ship “system” is thus heavily involved in this modelling process.

It was decided to numerically solve the differential equation written above using a finite difference iterative approach. The numeric values of H as a function of the accumulated mass M have been evaluated from the stability calculations results by means of linear interpolation and extrapolation from a set of calculated flooding conditions.

The consequence of using the results of the stability calculations (static in their nature) is that the accumulation process is considered as being a sequence of “quasi-static” states, thus no ship motions are taken into account in this model.

The time step used in the numerical integration was chosen to be fixed (i.e. not varying with time) and equal to 1 second.

The time constant involved in a mass accumulation process of this kind should be a lot higher of this value, thus ensuring the convergence of the method and a sufficient precision of the resulting function M(t), calculated by points.

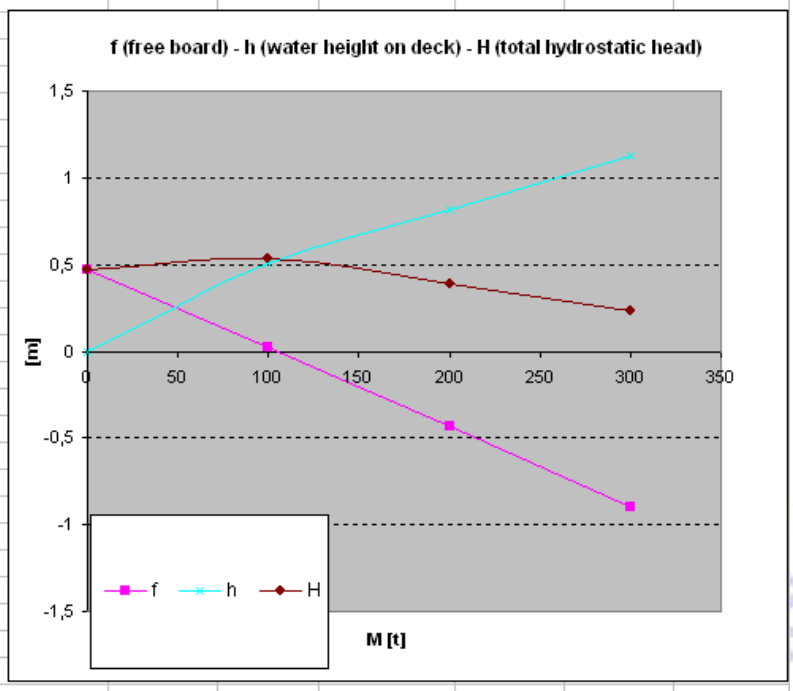
The mathematical problem has been attacked using the C++ programming language to implement a custom solver.

15.1.3 Example of calculation

A set of calculations with variable number of active scuppers is performed on the basis of the input data summarized below.

From SIKOB calculations with initial heel angle = 5° Critical Mass = 300 t

Displacement [t]	T [m]	M [t]	Heel angle [°]	f [m]	h [m]	H [m]
9622	5,85	0	5,05	0,47	0	0,47
9722	5,892	100	7,35	0,02	0,51	0,53
9822	5,934	200	9,68	-0,43	0,82	0,39
9922	5,976	300	11,93	-0,9	1,13	0,23



The results obtained with a constant input flow rate of 600 [m^3/h] and an initial angle of heel of almost 5 degrees are shown in Figure B3 below.

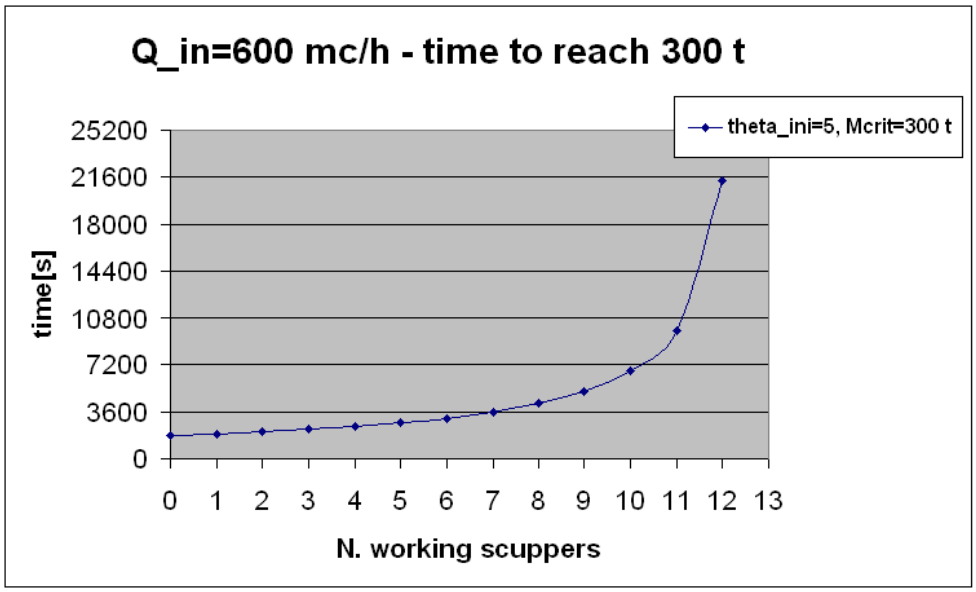


Figure B 3

The resulting time for 13 active scuppers has not been graphed because it can be considered as infinite.

These results show that even with 0 active scuppers almost half an hour is available before capsizing occurs; on the other hand this time frame does not increase at a high rate with the increment of the number of scuppers (e.g. with 7 active scuppers 1 hour is available). This behaviour depends from the fact that the initial condition (angle of heel equal to 5 degrees) impairs from the beginning the flow rate discharged from the scuppers with its low value of H. In any case with all the 13 scuppers active, the simulation predicts that the system does not tend to accumulate water.

16. Actions taken by the crew

According to the information gathered from the interviews, prior to the sinking of the vessel, most of the crew members and passengers were acting on their own initiative. The crew members were providing life jackets to the passengers, and tried to guide them to their mustering stations; however, the majority of the crew and passengers remained waiting for the abandon ship instructions from the master until the sinking of the vessel. During the last minutes they started looking for options to evacuate the vessel on their own, and most of them moved to the starboard side, where some crew members were fighting the fire. At the critical moment of sinking, as they indicated during the interviews, they started walking over the shell plating of the ship on the port side, to ultimately jump into the sea and start swimming, searching and trying to reach the un-opened life rafts, which were scattered randomly in the water. These life rafts had been inappropriately

released from an uncoordinated operation of deploying the safety equipment during the chaotic moments before the vessel sank.

Many of the life rafts were floating unopened and the passengers and crew started opening them to save their lives.

The 2/O had boarded a life raft and had activated the SAR, since he was also holding a GMDSS portable radio. He also declared that he activated the EPIRB just before the vessel sank.

The vessel had electric power up to the moment she sank, and apparently the master refused to leave the bridge.

17. The stability and important related matters

According to our records, the vessel was in compliance with SOLAS 90 requirements as one compartment.

During the investigations it was also noted that the number of passengers had been increased based on the Protocol of Space Requirements for Special Trade Passengers Ships of 1973, and the existing agreement between the Arab Republic of Egypt and the Kingdom of Saudi Arabia, for a Short International Voyage.

However, to the date of this preliminary report, it is not clear whether or not normal procedures were followed by the RO in issuing this certificate, while recognizing the fact that this could not have had a direct impact in the causes of the sinking.

RINA had also reviewed and approved calculations for the sister vessels and for the M/V AL SALAM BOCCACCIO 98 for 2,500 persons with satisfactory results. We had received the 2 intact stability conditions of departure and arrival for the vessel approved by RINA for a maximum of 2500 persons.

In the records appeared that RINA issued a certificate concerning the AA max value in 2002 indicating that the vessel was in compliance.

It was also noted that the quantity of passengers allowed on board at the time of the accident was less than the quantity required by SOLAS in Chapter II-1, Regulation 8.2.

The M/V AL SALAM BOCCACCIO 98 would have had to comply with regulation 8.2 as a two compartment ship by October 2010 taking into account the application of the regulation.

After reviewing the previous stability manual approved nº CDS0002315 dated February, 2004, we noted that the vessel was capable of allocating the quantity of passengers she was carrying at the time of the loss.

It is also a matter of concern that there was a possible discrepancy in the application and calculations required by resolution A.749(18), which required different GZ parameters, since the GZ specified in the stability manual was less than that required by this resolution.

However, it is important to underline that RINA states the following:

"…According to the principle of equivalence, in case of ships having a particular design, the RINA rules accept an angle of heel corresponding to the maximum righting g arm lower than 25º. In association with a larger area bellow the righting lever curve and higher GZ values, the comparison between the criteria of the intact stability code(here after referred "IS CODE") and the RINA equivalent criteria for ships of a particular design, indicates that, for a giving heeling moment, the static equilibrium angle for a ship having θ max lower than 25º and compliant with the RINA equivalent criteria is lower than the angle of equilibrium of a ship having a θ max between 25º and 30º.

The righting lever curve offered by the vessels is significantly high were tan the minimum required by both, the IS code and the RINA rules. An inclining arm close the maximum GZ value, requested by the IS code(0.2M), would list the vessel at an angle of about 5º, and in this final condition of equilibrium the vessel has still a large amount of intact and dynamic stability.

The same inclining arm applied to the minimum GZ curve in accordance with the IS CODE would cause a listing of about 27º and in this condition the intact and dynamic condition are compromised".

18. Events failures

- The sequence of failures may have started with the outbreak of the fire on board, which began at 1909 hours, or perhaps earlier.
- There was failure to follow established procedures as contained in the ISM manual, chapter 8, instructions 7, regarding procedures for fire on board.
- The decision to return to port when the vessel was only 28 miles from the port of departure could have been a significant and potential wiser decision.
- The general fire alarm was not activated at any time.
- There were not clear or correct orders given to the crew members on how to proceed, according to the instructions contained in the established procedures, and some parties were voluntarily acting on their own.
- The crew was not able to clearly identify what had ignited or initiated the fire at an early stage, nor the exact point of origin.
- The fire teams were not able to extinguish the fire from the initial attack.
- The vessel's fixed fire-fighting system was not capable of controlling or extinguishing the fire from its initial stage, which allowed the fire to expand out of proportion.
- The crew and especially the master did not properly consider the implications of using such a large amount of water during the fire fighting operation onboard.
- Despite recommendations, the master declined to make contact with other vessels in the vicinity, the company, or the competent authorities, at any

stage, to request instructions or to ask for help, except for the last minute May-Day signal.

- The scuppers were not able to drain the water efficiently.
- The crew was not able to clear the blocked scuppers or to pump out the water from the car-deck.
- There were no orders issued for controlling the passengers in panic, and the master refused to prepare them for evacuation, and instead, he ordered to maintain the passengers in their cabins.
- It seems that the master was not clear regarding the capacity and the implications of the required ballasting operations.
- It is questionable whether the proper tanks ordered to be used for the ballasting operation were correct, or whether the E/R followed these orders correctly.
- The master did not accept suggestions to notify the company, the vessels in the vicinity, or the authorities.
- The crew members and the passengers were unable to abandon the ship at a proper stage due to the lack of orders.
- The master did not consider it appropriate to abandon the ship as it was suggested by the 3/O. (This was recorded in the VDR and obtained from interviewed crew members)

19. Search and rescue

The SAR operations played a significant role in this accident, especially in the amount of lives at sea that was possible to preserve. At this stage, we are still collecting valuable information**,** and it is important to underline that there may have been a critical delay in the search and rescue efforts.

Our analysis of the information gathered brings us to the observation that there was a lack of coordination between the authorities engaged in the rescue efforts.

The first authority which could have saved some time in starting the rescue operations was the Safaga Port Authority, which was aware of the lack of contact with the ship, since they had been informed by the office on duty of the Management Company at approximately 0130 hours Egyptian local time, about such situation. Moreover, they were requested to establish contact with the vessel, and this was not possible.

It is important to remember that the vessel sank at approximately 0133 hours, Egyptian Local time.

Even though the authorities were advised of the loss of communication with the vessel, the SAR efforts started approximately 10 hours later. Additionally there is no indication that any action was taken by the VTS office, which might have lost the location of the vessel in the radar.

It was not until 0714 hours, Egyptian local time, that the chairman of the Red Sea Port Authority was informed by the vice president of the company that the vessel had sank, as reported by the 2/O of the M/V AL SALAM BOCCACCIO 98, who had later managed to establish contact with the master of the M/V Saint Catherine via VHF radio, while on a life raft near the site of the accident. Consequently, the master of the M/V Saint Catherine informed the Safaga office manager, who then informed the fleet manager and the operation director of the situation. According to the interviews, the operation director had relayed the information to the vice president approximately at 0700 hours, Egyptian local time.

However, during the communications established between the parties involved, the SAR operations started when a plane departed at approximately 1010 hours, Egyptian local time.

The first vessel arrived at the area of the accident at about 1500 hours, Egyptian local time, with reported bad weather conditions, which led into a delay of approximately 12 hours.

However, the EPIRB signal was sent at the moment of the sinking, and according to the declarations of the 2/O, he was able to activate the EPIRB manually minutes before the ship sank.

The EPIRB signal was first received by Scotland Station Kindloss at about 2358 hours UTC, and then delivered to France and from France's coordination point to the USA, and from the USA to Algeria.

The United States coordination center delivered the signal to the Panamanian authorities, and the Algerian authorities delivered it to the Egyptian contact point in charge of the Search and Rescue, as explained below:

The EPIRB signal was first detected at 23:32 hours UTC on February 02, 2006, by Algerian Earth Station (GEOLUT) without position, because the beacon did not have the capability to provide the location in its message.

Consequently, since the country coded on the beacon is Panama, the message alert was sent to Panama by USMCC according to the Cospas/Sarsat Data Distribution Plan (DDP).

At 0037 hours UTC on February 03, 2006, Algerian MCC received an alert message, with position in Egypt area at (DOPPLER B - 27 10.1N 034 40.4E), and they delivered it to Official Egyptian SAR Point of contact.

At 0110 hours UTC, Algerian MCC received the resolution (confirmation) in position

(RESOLVED 27 09.4N 034 54.8E), and they delivered it to the Official Egyptian SAR Point of contact.

For this alert the Algerian Cospas/Sarsat (MCC d'Alger) had sent 17 messages to the Official Egyptian SAR Point of contact.

Originator: Algerian Cospas-Sarsat MCC

Recipient: Official Egyptian SAR Point of contact

AFTN: address: HECCYCYX

Communications System Used: AFTN, messages sent "SS" priority Time of first Message: 00:37 hours (UTC) 3rd February 2006.

Time message received	number	time message sent
00:37 on 3rd Feb 2006	3796	00:40 on 3rd Feb 2006

01:10 on 3rd Feb 2006	3797	01:14 on 3rd Feb 2006
03:28 on 3rd Feb 2006	3800	03:34 on 3rd Feb 2006
08:26 on 3rd Feb 2006	3805	08:30 on 3rd Feb 2006
11:31 on 3rd Feb 2006	3808	11:34 on 3rd Feb 2006

Another important issue in the Search and Rescue operation is the action of the master of the M/V SAINT CATHERINE, registered in Panama, and managed by the same company than the M/V AL SALAM BOCCACCIO 98.

According to the information collected, and to the master's declaration, the vessel departed from Safaga Egypt to Duba, Saudi Arabia, at 0215 hours, and at that time he stated that no information was received from the M/V AL SALAM BOCCACCIO 98 concerning her arrival to Safaga Port.

Nevertheless, he stated that around 0250 hours approximately, he started calling the M/V AL SALAM BOCCACCIO 98 every 30 minutes without response.

Furthermore, at about 0500 hours, he was notified by the Safaga Office to keep calling the M/V AL SALAM BOCCACCIO 98.

According to the master's declaration, at about 0657 hours, he received a call from the 2/O of the M/V AL SALAM BOCCACCIO 98 informing that the vessel had sank, and that he was on board a life raft, specifying also the location of the sinking.

He checked the location of the sinking and verified that his vessel was about 30 Nm from that location.

According to his declaration, he decided not to proceed to the place of the sinking to avoid putting in danger the passengers he was carrying. Additionally, he considered the bad weather conditions at the moment, which were estimated at 8 in the Beaufort scale.

He continued his voyage to the Port of Duba and, after disembarking the passengers, he returned to assist in the rescue operation. This took place at about 1800 hours Egyptian local time, the day after the sinking.

However, after requesting the available calls reports and information collected, there is no indication that the company contacted the vessel during the night time when she was sailing to the Port of Duba. Additionally, we noted that the decision was made purely based on the master's own safety considerations.

Several vessels reported to have received the EPIRB signal of the vessel, as well as different coastal stations.

Therefore, one important question, still unanswered, is why the rescue of the survivors took such long valuable time, even when the complete route was less than 100 Nm between the two ports in a normally well transited area.

List of the numbers of rescued passengers and bodies found during the search and rescue operations in accident of M/V Al Salam Boccaccio 98

Vessel Name	Survivors						Bodies					
	3/2	4/2	5/2	6/2	7/2	8/2	3/2	4/2	5/2	6/2	7/2	8/2
Sharm Elshiekh	101	15					6	46	62	86		
Italian units		7						2				

Green Island	**39**											
Regola Star	**37**											
Elanora	**149**						**1**					
BMS		**6**						**61**				
Eltaef		**3**						**9**		**6**		
El Salam 94								**2**				
Elmotaheda		**1**						**1**		**27**		
Elriad								**7**	**5**			
Coast Guard unit		**22**										
Sudanese vessel		**1**										
Hel Chenok plane			**6**									
Total	**326**	**55**	**6**				**7**	**128**	**67**	**119**		
Total until 6/2 at 22:00	**387**						**Total till 6/2**			**410**		

Table 3

CHAPTER "C"

CONCLUSIONS

20. Conclusions:

It is difficult to understand how, given all the efforts made to improve aspects of safety of life at sea, coupled with the developing of new regulations, this still cannot be fully integrated into a plan of action when an emergency situation like this

arises, especially considering the human factor complexities during emergency situations.

At this stage of the investigation, we draw the following conclusions:

20.1 The vessel was certified and equipped with sufficient safety equipment for the number of passengers on board.

20.2 The vessels was designed, constructed and certified for unrestricted navigation.

20.3 The vessel was holding a certificate of exemptions for which she was equipped with alternative means, according to the International Conventions.

20.4 The master and crew members all held certificates and training, as required by the STCW 78 Convention, as amended; however, emergency procedures were not followed through accordingly.

20.5 The vessel had previously been inspected by the local authorities, the Flag State and the ROs; however, none of them were able to identify the possible cause of this accident.

20.6 The ISM audit filed to identify any possible misinformation between ROs.

20.7 The last annual safety inspection by the Flag State was not carried out in a timely manner; therefore, it was unable to identify possible documentation incongruence.

20.8 The vessel suffered a fire which, apparently, began in the car-deck; however, the origin of the fire could not be properly located at an early stage. During the course of the investigation, it was determined that the fire may have started in one of the following locations: a passenger's luggage loaded at the Port of Duba, Saudi Arabia, or in a fuel tank of one of the loaded vehicles.

20.9 The fire alarm detected at the panel was reset before the response teams were in place, perhaps because the crew members on watch in the bridge assumed it was part of the trouble stemming from auto-pilot dysfunction, or perhaps to avoid sounding the alarm. The alarm of the fire control panel is designed to automatically sound the general alarm after 2 minutes, unless it receives an acknowledgement from someone.

20.10 We cannot ascertain the origin of the fire; however, all evidence leads to a location at, in or near a trailer stowed in the port forward on the car-deck level.

20.11 The passenger's luggage was not subject to any rigid screening or inspection to avoid flammable or combustible materials being improperly carried on board.

20.12 The trailers on which the luggage was stowed did not offer any protection as to a fire resistance barrier or to protect the cargo enclosed until extinguished.

20.13 The accumulation of smoke due to the combustible material in the passengers' luggage, the cars, and other elements, may have caused a reduction on the visibility, as well as an obstacle in trying to locate the source, and contributed to difficulties in fighting the fire.

20.14 The number of cars and other elements in the cargo area prevented easy access to maneuver the fire hose lines in the area of the fire.

20.15 As a result of the fire-fighting operations, the water that was delivered on board created a critical increase in the level of water on the car-deck, which was impossible to discharge in a timely manner by the crew, thus generating an unsafe and unstable list condition.

20.16 As a result of the fire-fighting operation, the large volume of water delivered may have also contributed to the accumulation of debris, trash, and residue around the car-deck, and perhaps clogging the

scuppers, and thus impeding the water from being freely discharged overboard.

20.17 Emergency response procedures were not properly followed by the crew, as established in the Safety Management Manual of the vessel.

20.18 According to the stability book approved by RINA, the ship complied with SOLAS 90 standards as one compartment ship carrying a considerable amount of cargo with respect to the passengers, as per SOLAS, Chapter II/1/5.6.2, and ensured the compliance with SOLAS, Chapter II-1, Regulation 8-1, as well as compliance with the mandatory sections of the Intact Stability Code.

20.19 It was noted that there was confusion on the part of the master in understanding, accepting and issuing orders to the crew and passengers, particularly regarding which response actions should have been taken.

20.20 Weather conditions present at the time, such as current and wind, may have contributed to the increase on the list of the vessel.

20.21 The general confusion during the fire-fighting operation may have generated a lack of attention paid to the navigation of the vessel and the actual courses being navigated, which may have contributed to the shifting of the cargo, thus resulting in an additional factor that contributed to the increase of the list.

20.22 The crew began following the emergency procedures on their own, with no guidance or direct orders from the master.

20.23 There was uncertainty regarding the type of ballast operations required to correct the list.

20.24 The unclear instructions given to conduct the ballast operation may have actually generated the increase on the list of up to 25 degrees to starboard.

20.25 The master did not accept the recommendations of his officers to contact vessels in the vicinity, the company, or the authorities. Moreover, he ignored the recommendations to abandon ship.

20.26 The master also refused to be seen by other vessels in the vicinity, and instead ordered the lights on his vessel to be turned off.

20.27 The abandon ship operation was neither ordered nor carried out at any stage.

20.28 The ingress of sea water due to the excessive list of the vessel eventually caused the sinking of the ship.

20.29 The ISM system onboard did not work effectively due to the fact that the master and the crew never followed any of the established procedures.

20.30 It is a matter of concern whether a great deal of the paperwork required by the ISM Code is being followed just as a matter routine compliance on many of the ships, without actually putting these procedures into practice onboard.

20.31 The SAR operations were considerably delayed in arriving at the site of the sinking.

21. Main causes of the accident

At this stage, we have identified the following main causes that contributed to this accident, which lead to a massive loss of lives:

21.1 An uncontrolled fire that grew out of proportion.

21.2 An excessive list on the vessel caused by the water utilized during the fire-fighting efforts, which subsequently led to a progressive loss of stability on the vessel.

21.3 The failure of the master to notify, in a timely manner, the company, the vessels in the vicinity, or the authorities of the ongoing situation and to request help or assistance.

21.4 Orders to evacuate the vessel were never given or carried out, as per established procedures.

21.5 The significant delay by the appropriate authorities in starting search and rescue operations.

We are convinced, at this time, that had the above-mentioned procedures been conducted in a proper and timely fashion, following established procedures, this accident could have been prevented.

CHAPTER "D"

RECOMENDATIONS

Autoridad Marítima de Panamá
Dirección General de Marina Mercante
Departamento de Navegación y Seguridad Marítima
Sección de Investigación de Siniestros y Accidentes Marítimos
Panamá, Republica de Panamá

22. Recommendations at this stage of the investigation

22.1 To The IMO:

The ISM:

- It is of utmost importance to embark, as a matter of urgency, in a study to review the parameters contained in the ISM Code, as well as the procedures established by each individual system onboard vessels and their application during real life situations, taking into consideration the response by the crew members.

- The implementation of the ISM Code onboard should consider addressing normal daily safe working practices, including real emergency situations, through a practicable and user friendly system tailored to the type and trade of the vessel, as well as the culture of the crew members on board.

- The implemented ISM system should clearly identify, in a concise manner, the scope of the implementation audit for a newly established company, as well as for the initial audit.

Communications amongst the crew:

- It is recommended to review the parameters for communications between the master and his crew members during emergency procedures and preparedness in order to avoid misunderstanding of orders, as well as

discussing the effects of the actions to be taken during real emergency situations.

Fire-Extinguishing systems:

- It is of great importance to conduct a review, as a matter of urgency, of the type and performance of fixed fire extinguishing systems, in particular, the water type systems installed in the car-decks of Ro-Ro passenger ships, in order to avoid the effects caused by the excessive use of water during a fire-fighting operation.

Fire detection systems:

- The requirements established in SOLAS 74, Chapter II-2, as well as the FSS Code, with regard to fire detection systems within the car-decks of RO-RO passenger ships, should be reviewed, in order to include smoke detectors.
- Despite the fact that heat detectors are devices used for fire detection, it has been noted that, in this case, a smoke detector may have been able to detect the fire at an earlier stage than a heat detector, especially when dealing with car- decks.

Scuppers and water drainage in the car-decks on RO-RO Passenger ships:

- The design and performance of the scuppers on car-decks of RO-RO passenger vessels, as well as their capacity to drain water effectively, should be reviewed, as a matter or urgency, in order to clearly specify the characteristics and design, especially taking into account the large amounts of water needed to be drained, and considering that the flow of water from the fire extinguishing system shall never be higher than, or equal to, the drainage capacity of the scuppers.

- To include in the design and performance of the scuppers, arrangements to avoid the obstruction or clogging of the scuppers caused by residue generated during normal operations or while under an emergency situation.

- To review the installation of alternative means to drain water whenever the drainage system of the scuppers fails to drain the accumulated water in car-decks of RO-RO passenger ships.

Standardized distance between cars stowed in car-decks:

- A standardized distance between cars while stowed in the car-decks of RO-RO passenger ships should be established in order to allow easy movement of crew members within the car-deck during emergency situations.

Human Error:

- It is important to review the role of the human element in emergency situation response and crisis management behavior.

GMDSS and SAR:

- The uniformity of the GMDSS system worldwide, and its implementation by each member state, should be reviewed, in order to guarantee reception of emergency signals by the appropriate SAR centers in a timely manner so that search and rescue operations may be initiated as soon as possible.

- Assistance with regard to search and rescue operations should be implemented for countries with considerable passenger ship traffic conducting short international voyages.

VDR:

- A CCTV system could be incorporated as part of the integral interface of the VDR, to provide a clear view of the entire car-deck area by the officer on watch on the bridge. This may also be useful for recreating all possible scenarios on RO-RO passenger ships.

Intact Stability Code:

- A uniform Damage and Intact Stability Criteria must be established for all Flag States and ROs, as we recommend that the Intact Stability Code be made mandatory in its entirety.

IMO Code for the Investigation of Marine Casualties and Incidents:

- It is recommended that a review of the Code be conducted in the areas covering the procedure for carrying out investigations, and the availability of information by both parties, as well as cooperation problems where two States are involved in the investigation, covering ways to solve any controversy.

22.2 To the Flag State of the ship:

- Create a uniform standard for qualification and approval of inspectors acting on behalf of the Flag State, in order to verify the performance of the RO and the ship being certified.

- Implement more rigid procedures to control and monitor the RO through the establishment of a systematic inspection regime to be followed by qualified surveyors.

- To review the established procedures for communication and exchange of information between the Flag State and ROs, in order to avoid wrong cross-references, especially when two ROs are acting in the same vessel, and safety requirements may cause confusion in the applicability of the regulations, and may also affect certificates issued by another RO.

- To urgently carry out an assessment and to develop a rigorous inspection program for all RO-RO passenger ships registered under the Panamanian Flag, and to evaluate the existing compliance measures required by the Flag States and Classification Society Rules.

22.3 Port Authorities:

- The inspection of checked luggage when embarking at a port must be strictly enforced by the Port Authorities to avoid the loading of prohibited, hazardous, flammable, explosive, or toxic items within the luggage without the proper stowage and transportation procedures.

22.4 RO-RO Companies:

- It is strongly recommended that the stowage of luggage or cargo in open-type trailers in the car-decks of RO-RO passenger ships be avoided, and serious consideration given to the stowage of these items in enclosed areas designated for this purpose, where detection and fire-fighting measures may be implemented.
- It is strongly recommended to reiterate to all masters, watch standing officers, and crew members, that any emergency situation shall be immediately reported to the company, the authorities, and if practicable, to ships in the vicinity.

22.5 Future Actions:

In order to fully accomplish the objective of this investigation, it is strongly recommended that the Panama Maritime Authority hires an independent party to conduct a stability recreation of the accident in question of the possible different scenarios, as well as the probable causes for the sinking, utilizing a computerized model of the ship.

Eng. Reynaldo Garibaldi

Principal Investigator