Department for Planning and Infrastructure
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High Speed Thrill Boat Rides

The Safety Dilemma

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Abstract

The recent worldwide interest in outdoor adventure tourism has reached the marine industry in Australia. Boat operators are offering excitement tours and thrill rides on high-powered planing boats. Speeds well in excess of 50 knots are currently advertised by operators in Sydney and overseas.

A dilemma arises for the Marine Surveyor because the tours are promoted as thrill rides. To maximise the excitement the rider must believe or sense there is an element of danger. In fact the greater the perceived danger the greater the thrill! In contrast DPI and other regulatory authorities must ensure the operator provides a safe ride for the passengers, minimising any danger to an acceptable level. The challenge is to ensure this level of safety is achieved without compromising the thrill to such an extent that the ride is no longer attractive to patrons. Although billed as a thrill ride for the patron it can be terrifying for the surveyor who must assure the vessels safety.

There are immediate parallels with amusement park rides. However amusement park rides are usually operated in a controlled environment. The “Mad Mouse” car is constrained by rails and other rides have mechanical linkages. The outdoor excitement ride is held in an environment that is not within the operators’ control and unexpected situations may arise.

This paper examines three High Speed Thrill Ride boats currently operating in Western Australia and compares their survey requirements with those proposed under the NMSC’s new Category F2 Fast Craft draft standard. A recent DPI investigation of a high speed RIB accident in Western Australia is reviewed raising some questions relevant to the thrill ride vessels.

The author lists recommendations to better deal with the survey of High Speed Thrill Ride vessels.

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A. *Introduction*

All vessels operated for commercial gain in Western Australia must comply with the Western Australian Marine Act, 1982. The Act requires the vessels be surveyed in accordance with the Uniform Shipping Laws Code (USL) and other relevant standards called up by that code. The USL Code was first written in the 1980's and although amendments have been issued to 1997 it is not considered adequate for today's light high-speed craft.

One vessel type that causes special safety concern is the High Speed Thrill Ride (HSTR) boat. These boats are of light displacement, highly powered and very manoeuvrable. Surveying these craft to the USL code has proven difficult for the surveyor and leaves much uncertainty for designers and builders.

The NMSC has recently release a draft standard of the NSCV for Special Vessels, Sub section 1C, category F2 Fast Craft5. In doing so they have provided the marine surveyor with a valuable new tool to analyse the safety of these vessels.

This paper summarises the application of the draft standard to three existing HSTR boats currently in survey with the WA Department for Planning and Infrastructure. It also draws on experience gained from an investigation into the capsize of a new 9.6m Rigid Hull Inflatable Boat (RIB). Whilst not a HSTR boat this vessel is of the same hull geometry, power and level of engineering as one of the local HSTR vessels reviewed in this paper. Some of the findings of the accident investigation are highly relevant to HSTR boats.

B. The Safety Dilemma

HSTR boats are designed and operated to excite the passenger. They are actively promoted as providing a thrilling experience. A large component of the thrill is gained from changes in acceleration but another important aspect is the sense of an element of danger. In fact the greater the perceived danger the greater the thrill! In contrast DPI and other regulatory authorities must ensure the operator provides a safe ride for the passengers, minimising the danger to an acceptable level, creating a challenging dilemma for the surveyor, designer and operator.

Photo 1 Airborne

It is a challenge to ensure an acceptable level of safety is achieved without compromising the thrill to such an extent that the ride is no longer attractive to patrons. Consequently, the ride billed as providing a thrill for the patron can be down right terrifying for the marine surveyor who must assure the vessels' safety.

There are immediate parallels with amusement park rides. However amusement park rides are usually operated in a controlled environment. The "Mad Mouse" car is constrained by rails. Still other rides have mechanical linkages. The outdoor excitement ride is held in an environment that is not within the operators' control and unexpected situations may and do arise.

The obvious question is why should a government department survey and effectively assure the safety of this type of vessel. Because the vessel is operating commercially in WA the department is obliged to ensure it meets the requirements of the Marine Act.

Photo 2 Adventure tourism

There is economic pressure for this type of boating activity to continue. The tourist industry is of vital importance to the community in general and adventure tourism can contribute substantially to a local community's income. Although figures are not available for Australia, comparisons can be drawn with the long established New Zealand jetboat industry. In 2000 the then Maritime Safety Authority of New Zealand reported that approximately one million thrill rides are made each year in New Zealand at an average cost of NZ$70 per passenger1. There are also added benefits for the accommodation, food and beverage and other tourism services in the area. Work is created for naval architects, boat builders, repairers and service industries as well as crewing employment opportunities. After assessing the benefits to the community it is evident interest in this type of adventure tourism will increase.

Without a government certificate of survey, legislation in most states would not allow the vessels to operate. Additionally, it is unlikely operators would be able to satisfy insurers.

Although some operators have now been operating for several years the industry as a whole in Australia is still in its infancy. There is no national association or body to represent HSTR boats around the nation.

The very nature of thrill rides is that they have to become more and more extreme as patrons become experienced with the ride. It is likely speeds will increase significantly in the future as operators look for a commercial edge.

The significance of the tourism industry also makes it vulnerable. Should an accident occur with a boat full of foreign tourists the effects could be devastating not just for the passengers but and operator but for the industry as a whole.

C. Tools

Commercial Vessel Safety WA has several HSTR boats currently in survey. A different surveyor from DPI has surveyed each vessel. These surveyors have employed the principals, if not the letter, of the USL code to each vessel. Some vessels have been issued certificates with operational restrictions. Typically these restrictions have limited maximum speed, manoeuvring speed and areas of operation to try and overcome some of the uncertainties presented by this special breed of vessel. More recently we have required increased hull structure and operational experience.

One of the major difficulties when surveying vessels is to be consistent. When the regulations are open to interpretation by individual surveyors' consistency suffers leading to frustration and complaints from designers, builders and operators as well as possible differences in safety level.

The Category F2 Fast Craft draft standard states "Required Outcomes" that must be achieved in chapter 2. Additionally chapter 3 offers a "Deemed to Satisfy" solution as one method of meeting the "Required Outcomes".

The NMSC provides a spreadsheet program, F2 Standards Assistant, to guide the reader through the new draft standard. Three HSTR vessels currently in WA survey have been analysed using the F2 Standards Assistant to compare the draft standard requirements with our previous criteria. Table 1 summarises the input data for the NMSC's Standards Assistant spreadsheet.

Vessel name	Meas. length, Lm, (m)	Max laden speed, V, (kts)	Class & Op. area	Fully laden Disp,D , (t)	Hull form	No. of Pass	No. of Crew	Propulsion
A	10.35	40.0	1D	7.4	Mono	20	2	W/jet
B	8.00	40.0	1C	3.4	Mono	13	1	Outb'd
C	7.95	42.0	1E	4.9	Mono	13	1	W/jet

Table 1. Fast Craft Standards Assistant Input data

The F2 Standards Assistant summarises the parts of the new standard that are applicable to each particular vessel. The F2 Standards Assistant output for the three vessels is presented in Appendix A.

The Category F2 Fast Craft draft standard requires the vessel meets the "Required Outcomes" of Parts C to E of the NSCV plus nine outcomes specific to F2 Fast Craft. These specific "Required Outcomes" are each considered in the appraisal of the three WA HSTR boats.

The F2 Standards Assistant directs the reader to AS 3533-1997[3], the Australian Standard for Amusement Rides and Devices.

(i) Operational Performance

The draft standard requires the vessel be suited to the area of operations, forgiving of human error and be provided with information about the operational characteristics of the vessel.

The "Deemed to Satisfy" solution details investigations, surveys, trials and tests to establish and record the vessels operational performance. While some measurements can be taken and calculations performed, final analysis of the operational characteristics of a HSTR vessel is rather subjective. The draft standard tabulates typical undesirable effects, summarised here for planing monohulls in table 2. The table lists excessive heel, excessive trim, and excessive accelerations without giving any guidance on what is excessive. It also fails to note in what loading condition the trials are to be conducted. Many of the undesirable effects listed are known to be displacement and LCG dependant hence loading is critical to performance. AS 3533 also requires testing. The tests are to be conducted at full speed and service condition with 100% of the design load. Importantly AS 3533 requires the designer (or competent person nominated by the designer) to attend the tests and on completion certify in writing that the device has been tested in accordance with Section 4 AS 3533.1. This imparts a further sense of responsibility on the designer.

WA DPI surveyors come from a wide range of backgrounds, some have marine engineering qualifications, and some have a shipwrighting experience while others have Naval Architecture backgrounds. There are none specifically skilled to assess all of the operational effects of a Fast Craft.

All three of the WA DPI vessels analysed were tested for manoeuvrability, cruise speed and stopping distance. The USL code provides little guidance on the conduct of tests and trials. In each of the three vessels studied the trials have been summarised by the surveyor simply as satisfactory. The increased attention to testing and reporting called for by both the draft standard and AS 3533 is recognised as being very worthwhile. It allows comparison with other vessel data and provides important base data for any forensic investigation. In practice this will require far greater detail than current trials, including analysis by persons experienced with High Speed Craft. The trials should be recorded by video to capture vessel trim and GPS for speed and turn tactical diameter. The HSC code6 gives some guidance on the conduct of trials.

The draft standard is written and intended for vessels that are to be driven in a seaman like manner. The operator of the HSTR boat can oscillate the helm rapidly from port to starboard and vice versa to achieve a manoeuvre known as the Cha-Cha. Crash stops and 360-degree turns, known as Hamilton spins, are other common manoeuvres that do not appear in any texts on good seamanship or boat handling. The vessels are pushed to their structural, engineering and stability limits to excite the patrons.

Type of vessel	**Effect**
All vessels	1. Directional instability or yawing (often coupled to roll and pitch instabilities). 2. Broaching and bow diving in following seas at speeds near to wave speed. 3. Excessive heel during turning, either outward or inward during one or more of displacement, transition or high speed modes. 4. Excessive trim during one or more of displacement, transition or high speed modes. 5. Slamming giving rise to excessive accelerations and potential structural damage. 6. Plough-in in following seas due to insufficient reserve buoyancy forward. 7. Flipping of the craft that might arise from aerodynamic lift at high speed. 8. Horizontal accelerations.

Planing monohulls	9. Bow diving owing to dynamic loss of longitudinal stability when planing which can occur in relatively calm seas. 10. Reduction in transverse stability with increasing speed. 11. Porpoising, coupled with pitch and heave oscillations that can become violent. 12. Chine tripping, occurring when the immersion of a chine generates a strong capsizing moment.

Table 2. F2 Fast craft typical undesirable effects for planning hulls

It is interesting to note that many of the characteristics listed in table 2 as undesirable effects are indeed just the effects the operator of a HSTR is trying to induce albeit while under control!

(ii) Arrangement, accommodation and personal safety

The draft standard "Required Outcomes" for arrangement, accommodation and personal safety cover both the operating compartment and spaces accommodating persons. The outcomes required for the operating compartment require the compartment be located, arranged and equipped so the crew can monitor all hazards.

Good visibility is essential to the operator of a HSTR and the draft standard recognises the importance. Additionally good vision of the patrons is also essential. It has been shown that the riders own behaviour is a major cause of amusement ride injuries[2]. Amusement park rides such as the "big dipper" gives some indication of the thrill to be experienced. The rider can see a steep bit of track or a sharp bend ahead. Most HSTR ride patrons would be unaware of the motions to be expected on the boat. One solution to achieve the required outcome is for the operating compartment to be at the aft end of the vessel where the helmsman has good visibility of the vessel, surrounding waters and the passengers. Any problems need to be identified quickly and the correct action taken. Both WA DPI vessels A and B have the helmsman's station located on a raised platform at the aft end of the boat.

Photo 3 Thrill seeker enjoying (?) a high-g ride with good head support

The crew of vessel A brief passengers prior to departure from the wharf to raise their arm if they are experiencing difficulty. The signal is easily recognisable by the helmsman. Vessel C has the operating compartment in front of the passengers. It would be difficult, with engine, wind and water noise, for the helmsman to identify a passenger problem.

It is very important that ride patrons keep their heads upright and facing forward on high-g rides [4]. Many neck and soft tissue injuries occur due to a change in speed or acceleration when the head is also turned. Some of the newer amusement park rides in the USA arrange to have an activity occur directly in front of the rider at a time of sudden acceleration or deceleration so the rider is facing ahead.

This is more difficult to arrange in an outdoor thrill ride. In a HSTR patrons may well be admiring the view to one side when the boat is put into a crash stop. DPI included seats with head support as a survey requirement for vessel C.

Both the draft standard and AS 3533 require the operating compartment allow the crew (rider operator) to perform their duties without reducing their ability to control the craft. In HSTR vessels the helmsman experiences much the same ride as the patrons. The draft standards “Required Outcomes” are pertinent. Some vessels operating in WA offer little restraint for the helmsman. The accident investigation for the RIB identified the lack of helmsman restraint as a serious defect. The helmsman’s only effective brace was the helm wheel, which eventually failed catastrophically.

Photo 4 RIB helm wheel post accident

The functions of steering, or any other control, and personal restraint must be separated as far as possible. These issues are also addressed in sections 2.9 and 3.11 of AS 3533. DPI now requires high-speed vessels to have welded stainless steel helm wheels. Additionally structural connections on steering wheels shall not be covered with permanently moulded grips. Any cover or grip is to be able to be removed to enable the structure to be inspected. The RIB investigation noted the vessels helm wheel had been inspected the day before the accident during the operator’s routine scheduled maintenance. Although visibly distorted it was considered still fit for purpose. The pressed stainless steel rim to aluminium spoke connection was hidden from detailed inspection by the moulded rubber grip. Had the grip been able to be removed it is most likely the wheel would have been discarded. DPI are considering adopting Project P-22, Steering Wheels published by the ABYC Standards and Recommended Practices for Small Craft for future high speed vessels.

Photo 5 Helm wheel failed structural connection hidden by grip rubber

In the event of the helmsman being thrown from his station or incapacitated all three of the WA NSTR vessels will continue on their way. The draft standard does not mention any “dead man controls” however AS 3533 section 3.10.2 requires emergency stop controls. Additionally section 3.3.4 refers to a “maintain contact button” or “timing device” to bring the device (boat) to its stationary position in the normal stopping sequence.

Many of the principals of AS 3533 can be applied directly to the HSTR vessel. However, in some instances it stops short of providing absolute guidance for the surveyor. This is certainly the case for one of the more contentious issues, that of seat belts or other forms of personal restraint. Although AS 3533 requires restraints and locking systems for rides "*where by the nature of the device, patrons may –*

> *(a) be ejected owing to the motion of the device*
> *(b) be moved suddenly and unexpectedly*
> *(c) increase the risk to themselves or others through not being seated for the duration of the ride"*

However what appears clearly prescriptive is undone in the following note *"Restraints using mechanical releases are not considered suitable for waterborne rides"*. It goes further with section 2.8.9 "***Exceptions.*** *Where a hazard identification and risk assessment process has shown that, because of the nature of the device, a safer outcome is achieved by enabling the patron to part company with the vehicle in the event of a collision (eg. Bobsleds) then restraints need not be provided".*

The fitting of personal restraints on high-speed boats is a hotly debated issue within our own office and I suggest amongst surveyors around the nation. The case "for" is supported by reported incidents where passengers have sustained injury due to lack of restraint. WA vessel C has recently reported such an accident. Passengers are generally unaware of the motion of a High Speed Vessel. Additionally, part of the thrill of a HSTR vessel is the unexpected nature of the manoeuvres. Passenger ages may vary from the young to elderly and some may have physical and mental disabilities. As previously noted in reference 2 patrons behaviour can contribute to ride injuries. Our local operators have also reported incidents of passengers trying to leap from their seat to heighten the thrill as the boat launches off waves.

The case "against" enforcing the fitting of personal restraints centres on the difficulty in releasing a restraint when up side down under water. Surveyors who have undertaken the helicopter crash training course in Fremantle harbour talk of disorientation when suddenly immersed inverted in cold water - and they were prepared for it. Photo 6 shows seat damage resulting from water impact when the RIB landed upside down. The passenger may not have faired so well if still strapped to the seat.

Well-known power boating author, Dag Pike, recommends high-speed powerboat crew wear 5-point safety harnesses. In his book Fast Powerboat Seamanship[7] he notes the wearing of seat belts is mandatory in offshore powerboat racing.

Vessel A has voluntarily fitted lap belts after a short period of operation. The operator felt there was less likelihood of risky passenger behaviour if they were initially instructed to keep their lap belts on. Vessel C was required to fit high back seats and 5 point harnesses for helmsman and passengers as a condition of survey. Since then the helmsman has successfully applied for exemption from wearing the harness himself while driving as it restricted his movement.

He does endorse the passengers wearing harnesses. Vessel B has low backed seats and no personal restraint.

The draft standard requires the fitting of lap belts only.

The draft standard “Required Outcomes” state the accommodation spaces must be designed and arranged to protect the passengers’ health and safety from the risks of accelerations and decelerations.

Photo 6   Seat damage resulting from RIB capsize

By their very nature most HSTR boats are extremely noisy. Engine, water and wind noise combine with thumping music to drown out everything else. A passenger communication system of hand signals is entirely appropriate.

Many of the manoeuvres are dramatic and impart high accelerations on the vessel and its equipment. Items such as seating, which may appear quite robust on a conventional vessel, can distort markedly under load. Trials should be conducted with the seats fully occupied. Distortion can be measured during extreme manoeuvres with a simple dial gauge indicator. NSW Maritime report a passenger suffered a crushed and broken finger on a HSTR boat by having it wedged in a handrail when the weight of the passenger beside her shifted during a sharp turn. The handrail was subsequently modified to smooth out potential "finger traps".

The “Required Outcomes” of the draft standard do not specifically address external seating however the “Deemed to Satisfy” solution precludes external seating unless it is additional to the full compliment provided in sheltered spaces. Presumably this would be the subject of an equivalent solution application. Vessel A was required to issue passengers with protective glasses hats and jackets as a condition of survey.

All three WA DPI vessels would meet the “Deemed to Satisfy” solution for collision accelerations. However, it is noted vessel C has its fuel tanks located in the collision zone.

(iii) Watertight and weather tight integrity

WA HSTR boats A and C meet the requirements of one compartment subdivision. The below deck volume of the vessel B is filled with polyurethane foam. The vessel also has the benefit of the 5 compartment inflatable collar. As all of these vessels have a well deck configuration they would not meet the “Deemed to Satisfy” solution of the standard for reserve buoyancy.

(iv) Construction

The standard requires attention to increased loads, dynamic loads and fatigue loads, which may act on the craft at maximum speed. Attention is also drawn to the support for heavy masses required due to collision or impact.

The standard offers two “Deemed to Satisfy” solutions;

i) The standards specified in part C section 3 to the extent that they fall within the expressed application of that section; or
ii) The craft shall be designed, constructed and maintained in accordance with the rules of a Classification Society.

The difficulty here is that both the solutions above rely on the boat being operated in a seaman like manner. It is clearly possible to drive a high-speed light craft to destruction if one is not experienced. HSTR boats are really pushed to the limit and require considerably more robust scantlings than other vessels of a similar maximum speed. As an analogy, a police pursuit car is considerable modified compared with the same model family car.

The structures of the three WA vessels all meet the AS4132.1 for Heavy Weather craft. The “Heavy Weather” craft criteria increase the design pressure by 50% over the “Other” craft criteria. Although this simplistic approach has proven to be reasonably effective to date it should be noted that it allows the same structure for a 9m boat travelling 15.5 knots as it would at 50 knots (given that displacement and draft remain constant). A brief investigation has revealed they would also satisfy the requirements of Lloyd’s rules for Special Service Craft.

WA vessels B and C have reported no structural damage during the short time they have been operated. Vessel A has experienced repeated cracking of the bottom plate forward which has been repaired and strengthened on three occasions.

Records should be kept and compared to highlight any structural failures that can be attributed to regulation formulae so factors of safety can be increased accordingly.

(v) Engineering

(a) Propulsion systems

The draft standard requires an appropriate level of reliability, verification and protection of essential systems and manual or alternative means of control.

All three WA vessels meet the requirements of the USL code section 9, Engineering.

WA experience to date has indicated engine and propulsion system failures have not presented an unacceptable risk. The WA vessel A has suffered a number of failures of its propulsion system. The vessel was initially launched with 2 x 250Hp Mercury outboard motors. There were repeated gearbox and drive leg failures. Later, 2 x 300Hp Yanmar diesel engines were coupled to Bravo 2 stern leg drives. Again after further difficulties the stern drive legs were removed. The hull was extended 700mm and twin Castoldi 06 water jets fitted. The Castoldi jets have recently been replaced with 2 x 274 Hamilton water jets.

Propulsion system reliability tends to be self-regulating. The equipment is treated harshly in these vessels. Failed systems mean costly repairs and vessel downtime.

Both the draft standard and AS 3533 require engine overspeed protection. Most electronically managed marine engines suitable for small craft including the larger outboards are already equipped with over speed protection that will satisfy the "Required Outcomes" of the draft standard.

The WA DPI vessels are fitted with standard propulsion systems as summarised in table 3.

Vessel	Installed Power	Drive	Steering
A	2 x 300 Hp Yanmar Diesel	Hamilton Jet	Manual hydraulic
B	2 x 225 Hp Yamaha Petrol	Outboard	Manual hydraulic
C	2 x 315 Hp Yanmar	Hamilton Jet	Pulley and cable

Table 3. WA HSTR Propulsion systems

(b) Directional control systems

The Standards Assistant reveals all three vessels require backup directional control systems.

The "Deemed to Satisfy" solution offered by the draft standard is "*so that the likelihood of loss of directional control while travelling at high speed in **normal** operation is extremely remote.*"

Alarms that indicate failure of directional control devices are required by the standard. However, by the time an alarm has gone off the operator is most probably well aware he has lost control of the boat. The draft standard requires FMEA for;

a) The directional control system.

b) Propulsion machinery systems and their associated controls.

The draft standard notes that engineered solutions for controlling risk are preferred over operational solutions.

The capsize of a RIB on the Swan River highlights the severe consequences of steering gear failure at high speed.

Photo 5 Thrills and spills

RIB Capsize

(a) The incident

Last November a then recently launched RIB was being used for boat handling training exercises on the Swan River with six persons, including the helmsman, on board the vessel. The training program called for practice of tight high-speed turns. The training had been routinely carried out over the previous three months and the procedures were well known to the helmsman.

The helmsman looked for calm clear water to conduct the training exercise and decided the area around Lucky Bay was most suitable. After ensuring there were no other vessels, water users, objects in the water and waves or wakes in the vicinity he advised all on board of his intention to conduct a tight high-speed turn.

He gave the signal for a turn to port and checked that all on board acknowledged his signal. The helmsman reduced engine speed to 5200 rpm (approximate vessel speed of 41 knots) and reduced trim to just below the half trim marker. He then braced himself and proceeded to turn the helm fully to port.

Approximately 120 degrees into the turn the rim of the helm wheel broke from its spokes. The helmsman reports the vessels bow rose violently and the vessel turned sharply to starboard. The vessel capsized to starboard. All occupants were thrown clear of the vessel before it landed upside down narrowly missing some of the passengers. Review of the passengers' statements and discussions with the helmsman show concurrence that there was a sudden change of course to starboard and the bow rose violently.

There were no major injuries. Minor injuries consisting of bruises and scratches were reported.

The vessel although structurally intact incurred extensive water damage to engines and electronics. Seat backs were bent and steering system components broken. It was estimated vessel repairs would be in the order of $100,000 to $130,000.

All occupants reported the accident happened so quickly they were unsure exactly what happened. The persons sitting in the aft most seats nearest to the engines reported feeling a sudden jolt. When interviewed the helmsman believed the helm wheel failure was the cause of the accident. The builder believes the vessel having too much trim as it entered the turn resulted in the planing instability commonly referred to as chine walking caused the accident and consequently cited helmsman error as the cause of the accident.

(b) Post accident survey

A post accident survey was conducted on the vessel. The following items of damage were considered relevant to the investigation;

- *(i)* *The helm steering wheel was broken from the spokes. See photos 4 and 5.*
- *(ii)* *The steering hydraulic ram extension rod was broken where it connected to the link arm. See photo 6.*
- *(iii)* *The link arm was bent. See photo 6.*
- *(iv)* *The starboard engine cowl was damaged.*

(v) *The starboard seat backs were bent aft.*

(c) Conclusion

Based on the available evidence, the investigator concluded:

(i) *The RIB capsized as a result of a steering system failure. The most likely cause of the accident was due to the failure of the hydraulic cylinder rod end and drag link. Once released the engines have streamlined, changing the direction of thrust to impart a starboard moment on the vessel.*

(ii) *The drag link bar was incorrectly sized for this application.*

(iii) *The connection between the extension rod end and the drag bar was inadequate for the application.*

(iv) *The helm wheel failed as the helmsman responded to the loss of control when the extension rod failed.*

(v) *The helm wheel was inadequate and would have failed soon after this event if not discovered before.*

(vi) *The starboard side seat backs were bent and the starboard engine cover damaged when the vessel landed upside down and stern first on the water.*

As a result of the RIB capsize the steering gear on WA DPI vessel B was redesigned and replaced. None of the vessels in WA survey have a backup or emergency steering system. However, It is considered the systems are now so robust as to make catastrophic failure extremely unlikely.

Photo 6 Failed drag link bar and hydraulic ram extension rod

None of the reviewed vessels have been subject to FMEA for any of their systems.

(vi) Stability and Subdivision

The three WA vessels have had their stability assessed in accordance with the USL code, Section 8, Stability criteria. Vessels B and C meet the P & Q criteria. Vessel A satisfies the C2 criteria. It is considered all the reviewed vessels would meet the NSCV subsection 6 criteria without modification.

(vii) Equipment

The “Required Outcomes” refer to location of lifesaving equipment, scope and accuracy of navigation and avoidance equipment.

Additional to section 7 of the NSCV the vessels would need to have speed and distance measuring equipment, an echo-sounding device and a radar transponder. None of the three WA vessels are fitted with echo-sounding devices or radar transponders.

It is noted WA vessels A and B could have a reduced anchor weights by the “Deemed to Satisfy” solution of the draft standard.

(viii) Provision of Essential Safety Information

The draft standard requires both a craft operating manual and a maintenance and servicing manual. Of the three WA HSTR boats operating in WA boat C is the only one required for survey to supply both a vessel operating manual and a maintenance and servicing manual. The maintenance manual has a checklist of items that are to be checked on a monthly, daily and voyage basis. The operation of a HSTR vessel is in some ways more analogous to a light aircraft than a conventional vessel. Just as a light aircraft pilot has a walk around the plane and checks critical components so do the crew of vessel C.

(iix) Crewing and competencies

The draft standard notes a number of Fast Craft specific competencies. The three WA HSTR vessel operators all have the minimum requirement of Coxswains ticket. Additionally the vessel C was required that the driver have at least 25 hours of experience on the boat in the designated operational area before carrying passengers. It is noted that with each serious accident involving NZ jetboat industry the regulations governing crew experience have become more stringent. The NZ Maritime Rules Part 80 requires “*Any person driving a jet boat… must have not less than 50 hours experience as a jet boat driver, under the supervision of an experienced driver before driving solo with passengers. The 50 hours experience must include a period, acceptable to the authorised person, on the river on which that driver is to operate commercially*”.

The increased crew competencies required by the draft standard will help reinforce the critical role of the High Speed Craft crew. Poor or inexperienced helming can lead to structural failure or catastrophic dynamic instability. Operators, designers and builders need to be fully aware of the potential hazard.

John Cameron, the Chief Inspector of Hong Kong Marine police states[8] "the highest requirement is the specialist training for craft capable of 45 – 60 knots." He concludes that everyone's life is in the hands of the helmsman.

(ix) Operational Requirements

The draft standard requires a documented risk management be applied to local factors. None of the three reviewed vessels have been required to submit a risk analysis for their current survey.

All three WA HSTR vessels would have to provide a safety management system complying with part E of the NSCV.

Photo 7 Risk analysis is required to identify local factors

The draft standard states "*a person carrying out a risk assessment should as far as practicable, determine a method of assessment that adequately addresses the hazards identified, and includes one, or a combination of the following:*

- *(a) A visual inspection of the vessel and its associated environment.*
- *(b) Auditing.*
- *(c) Testing.*
- *(d) A technical or science evaluation.*
- *(e) An analysis of injury and near miss data.*
- *(f) Discussions with designers, builders, suppliers, owners, employers, employees, and other relevant parties.*
- *(g) A quantitative risk analysis*
- (h) *Professional judgment with or without a qualitative risk analysis."*

The author considers it probable that most risk analysis submitted by builders and designers will emphasise methods (a), (f) and (h) and may not be very scientific in nature. The assessing surveyor will have the added difficulty of identifying suitable professionals and experts with Fast Craft experience.

An analysis of technical and near miss data is one of the methods of assessing the risk. It would be extremely valuable if a central authority could collate data for HSTR vessels, or perhaps even all vessels with the FAST notation.

D. Recommendations

It is noted that the NSCV has attempted to provide safety standards that are not vessel type specific. However, as the HSTR vessel is so extreme it is recommended the following specific requirements be included in the survey of all HSTR vessels;

- All plan approval for HSTR vessels nationwide are undertaken by one central organisation / authority.
- A detailed database is established for all the FAST notated vessels (would include HSTR vessels).
- An incident reporting system be used that will publicly detail all FAST (and HSTR) notated vessel incidents.
- There be an increased number of surveys for HSTR craft and a summary of the findings of these surveys be sent to the plan approval organisation.
- A standard trials procedure is adopted for HSTR boats.
- Example documentation is provided for common FMEA and Risk Analysis cases for typical FAST notated vessels.
- Personal restraints (in excess of lap belts) are made compulsory on HSTR vessels.
- Seats with neck and head support are made compulsory on HSTR vessels.
- All HSTR vessel throttle controls are fitted with a “dead-man” switch.
- HSTR vessels are fitted with helm wheels that meet the requirements of ABYC P-22.
- The structure of HSTR vessel helm wheels must be readily accessible for inspection. Permanently moulded grips covering structural connections are not acceptable.

E. Conclusion

The draft F2 Fast Craft section of the NSCV is a welcome tool to assist the Marine Surveyor with survey of the difficult HSTR boats. The draft standard recognises that the design, construction and survey of modern high speed light craft is a specialist area that requires detailed attention.

The three reviewed WA DPI vessels fall short of the requirements of the draft standard typically in the areas of documentation, namely the Risk Analysis, Systems FMEA, Craft Operating Manuals and Maintenance and Servicing Manuals. These are also areas where the small craft builders are traditionally weak. Sample documents and guidance notes would be of great benefit. It would also help if we had a list of consultants specialised in this work.

The draft standard requires a far more professional, documented approach by the designer, builder, surveyor and operator than has been evident in the small craft industry previously. It is envisaged there will be some resistance from industry to the new approach. Good education will be required to achieve this shift in the industry. Those that can achieve it will form a barrier to entry for the unprofessional and backyard operators which may increase costs but have a flow on effect to improve small craft safety generally.

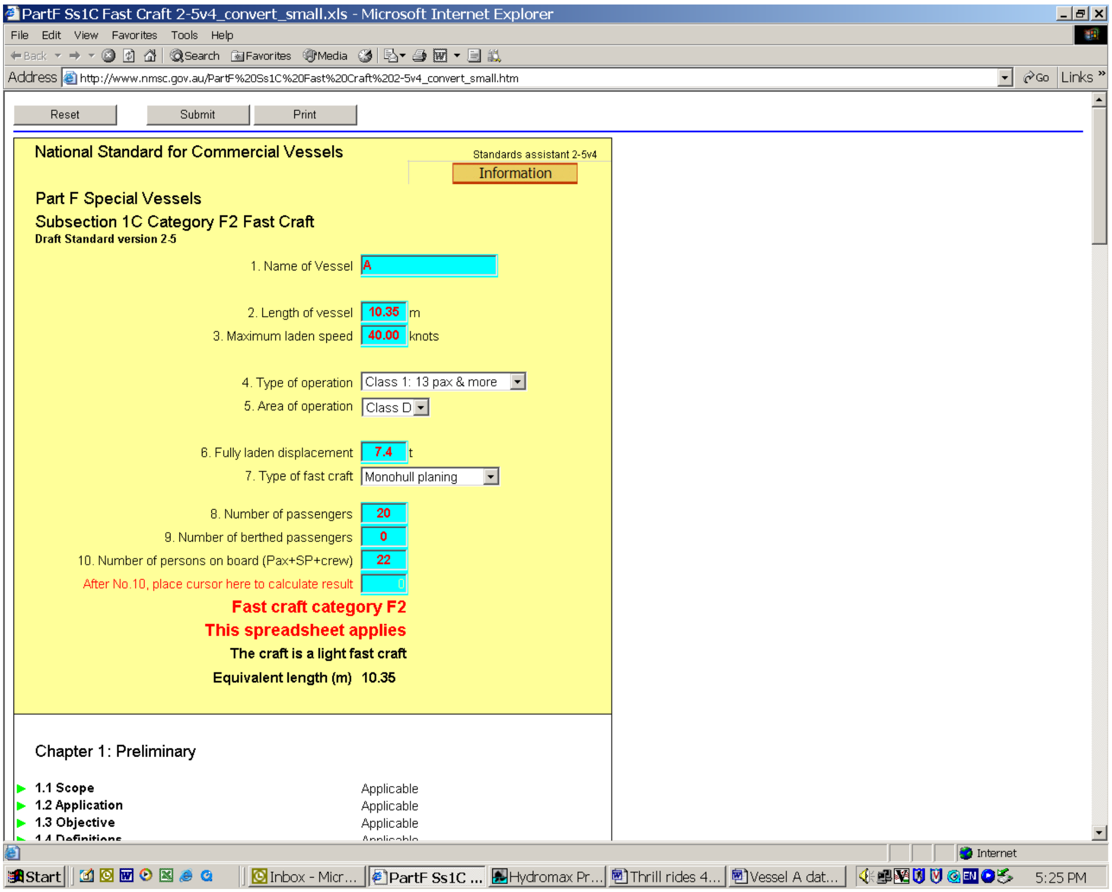
F. Definitions

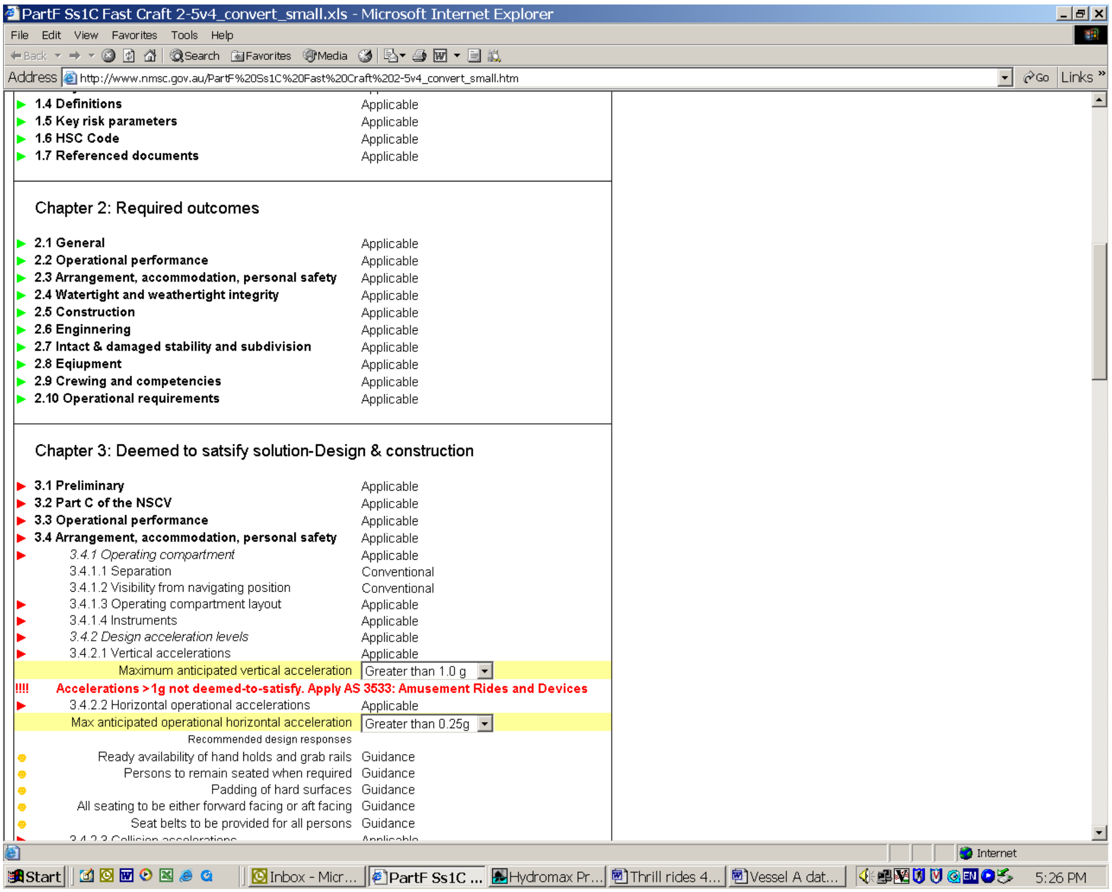
ABYC	American Boat and Yacht Council
FMEA	Failure Mode and Effects Analysis
HSC Code	International Code of Safety for High Speed Craft
HSTR	High Speed Thrill Ride
LCG	Longitudinal Centre of Gravity
NMSC	National Marine Safety Committee
NSCV	National Standard for Commercial Vessels
WA DPI	Western Australia Department for Planning and Infrastructure
risk	the chance that one or more hazards will cause something to happen that will have a detrimental impact upon safety. It is measured in terms of the likelihood and consequences of injury, illness or environmental damage.

G. *References*

1. Review of Safety Performance of Commercial Jet Boat Operations in New Zealand, maritime safety Authority of New Zealand, March 2001.
2. Woodcock, K, The THRILL program, Ryeson University, 2006
3. AS 3533.1-1997, Australian Standard, Amusement Rides and devices, Part 1: Design and Construction
4. Dynamic forces and patron safety, www.saferparks.org
5. NSCV, Part F, Special Vessel, Section 1, Fast craft, Sub section 1C, Category F2 fast craft
6. 2000 HSC Code, IMO, IMO 2001
7. Pike, D. Fast Powerboat Seamanship: The Complete Guide to Boat Handling, Navigation and Safety.
8. Cameron, J. Hong Kong's High Speed interceptors: The Challenges of Safety, Training and Crewing. Work Boat World, January 2005.

Appendix A. F2 Standards Assistant output for Vessel A.





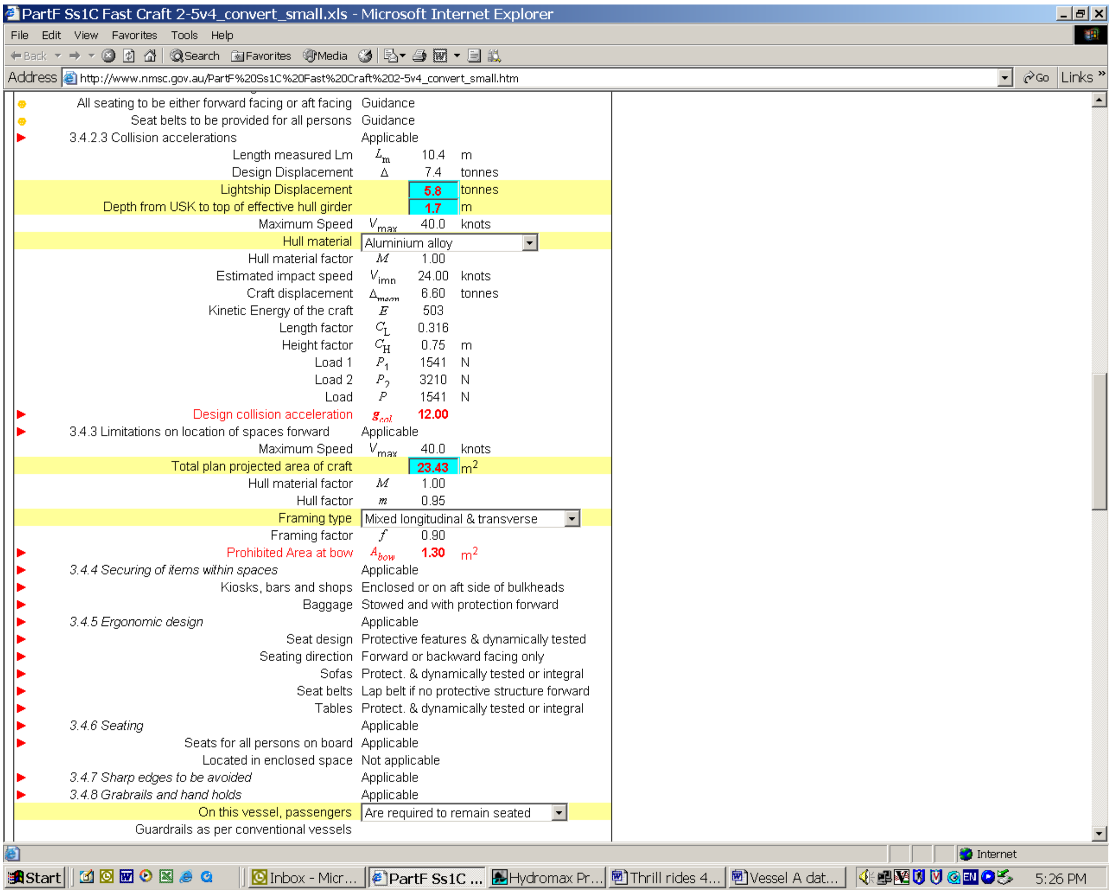
1.4 Definitions	Applicable
1.5 Key risk parameters	Applicable
1.6 HSC Code	Applicable
1.7 Referenced documents	Applicable

Chapter 2: Required outcomes

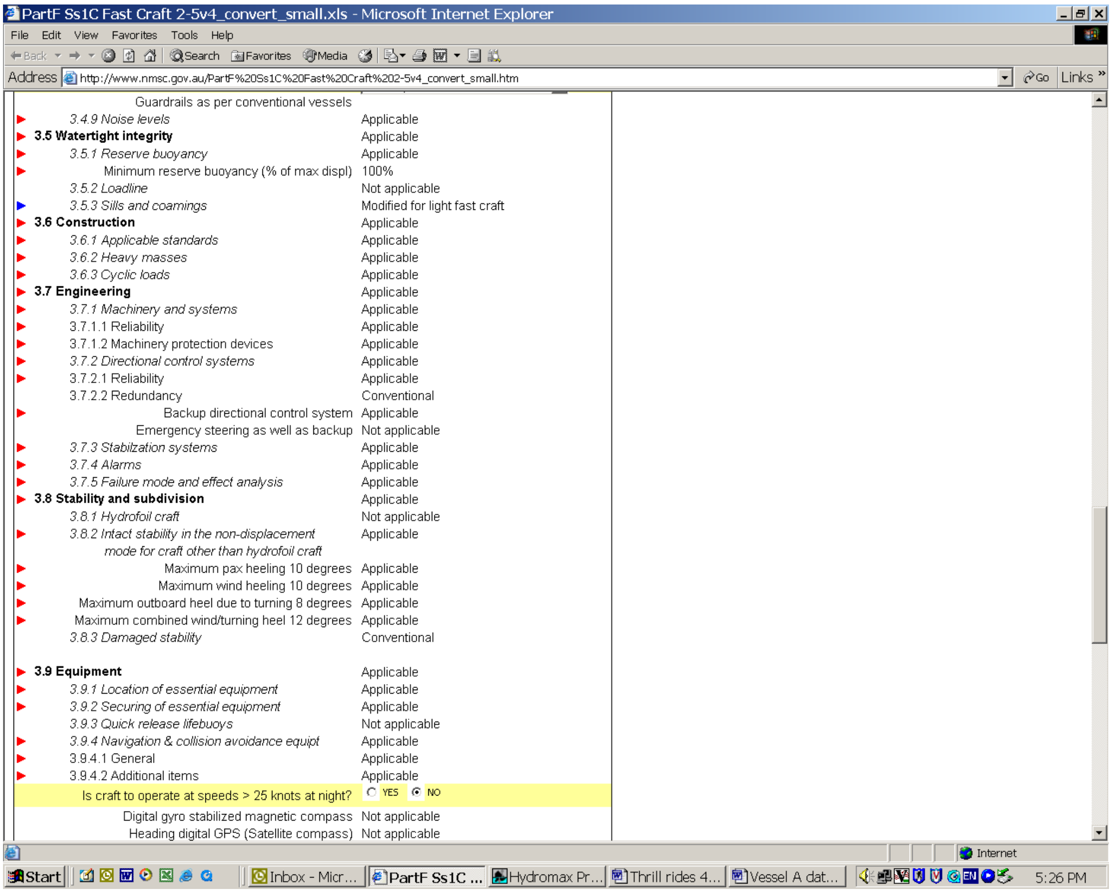
2.1 General	Applicable
2.2 Operational performance	Applicable
2.3 Arrangement, accommodation, personal safety	Applicable
2.4 Watertight and weathertight integrity	Applicable
2.5 Construction	Applicable
2.6 Enginnering	Applicable
2.7 Intact & damaged stability and subdivision	Applicable
2.8 Eqiupment	Applicable
2.9 Crewing and competencies	Applicable
2.10 Operational requirements	Applicable

Chapter 3: Deemed to satsify solution-Design & construction

3.1 Preliminary	Applicable
3.2 Part C of the NSCV	Applicable
3.3 Operational performance	Applicable
3.4 Arrangement, accommodation, personal safety	Applicable
3.4.1 Operating compartment	Applicable
3.4.1.1 Separation	Conventional
3.4.1.2 Visibility from navigating position	Conventional
3.4.1.3 Operating compartment layout	Applicable
3.4.1.4 Instruments	Applicable
3.4.2 Design acceleration levels	Applicable
3.4.2.1 Vertical accelerations	Applicable
Maximum anticipated vertical acceleration	Greater than 1.0 g
!!!! **Accelerations >1g not deemed-to-satisfy. Apply AS 3533: Amusement Rides and Devices**	
3.4.2.2 Horizontal operational accelerations	Applicable
Max anticipated operational horizontal acceleration	Greater than 0.25g
Recommended design responses	
Ready availability of hand holds and grab rails	Guidance
Persons to remain seated when required	Guidance
Padding of hard surfaces	Guidance
All seating to be either forward facing or aft facing	Guidance
Seat belts to be provided for all persons	Guidance
3.4.2.3 Collision accelerations	Applicable



All seating to be either forward facing or aft facing	Guidance		
Seat belts to be provided for all persons	Guidance		
3.4.2.3 Collision accelerations	Applicable		
Length measured Lm	L_m	10.4	m
Design Displacement	Δ	7.4	tonnes
Lightship Displacement		5.8	tonnes
Depth from USK to top of effective hull girder		1.7	m
Maximum Speed	V_{max}	40.0	knots
Hull material	Aluminium alloy		
Hull material factor	M	1.00	
Estimated impact speed	V_{imn}	24.00	knots
Craft displacement	Δ_{mom}	6.60	tonnes
Kinetic Energy of the craft	E	503	
Length factor	C_L	0.316	
Height factor	C_H	0.75	m
Load 1	P_1	1541	N
Load 2	P_2	3210	N
Load	P	1541	N
Design collision acceleration	g_{col}	12.00	
3.4.3 Limitations on location of spaces forward	Applicable		
Maximum Speed	V_{max}	40.0	knots
Total plan projected area of craft		23.43	m^2
Hull material factor	M	1.00	
Hull factor	m	0.95	
Framing type	Mixed longitudinal & transverse		
Framing factor	f	0.90	
Prohibited Area at bow	A_{bow}	1.30	m^2
3.4.4 Securing of items within spaces	Applicable		
Kiosks, bars and shops	Enclosed or on aft side of bulkheads		
Baggage	Stowed and with protection forward		
3.4.5 Ergonomic design	Applicable		
Seat design	Protective features & dynamically tested		
Seating direction	Forward or backward facing only		
Sofas	Protect. & dynamically tested or integral		
Seat belts	Lap belt if no protective structure forward		
Tables	Protect. & dynamically tested or integral		
3.4.6 Seating	Applicable		
Seats for all persons on board	Applicable		
Located in enclosed space	Not applicable		
3.4.7 Sharp edges to be avoided	Applicable		
3.4.8 Grabrails and hand holds	Applicable		
On this vessel, passengers	Are required to remain seated		
Guardrails as per conventional vessels			



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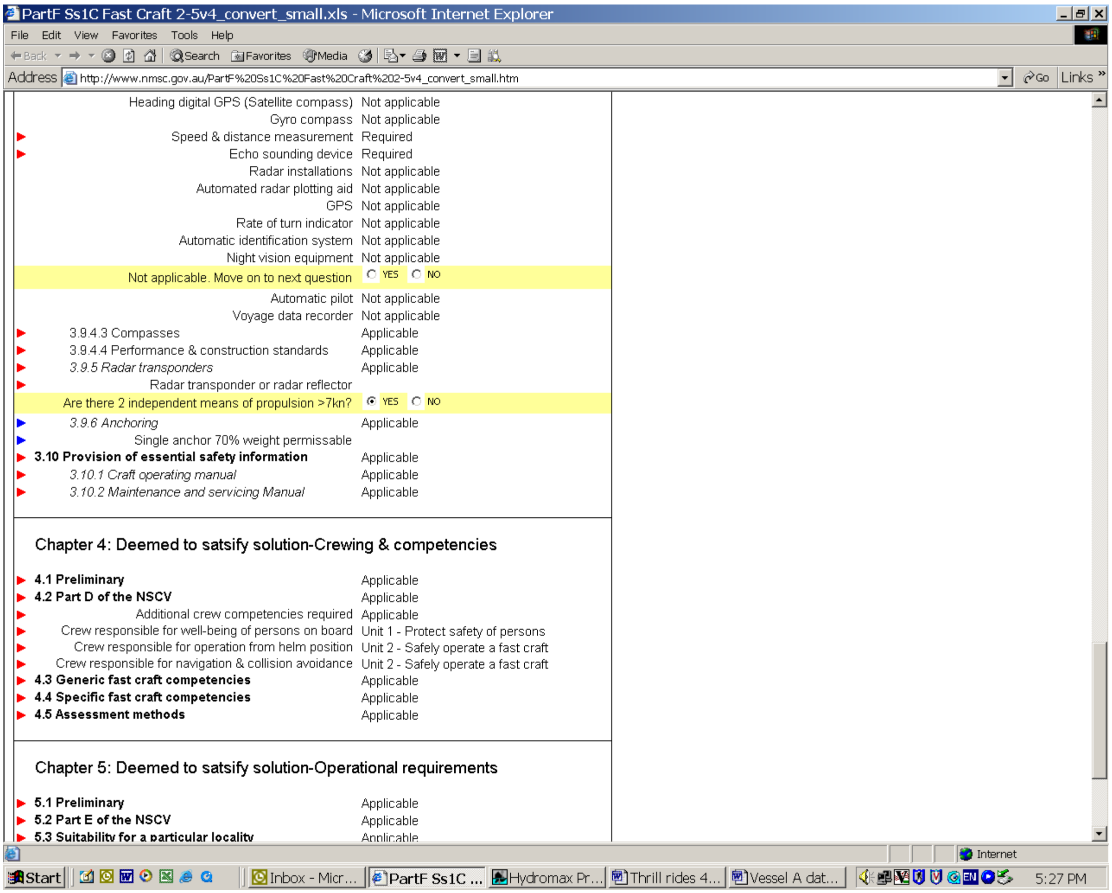
Guardrails as per conventional vessels	
3.4.9 Noise levels	Applicable
3.5 Watertight integrity	Applicable
3.5.1 Reserve buoyancy	Applicable
Minimum reserve buoyancy (% of max displ)	100%
3.5.2 Loadline	Not applicable
3.5.3 Sills and coamings	Modified for light fast craft
3.6 Construction	Applicable
3.6.1 Applicable standards	Applicable
3.6.2 Heavy masses	Applicable
3.6.3 Cyclic loads	Applicable
3.7 Engineering	Applicable
3.7.1 Machinery and systems	Applicable
3.7.1.1 Reliability	Applicable
3.7.1.2 Machinery protection devices	Applicable
3.7.2 Directional control systems	Applicable
3.7.2.1 Reliability	Applicable
3.7.2.2 Redundancy	Conventional
Backup directional control system	Applicable
Emergency steering as well as backup	Not applicable
3.7.3 Stabilzation systems	Applicable
3.7.4 Alarms	Applicable
3.7.5 Failure mode and effect analysis	Applicable
3.8 Stability and subdivision	Applicable
3.8.1 Hydrofoil craft	Not applicable
3.8.2 Intact stability in the non-displacement mode for craft other than hydrofoil craft	Applicable
Maximum pax heeling 10 degrees	Applicable
Maximum wind heeling 10 degrees	Applicable
Maximum outboard heel due to turning 8 degrees	Applicable
Maximum combined wind/turning heel 12 degrees	Applicable
3.8.3 Damaged stability	Conventional
3.9 Equipment	Applicable
3.9.1 Location of essential equipment	Applicable
3.9.2 Securing of essential equipment	Applicable
3.9.3 Quick release lifebuoys	Not applicable
3.9.4 Navigation & collision avoidance equipt	Applicable
3.9.4.1 General	Applicable
3.9.4.2 Additional items	Applicable
Is craft to operate at speeds > 25 knots at night?	YES NO
Digital gyro stabilized magnetic compass	Not applicable
Heading digital GPS (Satellite compass)	Not applicable



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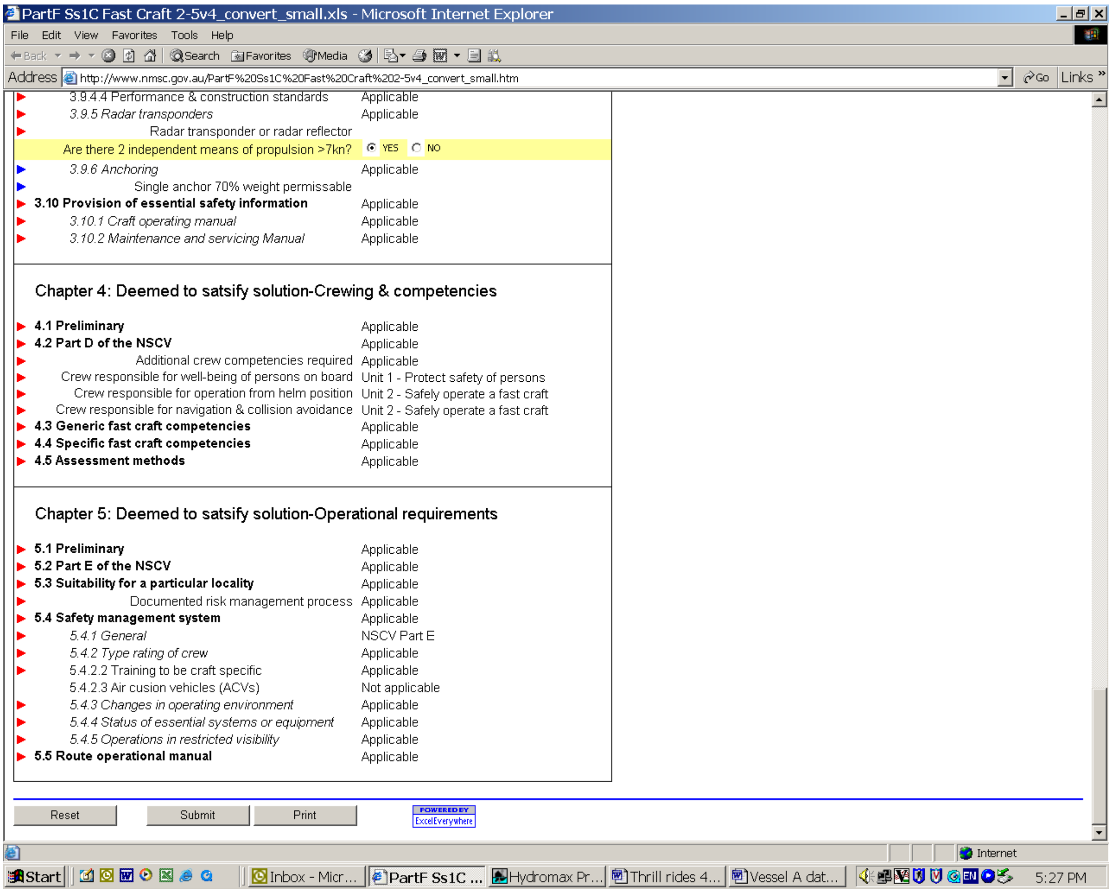
Heading digital GPS (Satellite compass)	Not applicable
Gyro compass	Not applicable
Speed & distance measurement	Required
Echo sounding device	Required
Radar installations	Not applicable
Automated radar plotting aid	Not applicable
GPS	Not applicable
Rate of turn indicator	Not applicable
Automatic identification system	Not applicable
Night vision equipment	Not applicable
Not applicable. Move on to next question	YES NO
Automatic pilot	Not applicable
Voyage data recorder	Not applicable
3.9.4.3 Compasses	Applicable
3.9.4.4 Performance & construction standards	Applicable
3.9.5 Radar transponders	Applicable
Radar transponder or radar reflector	
Are there 2 independent means of propulsion >7kn?	YES NO
3.9.6 Anchoring	Applicable
Single anchor 70% weight permissable	
3.10 Provision of essential safety information	Applicable
3.10.1 Craft operating manual	Applicable
3.10.2 Maintenance and servicing Manual	Applicable

Chapter 4: Deemed to satsify solution-Crewing & competencies

4.1 Preliminary	Applicable
4.2 Part D of the NSCV	Applicable
Additional crew competencies required	Applicable
Crew responsible for well-being of persons on board	Unit 1 - Protect safety of persons
Crew responsible for operation from helm position	Unit 2 - Safely operate a fast craft
Crew responsible for navigation & collision avoidance	Unit 2 - Safely operate a fast craft
4.3 Generic fast craft competencies	Applicable
4.4 Specific fast craft competencies	Applicable
4.5 Assessment methods	Applicable

Chapter 5: Deemed to satsify solution-Operational requirements

5.1 Preliminary	Applicable
5.2 Part E of the NSCV	Applicable
5.3 Suitability for a particular locality	Applicable



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Address http://www.nmsc.gov.au/PartF%20Ss1C%20Fast%20Craft%202-5v4_convert_small.htm

3.9.4.4 Performance & construction standards	Applicable
3.9.5 Radar transponders	Applicable
Radar transponder or radar reflector	
Are there 2 independent means of propulsion >7kn?	YES / NO
3.9.6 Anchoring	Applicable
Single anchor 70% weight permissable	
3.10 Provision of essential safety information	Applicable
3.10.1 Craft operating manual	Applicable
3.10.2 Maintenance and servicing Manual	Applicable

Chapter 4: Deemed to satsify solution-Crewing & competencies

4.1 Preliminary	Applicable
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Additional crew competencies required	Applicable
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Crew responsible for operation from helm position	Unit 2 - Safely operate a fast craft
Crew responsible for navigation & collision avoidance	Unit 2 - Safely operate a fast craft
4.3 Generic fast craft competencies	Applicable
4.4 Specific fast craft competencies	Applicable
4.5 Assessment methods	Applicable

Chapter 5: Deemed to satsify solution-Operational requirements

5.1 Preliminary	Applicable
5.2 Part E of the NSCV	Applicable
5.3 Suitability for a particular locality	Applicable
Documented risk management process	Applicable
5.4 Safety management system	Applicable
5.4.1 General	NSCV Part E
5.4.2 Type rating of crew	Applicable
5.4.2.2 Training to be craft specific	Applicable
5.4.2.3 Air cusion vehicles (ACVs)	Not applicable
5.4.3 Changes in operating environment	Applicable
5.4.4 Status of essential systems or equipment	Applicable
5.4.5 Operations in restricted visibility	Applicable
5.5 Route operational manual	Applicable

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