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Review Article

Odra: Naval and Merchant Vessels (Maritime science heritage: Sanatan Nau vigyan: Select discussions)

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Abstract
Odra (riparian) is a historical entity, a synonym for the Kalinga empire (India) which was maritime in nature and had a robust seafaring heritage. In this paper, the south-east Asian archipelago nexus is touched upon, along with less well known aspects of Indo-Asian maritime history. Historically-dated artifacts are presented; naval and merchandise issues ranging from the period c.1200 to 1900 C.E., are discussed. A possible depiction of the empire's fleet (c.12th C.E) is conceptualized. Boat-related numerical calculations are adduced, and associated physics and mechanics of ocean sailing are discussed. Ancient high speed and stable barges are discussed. In-continuum heritage practice and real-time modeling are presented.

1. Introduction

In Europe, c.17th C.E., Odisa,a province on the eastern shore of India was spelt as "Orixa'(Netherlands Institute for Art History, 2018). All Anglo-Saxon speakers and, more particularly, the English-without diacritical marks- intonate the Sa; Sh and Sha; et al., of the vernaculars, as 's' (only). Sa; Sh and Sha are conspicuous by their absence. Even Shakespeare did not coin a phrase. However, the Odisa administration chose to term "Odisa" as "Odisha". Therefore, the alphabet 'h' amidst the spelling Odisha is an malapropos. There being no room for any new mint or coinage in this treatise, the construct "Odisa" replaces "Odisha". In tune with the English model and method, we debit 'h' from the construction 'Odisha' to make "Odisa". The eminent historian, Panda (1999), has indicated that, by the first quarter of c.7th C.E., the coastal tracts of Odisawere mentioned as *Odra* in epigraphic records. C.699 C.E. is an early date in the epigraphic history of the world civilizations; so much so that, on such *datum*, barbarians roamed most parts of the globe. The Tirumalai inscription of Rajendra Chola (c.11th C.E.) mentions Odisa as *Odra visaya* (riparian domain). The Mahanadi delta valley regions in numerous historical and cultural treatises are mentioned as *upataka* (a Sanskrit phone and technical term). Furthermore, the lexicons (Bahadur, 1886; Kar, 1996) indicate *udu*as a synonym for 'water/aqua/star', *Udupu* for 'vela/velaka' (flotilla; constellation Vela), *Oda* as '*paikas* of *Utkala'* (the native martial class of Odisa), *Udika*as a 'rice type', and *Oria* as a luscious, delectable rice dish (Deepak & Naik, 2008c). Annually, 3-15 depressions and 1-2 severe cyclones cross this coastline, shedding 231 Billionm^3

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rain/yr., between 1st July - 30th Sep., of which run-off to the sea is 200 Billionm^3/yr. The coast experiences spring tide ingression between 50 kms, with short inter-tidal zones. Storm-assisted tidal bores ranging between 2-10m high are also experienced (Deepak, 2011). As a case (topically), transliteration of the phrase '*Odra gaonra phoda singh, kalingiya-O-utkala ate*' is indeed 'riparian village's lancing lion is clever and excellent'. This is a well-known phrase in the theatrical, literary and cultural domain of rural Odisa. And, Odisa, in her historical periods c.4th B.E.-14th B.E., was more popularly known via its Sanskrit name Kalinga, meaning 'clever and cunning' (Apte, 1957) which is an adjective and noun. She had robust maritime and political activity and filial connections with period-based south-east Asian archipelago kingdoms and sovereigns (Lalatendu, 1996; Anh, 1996; Miksic, 1999; Krailassuwan, 2019; Pradhan, 2005). Odisa, Indonesia, and Thailand are all agriculturally and meteorologically similar, with paddy land and rice eaters (supporting info). Majumdar (1986) cites noted historians Prof. S. K. Aiyangar, Radha Kumad Mukharjee, and others state that 'mastery over the ports of Kalinga (c.1020-30 C.E.) gave Rajendra Chola well-equipped ships and sailors accustomed to voyages in the very regions which he wanted to conquer'. **Figure 1** shows a satellite image of the Mahanadi delta-valley region (*upataka*). It drives home the historically-applied geographic technical term 'odra\riparian'.

Figure 1 Google Earth, 2008. Satellite Image of Mahanadi Delta In visible spectrum (downloaded with thanks) showing the maze of the Mahanadi delta drainage, i.e., riparian = Odra (a Prakrit -Odia phone; a verbal noun). No other delta shows similar features.

Prior to c.1200 C.E. (pre-ingress of Islam), all maritime-related sciences in the sub-continent lay under the larger gamp of 'Vedic nauvigyan', meaning perennial naval sciences. Maritime matters (naval or merchant) are loaded with navigational issues, such as computations (Deepak & Naik, 2008d) and engineering (Deepak, 2012). Therefore, these also construe 'maritime science and history' and specially 'Blue Sea Navy', and 'Blue Sea Merchandise Vessels'. Our objective is only for discussions and we will refrain from rewriting history, even inadvertently.

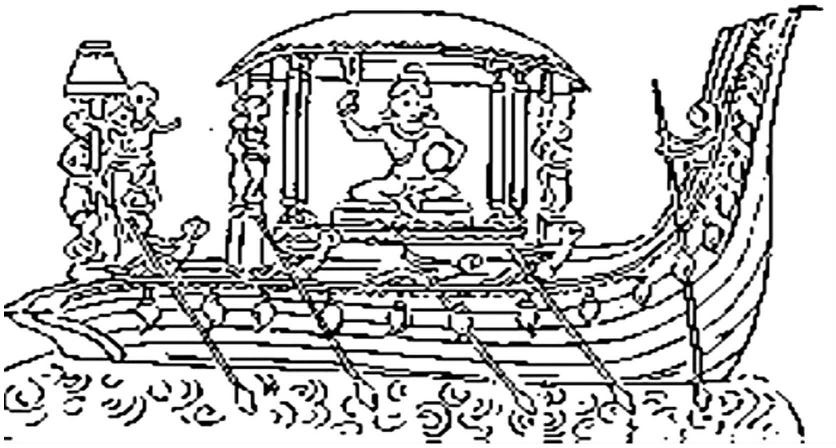


Figure 2A is the hand drawn sketch of the swing at Sri Jagannath, downloaded from the internet (with thanks). The website says that it is from the Ajanta murals, a UNESCO world heritage site (Maharastra- cave art). The Ajanta has no such art; however, it makes a close call with the actual image that is affixed on the Sri Jagannath's *Bhogamandapa*'s NE wall. The shrine is out of bounds for non-Hindus. An artist's impression of the actual image inside Sri Jagannath Temple in bass relief is also available in the National Museum, New Delhi, in the Navy Gallery (also with minor variations).

2. Medieval period (naval/military)

Discussions are archaeology based and backed by our decadal efforts. At Sri Jagannath Temple, on the *Kurma-Bedha* (turtle perimeter), beside the eastern gate (to the viewer's right), can be seen the mighty Kalinga's sovereign on a raised pedestal which on a swing (flat base) slung from a canopy on a large ship that is in sailing mode. The seated person is Sri Gajapati (Lord of Tuskers; emperor of erstwhile mighty Kalinga). The precinct is also out of bounds for non-Hindus. Cameras and every other form of optical recording devices are prohibited, even for Hindu priests and presbyters. **Figure 2** is a hand-drawn approximate sketch of the swing. The canopy rests on four ornate pillars sculptured in the form of young females facing a seated audience. There are a few more females standing towards the stern (each holding either an item of service or in reverent poses). The swing is slung from the four corners by long (tapering) indentures that have rings and hooks at either end to enable disbanding and refixing. The combination of ring and hook and solid bar type pendulums (variable form) also allow induction of mini swings in all axes of the horizontal plane. This permits the free suspended platform to remain (relatively) level. As the platform free plays in all axes, opposing wavelets are generated, leading to cancellation; stymie genesis of swings of greater wavelengths (wider pitch). Induction of forces by the roll and pitch of the flotsams becomes fractionated and cancelled (at the joints/hook points). This permits an easy sitting posture and also reduces nausea/seasickness. Two vessels have been jointed to make a large barge (an engineering feat). The emperor faces the starboard side, *alias* 'Senior side', and five oarsmen are visible, of which four are in a full-flexed state, each holding long oars. The fifth stands at ease at the bow. He could be a 'step-in' for any human or technical exigency and/or be the 'beat-man' (cadence provider). The vessel seems to be made of rows of planks (as is done at present). The sterns, having vertices as in modern naval frigates. The top side is horizontal, and the bottom side is angled at about 30-45° to the horizontal (towards water surface ~ visual assessment). The bow rises vertically upwards, with a prominent bulge. The bulge is the locus where the forward thrust peaks and also meets the opposing force (waves/water). Therefore, enlargement of the surface is called for, which is effectively provided by the curvature. The dormant energy in the waves is in dynamic inertia, and the waves that splash on to the bow (as the vessel fjords forward) become kinetic (active). Such opposing kinetic force is played out on the larger surface (thinning of water leads to fractionation, petering, and dissipation of the wave-inflicted opposing force/energy). The adsorbed component of the thrust/energy is then efficiently countered by the lines of forces (from the stern towards the bow) arising out of motion (velocity). The bow is the locus of convergence of the opposing forces in a moving vessel in any given fluid field. The higher the specific gravity of the fluid field, the heavier the permissible laden load (represented as 'DWT' in modern times; dead weight=DW; T = tonnage). The curvature/surface area of the bow can be large when the specific gravity of merchandise is less than that of seawater, e.g., oil, or only human passengers. In **Figures 2-4**, the opposing forces are jointly and efficiently vectored towards the tip of the bow; some of them dissipate into the air from the tip (the enstrophy point). Part of the momentum is projected in an inclined angle above the water surface. Enstrophy and the inclined line of the momentum jointly imparts lift. A high and wide bow is an energy vectoring/cancellation design (for aircraft carriers, the bow is an acute angled-height compensation). Frontal lift results in an angled float plane which, in turn, imparts additional buoyancy to the front segment of the ship (the load's vertical thrust is vectored towards the stern), reduces drag, and imparts concurrent gain in speed and displacement. High bows in traditional boats are also noted all over the Asian archipelago (e.g., snake boats); in the historical art of Barobodur/AngkorWat, Sumeria, and the Nile valley. In **Figure 2**, the bow is high, similar to modern day cargo vessels/oil tankers/aircraft carriers of large 'dead weight' capacity. Such a high bow would also have assisted the entrapment of tail wind and, consequently, in the upregulation of the driver potential (manifesting at the bow without the addition of any engineered dead weight). In other words, such design permits the conversion of wind energy into locomotion. The 30-45° angulation of the stern helps in its jutting out- hovering over the fluid media. Inertia loads the vertices of the stern with part of the deflected weight of the vessel, which due to the design function is consequently transposed in an angled form onto the fluid body and acts as an lever (Class-III type) at an angled thrust collinear to the direction of the displacement (natural mechanics). This can be correlated with jointed dual hull boats (**Figures 3** and **6b**). Compared to a mono hull, parallel jointed dual hull type design offers the least submerged contact area; least draught required; the least friction/drag and the maximum water plane area, while suspending and transposing much of the load in the compressed air zone between the twin hulls, which provides additional buoyancy, exponentially multiplies the displacement, and enhances commensurately vessel stability and the ability to attain high speed abruptly and maintain it. It is also a wave splitter design, a human engineered preferred design. It is interesting to note that, in 1998, the US Navy, in a joint venture with an Australian private firm, developed a high speed military catamaran named 'HSC Mananan' that was capable of speeds of >50 knots/hr. (~100 km/hr.), and which was termed HSV-X1 (high speed vessel-experimental-1). It used the concept of SWATH (small water-plane area twin hull), as in our **Figures 2-4**. High bow - low stern vessels are also noted in the festivity boats of Kerala (India) and in the south-east Asian archipelago nations. The Kalinga design apparently predates these.

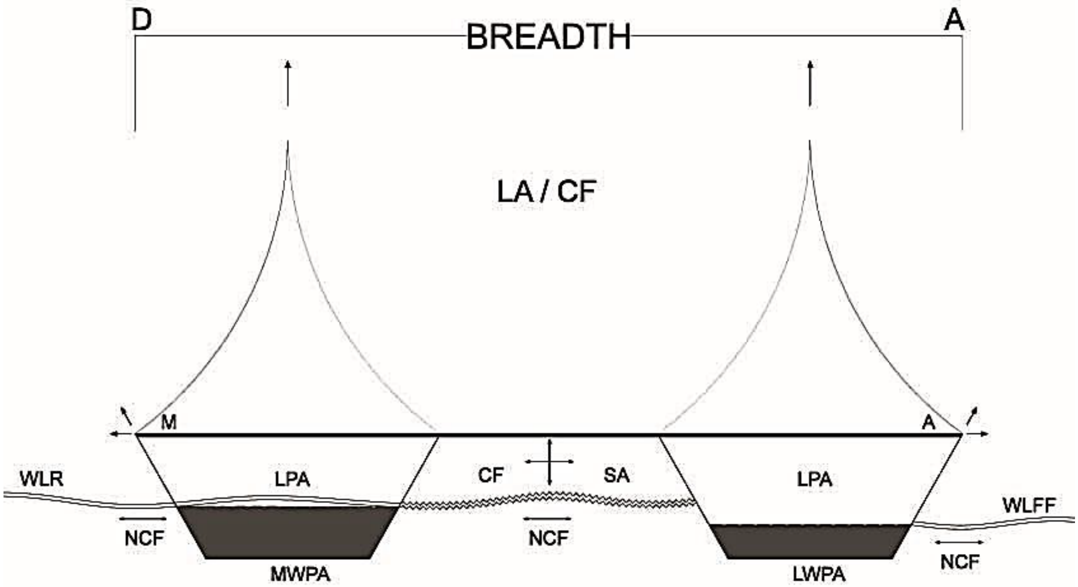


Figure 3 Frontal view of the swing at Sri Jagannath, assisted by CAD engineers, Rhythm Architects, Bhubaneswar.

Our **Figure 3** is the (conceptual) frontal view of **Figure 2** drawn using Auto-CAD. It is very similar to the front elevation of wind/paddle-propelled jointed canoes/catamarans. Two vessels have been placed at an equidistance with a common platform as the cementing bridge that triples the deck/merchandise area (DA/MA). The zone above DA is a 'large area' (LA) of uncompressed atmospheric fluid and exerts an effective down-thrust only when the vessel is not in fast forward motion (in rapid motion, vertical columnar thrust is significantly less). CF denotes 'compressed fluid', which develops when (paired) hulls of such a design move forward. Water, being a non-compressible fluid (NCF), exerts thrust equally all around. SA denotes 'smaller area'. At high speeds, more air is drawn into the inter-catamaran SA space, where it becomes compressed and provides lift to the barge, indicated by 'crossed-arrows'. At higher speeds, the inner sides of the hulls also develop low pressure (LPA), due to turbulence arising out of the canyon's architecture (Bernoulli's effect). Furthermore, at swift motion, the vessel's load (DWT) is, in part, transposed into the air from the vertices (indicated by arrows). All this reduces the vessel's thrust on the water plane and the consequent need for adequate displacement (displacement: DWT ratio is grossly in favor of DWT). MWPA represents 'more water plane area', and LWPA represents 'less water plane area'. Two levels of water are indicated. WLR and WLFF represent 'water level at rest' and 'water level at fast forward', respectively. Greater draft (WLR) is required when the vessel is berthed, and lower draft (WLFF) is required while in motion. The water plane area and friction from water (drag) that arise due to the WLFF phenomenon reduce significantly, with wavelet splitting/surface skimming action and LWPA jointly coming into play, resulting in dramatic gains in speed, along with stability (especially) in inland riparian waterways/stagnant water bodies which have shallow draught and surface wavelets. Such a design also permits motion against the flow in upstream conditions and in rapids. This is to show that the 'drag/friction' plane is reduced due to such a design, while the 'centre of gravity' remains located at the same place, with no alteration in 'bulk mass modulus'. Also, this significantly reduces roll and pitch (no sea sickness). Water surface in the inter-catamaran space is shown as a ripples whereas, in the outer side, the waves are indicated as having larger cross-sections and are of higher amplitudes. The ripple represent wavelets emanating from the opposite hulls (inner). The dual-hull system also results in wave splitting in performance and converts waves to wavelets. At sea, large cross-section waves are in dynamic inertia, alias an entropy state. Flotsam motion leads to fractionation (kutaka), which converts entropy into an enthalpy state (vortical foam-crested frothing wavelets). These are the signatures of non-linear energy dissipation (different from enstrophy that occurs from the bow head vertices).

(a)

(b)

Figure 4 (a) Real-time image of a heritage dual boat (construction phase; 2019) barge, alias ‘chapa’; (b) Chapa in motion; night; doing a slow rotation, dated 18th April 2018, Having departed from Brahma ghaat (viewers R - two bright light spots), housing an immaculate icon of Sri Brahma. https://odishabytes.com/lord-lingarajs-boat-ride-chandan-jatra/Courtesy: Odisha Bytes Bureau.

The starboard side of most naval vessels the world over is designated as the “senior” side. The officer’s gangway, or sea ladder, is shipped on this side, and as such this side of the quarterdeck is reserved for the captain. The flag or pennant of the ship's captain or senior officer in command is generally hoisted on the starboard yard. Nocturnally, it is also marked by the ‘red light” (Ship Deck Nomenclature, 2020). At the hull-water contact line, wavelike designs are seen. The barge is evidently in ‘fast-forward’ motion, which is why the emperor, with his right arm, has to hold on to a strap that is slung from the roof (on the opposite side of the motion), while his left hand is in *kati hasta bhangi* (hand on hip pose). The emperor strikes *lalita-asana* (elegant posture). In the Sri Jagannath temple artifact, the hands are reversed. To offset inertia, the stay arm has to be in the direction of the motion. (**Figure 2** is slightly erroneous, yet representative; hence, we have adopted it).

Indo literature (especially the regional recessions) talk much about *jala-kida* (water sports) and about *nau-vanijya* (maritime trade). On the sides of the barge are shown a line of designer moorings and buffers that allow smooth swift docking which reduced the chance of crashing (variant noted in the ship art of Angkor Wat). These designer buffers also prompt the beholder to think of it as the 'royal barge'. *Inter-alia*, the sculpture at the Jagannath temple represents the average of some regular, or that of a very special, event. In relation to the presence of ladies on a fast-forward royal barge decorated by the presence of an emperor of a maritime power and flagship (military standard),this may be related to when Julius Caesar marched onto Cleopatra's Egypt, and she welcomed the conqueror by arriving on a royal barge piloted/deck managed by ladies ~ c.48 B.E. (supporting info). Therefore, ladies on a royal barge is not new. The swing seems to be unique.

The underlying ethos is that a ship swings on the water surface and, in turn, induces motion onto the swing/*doli* via a delayed action mechanism. The flotilla and the swing oscillate variably across an imaginary line drawn from bow-to-stern. It can be unsettling for a person perched on a 'fast-forward' flotsam. When on a swing, this is negated, and also is a matter of show business, i.e., *adapa* (pomp). Sri Gajapati, the Supreme commander, is exhibiting 'adapa'. He is also relaxed because of his naval might and his able mariners. Women of this domain are also adept in matters maritime. Hence, in modern times, 'Fleet Review' is only done by the Supreme Commander of Maritime Super Powers, i.e., a Blue Sea Navy. The mural also embeds useful lessons of physics pertaining to simple harmonic motion(s). A well-loaded swing on a ship having a large deck will also tend to cancel roll (side to side undulating motion of the vessel, which induces sea sickness) and, in turn, imparts stability to the flotsam. All this is due to a delayed action mechanism, permitting smooth sailing. Thus, there is reciprocity.

Figure 5a Course sandstone artifact dated to c.12-14th C.E., Odisa State Museum, Bhubaneswar. It shows erstwhile Kalinga's infantry men wearing armored aprons and carrying regimental banners.

Figure 5b Image series showing the chatta (TL), dhwaja (TR and BR), and baanaa (BL) in the same panel of the infantry column. A stark difference is apparent.

TL = top left. TR = top right. BR = bottom right. BL = Bottom Left

Beside the emperor is an insignia on a staff. It is not a *Chatta* (umbrella),nor a *Dhwaja* (flag), nor any *Baanaa* (pennant) associated with peace time institutions, enterprises, *jani*-O-*jatras* (sojourns and fairs), battalions, investiture, *nijoga* (guilds) or *gotha* (squads) of the Gajapati and of the Holy Trinity at Sri Khetra Puri, or that of the Tripurantaka Mahadeva Sri Lingaraj, Bhubaneswar or others across Odisa. It is that of a *Thatta* (regiment). Historically, without variation, the *Chatta* either have flat or parabolic top architecture (**Figure 5b**, TL). The Chattas are depicted aplenty in the temple art of Odisa from c.650 C.E., and not the type as in **Figures 2** or **5**. In **Figure 5a**, we see stepped parallelogram types (inverted 'U's). The corner sub-artifact (umbrella type), as in **Figures 2** and **7a**, are a crass representation of the same member. They are heralded by well-built males wearing lower gowns that are suggestive of chain-laid armor (averred so, post close scrutiny). In Odisa/Kalinga, these types of devices, even to this day, are associated with the various *jaga-gharas* (watch-&-ward houses). These are actually standards/insignias. The *jagas* are erstwhile regimental sub-centers and to this day (at *Sri Khetra and Ekamra*) preserve and practice medieval martial arts as their sole *khela* (games). To this day, each *jaga* has a unique banner, having unique colors, which all morphologically are identical to that of the standard depicted in **Figures 2** and **5a**. The *jaga*(s) revere each and every standard profoundly, while they take immense pride in that which is their own (similar to modern-day regimental affinity). On the *Arunasthambha* (first light pillar) affront the Simhadwara of Sri Jagannath Temple, identical regimental colors are hoisted (with paraphernalia) on every ritualistic *tithee* (date), all in the name of the Routa, the Indranayaka, Gajaraaj, Maneemaa; Sri Gajapati's alias and/or the Purushottam/Narasimha, et.al., being the euphemisms for the Garuda (Field Marshall), alias the Emperor of the erstwhile mighty Kalinga empire. Hence, the image, as in **Figure 5a**, is that of the Supreme Commander and the variants, as in **Figure 5b**, are that of regimental banner(s). All are in the same army column (in fast forward march; in battle, respectively).

All our figures are native and indigenous members (non-imports). We are of the considered view that the device beside the emperor on the royal barge (**Figure 2**) is that of a standard of an erstwhile supreme naval command. On board is the supreme commander, majestically conducting a 'Fleet Review' (from the starboard side of the flagship). Therefore, this artifact (because of its internal value) has been selected for conservation at one of the most secured Hindu heritage sites, namely *Sri Mandira*, with prime placement (a perspective). The *Bhogamandapa* has a lower date of c.14th C.E., and upper date of c.15th C.E. (another engineering marvel). This means that the mural was placed in its present location between c.1300 to 1399 C.E. Its mint datum and place is open to debate. This mural is part of mankind's heritage. To the beholder, it provides a *samuchitadrisya* (composite pictograph, i.e., has numerous sub-themes embedded, as in stiganography) into the levels of maritime science in India, with a unique embedded window in the directions of her erstwhile connections, i.e., the Southeast Asian archipelago- *datum* basis. This should be considered. Similar to our other specimens, it is eloquent to the indulgent, more to the diligent, and most to the informed.

16 Bhendias (youths) make one Gotha (platoon); a few Gothas make a Jaga (alert-rapid action battalion); a few jagas make a Pentha (regiment); a few penthas make a Thatta (brigade); a few thattas make a Katta (corps), being barracked in Kataka (cantonment). Therefore, the term 'kataka' denotes cantonment and/or garrison headquarters of the corps. Odisa has the following historical settlements, having as many cantonment (type) call names, viz., Jajapur-Kataka (propitiation cantonment); Amaravati-Kataka (immortal's cantonment); Kataka (the cantonment); Puruna-Kataka (ancient cantonment); Sunapura-Kataka (golden abode cantonment); and Bhisama-Kataka (severe cantonment). Geographically, they are strategically located and, whence together taken on a geography map, make interesting defense formats. Apart from land routes, the katakas are interconnected by riparian routes. Such phonic composition is unique and suggests strategically-located unified defense command centers (Deepak, 2008). While Sri Gajapati was the 'Supreme Commander', the Kanika Rajgir (corner royal lion) was the field commander of the Kalinga admiralty. East India 'Kampani Sarkar' records indicate that the Maratha soldiers and sailors (c.1810 C.E.) used to be 'sitting ducks' against the Kanika sailors in the Kataka-Kendrapada-Jagatsingpur riparian regions, i.e., the Mahanadi delta (a collateral matter).

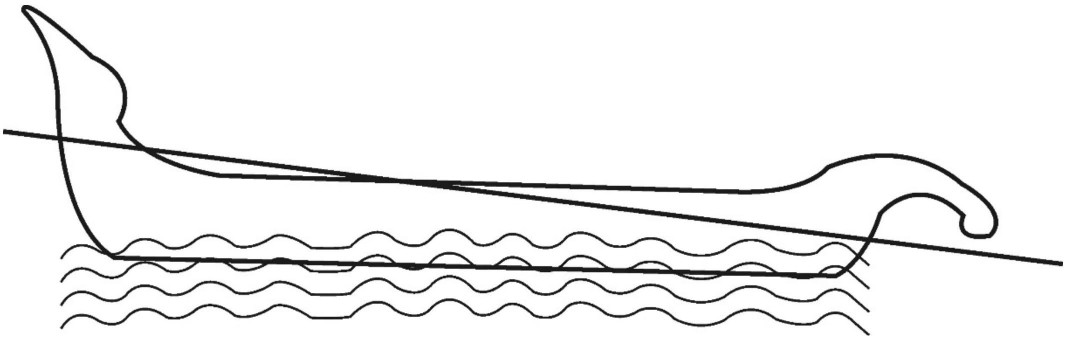
3. Medieval period (merchant navy)

Figure 6a is from the archeology gallery, Odisa State Museum, Bhubaneswar. Historians debate its datum variously to between c.9-14th C.E. The artifact too is native, original, and authentic (not an import). Hence, is a valid candidate for study. The *chitrakatha* (hieroglyphics) indicate that there were merchant vessels of various sizes and architectures and which moved in convoy. The *mahajan* (VIP; head merchant; deemed intercontinental trader) and/or the *Kandi* (captain) is seen reclining on a round back rest-pillow. His loin cloth seems to be in a slipped-off state. He is holding aloft, in his right hand, a *masala* (flaming torch), and is being feted from the front by a topless voluptuous lady holding out something- possibly, an erotic aroma item. There are nocturnal, moonless, starlit, placid sea conditions. Ostensibly, some serious private play is afoot; albeit, this is representative art.

Pachyderms prefer supine posture in shade during summer noon or while bathing and alpine nocturnally. The *samuchitakatha* (composite theme) is about full-grown bull tusker(s) being ferried in an alpine position. The location of the vessel is that of deep sea- as per the aquatic life shown around, i.e., squid and cuttle fish (Teuthida and Sepia officinalis, respectively). The front vessel is small and laden, it's largest/heaviest cargo being a juvenile pachyderm. The larger one is in the hind, which may mean that the lead ship is that of the fleet/convoy commander and/or the pilot vessel. Standing tuskers disturb the vessel's centre of gravity if the vessel is not of large displacement. All of this also drives home the message that, in ocean-going cargo ships, the merchandise used to be loaded in the front segment (as in the modern day), with the propeller (surface wind on sail) at mid, and the tail fin at hind.

In shipping, Simpson's Rule (2020) is used to determine the maximum safe load. In simple terms, **Figure 6b** represents the sketch of the transshipping vessel, as in **Figure 6a** (using a CAD platform; geometrically enlarged). For any object to remain floating, there is a float line (plane). It is inclined if the object be propelled from the hind, as in cases of propeller-driven vessels. We can see the vessel is inclined, although the elephant (heavy merchandise) is in the foredeck. An inclined float plane is also the hallmark of a well-engineered vessel (i.e., ocean going). We have provided the float plane as an inclined straight line, while the seawater surface is horizontal for the ancient vessel (**Figure 6a**) for easy appreciation by the non-initiated. Hence, the ancient master artist has drawn the ethos correctly (well-informed). The following vessel (part visible) is larger, with heavier merchandise, is more inclined, and is sailing at full draft (the lead vessel is not) and it too has a load towards the bow.

(a)



(b)

Figure 6a Fine sandstone artifact dated to c.12-14th C.E., Odisa State Museum, Bhubaneswar. It shows erstwhile Kalinga merchant vessels ferrying giant live cargo; a pilot vessel; juvenile tuskers as merchandise; traversing deep sea in a convoy. It is set at nocturnal time. The head merchant is visible. The following cargo vessel is larger; has full-grown bull tuskers as live merchandise; is in an alpine state; is loaded towards the bow; and is a cargo-size based shipping vessel. (b) Schematic presentation, drawn on CAD by engineers of Rhythm Architects, Bhubaneswar.

(a)

(b)

(c)

Figure 7a Annual (November) Water and Moon Festival, Thailand-in Khamer lingua, Bom Om Touk (pirogue racing festival). Royal/Imperial barges with insignia. An artifact similar to the regimental banner as in **Figure 2** may be noted. The pendant at the boat head shall swing harmoniously when the sailing is smooth; otherwise, it will signal rough conditions to the captain (Kalinga variant) (in Deepak, 2012). https://www.tourismcambodia.com/tripplanner/events-in-cambodia/water-and-moon-festival.htm. (b) Long tail boat, alias 'Mother Boat', discovered in the Butuan District, north Mindanao; popular heritage design in the archipelago ~ Artist's conjecture presented by Mary JLA Bolunia, Philippines National Museum. Source: Cambodia Tourism. https://www.google.com/search?sxsrf=AOaemvJeBVHvhsrF46wekqnFmmwItrCdfg:1631974434880&source=univ&tbm=isch&q=New+Discovery+Butuan+%27Mother+Boat%27&sa=X&ved=2ahUKEwj6tuTD2ojzAhXSX3wKHYEGB_oQjJkEegQIBhAC&biw=1920&bih=969&dpr=1#imgrc=Ee95l8Q6s4seyMandHoc Cheng Siny, 2001. *The Khmer touk* El *touk* kmer, *Techniques & Culture,* @ https://doi.org/10.4000/tc.313, pp. 509-521. In Odia, the term 'khamar'= iron smith. (c) Fishing boat, sun drying post-harvest. Puri beach (Odisa-India). Length 16 ft., longitudinal teak plank made with 8" width. Tar coated bottom.

There is similarity in the design of the swan breast bow with duck bill head and sterns in pan-Asian designs. There is apparent homology between the larger vessel, as in **Figures 6a** and **7a**. Similarity is also noted between the small vessel in **Figure 6b** with that of the images in **Figures 7b** and **7c**. Such designs are still in vogue in the archipelago.

4. Boat-hull building calculations

The rule of thumb is that, in every vessel, the water volume below the float plane displaces 64 times the weight of that type of seawater (displacement of the boat). The displacement of any vessel, minus the same vessel's weight, divided by five, is the maximum safe load. We may note that the float line is inclined (dips at stern), as in modern vessels (design engineering aspect). Seawater surface is the universal level (horizontal).

A full-grown bull tusker weighs between 4,000 - 6,000 kg (let us assume the mid value of 5,000kg in our case). The other visible load may work out to another 1,000 kg. Total = 6,000 kg. To displace such merchandise as a safe load, the vessel has to have a minimum designed displacement in the order of 35-40,000 kg (weight of the wet wood vessel assumed as an additional 1,000 kg). The formula to arrive at displacement is as follows (say for **Figure 6a**):

Length, i.e., *waterline in ft.* × Breadth, i.e., *waterline /Beam in ft.* × Depth (hull inside water/*draft in in.*) × 2.2 (lb.-to-kg conversion constant) = Displacement in kg.

This works out to an imaginary acceptable design vessel size of 48 ft.(L) × 8 ft. (B) × 42 in. (D), having a 39098 kg displacement of sea water. Safe designed carrying capacity works out to = 39,098 kg (-) 1,000 kg (÷) 5 = 7,619.6 kg (excess by an order of 26%).

At Ekamra,i.e., Bhubaneswar, the ancient/heritage unit of surface measure was theKathi, wherein 1K=16 inches (Deepak, 2015).Thus, for the same vessel, the dimensions(in ancient traditional units of measure)work out to 36 kathi L × 6 kathi W × 2.6 kathi of draft (*ghana,*i.e., depth), respectively, with a gross fractal ratio of 1 : 1/6th : ½. This is also a natural selection (100 : 16 : 8). This is reckon magic i.e., mankind's science heritage. This is illustration Rome & Roma.

5. Sailing considerations

The nautical distance between SriKhetra (Odisa) and Sri Lanka (with in-between stops along the Coromandala) is 3,000 km. The distance along the north of the doldrums between Batti-Aluo (Batticaloa), of Sri Lanka, and Sri Vijaya, of Jaba and Bali Desa (barley and sandy country) is another 3,000 km (total = 6,000 km). The term Batti-Aluo (Odia-Prakrit phone) alludes to an ancient oil-fired lighthouse. The above-described theoretical vessel can travel at an average speed of 25 km/hour (roughly 10 knots), which is slightly less than a steady breeze at the sea surface (Monsoon-mex, IMD, Govt. of India). The journey would take around 10 full sailing days. Accounting for in-between stops with sail-in and sail-out schedules, this works out to ½ a lunar month (14 days). The vessel, therefore, rightly sails out from Kalinga on full moon days (*poornimaa*), setting out in the early morning hours with the spring ebb. It spends the entire krisnapaksya (dark/waning phase) out at sea, with neap tide conditions, and sailsinto Sri-Vijaya (the destination) during the diurnal hours with the spring tide (new moon). Thus, the travelers spend the suklapaksya (waxing phase) performing mercantile activity and use the phase's (upregulating) spring tide to traverse deep inland,up and down the various inland riparian pathways in the archipelago diurnally. As in Kalinga, in Champa; Bali andKaam-Bodha geo domains too are all out-door cultural fairs and festivals (*jani-o-jatra*), and mini-macro trading (Banijya) is done during the diurnal hours of the waxing phase. Such a merchant/naval vessel, for the return sojourn, would set sail post noon, normally, on tithe dwitiya, i.e., the second day of the next waxing phase, or the second day post new moon (amavasyaa), i.e., *sukla dwitiya tithe* (phase). Thence, the sun and the moon, both being in the western firmament, with steady local land breeze and strong ebb, create a draw out to sea. Astrals are best visible during krisna paksya (waning phase), and the sea surface is also romantically lit by stars. Such a window extends between the waning and the waxing crescent phases (9-11 nights; lunar trajectory being swing dependent).The bright stars act as guides, i.e., multiple coordinates for navigation;an excellent GPS. The romantic waxing moon follows the vessel post-midnight and, by the gibbous phase, the vessel reaches the surface tide-affected coastal region. In Siddhanta, the moon's trajectory was held as erratic by c.5th C.E. (Shukla & Sarma, 1976). Hindu apex theological literature considered the moon's trajectory to be like the mind-mood-attitude of a damsel (Adi Sankara, c.8th C.E.). Hence, the moon was not taken as a member of the celestial guide.

It is relevant to relate that, on *tithe* kartik poornima, i.e., Bali jatra onset date at locus Chilika-Mahanadi delta domain (Kalinga shore line) the sail is set between the early hours of the morning and pre-dawn. There is a surface-hugging steady land-to-sea breeze. Thence, star Chaya-Agni, i.e., the star of Angkor Wat (stars being another aspect of Vishnu) is the brightest in rising mode on the eastern horizon, and star Vega (i.e., Vishnu/Sri Jagannath) is the brightest on the western horizon in setting mode. Either make an W-E sky line. This star pair makes an angle of 20-30° to Bali-Jatra boarding points and, in tandem, maintain a radiant presence on either horizon at sail between the early hours of the morning and the dawn. Soon, post-sail Vega dips beyond the horizon on the west. The sun rises in concordance with such a celestial line and traverses also from E-W, and Chayaagni, too, becomes invisible. Thence, all through the diurnal hours, the sunlight and its deep shadow acts as the celestial-terrestrial coupled guide (due east-to-due west sky line). Such an astral positional scheme alters at dusk, i.e., chayaagni is, thence, in the western firmament (setting mode; boat moving away), and Vega in the eastern (rising mode; boat sailing in). Such an astral position is maintained through the nocturnal hours. Day after day, such a scheme is repeated, until the destination is reached. This scheme reverses during the return sojourn. Thereis a saying that 'stars travel with you', for they are located at infinite distances. This pair of very bright large stars offers an excellent long line of vision (guide) to due east and to due west, apart from other cross-references, viz., *Matsyamukha* (Fomalhaut), *Nadimukha* (Archarner), and *Simha* (Regulus). Numerous inter-connected and inter-laid triangles are formed, posing as excellent tracking and vessel positioning guides; sailing days are available from any desired destination, etc. Deepak and Naik (2008c, 2008d) provide additional details about 'astro-compass'; Deepak (2012) presents navigational instruments, methodologies, uses and an inter-hemispheric common permanent guide (Deepak & Naik, 2008a; 2008b).

As per Indo-Asian naked eye positional astronomy (siddhanta), Vega and Chayaagni are signatures of Vishnu, and their on-ground (archeological) apex temple abode signatures belong to c.12th C.E. This imaginary celestial line connects either coast; either ends of an identical polytheistic faith committed to idolatry. The eastward march of Vishnu consciousness (Sanatan) is due to Islamic ingression into the Indian subcontinent (the second historical-cultural stimulus, the first being between c.2nd-8th C.E., i.e., the spread of Hinayana), which additionally necessitated cross-oceanic sojourns. However, maritime (secular) activity in this very domain predated this by over a millennia. The Sanskrit and/or Prakrit form of Angkor Wat (c.1125-50 C.E.) posits as Ananga Kara Bhatta. The then Gajapati of empire Kalinga was Ananga Bhima Deva III, c.1211-1238 C.E. (love/formless-lord gigantic; also, a synonym of Sri Jagannath/Ananta Vishnu).Chaya-Agni means 'fire's shadow', alias Surya-varman,which in turn easily posits as 'Helios and its projections'. Either are Sanskrit phones.The temples of Sri Jagannath-AngkorWat-Miatri Deva (Konarak) follow each other at short historical intervals (supporting talk).

6. A modern period naval dock-cum-fort

In this section, we examine the issues regarding naval matters during the modern period. We consider the relegated fort of Potagada (19.38°N\85°E), located on the left bank of the river Rusikulya, Ganjam, Odisa (also the core-land of ancient Kalinga). The term 'pota' means frigate/gun ship,and 'gada' means fort. The composite term pota + gada works out as 'potagada' Thus, from a naval/maritime perspective it connotes as 'frigate fort'. Hunter (1885), Ganjam

(2021), and Behuria (1995) gave the date of Potagada's making to c.1768 C.E., being commenced by Edward Costford, the first British resident of Ganjam, of the East India Co., which does not stand historical or archeological scrutiny. All other scholars, viz., Biswanath (2005) and Ku (2014), in difference to our translation, have opined that it denotes 'buried fort'. Kartikeswar Patra preceded us in indicating a military nexus (Kartikeswar, 2004). It is now established that it was a strategic naval "frigate port", and not a merchant port of call (Deepak, 2016).

6.1 Location and hydrology aspects

River Rusikulya drains east. Potagada, the frigate fort, faces south. The fort, with its battlements, abuts right into the waterfront and is almost on the river mouth-seashore junction. Sailing in and out was, thus, easy and quick. Between Calcutta (Fort William) and Madras (Fort St. George) Potagada is midway. Due to the narrow and sharply inclined coastal shelf and the unique ocean-atmosphere (landward driving), wind-on-sail propelled navigation had to get close (within visible range). Thus, it was well-located at a place of strategic vantage. It was abandoned in c.1815 C.E. due to plague.

6.2 Archaeological and architectural aspects

The at-surface topical archeological remnants at this neglected (until 2012) heritage site indicates a mud fort having a somewhat star-type shape, with a shield-type inner wall or fortification. **Figure 8**shows a satellite image of Potagada (downloaded, with thanks, from Google Earth). The outer ramparts offer near-exact homology with Portuguese-Dutch forts worldwide. It is also reminiscent of the Edwardian crown, when the viewer has his face towards the waterfront. It is very clear that the inner shield-type outline is reminiscent of (a) Anglo-Saxon classical medieval battle shields, (b) Suffolk-type shields of c.17th C.E., and (c) official seal sand crests of the East India Company **(Figure 9)**. A+b+c points to a mix of pan-European inputs? We are of the considered view that the inner shield was the initial size and architecture. Expansions followed, ranging over 1½ centuries. As a composite, they also appear as a crown, with a large jewel of pear shape. Interestingly, the current logo of the Indian navy has adopted a near-similar design (**Figure 10**) since around 2001.

Figure 8 Satellite image of Potogada. Google Maps at: https://earth.google.com/web/search/Ganjam+-+Odisha+/@19.37520777,85.05741531, 9.09824029a,671.05129967d,35y,0.00042881h,1.24741274t,0r/data=CigiJgokCQw40Cu8qTVAEQg40Cu8qTXAGbk8zShB9ElAIbY8zShB9EnA

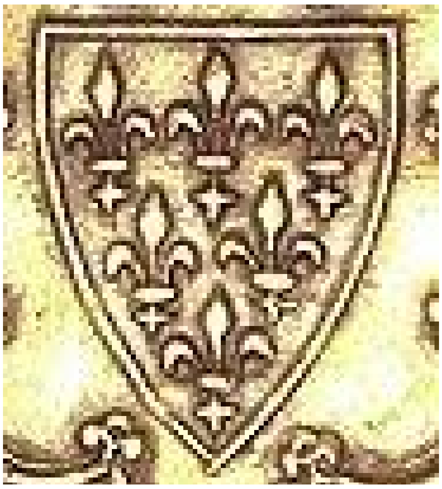


Figure 9 Select portion of battle shield, as used in the Europe of c.16-17thC.E.
https://www.britannica.com/topic/coat-of-arms

Figure10 Current logo of the Indian Navy.
https://www.google.com/search?q=Indian+Navy+Logo&oq=Indian+Navy+Logo+&aqs=chrome..69i57j0i512l2j0i20i263i512j0i512l6.4264j0j4&sourceid=chrome&ie=UTF-8

7. Discussion

Eminent historians have variedly indicated that, prior to the advent of the Cholas (Deccan-Indian peninsula), the Kalinga were ruling the seas (Behera, 1993; Majumdar, 1927). Indeed, there has been a one-way migration of men, and material from the domain of Kalinga to Chola, due to the geographical shift of the paramount power in c.11th C.E. and a two-way exchange between Sri Khetra-Sri; Lanka-Sri & Sri-Vijaya, i.e., Kalinga-Bali-Champa-Kama Bodha; etc., pre-datable by a millennium from the year c.11th C.E. (Hall, 1981).The use of the Kalinga coast and her naval wherewithal is again noted during the 'early modern European history' (The European World, 2017), which preceded the industrial revolution. This era saw the infusion of steam engines; vessels of large draught (which Rusikulya mouth did not have); enhanced in-sea stay-put abilities of frigates; and an absence of the First World War in the Bay of Bengal theater, which spelled doom for the frigate fort Potagada.

We have discussed all of these (seemingly) disparate aspects with a hope that such perspectives and models of ours will help the readers to research the sub-topics; consider the embedded indications; generate interest in the various aspects of Asian shared heritage; the green field(s) of research opportunities for scholars; and to salute those who all endeavored prior to us.

But for them, we would have been at a loss. Our adduced members constitute history of nautical-cum-maritime practices; sciences; and mankind's engineering heritage. This being a first-time, pioneering, and nascent article, we refrain from any conclusions because multi-lateral initiative is necessary, involving pan-Asian archaeology. Archaeology is the primary source for history of the sciences, as it adduces 'evidences'. Much archaeology and artifacts silently and tirelessly await enterprising scholars around the Asian-Pacific Rim regions. This is an arduous task indeed, With a large scope for employment possibilities also. Therefore, we have used the idea of Asian heritage (and not academic gymnastics). This communication does not seek, nor propose, any revisionist theory. Young minds may take the subject forward. Until then, let us set sail on a boat that has a swing.

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