Technical Meeting — 1 March 2023

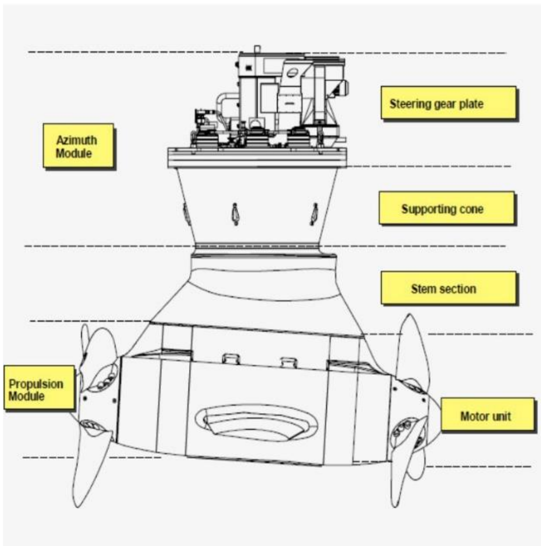
Philip Baldwin, Independent Contractor to Defence, Maritime Sustainment Division, gave a presentation on *Remediation of the LHD Propulsion Issues*, to a joint meeting with the IMarEST in the Henry Carmichael Theatre, Sydney Mechanics School of Arts in the Sydney CBD, and streamed live on 1 March. The presentation was attended by 20 with an additional 29 online.

Introduction

Phil began his presentation with the background to the issues. The Australian LHDs, HMA Ships *Canberra and Adelaide*, entered service in 2014 and 2015. Principal particulars of the vessels are

Length OA	230.82 m
Length WL	207.20 m
Length BP	207.20 m
Beam (maximum)	32.00 m
(moulded)	29.93 m
Depth (moulded)	27.50 m to Flight Deck
Draught	6.80 m
Displacement	27 400 t
Main engines	2×MAN 16V32/40 gensets
	each 7.45 MWe at 6600 V 60 Hz 3 ϕ
	2×GE LM2500 GT genset 22 MWe
Propulsion units	2×Siemens azimuthing thrusters

HMAS *Canberra*
(Photo from RAN website)



Overview of propulsion unit
(Drawing from Siemens technical manual, courtesy Defence)

The problems affecting the performance of the two Australian LHDs were profound, complex, and often interrelated. There were two aspects to the issues: technical and commercial. To deliver effective technical solutions there was a need to agree on commercial terms. However, this presentation looks only at the technical issues.

The LHDs were delivered with a number of complex problems which affected the propulsion system directly and impacted the general performance of the platform:

- Corrosion of the propellers: first the nuts holding the propeller blades onto the boss corroded. These were replaced with duplex stainless steel nuts, but then the propeller blades corroded!
- Excessive leakage of water and oil into the pod bilges.
- Cavitation erosion of the propeller blades.
- Complaints from ship's staff about high vibration levels: A notation of CEPAC2 (for Crew and Embarked Personnel Accommodation Comfort 2) had been awarded to the vessels by Lloyd's Register. However, as-built CEPAC2 measurements turned out to be non-compliant with LR rule requirements. High vibration levels were attributed to cavitation, consistent with blade erosion.

Investigations

A Transition and Remediation Program (TaRP) team was assembled, and led the extensive propulsion investigations into:

- propeller blade cavitation and erosion;
- propeller corrosion issues; and
- pod equipment issues.

Key players in the investigations were:

- Commonwealth of Australia (CoA): Naval Technical Bureau (NTB)/Directorate of Naval Engineering (DNE), Defence Science and Technology Group (DST), LHD Systems Program Office personnel, and LR's Technical Investigation Department (TID).
- Industry: Navantia (ship designer and system integrator), and Siemens (pod OEM)

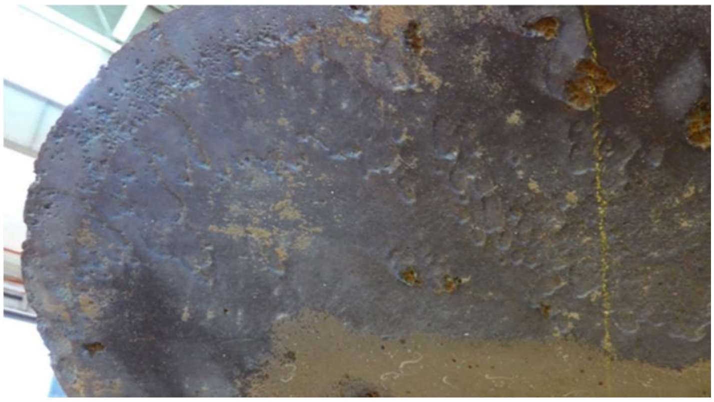
Investigations initiated in 2016 included

- Corrosion Investigation: This was led by NTB and DST and identified a number of issues which were leading to galvanic corrosion of the propeller blades including the impressed-current cathodic protection (ICCP) not performing to the design intent.
- Vibration Investigation: LR's Technical Investigation Department (TID) were contracted in July 2016 to undertake whole-of-ship structural vibration and CEPAC2 surveys, but no ship time was allocated.

Then within a single 24 h period in early March 2017, HMAS *Canberra* suffered excessive water/oil ingress in the propulsion pods resulting in a pod being locked and the vessel returned to Fleet base East, and HMAS *Adelaide* was identified to have oil quality issues, resulting in the vessel returning to Fleet Base East Sydney with a pod unavailable.

Consequently, in April 2017 the TaRP was formed to investigate and remediate LHD material shortcomings. Both LHDs were docked, HMAS *Addelaide* in May/June and HMAS *Canberra* in September/October. Pods were returned to standard with a five-year overhaul and new three-bladed propellers fitted on both vessels.

HMAS *Adelaide* propeller blade with tip-vortex cavitation and corrosion material removed at May 2017 dry docking after 19 months in service
(Photo courtesy Defence)



HMAS *Adelaide* propeller blade showing corrosion under stable sheet cavitation
at May 2017 dry docking after 19 months in service
(Photo courtesy Defence)

Sea Trials in 2017

Following the docking of HMAS *Adelaide*, an extensive trials program was undertaken with the following aims:

- Re-commissioning of the overhauled propulsion pods.
- Determine the structural vibration characteristics of the LHD platform via an empirical modal analysis (EMA), and the structural response with ship underway.
- Assess compliance with CEPAC2 requirements for vibration only (not noise).
- Measure hull pressures above the propellers.
- Observe propeller hydrodynamic performance.
- Conduct local vibration analysis of the ship's structure and machinery as required.
- ICCP and hull potential measurement and analysis.
- Multiple additional trials and tests related to sewage-treatment plants, air-conditioning plants and chilled-water systems, fire pumps, etc.

After the trials on HMAS *Adelaide,* the trials the programme was refined for HMAS *Canberra* to look at specific areas of concern, e.g. the main switchboards and masts.

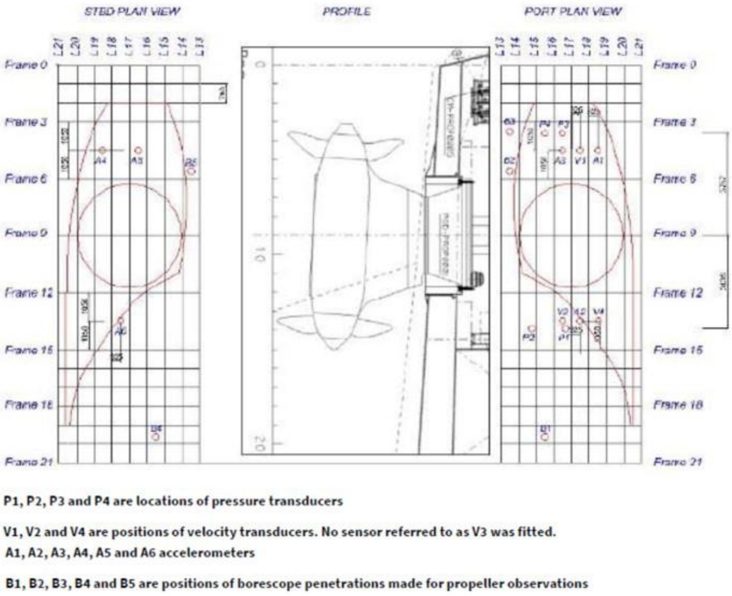


Diagram showing locations of propeller pressure observations
(Diagram courtesy Defence)

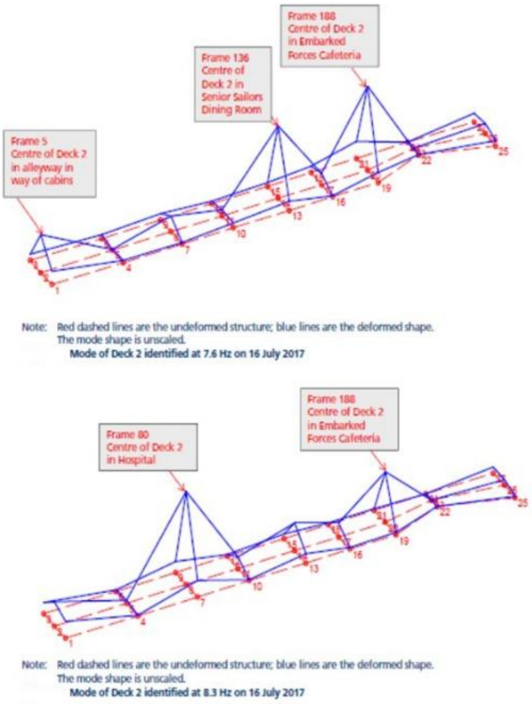
Structural Analysis

The empirical modal analysis was conducted and showed:

- On the Flight Deck and Superstructure, a mode was identified at 7.4 Hz corresponding to the propeller first blade rate at 148 rpm, characterized by rolling motion of the Flight Deck and Superstructure. The solution would be to reduce the propeller pressures exciting the hull.

- On 2 Deck, modes were identified at 7.6 Hz and 8.3 Hz corresponding to propeller first blade rates of 152 and 166 rpm respectively. The solution would require structural modifications to 2 Deck and reducing the propeller pressures exciting the hull.
- On the Aft Mast, local modes were identified at 5.9 Hz and 6.8 Hz, with vibration amplitudes exceeding MIL-STD-167-1 for electronic equipment. The solution would require local structural modifications to the mast and reducing the propeller pressures exciting the hull.

The maximum propeller pressures exciting the hull were measured at just above 5 kPa zero-to-peak at close to MCR. Vessels with passenger and crew comfort typically have lower hull pressures, e.g. 2–4 kPa.
For the excitation force, the first blade rate of the propellers was determined to be the dominant source of vibration.



Results of empirical modal analysis on 2 Deck
(Diagram by LR TID courtesy Defence)

Accommodation Comfort

In the trials program, the vessels were tested for compliance with LR's CEPAC2 notation, but with only vibration measured, no noise measurements. It was found that 52 compartments were above CEPAC2 limits for vibration, and 40 of the 52 were on 2 Deck! The Primary Casualty Reception Facility (PCRF; i.e. the hospital) was particularly badly affected, with CEPAC2 limits exceeded at a number of speeds. Exceedances could be expected to occur at lower speeds than at 85% MCR, the trial speed, but several exceedances were identified in the PCRF at even lower speeds.

Propulsion Pods

Two new propulsion pods were ordered in April 2018 for two main reasons: in the event of a total failure of a pod, for operational reasons a two-year lead time for a new pod was deemed unacceptable, and at mid-life refit, the time required for pod motor overhaul would result in an unacceptably-long docking maintenance period.
The main reason for the two-year lead time for new pods was that the material used to manufacture the motor permanent magnets comes from Russia, and that was before the war in Ukraine!

The Way Ahead — Structural Vibrations

The structural vibration problems were complex and multifaceted.
Navantia undertook further investigations on their prototype vessel, *Juan Carlos 1*, including EMA of a pod in dry dock and found a natural hull frequency of approximately 7.8 Hz at 156 rpm. This aligned and was coincident with predominant natural frequencies found here, particularly on 2 Deck.
Navantia estimated up to 4% variation of thrust seen by the forward and aft propeller blades.
They also found erosive cavitation and excessive hull pressures related to complex wake fields.
The solution options included redesign of the propellers, and/or stiffening the platform, i.e. structural changes.

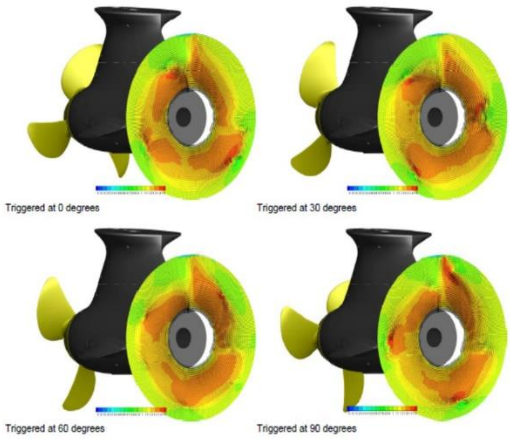
Propeller Redesign

Propeller redesign was considered the simplest and cheapest option, but it was *not* simple or cheap!

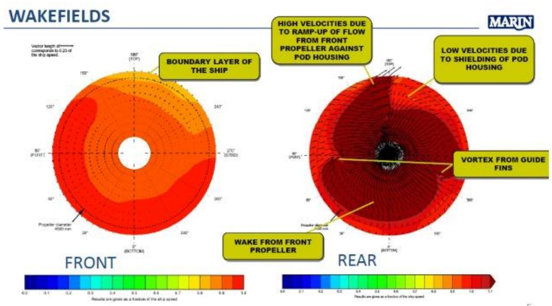
One option was to increase the number of blades on the propellers. This option would reduce the thrust seen by each blade, improve the wakefield flow onto the aft propeller, and lower the speed and therefore the power (excitation force) at which resonance occurs.

Prior to delivery of the Australian LHDs, the pod OEM/Navantia had engaged MARIN to modify the aft propeller pod to improve performance, and MARIN had tank tested a model. In late 2018, MARIN was provided with SATs propeller cavitation video and trials data from HMAS *Canberra*. They then re-ran earlier tank tests and adjusted scale and model coefficients to replicate, under tank test conditions, the hydrodynamic performance and cavitation observed at sea. This provided assurance that future tank testing of a new propeller design would closely replicate the actual performance at full-scale. Early in 2019, MARIN conducted particle-image velocimetry (PIV) testing and CFD modelling to determine the wakefield characteristics at the rear of the pod (behind the rotating forward propeller) i.e. on entry to the rear propeller. This information was shared with the pod OEM and Navantia to inform the re-design.

MARIN's pod model with forward propeller, and the green line showing the measurement plane of the PIV system to determine the wakefield flow into the aft propeller
(Photo from MARIN Report 27507-6-DT, courtesy Defence)



Orientation of front propeller and resulting velocity fields
(Image from MARIN Report 27507-6-DT, courtesy Defence)



Results of wakefield calculations
(Image from MARIN Report 27507-6-DT, courtesy Defence)

Four-bladed Propeller Design Study

A design study for a four-bladed propeller was initiated in May 2019, with the CoA contracting Navantia to manage the study. The propeller design specifications called for the same formal design criteria as the original, plus in priority order:

- Low shaft excitation forces.
- Prevention of cavitation erosion damage.
- Reduced vibration caused by propeller cavitation.
- Efficiency.
- A delayed cavitation inception speed.
- Prevention of inboard propeller noise.
- Reduction of hull pressures from 5 kPa to between 2 and 4 kPa.

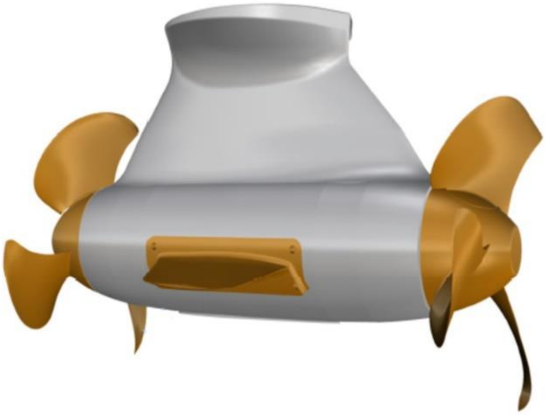
The original intent of the study had been for the pod OEM to work with MARIN on propeller redesign. However, the OEM was not in favour of the four-bladed approach, and teamed with another propeller designer to redesign the three-bladed propellers, making this a Mk 5 variation for the aft propellers.

Navantia teamed with MARIN to design a four-bladed propeller solution. Navantia, as the ship integrator, was tasked to advise the CoA on which was the optimal design.

The OEM had reservations about the motor shaft dynamic performance, in particular lateral vibrations—their preliminary calculations indicated that the 6 mm motor air gap would close if four-bladed propellers were used. CoA was not convinced about the validity of these findings as there was insufficient evidence to support them.,

OEM Propeller Design

The propeller designer developed a three-bladed propeller design to the OEM's requirements. These propellers were highly skewed (37 degrees of skew), both forward and aft. The design required a redesign of the pod fins, where the redesign specifications called for the original fins to be retained.



3D model of the complete redesign for the LHD vessels
(Image courtesy Defence)

MARIN Design

MARIN designed a four-bladed monobloc propeller (compared to the original design in which the blades were bolted to the boss). The monobloc design was a result of being constrained by the requirement to keep the boss to the original fundamental dimensions but incorporate an extra blade. The benefit was that the propellers had much cleaner lines and removed the need for the bolted securing arrangements of the blade which contributed to turbulence. The disadvantage would be that, if one blade were to be damaged, it would require replacement of the whole propeller. In the redesign the forward propeller was skewed and the aft propeller highly skewed. The forward and aft boss caps were different in length and form.

Tank Testing of New Propeller Designs

A number of different types of tests were undertaken:

- Open-water tests, with a pod model towed along the tank without the model hull to determine the loading of the forward and aft propellers and the open-water efficiency.
- Propulsion tests, with the model pod attached to the hull model to determine the power and shaft rpm of each design, run at both 100% and 80% MCR.
- Cavitation tests in open water with observations carried out in various conditions with the pod model towed along the tank without the model hull.

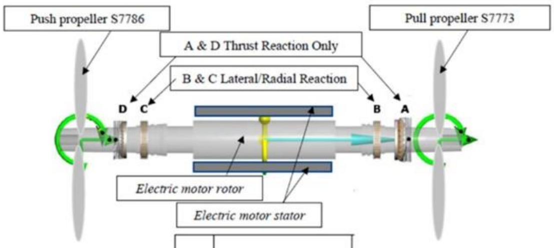
The results of the propulsion tests showed that the speed/power performance of both designs were almost identical, with the shaft rotation rate about 1 rpm higher than the design specification.

The cavitation tests showed that the three-bladed bladed design had erosive cavitation on both the forward and aft blades The four-bladed design showed no erosive cavitation, and root cavitation on aft blades could be eliminated by design modification. The hull pressure fluctuations levels were lower for the four-bladed design than the three-bladed design overall. The three-bladed design had higher harmonics, with amplitudes greater than 1 kPa. The total hull excitation force in the vertical direction (F_z) was about 50% less for the four-bladed design than for the three-bladed design.

Pod Shafting Vibration Analysis

The pod OEM's initial calculations indicated that four-bladed propellers would result in unacceptable levels of lateral shaft vibrations and the air gap in the motor would close. There were differences of opinion on the methodology for the determination of propeller forces and the analysis of the shafting vibratory response. Consequently, the

CoA decided that independent modelling and analysis was required and contracted LR TID (Southampton) through Navantia to conduct shafting vibratory analysis using input data (propeller forces) from both MARIN and the pod OEM. Extensive modelling was conducted.



bearing position	bearing designation
A	294/500 EN2M
B	C 39/560 KM/C3VL0241
C	C 39/560 KM/C3VL0241
D	293/500 N2

Bearing general arrangement of the pod OEM's three-bladed redesign
(Drawing by LR TID, courtesy Defence)

In summary, the results showed:

- Axial vibration: No first or second harmonic blade-rate axial vibrations occurred in the speed range, so this was unlikely to be a cause of concern.
- Torsional vibrations: Extensive model scenarios were completed, including manoeuvring, and results indicated that torsional vibrations were unlikely to be a cause for concern.
- Lateral vibrations: The maximum half-range vibratory lateral direct stress evaluated by forced damped analysis across 14 operating manoeuvres was 25.74 MPa, and unlikely to be a cause for concern.
- High-cycle Fatigue Combined Torsional and Reverse Vibration: High-cycle fatigue safety factors for 10^{10} cycles including torsional and bending stress concentration was assessed against DNV guidelines, and a safety factor of 4.75 resulted, and so unlikely to be a cause for concern.
- Total Stress and Low-cycle Fatigue Combined Torsional and Reverse Bending: For notched shaft locations a safety factor was calculated at 4.63, indicating that yield reversals were unlikely to occur.
- Electric Motor Air Gap: The minimum safety factor on the electric motor air gap of 3.28 mm was 26.8 and 3.6 for vibratory and total lateral shaft displacement, respectively. This meant that, in the worst condition, the air gap was 3.6 times larger than the radial movement of the shaft and the electric motor air gap would not be compromised.

The conclusion of the shaft vibration analysis was that, with the MARIN four-bladed propellers, the propulsion unit vibratory response was acceptable.

Re-design Conclusions

The overall conclusions of the redesign and testing program were:

The pod OEM's propeller designer produced three-bladed propellers which fulfilled all CoA requirements *except for* erosive cavitation, and the hull pressure fluctuations at the second and third blade passing frequencies were considered too high. This was therefore not a valid option without modifications.

The MARIN four-bladed propellers fulfilled all of the CoA requirements, noting that they had the potential to reduce thrust fluctuations by 77% of the original three-bladed propellers at 7.8 Hz, whereas the OEM three-bladed propellers had the potential for a 32% reduction of thrust fluctuations. Shaft vibration analysis indicated that the performance of the four-bladed propellers would be satisfactory.

After further discussions and negotiations with the pod OEM, the CoA selected the MARIN four-bladed propeller design.

Four-bladed Propeller Procurement

The CoA contracted Navantia (Australia) to:

- Produce manufacturing drawings for the new four-bladed propellers and their bosses.
- CoA review of drawings conducted by the Naval Technical Bureau/Directoratre of Naval Engineering.
- Obtain LR class approval for the new design in accordance with LR's Naval Ship Rules as at January 2019.
- Procure three ship sets of the four-bladed propellers, with the delivery of the first set in time for HMAS *Canberra*'s planned docking in September 2020.
- Identify suitable propeller manufacturers capable of meeting all of the requirements, and utilise Australian industry if possible.
- Manufacturing acceptance criteria in accordance with ISO 484/1 Shipbuilding—Ship Screw Propellers Manufacturing Tolerances, Part 1: Propellers of Diameter greater than 2.5 m.

Navantia sent a request for tender to three Australian and six international companies, covering Asia, Europe and the USA. Tender evaluation was conducted by a joint Navantia–CoA team.

Australian industry was unable to cast propellers of this size, the mass of the aft propeller at 14.5 t required a 20 t mould in-country and were uncompetitive on price. Not all international suppliers responded. However, the successful manufacturer provided a complete tender response and was able to meet all of the requirements, including the tight schedule, and so was awarded the contract.

Propeller Manufacture

Quality assurance was provided by the LR local office/surveyor, as CoA and Navantia were unable to conduct any inspections because of pandemic-imposed travel restrictions. The manufacturer provided very comprehensive production schedules and progress reports for the three ship sets of propellers. Each of the propellers in a ship set is different, although the boss caps are the same for both forward propellers, and the aft boss caps are the same for both aft propellers.

Setting up the mould for one of the new propellers
(Photo courtesy Defence)

Sea Trials

The first ship set was fitted to HMAS *Canberra*, and this was followed by propulsion plant commissioning and acceptance in six phases.

Following acceptance, there were vibration surveys, propeller observations and CEPAC2 noise and vibration measurements conducted to determine the effectiveness of the new propellers. Multiple non-propulsion-related trials were also carried out.

Environmental conditions for trials required Sea State 3 or less, with a depth of water of at least five times the nominal draft of 7 m. The helm was kept to a minimum, with a maximum of five degrees, for steady course trials. Propulsion trials included pod run-in and heat runs, steering trials, and a crash stop.

Structural Vibration Survey

A structural vibration survey was carried out to re-evaluate the structural response of the vessel at the same locations as those measured in 2017 and to determine the background (environmental) levels of vibration in the magazines and on the Nulka launchers.

For the survey, vibration transducers were installed at key locations in the ship, with three different configurations to cover the extensive survey for three separate days of trials. Pressure transducers were also installed in the hull plating above the forward and aft propellers, which were accessed via the pod void spaces.

For the vibration survey, the propeller speeds were increased progressively up and down through the operating speed range. During run ups, measurements were taken in 2 shaft RPM increment steps up to the maximum shaft rpm and, at each speed, data was recorded for two minutes. During run downs, measurements were taken in 3 shaft RPM decrement steps from maximum shaft rpm, followed by 5 shaft RPM decrement steps from mid-power to minimum rpm.

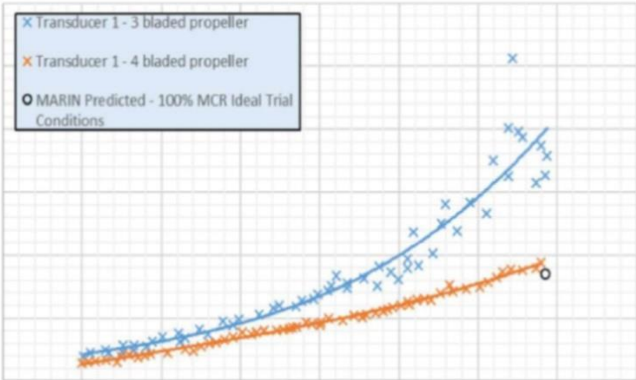
Propeller Observations

Borescope observations of propeller performance were conducted during run ups and run downs at zero helm by simultaneously viewing from four locations on the port side. Small-angle manoeuvring trials were conducted at 0, 6 and 10 degrees of helm at 90, 115, 140, 160 and maximum RPM.

The observation trials took approximately 10 h to complete, as they were required to be taken in daylight with the sun on the side where observations were being made.

The objective of the propeller observations and pressure measurements was to determine the comparative changes in terms of propeller cavitation and associated hull pressure levels of the four-bladed propeller design against the original three-bladed design. The main findings were:

- No sheet or root cavitation was observed during run ups or run downs on the forward propeller. Tip vortex cavitation was observed from 130 to maximum shaft RPM, but assessed as non-erosive.
- No sheet cavitation was observed on aft blades as they passed top-dead-centre. Tip vortex cavitation was present from 62 RPM and boss vortex cavitation from 74 RPM, but assessed as non-erosive.
- Cloudy dispersed cavitation was observed on the suction side root of the aft propeller from 95% of maximum RPM.
- The maximum pressure-pulse single-amplitudes for the forward and aft propellers were within the design acceptance levels.
- Pressure pulse levels for the four-bladed propellers reduced by 52% and 29% for the forward and aft propellers respectively, compared to the original three-bladed propellers.



Forward propeller pressure pulses at first-order blade rate
(Graph by LR TID, courtesy Defence)

The graph of pressure pulse measurements has an abscissa of shaft RPM and an ordinate of pressure; no units are shown as this is commercially-sensitive information.

In summary the observations and measurements showed strong correlation with the model tests conducted during the four-bladed propeller design study. The outcome supported and justified the comprehensive methods used to investigate and remediate the propeller problems.

A diver's inspection of the four-bladed propellers after 12 months service found them to be in as-new condition with no cavitation or corrosion damage.

CEPAC2 Trials

Crew and Embarked Personnel Accommodation Comfort 2 (CEPAC2) sea trials were conducted and required measurement of vibration and noise in about 500 compartments at 90% MCR. Three measurement teams were accompanied by ship's staff for guidance and compartment access. Measurements were completed in 14 hours in one day

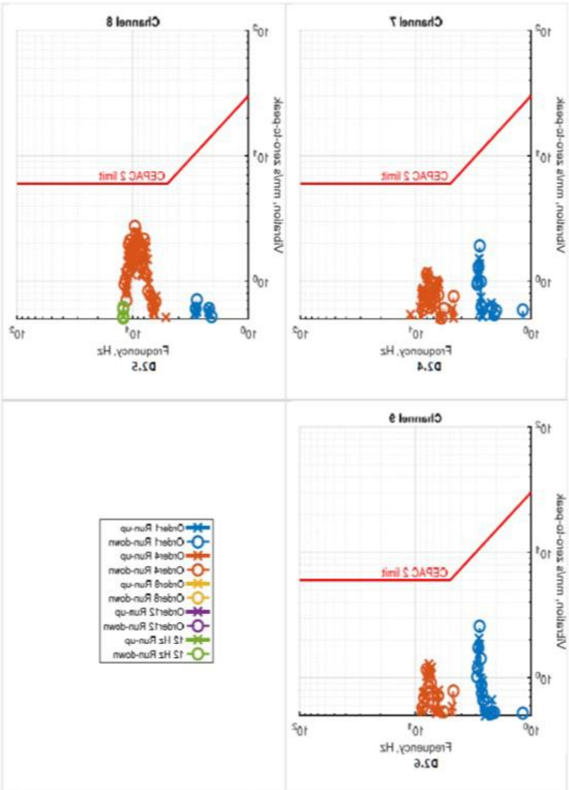
CEPAC2 harbour trials were conducted at anchor under normal harbour conditions, but with a reduced number of compartments for survey. Some machinery was required to be operated during the trial, e.g. air conditioning and lifts. These trials were also completed in one day.

Summary of CEPAC2 Noise and Vibration Measurements
(Table by LR TID, courtesy Defence)

Deck/Level	Number of measurements with the vessel underway		Number above CEPAC 2 Noise limit	Number above CEPAC 2 Vibration limits
	Noise	Vibration		
Level 06	1	1	0	0
Level 05	17	12	2	0
Level 04	26	19	4	0
Level 03	14	13	2	0
Level 02	19	17	0	0
Level 01	48	44	0	0
Deck 1	52	50	0	0
Deck 2	173	156	17	0
Deck 3	70	64	0	0
Deck 4	37	35	5	0
Deck 5	24	20	1	0
Deck 6	19	17	0	0
Total	**500**	**448**	**31**	**0**

Sample of CEPAC2 results
(Table by LR TID, courtesy Defence)

Measured location	Maximum noise levels		Measured noise levels		Below limits	Peak acceleration 1 Hz to 5 Hz mm/s^2 : frequency Hz						Peak velocity 5 Hz to 100 Hz mm/s : frequency Hz						CEPAC 2 limits			Date	Time	Remark
	dB(A)	NR	dB(A)	NR		X		Y		Z		X		Y		Z		1 to 5 Hz mm/s^2	5 to 100 Hz mm/s	Below limits			
Centre	90	85	57.7		Yes	36	1.8	70	1.8	82	2.7	0.2	11.0	0.5	11.0	0.5	11.0	189	6.0	Yes	15-03-2021	19:04:05	
Centre	85	80	58.5		Yes	11	1.8	42	1.8	47	2.7	0.2	21.9	0.3	11.0	0.4	11.0	189	6.0	Yes	15-03-2021	19:25:12	
Centre	90	85	60.5		Yes	17	1.3	30	1.8	64	2.7	0.2	11.0	0.3	11.0	0.6	11.0	189	6.0	Yes	15-03-2021	19:19:31	
Centre	90	85	57.4		Yes	28	1.8	68	1.8	61	2.7	0.3	21.9	0.5	11.0	0.5	11.0	189	6.0	Yes	15-03-2021	19:06:55	
Centre	110	105	63.4		Yes	19	1.8	57	1.8	41	2.7	0.2	21.9	0.4	11.0	0.6	11.0	189	6.0	Yes	15-03-2021	19:16:00	
Centre	90	85	67.3		Yes	37	1.8	101	1.8	92	2.7	0.3	21.9	0.5	11.0	0.6	11.0	189	6.0	Yes	15-03-2021	19:11:19	



Frame 80 PCRF (hospital) vibration levels during run up/run down
(Graphs by LR TID, courtesy Defence)

Reductions in Vibration Levels Compared to 2017

The following reductions in vibration levels, compared to the levels measured in 2017, were achieved in various locations around the vessel:

- Hull plating above the propellers: 60–70%
- Deck 5, main switchboards N1 41% and N2 62%
- Deck 2, Frame 5: 59% (previously above the applicable limit)
- Deck 2, Frame 80 in way of the PCRF (hospital): 82% (previously above the applicable limit)
- Deck 2, Frame 138 in way of the Senior Sailors' and Officers' Dining Rooms: 50%
- Deck 2, Frame 189 in way of the Embarked Forces Cafeteria: 68% (previously above the applicable limit)
- Deck 2, Frame 272: 51%
- Level 01, Frame 279: 62%
- Level 04, Commanding Officer's Sea Cabin: 59% (previously above the applicable limit)
- Level 05, Navigation Bridge: 61% (previously above the applicable limit)
- Level 05, Flight Control Room: 59% (previously above the applicable limit)
- Central Mast: 43%

Summary

Propulsion problems suffered by the Australian LHDs were caused by excessive cavitation and thrust variations, with hull pressure pulses higher than normal. Extensive technical investigations were subsequently undertaken to determine the nature and magnitude of the problem. Propeller redesign was considered the most cost-effective solution, and so a design study was undertaken which used empirical field data to inform the design and refine model and scale coefficients for tank testing. Extensive finite-element modelling of the shafting was completed to provide assurance that the system vibratory response within the operating speed range was acceptable and within classification society specifications. Redesigned four-bladed propellers have reduced the vibrations levels in the LHDs to acceptable levels which will not adversely affect the performance of the ship's systems and personnel.

Questions

Question time was lengthy and elicited some further interesting points.

The presentation was recorded and is expected t be available soon on the RINA YouTube channel.

The vote of thanks was proposed, and the "thank you" bottle of wine presented, by Adam Williams. The vote was carried with acclamation.

Phil Baldwin (L) with Adam Williams
(Photo Phil Helmore)