AMPASafetyEquipmentProject

FORMALSAFETYASSESSMENT

PersonalProtectiveEquipment
inMarinePilotLadderTransfers

Part3:Headprotection

preparedby

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Important Note

The information in this report replaces the report ‘Preliminary evidence regarding helmets’ prepared under the AMPA Safety Equipment Project in April 2007. The report dated August 2008 provides extensive revisions and additions, and this report provides some further minor revisions.

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1. INTRODUCTION

1.1 Project aims

The aim of the AMPA Safety Equipment Project is to investigate the usability of selected personal protective equipment (PPE) and marine safety equipment used by marine pilots in Australia during the pilot ladder transfer between the pilot vessel and commercial vessels. This investigation follows a ‘human factors’ and ergonomics approach as it focuses on the application and use of equipment in a given context, with consideration for the users, the influence of the environment, the organization of the task, work systems, and the interaction with other equipment.

The results from these investigations will provide practical and evidence-based advice regarding PPE items that reduce risk, increase risk and/or have no effect on pilot safety during the pilot ladder transfer. Pilots and their employers can then use this information to contribute towards their own assessments in managing and reducing risk in their specific work environments and with their own pilots.

1.2 Project methodology

Formal Safety Assessments

The methodology used for these reports is based on both the ‘Formal Safety Assessment’ as used by the International Maritime Organization (IMO), and on the requirements under Australian legislation for Risk Assessment and Risk Management.

Both the Formal Safety Assessment and the Risk Management approach have the same key elements:

*Hazard identification*
This involves identifying hazards in tasks. In this project this step includes considering actual or potential hazards when the equipment is used in the pilot transfer and hazards when the equipment is not used.

*Risk assessment*
In this phase the likelihood and consequence of the hazards are assessed and the relative contribution of the different factors that impact on this risk are evaluated and compared.

*Risk control*
Risk ‘controls’ or risk mitigation strategies are provided to address the assessed risks. In these reports the control options have been evaluated by the users to reduce the risk of additional hazards being introduced and to ensure the advice is sound and acceptable to the users.

*Cost Benefit Analyses*
This issue is not often included in Risk Management models however it is included under the IMO Formal Safety Assessment. This step is also a useful part of the
process to compare and contrast the different control options as well as the potential cost of doing nothing.

Assessment of ergonomic principles

The methodology in this report also incorporates the requirements for selecting and comparing items of PPE as outlined in the European Standard 'Personal Protective Equipment – Ergonomic Principles' IS EN 13921:2007. As this Standard explains:

“The application of ergonomic principles to PPE allows optimization of the balance between protection and usability.”

IS EN 13921:2007, page 5

PPE worn by marine pilots and other occupational groups is aimed at protecting the user from known hazards to their health and safety. However the PPE may also unintentionally create new hazards, as well as failing to properly counter the known hazards. Wearing and operating different marine safety equipment also has the potential to create hazards or to fail to operate as intended. Maintenance methods and testing schedules for all equipment can also influence usability, and may serve to reduce or increase risk for the pilot.

These reports explore the ergonomic issues of the interaction of the PPE with the pilot's body, including:
- biomechanical interaction
- anthropometric characteristics (human sizing and dimensions)
- thermal interaction
- interaction with the senses – eg vision, hearing, touch

The assessments include an examination of the interaction between the different items of PPE with each other and with typical functional tasks undertaken by the pilot. For example this includes the impact of helmet wearing while wearing a personal flotation device, or glove wearing when operating a marine radio.

PPE and equipment selected for review

In consultation with AMPA, a sample of PPE and equipment was selected for review. The rationale for this selection was as the PPE or equipment is commonly used by pilots in Australia, and/or has recently been proposed as being of potential benefit in the pilot ladder transfer (eg report by Weigall presented at Asia-Pacific Marine Pilotage Conference 2006).

Formal safety assessments have been prepared for each of the following items of PPE and equipment:

<table>
<thead>
<tr>
<th>Part 1</th>
<th>Footwear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 2</td>
<td>Gloves</td>
</tr>
<tr>
<td>Part 3</td>
<td>Head Protection</td>
</tr>
<tr>
<td>Part 4</td>
<td>Personal Flotation Devices, Wet Weather Jackets and Personal Locator Beacons</td>
</tr>
</tbody>
</table>
The project has been broken up into four chapters or ‘parts’, with each part providing a stand-alone report on the topic. The reports follow a similar format, and provide the reader with evidence-based material including data from peer-reviewed scientific journals plus information based on consultation with a wide range of users, subject experts, equipment manufacturers and equipment suppliers. The reports also provide user evaluation and performance testing of the PPE and other equipment where possible.

1.3 Using and applying this information and advice

The information from these assessments should contribute to an organisation’s own risk assessments and safety assessments, based on specific pilots and scenarios that are typical to the pilots’ work. The information in these reports should not replace these important port specific and pilot specific risk assessments.

For this project and the assessments, the use of PPE and marine safety assessment was restricted to the pilot ladder transfer task. Task analyses revealed the steps in the pilot boarding and disembarkation as:

**Boarding**
- Donning the relevant PPE (eg PFD, gloves, wet weather jacket)
- Walking around the deck of the pilot vessel to the ladder
- Reaching up then jumping or stepping onto the lower rungs of the ladder
- Climbing up the ladder, grasping and releasing the hands on manropes or side ropes
- Walking on the deck/within the commercial vessel

**Disembarking**
- Walking on the deck/within the commercial vessel
- Climbing down the ladder, most commonly sliding the hands down the manropes on the descent or less commonly holding the ladder’s side-ropes
- Jumping or stepping backwards off the ladder onto the pilot vessel

For this project it was therefore assumed that the pilot’s complete PPE is used for relatively short periods. Theoretically all the PPE could be removed once onboard the ship provided the footwear used during the transfer was replaced with alternative footwear. The PPE could also be removed once safely within the cabin of the pilot vessel.

If the above task analyses are not relevant to a pilot or if the ladder transfers are done differently to those observed for these reports, other hazards may be present, with different risks and different control options.

1.4 Personal Protective Equipment as a ‘control’

PPE is routinely used in situations where a risk to health and safety has been identified. The preferred and optimal solution is of course to eliminate or to redesign the task to remove the risk or to minimize the risk. PPE should only be used when the task has been improved as much as ‘reasonably practicable’ by...
other means. This hierarchical approach to risk control is also the law in each occupational health and safety (OHS) jurisdiction in Australia.

The use of PPE to reduce risks in the ladder transfer task is considered a very low level and relatively ineffective means of ‘controlling’ the risks associated with this task. However given that the most common transfer method and the internationally accepted method of undertaking pilot transfers is to use the pilot ladders, and most ports in Australia use this method, it is relevant that the pilots be provided with the most appropriate PPE to minimise risks wherever possible.

This PPE should be well suited to the task, the work environment and each specific user. Marine safety equipment is also important for the pilot as this can reduce the severity of the injury should a fall or other accident occur.
2. BACKGROUND

2.1 Policies and procedures regarding head protection

There are no national or state laws in Australia requiring pilots to use head protection during the ladder transfer task. According to the Australian Standards regarding occupational protective helmets (AS/NZS 1800:1998):

“...an occupational protective helmet should be worn:

a) where there is a possibility that a person may be struck on the head by a falling object;
b) where a person's head may strike against any fixed object; or

c) where inadvertent head contact may be made with electrical hazards”

The European Maritime Pilots’ Association (EMPA 2008) provides the following guidance to pilots:

“Headgear to individual requirements. Note that objections to standard safety helmets in the pilotage environment include the possible danger of neck injury during a fall into the water with a chinstrap secured and possible interference with lifejacket splashguards”

Further guidance regarding head protection is provided in the Code of Safe Working Practice for Australian Seafarers (AMSA 1999):

5.4.2 HEAD PROTECTION

5.4.2.1 Helmets may be designed for different purposes. A helmet designed to provide protection from objects falling from above may not be suitable for protecting seafarers from chemical splashes. The ship should be supplied with helmet types appropriate to the range of operations carried out on the ship. Australian Standard AS 1800–1998 (Occupational protective helmets), provides guidance on the selection, care and use of industrial safety helmets. Helmets supplied to the ship should comply with AS 1800–1998 or its equivalent.

5.4.2.2 In general, the shell of a helmet should be of one-piece construction, with an adjustable cradle inside to support the helmet on the wearer’s head and a chinstrap to prevent the helmet from falling off.

5.4.2.3 The cradle and chinstrap should be properly adjusted as soon as the helmet is put on to ensure a snug fit.

While there is no specific law or regulation regarding helmets for the ladder transfer task, each of the occupational health and safety (OHS) jurisdictions in Australia expect that decisions about personal protective equipment (PPE) are made as part
of an employer’s or site operator’s comprehensive risk assessment of the task and the risks.

Some ports and work sites around the ports (eg container terminals) have policies regarding wearing head protection, however they generally relate to the port’s work site that the pilot must walk through either prior to or following their pilotage task, rather than a requirement to wear protection on the pilot vessel or during the ladder transfer.

2.2 Helmet use by pilots

*Number of pilots wearing helmets*

According to data from a recent survey to pilots regarding safety issues and equipment (Tribe Research 2007; Weigall & Haley 2006), of the 90 respondents, only 6 reported always wearing helmets in the transfer, with most never wearing them.

<table>
<thead>
<tr>
<th>How often do you wear a helmet during the pilot ladder transfer?</th>
<th>Never</th>
<th>77</th>
<th>95.6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sometimes</td>
<td>4</td>
<td>4.4%</td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td>3</td>
<td>3.3%</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>6</td>
<td>6.7%</td>
<td></td>
</tr>
</tbody>
</table>

None of the 12 pilots from New Zealand wore helmets, as compared with 83% of the Australian pilots never wearing them.

There was also a significant difference in helmet wearing at major and minor ports, with pilots at major ports more likely to report never wearing a helmet than those pilots in minor ports.

As previously noted, anecdotal evidence suggests that pilots mainly wear helmets when they must comply with site safety policies at various industrial areas at the ports. The helmets used by these pilots are the common industrial safety helmet, generally used on building and industrial sites (and as referred to in the Code of Safe Working Practice for Australian Seafarers). Some pilots have reported that as they have to carry the helmets to use before or after their transfer they may also wear the helmet during the transfer in preference to carrying it separately or placing it in their bag.
Pilots’ beliefs regarding helmet use

Pilots interviewed for this report, and pilots consulted in the past, are almost unanimous in their opinion that helmet use for the transfer task is undesirable. Some common negative views expressed by pilots were that helmets:

- were not necessary as there was no or minimal risk of head damage
- would be cumbersome to wear
- would add to the many items they already need to carry and to think about
- could make swimming and flotation more difficult should a fall into the water occur
- did not look professional

Pilots appear to believe that any potential benefits of helmets would be outweighed by the risks and the inconvenience.

However at one port in Australia pilots have recently started wearing helmets for the transfer task and the impetus for this came from the port operator/owner. The pilots here did not consider that the standard industrial safety helmet suited the transfer task, and after much investigation they have been trialling a helmet designed for high impact water sports such as whitewater kayaking and wake boarding.

Pilots overseas appear to have similar reservations to the Australian pilots. At a port in England whose pilots have been using a helmet since late 2003 (Harwich Haven Authority) the Health, Safety, Security & Environment Manager there described “some significant opposition” to the introduction of helmets. There is also reportedly some continuing resistance from a few older pilots, with them commenting that they “feel a bit daft” wearing them (Phillips 2008).
3. HAZARD IDENTIFICATION

In the pilot ladder transfer task there are four key mechanisms of injury that can result in trauma to the head:

- Slips, trips and falls on the same level – with the head striking the deck of the pilot boat
- Slips, trips and falls from a height – with a fall from the pilot ladder
- Being hit by moving objects - having a tool or other item fall from the ship’s crew working above, such as when they are making adjustments to the accommodation ladder
- Hitting objects - striking the head on the side of the ship while climbing, such as if the ladder is suddenly twisted or jerked or swings back onto the hull

The most recent Australian review of work-related fatalities shows that falls from a height continue to account for the second main mechanism of injury after vehicle accidents (ASCC 2008), and traumatic brain injury is the main reason for fatality from falls (Helling et al 1999; Christensen & Emmanuel 1999).

In addition to the hazards associated with the ladder transfer, head-strike injuries from being onboard the pilot vessel have occurred, as well as head-strikes from walking amongst deck cargo, hatch cover support rails and low pipes on commercial vessels.

For example about 18 months ago a pilot in NSW struck his head against the pilot boat cabin after losing his balance when the pilot vessel heavily came alongside the ship. While not losing consciousness, the pilot reportedly suffered pain and trauma to the head. A helmet used in this scenario may have reduced the head trauma, together with other ‘higher order controls’ such as redesign options (eg use of different fendering material), different boat operations (eg slower manoeuvring alongside the ship) and possibly changes to work procedures (such as the pilot staying seated in the cabin until the pilot boat was alongside). As outlined in the introduction, an item of PPE is a ‘lower order control’. 
4. RISK ASSESSMENT

4.1 Likelihood and consequence of head trauma

Injury and incident data for pilot transfers

There is not enough data available for analysis from Australia or overseas that provides detailed information regarding incidence rates for head trauma. Data from one pilot organisation revealed that 35% of injuries from undertaking a transfer were from ‘being hit’ or ‘hitting a moving object’, with 4% of injuries from falls from a height. However this data is from a small sample size (26 accident cases) so may not be representative and should be used with caution (Weigall 2006a).

Despite the lack of formal records, some data was obtained for an earlier study (Weigall 2006b), from searching past reporting of pilot fatalities (Irving 1995; IMO 2006; British Ports Federation 1991), newspapers (Lloyds Register 2006; The Daily Astorian 2006; Ohira 2006), and from recent Marine Pilotage conferences (Taylor 2006; Harwich Haven Authority 2008a). These reports confirm that pilot ladder transfers have resulted in death and serious injury, with 6 deaths attributed to this task internationally in the year 2005-2006, with the primary mechanism of these deaths relating to falls from the ladder.

A brief review of the descriptions of these accidents indicates they resulted from:
- Falls from a height;
- Drowning (after being unconscious from head injuries);
- Crush injuries;
- Struck by pilot boat after fall from a height; and/or
- A combination of these mechanisms.

In studies of falls in other sectors, researchers have found that even in falls from heights of less than 3 metres, 59% of injuries sustained by the patients were rated as ‘moderate’ (such as concussion) or ‘serious’ (such as fractures) (Bjornstig & Johnsson 1992). Another study of 176 falls from heights of less than 6 metres found that 35% of the patients had sustained head injuries (Helling et al 1999).

Falls from the ladder

Falls from the ladder are fortunately uncommon however when they occur the risk of striking the head and sustaining serious injury is high. Head protection has been considered for the transfer task, and was recommended following an enquiry into an accident when a pilot ladder broke in NSW and the pilot fell (Beazley 1998); and has also been recommended following an enquiry into a pilot falling and being killed in the United Kingdom (Irving 1995).

A marine equipment supplier in England claims that one pilot organization who now uses helmets only did so following a pilot fall (Friar 2006). The supplier reported that in the enquiry into the fall “the health and safety came in” and directed that the pilots wear helmets.
In the most recently reported pilot accident, occurring in England in mid July 2008, the pilot fell 9 metres into the water when the ladder gave way. The pilot was boarding approximately 10 miles offshore in the middle of the night. He was wearing a marine helmet (brand Gecko) at the time, and it is believed that this helmet assisted to both reduce head trauma as well as assist in his rescue due to its colour and reflective markings (Harwich Haven Authority 2008; Phillips 2008). Other than being “shaken” and “bruised” the pilot was unharmed.

In recent personal communications the Harwich Haven Authority’s Health, Safety, Security & Environment Manager reported that their pilots have been wearing head protection since 2003 (using Gecko Marine Safety Helmets). He explained that their organisation had undertaken a comprehensive risk assessment of the pilot ladder transfer task and they identified risks from head strike and from being hit by falling objects.

The Authority then consulted with the pilots and others and sought head protection they considered most suitable to the tasks and the risks. Phillips (2008) reported that to his knowledge only two other marine authorities/ports in the United Kingdom currently require pilots to use helmets for both boarding and landing of pilots, and these two other ports provide the traditional industrial style construction helmets.

**Striking the head while transferring and while walking on the deck**

Headstrike can occur under any of the following conditions: heavy seas and strong winds, when the ladder swings out from the hull and swings back and/or if the ladder twists; if the pilot boat catches and pulls the ladder; and if the pilot loses their handgrip and slips to the side of the ladder.

Anecdotal information suggests that a more common situation is to strike the head when walking along the ship’s deck and on hatch coamings. Many pilots have stories of bumping, scraping or knocking their heads on containers, or on car carriers where there are low pipes and other fixtures and fittings that encroach over the walkway, particularly for taller pilots.

Head protection was also noted as being important to reduce injury when moving across decks of ships in the United Kingdom (Irving 1995).

**Falling objects**

The main risk of falling objects appears to be from the ship’s crew making adjustments to the rigging of the pilot ladder. Typical tools and equipment being adjusted or in use above the pilot boat include: radios, torches, stanchions, shifting spanners, marlin spikes, plus the weight of heaving lines with large ‘monkey fist’ knots at the ends. Weights of these items are estimated at between 1 and 5kg, so if dropped from a height can cause serious damage, as illustrated in the equation:

\[
P (\text{transmitted force}) = m \ (\text{mass}) \times f \ (\text{deceleration})
\]

When a falling object impacts a helmet, the object is subjected to deceleration, with the force transmitted through the helmet.
However according to pilots surveyed, in most cases they can reduce their exposure to falling objects by remaining in the pilot boat cabin until the rigging of the pilot transfer system is complete. At this time the pilot boat crew is often on the deck as adjustments are being made, and they also have the role of pulling and testing the ladder prior to use, so this group is at greater risk of injury from falling objects than the pilots.

**Effect of trauma to the head**

Blows or strikes to the head can result in damage to the face, scalp and skull and may also injure the brain. Impacts to the head can cause a momentary loss of consciousness or permanent ‘traumatic brain injury’ (TBI). A summary of the possible effects of traumatic brain injury is listed in Table 1.

**Table 1. Consequences of traumatic brain injury** (Khan et al 2003)

<table>
<thead>
<tr>
<th>Neurological impairment (motor, sensory and autonomic)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor function impairment – coordination, balance, walking, hand function, speech</td>
<td></td>
</tr>
<tr>
<td>Sensory loss – taste, touch, hearing, vision, smell</td>
<td></td>
</tr>
<tr>
<td>Sleep disturbance – insomnia, fatigue</td>
<td></td>
</tr>
<tr>
<td>Medical complications – spasticity, post-traumatic epilepsy, hydrocephalus, heterotopic ossification</td>
<td></td>
</tr>
<tr>
<td>Sexual dysfunction</td>
<td></td>
</tr>
</tbody>
</table>

**Cognitive impairment**

- Memory impairment, difficulty with new learning, attention and concentration; reduced speed and flexibility of thought processing; impaired problem-solving skills
- Problems in planning, organising, and making decisions
- Language problems – dysphasia, problems finding words, and impaired reading and writing skills
- Impaired judgement and safety awareness

**Personality and behavioural changes**

- Impaired social and coping skills, reduced self-esteem
- Altered emotional control; poor frustration tolerance and anger management; denial, and self-centredness
- Reduced insight, disinhibition, impulsivity
- Psychiatric disorders – anxiety, depression, post-traumatic stress disorder, psychosis
- Apathy, amotivational states

**Common lifestyle consequences**

- Unemployment and financial hardship
- Inadequate academic achievement
- Lack of transportation alternatives
- Inadequate recreational opportunities
• Difficulties in maintaining interpersonal relationships, marital breakdown
• Loss of pre-injury roles; loss of independence

Given the high levels of both cognitive and physical skills required of marine pilots to undertake the ladder transfer and to navigate vessels, even mild brain damage is likely to prevent a pilot from working in this profession.

4.2 Use of helmets in other sectors

The use of helmets is now commonplace in many recreational and industrial activities as well as in different means of transport, and the use and requirement for helmets is increasing internationally. The reason for the increase in helmet use is due to a combination of the perceived likelihood and consequence of head injuries in different activities, and the evidence of the benefits of helmets in preventing these injuries.

For example, a study undertaken for the ATSB showed that in children not wearing helmets at the time of a bicycle riding accident the risk of them suffering from concussion was six times higher than for helmet wearers (Acton et al 1993). A review of 5 studies of bicycle helmet use confirmed that helmet use reduced risk of head injury by 85% and brain injury by 88% and severe brain injury by at least 88%, and as helmet use has increased, head and brain damage have reduced (Thompson & Patterson 1998).

Studies into other road accidents – from cars, motorbikes, mopeds and other vehicles – also show the effect of helmet use in reducing fatality and injury rates (eg Javouhey et al 2006; Servadei et al 2003.) A major Australian study into head injury prevention in car accidents concluded that “safety could be improved …with simple, low cost head protection”. The authors found that wearing a soft-shell pedal cycle helmet was as effective as driver airbags, and provided greater protection than many other in-vehicle options such as improved interior padding, side impact bags and even advanced seat-belt designs. Wearing the helmets within the car was estimated to provide a significant reduction in all head injuries with resultant cost benefits to the community (McLean et al 1997).

There appears to have been less research into the value of helmets in industrial settings and falls from a height, however the available data suggests that helmets in these settings also serve to reduce the impact of injuries (Janicak 1998; Kines 2002). A study of mountaineering fatalities found that head injuries were the main cause of death in falls from a height, accounting for half of all cases (Christensen & Emmanuel 1999).

4.3 Helmet designs

There are currently more than 125 ‘standards’ around the world that relate to helmets and helmet design. There is no specific ‘Pilot Helmet Standard’ however there are many standards that have design criteria that address risks faced by
pilots. The Standards and/or helmets described in Table 2 all have some relevance to the pilot ladder transfer task.

The Australian Standard for the selection of occupational helmets outlines how helmets protect the head from trauma, as copied below:

"An occupational protective helmet protects against overhead impact by absorbing energy through:

- deformation of the shell
- crushing of the protective padding if provided; and
- stretching of the harness in some cases.

The residual force of the impact is spread over the surface of the head, thus lessening the chance of injury."

Table 2. Comparison of different types of helmets

<table>
<thead>
<tr>
<th>Standard and type of helmet</th>
<th>Features/design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bump caps or scalp protectors</strong>&lt;br&gt;EN 812:1997/A1:2001 Industrial Bump Caps</td>
<td>Design features&lt;br&gt;- Close-fitting&lt;br&gt;- Thin shell&lt;br&gt;Protection&lt;br&gt;- From striking the head against hard, stationary objects with sufficient severity to cause lacerations or other superficial injuries&lt;br&gt;Relevance to pilots&lt;br&gt;- Reduced risk of cuts, bruises and abrasion from knocking the head on the side of the ladder, the side of the hull and on cargo or fixtures on ships&lt;br&gt;Limitations&lt;br&gt;- Not designed to protect against falling objects or moving loads&lt;br&gt;- Not designed for use in water</td>
</tr>
<tr>
<td><strong>Occupational protective helmets</strong>&lt;br&gt;(formerly referred to as industrial safety helmets)&lt;br&gt;AS/NZS 1800:1998 Occupational protective helmets – selection, care and use&lt;br&gt;AS/NZS 1801:1997 Occupational protective helmets&lt;br&gt;EN 397:1995/A1:2000 Industrial safety helmets</td>
<td>Design features&lt;br&gt;- Type 1 – for construction industry, quarrying and factories&lt;br&gt;- Type 2 – meets requirements for Type 1, and is intended to withstand exposure to high temperatures, eg at steelworks etc&lt;br&gt;- Type 3 – meets requirements for Type 1, plus additional protection regarding inflammability for firefighting&lt;br&gt;Protection&lt;br&gt;- Protection from falling objects</td>
</tr>
</tbody>
</table>
### Standard and type of helmet

<table>
<thead>
<tr>
<th>Features/design</th>
<th>Relevance to pilots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety helmet</td>
<td>Reduced risk of trauma from falling objects from people working overhead, such as rigging the ladder etc</td>
</tr>
<tr>
<td>Limitations</td>
<td>Not intended to provide protection against off crown impacts</td>
</tr>
<tr>
<td></td>
<td>Not designed for use in water</td>
</tr>
</tbody>
</table>

### High performance industrial helmets

EN 14052:2006 High performance industrial helmets

<table>
<thead>
<tr>
<th>Design features</th>
<th>Protection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety helmet</td>
<td>Greater protection from falling objects</td>
</tr>
<tr>
<td></td>
<td>Protection from off crown impacts</td>
</tr>
<tr>
<td>Safety helmet</td>
<td>Impact for crown – 100J</td>
</tr>
<tr>
<td></td>
<td>Impact for off-crown – 50J</td>
</tr>
</tbody>
</table>

| Relevance to pilots | As for previous helmet, but with added impact resistance to off crown areas of the head |
| Limitations         | Not designed for use in water |

### Gallet aircraft helmet

Model LH – for pilots and crew (below)

<table>
<thead>
<tr>
<th>Design features</th>
<th>Key features of the LH model are reported as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety helmet</td>
<td>Protection against impacts and perforation by a shell in carbon fibers and aramid, and by an expanded polystyrene inner padding</td>
</tr>
<tr>
<td></td>
<td>Retention system for optimal security</td>
</tr>
<tr>
<td></td>
<td>High degree of passive noise protection.</td>
</tr>
<tr>
<td></td>
<td>Solar screens or for low visibility, anti-shock and treated anti-scratch.</td>
</tr>
<tr>
<td></td>
<td>Center of gravity assured natural stability</td>
</tr>
<tr>
<td></td>
<td>Weight – “less than 1kg”.</td>
</tr>
</tbody>
</table>

| Relevance to marine pilots | Pilots who undertake transfers via helicopters use helmets, and Gallet was reported as one common brand (exact model unknown). |
|                           | It would be more convenient for these pilots if the same helmet could be used for both helicopter and boat transfers |
| Limitations               | Not designed for use in water? |

### Mountaineering/rock climbing helmets


<table>
<thead>
<tr>
<th>Design features</th>
<th>Light weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Close fitting</td>
</tr>
<tr>
<td></td>
<td>Retention system with at least 3 separate attachment points to the shell</td>
</tr>
<tr>
<td></td>
<td>Chin strap, adjustable and 15mm wide</td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
</tr>
</tbody>
</table>

(Images of helmets are shown in the text)
### Standard and type of helmet

| Petzl - Vertex Best (below) | Petzl - Vertex Vent (below) | Vertex Best with optional light (LED) |

### Features/design

**Protection**
- Vertical energy absorption: 10kN for a drop ht of 2000mm
- Front energy absorption: 10kN for a drop ht of 500mm
- Side energy absorption: 10kN for drop ht of 500mm
- Rear energy absorption: 10kN for drop ht of 500mm

**Relevance to pilots:**
- Protection from objects falling from above, lateral impacts such as against the side of the hull, and from falls from a height

**Limitations**
- Not designed for use in water

The entire range of Petzl brand helmets was reviewed, and the following models considered most relevant: Vertex Best and Vertex Vent

**VERTEX BEST & VERTEX VENT**

**Technical specifications**

- Chinstrap designed to reduce the risk of the helmet coming off as a result of an impact during a fall; it has a breaking strength greater than 50 daN (EN 12 492 mountaineering helmet standard).
- Polycarbonate shell, resistant to impact and wear (meets EN 397 industrial helmet standard and EN 12492 standard).
- Meets all optional requirements of the EN 397 standard:
  - lateral deformation,
  - use at low temperatures (down to -30 °C),
  - electrical insulation,
  - molten metal splash.
- Customizable:
  - side slots for mounting hearing and/or eye protection,
  - the cut of the shell contours over the ears to fit standard hearing protection,
  - four headlamp clips.
- Complete and simple adjustment:
  - single headband size adjustment wheel, quick and precise to manipulate even while wearing gloves,
  - height adjustment of the headband to adjust the position of the straps on the neck,
  - chinstrap buckles can be adjusted forwards and backwards.
## Standard and type of helmet

<table>
<thead>
<tr>
<th>Features/design</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Comfortable:</td>
</tr>
<tr>
<td>o webbing suspension system,</td>
</tr>
<tr>
<td>o thick, replaceable foam headband.</td>
</tr>
<tr>
<td>• The headband retracts into the shell for storage.</td>
</tr>
</tbody>
</table>

The Vertex Vent model differs from the Best model as it has ventilation holes that can be closed with sliding shutters (for cold and/or windy conditions).

Head band - adjustable from 53 to 63 cm  
Weight - 465 g  
Available in - yellow, red, white, orange, black.

## Whitewater sport helmets

EN 1385 Helmets for canoeing and whitewater sports

Example of brands below:

**Predator**

**Gath Gedi**

(Note: See Table 5 for more detail regarding the performance requirements and how they compare with P.A.S. 028:2002 Marine Safety Helmet)

Design features
- Close fitting  
- Side protection  
- Chin strap

Protection*
- Helmets must withstand an impact of not less than 15J, and deceleration of the headform shall not exceed 250gn (where gn is an acceleration of 9.81m/second squared)  
- Helmets must float  
- For bumps, scratches and concussion.  
- For paddling in whitewater of classes 1 to 4 (ie non-powered sporting activities carried out in moving water, as classified by the International Canoe Federation)  
- The speed of impact is expected to be no greater than 18kmh/5ms (the highest recorded rate of flow of a white water river)  
- Most fatalities in these activities are from drowning after concussion and not from brain trauma.  
- This standard does not apply to extreme whitewater sports such as jumping off high waterfalls as helmets would need to have impact absorption characteristics.

Relevance to pilots:
- Reduced risk of bumps, scratches and concussion from striking the head on the side of the hull or onboard  
- Designed for use in water

Limitations
- Not designed to protect against falling objects or for falls from a height
### Standard and type of helmet

<table>
<thead>
<tr>
<th>Whitewater sport helmets (continued)</th>
<th>Features/design</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 1385 Helmets for canoeing and whitewater sports</td>
<td>Reported design features of Gath Gedi:</td>
</tr>
<tr>
<td>Gath – Gedi, additional illustrations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Low drag, good water immersion &amp; neutral buoyancy, which minimise the risk of neck and spine injury for water impact.</td>
</tr>
<tr>
<td></td>
<td>- Shell profiles shaped for freedom of movement and maximum peripheral vision.</td>
</tr>
<tr>
<td></td>
<td>- Moulded non-absorbent closed-cell soft foam liners contoured for comfort and rapid water drainage.</td>
</tr>
<tr>
<td></td>
<td>- Quick drying, even after extensive use in the water.</td>
</tr>
<tr>
<td></td>
<td>- Non corrosive components and adhesives for long lasting durability in the harshest marine conditions.</td>
</tr>
<tr>
<td></td>
<td>Options</td>
</tr>
<tr>
<td></td>
<td>- Ribbed peak</td>
</tr>
<tr>
<td></td>
<td>- Convertible visor (smoked or clear)</td>
</tr>
<tr>
<td></td>
<td>Existing users of the Gath Gedi Helmet:</td>
</tr>
<tr>
<td></td>
<td>- Surf Life Saving Association</td>
</tr>
<tr>
<td></td>
<td>- Port Kembla pilot vessel crew</td>
</tr>
<tr>
<td></td>
<td>Five sizes S, M, L, XL and XXL with a system that allows personal customisation for a secure fit</td>
</tr>
<tr>
<td></td>
<td>Weight - 350-410 grams</td>
</tr>
<tr>
<td></td>
<td>Colours – 9 colours</td>
</tr>
<tr>
<td></td>
<td>Cost - $174</td>
</tr>
</tbody>
</table>

### Marine helmets

<table>
<thead>
<tr>
<th>'P.A.S. 028:2002 Marine Safety Helmet'</th>
<th>The ‘P.A.S. 028:2002 Marine Safety Helmet’ has the following performance requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is a British ‘Publicly Available Specification’ (also referred to as a ‘Product Approval Specification’ and a ‘Product Assessment Specification’. The specifications have been developed “for marine safety helmets for use by occupants of small fast craft”</td>
<td>- Crown impact: 2m fall of striker/impact energy of 100J – maximum force to headform must be 10kN</td>
</tr>
<tr>
<td>The P.A.S is an interim specification in the absence of any current standards relating to helmets for small fast craft.</td>
<td>- Must float</td>
</tr>
<tr>
<td>Gecko Open Face Marine Safety Helmet</td>
<td>(Note: See Table 5 for more detail regarding the performance requirements and how they compare with EN 1385 Helmets for canoeing and whitewater sports)</td>
</tr>
<tr>
<td></td>
<td>The Gecko, illustrated claims:</td>
</tr>
<tr>
<td></td>
<td>- Close fitting shell allowing full peripheral vision</td>
</tr>
<tr>
<td></td>
<td>- Good interaction with lifejackets and overhead work such as helicopter rescue.</td>
</tr>
<tr>
<td></td>
<td>- Compatible with a wide range of add-ons such as full or half face visors, goggles, torches, retro reflective</td>
</tr>
<tr>
<td></td>
<td>- Markings and built-in communications systems</td>
</tr>
<tr>
<td></td>
<td>- Excellent prevention of wind and water entry providing increased heat retention and added buoyancy</td>
</tr>
<tr>
<td>Standard and type of helmet</td>
<td>Features/design</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
| RAN personnel wearing the Gecko Open Face Marine Safety Helmet | • Excellent cleaning properties enable hygienic use among multiple users.  
Technical specifications:  
• Shell- Kevlar Fibreglass construction with Lightweight grooved design giving good strength to weight ratio.  
• Inflatable liner- Inflates or deflates to accommodate the user’s head size allowing the tension of the fit to be adjusted according to the situation.  
• Foam comfort pad- 15mm thick circular comfort pad providing cushion protection to the top of the head. Can be removed for washing. Replacement pads are available.  
• Ear protection- Providing ear protection from external noise such as engine, wind, or inclement weather. Can be removed to improve acoustic clarity.  
• Strap assembly- Patented Fastex “click” closure buckle allowing one hand release and quick adjustment to the strap length. Sheathed in neoprene comfort tube to help prevent rubbing.  
• Visor- Manufactured from Lexan Polycarbonate and meeting the highest impact requirement of BS4110 Eye Protectors for Vehicle users. Good optical qualities.  

There are a few different models of Gecko – those with inflation and those with foam pads. In hot climates the foam pad design is reported to be cooler and more comfortable than the inflation model (As reported by supplier, based on RAN experiences)  

Weight – 700 grams  
Price – approx AUD $550  

Existing users of the Gecko Open Face Marine Safety Helmet:  
In Australia  
• Royal Australian Navy (RAN)  
• Australian Customs, Marine Division personnel  
• Surf Life Saving Association  

Overseas  
• Royal National Lifeboat Institute  
• Canadian Coastguard  
• Hong Kong Police  
• Swedish Rescue Service.  

RAN employee
Standard and type of helmet | Features/design
---|---
Optional extras for Gecko helmet ‘Gecko GRF 10’ | Taken from Gecko catalogue:

**Gecko GRF10** //

The GRF10 is designed specifically to integrate with the GMSH (Gecko Marine Safety Helmet) to provide a bespoke headset for use in radio communications.

**Key Features** //

- Waterproof
- Noise-cancelling microphone
  Allows for use in areas of very high noise
- Earphone tailored to speech bandwidth
  for clearer transmissions requiring less volume
- Press-To-Transmit (PTT) Switch

**RIB-COM Intercom** //

The RIB-COM is used to provide an intercom between two or more users in areas of high ambient noise and harsh physical conditions.

With a RIB-COM, crew members can converse clearly and comfortably from their normal positions within the boat. Thanks to the noise-reducing technology of the microphones, wind and engine noise is much lower over the RIB-COM than within the surrounding environment. It is possible to upgrade an existing installation by simply daisy-chaining the standard RIB-COM with a slave unit.

*The technical requirements and specifications listed in the standards all differ and use a wide range of test apparatus and measurement systems. It is not possible to compare all these methods, and the degree of detail is beyond the scope of this project.

As illustrated in the table, there is a wide range of helmets with different objectives, different designs, and with different testing requirements. They provide varying levels of protection from impact and aim to protect different parts of the head. Testing methods also vary.

### 4.4 Helmet testing and claims

**Helmet materials and designs**

No recent data could be located on tests on different helmet types at different impact energies. For example tests conducted in 1988 showed a shortcoming of
typical injection-molded helmets as compared with glass reinforced polyester (GRP) climbing helmets. In this study, in the injection-molded helmets the transmitted forces rapidly increased above impact energies of 60J, increasing to 515g (peak deceleration) at 100 J, with the GRP climbing helmet at only 135 J when subjected to the same impact energy (100 J) (Rowland et al 1988).

This study also identified that while most helmet standards focused on reducing impacts to the crown of the head, studies show that in typical industrial situations the crown is subject to between 26 – 28% of strikes, with the frontal area subject to between 38 – 46%. In these settings, the least impact occurs to the sides of the head (between 7-8% each side) and between 13 – 20% for rear head strikes.

**Helmets for canoeing and whitewater sports**

(Standard EN 1385)

As the previous table of helmet designs illustrated, there are two key standards relating to use of helmets in the water, and each have relevance to the pilot ladder transfer task and in protecting the pilot from head trauma.

One helmet developed in Australia, the Gath Gedi, is used by a variety of users including:

- a large number of white water kayakers, in Australia and overseas
- a sea and helicopter rescue service in South Africa
- beach lifeguards in Australia and California

Gath’s Marketing Manager provided correspondence from a number of these satisfied customers, who all wrote positive reports about their experiences with the helmets. In each case the Gath helmet owners described situations where they struck their head on rocks and coral reefs in rivers, waterfalls, and under waves. The helmet users had often hit the objects from a height (reportedly up to 4 metres) and they all believed that if they had not been wearing the helmet they would have been seriously injured or killed.

**Helmets for Marine Safety**


The Australian supplier for the Gecko Marine Safety Helmet also provided examples of satisfied clients (Anderson 2008). For example she reported that a crew member of a Royal Australian Navy (RAN) boarding party would have died had it not been for the Gecko helmet.

The RAN group was reportedly attempting to board an illegal fishing vessel with a hostile crew in northern Australian coastal waters, and a crew member threw a bottle filled with concrete towards the RAN group and struck the head of one of the boarding party. This missile caused the Gecko helmet to “shatter” but caused no injury to the RAN member (Anderson 2008). Anderson offered to provide other case studies or testimonials if required. Defcon Technologies has provided these helmets to the RAN for at least 5 years.
4.5 Risks of helmet use in the ladder transfer

Strain on neck and drag effect in water

A helmet that traps water and cannot resist the dragging effect and pulling forces of strong currents and turbulent water may cause injuries to the neck. Neck injuries could also occur if the user falls or jumps into the water from a height.

Helmets designed specifically for water sports are designed to stay on should the user be submerged. If the helmet lets in water it must also be designed to allow the water to escape through vents and holes in the sides and top of the helmet.

Increased weight when wet

Some helmets, such as motorbike helmets, use absorbent foam materials to assist with shock absorption. If these helmets are used when immersed in water the foam can become water-logged and so increase in weight, creating a heavy load for the head and neck to support until the helmet can be removed.

Helmets with large, protruding peaks

Helmets often have a peaked front to reduce sun exposure, protect the user from rain and to generally shield the eyes. However if the user falls or jumps into water with a rigid peak on their helmet, the force of the water is likely to create a jarring force on the head, forcing the neck into rapid extension or flexion (depending on the angle of fall). According to kayakers, some designers are now offering removable peaks that will also move with the water rather than moving the entire helmet.

Reduced vision

Helmets allow different fields of vision depending on the shape of the peak (portion extending over the eyes) and the sides. For example the common 'safety helmet' used on industrial sites and by pilots on some wharves and dockside is wide with a rim that partly obscures the vertical visual field. The maximum vertical field seen by an uncovered head when looking up with the head positioned centrally is 40 degrees. The pilot requires full vision of both the peripheral and vertical visual fields when undertaking the ladder transfer.

Restricted neck movements

As pilots wear jackets with bulky collars, and personal flotation devices that can add to this bulk behind their neck, any helmet that is cut low over the back of the head could restrict the pilot's ability to extend their neck to look up from the pilot vessel to the ladder and for climbing the ladder.
Discomfort

Some helmets are relatively heavy (eg 1kg) or have linings that warm the head and may be too hot and uncomfortable if worn for long periods. This is mainly a problem in warm climates, and is reported as a problem in tropical areas and where people are exposed to the sun as well as humidity.

Corrosion and damage

When helmets are not suited to the marine environment any metal fixings and screws etc will corrode and weaken the helmet.

Entanglement and/or windage

A bulky helmet or one with protruding parts could pose a risk of catching a manrope or other loose ropes. Some helmets may be affected by strong winds with the wind catching under the helmet and potentially affecting the pilot’s balance on the ladder.

Damaged helmets

If helmets are not cared for and stored in accordance with the manufacturer’s instructions they will not provide the stated protection and may provide a false sense of security to the user.

For example the Australian Standard regarding care of protective helmets (AS/NZS 1800: 1998) warns against:
- storage or placement of helmets near any window, particularly the rear window of motor vehicles as excessive heat can be generated, and the helmet may also become a missile in an accident or with sudden braking
- using petroleum and petroleum products and various cleaning agents, paints and adhesives
- using aerosol sprays such as insect repellents that contact the helmet

Damage to helmets is reportedly often not visible to the user, so this item of equipment needs to be handled and stored with care to maintain its structural integrity. It may also require expert assessment. The standard also provides advice about recommended routine checking and maintenance procedures (see AS/NZS 1800: 1998).

Poorly fitting helmets

Studies regarding head protection often describe how helmets are incorrectly or poorly fitted, so fail to provide the user with the stated protection. Poor fit can be from:
- users failing to make the recommended adjustments
- users with head size or shape not suited to conventional helmets
- users with hair or head-dresses (eg turbans, veils, scarves etc) that affect fit
4.6 Benefits of helmet use in the ladder transfer

The scientific literature provides strong evidence regarding the benefits of wearing head protection. Helmet use can reduce injury risk in the following situations:

- striking the head against objects such as the hull and ship fittings and fixtures
- falls from a height; and
- loads falling from a height onto the pilot.

Providing a helmet is carefully chosen to eliminate or reduce the potential problems for the pilot as listed above, it should be a very useful piece of personal protective equipment.

Another benefit of a helmet for the pilot transfer is increased visibility, with helmets in a high visibility colour and/or with reflective markings being easier to locate in the water than a bare head. For example the report into the July 2008 pilot ladder fall stated (Harwich Haven Authority 2008):

“in the darkness, he (the pilot) was easily detectible by the white ‘Gecko’ helmet he was wearing”.

The ideal pilot helmet would also fit snugly onto the head, be lightweight to prevent damage to the neck, and allow unrestricted movement of the head. It should not be possible to push the helmet back to reveal the forehead, nor should it be removable without releasing the chin straps. This prevents the helmet becoming dislodged in moving water, and ensures that should an impact occur the helmet can still be ready for further possible impacts.

4.7 User evaluation & performance testing

Review by pilots

A selection of helmets was taken to show and trial with pilots. The helmets chosen were:

- Gecko - Marine Safety Helmet
- Gath - Gedi
- Petzl – Vertrex Best
- Petzl – Vertrex Vent

These helmets were selected as they appeared best suited to the task of ladder climbing and provided some protection for falls from a height as well as side protection. The Gecko is already in use in the UK in one known pilot service (Harwich), and both the Gecko and Gath have recently been approved for Surf Life Saving Australia use by the National Board of Lifesaving (Bruce April 2008).
A brand of rock climbing helmets was also selected (Petzl), as it was thought that these helmets may also meet requirements of port work sites where industrial helmets are required, therefore providing pilots with one helmet for both tasks.

The 4 styles of helmets were taken to a total of 14 pilots from 2 different employers. Where possible a range of sizes was taken to allow users to try the helmets for fit. The pilots were provided with the helmets’ technical specifications and key features, and then given the opportunity to try them on and to discuss design and use factors they identified as being either advantages or disadvantages.

Most of the pilots were reluctant to consider the use of helmets, and tended to be negative about their value. However in private conversations some pilots both at these and other ports have expressed interest in helmet design and options, and do wear various rock climbing and water sports helmets. These pilots are clearly in the minority at present.

The pilots reported the disadvantages of helmets as being: another thing to carry and to remember; fear of restricted vision; fear of being restricted in floating should they fall in the water; feeling unbalanced; and an unnecessary encumbrance. These concerns were the same as reported in interviews undertaken earlier in this project (in March and April 2007).

In trying on the helmets in a meeting room (not at sea) and following discussions, the helmets were rated by the pilots. Table 3 provides a summary of their key findings.

**Table 3. Pilot ratings of provided helmets**

<table>
<thead>
<tr>
<th>Helmet make and model</th>
<th>Main comments</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
</table>
| Gecko - Marine Safety Helmet | • Comfortable fit*  
• Easy to adjust  
• Good shape at nape of neck (to allow for collars and PFDs)  
• Good protection around the side of the head and the ears, including the outer edge of the cheek bone  
• Good to have ear holes  
• Appearance is ok | • The heaviest at 700grams  
• Does not fit a large head (ie 63.5mm) |                                                                 |
| Gath - Gedi            | • Most lightweight (350-410 grams)  
• Closest fitting  
• Lowest profile  
• Appearance is ok |                                                                 | • Maybe some restriction with PFDs at the back of the head when looking up?  
• Does not fit a large head (ie 63.5mm) |
| Petzl – Vertrex Best & Vertex Vent | • Lightweight  
• Vented model would be good in warm weather  
• Good shape at nape of neck (to allow for collars and PFDs) |                                                                 | • Seems to sit high  
• Less head coverage  
• Doesn’t feel snug fit  
• Less side impact protection |
*Note. The Gecko helmet is easiest to adjust, and due to the nature of the padding – being self-inflating – most pilots automatically found this to be a comfortable fit.

Pilot boat crew in one port in Australia are already using the Gath Gedi and report liking this helmet, but the pilots at the same port do not use the helmet.

There is a problem with sizing for people with relatively large heads. While the Gecko claims that the helmet fits all heads, the sizing is actually for 57cm to 62cm. In contacting the UK manufacturer, they stated that they could increase the size by possibly 5-10mm by adding a section during manufacturing. The pilot in the testing who could not find a helmet to suit him explained that he always had problems finding head protection, including for sports activities.

**Performance testing in water**

The 4 selected helmets underwent trials in water. These trials involved one volunteer who followed a series of tasks with each of the helmets then provided verbal feedback. The subject gave her informed consent to the trial, and was made aware of potential hazards and the risk mitigation strategies. The tasks were all undertaken in a public, indoor, heated swimming pool, in a water depth of 1.3metres.

Methodology included:
- The tests were explained to the pool supervisor and approval was given for the testing
- A pool lifeguard was in attendance at the pool during the assessments
- The volunteer subject was a 46 year old female, 1.71m tall, 50kg, average swimming skills, wearing swimwear, with no illnesses or injuries that should affect her ability to complete the tasks
- The helmets were all fitted and fastened to the manufacturer’s instructions
- Care was taken to fasten the helmets securely under the chin to reduce risk of their movement in the water
- Marine pilots were not used to participate in this task due to both timing constraints and also the expected lack of interest and desire by the pilots to wear the helmets

The tasks and user feedback are provided in the following table.

**Table 4. Helmet performance in water**

<table>
<thead>
<tr>
<th>Tasks:</th>
<th>Gecko</th>
<th>Gath Gedi</th>
<th>Vertex Vent</th>
<th>Vertex Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swimming wearing the helmet</td>
<td>No restriction, helmet was streamlined and snug fit and did not restrict movement. Swimming including head rotation to breath was</td>
<td>No restriction, helmet was streamlined and did not appear to restrict movement. Swimming including head rotation to breath was</td>
<td>Not as comfortable as more fitted helmets, but able to swim and turn head etc as required</td>
<td>Same/similar to Vertex Vent.</td>
</tr>
</tbody>
</table>

Swimming freestyle 25m wearing the helmet |
### Helmet type and feedback on tasks

<table>
<thead>
<tr>
<th>Tasks:</th>
<th>Gecko</th>
<th>Gath Gedi</th>
<th>Vertex Vent</th>
<th>Vertex Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duck dives x 4</td>
<td>comfortable</td>
<td>breath was comfortable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From a standing position in the pool</td>
<td>Very buoyant helmet, so as soon as I dived the helmet brought me quickly to the surface</td>
<td>Also quite buoyant helmet. this also assisted in bringing me quickly to the surface, but not as powerfully as Gecko</td>
<td>Not quite as comfortable when diving as with marine helmets. No buoyancy effect</td>
<td>Very similar to the Vent…. No buoyancy effect</td>
</tr>
<tr>
<td>Jumping into the pool from the 2nd step down into the water</td>
<td>No restriction or discomfort noted.</td>
<td>No restriction or discomfort noted.</td>
<td>Felt OK but not as good as with marine helmets</td>
<td>Definite pulling feeling on the head and neck, with strain on chin strap</td>
</tr>
<tr>
<td>Head height 1100mm above water surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jumping into the pool from the 1st step down into the water</td>
<td>No restriction or discomfort noted.</td>
<td>No restriction or discomfort noted.</td>
<td>Slight discomfort from webbed chin strap</td>
<td>Did not attempt (for fear of discomfort or injury)</td>
</tr>
<tr>
<td>Head height 1300mm above water surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jumping into the pool from level with the water surface</td>
<td>No restriction or discomfort noted.</td>
<td>No restriction or discomfort noted.</td>
<td>Discomfort from chin strap, and feeling of pulling on the head</td>
<td>Did not attempt (for fear of discomfort or injury)</td>
</tr>
<tr>
<td>Head height 1700mm above water surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chin strap comfort</td>
<td>Excellent. Neoprene tubing covering most of the webbing and inflation tube is</td>
<td>Very good. Soft, fleecy fabric covers some of the webbing at the chin</td>
<td>OK for swimming, but not for jumping. Webbing tends to dig into the skin and cause</td>
<td>As for Vertex Vent</td>
</tr>
<tr>
<td>When worn in pool tests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Helmet type and feedback on tasks

<table>
<thead>
<tr>
<th>Tasks:</th>
<th>Gecko</th>
<th>Gath Gedi</th>
<th>Vertex Vent</th>
<th>Vertex Best</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>very comfortable, even with jumps from a height</td>
<td>Fabric tubing is 70mm long</td>
<td>discomfort</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neoprene tubing is 120mm long</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dropping the helmet into water</td>
<td>Very buoyant, floats on surface</td>
<td>Very buoyant, floats on surface</td>
<td>Sinks</td>
<td>Sinks</td>
</tr>
<tr>
<td>Holding helmet under water and releasing</td>
<td>Difficult to hold it down in the water – took off when released</td>
<td>Easier to hold it down in the water – but also took off when released</td>
<td>Sinks</td>
<td>Sinks</td>
</tr>
<tr>
<td>Submerge for 30 seconds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visibility of helmet in water</td>
<td>Excellent</td>
<td>Very good</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td></td>
<td>Available in high visibility colours (red and yellow) plus white.</td>
<td>Available in high visibility colours (red and yellow) plus white and 6 other colours.</td>
<td>Available in high visibility colours (red and yellow) plus white and 2 others.</td>
<td>Available in high visibility colours (red and yellow) plus white and 2 others.</td>
</tr>
<tr>
<td></td>
<td>Supplied helmet has reflective tape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Visual fields&quot;*</td>
<td>Just able to see edge of the helmet – but very minimal restriction to visual fields</td>
<td>No restriction</td>
<td>No restriction</td>
<td>No restriction</td>
</tr>
<tr>
<td>Ability to see any of the helmet when wearing it</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dryness of helmet 24 hours after use in pool</td>
<td>Dry and comfortable</td>
<td>Dry and comfortable</td>
<td>Webbing material in head cradle and chinstrap still damp enough to make your hair damp</td>
<td>Webbing material in head cradle and chinstrap still damp enough to make your hair damp</td>
</tr>
<tr>
<td></td>
<td>Rinsed in fresh water then stored in room at between 10-20 degrees Celsius</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Visual fields were not formally tested.

The results of the performance testing in water highlighted the advantages of the marine rescue helmet design and the whitewater sports helmet design over the two rock climbing design helmets. The rock climbing designs were eliminated from further trials. This trial highlighted that the pilot helmet requires the ability to:

- stay firmly in position, even in turbulent water and/or strong winds
not create strain on the head or neck when in the water
not create strain on the head or neck when falling or jumping into the water from a height
provide buoyancy

**Evaluation of marine safety helmet vs whitewater sports helmet**

In order to further compare the characteristics of the two helmets designed to be used in water, the standards and specifications to which they were designed were reviewed in more detail. The standards use various test methods and have different requirements for manufacturers to meet, and they are generally not simple to compare. The following table (Table 5) provides a summary of what appear to be the key differences between the two styles.

<table>
<thead>
<tr>
<th>Performance requirements</th>
<th>Draft Product Assessment Specifications (P.A.S. 028:1998)*</th>
<th>CE EN 1385 Helmets for canoeing and whitewater sports</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shock absorption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Crown impact</td>
<td>Fall of 2metres</td>
<td>Capable of withstanding an impact of not less than 15 J</td>
</tr>
<tr>
<td></td>
<td>This corresponds to an impact energy of nominally 100 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Force transmitted to headform** shall not exceed 10 kN</td>
<td></td>
</tr>
<tr>
<td><strong>Shock absorption</strong></td>
<td>Fall of 0.5m</td>
<td>Not specified</td>
</tr>
<tr>
<td>• Off-crown impact</td>
<td>This corresponds to an impact energy of nominally 25 J</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acceleration not to exceed 250 g at any time</td>
<td></td>
</tr>
<tr>
<td><strong>Resistance to penetration</strong></td>
<td>1.5kg striker (cylindrical shape with conical end, radius point 0.5mm)</td>
<td>Not specified</td>
</tr>
<tr>
<td>• Crown penetration</td>
<td>Point of striker must not contact surface of the headform</td>
<td></td>
</tr>
<tr>
<td><strong>Resistance to penetration</strong></td>
<td>3kg striker (cylindrical shape with conical end, radius point 0.5mm)</td>
<td>Not specified</td>
</tr>
<tr>
<td>• Off-crown penetration</td>
<td>Point of striker must not contact surface of the test headform</td>
<td></td>
</tr>
</tbody>
</table>
### Performance requirements

<table>
<thead>
<tr>
<th>Performance requirements</th>
<th>Draft Product Assessment Specifications (P.A.S. 028:1998)*</th>
<th>CE EN 1385 Helmets for canoeing and whitewater sports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention system strength</td>
<td>4kg drop weight guided a distance of 600mm&lt;br&gt;Maximum dynamic extension not to exceed 35mm, and residual extension shall not exceed 25mm</td>
<td>4kg drop weight guided a distance of 150mm&lt;br&gt;Maximum dynamic extension not to exceed 25mm</td>
</tr>
<tr>
<td>Retention system effectiveness</td>
<td>10kg drop weight guided in freefall a distance of at least 180mm&lt;br&gt;Helmet to remain on headform</td>
<td>Static load with mass of 4kg&lt;br&gt;Front edge of helmet not to move upwards by more than 80mm</td>
</tr>
<tr>
<td>Buoyancy</td>
<td>Must float to surface after 4 hours of total immersion</td>
<td>Must float to surface after 4 hours of total immersion</td>
</tr>
</tbody>
</table>

*At the time of preparing this table the updated PAS 028 (2002) was not available

**A ‘headform’ is a rigid object designed to simulate a human head for use in testing protective headwear

In summary, this comparison shows that the specifications for the Marine Safety Helmet are more demanding and are different to those for the Canoeing and Whitewater Sports helmets, and the Marine Safety Helmets are designed to absorb more shock and to better resist penetration.

### 4.8 Cost benefits

The use of suitable helmets will reduce the risk of head trauma to pilots. While the likelihood of serious trauma is low, the consequences include serious injury and death.

Helmets used across leisure, sporting and industrial settings have been proven to reduce the impact of trauma to the head. The ‘cost’ of a fatality as a result of a fall includes many hidden costs, particularly if the risk is deemed to be foreseeable and limited actions were taken to reduce the risk, including those actions that are considered to be ‘reasonably practicable’.

Should a fatality or serious injury occur some of the costs include:-

**Pilot’s costs:**
- disability
- pain and suffering
- possibly never able to return to pilotage
- possibly never able to be employed again
- family trauma

**Business costs:**
- reduced staff morale and ongoing trauma
- lost time
- workers compensation
- negative impact on company profile in the community and business circles
- staff training and replacement costs
- inability to service clients
- potential fines and legal fees

Based on the evidence in this report, the potential value of a helmet far outweighs the potential costs if a pilot does not wear a helmet and sustains serious head trauma.

The helmet that provides the most protection for pilots has been assessed as a Marine Safety Helmet, and the brand tested was a Gecko Marine Safety Helmet. The cost of this helmet is approximately $550 as compared to the Canoeing and Whitewater helmets that retail for approximately $130 - $175. Lifespan of a helmet and replacement schedules have not been assessed for the helmets, however a comparison in Table 6 provides some cost estimates based on different periods of use.

**Table 6. Cost per wear of Gecko helmet vs Gath helmet**

<table>
<thead>
<tr>
<th>Years helmet is in use</th>
<th>No. of jobs per pilot in this period*</th>
<th>Cost per job or ‘cost per wear’ For Gecko Helmet (Helmet cost $550)</th>
<th>Cost per job or ‘cost per wear’ For Gath Helmet (Helmet cost $174)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>325</td>
<td>$1.69</td>
<td>$0.54</td>
</tr>
<tr>
<td>2 years</td>
<td>650</td>
<td>$0.84</td>
<td>$0.27</td>
</tr>
<tr>
<td>3 years</td>
<td>975</td>
<td>$0.56</td>
<td>$0.18</td>
</tr>
</tbody>
</table>

*Number of jobs per year is based on data from an earlier study into pilot activity at 2 ports in NSW, and is an average of jobs undertaken by an unlimited pilot per year. Other ports should substitute their own figures for comparison.

Given that pilots are not all undertaking pilotage tasks at the same time, it may be possible to share helmets between pilots. As the Gecko helmet is designed as a ‘one-sized’ helmet with a self-inflating liner to fit different heads, it is easy to share between users after wiping the lining clean. This would significantly reduce purchasing costs while still providing increased safety for all pilots in the organization. The Gedi helmet is not designed to be shared as it comes in 5 sizes and with extra padding strips to assist the user with customising the helmet.
5. RISK CONTROL

5.1 Conclusions

The rates of head trauma, traumatic brain injuries and fatalities from brain injury for pilots in Australia and overseas is not known due to the lack of available data. Anecdotal evidence suggests that minor cases of bumping the head are common, and serious injuries are rare. The likelihood of headstrike from the side of ships’ hulls and when on the pilot vessel are more common.

However the author is aware of a number of cases of pilot falls from a height over the past 3 years where the pilots fell back onto the pilot boat but did not strike their heads. Had these pilots landed differently, the outcomes would have been very different. The risk of falling from the ladder is clearly a foreseeable risk in this task.

Despite the apparently low likelihood of serious events, the consequences of traumatic brain injury can be significant, resulting in permanent disability or death. Helmets are designed to counter the impact of each of the main head injury mechanisms encountered by pilots.

On balance, the advantages of pilots wearing a suitable protective helmet on the pilot vessel, in the pilot transfer, and when walking across ships’ decks appear to outweigh the potential risks. Based on this review of available the injury records, standards, scientific literature, and performance testing it is therefore recommended that marine pilots be encouraged to use an appropriate design of protective helmet during the ladder transfer task.

5.2 Recommendations

Helmet type

The helmet designs that appear best suited for use by the pilot in the ladder transfer are those designed for water use, including helmets designed to meet the requirements for ‘Helmets for Canoeing and Whitewater Sports’ and those for ‘Marine Safety Helmets’. Each has characteristics that provide some protection to the head while also being suited to water immersion, including falls from a height into the water and swimming in the water.

Of these two helmet types, the specifications for the ‘Marine Safety Helmets’ are more stringent than those for ‘Helmets for Canoeing and Whitewater Sports’. Marine safety helmets are designed to sustain a greater degree of shock absorption, as well as being resistant to penetration. The ‘retention system strength’ and ‘retention system effectiveness’ are also at a higher level.

The helmet that therefore appears to best suit the pilot’s work and to provide them with the greatest level of head protection is a Marine Safety Helmet. The brand used and reviewed in this project was the Gecko Marine Safety Helmet, and this helmet was rated as superior to the Canoeing and Whitewater Sports helmet that was used in the water testing and the user trials (the Gath Gedi). As only one
The Marine Safety Helmet was reviewed; comparisons cannot be made with other brands that may also meet or exceed the Marine Safety Helmet requirements.

The key features of the Gecko Marine Safety Helmet are:
- very high level of shock absorption (as compared to other standards)
- very high level of resistance to penetration by objects (as compared to other standards)
- added buoyancy
- close fitting, balanced and comfortable to wear
- comfortable in jumping into water from a height
- comfortable to swim in
- protects as much of the head as possible without impairing vision, hearing or balance

There are also a number of optional extras that the Gecko helmet provides, such as head lights and a hands-free communication system (radio-microphone), and these may provide added benefits to the pilots.

**Further user evaluation and consultation with pilots, their employers and marine authorities**

Further user evaluation with the recommended helmet is strongly recommended. At this stage only 5 pilots have had the opportunity to use the recommended helmet in water and to experience its use, and only 15 pilots have seen the helmet and had the opportunity to try it on. Also, other stakeholders have not been directly involved in the helmet assessments. At the time of the user evaluation four different helmets were presented, and the two rock climbing helmets have since been found to be inappropriate.

It is important to note that the overwhelming majority of marine pilots in Australia are concerned that wearing helmets may increase their risks on the ladder transfer, as well as affecting their ability in the water. Pilots have not traditionally worn helmets, and they are considered by some pilots to detract from their professional appearance. Consequently pilots are very reluctant to wear helmets in the ladder transfer.

As part of the ongoing user evaluation, the pilots must have an opportunity to review and to consider the evidence. They should have their questions regarding head protection and head injury addressed by personnel who are experts in the field, and who are independent and not associated with the pilots’ employers or seen to be biased or not objective. The pilots should also have the opportunity to fully review the recommended helmet, with each concern properly investigated and tested by either the helmet manufacturer or supplier or other suitable party. These further tests might indicate that modifications to the helmet are required to better meet the pilots’ requirements.

Once pilots, marine organizations and employers have had a chance to consider the existing evidence and to arrange any further testing they will be better placed to make a decision on the value of head protection for the pilot ladder transfer. They will then be able to decide for themselves if head protection is desired, and if a current helmet meets their needs.
6. REFERENCES

**Australian and International Standards and Specifications**

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AS/NZS 1801:1997, Occupational protective helmets


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