FERRIES

A PLAN FOR ASSAM

A team from ITS, Indonesia won first prize in the Worldwide Ferry Safety Association's annual student design contest with the plans for *Lakshmi*, an innovative ferry designed to handle the complex Brahmaputra River

The 35.48m loa *Lakshmi* utilises a monohull to help prevent the ferry from running aground on the Brahmaputra River

Spanning more than 3,800km in length, the Brahmaputra is one of Asia's major rivers, running through Tibet, India and Bangladesh. As well as being the widest river in India, the Brahmaputra has an average depth of 38m, descending to 120m at its deepest points, and often undergoes significant fluctuations in current.

Unfortunately, the river has seen its fair share of boat accidents over the years. Perhaps most memorable was the much-publicised capsizal of an overcrowded ferry in Assam, northeastern India, in 2012 – an incident that claimed the lives of at least 103 persons, and which sparked further outrage when police reports revealed that the boat was not carrying lifejackets. As recently as September 2021, two passenger vessels collided on the Brahmaputra while the river was swollen during monsoon season, causing one fatality and depositing dozens of passengers into the water.

As such, the Brahmaputra caught the attention of the Worldwide Ferry Safety Association (WFSA), which selected the river for its ninth Annual International Student Design Competition for a Safe, Affordable Ferry. The WFSA prides itself on making this contest more challenging by the year; for example, the 2020-2021 competition, won by Germany's City University of Applied Sciences (Hochschule Bremen), called for a ferry for the Amazon, designed to limit the onboard spread of viruses: a timely challenge, given that COVID-19 cases were exploding in Brazil at the time (see *Ship & Boat International* September/October 2021, pages 24-28). However, for this year's contest, Dr Roberta Weisbrod, WFSA executive director, commented that the Brahmaputra River itself would "create the challenges" for the participating student teams.

Technical Particulars

Lakshmi

Length	**35.48m (oa) / 32.32m (wl) / 31.5m (bp)**
Breadth	**11m**
Depth	**3m**
Draught	**1m**
Displacement	**277.8tonnes**
Deadweight	**112.9tonnes**
Lightweight	**163.56tonnes**
Service speed	**15knots**
Passengers	**150**

The contest called for a ferry capable of carrying 150 passengers and eight vehicles, plus motorbikes, bicycles and freight such as agricultural products. In total, 12 international student teams submitted ferry designs, and first prize was awarded to Team Nawasena ITS, drawn from the Department of Marine Engineering at Indonesia's prestigious Institut Teknologi Sepuluh Nopember (ITS), a university specialising in science and technology.

Strong pedigree

Nawasena ITS was founded in 2017 "to focus on research and development of an affordable, safe, reliable, efficient and environmentally friendly ship design for the future", explains Anak Agung Madya Kusuma Dewa, part of the team's 3D modelling and visualisation division. He tells *Ship & Boat International*: "The team consists of 11 undergraduate students, with two faculty advisors, and contains five divisions, each comprising two to three members" (see box).

He continues: "Our team has taken part in several ship design competitions, in Indonesia and internationally." Domestic wins have included prototype patrol boat and autonomous submarine designs for Indonesia's naval-oriented KKCTBN contest, and the team has also participated in the Cruise Lines International Association (CLIA) Life Saving Appliance Innovation competition. And, of course, Nawasena ITS achieved second place in a number of previous WFSA ferry design contests, highlighting the team's strong pedigree in ship design.

Together, the team developed the concept for the aluminium ferry *Lakshmi*, named after the Hindu goddess of wealth and good fortune. A monohull was selected, Dewa says, to anticipate the risk of the vessel running aground or losing stability – a crucial consideration when operating on a river prone to shifting sandbanks.

Part of the team's research included checking the capabilities of domestic Indian shipyards, fulfilling another staple criterion of the annual student contest. "Based on our search and comparisons, Cochin Shipyard in Kerala has the facility to build *Lakshmi*, and has a reputation for constructing various vessels in steel and aluminium," Dewa says. "Moreover, some of the existing Brahmaputra ferries are being built at Cochin." The proposed operational route would also be located 118nm from Pandu Shipyard, which houses a repair shop that could accommodate *Lakshmi*'s repair and maintenance needs.

Vehicle deck

As well as meeting the 150-pax capacity specified by the WFSA, *Lakshmi* can carry eight four-wheel vehicles, 44 motorcycles and 10 bicycles on its vehicle deck, which features a ceiling height of 1.5m. This deck is fitted with both side and bow ramps, to permit multiple berthing procedures. Dewa explains: "These will depend on the type of terminal, and on the seasons. Some terminals on the Brahmaputra have low accessibility for ferries: the riverbanks have a sloping geography, and can only be accessed by a beaching procedure via the bow ramp. Also, ferries usually won't be able to reach certain floating barge terminals – such as the one at Kamalabari – as the water level is too low during dry seasons." In this scenario, beaching via the bow ramp door would be the best means of passenger embarkation/disembarkation.

Dewa continues: "During rainy seasons, however, *Lakshmi*'s passengers will mostly use the side ramp door like any other ferry in Assam, as almost all of the terminals on the Brahmaputra are floating barge types."

All cargo space is located on the vehicle deck. The port side offers approximately 38.7m^2 of cargo space, has a 3tonne weight limit and houses an 11.6m^2 chiller and a 12.6m^2 freezer, enabling the carriage of perishables and frozen goods. The port area also features an air-con unit and an elevator for disabled passengers – the latter accompanied by four tie-down points for wheelchair users.

The starboard side of the vehicle deck, meanwhile, provides 43.4m^2 of cargo space, has a 3.7tonne weight limit and features an emergency generator room and a bicycle rack. The vehicle deck is fitted with 250mm x 50mm wooden grating for even load distribution.

Upper decks

Up a short flight of steps, the tween deck offers four crew cabins (starboard and port) and toilets. Each cabin can accommodate two crew members, and

Meet the team

For the ninth WFSA student design contest, Team Nawasena ITS comprised:

Faculty advisors
Dr Achmad Baidowi, ST, MT
Dr Ir. Agoes Santoso, M.Sc, M.phil

Hull and hydrodynamics division
Reza Bagus Ramadhan
Ipung Nur Wahyu Fadholi

Machinery and electric division
Priskila Putri Irene
Muhammad Raffi Adhitama

General arrangement, innovation and economy division
Ghavin Ghavyero
Dewantoro Abimanyu

Construction and scantling division
Rizal Izzuddin Alqosam
I Wayan Attita Dharma Thandava
Ari Nur Setyanto

3D modelling and visualisation division
Anak Agung Madya Kusuma Dewa
Joel Herdian Seciawanto

Members of Team Nawasena ITS, Indonesia designed the winning entry in the WFSA contest

is furnished with bunk beds and storage lockers. Ascending to the next level of the vessel, one accesses the passenger deck, featuring male/female toilets (including washroom facilities for disabled passengers) and seating.

Each seat features an overhead compartment for the storage of hand luggage. Also, cognisant of the fact that COVID-19 hasn't gone away, the team has positioned a disinfection chamber at the entrance to the passenger deck, while partitions between the seats limit direct contact with other passengers. A HEPA filter would also be applied to the cabin air duct. Additionally, a shower room, aft, could be converted into an isolation room for passengers exhibiting coronavirus-related symptoms.

At the top of the ship, the navigation deck features the navigation room at the fore, along with the crew mess and separate rooms for the captain and chief engineer. The aft of the deck is occupied by an array of solar panels, to which we will return shortly.

Stability and power

For the ferry's scantling arrangement, Nawasena ITS consulted ABS' rules for building and classing aluminium vessels. *Lakshmi* was also designed to comply with IMO's Intact Stability Code – IMO A.740 (18) – and with Annex 8 of the MCA's International Code of Safety for High-Speed Craft (HSC) 2000, regarding the stability of monohull craft. Both of these goals were achieved after the team undertook a floodable length test, to demonstrate that the ferry could withstand a two-compartment flooding scenario.

This was largely achieved by placing a urethane-type, US Coast Guard-approved expanding flotation foam, with a density of 32kg per m^3, inside a watertight compartment inside the hull. "The foam prevents water ingress in the compartment, which could result in a loss of buoyancy," the team says.

Lakshmi would run on a diesel-electric powertrain, using a type of biodiesel as the fuel. "The biofuel used on this ferry is B20, a mix of petrol-based diesel and biodiesel with an 80:20 ratio," says Dewa. "The biodiesel itself will be made from vegetable oil, and will be produced locally, as India's biofuels industry has been in talks with the government since 2018, in line with the country's National Policy on Biofuels." The ferry would also draw on 12 batteries with a combined rating of 57.6kWh to power onboard equipment, such as fans, blowers, lights and navcomms. Additional battery banks could be installed on the vehicle deck as part of future upgrades, Dewa hints.

The batteries can be charged by the onboard generators or by the aforementioned 24 solar panels, which are arranged across the open aft space of the navigation deck (66m^2) and the wheelhouse roof (39m^2). Dewa elaborates: "The optimum capacity of 24 x 600W panels is 86.4kWh for six hours of average sunshine in Brahmaputra per day, connected in eight strings of three: three in series, eight in parallel. The system uses MPPT charge controllers that are suitable for charging the batteries while being capable of withstanding the high voltage and current of the system.

"Using a 120A charge current from the two battery chargers, the 12 batteries will be fully charged for 10 hours – equating to approximately 12.5 voyages." The set-up would grant the ship a service speed of 15knots. Based on the team's route planning analysis, *Lakshmi* would average five trips per day in calm water and 6knot river currents, and each trip would likely take around 45-50 minutes.

Lakshmi would be fitted with three 1,800kW ABB AMG 0450 generators, one installed for redundancy, as well as a 99kW CAT C4.4 harbour generator, plus a 50kW Cummins Onan generator for emergency use. Nawasena ITS has calculated that, when sailing, the ferry would have a power requirement of 2,899.1kW, supplied by two of the ABB main generators. In port, however, the power requirement would be 75.5kw, supplied by the CAT harbour generator. According to the team's predictions, conducting harbour operations purely on electric power could gift the operator a 19% fuel saving.

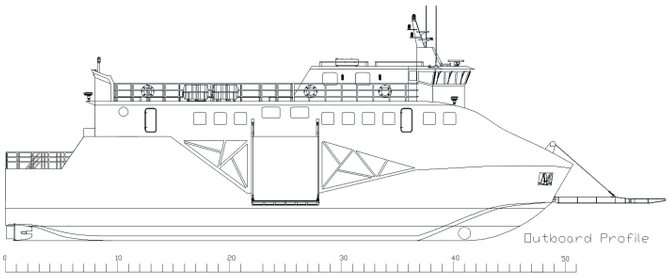
Onboard safety

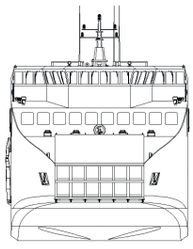
Nawasena ITS also developed a comprehensive safety plan for *Lakshmi*. The ferry would feature four evacuation systems: two port, two starboard. Having run a simulation for the process, the team believes that evacuation of the passengers would take less than eight and a half minutes.

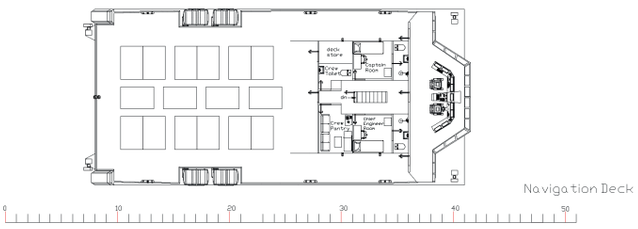
Dewa says: "We have compared several marine evacuation system products…based on our findings, Viking Life Saving Equipment and Survitec could be the choice – for instance, the MiniSlide from Viking, or the Easyscape slide from Survitec. The products are suitable for operations in inland waterways where sailing condition is considered light."

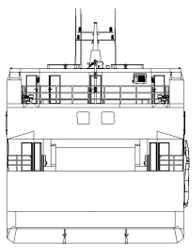
The safety plan also accounts for potential fire risks, and so *Lakshmi*'s design includes a quick-closing valve for the fuel manifold, to cut the fuel line from the service tank to the engine in the event of

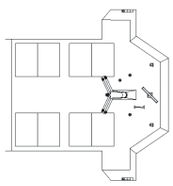
The general arrangement of *Lakshmi*

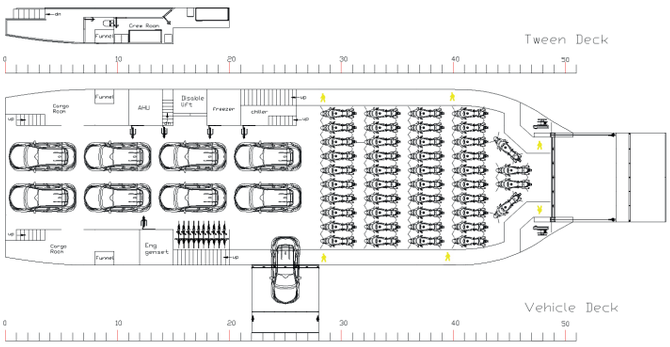


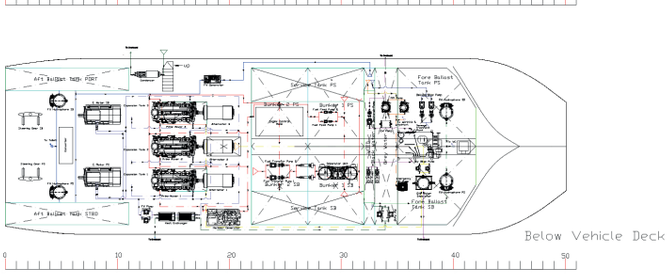










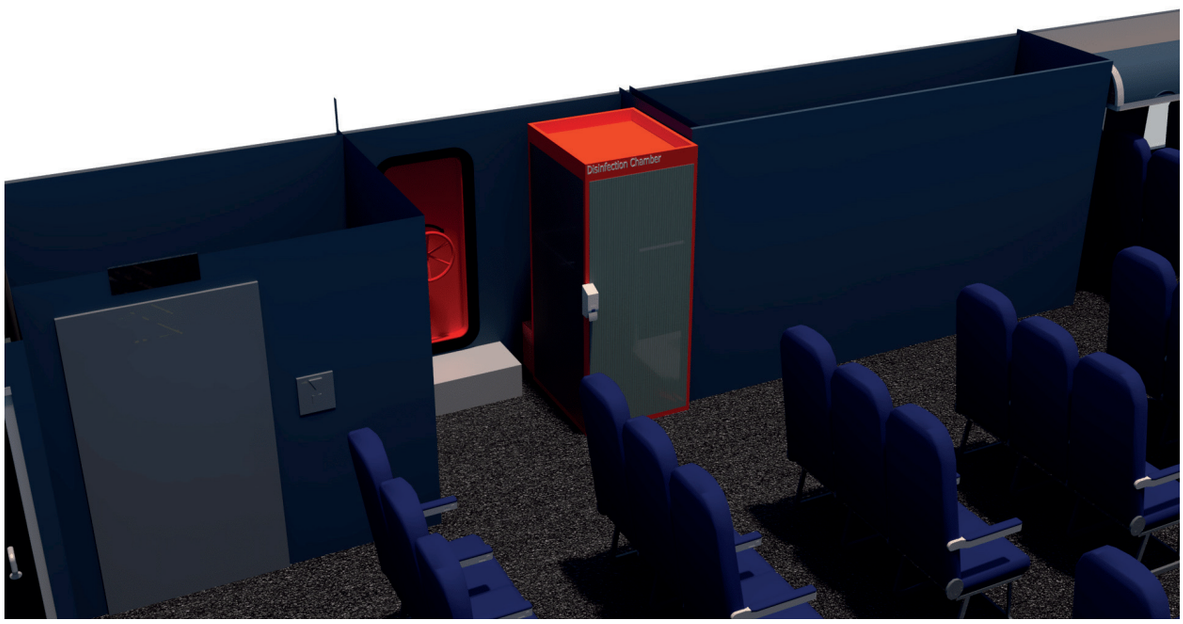


Solar panels mounted on the navigation deck and the wheelhouse roof would capture the energy to top up *Lakshmi*'s onboard batteries

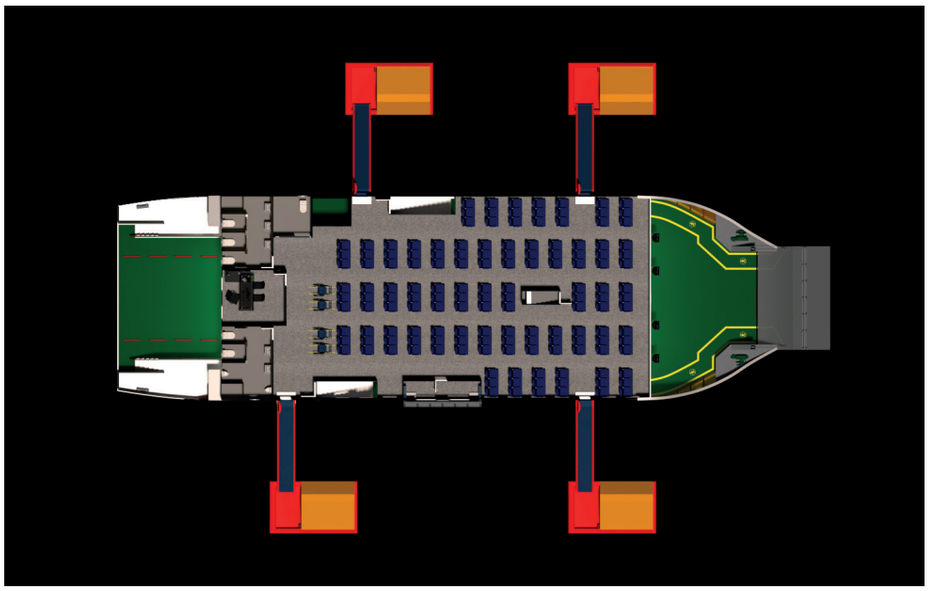
an emergency. The ferry also carries multiple items of firefighting equipment, including: two aerosol extinguishers for the main engines; three sprinklers; four hydrants; five portable fire extinguishers; and a fireball extinguisher.

Given Brahmaputra's high volume of sediment, the team factored in a double filter for the vessel's sea chest, to prevent sand particulates from circulating and causing inner pipe damage. This filter would most likely be a stainless steel basket, possibly with a thickness of 2-6mm. And, mindful of previous ferry accidents on the river, the team has added a pan-tilt camera to *Lakshmi*'s inventory, to be used to help the crew to avoid objects "such as rocks, floating logs and other ferries", says Dewa. The camera would also track the speed and acceleration of any approaching vessel. He continues: "The camera also helps the navigator to have a great view of the vessel's surroundings for berthing and sailing."

Finally, to tackle the perennial problem of passenger overcrowding, *Lakshmi* would be fitted with an automatic passenger count sensor and image recognition camera. "This would send a warning to the navigation deck or to the port whenever overcrowding occurs," says Dewa. The sensor system would be installed at the entry door(s) and inside the passenger cabin. Simultaneously, sensors applied to *Lakshmi*'s waterline mark would detect overloading of cargo, including agricultural goods, frozen cargo and vehicles. "An overloading of cargo will result in additional draught," says Dewa. "If the sensor is submerged long enough – say, for five minutes – a warning will be sent to the crew that cargo overloading has occurred."



A disinfection chamber is installed at the entrance to the passenger deck, as a measure against the spread of COVID-19



Evacuation slides port and starboard should facilitate passenger evacuations in less than eight and a half minutes

Payback period

With the design completed, the team turned its attention to the issue of cost, and worked out that *Lakshmi*'s capex would come to approximately US$1.6 million. Of this total, 53% of expenditure would be attributable to the onboard machinery, with 21.1% taken up by construction costs, 16.7% by labour costs, 3.1% by the onboard safety equipment and the remainder by passenger and navigation equipment.

Dewa says: "We created several scenarios for cost analysis with three different ticket prices, based on the existing Brahmaputra ferry ticket prices and with a subsidy from the Government of Assam. We found that, with the exact ticket price as that listed for the existing Kamalabari-Nimati ferry service, *Lakshmi* would have an income of US$1.19 million, with a payback period of 3.1 years."

The WFSA presented the first prize to Nawasena ITS during a presentation in late May, attended by various maritime industry players, among them John Waterhouse, chief concept engineer at Seattle-based naval architect Elliott Bay Design Group (EBDG). Second prize was awarded to the student team from Polibatam, Indonesia, which submitted the design for *Shankara*, a monohull ferry using azimuth thrusters for enhanced manoeuvrability and LIDAR sensors for obstacle avoidance, and which would feature a turntable on its vehicle deck, to expedite parking. Joint third prize went to the University of British Columbia, Canada and to the University of Indonesia. **SBI**

ELECTRIFYING CONTEST

While the Annual International Student Design Competition for a Safe, Affordable Ferry has always given teams a clear set of criteria for the vessel design – often taking into account the specific environmental conditions and cultural norms of the areas of operation – the WFSA has "always been neutral about the power source" selected by the student teams, Dr Weisbrod comments. However, that's about to change: the 10th iteration of the contest, running from 2022-2023, is specifically calling for an electric ferry for the Pasig River in Manila. Announcing the details via a Zoom webinar in late July, Weisbord said: "This is the time for electric ferries: everyone senses it, there's a palpable excitement, and it's great to be in just as the wave is beginning."

The webinar featured contributions from various industry experts, to provide guidance to student entrants. John Waterhouse of EBDG told attendees: "Every electric ferry is different, to meet the service needs, the energy profile, the shoreside infrastructure and the realities of schedule and budget. This means that there is no standard configuration of equipment that can just be dropped into a hull." He encouraged designers to "work closely with your technology providers". Teams will have to factor in additional loads, such as cooling systems and extra cabling, and work out how these will affect the energy profile. Waterhouse said: "This energy profile should cover 24 hours of operation, to identify periods of peak usage and periods when the vessel may be idle, thus allowing recharging." Dealing with complex cooling systems could prove particularly challenging when designing the vessel, he warned.

To register: www.ferrysafetydesigncompetition.org