FERRY SAFETY INVESTIGATION
REPORT

SUPERCAT 4 LOSS OF CONTROL AND COLLISION
SYDNEY COVE, NSW
11 OCTOBER 2016
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EXECUTIVE SUMMARY

On 11 October 2016, the Harbour City Ferries (HCF) vessel SuperCat 4 collided with the backboard at the southern end of Circular Quay Wharf 5. The vessel, carrying 130 passengers, was berthing following a scheduled service from Watsons Bay to Circular Quay. The vessel was approaching the wharf when its control system failed to respond when the master engaged astern¹. As a result, the vessel continued past its berth, collided with the backboard at low speed and recoiled. A number of passengers fell and suffered injuries. Ambulance NSW transported five of the injured passengers to hospital. SuperCat 4 suffered no visible damage.

The investigation determined that the collision was due to a control failure of the Twin Disc EC 300 control system that was initially unrecognised by the crew. By the time it was identified, the collision was imminent.

Full details of the Findings and Recommendations of this ferry safety investigation are contained in Parts 3 and 4 respectively.

¹ Engaged astern is the action of placing the gearing into reverse.
PART 1 FACTUAL INFORMATION

Introduction

1.1 At approximately 1610^2 on Tuesday 11 October 2016, the HCF SuperCat 4 was completing a regular scheduled service from Watsons Bay to Circular Quay carrying 130 passengers. SuperCat 4 was approaching Wharf 5 East, Circular Quay, when both the engines failed to respond to the master’s command input. As a result, SuperCat 4 continued past the intended berth and collided with a safety barrier.

1.2 The impact resulted in 20 passengers suffering injuries from falls. Ambulance NSW conveyed five of the injured passengers to hospital.

Location

1.3 The incident occurred at Wharf 5 East, Circular Quay (see Figure 1). Circular Quay is within Sydney Cove, which is located at the northern end of Sydney’s central business district. It is the main hub for waterborne passenger transport on Port Jackson.

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^2 Times in this report are in 24-hour clock form in Australian Eastern Daylight Savings Time.
1.4 Sydney Cove is a high-volume traffic area and users must comply with Schedule 6 of the *Marine Safety Regulation 2016 (NSW)*\(^3\).

**Environmental information**

1.5 The Bureau of Meteorology recorded the weather during the afternoon of 11 October 2016 for Sydney Harbour as clear with a southeasterly breeze of up to 20 knots\(^4\). The master reported a light southwesterly breeze of less than 8 knots in Sydney Cove at the time of the incident. OTSI determined that the environmental conditions played no part in the incident.

**Vessel information**

1.6 *SuperCat 4* (see *Figure 2*) is an aluminium catamaran high-speed ferry, 34 metres in length with a beam of 9 metres. The vessel is powered by twin Yanmar 6AYM-WGT 670 kilowatts six cylinder diesel engines. The engines provide drive to propellers through conventional ZF 250A gearboxes and shafts. *SuperCat 4* carries a maximum of 326 passengers plus a crew of three. *SuperCat 4* has a normal operational speed of 24 knots.

![Figure 2: SuperCat 4](source OTSI)

1.7 *SuperCat 4* is one of four vessels of her class operated by the HCF. When originally built, the SuperCat class ferries were fitted with Rexroth MAREX OS engine control units. HCF retrofitted all four vessels with Twin Disc EC300 type controllers in 2014.

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\(^4\) A knot is a unit of speed equal to one nautical mile (1.852 km) per hour.
The crew

1.8 At the time of the incident, the vessel had a crew of three appropriately qualified persons. The master held a Master less than 35 metre Certificate and a Marine Engine Driver grade 2 Certificate. The engineer held a Marine Engine Driver grade 1 Certificate. The deckhand was qualified as a General Purpose Hand (GPH).

1.9 The company inducted and assessed the crew to operate SuperCat 4. The master had worked for Sydney Ferries / HCF for 21 years and had over 10 years’ experience on the SuperCat class. The engineer had 16 years’ service with the company, working both as a maintainer and operator of the fleet of vessels. The GPH had 10 years’ service with the company. All three crew had operated this class of vessel extensively.

The incident

1.10 While SuperCat 4 operates at high speeds in open water, Schedule 6 of the Marine Safety Regulation 2016 (NSW) requires all vessels to operate at no more than 8 knots (see Figure 3) when navigating within the confines of Sydney Cove.

1.11 When SuperCat 4 reached Sydney Cove, the vessel’s intended berth was occupied, requiring the master to wait for it to become clear. When the berth became available, the master engaged ahead thrust on the both engines. The vessel picked up speed reaching approximately 10 knots as it approached the wharf.

1.12 Approximately two boat lengths from the wharf, the master slowed SuperCat 4 and transferred control from the main to the starboard control station. The master re-engaged ahead on both engines and adjusted course to line up with the berth. As the vessel neared the wharf, the master placed both engine controllers in neutral. The master received no indication or warning that the control transfer had failed or that any fault with the control unit had occurred.

1.13 The bow of the vessel passed the end of the wharf at approximately 8 knots. The master, upon reaching a position alongside the wharf that was suitable for securing the vessel and unloading passengers, placed both engine controllers astern. The vessel did not respond to the master’s input.
1.14 SuperCat 4 passed beyond the master's intended berthing position. The crew realised that control had been lost. The engineer, after confirming with the master, activated the back-up control system. Before the back-up controls could stop SuperCat 4, it collided with the backboard. Collision with the backboard resulted in the vessel recoiling causing passenger injuries.

1.15 Prior to the collision, the GPH noticed that the vessel was not stopping and shouted a verbal warning to the passengers to brace. In spite of this warning, a number of passengers were injured by falls following the impact.

1.16 SuperCat 4 collided with the backboard at approximately 5 knots, as indicated by the Forward Looking Infra-Red (FLIR) camera video recording. The vessel struck the backboard almost square, suffering no visible damage to the bow (see Figure 4).
The backboard, designed and built to withstand the impact of much larger ferries, was displaced slightly from its normal position. The western upright pile and horizontal timbers presented minor deformations after the impact (see Figure 5).
1.18 The engineer, having successfully activated back-up control of the engines, manoeuvred the vessel alongside the wharf. Once the vessel was secure to the wharf, the crew and wharf staff attended to the passengers.

1.19 The master reported the incident to the HCF control room. Wharf personnel called Ambulance NSW and then assisted the crew to disembark the passengers safely.

1.20 Ambulance NSW transported five injured passengers to hospital.

1.21 OTSI received notification of the incident at 1620.

1.22 The OTSI duty officer informed HCF that the vessel could return to the Balmain Shipyard base under quarantine pending an OTSI investigation.

1.23 OTSI investigators arrived at 0800 the following day to examine the vessel and interview the crew. Following this inspection, the Chief Investigator determined that OTSI would conduct an investigation into the incident.
PART 2 ANALYSIS

Introduction

2.1 The investigation focussed principally on the factors that contributed to SuperCat 4’s loss of control and the eventual collision with the backboard.

Crew actions

Master

2.2 The master described that the vessel was responding normally to command input prior to the collision. The master recounted that, following the period waiting at the designated line in Sydney Cove, both engines responded to a number of command inputs.

2.3 The master reported that when command was transferred to the starboard wing station, the engine control levers were placed into gear to confirm that the transfer of control had been successful.

2.4 The master did not communicate with the engineer to confirm the successful transfer of control to the starboard wing. However, at the time of the accident there was no company requirement to do so.

2.5 The master reported that the vessel followed command input from the starboard station immediately prior to coming alongside the wharf, including the command to neutral. Review of CCTV footage from a nearby building, confirmed the vessel responded to the masters commands from the starboard wing station.

2.6 When the master placed both engine controllers astern, the master did not recall any audible alarms or lights to warn of a control failure.

2.7 The master, concentrating on steering the vessel in close confines with the wharf, did not immediately comprehend that engine thrust controllers had failed. It was only when the engineer enquired as to whether indeed he had control that the master instructed the engineer to engage “back-ups astern”.
2.8 The master, standing at the starboard wing station was concentrating on the approach to the wharf. In this location, the master had no clear line of sight to the speed indicator on the port side of the wheelhouse (see Figure 6).

2.9 The berthing of a ferry at a dead end wharf increases the risk of collision following a control failure. The crew can mitigate this risk by a low speed approach to the wharf. A slower approach grants the crew more time to implement an effective response in the event of a control failure.

2.10 Unbeknownst to the master, SuperCat 4 approached the wharf at a slightly higher speed than normal (10 knots as opposed to 8 knots). The master had no readily available indication of vessel speed without leaving his control station and was unaware of the approach speed.

2.11 Had the master realised the approach speed, he may have responded by slowing further from the wharf. The lower speed would have provided more time for an effective response, once the failure was identified.

**Engineer**

2.12 When the master moved to the wing station, the engineer moved to standby the back-up controls near the centre control station. As per the company’s Fleet Generic Operations Manual, the Engineer is required to standby the backup controls, confirm that they are ready for operation and report back to the master.

2.13 The engineer did not notice any indication of a loss of control during the approach to the wharf.

2.14 The engineer noted that something was wrong when the vessel did not stop at the expected berthing position. He looked towards the master, noted that the master had engaged both control levers astern, but that the vessel was still drifting forwards. The engineer recounted that he thought the engines may have been revving but that no reverse thrust was noticeable. Examination of the FLIR recording confirmed that the engines were revving prior to the impact.
2.15 Realising that something was wrong the engineer asked the master if he had control. The master responded with the command “control failure, back-ups astern”.

2.16 Following the master’s command to engage the back-up controls astern, the engineer repeated the instruction and initiated the back-up control activation procedure. Activation of the back-up controls procedure takes approximately six seconds to complete. The vessel’s proximity to the backboard combined with the cumbersome back-up activation process, resulted in the engineer gaining control just as the vessel struck the backboard.

2.17 The engineer slowly manoeuvred the vessel alongside the wharf with the back-up controls.

2.18 Following the incident, the engineer noted that the back-up control head was displaying a fault code. The fault code was illuminated on a 3mm LED light, which was challenging to see, especially in daylight.

2.19 The engineer did not recall any audible alarms or lights to warn of the control failure.

GPH
2.20 As the vessel approached the wharf, the GPH was on the main deck outside the passenger cabin doors, preparing the deck lines to secure the vessel.

2.21 The GPH stated that he realised something was wrong when the vessel passed the normal berthing location and the engines could be heard revving like “…a car in neutral…”

2.22 The GPH, seeing the vessel continue towards the backboard, shouted a warning to passengers to brace.

2.23 When the vessel was secure the crew assisted by wharf staff attended to the passengers, including administering first aid to the injured.

Vessel handling and wharf approach speed
2.24 *SuperCat 4* is a low displacement and comparatively fast (for its size) ferry. It has a good power to weight ratio which allows it to quickly accelerate to
operating speed. SuperCat 4 is steered by a pair of relatively small high speed rudders located near the stern of each pontoon (hull). The rudders work by deflecting water that passes over their surfaces. The resulting force changes the vessel’s direction.

2.25 Passenger ferry operations in Sydney Harbour are varied. Some services perform over 100 berthing manoeuvres during a typical shift. Others services travel for long periods at high speed making less than 20 berths in the same period.

2.26 Ferry design is often a compromise between handling and speed. Good low speed handling characteristics are desirable traits for a ferry which has a high frequency of berths. Conversely the need to quickly transport commuters to distant wharves suits vessels that can achieve higher speeds.

2.27 Generally, a larger rudder and/or faster water flow over the rudder will result in an increase of the vessel’s ability to alter course. While a large rudder is desirable in low speed manoeuvres such as berthing, it can cause harsh and uncomfortable movements at high speeds. Small rudders offer smooth high speed characteristics but sluggish low speed response.

2.28 As designed and built, the SuperCat class small rudder size in conjunction to a shallow draught and high superstructure resulted in less than desirable low speed handling, especially during windy conditions. Following feedback from operational masters that wharf approach speeds were high due to lack of steering, the rudder size was increased.

2.29 While the modification improved low speed handling, approach speeds are still higher than most vessels in the HCF fleet. A further challenge for masters attempting slow approaches to wharves is that the vessel’s slowest speed when in gear is 7 to 8 knots.

2.30 This higher approach speed makes the early identification of a loss of control important, especially where the wharf is a dead end like Circular Quay. Early identification of a failure allows the crew more time to effectively implement response procedures.
2.31 Observations of SuperCat class ferries as they cross the end of the wharf in similar conditions, is approximately 1 to 1.5 knots slower than SuperCat 4’s speed of 8.3 knots on the day.

2.32 1 knot equates to travelling approximately half a metre per second.

**Engine controls**

2.33 Four EC300 Power Commander stations control the main engines. Two are located at the main helm position and one each at the port and starboard wing controls (see Figure 6). Each of these control stations has two levers, one for each engine.

![Figure 6: Wheelhouse layout](source)

2.34 The master first selects and activates the desired control station using the ‘Station Select’ button. The master moves the levers on the controller through their range to produce an input command to the engine. The left side lever is for the port engine and the right side is for the starboard (refer Figure 7).
2.35 The controller provides input for forward and astern thrust, and centres in a neutral position. This type of controller enables the selection of opposing thrust commands on the port and starboard engines. Moving the controller away from or back towards the neutral position increases or decreases thrust respectively.

2.36 The EC300 controller on the *SuperCat 4* has 3mm LED lights that illuminate to signal system status. When the system identifies a fault within the controller or control system (see Figure 8), the light flashes in set sequences to indicate a fault code and to assist in troubleshooting a failure. This light is challenging to see, especially in bright sunlight.

2.37 The system on the SuperCat class did not have an audible alarm accompanying this light. The master focuses their attention outside the vessel when manoeuvring. If a failure occurs in the control system, the poor luminosity of the LED lights often does not attract the master’s attention. The addition of an audible alarm in conjunction with the light would most likely improve a master’s awareness of vessel status and facilitate faster response times.
2.38 The EC300 system has inbuilt ‘smart’ protection software to minimise driveline damage and lessen risk of engines stalling when a change of thrust direction is applied. This software utilises a number of parameters, including engine speed, propeller revolutions and vessel speed, when determining how best to engage the opposite gear.

![3mm LED indicators](image)

Figure 8: LED lights

2.39 The vessel speed is displayed on a panel on the port side of the wheelhouse (see Figure 6). When a master is at the starboard wing station, they cannot easily identify vessel speed.

2.40 Due to the responsive nature of the SuperCat 4, relatively small movements of the control levers affect vessel speed. The challenge with monitoring speed, combined with the responsive nature of the vessel may have contributed to the failure to adhere to posted speed limits in Sydney Cove.

**Back-up control system**

2.41 The back-up control station is located close to the central main control position (see Figure 6). The back-up system is on a separate circuit to the other three units.
2.42 When the vessel is operating normally, the back-up system is powered down and does not have access to real time engine parameters. When activated, the protection software 'assumes' the vessel is stopped and protection is not required. Selection of opposite thrust while moving risks stalling the engines. This risk increases in conjunction with vessel speed.

2.43 The company has endeavoured to mitigate the likelihood of an engine stall with a detailed activation procedure.

2.44 While the procedure is simple, it is time consuming, with a stipulation to wait two seconds between steps one and two, and again between two and three. The delay between steps can be challenging to adhere to in abnormal situations which are often time critical.

2.45 Step three of the procedure (see Figure 9) instructs the operator to place the controls in the forward position (forward thrust). Placing the control in the forward position is required to provide the protection software with data. The control system then utilises this data to minimise the likelihood of an engine stall following a reversal of thrust.

2.46 Placing the controls into the forward position prior to pulling the levers to astern is counterintuitive when stopping the vessel. This is especially so during abnormal situations where the operator is time poor and under stress.
2.47 The back-up control activation procedure while improving system response is
time consuming and counterintuitive for the operator.

Company Safety Management System (SMS) and dead end wharves

2.48 At the time of the incident the company SMS contained general manoeuvring
instructions. It also contained specific instructions related to vessel types and
dead end wharves. These instructions required a master to maintain a safety
first attitude to any wharf approach.

2.49 The SMS included broad instructions for a master, when approaching a wharf,
to:

- maintain good communications with crew throughout berthing manoeuvre
- test the transfer of control stations prior to commencing a berthing
  manoeuvre
- be in control of vessel throughout the manoeuvre
- if the master expects a collision is imminent, they are to alert passengers
  by initiating a broadcast on the public address system.

2.50 In addition to these instructions a specific section related to dead end wharves
included a requirement for the vessel’s engineer to be standing by the back-
up controls. The engineer is to establish that the back-up controls are set to neutral and minimum power before reporting to the master that “…back-up control is ready…”

2.51 The SMS instructs a master to maintain good communications with the crew. It did not specifically demand confirmation of a successful transfer of control station. This instruction was generic, unlike the more specific instruction to the engineer to confirm that back-ups are ready.

2.52 There was no instruction for the master to confirm that the control has successfully transferred stations.

Vessel Data Recording System (VDRS)

2.53 SuperCat 4 is fitted with a VDRS which records and stores important data from vessel systems. This data can be downloaded and used to analyse vessel performance, faults and incidents.

2.54 Following the replacement of Rexroth controls with the Twin Disc Power Commander system, the VDRS no longer recorded critical command input and status.

2.55 HCF did not reconfigure the system to record this data after the control replacement. HCF believed that the Twin Disc system, which had its own fault recording system, would carry out this function.

2.56 The Twin Disc system does not record real time data; rather it records a time stamp of event faults. Interrogation of the log following the event found no evidence that a control failure had occurred. The recorded time stamp showed the active control station as main and not starboard, where the master was located. It also showed that the wing control levers were in neutral when in fact they were in astern.

2.57 The starboard back-up controller showed a fault log. The fault, ‘Bad serial comm address fault’, is commonly seen when the station select button is depressed at the same time that the system is activated.

2.58 From the evidence available, Twin Disc, Inc. could not satisfactorily conclude that the starboard control had been selected.
2.59 HCF had conducted a risk assessment prior to the change of control systems. The risk assessment did not address the interaction between the existing VDRS and the EC300 control system during the change management process.

2.60 It is likely that, had a more inclusive risk assessment been carried out, the Twin Disc system's lack of recording capability would have been identified.
PART 3 FINDINGS

3.1 From the available evidence, the following findings are made with respect to the collision of the ferry SuperCat 4 with the Wharf 5 backboard at Circular Quay that occurred on 11 October 2016.

Contributory Factors

3.2 When the master placed the control levers into astern, both gearboxes failed to respond.

3.3 An audio alarm and an effective visual warning were not available to alert the crew when a failure occurred. This significantly reduced the time available to allow for an effective response to the control loss.

3.4 The control failure was not realised by the master or engineer until the controls were placed astern and the vessel failed to slow.

3.5 The back-up control system is isolated when not active and has no access to real time vessel parameters. In order to provide the back-up system with real time data following activation, the engineer is required to follow a protracted and counterintuitive activation procedure.

3.6 SuperCat 4 has a high berthing speed compared to other vessels in the HCF fleet. The master did not have a speed indication readily available at the starboard wing control.

3.7 The higher approach speed reduced time for effective response following the identification of the control failure. However, it was not the initiating factor in the accident sequence.

3.8 The SMS contained a generic ‘umbrella’ procedure for berthing vessels.

3.9 There was no requirement for the master to confirm with the engineer that a transfer of control station is successful.

Other Safety Factors

3.10 The current backboards were designed for heavier vessels. They were designed to crumple and dissipate the energy of a vessel impact. As the modern fleet of ferry vessels are predominantly of lighter construction, the
backboard design causes these vessels to recoil rather than absorbing the impact energy.

3.11 The HCF change management process assumed that the Twin Disc system would capture data.
PART 4 RECOMMENDATIONS

Harbour City Ferries

4.1 On vessels utilising the EC300 controllers, install an audible alarm and improve the effectiveness of existing visual warning lights to indicate manoeuvring control failure.

4.2 Reconfigure the VDRS to ensure that the Twin Disc EC300 data is captured.

4.3 Develop an effective procedure for berthing at dead end wharves that includes testing of controls astern followed by closed loop communication and confirmation between crew.

4.4 Develop an effective procedure for the transfer of control stations that includes verbal communication between the crew confirming successful transfer.

4.5 Install a speed indicator that is readily visible at all control positions and reinforce crew awareness of Schedule 6 of the Marine Safety Regulation 2016 (NSW).

4.6 Review current change management processes to include a thorough risk assessment is conducted. The risk assessment should include all factors which are likely to affect safe operations of the vessel.

Transport for NSW/Roads and Maritime Services

4.7 Review the adequacy of the backboard design to cater for a contemporary fleet configuration and mitigate the risk of passenger injury.
PART 5 REMEDIAL ACTIONS

5.1 HCF confirmed that all SuperCat/Emerald class vessels have been fitted with audible alarms to indicate a failure of the twin-disc controls, with additional clutch status LED indicators.

5.2 HCF confirmed that VDRS was reconfigured to capture the data generated by the Twin Disc EC300 control system.

5.3 HCF confirmed that procedures were improved for berthing at dead end wharfs.

5.4 HCF confirmed that the transfer of control stations procedure is now supported by closed loop communication between the crew.
Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- Transport for NSW
- Harbour City Ferries
- Australian Maritime Safety Authority
- Roads & Maritime Services
- Port Authority NSW