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Intermodalism in the transportation network of the Roman Empire

Amelia Carolina Sparavigna and **Mauro Maria Baldi**
Politecnico di Torino

In this paper we are proposing a preliminary work for evidencing some features of intermodalism in the transportation network of the Roman Empire. We will show that intermodal terminals for oversea and overland transportations existed such as containers and shipping documents. For them, the Empire that had some specific logistic systems too.

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Introduction In ancient times a large overland transportation network was that of the roads of the Roman Empire. This network had Rome at its center, from which several main roads were fanning out. With the growing of the empire, other cities besides Rome, became hubs of such huge overland system. As discussed in [1], the network of main roads, the viae publicae, had a structure similar to that of a modern air transport system, with a few hubs and links of rather different lengths. Essential for the growth of the Empire, by enabling it to move armies in a fast manner, this network was fundamental in maintaining both the stability and expansion of Rome. Besides the main roads, the Empire had other networks of roads and tracks, that had a regional and local character, such as that of the roads made for the land subdivision [2] and that of the tracks for moving herds of animals [3], which Rome had inherited from ancient Italic populations.
The Roman Empire possessed also another principal transportation network, which was important as that of the main roads and strongly linked to it. This system consisted in the network of oversea transportation, which had the peculiarity of being much cheaper and faster than moving goods by road. For transporting goods by sea rather than by river or land, the cost ratio was approximately 1:5:28 [4]. Some ports, by the 2nd century, were also connected to the trade network based on caravans, so that Rome was directly linked to the far East.
Being the transportation in the ancient Rome based on quite different interconnected networks, we can propose that, among the first actors of intermodalism there was also the Roman Empire. Here we will start a preliminary work for evidencing the intermodal features of the Roman transportation system. We will see that hubs and intermodal terminals, such as containers and shipping documents existed. The last section of the paper will be devoted to an example of transportation planning made by means of ORBIS, the Stanford geospatial network model for the Roman world.

Roman Roads Roads were built from about 300 BC, through the expansion and consolidation in Italy of the Roman Republic and then under the Early Empire [5]. Besides being an efficient means for the overland movement of armies, they were also used by civilians with a system of inland carriage for trading goods [6]. Of course, when we are mentioning the Roman roads, we are thinking of the broad, long-distance roads, built to connect major towns and military bases to Rome, roads that were stone-paved and flanked by footpaths. These roads were laid along accurately planned and surveyed courses, being therefore more resembling the modern systems of highways or of airlines. Besides these highways, the Romans had also the system of small local roads, linked to the system of the main roads. At the peak of Rome's development, there were about 30 highways radiating from the capital, and during the late Empire, the provinces were interconnected by about 370 great roads. The whole

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system of these main roads had a length of more than 400,000 km, of which over 80,500 km were stone-paved [6-8]. The courses of many Roman roads is still existing, being some of them overlaid by modern roads, such as Via Appia, Via Aurelia and Via Emilia.
According to Ulpian, there were three types of roads [9]: a) Viae publicae, consulares, praetoriae or militares, b) Viae privatae, rusticae, glareae or agrariae and c) Viae vicinales.
The Viae publicae, consulares, praetoriae and militares included public main roads, constructed and maintained at the public expense. They bear the names of their constructors (e.g. Via Appia, Cassia, Flaminia). Such roads led either to the sea, or to a town, or to a public river, or to another public road [9]. As previously told, transportation was made also by sea and by river, and therefore in [9] we find a feature of intermodalism in some nodes of the networks of viae publicae.
The Viae privatae, rusticae, glareae and agrariae included private or country roads, originally constructed by private individuals, who could use them also for public transport. Such roads benefited from a right of way. The Viae vicinales were the third category and comprised roads at or in villages, districts, or crossroads, leading through or towards a vicus or village [9].

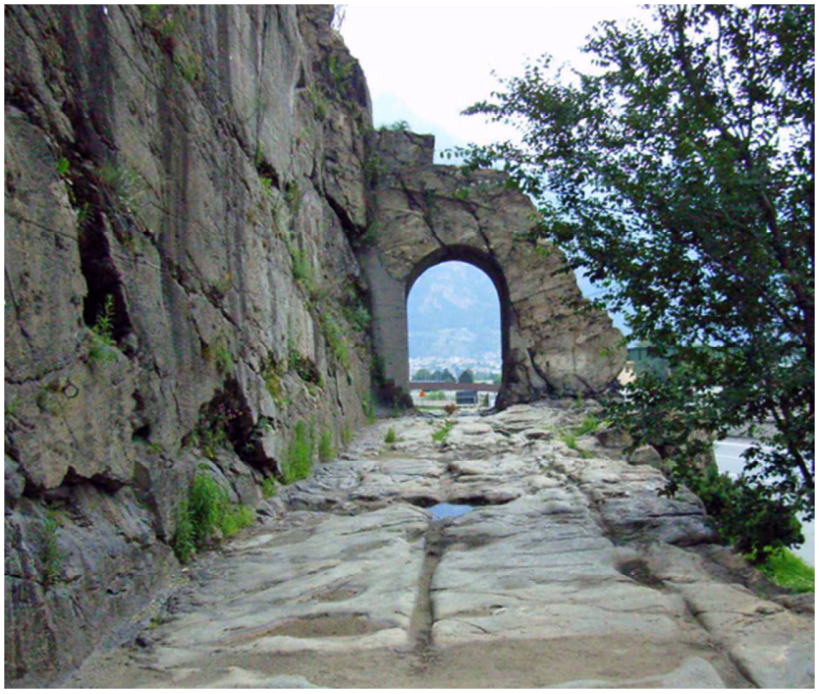

Figure 1: The Roman road to Gallia, near Donnas in Valle d'Aosta (Courtesy Lysippos, Wikipedia). Note the two grooves worn into the road by the passage of wheels.

In the Figure 1 we can see the Roman road to Gallia. We can also see the grooves worn by the carriages in the stones of the road. The evidence of such rutted roads marked by wheels suggests that a gauge existed for the distance between the wheels of carts. Probably the Romans used carriages that employed some form of suspension for having a more comfortable travel. On the infrastructure of the roman roads, it was running the cursus publicus, that is, the state-run courier and transportation service of the Empire, created by Augustus to transport messages, officials, and tax revenues. To support this service, a series of forts and stations were disseminated along the major roads. Stationes provided horses to dispatch riders and vehicles for magistrates or officers of Empire.

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Itineraria We can have a picture of the network of Viae Publicae by their "itineraria". In origin, itineraria were simply lists of cities along the roads. To sort out the lists, the Romans drew parallel lines showing the branches of the roads. On the lines, they placed symbols for cities, way stations, water courses, and so on (Figure 2). Because the itinerarium does not represent landform, it is not a map, it is a graph [1]. A beautiful example of an ancient graph is the Tabula Peutingeriana, one of the main itineraries showing the road network, which covers Europe, some parts of Asia and North-Africa. The Tabula Peutingeriana is an illustrated itinerarium kept by the Austrian National Library in Vienna. The original map upon which it is based probably dates to the 4th or 5th century and was itself based on a map prepared by Agrippa during the reign of the emperor Augustus. The present map is a 13th-century copy.

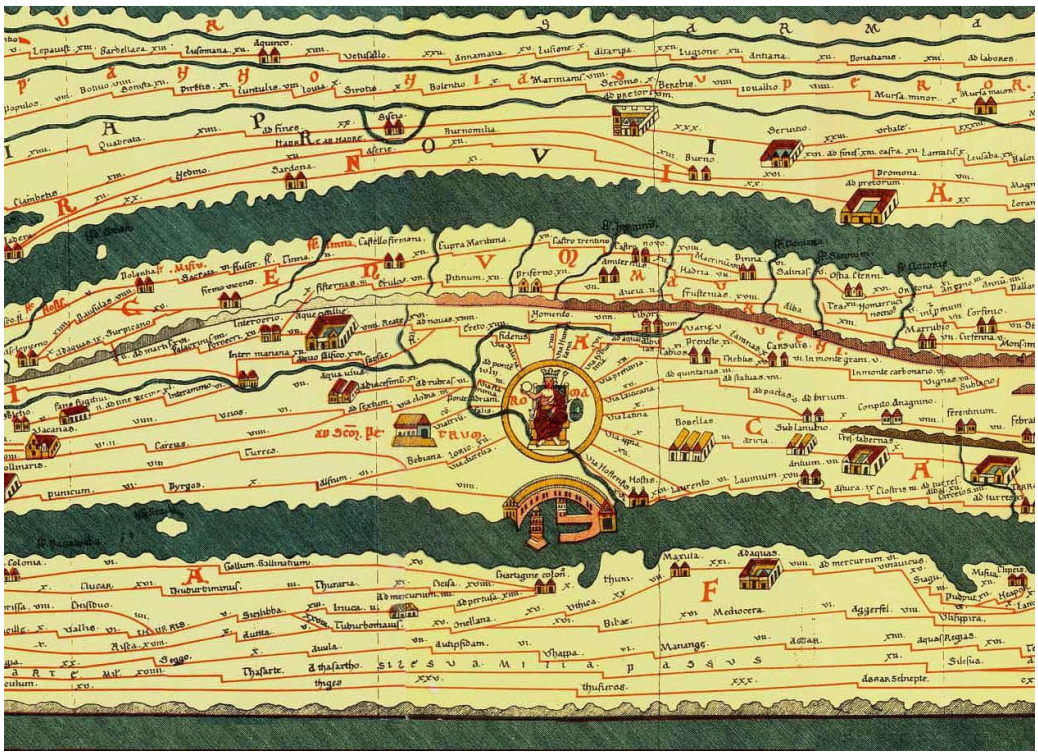

Figure 2: The part of the Tabula Peutingeriana showing Rome and Consular Roads (courtesy Wikipedia).

Oversea Transport As discussed in [10], the transport system of the Roman Empire that existed between the 3rd century BC and the 2nd century AD was a fundamental component of the Mediterranean system of trade, composed by two interdependent transport systems: overland and oversea. The oversea transport was essentially a coastal maritime shipping. Many of the major cities were located on along the coast of the Mediterranean Sea: Portus/Ostia, Massalia, Alexandria, Cartage, Antioch, Cesarea among the others. These cities “were the focal points of the maritime trading network that enabled the Romans to declare proudly but accurately that the Mediterranean was Mare Nostrum” [11]. These cities were serviced by the overland network that allowed moving goods from the sea to the inland. In fact, one of these essential roads was Via Portuensis, connecting the port of Ostia to Rome.

As previously told, the transport by sea was the cheapest and fastest method to move goods and persons. It was possible to move of 1,000 nautical miles in 9 days [4]. Travelling on sea was even more comfortable that overland, because a road travel was either by foot or in carriages or chariots that could bounced on cobblestones. However, sea had its risks, connected to weather and piracy, and was also restricted for seasonal response, because in the period between November and March is was not possible to guarantee a safe passage [4].
Roman transport ships were wooden vessels with square rigs and a large hold able to contain amphorae filled with wine, olive oil and other goods. Normal-size sea vessels held about 3,000 amphorae while large freighters held as many as 10,000 [12]. Grain was the main commodity, followed by wine and olive oil. "As time went the ships became larger and larger. Galleys rated as "fours," "fives," and "sixes" were introduced between 400 B.C. and 300 B.C. They were followed up by "16s," "20s" and "30s." The Emperor Ptolemy IV built a massive "40." The numbers refereed to the number pulling each triad of oars" [12].

Containers and Shipping Documents The World Shipping Council is telling that an intermodal cargo transport requires that all the sections of the transport chain can be integrated. To have an intermodal transport, it is not "simply a question of putting cargo in containers. The ships, port terminals, trucks and trains had to been adapted to handle the containers" [13]. The reference explains that on 26 April 1956, Malcom McLean's converted a World War II tanker into a container ship. The McLean's enterprise later became known as the Sea-Land Services, "a company whose ships carried cargo-laden truck trailers between Northern and Southern ports in the USA. Other companies soon turned to this approach" [13]. The logical next step in the intermodalism was that of having container sizes standardized, so that they were efficiently stacked and, consequently, "ships, trains, trucks and cranes at the port" were built to fit them [13]. It was in 1961, the International Organization for Standardization (ISO) set standard sizes. The two most important, and most commonly used sizes even today, are the 20-foot and 40-foot lengths.
That a sort of standardized transport by road existed at Roman time is shown by the grooves on the stones of roads (Figure 1). However, other standards existed, in particular for the units of measurements. It Is interesting to note the fact that Foot, the unit of length in the US customary systems of measurement, had origin from a standard measure of the Roman Empire [14]. To the Foot was linked the Amphora, the measure of capacity most frequently mentioned by Roman authors. The Amphora (also called Quadrantal or Cadus), a standard of which, Amphora Capitolina, was held in the Campidoglio [15], was corresponding to the Cubic Foot. For the dry volumes, the Romans used the Sextarius. Besides being a unit of measurement, the amphora was also a container.
As a container, several types of amphorae existed. Amphorae designed for marine transport had pointed bottom so that they can be stacked as in the Figure 3, which showing an example of stacking for transportation given by the Museum of Underwater Archaeology at Bodrum Castle, Turkey. The museum archaeologists have devised a rack and roping method to illustrate how the cargo might have been kept from shifting. As we can imagine, it means that there were some standards for building amphorae and racks for oversea transportation. And, from ports to towns, it is reasonable to suppose a transportation by roads of amphorae based on a similar stacking method on racks in carriages.
Today we cannot move a container without shipping documents. The amphorae too had their shipping documents. The amphora had a "titulus pictus", a commercial inscription made on its surface. The inscription specifies information such as origin, destination, type of product, etc. We know that the tituli picti were frequent on Roman containers used for trade, because of a special place which exists in Rome, the Monte Testaccio. It is an artificial mound composed of testae, the fragments of broken amphorae. To remark the importance of Rome: it has also one of the largest spoil heaps of the ancient world, containing the remains of an estimated 53 million amphorae [16]. This Monte Testaccio allows archaeologists to have direct information of Roman economy.

An previously told, some amphorae found the mound are still bearing their tituli picti. These tituli were "painted or stamped inscriptions, which record information such as the weight of the oil contained in the vessel, the names of the people who weighed and documented the oil and the name of the district where the oil was originally bottled. … The tituli picti on the Monte Testaccio amphorae tend to follow a standard pattern and indicate a rigorous system of inspection to control trade and deter fraud" [16]. The procedure was the following: the empty amphora was first weighed, and its weight marked on the outside. "The name of the export merchant was then noted, followed by a line giving the weight of the oil contained in the amphora (subtracting the previously determined weight of the vessel itself). Those responsible for carrying out and monitoring the weighing then signed their names on the amphora and the location of the farm from which the oil originated was also noted. The maker of the amphora was often identified by a stamp on the vessel's handle" [16,17]

Figure 3: A suggestion on how amphorae may have been stacked on a ship (Courtesy Ad Meskens for Wikipedia).

Planning a transport How can we imagine an intermodal planning made during the Roman time? A trader had to consider several factors concerning oversea and overland transportation. Moving goods by maritime transportation was cheap and fast, but had some problems. The overland transportation was expensive and slow. Then, we can imagine that the Roman traders, relying on their experience and good luck made decision of asking trusted carriers to move their cargoes. Probably the logistics of these carriers was based on the itineraria and on the graphs they could obtain from them. Each line of the graph had specific costs and specific risks for transportation. Based on the planning, the carrier decided for the best possible choice [18-20].

To have an idea of such itineraria, we can use an interesting software which had been created for the Roman World. It is ORBIS/Via [21]. ORBIS is an interactive geospatial network model of the Roman world created by Stanford University [22], like a Google Maps for the Roman world. Using it, we can understand features of the Roman transportation system and of the factors, such as time and cost, influencing people and cargo travelling in antiquity. "By simulating movement along the principal

routes of the Roman road network, the main navigable rivers, and hundreds of sea routes in the Mediterranean, Black Sea and coastal Atlantic, this interactive model reconstructs the duration and financial cost of travel in antiquity … Conventional maps that represent this world fail to capture the actual travel conditions that determined the flows of people, goods and information" [21]. The software created at Stanford University evaluates the time (in days) and the costs (in denarii) for traveling in the modes foot, pack animal, ship, and caravan, between the cities of the Empire. The software considers travelling along principal roads and by river and by sea routes. In this manner, using it we can act as a Roman carrier who had to decide the itinerarium for people and cargoes.
In the Figure 4 we can see three itineraria from Augusta Taurinorum to Constantinople, after a snapshot of ORBIS. In the Figure they are also given the tables for time and cost.

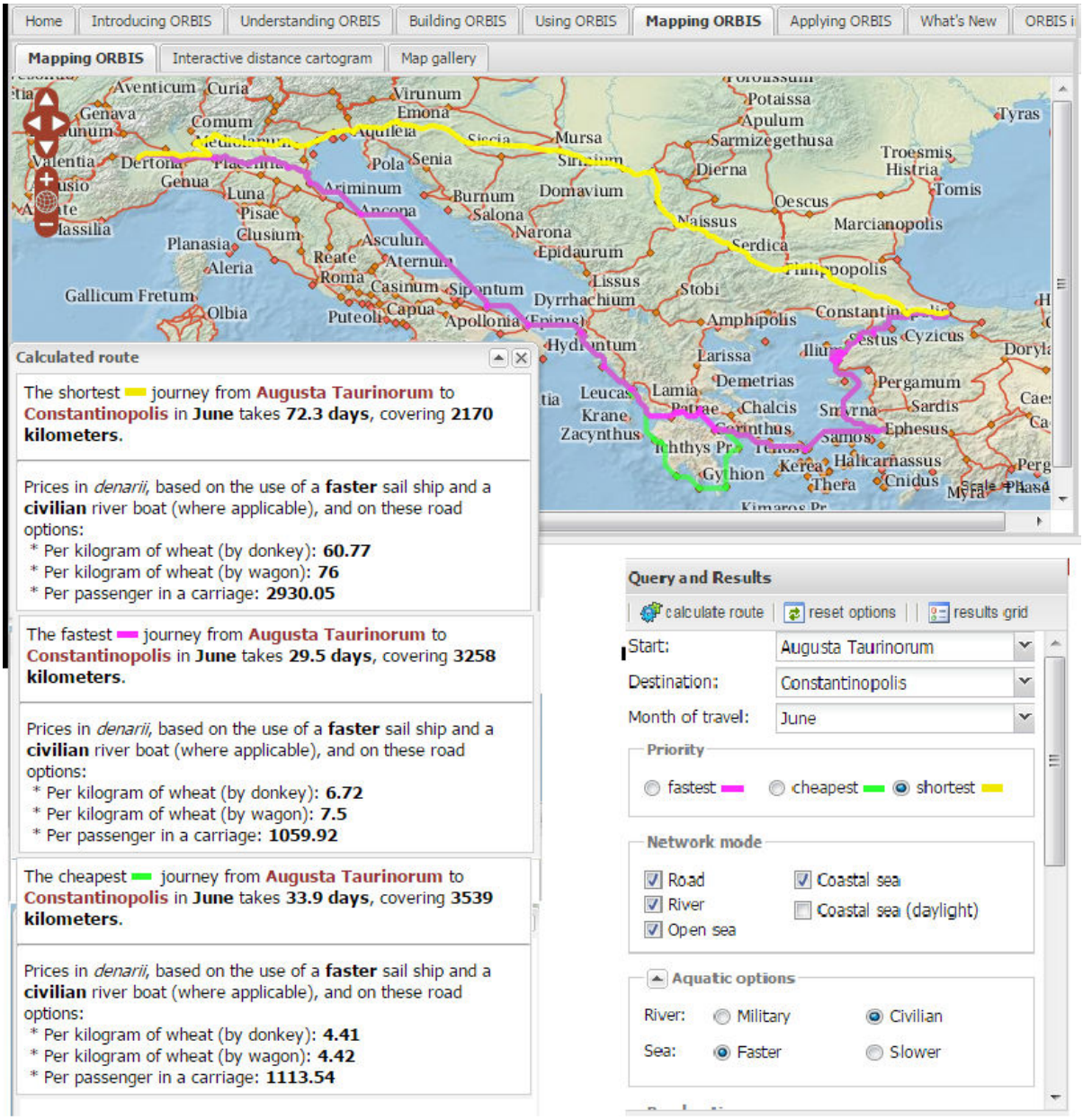

Figure 4: Snapshots of ORBIS simulation of a Roman travel from Augusta Taurinorum to Constantinople.

Conclusions In this paper we have started our work for evidencing some features of intermodalism in the transportation network of the Roman Empire. We have seen that the network was intermodal. It had terminals, such as Ostia, that were connecting oversea and overland transportations. Containers, the amphorae, existed such as the shipping documents, tituli picti. Probably, graphs based on the itineraria were used by the carriers as logistic planning for the transportation of people and cargoes.

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[18] Today software exists for the trip plan of transportation. Among the several available system, the OpenTripPlanner (OTP) is an open source multi-modal journey planner [19]. Another well-known example of such systems that can provide a traveler with an itinerary for an intermodal journey, is the Google Transit [20].
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