Report on the investigation of

the hull failure of the rigid inflatable boat

Big Yellow

Porthmeor Beach

St Ives Bay, Cornwall

26 August 2005

Marine Accident Investigation Branch
Carlton House
Carlton Place
Southampton
United Kingdom
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Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, persuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ALB	-	All Weather Lifeboat
BMF	-	British Marine Federation
CG	-	Coastguard
CSM	-	Chopped Strand Mat
DSC	-	Digital Select Calling
DTI	-	Department of Trade and Industry
GPS	-	Global Positioning System
GRP	-	Glass Reinforced Plastic
HIN	-	Hull Identification Number
hp	-	horsepower
H&S	-	Health and Safety
ILB	-	Inshore Lifeboat
ISO	-	International Standards Organisation
LACORS	-	Local Authorities Coordinators of Regulatory Services
lph	-	litres per hour
LSA	-	Life Saving Apparatus
m	-	metre
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Notice
MSN	-	Merchant Shipping Notice
NCI	-	National Coastwatch Institution
nm	-	nautical mile
RCD	-	Recreational Craft Directive

RIB	-	Rigid Inflatable Boat
SCV2	-	Report form for an MCA Code Compliance Examination and Declaration
SI	-	Statutory Instrument
UKHMA	-	United Kingdom Harbour Masters' Association
UTC	-	Universal Co-ordinated Time
VHF	-	Very High Frequency

Kill cord	-	A connection between the helmsman and the engine stop system which, if pulled in an emergency, will stop the engines
Stuffing	-	Bow of a vessel being driven into a wave
Type Approval	-	Compliance with an agreed standard

SYNOPSIS

During the early afternoon of 26 August 2005, an FRM 900, 9.1 metre RIB was conducting a high speed, thrill ride in the vicinity of St Ives Bay in Cornwall. There were 12 passengers onboard, 6 of whom were children. As the RIB headed back towards the harbour, it came to an abrupt stop as the forward section of the hull split open, immediately flooding the boat. The front bench seat was torn from its deck mountings, throwing two of the children into the water. All were rescued and none suffered serious injury.

Both the RIB and operating company were known as *Big Yellow.* The company had been operating from St Ives harbour since acquiring the RIB in June 2005. The company advertised its trips as the "Ultimate RIB Ride" and passengers expected an exciting, high speed experience.

Earlier in the morning of 26 August, the RIB had undertaken one uneventful trip. At 1215 the skipper's fiancée gave a rudimentary safety briefing to the next group of waiting passengers. Once embarked, the skipper advised his passengers to raise a hand should they have any difficulties during the trip.

The RIB left the West Pier in St Ives harbour at 1230 and headed towards Carbis Bay. The weather conditions were good and there was about a 0.5 metre swell running. The skipper conducted a number of high speed manoeuvres before heading towards St Ives Head and on to Porthmeor Beach. Once around St Ives Head, the RIB passed the single handed fishing vessel *Elisha.* By now, the swell had increased to between 1 and 1.5 metres, and the RIB's speed was about 25 knots. The passengers were being bumped about in their bench seats, but none raised a hand to indicate concern.

After manoeuvring off Porthmeor Beach, the skipper reversed his course into the now, mainly following sea. Soon after, the RIB stuffed into a trough. The skipper felt something unusual in the RIB's handling, the deck heaved slightly, there was a loud crack and the forward part of the hull momentarily adopted an angle of about 45 degrees from the horizontal. The front bench seat was torn from its deck mountings, plunging two children into the water. They were pulled back onboard soon after. The skipper rushed forward, heaved the two anchors and liferaft into the water and then set about accounting for his passengers.

Fortunately, the skipper of the fishing vessel *Elisha* saw what had happened and made his way towards the RIB. At the same time, the watchman in National Coastwatch Institution's lookout at St Ives Head also saw the accident, and alerted the emergency services. The lifeguards at Portmeor Beach also saw the accident, and immediately sent two lifeguards, on a jetski, to provide assistance. *Elisha* and the jetski evacuated most of the passengers, with the remaining being rescued by the St Ives ILB. The St Ives ALB and CG rescue helicopter were also despatched to the scene. The ALB towed the RIB into St Ives harbour, where it was met by the local police, harbourmaster and an MCA representative.

The post accident survey identified catastrophic GRP hull damage. The hull was split from the stem, down both port and starboard sides for about half the RIB's length. It was also found that there was no longitudinal hull stiffening, the transverse framing was very flimsy, and its glass reinforced fibre encapsulation appeared to be poorly bonded to the hull.

The RIB, one of 13 built in the FRM 900 class, was manufactured in May 2004, nominally in accordance with the EU's Recreational Craft Directive standards. Before fitting out, it was subjected to the MCA's Yellow Code (Safety of Commercial Motor Vessel – Code of Practice) compliance examination by an authorised surveyor/examiner of MECAL Ltd, which is one of MCA's Certifying Authorities. In June 2005, the boat was once again examined for Code compliance as part of the change of ownership process.

During the investigation, it was found that the boat building company's RCD documentation, tests and records were not RCD compliant, and that there were no calculations or professional design input to support the boat's build process or structural strength.

A number of anomalies with respect to the RIB's Yellow Code examinations were also identified. The most important being that structural strength of the RIB was assumed to be compliant because it had apparently been built to the required RCD standard. In fact, this was not the case.

To assist in establishing the cause of the accident, stress calculations and laboratory testing of hull samples were conducted, and the services of a specialist GRP surveyor sought. The investigation determined that the cause of failure was due to the RIB's light construction and inadequate hull stiffening to cope with the normal in service forces.

The investigation also found that the skipper lacked some of the necessary qualifications and endorsements, and that the harbourmaster was unaware of the qualifications required for the boat's operation.

Recommendations have been made to help prevent this type of accident re-occurring. They focus on:

- The need to verify the condition of the other 12, FRM 900 RIBs.
- The boat-builder's RCD compliance procedures.
- Clarification of the status of the RCD in relation to Code compliance examinations, especially those aspects relating to hull strength.
- Alerting local authorities on the importance of conducting RCD compliance checks on boat-builders, especially those that operate under self assessment rules.
- Advice to harbourmasters and boat operators on the qualifications required for small vessel commercial activities, and the need for risk assessments to have been undertaken on the vessel's intended operation.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *BIG YELLOW* AND ACCIDENT

Vessel details (Figure 1)

Registered owners and operators	:	Geoffrey and Kingsley Matthews – St Ives Cornwall
Builder	:	Ferryman Boats Limited, Springtown Industrial Estate, Springtown, Londonderry, Northern Ireland
Built	:	May 2004
Type	:	FRM 900 Rigid Inflatable Boat
No of persons to be carried	:	Maximum 12 passengers and 2 crew
Hull construction	:	Glass reinforced plastic, deep vee moulded hull, incorporating a reverse chine
Inflatable Tubes	:	2 x 500 mm diameter Hypalon inflatable tubes, divided into 5 sections
Length overall	:	9.1m
Displacement	:	2.962 tonnes (including engines, fuel, fittings, passengers and crew)
Engine type and total power	:	2 x Suzuki 140 outboard engines – producing 280 hp
Maximum speed	:	Approximately 40 knots

Design and operating criteria

Recreational Craft Directive - Design Category	:	Design Category B – for operation in wind force up to force 8 and significant wave heights up to 4m
Recreational Craft Directive – Build Module	:	Aa – builders self assessment with tests for stability and buoyancy conducted by a Notified Body
Approved MCA Operating Area Category	:	Category 4 – up to 20 miles from a safe haven, in favourable weather and in daylight

Accident details

Time and date	:	1245 on 26 August 2005
Location of incident	:	50° 13'.2N 005° 28'.6W, 2 cables NNW of St Ives Head
Persons on board	:	12 passengers and nominally 2 crew (status of 1 crew unclear – paragraph 2.9.4)
Injuries/fatalities	:	9 passengers suffered soft tissue injuries – minor abrasions and bruising, one shoulder dislocation
Damage	:	Partial detachment of the upper port and starboard sides of the hull along the reverse chineline for approximately 3m from the stem. Stress cracking to the starboard side of the gel coat. Partial deck separation and detachment of the front passenger bench seat.

Figure 1

Big Yellow - following trials on the River Foyle, Northern Ireland

1.2 BACKGROUND

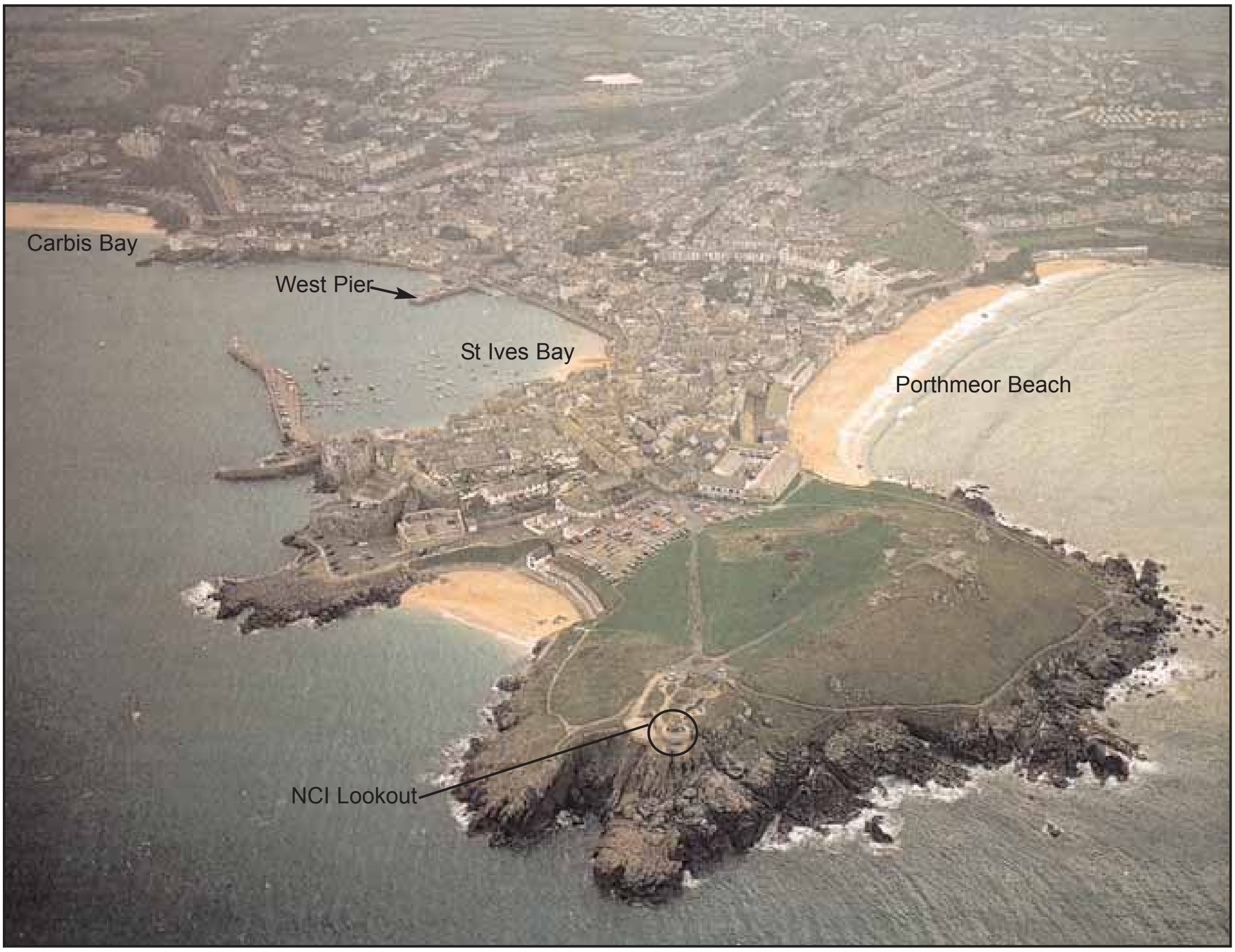
(All times are UTC+1)

1.2.1 Pleasure trip arrangements

Father and son, Geoffrey and Kingsley Matthews, established the Big Yellow company in June 2005 after acquiring a 12 passenger model FRM 900 RIB from Falmouth Yacht Brokers. Following purchase, the RIB was named *Big Yellow*.

The company operates in the vicinity of the relatively benign conditions in St Ives and Carbis Bays, and in the more demanding seas off Porthmeor Beach in Cornwall. The son, Kingsley Matthews, acts as the boat's skipper while his father, Geoffrey, deals mainly with passenger ticket sales. Up to 12, fee paying passengers can experience what is marketed as "The Ultimate Rib Ride". Passengers are embarked from one of three piers in St Ives Bay, and are advised to expect an exhilarating, fast trip, incorporating wave bouncing and sharp turns. An aerial view of the operating area is at **Figure 2**.

Figure 2



Aerial view of operating area

Trips cover approximately 6 -7 miles and last between 15 and 20 minutes, depending on the prevailing sea conditions. A turn round time of about 30 minutes is usually planned into the schedule, but this may be reduced dependent upon the level of passenger demand. During busy periods, the company expects to run between 10 and 12 trips a day.

1.2.2 National Coastwatch Institution (NCI) lookout

The NCI operates a watch station on the cliffs of St Ives Head **(Figure 3)**. The location provides unrestricted views of *Big Yellow's* area of operation and was manned at the time of the accident[1].

Figure 3

National Coastwatch Institution - St Ives Watch Station

1.3 NARRATIVE

1.3.1 Pre-departure actions

Prior to the accident, *Big Yellow* had been re-fuelled, and one uneventful trip, with 11 passengers onboard, had taken place. *Big Yellow* returned to the West Pier in St Ives Bay at about 1215 in preparation to embark the next group of passengers.

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[1] The NCI is a voluntary organisation set up in 1994. Its purpose is to restore a visual watch along high risk sections of the coast following the closure of several small Coastguard stations.

Six adults and 6 children, the youngest being 9 years of age, were given a rudimentary safety briefing by the skipper's fiancée as they prepared to embark onto the RIB. The safety briefing only covered fitting and operation of self-inflating lifejackets, and the passengers were particularly advised not to pull the manual inflation red toggle while in the RIB.

No other safety equipment i.e. safety helmets were provided.

Once the passengers had taken their seats, the skipper enquired if any suffered from back problems as the ride was expected to be fairly bumpy. None of the passengers raised any concerns. They were also advised to hold firmly onto the hand rails located in front of them, and to raise a hand should they be in difficulty at any time during the trip.

The skipper's fiancée then embarked, and the skipper connected his "kill cord" to the control console and started the two outboard engines. *Big Yellow* departed West Pier at 1230 with the passengers looking forward to an exhilarating and exciting trip.

1.3.2 Pleasure trip

After leaving the harbour confines at 5-6 knots, the skipper increased speed to about 25 knots. He conducted a series of thrilling "figure of eight" turns as he headed towards Carbis Bay situated to the south-east of St Ives Bay.

There was a slight "chop" to the sea in the Carbis Bay area, with wave heights of about 0.5m. However, the passengers thoroughly enjoyed this part of the trip and it clearly met with their expectations. Although some suffered minor discomfort because of the boat slamming into the waves, they all felt safe in the prevailing conditions and none raised a hand to indicate concern.

Having arrived at the south-easterly end of Carbis Bay, the skipper turned the RIB onto a north-westerly course towards St Ives Head. On the way, he again carried out a number of high speed turns.

Once around St Ives Head, the predominantly head on sea became confused by a combination of underlying swell, wind waves and the direction of the tidal stream. The swell height had by now increased to between 1 and 1.5 metres.

At 1240, *Big Yellow* passed the 5.5 metre, single handed fishing vessel *Elisha* **(Figure 4)**, which was stationary off the NCI's watch station at St Ives Head. The skipper noticed the RIB passing by, but there was nothing in either her speed, or the manner in which she was being handled, that raised his concern. Once passed *Elisha, Big Yellow* headed towards the western end of Porthmeor Beach. There she was also seen by the Porthmeor Beach lifeguards, and again there was nothing to raise their concern.

The skipper drove the RIB over the waves at between 22 and 27 knots. The passengers were now screaming through a combination of trepidation and excitement. However, none indicated any concerns to the skipper.

Figure 4

FV *Elisha* (SS92) in St Ives Harbour

1.3.3 Accident

After manoeuvring in the waters off Porthmeor Beach, the skipper reversed his course into the now, mainly following sea. He headed back towards St Ives Head with the intention of then going into St Ives Bay to disembark his passengers.

The skipper slightly reduced the speed of *Big Yellow* before leaving the swell crests of a number of waves. The reduction in speed was clearly heard by the skipper of *Elisha*, which was about 1 cable distant. However, the RIB drove into a swell trough ahead (this is commonly known as “stuffing” the boat) and shipped water, soaking the - now nervous - passengers. Very soon after leaving the next wave crest, the RIB’s bow once again “stuffed” into a trough at a speed of 25.6 knots. The skipper felt a strange movement to the RIB, the deck heaved slightly and there was a very loud crack. Immediately after, the forward part of the upper section of the hull parted and momentarily adopted an angle of about 45 degrees from the horizontal. The RIB came to an abrupt halt.

At that point, the passengers were screaming, having been thrown about the boat and some having lost sight of family members. A number of lifejackets had also self-inflated under the influence of the shipped water, adding to the noise levels and confusion.

The RIB was now full of water but still afloat. The marine ply deck had been torn up, and one female passenger had trapped her legs between the sheets of marine ply deck.

The front bench seat had been torn from its deck securing arrangements. However, the seat's exposed screw fastenings had not punctured the inflatable tubes, and they remained at normal pressure throughout the accident.

As the seat was torn away, two boys aged 10 and 13 were thrown into the water. The father of the boys immediately dived into the sea in search of them. One of the boys was soon pulled back into the RIB from the transom area. At the same time, the father located his other son and guided him back towards the RIB. Both father and son were then quickly hauled onboard.

On seeing the damage to the hull and bench seat, the skipper ran forward to assess the situation and assist the distressed passengers. His fiancée accompanied him. In doing so, the engine "kill cord" connected to the skipper, became disengaged from the control console, and the engines immediately stopped.

Although the RIB was still afloat, it was nevertheless clear to the skipper that the boat had suffered catastrophic failure. He threw both anchors overboard in an attempt to prevent the boat from drifting. He also threw the liferaft overboard and pulled the painter rope to inflate it. The liferaft successfully inflated, but in the upside down position. The skipper turned it the correct way up and secured it to the RIB.

The skipper then turned his attention to making a headcount of his passengers and was able to confirm all were onboard.

While the boat was flooded throughout its length it was being supported by the inflatable tubes. The boat remained afloat with the water level at the underside of the tubes.

Despite the emergency, the skipper made no attempt to alert the emergency services, even though a VHF radio with DSC facility was carried onboard the RIB.

1.3.4 Rescue

At 1245, moments after the accident occurred, the NCI watchkeeper noticed that *Big Yellow* had stopped. He saw, what he believed to be, two people in the water, and the liferaft inflating. He immediately contacted Falmouth CG by telephone and advised them of the situation.

As Falmouth CG activated the rescue helicopter, R193, from nearby HMS Culdrose and the St Ives ILB and ALBs, the skipper of *Elisha* quickly hauled in his handlines and immediately made his way towards *Big Yellow.* Meanwhile, the accident was seen by the lifeguards on Porthmeor Beach, which was about ½ mile away. They immediately sent a jetski with 2 lifeguards onboard, to the scene. Another small, single handed fishing vessel, *Mark James*, also made its way towards the accident site. A chartlet showing the accident key points and environmental conditions is at **Figure 5**.

Arriving first on the scene, it was obvious to *Elisha'*s skipper that the RIB, although still afloat, was beyond use. The passengers were clearly distressed, so he set about transferring them to his vessel. He embarked nine passengers. During the transfer, an adult male passenger dislocated his shoulder, and opted, with two other passengers to remain with the skipper and his fiancée onboard *Big Yellow.*

Very soon after, the lifeguard jetski and *Mark James* arrived. The passenger with the dislocated shoulder was transferred to the jetski and landed at Porthmeor Beach. He then went to Smeton Pier in St Ives Bay to await the arrival of his son who was onboard *Elisha.*

The skipper of *Mark James* offered to take the remaining passengers and crew onboard, but they declined, preferring to await the imminent arrival of the ILB. At 1303, the St Ives ILB, and the rescue helicopter, arrived on the scene. The remaining passengers and the skipper's fiancée were embarked onto the ILB and landed soon after at Smeton Pier. Meanwhile, the helicopter circled the area and recovered a piece of timber, which the crew believed *Big Yellow* might have struck.

The skipper of *Big Yellow* remained onboard his boat, with one of the lifeguards, and awaited the arrival of the St Ives ALB. At 1325 the ALB started towing *Big Yellow,* stern first. They arrived at the West Pier in St Ives Bay about 1 hour later.

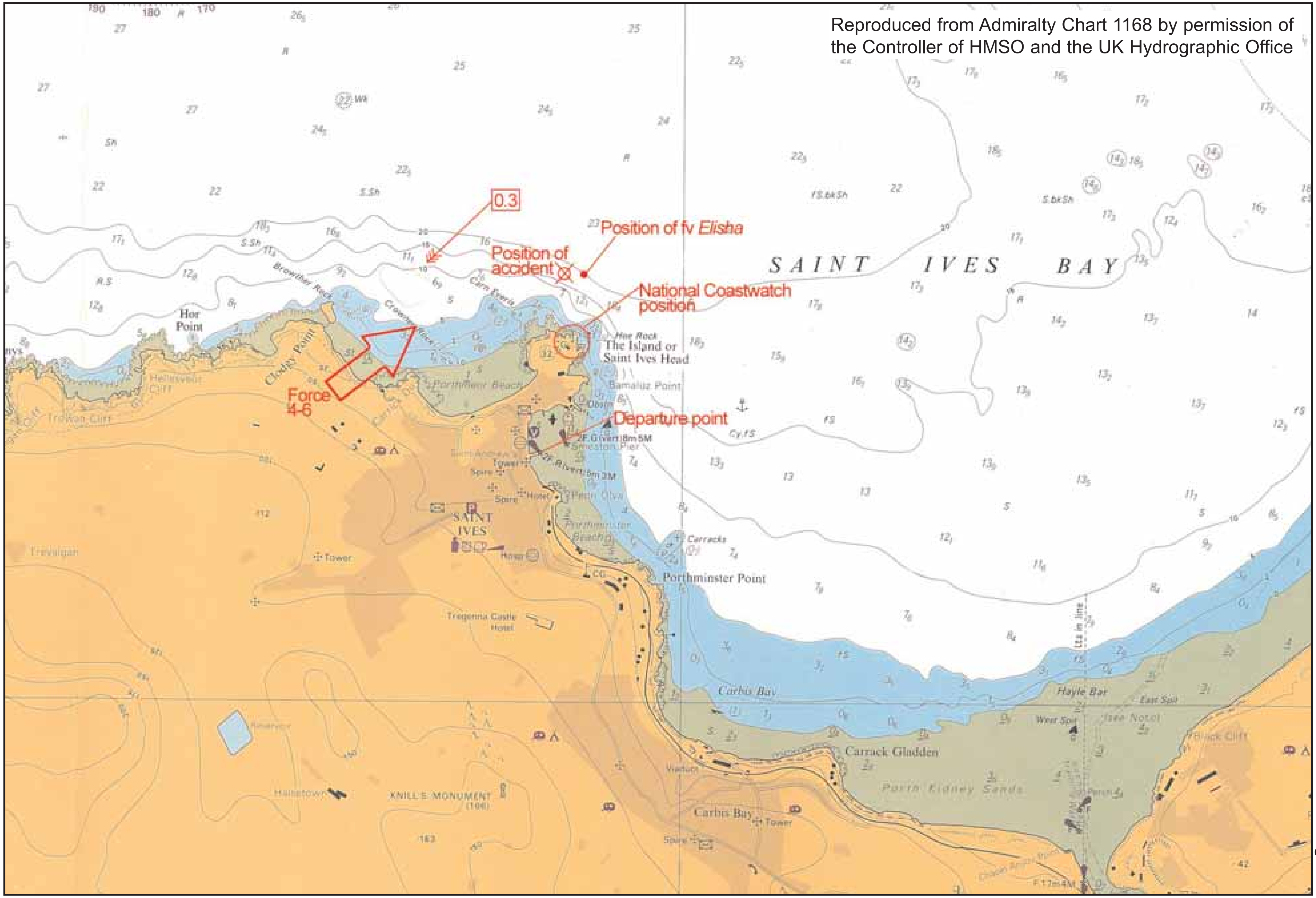
Nine passengers were transferred to the Royal Cornwall Hospital for medical checks, and were released soon after. One passenger suffered a dislocated shoulder, other injuries comprised soft tissue bruises and abrasions.

1.4 ENVIRONMENTAL CONDITIONS

The environmental conditions were confirmed from NCI (St Ives) records and from the skipper of the fishing vessel *Elisha*.

Visibility throughout the incident was good, at about 11nm. The sea was moderate, and there was a swell between 1 and 1.5 metres off Porthmeor Beach. There was a south westerly wind, at force 4 gusting 6. The tide was ebbing at about 0.3 knot, setting in SW direction, parallel to the coast. High water at Falmouth was predicted at 1032, and it was 4 days after the spring tide.

Figure 5



Chartlet showing accident key points

1.5 HISTORY OF RIB MOULD AND DESIGN CHANGE

1.5.1 History

The hull mould from which the FRM 900 is constructed was first conceived in 1991. Blue Water Maritime (BWM) Ltd of Hamble, Hampshire was the first manufacturer to use it for their BWM Rapier 8.5 RIB.

The mould and designer later transferred to Loxton Marine in Bridport, Dorset, where, in 1998, the designer modified the hull form to incorporate a reverse chine (see Section 1.5.2). RIBs continued to be marketed as the BWM Rapier 8.5.

Loxton Marine went into receivership in the late 1990s, and the mould was sold to South Down Marine in Kilkeel, Northern Ireland where the product was advertised as the Barracuda 8.6. It is believed that only one of this type was manufactured and sold, its whereabouts is unknown. At about the same time, the RIB was once again marketed by BWM Ltd of Hamble, but was now sold as the BWM Animal. In 2000, Parker RIBS based in Czosnow, Poland purchased an identical mould and produced a boat under their “Parker RIB 900 RS” logo.

In early 2001, Paul Ferry of Ferryman Boats Limited of Londonderry, the builder of *Big Yellow,* bought the mould from South Down Marine, having previously worked there. The RIB is currently marketed by Ferryman Boats Ltd as the FRM 900, and to date 13 of them have been built and sold **(Figure 6)**.

1.5.2 Design change - reverse chine

The only major recorded design change to the mould was the introduction of the reverse chine in 1998. The purpose of the reverse chine is to act as an “anti-stuffing” device by accentuating the bow upward lift and, at the same time, deflecting waves **(Figure 7)**. This helps to prevent the bow stuffing into the back of a wave, in following sea conditions.

The principle of the design has been incorporated in some models of large ocean-going catamarans.

1.6 HISTORY OF *BIG YELLOW*

Big Yellow was built by Ferryman Boats Ltd in Northern Ireland, and then transported to its owner in Newquay, Cornwall in May 2004. The boat, at this time, was named *Finns Flyer.* The RIB was intended for commercial use, but the owner was unable to gain the required operating licence from the District Council. Consequently, it was only used for short personal trips, and had accumulated only 60 running hours before it was taken out of the water in September 2004, and stored.

The owner did not experience any difficulty with the boat, but he did make bow contact with a 6m long, 75mm diameter log while travelling at about 20 knots. He stated that there were no visible signs of damage to the hull.

Figure 6

View of the FRM 900 mould

Figure 7

Undamaged reverse chine arrangement

During mid June 2005, *Finns Flyer* was transferred to Falmouth Yacht Brokers, and put up for sale, after the owner's business went into receivership. The boat was cleaned and examined by the staff from Falmouth Yacht Brokers, but they reported no defects.

Following a successful test run, the current owners purchased the RIB at the end of June 2005 and renamed it *Big Yellow*. While no specific pre-purchase survey was conducted on behalf of the new owners, they arranged to meet with the receivership surveyor at Falmouth Yacht Brokers, who indicated that the RIB was in a satisfactory condition.

1.7 FERRYMAN BOATS LTD – BUILDER OF *BIG YELLOW*

1.7.1 Organisation and facilities

Ferryman Boats Ltd is based in Londonderry, Northern Ireland and was established in April 2001. The company specialises in manufacturing GRP RIBS, small fishing vessels and related maintenance work.

There are currently 3 full time employees, including the owner. The laminator and engineer have been with the company since its inception. Additional laminators are employed dependent on manufacturing demand.

The company has a single boatbuilding shed, where several boats can be manufactured concurrently. The shed temperature is controllable for GRP lay-up purposes, and is normally set between18-22°C. There is no dust extraction equipment, and no humidity monitoring equipment or control.

1.7.2 Experience of owner

The owner had been employed in banking until 1995, after which he owned a ship chandlery business. At the end of 1999, he was approached by the owner of RIB builders, South Down Marine, enquiring if he wished to purchase the company as a going concern. He declined, but decided to enter the boatbuilding business and was employed by South Down Marine for just over 1 year as a GRP laminator.

This "on job training" provided the opportunity for him to learn the basics of the trade. In April 2001, he bought the full range of GRP moulds from South Down Marine following the death of the owner, and established Ferryman Boats Ltd. The FRM 900s are built to the same process as that used at South Down Marine.

1.7.3 Sales

To date there have been 13 FRM 900 RIBs sold. *Big Yellow* is the only FRM 900 that is known to be used for "white knuckle" thrill rides or for carrying passengers. The others are believed to be for private leisure purposes or as diving support boats.

1.8 *BIG YELLOW* - FRM 900 CONSTRUCTION

1.8.1 Build standard

Big Yellow was intended and equipped for commercial use to carry 12 passengers and 2 crew. The owner of Ferryman Boats Ltd states that all vessels manufactured by his company, including the FRM 900 RIB class, are built to comply with the European Recreational Craft Directive (RCD). The RCD is discussed in more detail in Section 1.11.

1.8.2 General arrangement

Big Yellow is based on the generic, deep vee, 8.6m mould of the FRM 900 class. It is 9.1m overall length with a beam of 2.7m. Two, 500mm diameter, 5-section, Hypalon inflatable tubes are fitted to the moulded hull flange and secured in place by adhesive tapes.

A bow anchor locker is fitted on the deck, with the liferaft stowed immediately abaft. Also fitted to the deck are 4 x 3 person bench seats supported by stainless steel frames with aluminium LSA lockers beneath.

A steering console **(Figure 8)** is located towards the stern. It is fitted with two backrests for crew use. The console houses the engine monitoring equipment, engine power and steering controls. There is also a magnetic compass, Garmin GPSMAP 182C GPS receiver, an Icom IC – M601 VHF radio and a Garmin 160 Blue Fishfinder fitted to the console.

Figure 8

Steering console

Two Suzuki 140 hp outboard engines provide the power for the boat to achieve speeds in excess of 40 knots. Fuel is supplied from a centreline, 250 litre stainless steel fuel tank. There is also a 6750 lph electric bilge pump fitted.

1.8.3 Lifesaving apparatus

Big Yellow carried a 14-man Nautiv Atlantic liferaft which had to be manually launched. This was inflated by tugging the painter rope. There was no hydrostatic release system fitted. Sixteen, Typhoon self-inflating lifejackets, 2 lifebuoys, 2 red hand-held flares, and 2 buoyant smoke flares completes the LSA suite.

1.8.4 Hull shell construction

The GRP hull has an average thickness of 10mm, and is laid in the traditional manner, starting from the transom, working forward on either the port or starboard side. Once completed, the opposite side is laid up. GRP material overlaps the centreline throughout the hull length by about 200mm, thus providing a double thickness of 20mm of GRP, along what would traditionally be the keel. The centreline stainless steel fuel tank is “glassed” into the hull after the hull lay up is complete.

The GRP hull is built up by first applying the mould release wax and brushing in the 2mm thickness pigmented gel coat. The total GRP lay up system comprises:

- 1 layer of 300 gram csm - which is allowed to cure
- 1 layer of 600 gram csm - which is allowed to cure
- 2 layers of 600 gram csm - laid as a single action and allowed to cure
- A single sandwich construction laid as a single action and allowed to cure. The sandwich comprises:
  - 1 layer of 600 gram csm
  - 1 layer of 600 gram woving roving
  - 1 layer of 600 gram csm

The materials used are shown at **Figure 9**. Between 1 -1.5% catalyst, by volume, is added to the resin and rolled into the GRP materials during the hand laying process.

1.8.5 Internal structural members

Apart from the deck and centreline fuel tank, the FRM 900 design does not incorporate any dedicated structure, such as longitudinals or stringers, to provide longitudinal stiffness[2].

[2] South Down Marine's Barracuda 8.6, which the owner of Ferryman Boats Ltd helped to build, was not fitted with longitudinals (see paragraph 1.7.2)

The stainless steel fuel tank is shaped to match the hull profile. It is 2.5 metres long, 40cm wide and 25cm high. The after end of the fuel tank is positioned about 2.0m forward of the transom.

A series of under deck, frame type structures provide a degree of transverse stiffness. The first is located 300mm from the transom, with the remainder spaced at 450mm intervals throughout the length of the hull. The structure's main purpose is to support the plywood deck. The frames comprise an 18mm x 75mm wide marine ply stringer fitted across the hull. These are encapsulated by 2 layers of 600 gram csm and a single layer of woving roving, which are blended to the hull **(Figure 10)**. A lightening hole also serves to reduce weight and allows for drainage of the bilge pump suction.

The 300mm upstand, from the deck to the flange/tube interface, is totally unsupported in both longitudinal and transverse directions.

1.8.6 Deck and tube arrangements

The deck is manufactured from sheets of 18mm marine ply. The underside is covered with a single layer of 600 gram csm, the purpose is not so much to improve its strength, but to form a water barrier.

Two layers of 600 gram csm are laid on top of the transverse frames.

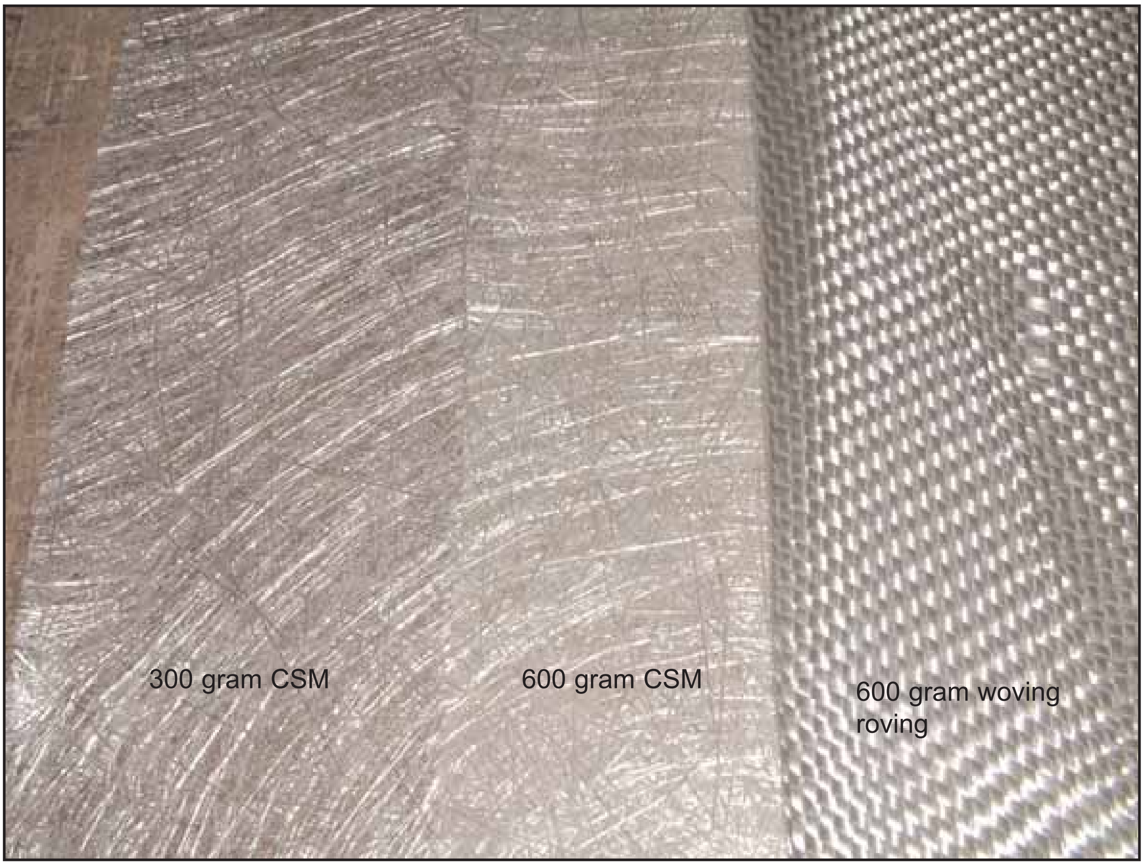
While the resin is still wet, the deck is laid on top and fastened to the marine ply stringer with size 10, self-tapping screws at approximately 460mm between centres.

Gaps between the deck edge and hull interface are plugged with a filler compound mixed with resin which is laid into a gulley fitted around the deck edge **Figure 11**. Two layers of 600 gram csm are then laid on top of the deck and are blended into the hull flange. A non slip surface is stippled onto the deck comprising a 50/50 mix of gel and resin, pigment, wax and dried builder's silver sand.

The Hypalon tubes are located onto the hull flange. Any gaps are filled with the filler and resin mix. A single layer of 600 gram csm is used to cover inboard filler and is blended to the hull and deck flange. Tapes are then glued to the inner and outer face of the tubes holding them firmly in place.

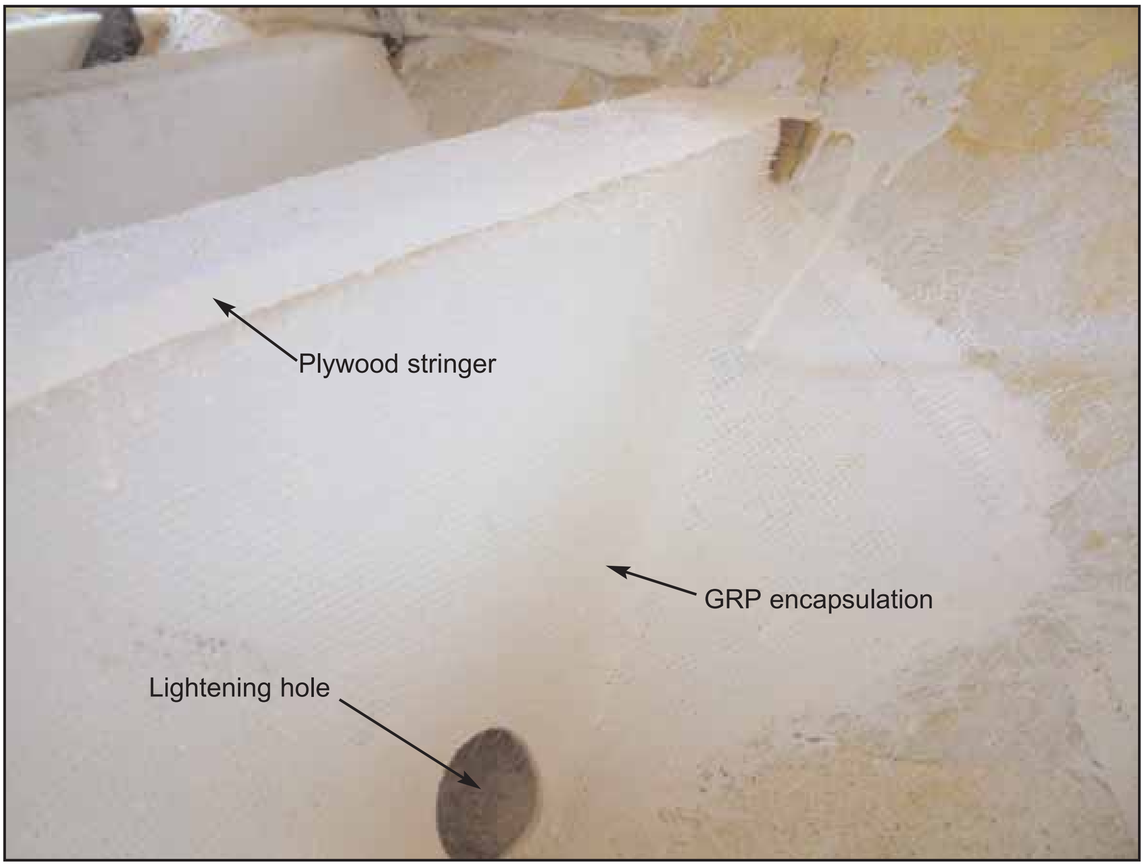
In common with many other RIBs, there are no access points in the deck to allow for under deck hull inspection. The deck and tube configuration is shown at **Figure 12**.

Figure 9



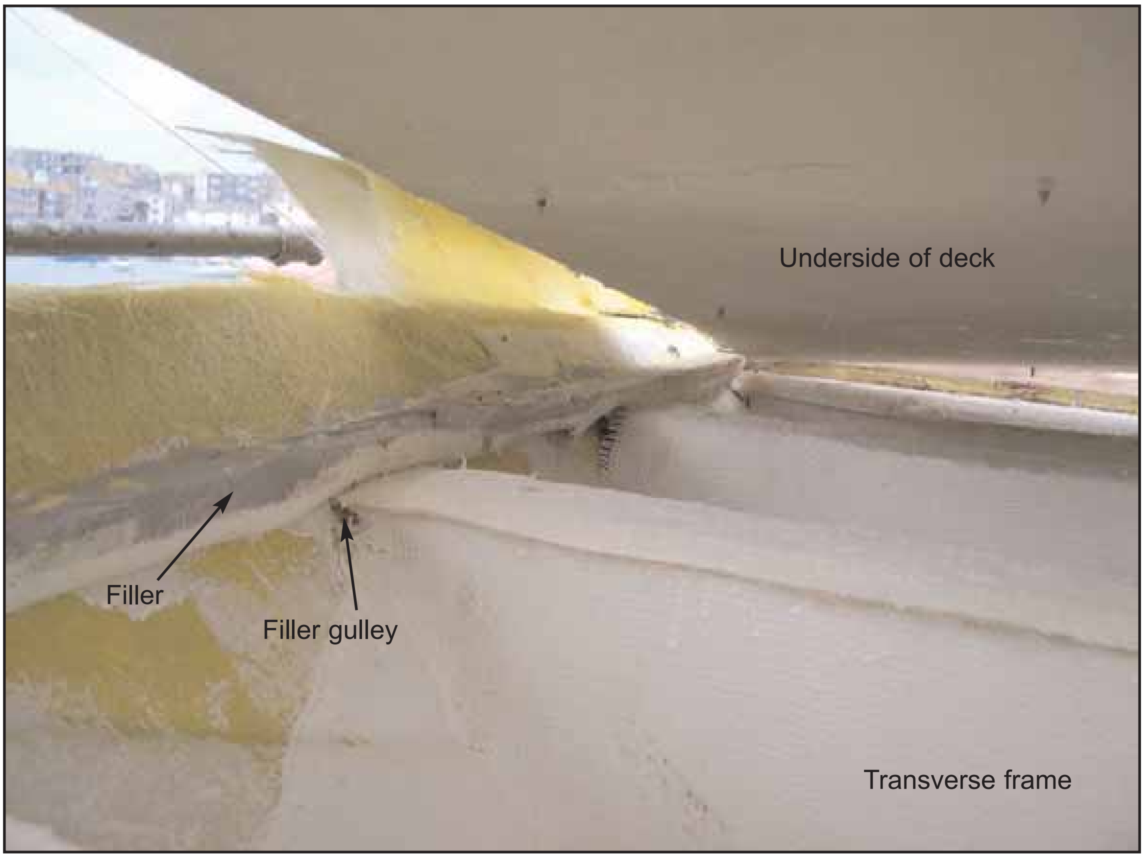
Materials used for hull lay up

Figure 10



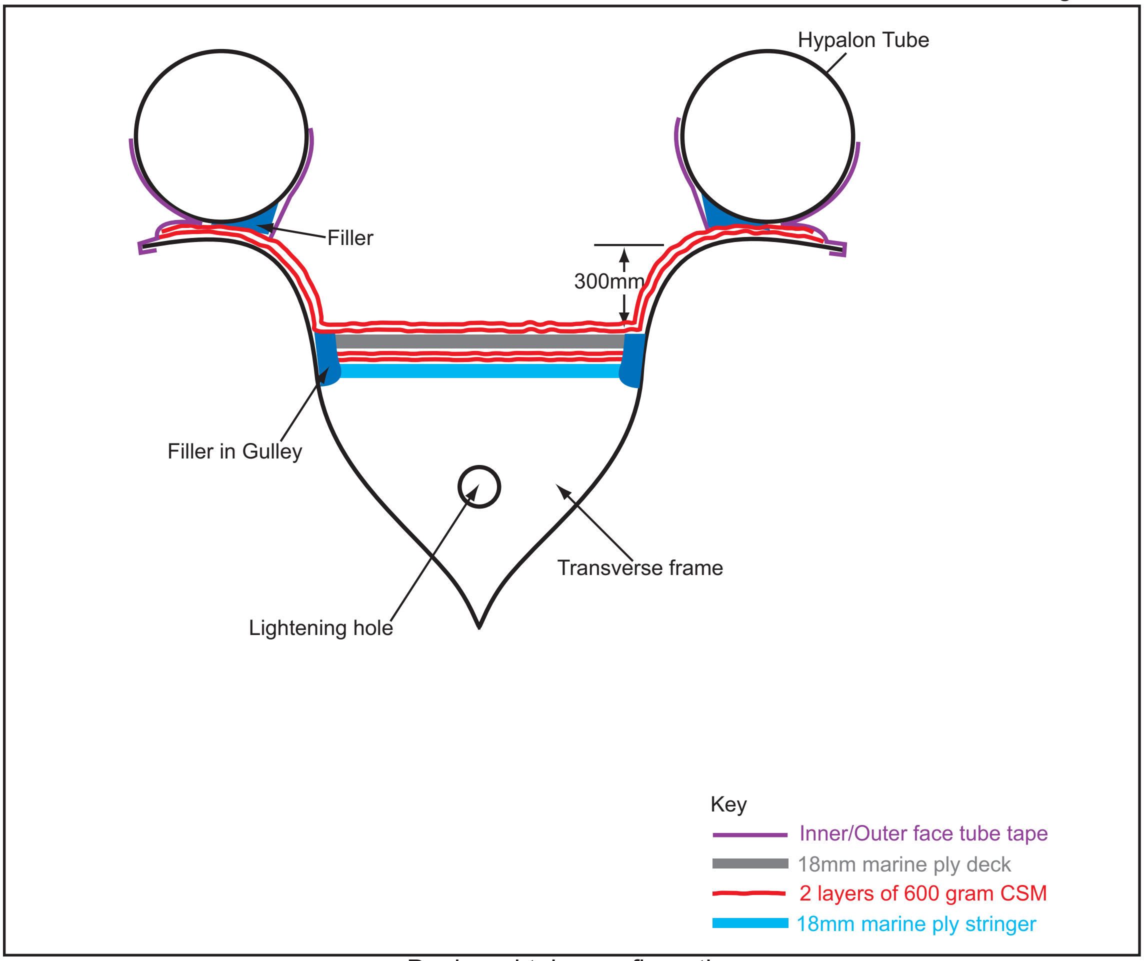
Transverse frame arrangement

Figure 11



Deck edge/hull interface seal arrangements

Figure 12



Deck and tube configuration

1.8.7 Seating

The 4 rows of seats are supported on tubular stainless steel frames. The flat bar stainless steel base is bolted to an 18mm marine ply sole plate by recessed M10 stainless steel nuts and bolts. The recess is filled with the proprietary compound, Sikaflex, to prevent water ingress into the timber grain.

Once assembled, the marine ply sole is screwed into the deck using 3 x size 10, 30mm self-tapping screws. A single layer of 600 gram csm is used to cover the sole plate and is blended into the deck csm.

1.9 POST ACCIDENT SURVEY

Two MAIB inspectors attended the boat soon after the accident, while it was on its trailer at the West Pier in St Ives Bay. Also in attendance were the owners and the MAIB's contracted GRP specialist surveyor. The initial survey identified significant damage to the hull and seating arrangements. All other equipment, including the engines, was undamaged.

The boat-builder's unique Hull Identification Number (HIN), FMNFRM90D404, was etched into the gel coat on the outboard face of the transom.

1.9.1 Hull damage

The hull had suffered extensive, symmetrical damage which included areas of de-lamination. A port and starboard longitudinal split had separated the hull for a total distance of approximately 4.2m from the stem reverse chine line to a point under the passenger seating area **(see Figure 13)**.

There was evidence of gel coat detachment at the beginning of the reverse chine, at the stem **(Figure 14)**. The nature of this apparent old damage suggested that it might have been caused by the RIB touching rocks, pier steps, or during trailer loading or unloading. The area also appeared to have been "buffed" up in readiness for repair.

From forward, the split extended along the line of the reverse chine to a 280mm x 270mm area of apparent de-lamination which was just above deck level. The split line ran from the upper after corner of this area, and then continued to split the tube support flange for a length of approximately 2.6m **(Figure 15)**.

There was also evidence of stress cracking on the port and starboard sides just above the deck line **(Figure 16)**.

The upper part of the hull could easily be lifted to expose the under deck structure, as shown at **Figure 17**. A schematic illustrating the extent of the hull damage is at **Figure 18**.

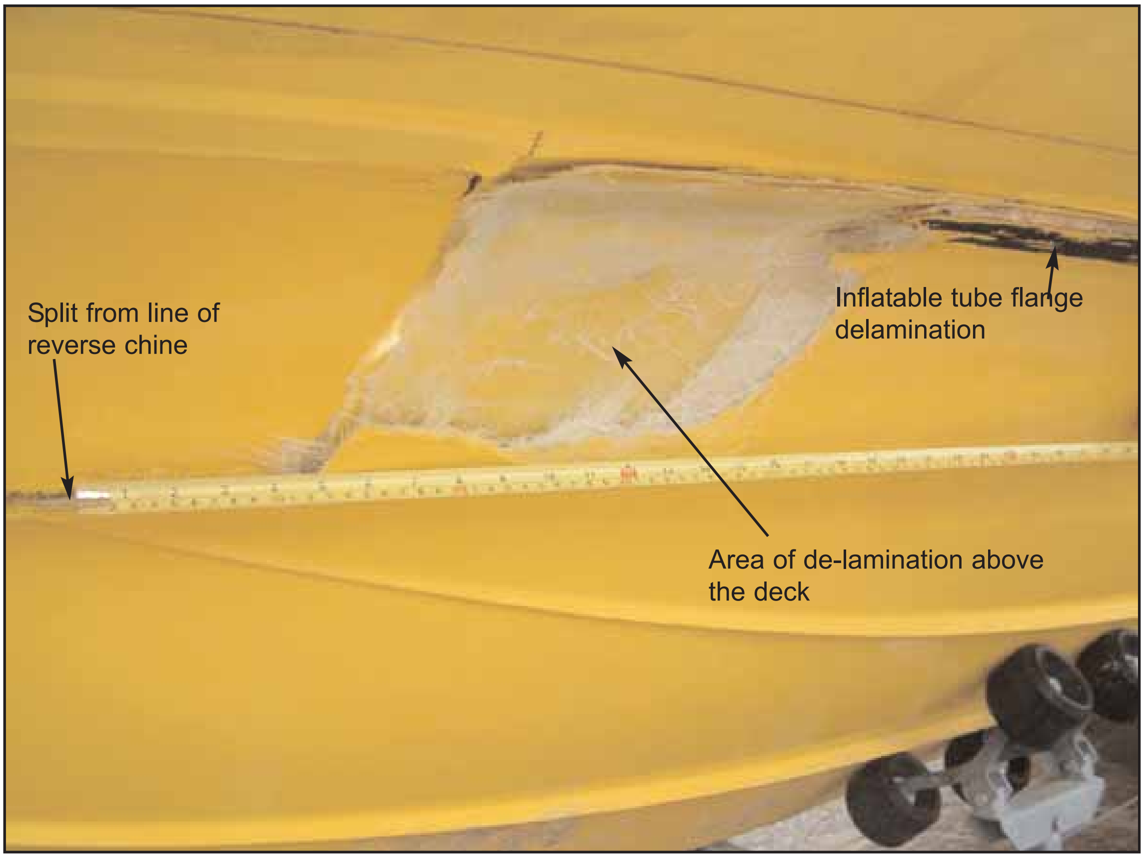
Figure 13

Symmetrical damage from stem

Figure 14

Gel coat detachment at start of reverse chine

Figure 15



Extent of hull split

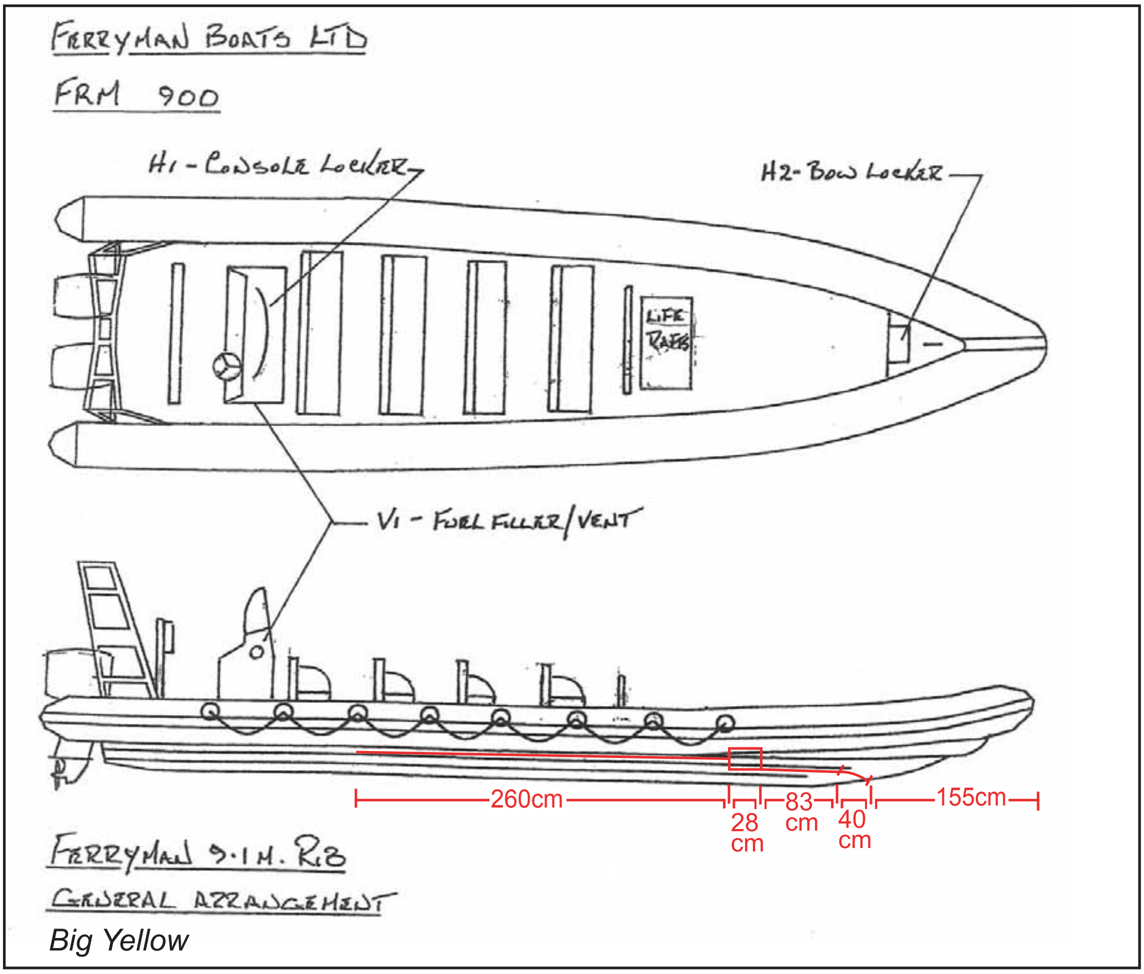
Figure 16

Area of stress cracking

Figure 17

Hull lifted to show extent of damage

Figure 18



Schematic of hull damage

1.9.2 Below deck structure

There was no obvious damage to the deck supporting marine ply stringers, or to the csm layers retaining these in position. But it was noted that, in some cases, the csm draped over the stringers appeared to lack firm adhesion to the hull and resin impregnation. It was found that the stringers were very flexible and could be easily depressed using light hand pressure.

1.9.3 Deck

The marine ply sheets forming the deck were intact. The GRP layers covering the deck had failed at the marine ply butt joints coincident with the apparent area of de-lamination referred to in Section 1.9.1 above **(Figure 19)**.

There were also large areas of csm detachment from the deck covering.

1.9.4 Inflatable tubes

The tubes were in good condition, although there was some evidence of tube securing tape detachment.

1.9.5 Seating

The front bench seat pad piece remained fastened to the stainless steel bench frame with its M10 stainless steel fastenings **(Figure 20)**. However, the pad piece csm covering, and self-tapping screws, had failed, resulting in the bench being torn from the deck **(Figure 21)**.

Figure 19

Failure of CSM over deck butt joints

Figure 20

Front bench pad piece

Figure 21

Front bench pad piece - failure of pad piece CSM covering

1.10 INDEPENDENT SURVEY AND LABORATORY TESTING AND ANALYSIS

It was not possible during the initial survey to definitively identify the mode or direction of failure of the hull, or whether there were any pre-existing defects or repairs which might have contributed to the accident.

To examine these points in more detail, the following independent specialists were contracted by the MAIB:

- David Cox (Marine Surveyors and Consultants Ltd), who are GRP specialists, were commissioned to survey *Big Yellow* and review the boat's construction standards.
- DRB Materials Technology Ltd of Lymington, Hampshire were contracted to conduct microscopic examination of ten hull samples, to check the quality of the boat's lay up and for any pre-existing defects. They also carried out a series of 3-point bend tests and tensile tests to ascertain the GRP flexural properties on additional samples taken from the hull, above the deck line.
- MSA Technology Ltd, also of Lymington, Hampshire, carried out stress analysis calculations, focusing on those relating to the strength of the hull above the deck line.

The results of this independent work are discussed in Section 2.

1.11 RECREATIONAL CRAFT DIRECTIVE

1.11.1 Background

The RCD was laid before the European Parliament on 16 June 1994, and application to Member States came into force on 16 June 1996. Statutory Instrument (SI) – 1996 No. 1353, Consumer Protection, Recreational Craft Regulations 1996, mandates the requirement[3].

The purpose of the RCD is to promote the free trade of recreational craft within the Member States of the European Union. The Directive applies to vessels between 2.5m to 24m in length overall and provides buyers with the confidence that vessels are built to a required, safe standard.

1.11.2 Build module choice

Manufactures are required to prove RCD conformity. They are able to do this by selecting an appropriate build module designator as laid out in the table at Chapter 2 of the RCD. A copy of the full table is at **Annex A**.

[3] SI 1996 No1353 has since been superseded by SI 2004 No 1464 - The Recreational Craft Regulations 2004. These came into force in 2 stages. The first stage on 30 June 2004 and the second stage on 1 January 2005.

Module selection is based on the length of the vessel and the physical conditions that might be encountered. This is known as the Design Category as set out in Table 1 below.

Design Category	Wind force (Beaufort scale)	Significant wave height (m)
A – "Ocean"	Exceeding 8	Exceeding 4
B – "Offshore"	Up to, and including, 8	Up to, and including, 4
C – "Inshore"	Up to, and including, 6	Up to, and including, 2
D – "Sheltered waters"	Up to, and including, 4	Up to, and including, 0.5

Table 1

Modules range from, Module A (Internal production control and self assessment by the manufacturer), to Module H (Full quality assurance with the intervention of a notified body to approve and control the manufacturer's quality system).

A fundamental element of the quality assurance self assessment system is the maintenance of accurate technical documentation. This should include system drawings, results of tests and examinations, and design calculations as required by Annex XIII of the RCD.

The FRM 900s are built to Design Category **"B"**. They are under 12m length overall, and therefore fall under build Module **Aa** as laid out at **Annex A**. The criteria for build Module **Aa** is defined in Table 2 below.

Design Category	Module	Title	Description
B	A	Internal production control	Internal conformity assessment and production control by the manufacturer who draws up a written declaration of conformity in accordance with Annex XV of the RCD.
	Aa	Internal production control plus tests	This is Module A, plus tests of stability and buoyancy carried out on the responsibility of the notified body, which issues an examination report.

Table 2

1.11.3 Essential safety requirements

Annex I to the RCD **(copy at Annex B)** sets out the safety essential requirements for the design and construction of recreational craft. The Annex also identifies appropriate harmonised standards against each requirement, where these are available. Builders are not obliged to use these, but they must demonstrate that an equivalent standard, or other method of compliance, has been used and achieved.

1.11.4 Declaration of conformity

The RCD Annex XV requires a written declaration of conformity to be provided by the manufacturer, which is unique to each vessel. This should accompany the owner's manual. In the case of *Big Yellow* the following should have been included:

- Details of the manufacturer and the craft.
- References to the relevant standards used, or alternatives to satisfy the safety essential requirements.
- Reference to the EC type examination certificate issued by the notified body, and details of the body.

A copy of the Declaration of Conformity presented for *Big Yellow* is at **Annex C**. It was noted that neither the previous, nor current owner of *Big Yellow* had a copy of the Declaration. No Declarations could be provided for any of the other boats in production, suggesting that the requirement to do so was not understood by the builder.

1.11.5 Notified Body – testing of buoyancy and stability

Notified Bodies are organisations that are approved by EU Member States to carry out specific tasks in support of certain requirements as set out in the build module choice.

In the case of the FRM 900s, there is a requirement under build module **Aa** for a Notified Body to check the boat's buoyancy and stability. However, the FRM 900 has, itself, never been subjected to these tests. The examination report by the Irish Sailing Association **(Annex D)** – a notified body, is for the FRM 760-860 range of RIBs and not specifically for the FRM 900. The report is re-issued upon annual application and a statement by the builder that the original boat has remained unchanged since testing. The testing in this case was undertaken on a RIB built by South Down Marine Ltd in 2001. This is where the owner of Ferryman Boats Ltd worked, and from whom the moulds were purchased.

The applicability and confusion over the transfer of documentation from South Down Marine Ltd to Ferryman Boats Ltd is discussed at Section 2, paragraph 2.7.2.

1.12 MONITORING AND ADVICE ON RCD COMPLIANCE

1.12.1 Local Authority responsibility

The responsibility for monitoring RCD compliance rests with the county councils. In England, Scotland and Wales, Trading Standards Officers of the Weights and Measures Authorities, attached to the councils, assume this responsibility. In Derry, Northern Ireland, the responsibility for enforcing consumer protection rests with Derry City Council's Environmental Health Department.

Each council approaches the inspection requirement in a different manner. In Hampshire, boat-builders are inspected annually. In Derry, as in most other areas, inspections are reactive and are based on risk assessments, with organisations being targeted accordingly.

1.12.2 Local Authorities Coordinators of Regulatory Services (LACORS)

LACORS, based in London, has the responsibility to provide and disseminate regulatory advice, guidance, good practice and information to local authorities. LACORS has an RCD specialist who coordinates related issues throughout the United Kingdom local authorities.

1.12.3 British Marine Federation (BMF)

The British Marine Federation is the trade association for the British boating industry, and its 1500 members account for about 90% of the marine industry manufacturers. The Federation offers its membership a wide range of marine related services including seminars, workshops and full training courses. In relation to this accident, the BMF was able to offer comprehensive and pragmatic advice on all aspects of the RCD requirements.

BMF is also the DTI's recognised organisation for allocating and recording elements of a vessel's Hull Identification Number as required by the RCD.

1.13 EXAMINATION FOR MCA CODE COMPLIANCE

1.13.1 Yellow Code and Harmonised Code

The Safety of Small Commercial Motor Vessels – Code of Practice is commonly known as the Yellow Code. The primary aim of the Code is to set standards of safety and protection for all those onboard commercially operated vessels of less than 24 metres Load Line length, and carrying no more than 12 passengers. It also sets out manning and crew qualification requirements.

The Code was established in Statute by SI 1998 No 2771 and amended by SI 2000 No 482 – The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure).

Section 4.5 of the Code deals specifically with RIB construction standards and associated hull strength tests. It is also relevant that paragraph 1.12 covers the agreement for the mutual recognition of EU standards. These are acceptable,

> *"provided that the proposed standard, code of practice, specification or technical description provides, in use, equivalent levels of safety, suitability and fitness for purpose".*

The Yellow Code has now been amalgamated with various other Codes of Practice. It is not yet supported by statute, but was published in October 2004 by the MCA as MGN 280 (M) – Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats – Alternative Construction Standards. This Code is colloquially known as the "Harmonised Code".

1.13.2 Certifying authorities and examinations

The MCA delegates the responsibility to examine vessels, issue and sign declarations, examinations and certificates to a number of approved Certifying Authorities. MECAL Ltd, based in Plymouth, undertook the Code compliance examinations for *Big Yellow*.

Code compliance examinations are undertaken, out of, and in the water. Certificates are valid for 5 years. Vessels are also subject to annual examinations by the owner and a further, intermediate in water examination by the Certifying Authority no later than 3 years after the compliance examination.

The Certifying Authority issues a new decal disc annually, after each examination. On change of ownership, all certificates are cancelled and the new owner has to apply for the vessel to be re-examined.

1.13.3 *Big Yellow e*xaminations

Big Yellow was examined for Code compliance to operate in Area Category 4. This is defined as:

> *"up 20 miles from a safe haven, in favourable weather and in daylight."*

The post build examination was undertaken in Northern Ireland on 27 May 2004 on behalf of the previous owner when the RIB was known as *Finns Flyer.* A copy of the surveyor's completed SCV2 Compliance Document – RIBS is at **Annex E**. The MECAL Ltd authorised person conducted stability, swamp and damage tests in accordance with the Code requirements. He was also present during performance trials on the River Foyle. On completion of the examination and tests, a Small Commercial Motor Vessel Certificate was issued, valid until 27 May 2009. A copy of the certificate is at **Annex F**.

1.14 RIB OPERATING COMPANY

1.14.1 Area of operations

Although *Big Yellow* was coded to operate in Area Category 4 (see Section 1.13.3) the skipper had restricted his area of operation to MCA Area Category 6, which is far less demanding than Area Category 4. This is defined in the Red Code (Safety of Small Vessels in Commercial Use for Sport or Pleasure Operating from a Nominated Departure Point) and Harmonised Code as:

> "*to sea, within 3 miles from a nominated departure point(s) named in the certificate and never more than 3 miles from land, in favourable weather and daylight."*

1.14.2 Crew qualifications

The skipper held an Apprentice Boatman's Licence, a first-aid certificate and a National Powerboat Level 2 certificate gained in April 2002. This was appropriate for operations in Area Category 6. However, the qualification did not carry the Code required endorsement of:

> *" valid for vessels of up to 24 metres in length used for commercial purposes."*

The skipper's fiancée, who conducted the passenger safety briefing, held no marine related qualifications.

1.14.3 Health and Safety at Work Provisions

The Company did not have a Health and Safety policy, and the owners had not undertaken a risk assessment of their operation.

1.15 PENWITH DISTRICT COUNCIL AND ST IVES HARBOURMASTER'S INSTRUCTIONS

Penwith District Council does not have any specific licensing requirements for operations in St Ives harbour. However, as part of his general duties, the harbourmaster issues broad instructions in the form of Codes of Practice to ensure safety within his area of jurisdiction. A copy of the Code for Fast RIB Operations is at **Annex G**. In the interest of public safety, the harbourmaster also requires companies carrying fee paying passengers to seek his approval to operate.

The owners of *Big Yellow* were well known to Penwith District Council and the St Ives harbour harbourmaster. For the past 4-5 years, the skipper of *Big Yellow* had operated a small company offering low power, self-drive, pleasure boat rides within the confines of St Ives harbour.

The business had been conducted to the harbourmaster's satisfaction. When he was approached to approve the *Big Yellow*'s operation, he confirmed that the Code compliance examination had been completed and that the skipper held the appropriate powerboat qualification. He then recommended to Penwith District Council that the request to operate the *Big Yellow* pleasure rides should be endorsed.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 CIRCUMSTANCES OF THE ACCIDENT

The failure of *Big Yellow*'s hull occurred during a routine pleasure trip, in sea conditions that the boat should easily have been able to cope with. The RIB was theoretically designed to operate in wave heights of up to 4 metres. In this case the swell height was between 1 and 1.5 metres, and the boat was not overloaded when compared to its specification.

Trips are advertised as the "Ultimate RIB Ride" and passengers expect to be thrilled when paying for this type of excursion. There will inevitably be periods of high speed and wave slamming, and there is a suggestion that the skipper might have been going too fast for the prevailing conditions. There is no evidence to support this. Experienced mariners who saw the RIB just prior to the accident raised neither concerns regarding its speed, nor the manner in which it was being handled. It is usual RIB operating practice, when in a head on sea, to jump the wave crests, and in a following sea to slightly reduce the engine power at the crest of the wave and increase power to drive out of the following trough. The engine variations were clearly heard by the skipper of the nearby fishing vessel *Elisha*, suggesting that the RIB was being handled correctly.

Scrutiny of the GPS data confirmed the boat's speed was consistent with the trip made earlier on the day of the accident. The RIB's tracks and associated speed profile for 26 August is at **Figure 22**. There was nothing to suggest that the accident trip circumstances were unusual to those previously experienced.

Just before the accident, the skipper noted that he felt a slight undetermined change in the boat's handling characteristics. This was soon followed by a slight heave of the deck in the vicinity of the forward passenger bench seat. Almost immediately, the forward section of the hull parted, opening the boat to the sea. This suggested that the hull failure might not have propagated from the stem, as first suspected, but from a point further aft.

Following the failure, the skipper and his fiancée did what they could for the passengers. They were clearly in shock themselves, but they managed to launch the liferaft, stop the drift of the boat by dropping the anchors, and to account for their passengers. It was, however, disappointing that the skipper did not attempt to alert the emergency services, despite a VHF radio being readily available. He made this decision because he was aware of the close proximity of *Elisha.*

Big Yellow was being used well within the appropriate operational limits set out in the MCA's Yellow Code. However, it is apparent that, due to the lack of any handling, environmental or loading extreme circumstances, the boat's structure was unable to withstand the normal in service forces, and was therefore unsuitable for its intended role.

Figure 22

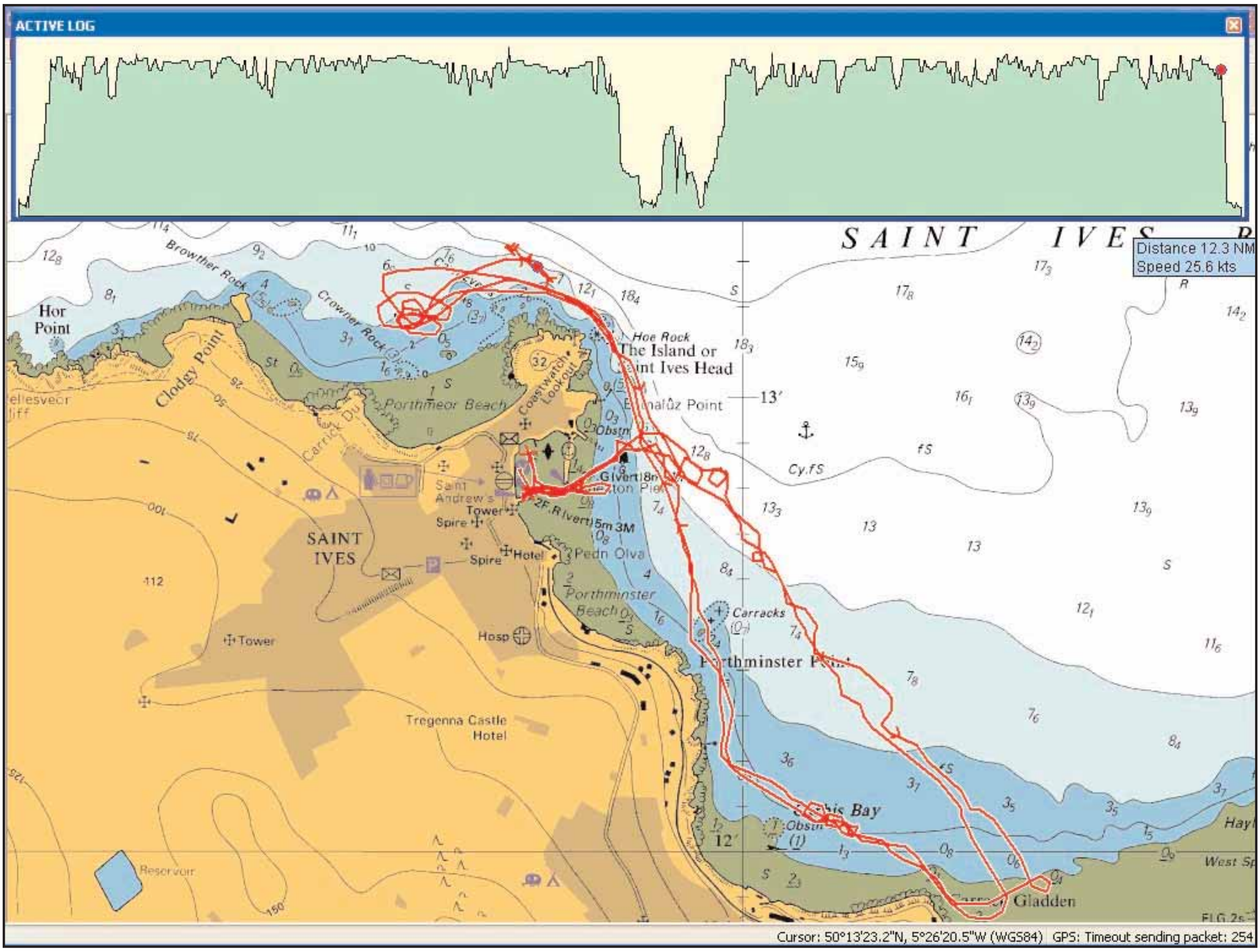


Chart of St Ives Bay with RIB speed profile for 26 August 2005

2.3 STRUCTURAL STRENGTH OF THE RIB

The structural strength of a GRP RIB is dependent on the adequacy of the hull and internal structure lay up specification, the skill of the laminator and the correct environmental controls. The RIB's internal hull construction must also provide the necessary longitudinal and transverse stiffness to cope safely with the boat's "in service loads".

2.3.1 Lay up specification

The lay up of *Big Yellow* was compared to other manufactures' specifications who build similar craft for leisure use. There were notable differences in the number of layers used, and especially in the amount of woving roving in the construction[4]. Some areas of *Big Yellow*'s hull were only 7mm thick, compared to up to 12mm thickness in some other RIB manufacturers' specifications.

The exact number of layers and materials selected is dependent on the boat's specification. In this case, the FRM 900s were built to RCD Design Category B and declared suitable by the MCA's Certifying Authority to operate in Area Category 4 (see Sections 1.11.2 and 1.13.3 respectively). The hull lay up specification should be supported by comprehensive stress calculations that clearly demonstrate its fitness for purpose in order to operate in the designated operating area. No stress calculations were carried out, neither were any tests conducted to prove the structural strength of the boat (see Section 2.3.4 Hull strength testing).

Table 3 below illustrates the significant differences between the Ferryman Boats Ltd's, very light lay up specification, and that used by Parker RIBs, who also use an identical mould for their leisure RIBs.

Ferryman Boats Ltd	Parker RIBS
Gel coat 1 layer of 300 gram csm 1 layer of 600 gram csm 2 layers of 600 gram csm A single sandwich construction comprising: 1 layer of 600 gram csm 1 layer of 600 gram woving roving 1 layer of 600 gram csm	Gel coat 1 layer of 300 gram csm 3 layers of 450 gram csm I layer of 800 gram woving roving 1 layer of 450 gram csm All chines filled with filler 1 layer of 450 gram csm 1 layer of 800 gram woving roving 1 layer of 450 gram csm 1 layer of 800 gram woving roving 1 layer of 300 gram csm

Table 3

2.3.2 Boatbuilding environmental controls

Because a GRP boat is constructed from various glass and resin materials, it is important to maintain specific environmental conditions to ensure a good quality product.

[2] Woving roving has approximately twice the tensile and flexural strength of csm. Textbooks emphasise the use of woving roving in areas where strength is critical.

The ideal workshop temperature for hand laying GRP is about 18ºC. Higher temperatures will result in premature gelation of the resins, and will weaken the laminate. Humidity levels above 75% will allow the glass fibres to pick up moisture, which will affect the bond and cure and also weaken the laminate.

Laboratory examination of the hull samples did not identify any temperature or high moisture content defects, therefore inadequate environmental controls were not considered to have contributed to the accident.

2.3.3 Hull stiffening

MAIB's post accident hull survey identified that there was no dedicated longitudinal structural stiffening fitted to *Big Yellow*. Longitudinal structure is necessary to withstand the hogging, sagging and slamming forces experienced by the hull during normal operation and while on a drying mooring. It was the opinion of the builder that some longitudinal stiffening was provided by the centreline fuel tank which was encapsulated into the hull. Provided the tank is completely rigid, then this would be the case, but only over the length of the tank. However, there will be discontinuity in strength at the forward end of the tank itself which is approximately in the midships position of the hull. It is possible that this would create a "hinge" effect at this point when the RIB is under dynamic loading, and would weaken the structure.

There was some transverse stiffening provided by the transverse frame arrangements (see Section 1.8.5). But their effectiveness, in some cases, was compromised by poor bonding of the csm encapsulation to the hull. The 300mm section of the hull, from the deck to the tube flange, was totally unsupported in the transverse direction **(Figure 12)**, and would have flexed through the natural tendency of the hull to twist in a seaway.

The lack of hull strength was fundamental in setting up the stresses which led to the eventual hull failure.

Despite the RCD requirement to maintain hull stiffening scantling calculations in the FRM 900 technical file, none were held.

Figures 23 and 24 illustrate the difference in stiffening arrangements between two manufactures of RIBs from the same hull mould.

2.3.4 Hull strength testing

To satisfy the MCA Code Compliance examinations, a new RIB is to be subjected to a 'Drop Test' in accordance with paragraph 4.5.3.1 of the MCA's Yellow Code.

The RCD also covers the requirements for a 'Drop Test' for RIBs up to 8 metres in length. The ISO (ISO 6185-4) covering RIBs between 8 and 24 metres length is currently being drafted. The test requires that the RIB be dropped at its

Figure 23

Transverse stiffening - FRM 900

Figure 24

Under deck structural stiffening - Parker RIBs 900RS normal operational weight from a height of 3 metres in a horizontal plane, with the bow set down by 45 degrees and with the stern set down by 45 degrees. There should be no visible distortion, cracks, tears or separation to any part of the hull or components.

Had the Yellow Code requirement been fulfilled then it is possible that it would have identified weaknesses of the hull structure.

2.4 REPORTS OF HULL CONTACT

2.4.1 Impact damage

The previous owner reported that, while operating in Newquay harbour the boat made contact, at high speed, with a large piece of wood. In addition, the crew of the rescue helicopter recovered a length of timber which they believed *Big Yellow* might have hit. There is supposition that either of these might have initiated the failure, and could explain the damage seen to the gel coat at the beginning of the reverse chine, located at the stem.

Passengers onboard at the time of the accident were confident the RIB did not hit anything during the trip. Examination of photographs while the RIB was at Falmouth Yacht Brokers did not reveal any damage to the stem gel coat. Discussions with the the staff from Falmouth Yacht Brokers confirmed that during their "out of water survey" they saw no damage to the vessel's stem or in any other areas of the hull. The gel coat damage must have occurred sometime during the current ownership, and might have happened during loading or offloading from the RIB's trailer, or during berthing operations.

Laboratory microscopic examination of the hull and deck samples confirmed that the RIB had not suffered any impact damage that initiated the hull failure on 26 August 2005. Therefore, the suggestion that the boat made contact with a floating object, causing the hull to fail, cannot be supported.

2.5 RESULTS OF INDEPENDENT SURVEY AND TESTING

2.5.1 Laboratory testing by DRB Technology

Laboratory examination of the wide ranging hull samples provided the opportunity to check for hull lay up defects, strength characteristics and compliance with the boat-builder's specification.

It was found that the lay up of the hull was in accordance with the manufacturer's specification, and that its strength characteristics were as expected for this composition and thickness. However, this does not mean that the specification was adequate for the boat to satisfy its RCD Category B status.

Some resin rich areas were found in the lay up, and there were also some areas of high void contents. While these were not widespread, it is significant that they were in the 300mm unsupported hull area above the deck.

The laboratory examination was unable to find an overall failure origin, and there was no evidence to suggest that poor laminating was a factor in the accident. DRB Technology's report "Discussions and Conclusions" are at **Annex H**.

2.5.2 Stress Analysis by MSA Technical Solutions Ltd

The results of the stress analysis identified that the unsupported sides of the hull above the deck was the major limitation to the ultimate strength of the hull. It was calculated that the stresses in the topsides of the hull would increase significantly when the boat's hull form and inflatable tubes were submerged to a greater depth than normal, i.e. in a heavy swell, and would have contributed significantly to the hull failure.

It was further calculated that the dynamic stresses caused by wave bouncing could have resulted in hull failure when the boat dropped by 1 metre.

The report's "Discussion of Results" and "Conclusions" sections are at **Annex I**.

2.5.3 GRP surveyor's report

The report identified the cause and mode of the hull failure. It confirms that the failure was initiated by flexing of the hull above the deck line due to its lack of stiffness.

The failure mode is described at paragraph 2.6 and is fully explained in the GRP surveyor's report "Conclusion and Recommendations" at **Annex J**.

2.6 CAUSE AND MODE OF FAILURE

Poor hull longitudinal and transverse stiffening and a light lay up specification, coupled with inappropriate use of filler in stress areas, all combined to cause the failure.

The hull failed because the buoyancy forces created a bending moment to the hull which, in turn, resulted in compressive forces being set up in the deck GRP covering, causing the deck to buckle and the hull area above the deck to fail. The fracture line then followed the stress raising area of the reverse chine, opening the hull to the sea. The rush of incoming water, and influence of the tubes trying to resist the opening up of the hull, resulted in the wrenching de-lamination of the tube carrier flange.

2.7 COMPLIANCE WITH RECREATIONAL CRAFT DIRECTIVE

2.7.1 Monitoring of RCD compliance

The RCD provides comprehensive guidance and instruction for boat-builders to construct vessels to an agreed standard. The effectiveness of the system is largely dependent on the diligence of the builder to comply with the RCD requirements. This is especially the case where self assessment of quality procedures apply, such as with the FRM 900 class.

The boat builder did not fully understand the requirements of the technical standards related to the RCD, or the requirement to be able to demonstrate conformity by reference to any appropriate technical drawings or design data. Despite advertising the FRM 900 as being RCD compliant, there was no evidence to support this claim.

It was noted that none of the three FRM 900s inspected had been fitted with the mandatory European Community, CE marking plate indicating full RCD conformity.

Big Yellow was etched with a unique HIN (Section 1.9), but this did not conform with the RCD, ISO 10087:1995(E) requirement, in that the country of origin was omitted. In addition, the BMF, as the DTI's recognised organisation, had not allocated a unique manufacturer's identification code (ISO 10087:1995(E) refers) and was therefore unaware of the RIB manufacturer. It was reasonable that the builder should have known this because the RCD directs builders to the relevant ISO.

Monitoring the FRM 900 boat-builder's compliance with the RCD was the responsibility of Derry City Council's Environmental Health Department. The Council, in common with many others, does not have a structured inspection regime to check boat-builders, so Ferryman Boats Ltd had never been subject to compliance checks.

It appears that most district councils adopt a reactive, i.e. responding to accidents and failures, and not a proactive policy in relation to inspections. Had a structured inspection regime been in place, and formal inspections been carried out, it is possible that the RCD shortcomings would have been identified and enforcement measures taken to improve production compliance standards.

2.7.2 Technical construction file

During the investigation, it was found that none of the RCD required documentation produced related to the FRM 900 class. The Technical Construction File shown was in fact produced for the Barracuda 8.6 metre RIB, which was built at South Down Marine.

It could be argued that, as the Barracuda 8.6 metre and the FRM 900 are from same mould, the supporting documentation could reasonably have been transferred to Ferryman Boats Ltd on purchase of the mould from South Down Marine. However, there is nothing in the documentation to establish that the lay up and hull structure configuration of the FRM 900 class were the same as that for the Barracuda 8.6 metre RIB.

The file was originally constructed by the surveyor who conducted the successful and recorded stability and buoyancy tests at South Down Marine. While the surveyor's guidance sheets matched with the RCD's Safety Essential Requirements, many of the related Test/Inspection Records Sheets were incomplete, and none had been signed or dated.

In particular, there were no:

- Hull, laminate strength or stiffening scantling calculations to support the construction.
- General arrangement, system and electrical drawings.
- Lists of recognised RCD standards, or alternatives to which the RIB was constructed.
- Lists of Hull Identification Numbers for RIBs purchased.
- Records of the boat having completed a "Drop Test" at South Down Marine.
- Records held of EC Declaration of Conformity for the boats sold.
- Records of the hull strength Drop Test having been conducted.
- Stability and buoyancy test results for the FRM 900 – although those for the Barracuda 8.6 were held.

It was also noted that the boat "Owner's Manual" was very poorly presented. It lacked system, electrical and general arrangement drawings and a RCD Certificate of Conformity.

2.8 CERTIFYING AUTHORITY - YELLOW CODE COMPLIANCE EXAMINATIONS

As *Big Yellow* was being operated commercially, it was required to comply with the MCA's "Code of Practice for the Safety of Commercial Motor Vessels" – the Yellow Code. The purpose of Code compliance is fully described at Section 1.13.

2.8.1 SCV2 – Compliance Document - RIBs

Review of MECAL Ltd's, Yellow Code Compliance Document SCV2 (copy at **Annex E**) dated 27 May 2004 and 29 June 2005, has identified a number of confusing areas regarding the interpretation of the Yellow Code and examination procedures.

The results of the Yellow Code compliance and change of ownership examinations conducted on 27 May 2004 and 29 June 2005 respectively, are recorded and initialled by the surveyor/examiners on the same SCV2. This is confusing because it is unclear who made the annotations in the various Code section boxes, and makes follow up investigations difficult. This practice is also contrary to MECAL Ltd's instructions. These require the new owner only, to annotate changes and bring these to the attention of the surveyor/examiner conducting the change of ownership examinations. It is also noted that page 9 of the document, containing the owner/skipper's signature stating that he agreed with the document and understood the manning requirements, is missing, suggesting that the compliance documentation was incomplete.

2.8.2 Structural strength - type approval and safe history

Section 4 of the SCV2 covers the construction and structural strength of the boat. It is clear that the surveyor/examiner, on 27 May 2004, interpreted that the boat satisfied the Type Approval standard because it apparently complied with the RCD requirements. In this matter, the Yellow Code can be confusing and open to interpretation. Paragraph 1.12 of the Code (copy at **Annex K**) refers to the general mutual recognition of EU standards, and that these are to be accepted where they ensure equivalent levels of safety, suitability and fitness for purpose. In fact, the RCD does not yet specify structural strength standards as the related ISOs are waiting for EC ratification. Therefore, using the apparent RCD compliance to satisfy the Code construction standard, was inappropriate.

The surveyor/examiner also knew that, AEA Technology, as the Notified Body, conducted tests on similar RIBs built at South Down Marine. He did not appear to be aware that the tests by the Notified Body included only those for stability and buoyancy, and not tests for structural strength. Had the surveyor/examiner been more familiar with the RCD, he might have examined the RIB's Technical Construction File and found it lacked the necessary hull strength calculations to support Yellow Code compliance. An opportunity was therefore missed to adequately assess hull structure strength and construction standards.

Vessels can also be considered to satisfy the structural strength requirement by proving that they have a 5 year safe history. This definition was "ticked" as being compliant by the surveyor/examiner. He believed this was satisfied because the mould was originally in use by South Down Marine in early 2000, although this still provides less than a 5 year history. In fact, changes had been made to the tube diameters by Ferryman Boats Ltd, and the RIB should not have been considered to be the same as that marketed in 2000 by South Down Marine.

2.8.3 Impression of hull condition

Both authorised surveyors/examiners commented that the outward appearance of the hull was particularly good. While this might have been the case, it is not necessarily representative of the inboard condition of the hull. Such an assessment can only be done by examining the areas under the deck. This was not possible because, in common with many other RIBs, no deck accesses were fitted. It therefore follows that it is important to closely examine drawings, construction photographs and calculations when assessing the status of hulls for which there are no under deck access facilities.

2.8.4 Manning

Item 26 of MECAL's Code Compliance Examination Report **(Annex E)** records that the manning requirements had been complied with, when in fact they had not been. The owners understood from this that they had the necessary documentation for operating the vessel. This view was reinforced because the harbourmaster did not raise any objections. However, the owner and skipper of *Big Yellow* stated he was unaware of the manning and qualifications requirements as laid out in the Yellow Code. It is reasonable to expect that owners undertaking commercial ventures would be aware of these fundamental requirements for safe operation. It would nevertheless be helpful if, during Code examinations, the surveyor/examiner emphasised the qualification requirement by providing the owner with either the appropriate reference or an extract of the instruction.

2.9 OPERATING COMPANY PROCEDURES

2.9.1 Operating authority

Notwithstanding that the St Ives harbourmaster had approved *Big Yellow'*s application to operate its RIB, MECAL Ltd's transfer of ownership examination and certification had not been completed. SI 1998 No 2771, The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998, paragraph 5(4),(a) states that:

> *"a vessel shall not proceed, or attempt to proceed, to sea unless the certificate is currently in force".*

The operating company was not aware of the requirement for a valid operating certificate. It made an assumption that, because an examination had been undertaken, the necessary approval was automatically given, when clearly this is not the case. It would be helpful if Certifying Authority surveyors/examiners could emphasise this point on completion of their examinations.

2.9.2 Crew's qualifications

The crew's qualifications requirement is set out in the appropriate Code and is consolidated in the Harmonised Code under MGN 280 (M). By attending the required courses, crews are best placed to cope with an emergency situation and improve the chances of survival both for themselves and their passengers. It is the professional responsibility of every skipper to ensure that he/she and his crew are properly qualified for their roles. In undertaking this venture, it is perfectly reasonable to have expected the skipper to be aware of the requirement. While the page cannot be located, the skipper indicated that he signed the MECAL Ltd Code Compliance Document stating he understood the manning requirements.

The skipper had the appropriate first-aid qualification, but he had not attended a Basic Sea Survival Course, and he was not in possession of a valid Radio Qualification or Medical Fitness certificate.

His lack of qualifications did not seriously jeopardise safety in this case, but he was unfamiliar with the method of liferaft launching. It was also noted that he did not use his VHF radio to raise the alarm. This might have been due his lack of training, but was more likely due to the rapid response of other vessels in the area. Had he been operating in more remote areas, the outcome could have been different. It is essential to alert the emergency services in the event of an accident of this severity, in order to improve the chances of survival, and the skipper should have made an automatic decision to do so.

2.9.3 Safety briefing

The importance of the safety briefing cannot be over emphasised. A comprehensive briefing gives passengers some degree of understanding and confidence when faced with an emergency situation. This was especially so in this case, as many passengers would not have been onboard a boat before, or at best, would have had very limited marine experience.

The safety briefing given by the skipper's fiancée was inappropriate. She had received only superficial instruction herself from the skipper, and had no marine experience. The instruction not to pull the inflation toggle of the lifejacket caused confusion, because passengers were not informed when it should be operated.

No advice was given on the actions to be taken in the event of an emergency, except that passengers were to raise a hand if they were concerned. The company should review the content of their safety briefings. Guidance in this area is given at the Yellow Code in Annex 9, and in the Harmonised Code in Annex 7.

2.9.4 Status of second crew

There was confusion over the status of the skipper's fiancée. The passengers' impression was that she was a member of the crew, because she had given the safety briefing. On the other hand, both the skipper and his fiancée considered she was onboard for pleasure, and was not a crew member. It therefore follows that the passenger numbers had been exceeded, although the total number onboard remained within the permissible limit of 14 people.

MSN –M.1194 – The Status of Persons Carried on United Kingdom Ships, sets out the definitions of crew and passengers; this should have been known by the operating company.

2.9.5 Risk assessments

During discussions with the owners, it was clear that they were unfamiliar with risk assessment procedures or of their H&S responsibilities. No risk assessments had been conducted to identify hazards to passengers/workers, so there were no control measures in place to minimise hazards.

The lack of a risk assessment did not impact on this accident. However, in a different situation, it might well have done. It appears that no advice had been given to the owners, either by Penwith District Council, St Ives harbourmaster or the Code compliance surveyor/examiner on their responsibilities as laid out in MGM 20 (M+F) – Implementation of EC Directive 89/391 Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997.

The Yellow Code does not cover H&S issues. However, Annex 3, paragraph 2.10 of the Harmonised Code (MGN 280 (M)) – covers the subject in detail. It would have been helpful to the owners if the Code compliance surveyor/examiner had highlighted the requirement.

2.10 ST IVES HARBOURMASTER'S APPROVAL TO OPERATE

The skipper approached the St Ives harbourmaster for approval to operate the *Big Yellow* pleasure trips. The harbourmaster was aware that the RIB had been examined for Yellow Code compliance by MECAL Ltd, and he felt satisfied that the RIB was safe for its intended operation. However, he was not aware that the certification process was incomplete and that the boat was therefore not fit to conduct commercial operations.

The harbourmaster also sighted the skipper's Powerboat Level 2 qualification certificate, but was unaware of the need for it to be "commercially endorsed". While content that he held the appropriate operating qualification, as an ex-fishing vessel skipper, the harbourmaster was surprised that the skipper did not have any other qualifications other than his first-aid qualification. Although unsure of the specific requirement, he did not pursue the matter further. Had he done so, it is likely that the harbourmaster would not have given his approval to operate.

The UK Harbour Masters' Association (UKHMA) and the MCA are sources of expert advice in this respect. In the short term it would be very helpful if the UKHMA were to advise its membership of the broad content of the MCA's Codes of Practice and of MGN 280(M) – Harmonised Code when considering approval to operate.

In the longer term, 'approvals to operate' guidelines, including possible checklist, would more appropriately be held in the MCA's publication 'Guide to Good Practice on Port Marine Operations'. The Port Marine Safety Code Steering Group, facilitated by the MCA, is best placed to take this forward.

Clearly, when harbourmasters consider applying any guidelines, these should not conflict with local licensing requirements or bye-laws.

2.11 OTHER IN SERVICE FRM 900 RIBS

The MAIB has no record of any other recorded FRM 900 RIB hull failures. While two other FRM 900s have been visually examined, and found free of external defects, they could still have suffered some degree of unseen hull failure to the inaccessible areas under the deck.

Without a full and thorough examination and strength calculations, the integrity of the boats, their fitness for purpose, and the safety of those onboard, must remain in doubt. Once the hull strength has been determined, there may be a need for the manufacturer to recall the RIBs for modifications, or alternatively revise the Design Category to one which is less demanding.

2.12 FATIGUE

The skipper had been well rested during the evening before the accident. He had only completed one uneventful trip prior to the RIB failure, and the weather conditions were good. Fatigue is not considered a causal factor in this accident.

2.13 EMERGENCY RESPONSE

The co-ordination and rapid response of the emergency services, and the support provided by the nearby fishing vessels and Porthmeor lifeguards, did much to calm the situation. Passengers were quickly and efficiently removed from the scene in a thoroughly professional and safe manner.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES

The following safety issues have been identified by the investigation. They are not listed in any order of priority:

1. *Big Yellow*'s hull structure failed in sea conditions which were within her declared operational limits and was therefore unsuitable for its intended role. [2.2]

2. The skipper did not use his VHF radio to alert the emergency services. [2.2]

3. The thickness of the hull lay up specification was much thinner than that of other RIB manufacturers using an identical mould. In particular, there were notably less layers of woving roving required to improve strength essential in strength critical constructions. [2.3.1]

4. There were no hull structure stiffening calculations or longitudinal hull stiffening to cope with the normal in service forces. [2.3.1, 2.3.3, 2.6]

5. Transverse stiffening encapsulation was not completely bonded to the hull, and the 300mm distance from the deck to the tube flange increased the risk of hull twisting in normal service conditions. [2.3.3]

6. A "Drop Test" to prove hull strength had not been carried out for Yellow Code compliance examination purposes. [2.3.4]

7. Ferryman Boats Ltd has never been subject to any RCD compliance checks by Derry City Council's Environmental Health Department. [2.7.1]

8. No CE marking plates, indicating RCD compliance, were fitted to any of the FRM 900s inspected. [2.7.1]

9. None of the RCD documentation related to the FRM 900 class of RIBs, and that which was held was incomplete. [2.7.2]

10 MECAL Ltd's Yellow Code compliance authorised surveyor/examiner used apparent RCD compliance as proof of structural strength. [2.8.2]

11. The Yellow Code and Harmonised Code is confusing over the applicability of RCD in relation to compliance examinations. [2.8.2]

12. In this case, and in many other RIBs, there is no method of accessing the area below the deck to assess the condition of the inboard hull structure. [2.8.3]

13. The owners of *Big Yellow* were not in receipt of a current MECAL Ltd compliance certificate at the time of the accident, and were therefore ineligible to operate the boat for commercial purposes. [2.9.1]

14. *Big Yellow*'s skipper did not have all the necessary qualifications or "commercial endorsement" to operate the boat commercially. [2.9.2]

15. Passenger safety briefings were superficial, and did not cover actions to be taken in an emergency. [2.9.3]

16. The owners of *Big Yellow* were not aware of their H&S responsibilities and need to conduct risk assessments. [2.9.5]

17. St Ives harbourmaster was unaware of the qualifications and endorsements required for *Big Yellow*'s operation. [2.10]

18. The structural condition and fitness for purpose of the other in service FRM 900 RIBS is not known. [2.11]

SECTION 4 - ACTION TAKEN

4.1 THE MARINE ACCIDENT INVESTIGATION BRANCH

In view of the risk to public safety, the Chief Inspector of the Marine Accident Investigation Branch has written to Ferryman Boats Ltd making the following recommendations:

226/2005 Confirm, through professional advice and calculation, that the structural strength and design of the FRM 900 class of RIBs fully meet the RCD Design Category B requirements or a lesser category as appropriate.

227/2005 Advise existing owners of FRM 900 RIBs of any modifications required to their boats, or restrictions in use, to ensure that they are operated safely within their defined structural strength operating limits.

Derry City Council's Environmental Health Department was also advised of the recommendations.

4.2 MECAL LTD

MECAL Ltd has completed an internal investigation involving a review of its authorised surveyor/examiners, and internal quality processes. A number of changes have also been proposed to improve MECAL Ltd's Code and change of ownership examination and certification procedures. Recommendations have also been made to the MCA of the need to take into account a vessel's intended operation when considering its construction and structural strength.

4.3 FERRYMAN BOATS LTD

Ferryman Boats Ltd has:

- Carried out a limited external hull survey of 8 FRM 900 RIBs which have been reported as defect free. The builder has also advised all FRM 900 owners to examine their RIBs for hull or deck defects.
- Employed the services of a professional naval architect who has developed a new internal stiffening arrangement supported by calculations.

SECTION 5 - RECOMMENDATIONS

Ferryman Boats Ltd is recommended to:

2006/149 Completely review its manufacturing procedures, testing and recording methods to ensure complete RCD compliance.

The Maritime and Coastguard Agency is recommended to:

2006/150 Provide instructions to Certifying Authorities on:

- The applicability of the RCD when conducting Code compliance and transfer of ownership examinations.
- The need to closely examine structural drawings and calculations when examining RIBs that do not have access to under deck areas.

The Department of Trade and Industry and the Local Authorities Coordinators of Regulatory Services are recommended to:

2006/M151 Advise officers of local authorities, in the interest of public safety, of the importance of conducting boat-builders' RCD compliance checks, especially for those building under self assessment rules.

The Port Marine Safety Code Steering Group is recommended to:

2006/152 Review the 'Guide to Good Practice on Port Marine Operations' to include the following advice to harbourmasters when considering approval to operate within their harbour limits.

The following should be considered:

- The professional qualifications and endorsements required for skippers and crews of vessels operating under the Red, Brown, Blue and Yellow Codes and Harmonised Code under MGN280 - Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats – Alternative Construction Standards.
- The need for Coded vessels to be in possession of a valid "Small Commercial Vessel Certificate".
- The need for owners of Small Commercial Vessels to have conducted a risk assessment of their procedures in accordance with MGN 20 (M+F).

The United Kingdom Harbour Masters' Association is recommended to:

2006/153 Advise its membership of the applicability of the MCA's Code of Practice and of MGN 280(M) – Harmonised Code when considering 'approval to operate' craft within their harbour limits.

The Owners of *Big Yellow* are recommended to:

2006/154 Ensure that crew qualifications and manning for company vessels are in accordance with MGN 280 (M) – Small Vessels in Commercial Use for Sport or Pleasure, Workboats and Pilot Boats – Alternative Construction Standards.

2006/155 Develop company risk assessment procedures in accordance with MGN 20 (M+F) - Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997.

Marine Accident Investigation Branch
March 2006

Safety recommendations shall in no case create a presumption of blame or liability