From Amphora to TEU: Journey of a container

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Abstract

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1. Introduction

Goods (also called 'commodities') have always been shipped either as units or as dry or liquid bulk.
In the field of maritime logistics[1, 2], a container is meant to contain goods in order to protect them and to ease their transportation. Modern containers are large boxes made of steel that can be placed on board a ship (sea and river), on a train and on a truck.
Ancient containers are amphorae, dolia, barrels, sacks that could be placed on board a ship, on a cart, on a camel or donkey.
Amphorae were used mainly for liquids, and containers are used mainly for dry goods, but exceptions exist for both.
Containers were standardised to optimise storage on land and on board transportation means such as ships and trucks. This aim was rather well achieved in modern times with a space-time frame of the whole planet over around 50 years, but was not achieved in ancient times with a space-time frame of the Mediterranean area over around 1000 years[3].

This presentation aims at comparing ancient and modern maritime chains of logistics rather than giving an exhaustive description of containers and we will therefore concentrate on one type of container for each period: the ancient Dressel 1B amphora and the modern TEU container.
After a short presentation of ancient and modern containers, we will try to put ancient and modern logistics side by side on the following aspects:

- Stowage on board,
- Loading & unloading,
- Exporting & importing,
- Ships & sailing,
- Return cargo.

2. Definitions

a. Amphorae

Many different types of amphora have been identified, depending on their date and place of production[4, 5]. The first amphorae were used for transport of wine and date from around 350 BC (so-called 'Greco-Italic' type). Many millions have been produced especially during the Roman Empire.

As a volume, one amphora quadrantal is one Roman cubic foot (nearly one modern cubic foot) = 2/3 artaba = 2 modii castrensis = 3 modii = 8 congii = 48 sextarii, or 26 litres. A full amphora (olive oil, wine, fish sauce) weights around 50 kg, out of which around half is tare.

[1] Stopford (2003).
[2] See short movies of European Harbour Masters' Committee: http://www.harbourmaster.org/ehmc-films-chain.php
[3] This is fortunate as it enabled experts in 'amphorology' to determine where and when amphorae found in wrecks were made.
[4] University of Southampton (2014) *Roman Amphorae: a digital resource*
[5] http://www.anticopedie.fr/dossiers/dossiers-gb/amphora.html

Depuis 3000 ans la conquête éco de territoires a généré des flux de mchd de tte nature ~~la conquête~~ L'expansion des pop. en Med a déjà créé à l'époque une éco globale où ts les biens ~~pd~~ s'échangeaient de l'E à l'O et du N au S : on pouvait parler de Méditerranéisation de l'économie. Aujourd'hui, la mondialisation n'est que l'image moderne de ce phénomène. Ce sont les tp^rts des hommes et des biens qui a permis cette expansion maintenant globale au niveau mondial.

Cela a généré des tp^t des mchd d'1 continent à l'autre, d'abord ds des amphores il y a 3000 ans, aujourd'hui ds des conteneurs.

Amphores et cont sont des contenants destinés à la fois au stockage et à la préservation des pd^ts, à leur manipulation (manutention), à leur déplacement (tp^t).

→ l'amphore = contenant pour pd^t unique

→ le CONT = ——— ——— — ou multiple

Durant des siècles, le "packaging" des mchd pour leur stockage, manipul^tion, tp^t s'est résumé à des colis, ballots et ballots pour les dry, et à des "tanks" pour les vracs liquides, et enfin à des tas pour le vrac sec. Les civilisations méditerranéennes ont aussi déplacé des tonnes de biens de tte nature en "break bulk", en bulk et en amphores pour les VL.

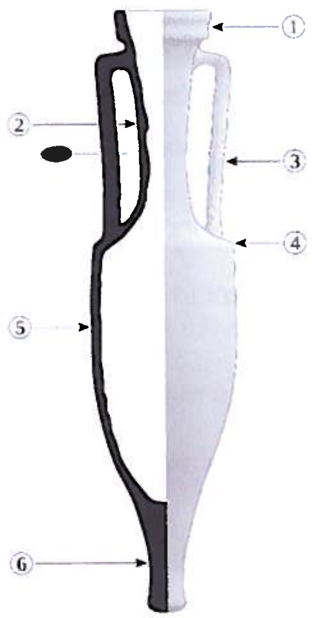
∩ si les contenants ont Δ (les amphores sont devenues des fûts), les caisses des cartons, il y a encore 50 ans les tp^ts se faisaient de la m̄ manière (+/-) qu'il y a 3 millénaires.

Depuis 50 ans, est apparu un nv mode de tp^t, standardisé afin de permettre de tp^ter plus facilement, plus loin, mieux protéger les biens et cela plus vite. Une nouvelle ère des tp^t est alors apparue.

3000 ans après la révolution des tp^rts par les amphores, permettant de tp^ter des VL, le cont a apporté une nouvelle révolution, ouvrant la voie à l'éco globale, à ~~la~~ l'usine mondiale, la mondialisation, avec ts ses avantages et tous ses travers.

It may be noted that Egyptian grain was transported in sacks of one artaba (39 litres) with a unit weight of around 30 kg.

Note also that wooden oak barrels (500 to 1000 litres) gradually took over from amphorae (and dolia) for storage of wine during the Roman Empire.



Dressel 1B amphora (from https://commons.wikimedia)

Legend:
1- rim (lèvre)
2- neck (col)
3- handle (anse)
4- shoulder (épaule)
5- belly or body (panse)
6- foot (pilon ou pied)

Dimensions:
- Height: 100 to 122 cm
- Diameter of the belly: 28 to 30 cm
- Diameter of the opening: 15 to 18 cm
- Height of the rim: about 6 cm
- Weight: 24 to 26 kg (empty)
- Capacity: 24 to 26 l.

Original manufacture place: Tyrrhenian coast (Etruria, Latium and Campania)
Late Republic period, until 10 BC

1967 le 1er PC ?

b. TEU container

So-called 'containerization' was introduced in the 1950's and the number of containers transported increased exponentially over the past 50 years and was multiplied by a factor 10 in the last 20 years. It is viewed as a major evolution in transportation of goods. Around 700 million container movements are recorded yearly in the world's ports of over 100 countries involved in seaborne trade[6].

The standard intermodal container is designated as twenty feet long (6.1 m) and 8 feet (2.44 m) wide and 'TEU' stands for 'Twenty-foot Equivalent Unit'. Additionally, there is a standard container with the same width but a doubled length of forty feet called a 40-foot container which has found wider acceptance, as it can be pulled by semi-trailer truck. Some containers may reach 48 ft and even 53 ft (in the USA). The height is 8 ft 6 inch (2.59 m).

As a volume, one TEU is around 33 m^3 and the total weight may not exceed 30 tons, including a tare of around 2 tons[7].

In Europe 40' container cannot offer same capacity as trailer (33 europaletts) due limited inside wide. Now "45' palett wide" are developed in Europe to propose 33 europalett capacity -

Diversité → dry, reefer, tank, bolster, open top -
→ ts les jrs ... ceux qu'on imaginait pas il y a 20 ans le break.

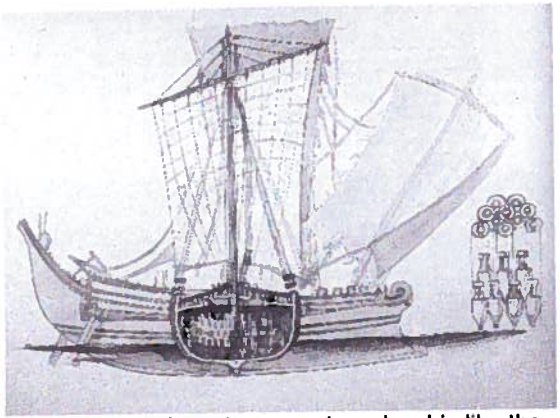
[6] http://donnees.banquemondiale.org/indicateur/IS.SHP.GOOD.TU?end=2014&start=2000&view=chart
[7] https://www.cma-cgm.fr/produits-services/conteneurs

Twenty-foot equivalent unit (TEU).

3. Stowage on board

Ancient

The Madrague de Giens[8] shipwreck discovered in 1967 near Giens in France, had an estimated cargo capacity of 8000 Dressel 1B type amhorae for wine. This is a freight of 400 tons for a 40 x 9 m ship. Thousands of smaller ceramics, or other valuable small cargo, were often placed in-between the amphorae as a secundary cargo.



Arrangement of amphorae on board a ship like the Madrague de Giens (drawing JM. Gassend, 2005).

Modern

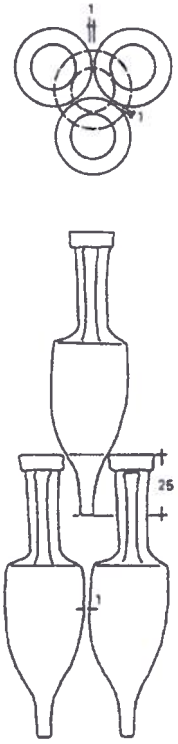
One of the largest container ships is the Marco Polo with a capacity of 16 000 TEU, that is a cargo of nearly 200 000 tons for a 396 x 54 m ship[9]. It seems that in 2016 the length is not increasing over 400 m, but the width is heading for 60 m to cope with 20 000 TEU on board. This width may become a problem for gantry cranes supposed to load and unload these ships.

The 16 000 TEU Marco Polo container ship (picture CMA-CGM).

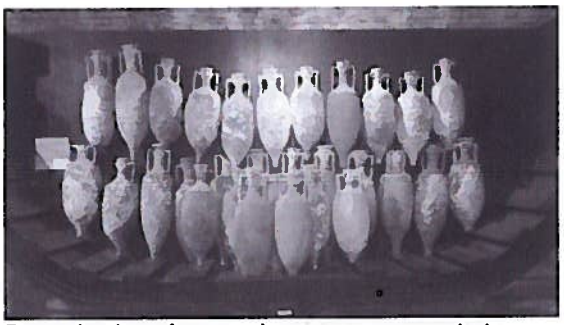
Container ships have a draught of nearly 15 m requiring quay walls of around 20 m height and adequate dredging to keep the required water depth. Bulk carriers (oil, coal, iron ore) may even have a draught over 20 m. Containers are stacked on 15 to 20 tiers or levels, half of them in the hold below deck and half on deck. They must be securely fastened to each other with twist-locks and to the ship's structure with lashing bars.

[8] https://en.wikipedia.org/wiki/Madrague_de_Giens_(shipwreck)

[9] http://www.cmacgm-marcopolo.com/



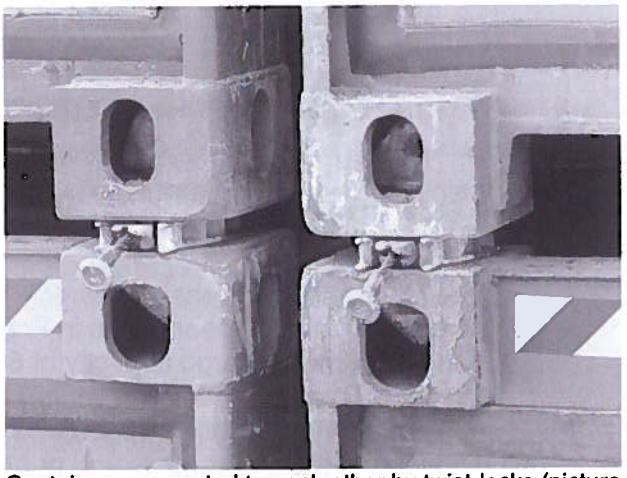
Typical arrangement suggested by P. Pomey (1997) based on his work for the Madrague de Giens.



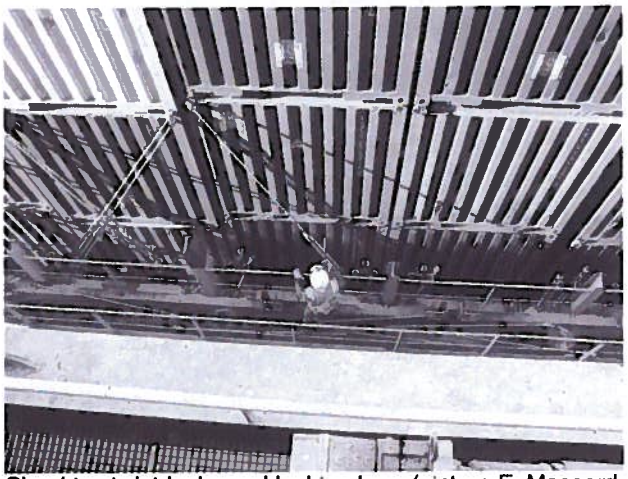
Reproduction of an amphorae arrangement at Antibes' Musée d'Histoire et d'Archéologie (picture A. de Graauw, 2012). This arrangement with many different types of amphora is obviously not very optimised.

Rack and roping device to illustrate how the cargo might have been kept from shifting, at Bodrum

Twist-lock on a rear corner of a container semi-trailer; the container corner is placed over it and to close the lock, it has to be turned 90°(picture Wikipedia).



Containers connected to each other by twist-locks (picture F. Massard, 2007).



Checking twist-locks and lashing bars (picture F. Massard, 2007).

Modern secured systems aren't able to face tremendous storms at sea and sometimes, accidents are occuring. Vessels could lose containers which could float "between 2 waters" constituting risks of collision with other vessels.

Museum of Underwater Archaeology.

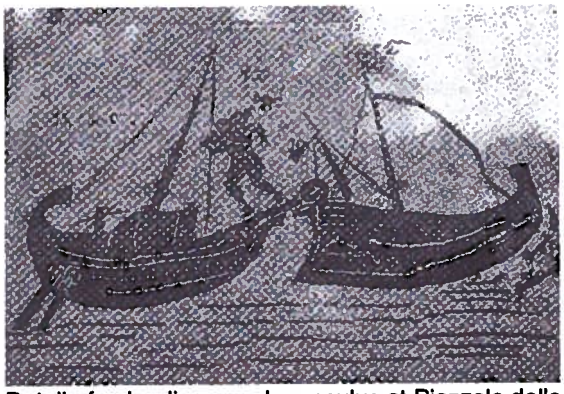
The foot of the amphorae could obviously not be placed directly on the ship's hull as it would perforate it during the trip at sea. Hence, the bottom row of amphorae was placed on some protective layers of straw as shown above. It may also have been sand (perhaps more valuable pozzolana?) used both for protecting the hull from the bottom row of amphorae and for ballasting the ship.

Only few accidents happen … (picture http://www.vessels-in-france.net)

4. Loading and unloading

Ancient

One way of unloading a large sea going ship that could not enter rivers was to transfer goods onto smaller ships called lighters (*lenunculus or navis caudicaria*) that were rowed or towed up-river.



Detail of unloading on a lenunculus at Piazzale delle Corporazioni, Statio 25 (from Pomey, 1997).

Detail of the Torlonia relief showing a ship moored bow first to a mooring ring with a dock-worker (*saccarius*) carrying one amphora and walking on a gangplank from the ship to the quay. Note the linesmen boat just below the mooring line (picture Testaguzza, 1970, on www.ostia-antica.org).

Early Kerkouros ships usually docked stern first, while later Corbita ships docked bow first as shown on the Torlonia relief above.

Modern

Container ship are loaded and unloaded by means of giant gantry cranes that can reach over the whole width of the ship, i.e. they must lift up to 120 tons (4 TEU) at a distance of up to 60 m. This means that modern container ships are always moored alongside the quay. This enables loading/unloading by several cranes simultaneously in order to have the ship at berth no more than a few days.

Five gantry cranes with lifted arm allowing ship movement. Such a berth can move around 150 TEU per hour (picture https://www.marinetraffic.com).

Large Maersk container ship berthed port-side

Alongside docking was required if heavy cargo (live animals, barrels) was to be lifted by cranes or derricks.

This relief was found in Portus. Amphorae with wine are being carried from a ship to the quay by dock-workers (*saccarii*). The three civil servants (*tabularii*) take notes. The first porter receives a token of receipt (picture Pavolini, 1986, on www.ostia-antica.org).

Weights, measures and coins were under control of *agoranoms* (in the East) and *aediles* (in the West). *Mensores* and *sacomarii* were legally in charge of measuring and weighting at loading and unloading the ships. *Togati* oversaw the validation of the trade procedure, including weighing and measuring.

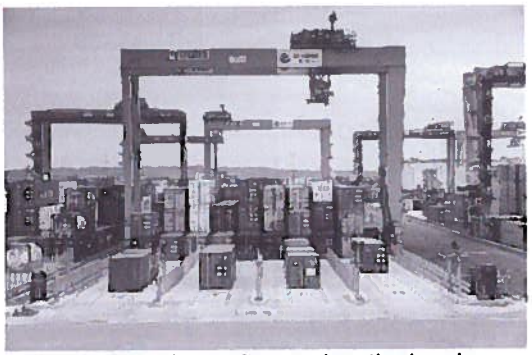
Grain measure at Aula dei Mensores in Ostia. On the left, a porter brings in a sack of grain; the small man is counting the number of sacks, up to 9 to fill the grain measure placed in the centre of the picture; he gives a token to the porter for each sack delivered; the *mensor*, holding a measuring rod, is in the centre of the picture (from www.ostia-antica.org). According to Arnaud (2015) the man with a *toga* behind the grain measure might be a *togati* and the man on the right the *navicularius*.

Following measurement, the goods were stored in warehouses (*horrea*).

(picture https://gcaptain.com).

Shipowners have to optimise the loading of their ship in order to have the boxes ready to be unloaded when reaching each port of call during the trip. They also have to take into account the weight of the boxes and the distribution of loads on board, and many other constraints. This job is not conducted by the captain of the ship any more, but by the company's headquarters using sophisticated computer programmes for this task.

The same holds for the giant areas for container storage where each container is registered in x,y,z position with help of computers.



Fully automated container park at the London Gateway (picture http://www.kalmar.fr).

Goods in bulk are stored in silos (grain), in tank farms (oil) or in the open (coal and iron ore).