Danish Maritime Accident Investigation Board

# MARINE ACCIDENT REPORT
## December 2016


# INUK II
## Foundering on 14 August 2016

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**This marine accident report is issued on 30 December 2016.**

**Front page:** INUK II**. Source:** IceCap Tours.

The marine accident report is available from the website of the Danish Maritime Accident Investigation Board (www.dmaib.com).

## The Danish Maritime Accident Investigation Board

The Danish Maritime Accident Investigation Board is an independent unit under the Ministry of Business and Growth. It carries out investigations as an impartial unit that is, organizationally and legally, independent of other parties. The board investigates maritime accidents and occupational accidents on Danish and Greenland merchant and fishing ships, as well as accidents on foreign merchant ships in Danish and Greenland waters.

The Danish Maritime Accident Investigation Board investigates about 140 accidents annually. In case of very serious accidents, such as deaths and losses, or in case of other special circumstances, either a marine accident report or a summary report is published, depending on the extent and complexity of the events.

## The investigations

The investigations are carried out separately from the criminal investigation, without having used legal evidence procedures and with no other basic aim than learning about accidents with the purpose of gaining and promoting an understanding of safety. Consequently, any use of this report for other purposes may lead to erroneous or misleading interpretations.

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# 1. ABSTRACT

On 14 August 2016, a tour boat, INUK II, sank in the bay of Ilulissat, Greenland. The 23 passengers and three crew members were evacuated onto another tour boat before INUK II foundered. The accident did not result in loss of life or serious injury. However, the accident provided an opportunity to gain a general understanding of the effectiveness of the tour boats' design and equipment to handle an emergency. Therefore, the accident investigation had two purposes: Firstly, the purpose of the investigation was to establish the technical circumstances that led to the tour boat losing buoyancy, including the circumstances under which the passengers were evacuated. Secondly, to gain an understanding of the problems associated with implementing the strategies for handling evacuation.

The investigation has established that, during the repairs of INUK II, a hose connecting the aft deck drain to the discharge pipe was removed. After the repairs were completed, the drain hose was not mounted again. Once INUK II was put into operation, it was only a matter of embarking enough passengers before the discharge pipe would be submerged below the waterline resulting in flooding of the boat. On the day of the accident, INUK II was transporting the maximum number of passengers which increased the draught to such an extent that the hull discharge pipe was submerged. INUK II gradually lost all buoyancy as water flowed into the steering gear/storage compartment and subsequently into the engine room.

INUK II was equipped with the mandatory lifesaving equipment and procedures, and was manned with a crew who held valid certificates. However, the investigation into the accident on 13-14 August showed that INUK II's designed ability to be successfully evacuated could be questioned because of the uncertainty caused by generic procedures and the sparse time available to evacuate the boat. The first problem of uncertainty is relatable to various categories of ships, but the latter problem was closely connected to the size of INUK II and the number of passengers that the boat was certified to carry on board.

The maximum capacity of passengers was determined by the maritime authority on the basis of prescriptive legal requirements about the capacity in terms of space, seats and the available lifesaving equipment. However, the regulation was abstract in relation to how the equipment was to be utilized because there were no requirements for the content in the safety management manual or a requirement for any actual testing of the lifesaving equipment. In order to bridge the gap between the prescriptive and the abstract requirements, the owner hired a consultant who had the necessary knowledge about how to make a safety management manual which could be approved by the maritime authority. However, the consultant had no knowledge about the operational realities of evacuating INUK II and an actual test of the lifesaving equipment was not made. The result was a procedure for evacuation which was unusable for the crew members on INUK II.

The lack of integration and feedback between the maritime authority, the owner, the consultant and the crew members kept the problems associated with an evacuation hidden. It is there-

fore doubtful how effective the lifesaving equipment and procedures would be in an emergency. Not only on INUK II, but also on other tour boats of similar size, passenger capacity and trading area.

The Danish Maritime Authority has informed DMAIB about preventive measures to be taken in 2017.

# 2. FACTUAL INFORMATION

## 2.1 Photo of the ship


*Figure 1: INUK II with passengers on board*
*Source: www.icecaptours.com*

## 2.2 Ship particulars

| | |
|---|---|
| Name of vessel: | INUK II |
| Type of vessel: | Passenger ship |
| Nationality/flag: | Denmark |
| Port of registry: | Ummannaq, Greenland |
| IMO number: | None |
| Call sign: | OU 7745 |
| Year built: | 1999 |
| Shipyard/yard number: | Faaborg Shipyard A/S/1064-1999 |
| Classification society: | None |
| Length overall: | 12.85 m |
| Breadth overall: | 3.70 m |
| Gross tonnage: | 12.1 |
| Draught max.: | 2.23 |
| Engine rating: | 421 kW |
| Service speed: | 15 knots |
| Hull material: | Glass reinforced plastic (GRP) |

## 2.3 Voyage particulars

| | |
|---|---|
| Port of departure: | Ilulissat, Greenland |
| Port of call: | Ilulissat, Greenland |
| Type of voyage: | Coastal |
| Cargo information: | None |
| Manning: | 3 |
| Pilot on board: | No |
| Number of passengers: | 23 |

## 2.4 Weather data

| | |
|---|---|
| Wind: | North-west – 6 m/s |
| Wave height: | 0.5-1.0 m |
| Visibility: | Good |
| Light/dark: | Night |
| Current: | Unknown |

## 2.5 Marine casualty or incident information

| | |
|---|---|
| Marine casualty/incident: | Foundering |
| IMO classification: | Very serious |
| Date, time: | 13 August 2016, approximately 2330 (UTC+4) |
| Location: | Off Ilulissat, Greenland |
| Position: | Approximately 69°13,40' N – 051°06,50' W |
| Place on board: | Steering gear/storage room |
| Human factor data: | Yes |
| Consequences: | The ship was lost and later salvaged. Passengers and crew were evacuated to other ships. |

## 2.6 Shore authority involvement and emergency response

| | |
|---|---|
| Involved parties: | The tour boat CLANE and four zodiacs from the cruise ship L'AUSTRAL. |
| Speed of response: | 5 minutes |
| Actions taken: | All passengers and crew members evacuated from INUK II |

## 2.7 The ship's crew

| | |
|---|---|
| Master: | 29 years old. Held a certificate as mate (STCW II/3). Had worked for the company for one season. |
| Deckhand: | 25 years old. Held a national certificate of competency valid for service as master on ships less than 15 metres and up to 12 passengers. He had worked for the company for three years. |
| Guide: | 24 years old. Acted as guide. He had no professional maritime experience, but was familiarized with the daily operations on INUK II. |

## 2.8 Location of the accident

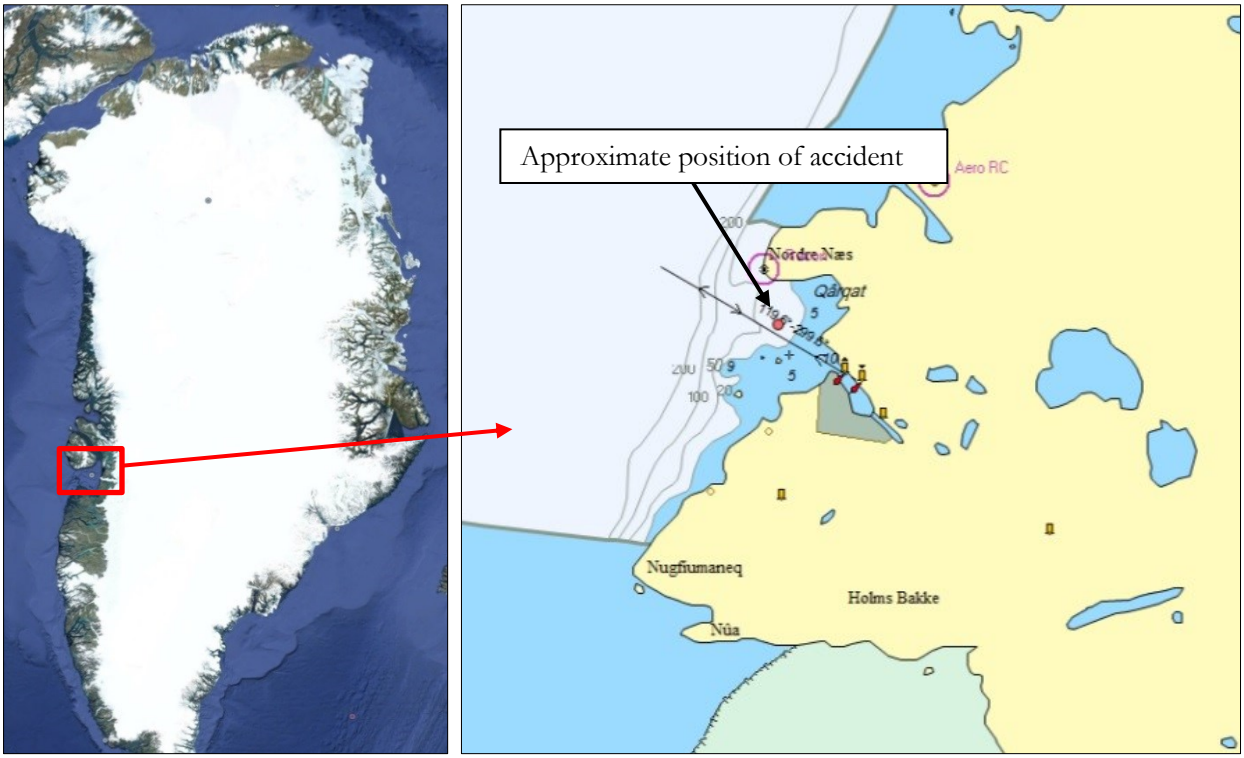


*Figure 2: Approximate position of the accident, port of Ilulissat, Greenland*
*Source: Google Maps/ © Made Smart Group BV 2016, C-Map data © Jeppessen AS 2016*

# 3. NARRATIVE ABOUT THE ACCIDENT

The narrative is presented from various perspectives, i.e. the crew on INUK II and some of the passengers. Statements of time are given in local time in Ilulissat, Greenland (UTC+4), unless otherwise specified.

On 13 August 2016 at 1900, the cruise ship L'AUSTRAL dropped anchor at the entrance of the Port of Ilulissat. Several local tour boats had been hired via an agent in Nuuk, Greenland, to bring the guests on a guided tour to see the icebergs and sunset at the nearby fjord (Icefjord). One of these tour boats was INUK II.

INUK II was a tour boat had a capacity[1] of 24 persons: 22 passengers and two crew members. On the day of the accident, INUK II was scheduled for two tours: One tour with 17 passengers arranged by the boat owners and afterwards a tour arranged by an agent who acted on behalf of the cruise ship L'AUSTRAL.

On the first tour there were two crew members on board (master and deckhand). INUK II followed a regular route with duration of two hours. The passengers were mostly indoors and a few were on the aft deck. INUK II returned to port and stayed for 1-2 hours. During the port stay the master checked the entire boat because it had recently been ashore for repairs and had recently had a leak aft on the diesel oil system. Afterwards the crew held a tabletop exercise[2]. The master coordinated the tabletop exercise, where the crew members were asked different questions related to e.g. possible evacuation scenarios, and the crew discussed how an evacuation could be carried out under different circumstances.

INUK II departed from port and proceeded to L'AUSTRAL. Several tour boats were to embark passengers from the cruise ship, and therefore INUK II was waiting for approximately half an hour before getting alongside the ship.

At 2140, INUK II came alongside L'AUSTRAL. During the process of getting alongside, there was a misunderstanding between the guide standing on INUK II's foredeck and the deckhand on the cruise ship causing the forepart of the tour boat to slam into L'AUSTRAL. After an inspection of the hull, the master deemed that the damage would not affect the seaworthiness of the boat because it was above the water line and the hull was not penetrated.

Once the boat was secured alongside the cruise ship, 23 passengers boarded the tour boat. The passengers were of French and Italian nationality in the age between 18 and 82. When all the passengers had boarded the boat, the master manoeuvred the boat away from the cruise ship.

[1] Based on the capacity of the liferafts.

[2] A tabletop exercise involves key personnel discussing simulated scenarios in an informal setting.

Meanwhile, the deckhand instructed the passengers about the location of the liferaft, lifejackets and immersion suits.

INUK II proceeded to the Icefjord for the sightseeing tour approximately 5 nautical miles away. During the tour, the boat stopped by an iceberg so the passengers could enjoy the scenary and the sunset. The tour was scheduled to last 2.5 hours and proceeded normally until the boat was heading back to the cruise ship.

An alarm by the conning station suddenly sounded. It was the bilge alarm indicating that there was liquid in one of the compartments below deck, and it was common that it was activated by minor water leakages, e.g. from the engine. Therefore, the alarm was in general not considered to be an indication of an emergency. As a precaution, the master started the bilge water pump, and the deckhand inspected the compartments forward below deck. He saw nothing out of the ordinary. The rest of the ship's compartments were not inspected because the master did not want to make the passengers anxious. Furthermore, INUK II was close to the cruise ship, and the passengers were to be disembarked within a short while. As the voyage proceeded, the deckhand noticed water on the aft deck, but it did not concern him because it was not uncommon to have the stern wave wash onto the deck. Simultaneously, the guide noticed that INUK II was becoming increasingly unstable and had started to roll excessively. At this point, it was around midnight and dark.

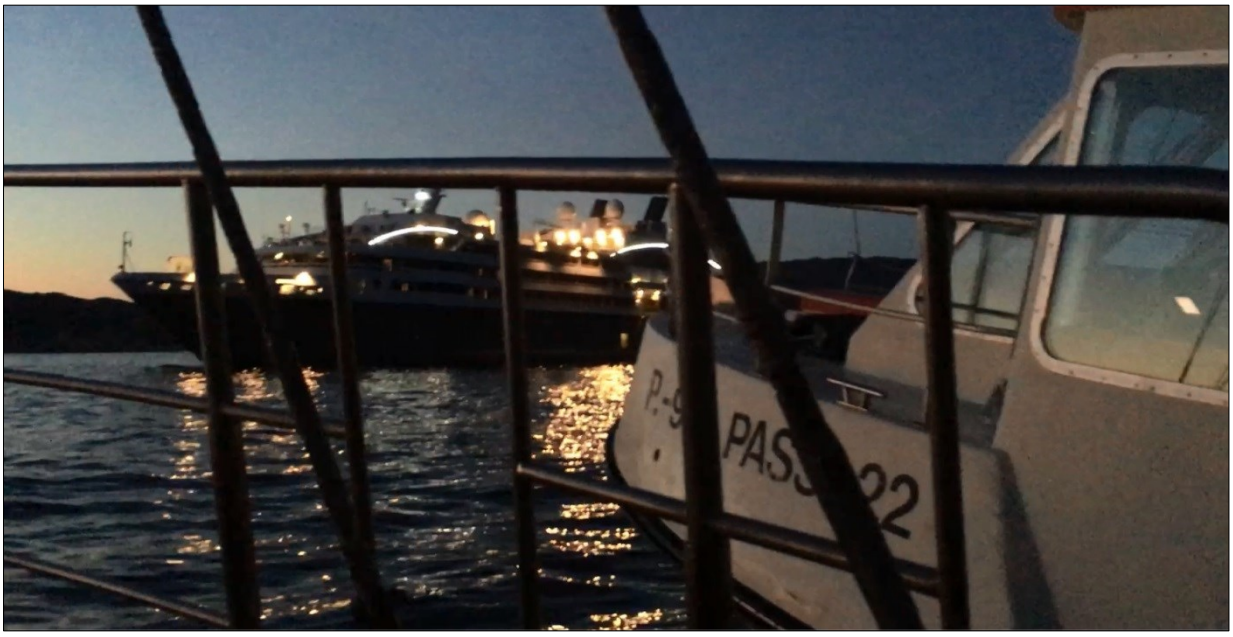

*Figure 3: INUK II and the cruise ship L'AUSTRAL at the time of the accident*
*Source: Private photo*

Suddenly, all steering was lost and the boat became unstable, and the aft deck was about to be submerged. The master, using the VHF, called for assistance from a nearby tour boat CLANE. The master's intention was to ask CLANE to tow INUK II to the cruise ship so that they

could disembark the passengers and then be towed to the port for repairs of the steering gear and investigate the stability of the boat. The passengers were assembled in the passenger lounge, and the master informed them about the loss of steering and that they were to be disembarked soon. The passengers were not visibly anxious or in a state of panic.

The tour boat CLANE had been part of the same excursion tour for the cruise ship. CLANE was about to return to port after having disembarked passengers to the cruise ship when the master heard a call on the VHF for immediate assistance from INUK II due to loss of steering. He immediately turned the boat around and set course towards INUK II which was about 250 metres away. As CLANE was approaching INUK II, the master on CLANE saw that the stern was low in the water. The master shouted to the crew on INUK II that they were sinking. He then notified the two deckhands on CLANE to be standby for embarking the passengers from INUK II.

On INUK II, one of the passengers told the master to call the cruise ship. The master then immediately called the cruise ship on VHF channel 10. By now the crew on INUK II realized that the deck would be fully submerged within a very short time and that there was no time left for donning the lifejackets and/or immersion suits.

On L'AUSTRAL the zodiac crew members were alerted and set course towards INUK II.

When CLANE came alongside INUK II's port side, the aft deck of INUK II was partly submerged and the liferafts mounted on the aft were under water. The master on INUK II was standing at the deck in water up to the waist and was in the process of releasing the liferafts. The attempt was abandoned as CLANE arrived.

The master on CLANE told the master on INUK II to tie the boats together. The master on INUK II realized that the passengers had to be evacuated immediately. The passengers were asked to leave the passenger lounge. In order to do so, the passengers had step into the freezing cold water on the partly submerged aft deck and step on a bench on the deck. From there they could climb onto CLANE. One of the passengers panicked and blocked the doorway and had to be forcefully assisted onto CLANE.

INUK II was increasingly unstable and listed excessively side to side. In order to compensate for the rolling motion, the guide on INUK II stood on top of the wheelhouse trying to use his body weight to keep the boat upright.

The master on INUK II instructed the deckhand to make a distress call on the VHF, but the deckhand overheard it. However, the master of CLANE sent a VHF mayday relay to Aasiaat Radio at 0017 and called the cruise ship on the VHF. The master of INUK II overheard the distress call and was thereby reassured that the distress message had been sent. Moments later, four zodiacs from the cruise ship arrived (figure 4).

*Figure 4: Evacuation from INUK II at approximately 0036 on 14 August 2016*
*Source: Private photo*

The passengers became wet and cold from standing in the water that flooded the aft deck, and some of the elderly passengers found it difficult to climb onto CLANE as INUK II became increasingly submerged. Therefore, a crew member from one of the zodiacs went on board INUK II to evacuate some of the passengers to the zodiacs. When the last passenger had been transferred from INUK II, the master of CLANE asked one of the crew members on INUK II to search the cabin for passengers, but he was nervous about going in the cabin while the boat was sinking. Finally, a seaman from one of the cruise ship's zodiacs went on board and checked the all the compartments above deck to verify that all the passengers had been evacuated.

As soon as the passengers and crew had been transferred to the zodiacs and CLANE, the ropes connecting CLANE to INUK II were removed so INUK II would not pull CLANE down as it was sinking. Meanwhile all the passengers were transferred from CLANE to the zodiacs and brought back to the cruise ship. The crew discussed the possibilities of mitigating the situation to prevent INUK II from sinking by towing it aground. However, the boat was sinking so rapidly that it was not deemed possible without endangering the crew on CLANE. Therefore, INUK II was abandoned and left to founder. The engine on INUK II was in continuous operation until the wheelhouse was partly submerged.

The passengers on CLANE were transferred to the zodiacs and brought to L'AUSTRAL where they arrived at approximately 0020. No passengers or crew members were physically injured during the evacuation.

# 4. INVESTIGATION DATA

The investigation had two goals: Firstly, to establish the technical circumstances of how INUK II lost buoyancy and sank. Secondly, the accident provided an opportunity to gain knowledge about the effectiveness of the evacuation strategy of a tour boat in arctic areas.

Therefore, this section contains different subject areas: A description of INUK II and how the boat was operated at the time of the accident, the lifesaving equipment and its intended use, INUK II's regulatory framework and, finally, a description of the technical circumstances which led to the sinking of INUK II.

## 4.1 The operation of INUK II

In 1999, INUK II was purpose built as a passenger tour boat for use in the coastal waters of Greenland with a certified capacity of 22 passengers. The owner was a company which operated 3-4 tour boats and was specialized in excursion tours in Greenland and occasional transportation of passengers between settlements. Some of the tour guests were from cruise ships that arrived in Ilulissat. Usually the local tour boats were hired by an agent located in Nuuk and assigned to do specific tour routes, e.g. excursions to the Icefjord. It was not uncommon for the crew ships to assign an escort to be part of the excursion group to bridge any language barrier between the crew and the passengers. The escort was not considered to be a passenger, but part of the crew. Therefore, 23 persons were usually embarked from the cruise ship. However, on the day of the accident no escort was assigned to INUK II, but the crew on INUK II were unaware of that because they were led to believe that one of the passengers was an escort.

The owner and operator of the tour boats were normally manned with two crew members and occasionally one guide. The crew were mostly local residents, but crew members were also hired from Denmark because it was difficult to find available seafarers with the mandatory certification for operating the boats in the local area during the peak. Familiarization and training was achieved by crew members being supernumerary on one of the boats and by oral handovers. On 13 August 2016, INUK II had three crew members: The master, a deckhand/mate and a guide. The master on INUK II had been hired from Denmark and had the year before operated the boat for a summer season.

The navigation of INUK II was primarily based on the crew's shared knowledge about the local area, which had been passed on from other crew members, who had more experienced navigating the area. This knowledge consisted, inter alia, in what type of ice it was safe to manoeuvre in and which icebergs could be approached safely. When navigating in the local area, the voyage was not planned in detail because the presence of ice made improvisations necessary. Navigation was primarily done by knowledge about the local area, echo sounder and, in restricted visibility, by radar. The chart plotter was mainly used for showing the tourists the progress of the tour and pointing out specific locations. It was not used for navigation because

no reliable charts were available for the area. When the tour boat was on whale watching tours, the echo sounder was turned off because it could disturb the whales and drive them away.

During the peak season, several tour boats operated in the same area to meet the demand from the growing number of tourists. Usually, the individual tour boat aimed at keeping a large distance to the other boats in order to give the passengers a sense of seclusion and an optimal experience of the scenario in the Icefjord.

After the 2015 season, INUK II was brought ashore to be cleaned and inspected by the Danish Maritime Authority. Before putting INUK II into operation for the season 2016, the owner sent the boat to the local workshop for inspection of the propulsion shaft bearings and minor repairs. The owner of INUK II used this workshop, which was mainly working with cars and minor repairs of leisure boats, on a regular basis. At the workshop, both propulsion propeller shafts were removed, and the bearings and stern tube sealings were inspected and replaced. On the rudder stock, seals and sleeves were replaced. Prior to setting the boat afloat, one of its regular crew members inspected the boat. The area of interest was primarily the sea filters and over board valves. INUK II was set afloat in late July and tested prior to the first tour of the season. Everything was found to be in good working order. Other smaller repairs and cleaning jobs were also made while the boat was waterborne, e.g. another workshop made repairs on the boats propulsion engine fuel system located in the steering gear compartment, and the crew cleaned and tidied up the boats different compartments.

## 4.2 INUK II's safety equipment and emergency procedure for evacuation

INUK II did not have a safety plan. To illustrate the location of the on-board safety equipment, the DMAIB has made an illustration showing the equipment on an extract from the general arrangement plan (figure 5).

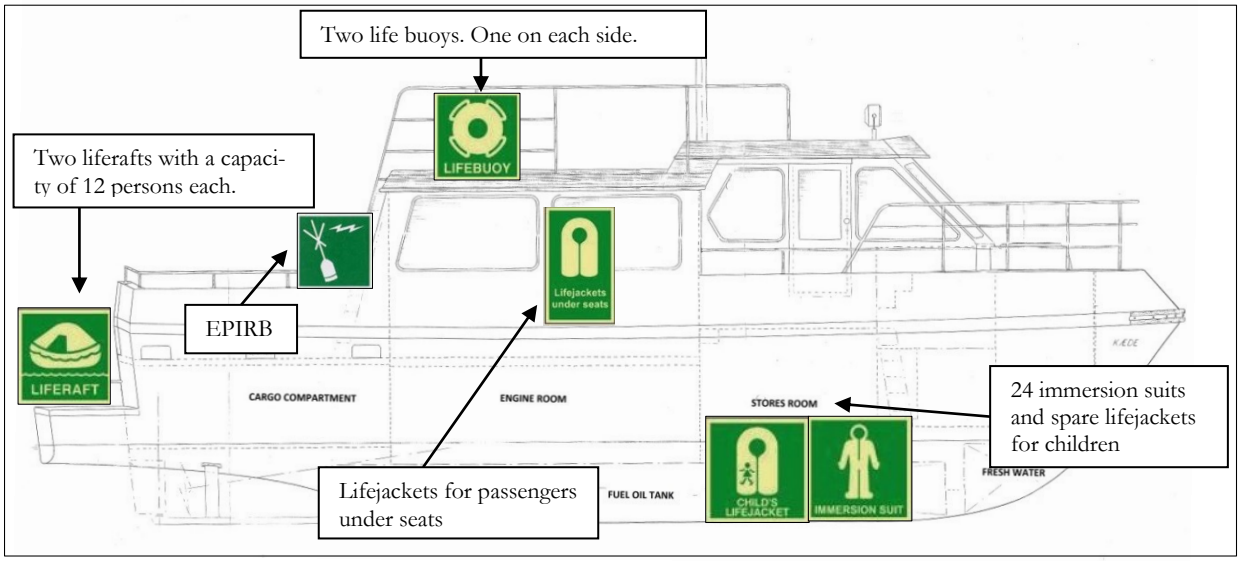


*Figure 5: Extract from general arrangement drawing*
*Source: Faaborg Shipyard/DMAIB*

The boat was equipped per the regulatory requirements (see section 4.4) with two certified liferafts with a capacity of 12 persons each. They were located on the aft ramp of the boat and mounted with hydrostatic release mechanisms ensuring that the liferaft would be automatically released when submerged below a given water depth. Originally the liferafts had been mounted above the passenger lounge, but it was decided to replace them with a different type and move them to the aft of the boat, because it provided more stability when the passengers stood on the roof of the passenger lounge (see figure 5). The crew had never seen either type of liferaft inflated and were therefore not familiar with their design.

Lifejackets for the passengers were located under the seats in the passenger lounge and supplementary lifejackets for children were located in a compartment under the conning station together with the approved immersion suits of varying sizes. The immersions suits were of two different approved types: One type was a neoprene suit to be worn with a special type of underwear and not regular clothing. The other type could be donned with regular clothing. Both types were to be worn with a lifejacket. There was no procedural or regulatory requirement for the boat to carry immersion suits for children. The regulation did not elaborate on the use of the immersion suits, i.e. were the passengers meant to jump into the sea wearing them, or were they to be used as warm clothes in the liferafts?

On the wheelhouse were two life buoys (with lines and light). An EPIRB[3] was mounted aft of the accommodation next to the entrance door.

The utilization of the lifesaving equipment was part of the boat's safety management manual which, as stated in the manual, was meant to ensure that the boat was operated in a safe manner.

*4.2.1 INUK II's safety management manual*

INUK II's safety management manual was based on the framework of the International Safety Management Code (ISM). The manual was in Danish and contained information and procedures/checklists about the operation of the boat, including how to respond to various emergency situations. The procedural framework was made by a marine consultant specialized in ship survey and consultancy. An evacuation exercise, including operationalization of the lifesaving equipment, had never been carried out, which meant that the procedural text was based on the consultant's conception of evacuation rather than on actual operational experience from INUK II.

The safety management manual's procedure for evacuation contained six stages:

> "1. The master of the ship reports to the coast radio station by VHF (mayday message). The GMDSS alarm button is to be activated.
> 2. All on board are brought on deck donned life jackets and are distributed between the ship's life rafts.
> 3. The master of the ship takes command of a life raft.
> 4. The deck hand takes command of a life raft.
> 5. On the master's command the life rafts are launched and inflated.
> 6. On the master's command all on board are evacuated to the life rafts."

The prescriptive language used in the procedure indicated that the procedure was an *instruction* about how the evacuation was to be carried out, including a reference to when the lifejackets and the liferafts were to be used. There was no reference to the immersion suits in the safety management manual. The procedure was seemingly specific about what the crew was supposed to do to achieve an effective evacuation, but the text did not include any reference to the circumstances that would cause the need for an evacuation, e.g. the boat being partly submerged, loss of stability, fire, etc. Thereby, the manual was designed with the underlying assumption that the boat was in a stable condition and that the evacuation could be carried out independently from other events. This assumption represents a discrepancy between how the procedures imagined an emergency and the actual practical problems which crewmembers can meet in an actual emergency.

[3] Emergency Position Indicating Radio Beacon.

This discrepancy became visible during the events on 14 August 2016. During the sinking of INUK II, the procedure did not address inter alia the boat's worsening stability and the facts that the water on the aft deck hindered the passengers from mustering on the deck, the elderly passengers had problems climbing the bulwark, there was not sufficient time to don the lifejackets, etc. The discrepancy between the procedure and the actual emergency made the procedure irrelevant in an emergency and was therefore unusable for the crew members. This discrepancy motivated the DMAIB to investigate the effectiveness of the evacuation strategies on INUK II.

### 4.3 Investigation of the evacuation system on INUK II

That procedures tend to be under-specified has previously been investigated by the DMAIB[4] where it was found to be a general problem in some shipboard operations. In relation to INUK II, the lack of specification concealed several problem areas related to the effectiveness of the evacuation system. In this context two overall problems, which are highly interdependent, will be described:

- The uncertain environment in which the evacuation is to be carried out.
- The time available for evacuating the passengers.

An evacuation is only brought about if it is concluded that it is unsafe to stay on board the boat. The circumstances under which that conclusion is reached can vary depending on the accident event, e.g. collision, flooding, fire, grounding or any combination of those events. Immediately after, or during, the accidental events the master needs to weigh the pros and cons of different options, e.g. to ground the boat, transfer the passengers to another vessel, return to port or evacuate the passengers via the liferafts. Any of the mentioned strategies involves a high degree of uncertainty about the effectiveness which can only be judged in hindsight. Especially evacuation via the liferafts is a solution which is inherently uncertain inter alia because the master typically does not have any prior experience with such an evacuation. Furthermore, it is not common for tour boats in Greenland to have full-scale drills involving liferafts, including having all the passengers don lifejackets and immersion suits.

In the absence of an actual evacuation drill, it is difficult to estimate how much time it would take to evacuate the passengers and crew from INUK II into the liferafts because it depends on several interconnected factors, e.g.:

- How does the boat's design support the strategies set out by the procedures and the conceptual design of the lifesaving equipment?
- The number and composition of the passengers, i.e. number of children, elderly and/or persons who are disabled? How anxious are the passengers and how willing are they to receive instructions?

[4] Proceduralization of marine safety (DMAIB, 2016).

INUK II was equipped with the lifesaving equipment which was required per the Danish/Greenland regulation (see section 4.4). The equipment was not designed for a particular type of boat or ship, but generic and approved for use on board e.g. large passenger ships, cargo ships and small passenger craft. After the accident on 14 August, the DMAIB investigated the design of INUK II in relation to the on-board equipment for evacuation.

In the evacuation procedure, it was described that the evacuation was to be made from the deck area where the passengers were to don the immersion suits and lifejackets. The boat was designed so that there was no room for the immersion suits and lifejackets outside; therefore they were stored inside. All the immersion suits were stored behind a ladder in a storage room in the forward part of the boat. In an evacuation scenario, all the immersion suits had to be removed from the storage room and distributed among the passengers and crew according to size and type. It is uncertain how much time the passengers need to put on the immersion suits and lifejackets. In this context, it becomes relevant to consider how much space is available in order to estimate the time needed to make the passengers ready for disembarkation. Below, the picture on the left shows the aft deck on INUK II (figure 6).

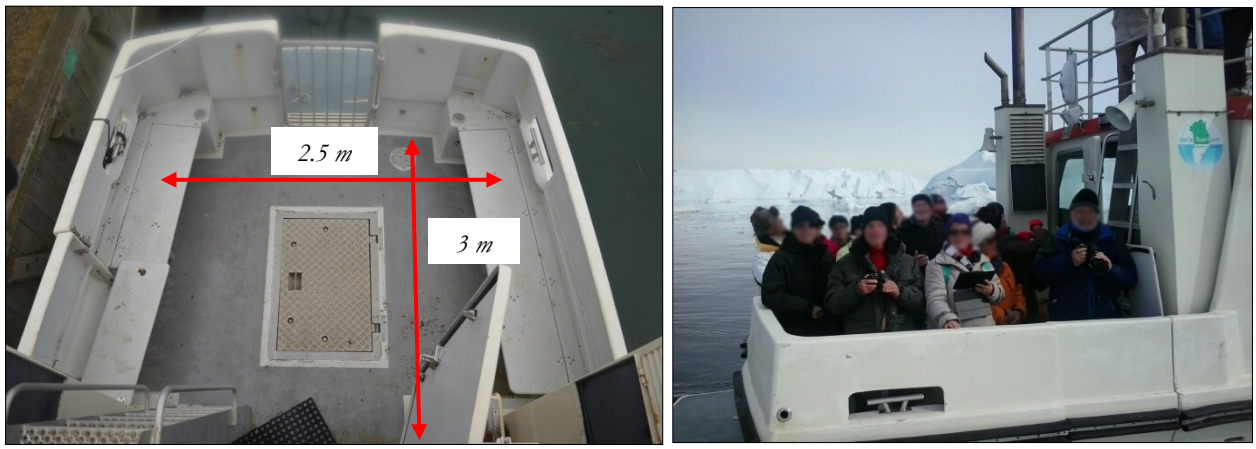


*Figure 6: Photo of the aft deck*
*Source: DMAIB/private photo*

The aft deck area was the only place with direct access to the inflated liferafts. The aft deck area was approximately 7.5 m² which gave 22 passengers about 0.3 m² each. The picture on the right shows approximately 13-15 passengers on the aft deck. From the picture, it is evident that it would not be possible to accommodate all the passengers on deck while assisting them in donning the lifesaving equipment. The lack of space would have the implication that most of the passengers would have to be on standby in the passenger lounge if there should also be room for the crew members to inflate and secure the liferafts. In an adverse situation with fire, flooding or loss of stability, this scenario would result in a situation where the doorway to the passenger cabin would become a bottleneck where passengers would insist on having access to the deck area.

It would not be expedient to assemble the passengers on the forward deck because they would have to climb the boat's railing and jump onto the liferaft and land on top of the canopy of the liferaft. This could injure the passengers sitting inside the raft. Furthermore, access to the forward deck area was through the passenger lounge and wheelhouse or via the top of the superstructure, which would create a bottleneck effect so that the passengers would have to wait in line inside the passenger lounge.

All the immersion suits on board INUK II were designed to protect the passengers and crew from hypothermia from immersion in cold water. It was, however, unclear when the immersion suits were to be donned because neither the on-board safety manual nor the regulation stated in what situations the immersion suits were to be used. The crew had the perception that the immersion suits and lifejackets were to be donned prior to entering the liferafts so that they would stay warm while waiting for assistance. It was not considered to be an option that the passengers should jump into the sea while wearing the immersion suits. Furthermore, there was no designated equipment to protect children from hypothermia.

The crew's perception of how long it would take to evacuate the boat was one notable area where there was a discrepancy between the general principles of the lifesaving equipment and the practical implementation of the equipment. The investigation into the layout of INUK II and its lifesaving equipment confirmed the doubts the crew members had about the effectiveness of the lifesaving equipment and the emergency procedures in an evacuation scenario – specifically that time would be an issue in an evacuation scenario. Before the accident, at the table top exercises, it was recognized by the master that a successful evacuation would be completely dependent on the time available, and it was concluded that the passengers would most likely not have time to put on the immersion suits and lifejacket prior to boarding the liferafts. This reasoning was based on the number of passengers and the size of the boat, which made the stability sensitive to ingress of water. During drills, the crew had discussed this, and the master reached the conclusion that the passengers would have to be evacuated to the liferafts first and then don the immersion suits and lifejackets inside the raft. Thereby, it was recognized by the crew members that it would not be feasible to use the evacuation procedure because it offered no aid in the complexity of an actual evacuation scenario.

The DMAIB's investigation of INUK II and its lifesaving equipment indicates that an orderly evacuation would not likely be possible with the existing on-board strategies. On 14 August, the quick evacuation (approximately 15 minutes) of INUK II was made possible because assistance was rendered by other boats. This topic will be further elaborated in the analysis section (section 5).

## 4.4 Certification and manning

*4.4.1 INUK II — certification and trading area*

INUK II was initially surveyed and approved by the Danish Maritime Authority in 2001. During the last seventeen years, the regulatory framework and survey regime for INUK II had undergone a continuous development. In 2001, INUK II was certified by the maritime authority according to "Guidelines about requirements for P craft"[5] (passenger ships in domestic trade below GT 20). Furthermore, it was required to comply with the International Safety Management Code (ISM code)[6]. In 2006, INUK II was surveyed according to Notice D from the Danish Maritime Authority (Technical regulation on the construction and equipment, etc. of passenger ships engaged on domestic voyages). These regulations stipulated various specific requirements for the lifesaving equipment, but did not prescribe how it was to be used. On 17 May 2016, the Danish Maritime Authority made the annual survey of the boat (it was not classed) while it was on shore. The Authority found minor deficiencies which were to be rectified before the boat was put in to operation. In August 2016, the owner forwarded documentation for the completion of the deficiencies, and a permit for carriage of passengers was issued electronically.

Historically, INUK II's geographical trading area varied between a large area covering almost the entire east coat of Greenland and smaller local areas:

In 2002, INUK II was approved for the following trading area with 22 persons: *"… voyages in western Greenland within 10 nm of the outer rocks from Cape Cort Adeler on the east coast to "Djævlens Tommelfinger" by Upernavik* [Translation from Danish]*"* (figure 7):


*Figure 7: Trading area of INUK II in 1999*
*Source: © Made Smart Group BV 2016/C-Map data © Jeppessen AS 2016*

[5] Guidance from the Danish Maritime Authority no. 10001 of 3 January 1994.
[6] Technical regulation no. 1 of 11 January 1996 about safe operation of passenger ships.

In 2005, INUK II was issued with a "Permit for carriage of passengers" with a capacity of no more than 22 passengers for an area restricted to: *"The fjord of Ummannaq and Disco Bay"* (figure 8):

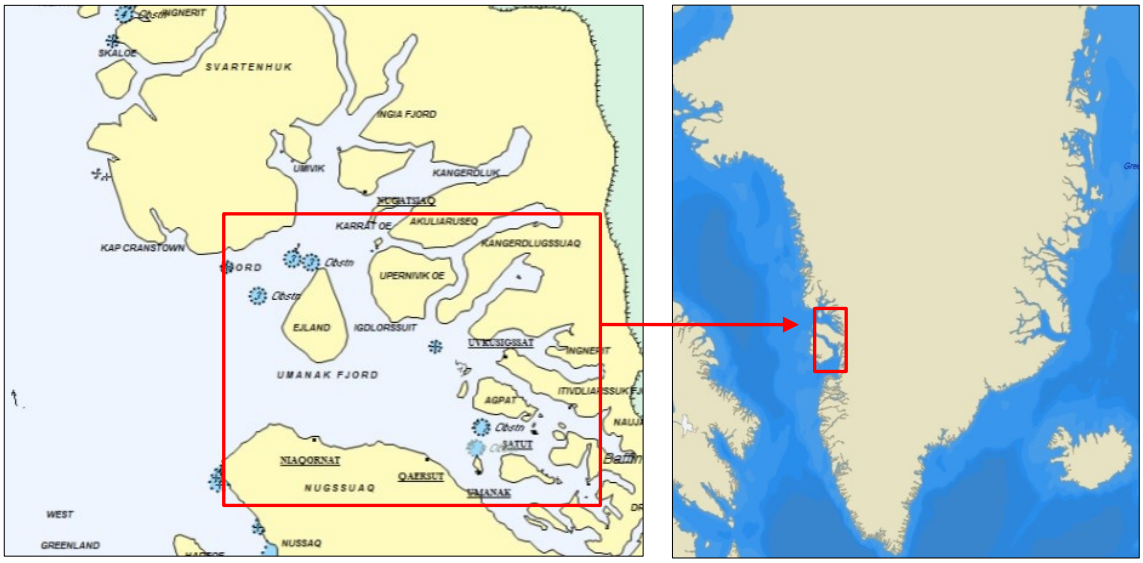


*Figure 8: Trading area of INUK II in 2005*
*Source: Google Maps/© Made Smart Group BV 2016/C-Map data © Jeppessen AS 2016*

In 2008, INUK II was issued with a new "Permit for carriage of passengers" with a capacity of no more than 22 passengers. The new trading area was: *"Navigation between Attu Aasiaat – Nuussauaq peninsula – Saqqaq within the basis line. However, within the 4 hours from the nearest port"*[7]. Below is an illustration of the trading area (figure 9).

[7] The term 4 hours from nearest port is related to the medicine chest that INUK II was equipped with.

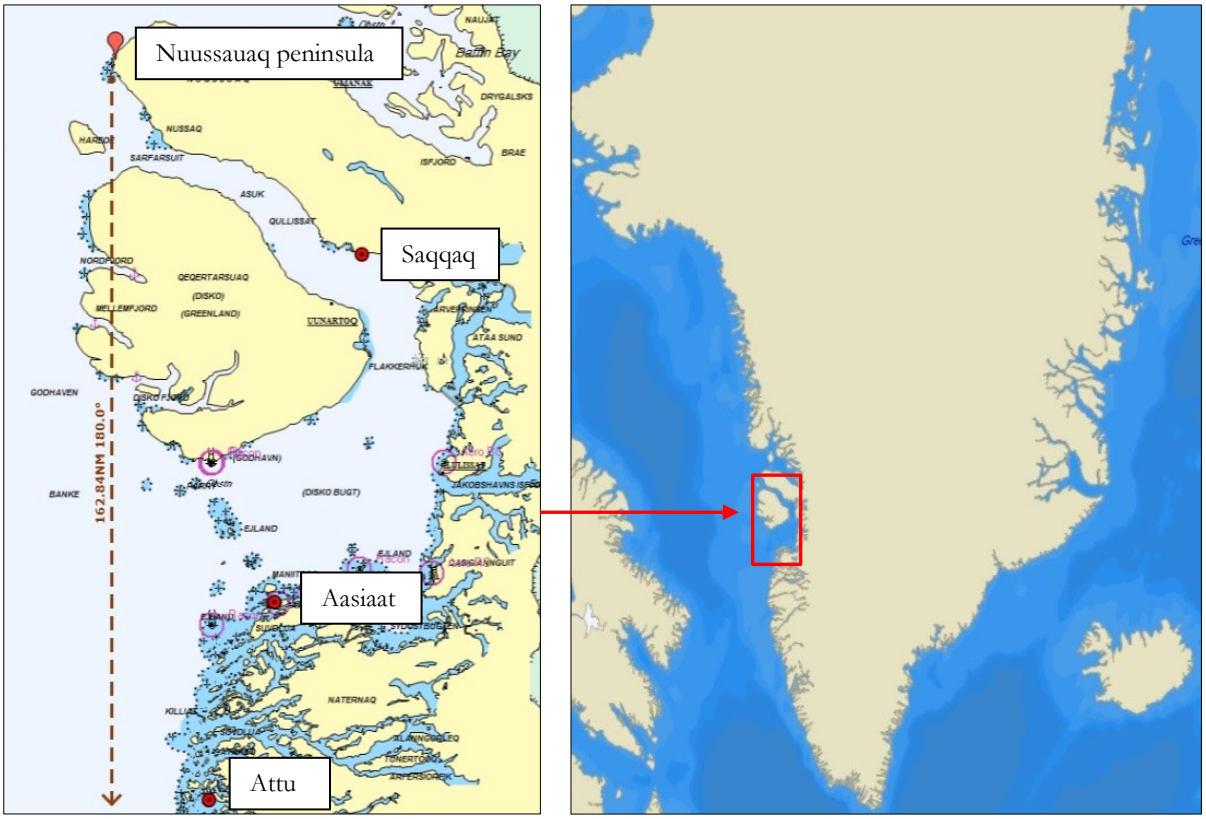


*Figure 9: Trading area of INUK II in 2008*
*Source: Google Maps/© Made Smart Group BV 2016/C-Map data © Jeppessen AS 2016*

### *4.4.2 Manning*

INUK II had two minimum safe manning documents. The first document was related to the large trading area from 2001, where the requirement was one master certified as "skipper home trade" (STCW II/3 with 12 months' seagoing experience on merchant vessel) and "one person" who would act as a deckhand with a certificate of competency in sailing merchant vessels. The second document was from 2005 and was valid for Ummannaq Fjord (north of Disco Bay) where the minimum safe manning requirement was one master with a certificate of competency in sailing merchant vessels and "one person" without prior seagoing experience or training.

On the day of the accident, INUK II was navigating in the Disco Bay and the Icefjord south of Illulisaat, which meant the first minimum safe manning document from 2001 was to be applied. INUK II was manned by a master holding an STCW II/3, but without the necessary seagoing experience. The other crew member did not have a certificate of competency in sailing merchant vessels, but only a certificate for sailing vessels carrying up to 12 passengers of less than 15 metres in length.

It was not uncommon for the crew on INUK II not to be certified according to the safe manning document mainly for two reasons: There were few available seafarers in the area with the required certificates who were able to do seasonal work and it was a common understanding

among the seafarers that the confined trading area of Disco Bay did not require full skipper home trade certification, and that a certificate of sailing in merchant vessels was sufficient. The master on INUK II came to Greenland during the peak season and adopted these local work conditions. The investigation has not established any connection between the events related to the accident and the lack of mandatory certification of the crew members.

### 4.5 Investigation of the salvaged INUK II

INUK II was salvaged on 25 August 2016 and brought to the port of Ilulissat. The boat was found to be structurally undamaged except for minor damage on the aft ramp most likely caused by the foundering and the salvage operation. The liferaft containers had been released, but were not inflated. The other lifesaving equipment was still stored on board, i.e. lifejackets and immersion suits.

An investigation of the steering gear/storage compartment revealed a missing hose which had connected the drain from the aft deck to the over board discharge. On figure 10 below is an illustration of the layout of the drain.

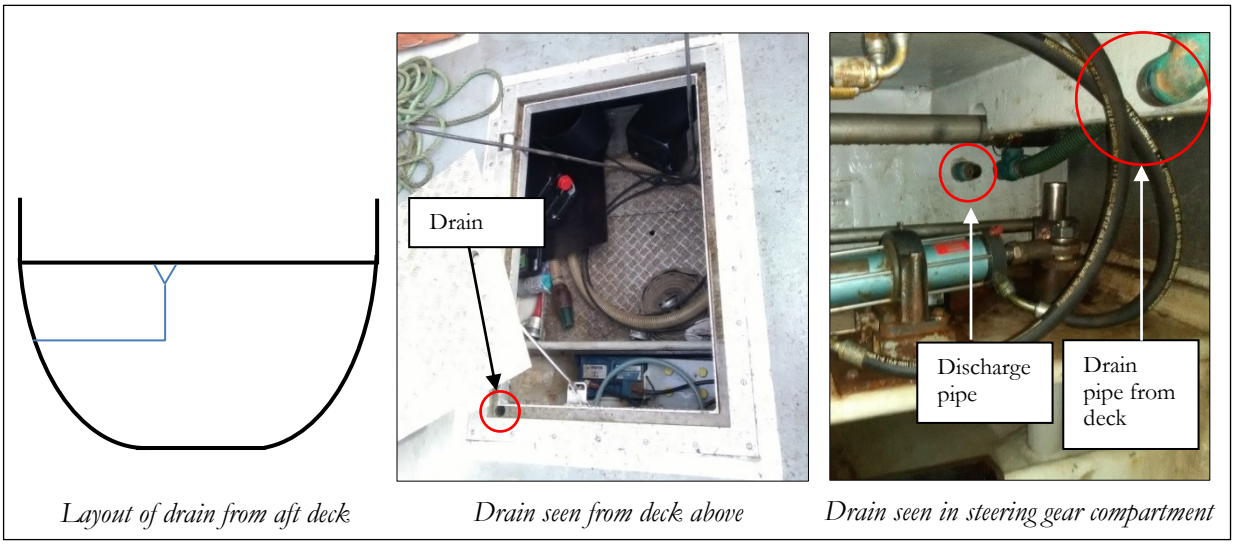


*Figure 10: The drain from aft deck*
*Source: DMAIB/Private photos*

The drain was designed to drain water from the aft deck preventing it from entering the compartment below deck when the hatch was opened. Both the drain hole and the discharge pipe were made of 1 inch galvanized steel pipe, which were normally connected by a flexible hose. It was established from the investigation of the wreck that the flexible hose was missing. It is likely that the hose was removed while INUK II was at the local workshop for repairs. To get access to the rudder stock it was necessary to dismantle the hose connecting the drain from the deck to the discharge pipe. After the reassembly of the rudder stocks, the repair team did probably not connect the hose again leaving the discharge pipe open to the sea. It was, however, also a possibility that the hose was removed during the repairs of the boats fuel system lo-

cated in the steering gear compartment. It has therefore not been possible to determine with certainty why the drain hose was missing. The hose has not been found by DMAIB.

Below is a picture of the salvaged INUK II (figure 11). The red circle on the picture shows the penetration of the hull where the discharge pipe was mounted.

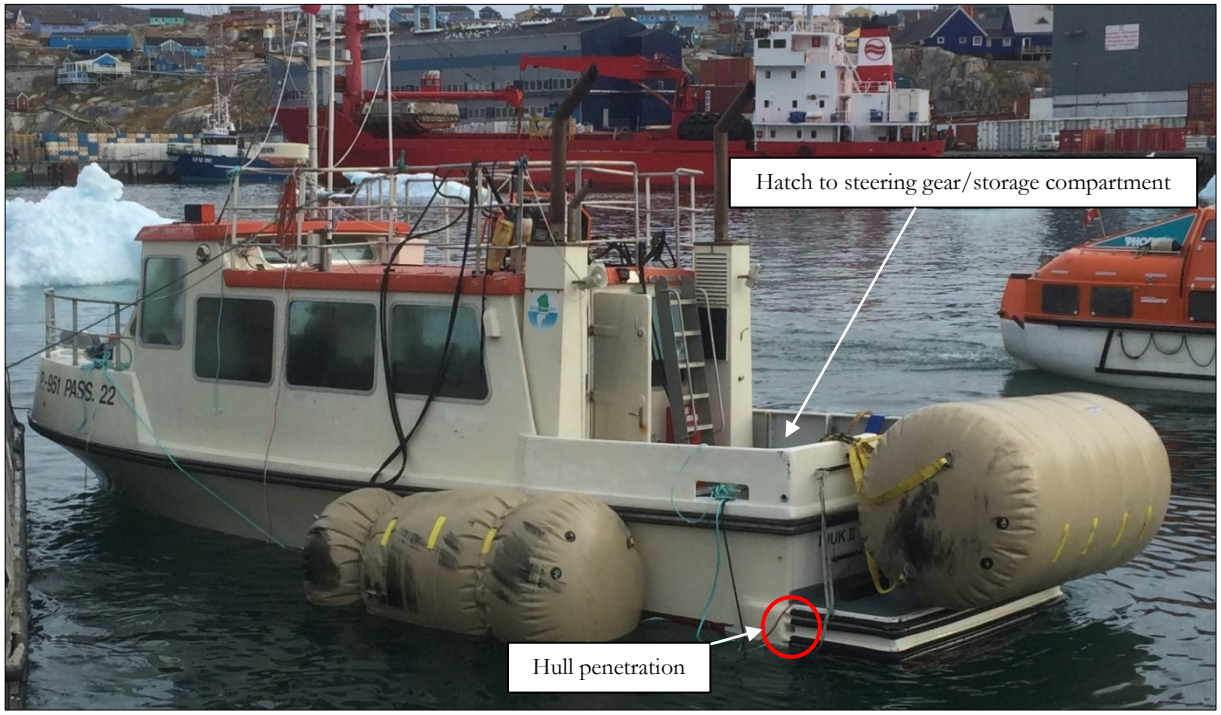


*Figure 11: The salvaged INUK II*
*Source: DMAIB/Private photo*

During normal operation, the hull penetration was above the water line on the port side. However, if the boat had embarked the maximum number of passengers, then the hull penetration where the discharge pipe was connected would be below the water line, which can be seen on the photo (figure 12) below showing the starboard side.


*Figure 12: The starboard side of INUK II*
*Source: Private photo*

### 4.6 The cause of the flooding and loss of buoyancy

On the last excursion tour on 13-14 August, 23 passengers were embarked from the cruise ship L'AUSTRAL. As INUK II departed from the cruise ship, the total number of persons on board was 26, including the crew. The weight of the passengers and the speed of the boat, which made it trim aft-wards, submerged the hull penetration where the over board drain from the deck area was mounted. As the hose connecting the drain from the deck to the discharge pipe was missing, the water could freely run into the steering gear/storage compartment. The missing hose had not been detected during the sea trial or the previous tour on the same day because INUK II had not been operating with full passenger capacity since it was set afloat.

The steering gear/storage compartment was not equipped with a bilge alarm, but a bilge alarm was mounted on the aft part of the engine room (figure 13). This meant that the crew members were unaware about the water ingress until the water had reached the aft part of the engine room. The bilge alarm switch was mounted 2-3 inches from the bottom of the engine room in a recess (figure 13), which meant that it would be triggered by relatively small amounts of water. The sensitivity of the alarm was consistent with the crew members experiencing frequent bilge alarms from small amounts of bilge in the engine room.

Later, when the water had reached a level of approximately 300 mm in the steering gear/storage compartment, the water gushed through a ventilation fan housing opening connecting the steering gear/storage compartment with the engine room (figure 13). By then the free surface effects of the water in the compartments made INUK II unstable and the weight of the water made the buoyancy diminish.

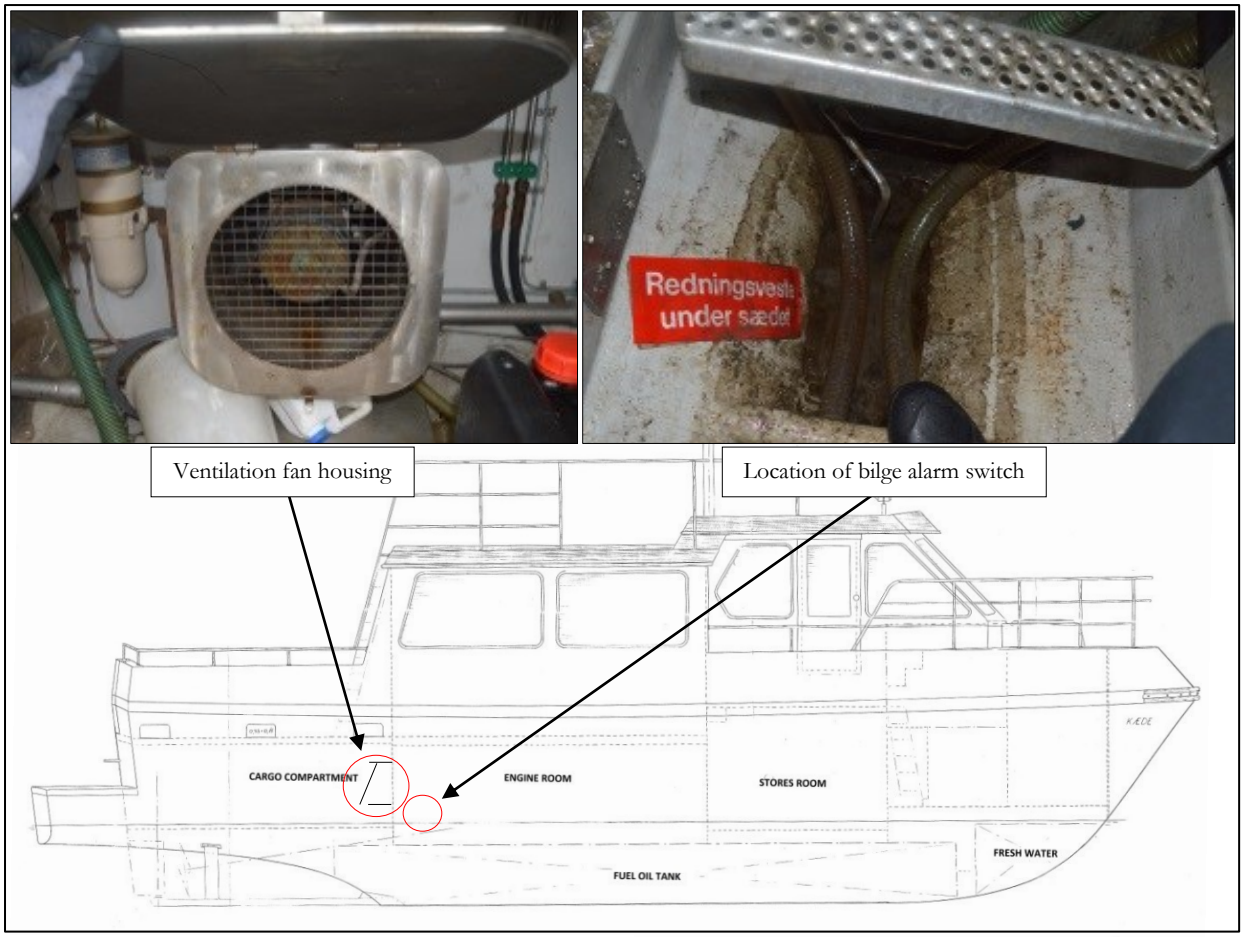


*Figure 13: INUK II*
*Source: DMAIB/Faaborg Shipyard*

The platform mounted on the rear of the boat was hollow and water tight and thereby provided some buoyancy, which delayed the loss of buoyancy in the aft part of INUK II. This delay gave the passengers and crew time to evacuate the boat. As the steering gear compartment was gradually filled, the water could flow into the forward storage compartments via the openings in the bulkhead made for cable penetrations (figure 13).

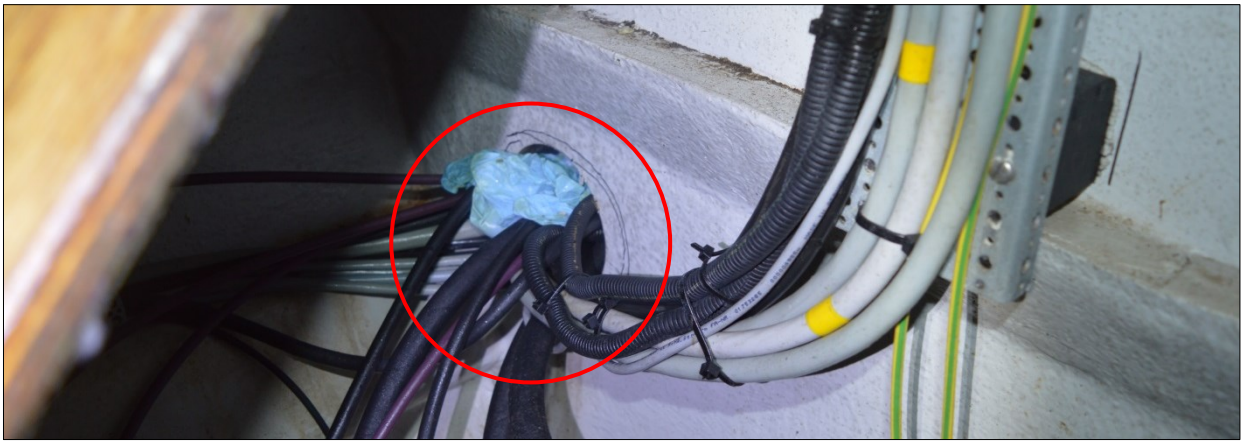

*Figure 13: Cable penetration in forward storage compartment on INUK II*
*Source: DMAIB*

In the steering gear compartment, the hydraulic steering gear was mounted on a pedestal thereby delaying the malfunctioning of the steering gear. The steering gear malfunctioned approximately at the same time as the forces from the waters' free surface came into full effect. At this point the passengers and crew noticed the boat becoming unstable because it started to roll excessively. During the process of evacuation, the rolling motion was dampened because INUK II was tied to the tour boat CLANE and because a crew member used his body weight as a righting lever by leaning out from the ship's side. In the final stages of the evacuation, the water level on the aft deck was approximately one metre. The aft deck area was gradually submerged until the aft part of the boat was finally submerged at approximately 0050 (figure 14).


*Figure 14: INUK II at approximately 0050 on 14 August 2016*
*Source: Private photo*

The propulsion engines were in operation until the entire aft part of the boat was submerged. It can be seen on the photo above that the batteries (located below the wheelhouse) supplied power to the navigational lights until it finally sank on 19 m depth at approximately 0200 on 14 August 2016.

# 5. ANALYSIS

## 5.1 The flooding and loss of buoyancy

The investigation has established that, during the repairs of INUK II's rudder stock or the fuel system, a hose connecting the aft deck drain to the discharge pipe was removed. After the repairs were completed, the drain hose was not mounted again. Once INUK II was put into operation, it was only a matter of embarking enough passengers before the discharge pipe would be submerged below the waterline resulting in flooding of the boat. On the day of the accident, INUK II was transporting the maximum number of passengers which increased the draught to such an extent that the hull discharge pipe was submerged. INUK II gradually lost all buoyancy as water flowed into the steering gear/storage compartment and subsequently into the engine room because none of the other compartments were separated by watertight bulkheads.

The crew members did not respond to the bilge alarm as if it was a serious water ingress for a number of reasons. Firstly, it was a common occurrence that the alarm was triggered because the alarm switch was sensitive to small amounts of water shifting in the engine room. Secondly, the master was hesitant to inspect all the compartments closely because experience had shown that it needlessly made the passengers anxious when the crew opened all the hatches in the passenger lounge and aft deck. Therefore, only the forward compartment was inspected. Thirdly, the short distance to the cruise ship where all the passengers were to be disembarked could have influenced the decision not to stop the boat and inspect all the compartments below deck. Instead it was decided to proceed.

The investigation did not bring clarification to why the hose was not mounted after having been removed. Presumably the mechanic for unknown reasons forgot to mount the hose again after having removed it to get access to components in the cramped steering gear compartment. The local workshops that carried out the repairs were not able to test the systems on the boat while it was on shore or in the water, because it was not customary for the workshops to carry out sea trials as they were not specialized in boat repairs. Therefore, the deckhand on INUK II made the inspection of the boat prior to and after the boat was set afloat. During the inspection, the deckhand was preoccupied with the overboard valves below the waterline and therefore the aft deck drain was not inspected. The deckhand did not have experience and/or training in marine engineering, and there was no written guidance on how to inspect the functioning of the boat's machinery and equipment. In the absence of technical knowledge and procedural guidance, the deckhand's inspection of the boat's reliability was mainly based on the sea trial, which did not reveal any malfunction. On that basis INUK II was put into service. The master on INUK II made a visual inspection of the boat on 13 August 2016 before embarking the passengers for the first excursion and no anomalies were found.

## 5.2 The evacuation of INUK II on 13-14 August 2016

The master's decision to evacuate INUK II should be viewed in the context of the preceding events to understand how and why the decision was made.

The excursion tour on 13 August 2016 progressed normally until INUK II lost steering on the return voyage. The crew experienced this event as an operational disturbance with no effect on the watertight integrity of the boat. Gradually, the crew and some of the passengers realized that something was wrong besides the steering gear failure. The boat started to act unstable by rolling excessively. Having no knowledge about the water ingress, the crewmembers acted in an uncertain environment where they tried to make sense of the boat's behaviour. The master on INUK II realized that the boat was about to lose buoyancy as the aft deck became submerged. Instinctively, the master considered releasing and inflating the liferafts because it was part of the training, but soon realized that it would be more expedient to transfer the passengers to CLANE. At this point it did not make sense for the master to ask all the passengers to put on immersion suits and lifejackets because valuable time would be lost in the process. Approximately 20-30 minutes went from the steering gear malfunctioned to all the passengers were transferred to CLANE and the zodiacs from the cruise ship L'AUSTRAL.

The events indicate that the evacuation of the boat was not a single decision made with full knowledge about the circumstances (e.g. what caused the water ingress), but rather a process of managing uncertainty and collecting information until it became certain what was going on. Once enough information was available to determine that the boat would sink, the crew started to transfer the passengers to CLANE.

It is inherently difficult to predict when an emergency will occur which will necessitate an evacuation. Emergency situations are often preceded by events which are typically characterised as operational disturbances which are manageable. Only when there are no options left to normalise the situation, is the situation perceived as an emergency. By then, time can be sparse to prepare the equipment and assist all the passengers in donning the lifesaving equipment. The implication is that there is a time limit for the crew to realise that an evacuation is necessary. Not all the passengers will be able to evacuate the boat once that time limit has been reached.

There were two determining factors which enabled the safe evacuation of the passengers from INUK II: Firstly, assistance could be given within a few minutes because CLANE was nearby, and the cruise ship quickly deployed zodiacs in time to evacuate the remaining passengers, who had difficulty climbing onto CLANE. Secondly, INUK II did not lose stability and capsize as the compartments were flooded. The boat thereby acted as a semi-stable platform for the passengers as they were evacuated to CLANE and the zodiacs.

### 5.3 The emergency preparedness on INUK II

Traditionally, investigations of accidents in Greenland involving small boats carrying passengers have been based on sparse information about the circumstances because the crewmembers perished and the boat sank in an unknown location. Therefore, the DMAIB has no record of an evacuation of small passenger boats where the lifesaving equipment has been in use. The foundering of INUK II provided an opportunity to learn about the boat's emergency prepar-

edness, which could offer general knowledge about the effectiveness of lifesaving equipment on excursion boats.

INUK II was certified to operate in different trading areas with little or no presence of marine traffic. In such areas, it was vital that INUK II and the crew members were independently able to handle a variety of emergency scenarios. From a regulatory perspective, INUK II seemed able to deliver solutions to an emergency which involved an evacuation of the boat, i.e. the boat was surveyed, approved and held a valid trading permit. The boat was equipped with the mandatory lifesaving equipment and procedures, and had a crew who held valid certificates and was familiar with the trading area. However, the investigation into the accident on 14 August showed that INUK II's designed ability to deliver a successful evacuation could be brought into question for mainly two reasons: Firstly, the uncertainty which is caused by underspecified procedures and lack of experience in handling emergency situations. Secondly, the sparse time available for initiating all the necessary initiatives related to the evacuation. The first problem is relatable to various categories of ships, but the latter was closely connected to the size of INUK II and the number of passengers that the boat is certified to carry on board. The number of passengers was determined by the authorities by INUK II's capacity in terms of space, seats and the available lifesaving equipment and was thereby specific in relation to the mandatory equipment and design of the boat. However, the regulation was abstract in relation to *how* the equipment was to be utilized because there were no requirements for the content in the safety management manual or any actual testing of the lifesaving equipment.

The master on INUK II had, already before the accident, realised that the orderly and safe evacuation of all the passengers by using the boat's equipment and procedures could prove to be difficult, and that the process would be highly dependent on the available time. Specifically it would be time-consuming to initiate the process of mitigating the cause of the emergency (e.g. flooding, fire, etc.), assisting all the passengers donning the immersion suits and lifejackets while at the same time sending distress messages and launching the liferafts. To resolve these problems, the master took the initiative to having tabletop exercises where a strategy was developed to make the seemingly impossible situation possible, e.g. that the lifejackets and the immersion suits could be transferred to the liferafts depending on the limited time available. The table top exercise thereby acted as a strategy for mitigating an underspecified safety management system. However, the table top exercise also effectively created a structural secrecy about the problem associated with evacuating the boat. The actual ability of INUK II would remain hidden until an accident happened which necessitated an evacuation where the lifesaving equipment was to be used.

### 5.4 INUK II's compliance with regulation

On 14 August, INUK II did not comply with the regulations set out by the Danish Maritime Authority in several respects. The investigation has not found that the non-compliance with the regulation had any effect on the events on 14 August.

Two of the crew members (the master and the deckhand) did not have the required certificates for operating the boat in the specific trading area. The crew members' lack of mandatory certification for operating INUK II in the Icefjord was a result of the owner's and master's absence of knowledge about the legislative framework applying to INUK II and crew certification in general. Furthermore, the difficulty in recruiting seafarers had necessitated a practise of assigning the available crew members to the various boats without a focus on what legal requirement applied for the individual boats.

The liferafts had been moved from the top of the accommodation to the aft of the boat without prior approval by the authorities. The relocation of the liferafts had a positive effect on the stability of the boat by moving weight from the top of the boat to the platform. Furthermore, in an attempt to release the liferafts, the crew members would have to climb the accommodation which would worsen the stability of the boat. However, the positioning of the liferafts on the stern platform made it difficult to release them when the boat was sinking by the stern.

The number of passengers was 23 which exceeded the limit of 22 passengers as stated in the permit for carriage of passengers. In the trading permit there was no reference to how many crew members INUK II could carry. However, as the capacity in the liferafts was 24 and the number of persons on board was 26 (23 passengers and 3 crew members) then the maximum capacity of persons on board was exceeded by 2 persons.

# 6. CONCLUSIONS

On 14 August 2016 the excursion boat INUK II sank as a result of water ingress in the steering gear/storage compartment. All 23 passengers and three crew members were evacuated safely to another excursion boat which was nearby before INUK II was fully submerged.

The accident provided an opportunity to gain a general understanding of the effectiveness of the tour boats' design and equipment to handle an emergency. Therefore, the accident investigation had two purposes: Firstly, the purpose of the investigation was to establish the technical circumstances that led to the tour boat losing buoyancy, including the circumstances under which the passengers were evacuated. Secondly, to gain an understanding of the problems associated with implementing the strategies for handling evacuation situations.

The water ingress was caused by the absence of a hose connecting the drain from the deck to the discharge pipe mounted in the boat's hull, which enabled water to penetrate the hull through the discharge pipe into the steering gear/storage compartment. During repairs of the boat, the hose had been removed, but had not been refitted after the repairs were completed. Once INUK II was put into operation with the maximum amount of passengers, the discharge pipe was submerged allowing water to flow into the boat.

INUK II was equipped with the mandatory lifesaving equipment and procedures, and was manned with a crew who held valid certificates. However, the investigation into the accident on 14 August showed that INUK II's designed ability to deliver a successful evacuation could be questioned because of the uncertainty brought about by an accident, generic procedures and the sparse time available to evacuate the boat. The first problem of uncertainty is relatable to various categories of ships, but the latter problems were closely connected to the size of INUK II and the number of passengers that the boat was certified to carry on board.

The maximum capacity of passengers was determined by the maritime authority on the basis of prescriptive legal requirements about the capacity in terms of space, seats and the available lifesaving equipment. However, the regulation was abstract in relation to how the equipment was to be utilized because there were no requirements for the content in the safety management manual or a requirement for any actual testing of the lifesaving equipment. In order to bridge the gap between the prescriptive and the abstract requirements, the owner hired a consultant who had the necessary knowledge about how to make a safety management manual which could be approved by the maritime authority. However, the consultant had no knowledge about the operational realities of evacuating INUK II and an actual test of the lifesaving equipment was not made. The result was a procedure for evacuation which was unusable for the crew members on INUK II.

The lack of integration and feedback between the maritime authority, the owner, the consultant and the crew members kept the problems associated with an evacuation hidden. It is therefore doubtful how effective the lifesaving equipment and procedures would be in an emergency. Not only on INUK II, but also on other tour boats of similar size, passenger capacity and trading area.

# 7. PREVENTIVE MEASURES TAKEN

DMAIB has received the following from the Danish Maritime Authority:

> "On the basis of the investigations of the INUK II incident made by the Danish Maritime Authority and the information contained in the draft report issued by the Danish Maritime Accident Investigation Board, the Danish Maritime Authority has planned focused measures in connection with the first survey of small passenger ships.
>
> As part of the Danish Maritime Authority's forward-looking strategy for enhanced focus on the operational safety of passenger ships, the Danish Maritime Authority will, already next year, apply the strategy to small passenger ships. This means that in 2017 surveys and control of small passenger ships will be made with special focus on whether the safety concept for the ships is realistically practicable in operational conditions. In this connection, special focus will be on whether it will be possible to carry out evacuation, fire-fighting and rescue operations in a manner that is operationally safe and

sound in consideration of the ships' size, arrangement and equipment, the number of passengers and the composition of the crew.

On selected ships that are comparable to INUK II, the measures will be given first priority".