

# The historical development of the port of Livorno (Italy) and its new Port Plan 2010 in advanced stage of elaboration

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## *Abstract*

*The geographical location makes the port of Livorno one of the most important in Italy. The port, in-fact, benefits of an extended network of roads and rails connecting it with the rest of Italy, and central and southern Europe as well. The history of Livorno and of its port is inextricably linked to that of Pisa and Florence, and to the complexity of events that determined the political set-up of the region along several centuries. Looking at the new Port Plan of Livorno has made it necessary an extensive overview of the history of both the port, and of its planning.*

**Keywords:** *History, Italy, Livorno, Plan, Port.*

## 1. Geographical context

The Port of Livorno is the most important port in Tuscany and one of the most important in Italy, as it has a strategic geographical location, and a good inland transportation infrastructure (see Fig.1).

In 2008 the Port of Livorno has passed the milestone of 34 million tons handled in total. In 2009, in connection with the serious global recession, the port recorded a decline of 21.3% of traffic. Nevertheless with respect to the other Italian ports in 2009 Livorno has maintained a balanced distribution of traffic: 35,9% of ro-ro and ro pax, 27,9% of liquid bulk, 27,9% of containers, 7,9% of packaged goods and 2,5% of dry bulk. The traffic of cruise ships, favoured by the proximity of many cities of art, is steadily increasing in recent years.

The port lies at the southern end of an arched sandy beach about 60 km long. This arched beach constitutes a physiographic unit bordered to the North by the mouth of the river Magra, and to the South by a rocky headland of moderate height. This slightly protruding headland represents the extreme offshoot of the Monti Livornesi (Livorno Mountains). The most important rivers flowing within this physiographic unit are Magra, Serchio and Arno. Their annual flow is on the average about 40, 46 e 110 m<sup>3</sup>/s respectively. It is to be noticed that the mouth of the river Arno is located just 10 km away from Pisa, and approximately 13 km to the north of the port of Livorno (see Fig. 2).



*Figure 1. Geographical context*

## 2. History of Livorno Port from its origins to the Unity of Italy

Like most of the Italian ports, the port of Livorno has a long and complex history. The origins of the port are inextricably linked to the history of Pisa and its port, and to the complexity of event that determined the political set-up of the region along several centuries.

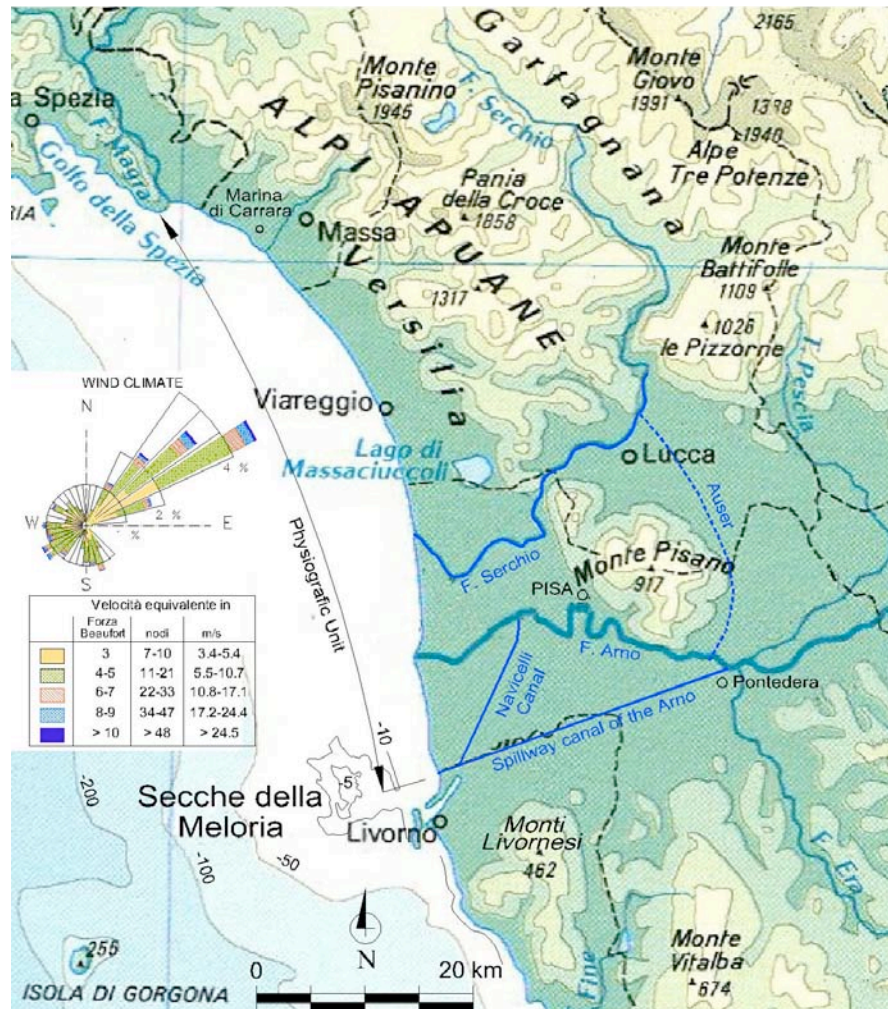


Figure 2. Physiographic unit delimitation

Although the original settlement of Pisa was likely to be Etruscan, the information on its ancient port are uncertain and fragmentary. At the beginning of commercial navigation, a large lagoon named "Sinus Pisanus" was known to be located south of the mouth of the river Arno (see Fig. 3). The lagoon was protected by a barrier-beach, and was characterized by a complex hydrography. In particular, the lagoon was dotted with small islands, channels and marshes low. A secondary branch of the Arno river - the so-called Arnaccio - flowed into the lagoon.

The safest access to the lagoon was located at the southern end of the "Sinus Pisanus", in coincidence with the southern boundary of the physiographic unit. The entrance was located at a place called "Turruta" or "Triturrita" (sometimes the names Liburnus, Labrone, Herculem Labronem are used) and was controlled by a system of fortifications, probably

comprising three towers. Ships (often including military vessels) could sail along the lagoon in order to reach Pisa, and other locations. It was also possible to reach the city by sailing the Arno river. The mouth of the river was characterized by low flows which were much higher than current ones. Indeed - at that time - the river Auser (now called Serchio) flowed into the Arno near the modern town named Bientina, increasing the flow of the Arno (Fig. 3).

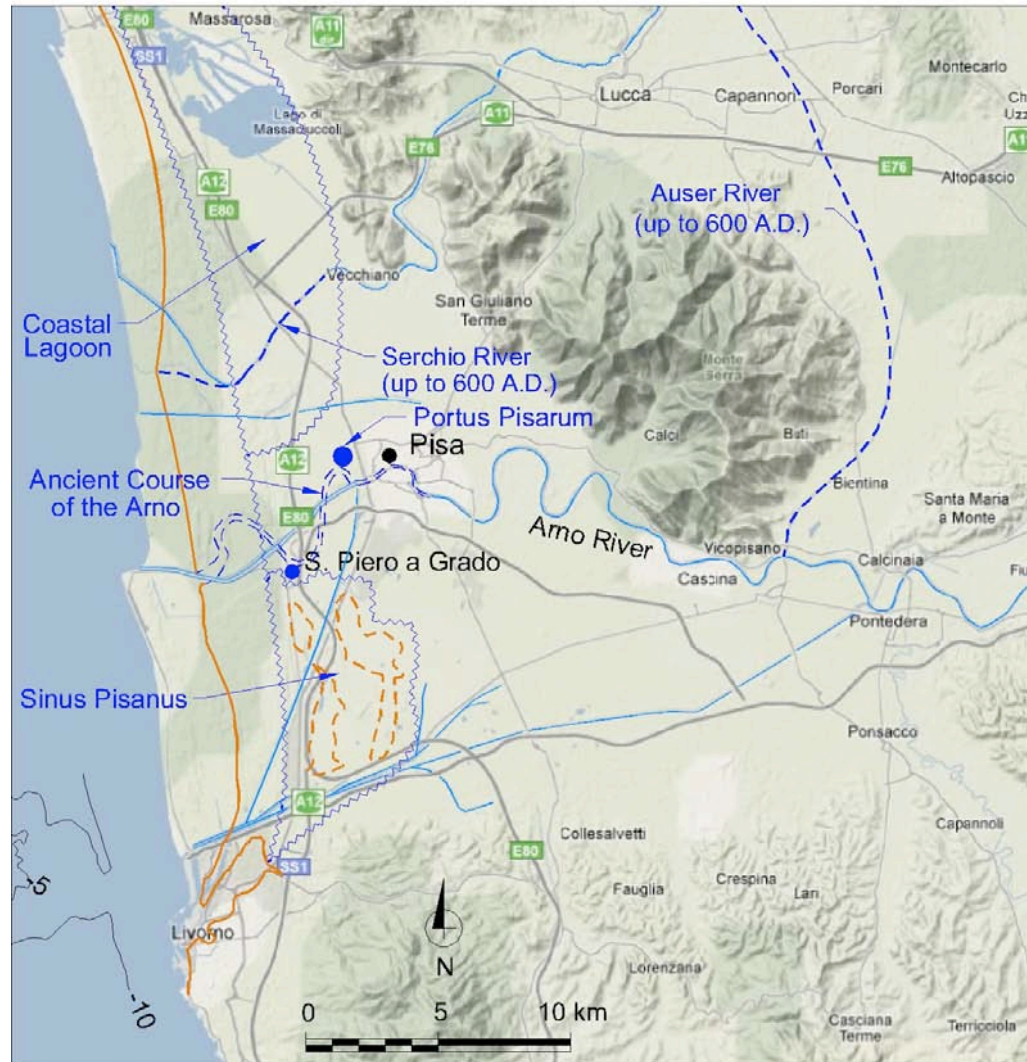


Figure 3. Coastline planimetric shape in the north of Livorno in different historical periods.

At present, the mouths of Arno and Serchio are separated (Fig. 2). The maximum flow of the two rivers is almost equal (in the order of  $3.000 \text{ m}^3/\text{s}$ ), while the low flow of the two rivers is about 3 and  $11 \text{ m}^3/\text{s}$  respectively. The mouth of Serchio was diverted by Bishop S. Frediano in 600 A.D., probably to reduce the flow of maximum flooding of the Arno. The new course of the Serchio (called "Auserculus", from which the name "Serchio" comes) surrounded to the north the city of Lucca and ended its run to the sea with a mouth separated from that of

the Arno. The diversion of the final stretch of the Serchio river, which persists until today, has reduced the navigability of the final stretch of the Arno (Fig. 2).

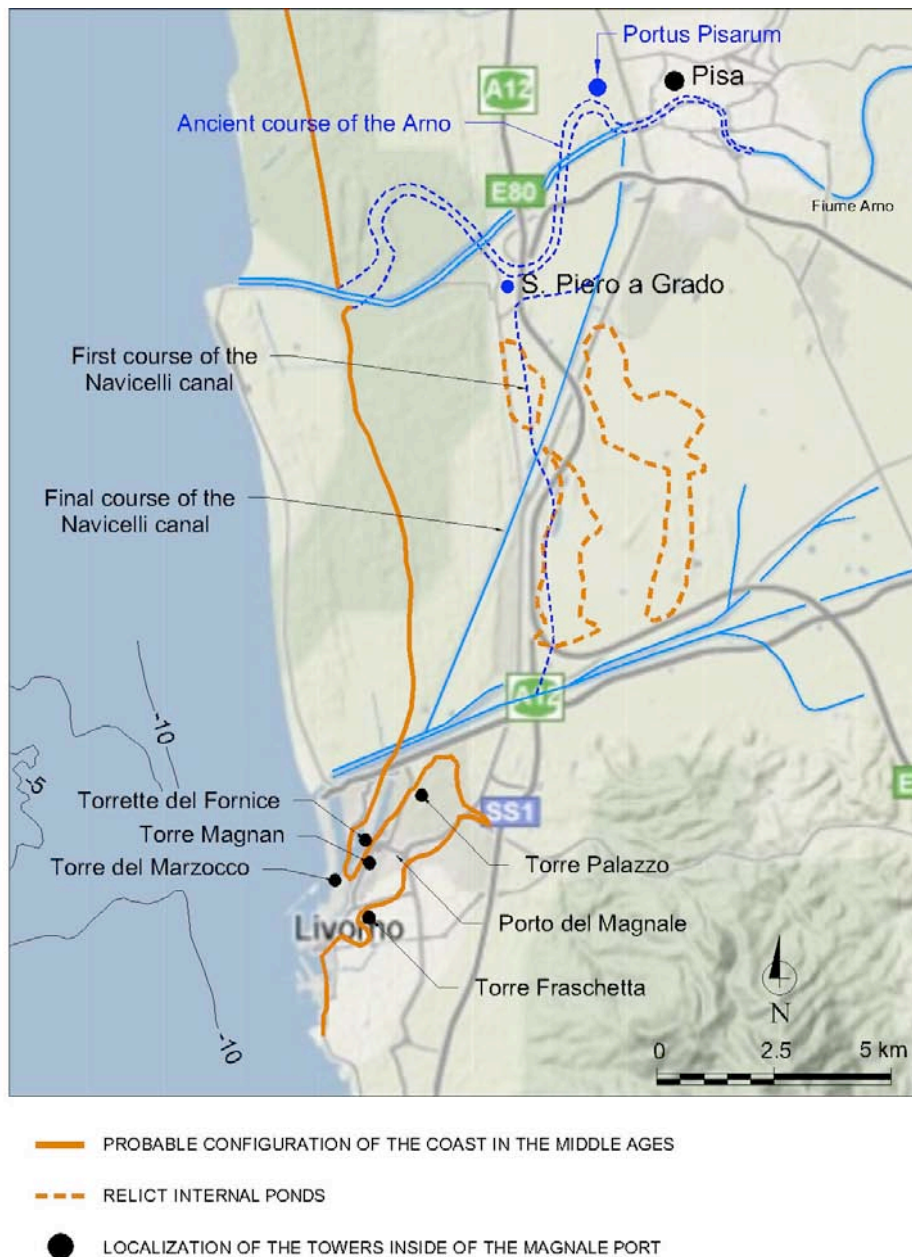


Figure 4. The Port of Magnale at the time of splendour of Maritime Republic of Pisa.

The most ancient port of Pisa, named “Portus Pisarum”, was located close to the town in a sheltered bend of the Arno river (Figs. 2 and 3). It was a river port, as it was at that time the port of Ostia, the ancient port of Rome. This has been shown by both the ship wrecks and the maritime-facility remains recently discovered (1998) in the pine forest of San Rossore, close to Piazza dei Miracoli in Pisa. The wreck conditions suggest that a calamitous event (probably a joint flood of the Arno and Serchio rivers) suddenly occurred destroying the port and sinking the ships. It is to be noticed that, due to the flooding of the river, the wandering

of the mouth, and the siltation of the coastal lagoon, the citizens of Pisa considered “Portus Pisanus” unsafe even before this calamitous event. In fact, a second port – located 7 km from Pisa, closer to the mouth of the river Arno - was already used at that time. This second port was located at Grado (from Latin “gradus”, which means “call”) (Figs. 3 and 4). At present, the city of Grado is famous for the presence of the Basilica of St. Peter, remarkable monument built between the X and the XII century. The Basilica stands over the ruins of a previous early Christian building, erected in honor of St. Peter who landed in Grado in 42 AD, coming from Antiochia. The Port of Grado was probably the main dock until the I century and maintained a certain importance until to the III-IV century, when it was in turn abandoned in favor of the port of Triturrita, later called “Portus Pisanus” which means port of the inhabitants of Pisa. The name “Portus Pisanus” was used to distinguish it from the previous “Portus Pisanus”. “Portus Pisanus” was located in the southern edge of the Sinus Pisanus at a creek sheltered from offshore-coming waves by the Secche di Meloria (Meloria banks, see Fig. 2). The banks helped to make the entrance of the creek more safe and less prone to silting respect to the rest of the sandy coastline.

“Portus Pisanus” was modified over the centuries in order to solve the problem of the lagoon siltation. In the age of greatest splendor of Pisa - between 1100 and 1300 – the port was located at the western and outer part of the creek (see Fig. 4), and was called “Porto del Magnale” (port of Magnale). Several channels (Arnaccio, Fosso Reale, Fosso Torretta, Fosso Tora) flowed in the creek, draining water from the Arno and Ugione floodplains. It is to be noticed that the river Ugione came from the nearby hills of Livorno. The “Porto del Magnale” was built in some decades on the basis of an actual plan developed. Although unknown, the plan designer is likely to be one of the brilliant architects who worked in Pisa at the time (e.g. Diotallevi, Bonanno, Gherardo di Gherardo, Rainaldo). The port was characterized by major defenses and equipment. A tower called “Meloria” was built offshore the port in order to indicate the homonymous banks. Further five towers were built close to the entrance to the port. These towers were called Frascetta, Rubra or Rossa, Magnan or Magnana, del Fornice or dell’Ingresso and Palazzo. It seems that the towers’ location was chosen in order to answer to both functional (or logistics), and symbolic requirements. This symbolic requirements are assumed to be linked to navigation, to time and to the celestial sphere. By way of example, some author claims that the chosen location of the towers was intended to draw the constellation of Cassiopeia.

The goods were transported from the port of Magnale to Pisa mainly by sailing along the coast and the Arno river. Although possible, such a method of transport was rather difficult. A navigable canal was designed and excavated (1160) in order to by-pass these difficulties. The canal went from the Arno’s lagoon (between Vettola and St. Pietro a Grado) to the “Laguna di Stagno” (Pond’s lagoon), located just to the north of the port of Magnale. The new waterway, indicated in Fig. 4 with “First course of Navicelli Canal”, was characterized by a tortuous path, and did not have the success expected, because of the damages caused by natural events and by human actions.

“Portus Pisanus” was repeatedly attacked by Genoa and its allied during the second half of the XIII century. In particular, it was partially destroyed in 1268 by Carlo D’Angiò, allied of Genoa. A great naval battle was fought between the fleets of Genoa and Pisa at the “Secche della Meloria” (“Meloria Banks”) in 1284 (Fig. 2). The battle ended with the defeat of the fleet of Pisa. Later on Pisa, whose power had in reality vanished, tried to reactivate the efficiency of the Port, but the Genoese and the Florentines destroyed permanently the port together with its towers in 1290. Obstinate, the citizens of Pisa proceeded to reconstruct and repair at least some of the port’s towers and building, and to dredge the harbor. Finally, the port was moved for sake of safety close to the small village of Livorno.

The town of Livorno stood immediately south of the “Porto del Magnale”. The toponym Livorno appears for the first time in a document dated 1017. Livorno is derived from the Latin "Liburnus" which some author bring back up to a name of Etruscan origin, others to the fast warship named "liburna", others to the name of the Illyrian population “Liburni”. In ancient sources, in addition to "Liburnus", the name "Labrone" appears. This last name is for sure of Latin origin, as it comes from "labrum maris" indicating “the position that touches the sea”. It is to be noticed that in modern Italian both adjectives “livornese” and “labronico” are used to indicate somebody or something “belonging to the town of Livorno”. The English translation of “Livorno” is “Leghorn”. Note that Livorno is one of the few Italian towns which has a direct translation in English of its name.

Pisans encircled the small town with a square plant fortification (named “Quadratura dei Pisani” or “Rocca Nuova”) that was the oldest part of the future “Fortezza Vecchia” (Old Fortress) (Fig. 5). Moreover a majestic lighthouse, called “Fanale dei Pisani” (Light of Pisans) was built in 1303 (Fig. 5). The lighthouse was very famous also at that time (it is mentioned from Dante and Petrarca) and survived until the end of World War II.

The Genoese Pierino Grimaldi, on behalf of the Republic of Florence enemy of Pisa, devastated again "Portus Pisanus" in 1362.

In the turbulent period that preceded the fifteenth century, Livorno fell in 1399 under the sovereignty of Gian Galeazzo Visconti, Duke of Milan. The Duke of Milan gave Livorno to Genoa in 1408.

In 1421 Livorno was sold to the Republic of Florence, who had absolute need of an access to the sea, for 100,000 gold florins. One of the first intervention of the Florentines consisted in starting the reconstruction work of the tower named "Torre Rossa" on the basis of the project attributed by some to Lorenzo Ghiberti. Later the tower was called the "Torre Nuova" or “del Marzocco”, but it was finished only by Grand Duke Cosimo III, in 1704 (Fig. 4).

In 1434, the triumphant return to Florence of Cosimo il Vecchio (Cosimo the Elder), exiled the year before in Venice, in practice marked the beginning of the Medici power in Florence and in the annexed territories (the so-called “criptosignoria” of the Medici). However, after repeated attempts to restore the Republic, only in 1531 Alessandro de' Medici, with the decisive help of the troops of Charles V, in agreement with Pope Clement VII (of the Medici family), took possession of Florence and its territories with the title of Grand Duke of Tuscany, title that was transmitted by hereditary right. Therefore Livorno became part of the Grand Duchy of Tuscany under the Medici. After the Medici, came to an end in 1735 due to lack of direct heirs, the Lorraine succeed to the grand duchy with the first Grand Duke Francis III Stephen.

The merit of the development of the city of Livorno and of its port is unanimously acknowledged to the Medici, who used Livorno as the access to the sea of the Grand Duchy.

The “Fortezza Vecchia” (“Old Fortress”) was completed in 1534, respecting summarily the plan of Antonio da Sangallo, commissioned by Cardinal Giulio de' Medici (Fig. 5). The fortress served to control the town and the harbor. The waterway connecting Pisa to Livorno, long 22 km and named Canale dei Navicelli (Navicelli Canal), was successfully completed in 1573. As mentioned before, a first attempt, unsuccessfully, to dig this canal was done in 1160. The final course of the “Navicelli Canal”, which is still working today, has a straight path, while the previous one was tortuous (see Fig. 4).

On 28 March 1577, the construction of the town was started according to the plan commissioned by Francesco I de' Medici to the famous architect and urban planner B. Buontalenti. At that time famous Italian artists debated on the “forma urbis”, which in Latin means “shape of the ideal town”. In the design by Buontempi, the map of the town was pentagonal and the "Old Fortress" was located at one of the vertex (see Fig. 5).



Figure 5. The city of Livorno and the port in the Medicean era.

Ferdinand I, brother of Francis, became Grand Duke in 1587, and proclaimed Livorno "free port". He also promulgated the *Leggi Livornine* (Laws of Livorno) to provide privileges and concessions for those who lived in Livorno. These laws became the engine of demographic and economic development of Livorno. The laws guaranteed for freedom of worship and of religious profession and politics. They also allowed access to and presence in the town to anyone who was found guilty of crimes, except some, as murder and counterfeiting. Livorno became a cosmopolitan, multiracial and multi-religious town and in 1606, with a solemn ceremony, was officially elevated to the rank of "city". The population was in that year of about 10,000 inhabitants. The Grand Duke Ferdinando I supported the realization of the *Darsena Vecchia* (Old Dock) which was a small basin with the entrance facing south-west (Fig. 5). In the dock came some canals which penetrated inside the city and were used by vessels for commercial activities. The *Darsena Vecchia* was defended from the action of the sea by a breakwater called *Andana degli Anelli* (Andana of the Rings) or "Arm of Ferdinand" ("Braccio di Ferdinando") (see Fig. 5). In Italian the term "ormeggio in andana" had at that time the meaning of vessels moored in some rows, parallel to a quay. In Livorno there was the custom to moor the ships parallel to the quays in a predetermined order, which depended on the type of ship. The loading of the ships was done by means of small boats, called "i *Navicelli*", which were subjected to strict controls by the Authority.

In the early seventeenth century, during the reign of Cosimo II, a large basin open toward north was built on the west side of the "Andana" (see Fig. 5). The basin was sheltered by a breakwater made by two arms: the first, named "Molo Cosimo", oriented for south-east towards the *Fanale dei Pisani* (Light of Pisani); the second oriented towards north-north-west



and named “Molo del Forte”. The Fortress called “del Granatiere” or “del Molo” (“Forte del Molo”) was located in the extremity of the second arm (Fig. 5). The basin was not very deep and it was subjected to siltation. Vessels with greater draught were forced to anchor in the bay, near the tower named “della Vegliaia”.

During the successors of Cosimo II and later during the Grand Dukes of Lorraine, the port structure remained essentially unchanged until the middle of the XIX century. Hence, in conjunction with the city's urban growth, the birth of the first industrial activity and the opening of the railway between Florence and Livorno called "Leopolda", it were begun the works to expand the port towards north.

The construction of the Diga Curvilinea (Curvilinear Breakwater), located in front of the harbor built by the Medici family (named "Porto Mediceo"), was started in 1858 (see Fig. 6).



Figure 6. Project of the Diga Curvilinea (Curvilinear Breakwater) and of the Diga Rettilinea (Straight Breakwater) of the Poirel (1851).

The breakwater was designed by the French Victor Poirel who had previously worked at the port of Algiers. Poirel was also the author of the first Port Plan (meant in the modern sense of the word) after those developed by A. Cialdi in the 1853 and in the same years for "amusement", by A. Manetti. At the same time it was begun also the construction of the Diga Rettilinea (Straight Breakwater). The breakwater (see Fig. 6) was not connected to the land and was built to protect the (Medicean Port) from waves coming from north.

The Diga Curvilinea represented an innovative work and became the emblem of the port of Livorno. It is still working today and requires limited maintenance works. It is interesting to note that it is a rubble mound breakwater and that it was realized with parallelepipedal blocks of constant shape. These blocks were not built by using concrete, as it was done later for

others breakwaters (e.g. for the Casablanca breakwater), but they were obtained by cutting rock formations with suitable equipment.

The works designed by Poirel were almost entirely built before the Unit of Italy, which was proclaimed in 1861 with temporary capital Turin until 1865, Florence until 1871 and then in definitive form in Rome. The Diga Rettilinea was completed in 1866 by the new State.

### 3. The Livorno Port between 1861 and the present days

Initially the Unification of Italy represented a negative factor for the Port of Livorno. In fact the free port was abolished since 1868. Consequently, trade and industrial activities (primarily small manufacturing activities) that derived benefit from the free port, underwent a drastic reduction. Even the new railway line Pisa-Rome didn't pass through Livorno.

The Italian government was asked to expand the port in order to compensate for the loss of the ancient privileges. In the period before the end of the XIX century, the works to expand the port proceeded slowly. The Andana degli Anelli and the Diga Rettilinea, which was connected to the land, were widen (see Fig. 7). A new quay was built close to the Fortezza Vecchia obtaining the new dock named Darsena del Mandraccio (Mandraccio Dock); the Dock was directly connected with the Canale dei Navicelli (Navicelli Canal).

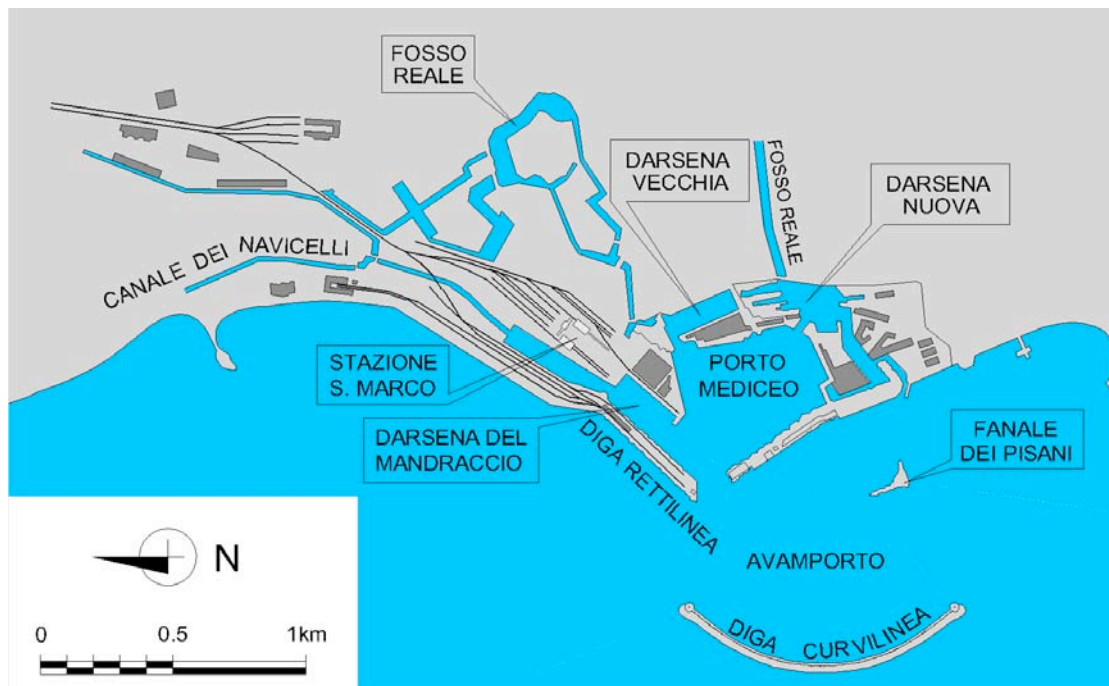


Figure 7. The Port of Livorno in 1905.

The construction of the new breakwater named “Vegliiaia” (Diga della Vegliaia) was approved in 1881 (see Fig. 8). The breakwater was built between 1880 and 1900 with the aim of sheltering from southern coming waves the outer port, created by the Diga Curvilinea. As the Diga Rettilinea, the Diga della Vegliaia was not connected to the land due to the prevalent opinion at that time, that this would have preserved unchanged the longshore sediment transport.

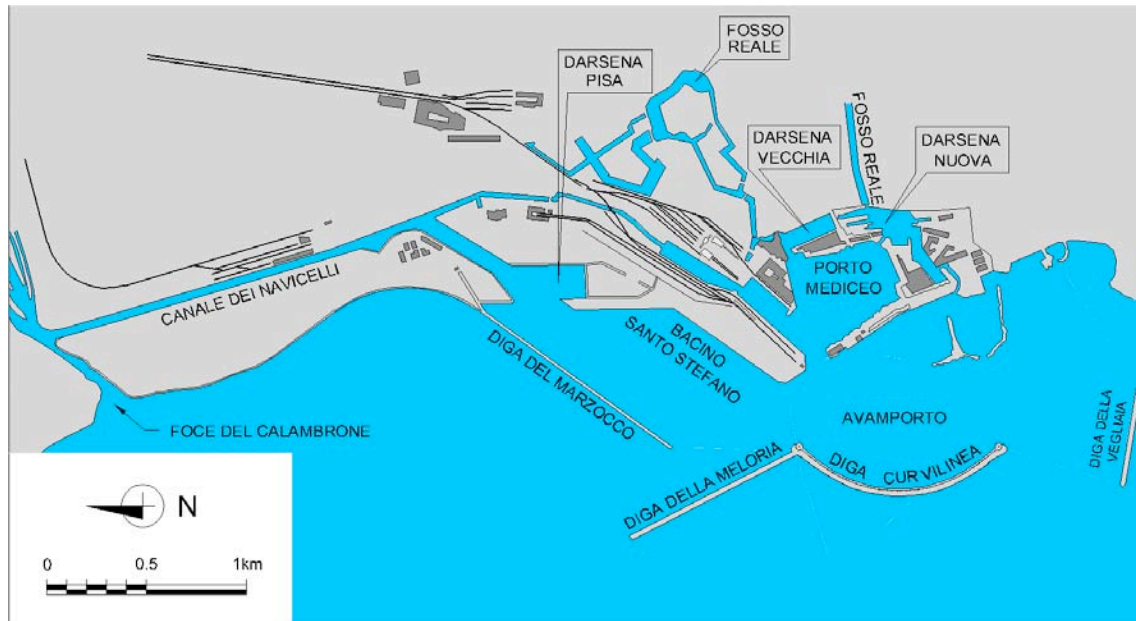


Figure 8. 1908 Port Plan (Eng. L. Cozza).

The shipbuilding industry grew significantly since 1886 under the impulse of the Orlando family. The family purchased an area that until 1852 was occupied by the structures of Lazaretto S. Rocco (Lazaretto S. Rocco), founded in 1590 by Ferdinand I de 'Medici. With the construction of the Arsenal in a part of the east side of Lazaretto, the Fosso Reale (Real Ditch), name given to the long ditch that ran along the outside of the walls, was enlarged, eliminating a substantial portion of the rampart which had lost its original defensive role, to build a Dock called St. Rocco and later Darsena Nuova (New Dock). The Darsena Nuova was connected to the Porto Mediceo (Medicean Port) in order to allow the transit of ships to shipyards. A new slipway and a new dry dock, on the north side of the Darsena Nuova, were built between 1861 and 1867. Furthermore a new rail link between the Diga Rettilinea and Stazione S. Marco (S. Marco Station) was built (Fig. 7).

Only in the first decade of 1900 the initiative of expanding the Port of Livorno took place. Indeed in 1908 the Livorno Port Plan, developed by Eng. L. Cozza belonging to the Civil Engineers Office of the State, was approved. The Livorno Port Plan was part of a renovation plan of all the Italian ports assigned to a Parliamentary Committee established in 1906.

The Cozza Plan (see Fig. 8) proposed the construction of two new breakwaters. The first, named Diga della Meloria (Meloria Breakwater), was the straight continuation towards north of the Diga Curvilinea (Curvilinear Breakwater). The second, named Diga del Marzocco (Marzocco Breakwater), was connected with the Marzocco Tower and run, parallel to the Poirel Straight Breakwater, towards south-ovest. In this way a second harbor entrance, wide 300 m, and a wide basin, named Bacino S. Stefano (Santo Stefano Basin), were created. Also the construction of a large embankment, made with dredged material and to be used for industrial activities, was included in the Plan.

The works for the construction of the new harbor started in 1910, concomitantly with the inauguration of the new railway station of the line Pisa-Livorno-Roma which followed a course along the coast instead of the previous inland course.

After a period of inactivity due to the first World War, in 1922 the SICAM (Italian Manufacturers and Maritime Contracts Union) proposed a variant of the Port Plan. The

variant was developed by Prof. Eng. Coen Cagli, famous expert of maritime constructions who was involved in the Genova Port Plan and in the constructions of many works of the same port. The Coen Cagli Plan (see Fig. 9) included the enlargement of the port to the north of the town inside the coastline, through a series of canals and docks where industrial plants were to be made close to the quays. Coen Cagli was inspired by the great ports of the north Europe falling into the category of inland ports, whose construction costs were much lower than those of the ports entirely conquered the sea. Following this idea some years later it was proposed the realization of an inland port in Venice-Marghera, where extensive flat areas near the sea was available, in the likeness of the hinterland of Pisa and Livorno.

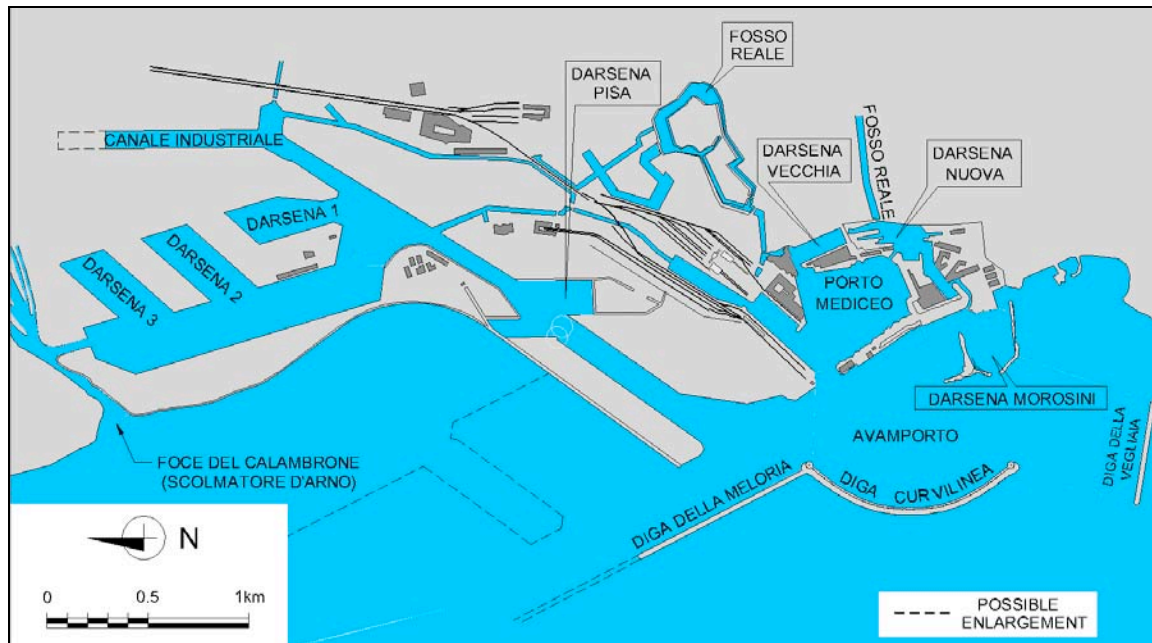


Figure 9. 1923 Port Plan (Eng. L. Coen Cagli).

The Coen Cagli Plan didn't jeopardized the development of the port in the sea (outside of the coastline) to be achieved through the extension of the Meloria Breakwater and the realization on the back of this of a series of protruding wharfs slightly oblique (as in Genoa) and rooted to a large embankment (Fig. 9).

The plan was clearly projected into the future, even if proposed only the immediate implementation of a long stretch of the Canale Industriale (Industrial Canal) and of Darsena n. 1 (Dock no 1) named Darsena Inghirami (Inghirami Dock).

The plan was approved in 1923 and its realization started in the following years. It was favorite also by some laws which provided incentives to Industrial plant built close to wharfs. The works which were completed before the Second World War, were the canal for the access to the industrial area and the Darsena Inghirami.

During the Second World War the harbor was subjected to very large damages. Besides equipments, ships and quays destroyed by air raids and by the German sappers, during the retreat of the German troops many historical buildings, as the "Health Palace" ("Palazzo della Sanità") located close to the Old Fortress, the "Magnale Tower" and the monumental "Light of Pisans", were destroyed.

Immediately after the war the harbor reconstruction began. It was particularly complex. A review of the Port Plan was necessary. It was carried out in 1949 by the Civil Engineers

Office for Maritime Works of the State managed by Eng. A. Migliardi and was approved by the Ministry of Public Works in 1953 (fig. 10).

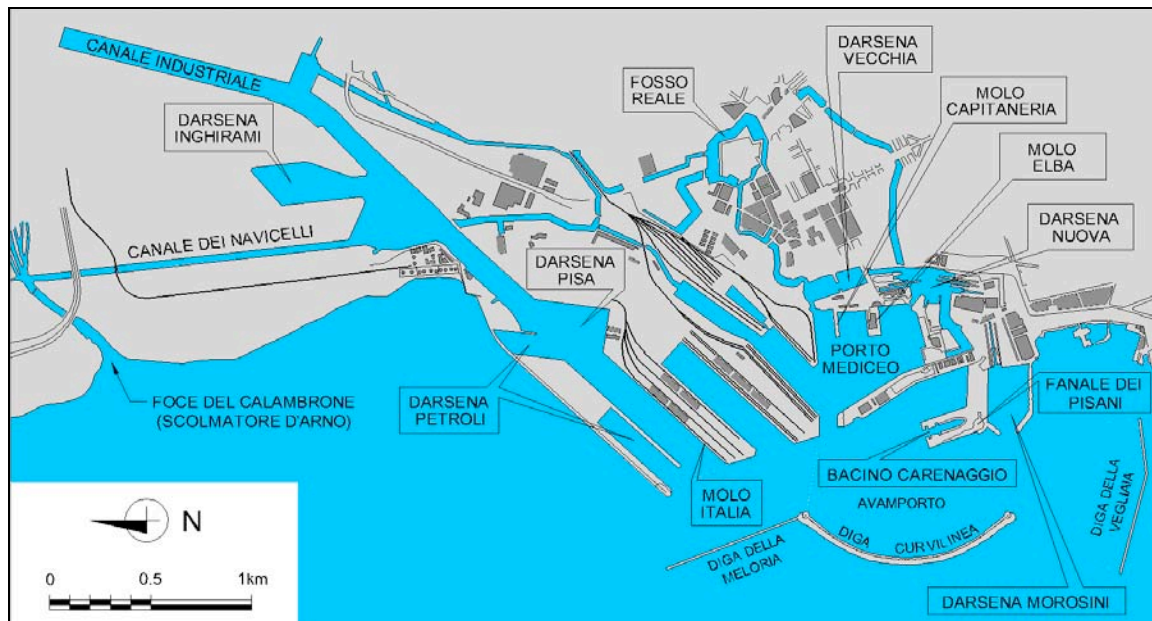


Figure 10. 1953 Port Plan.

The Plan included different phases of implementation. First it was necessary to reconstruct the quays and their equipments, to deepen some basins and to carry out a rational distinction of the quay functions. Then the works aimed at improving the harbor functionality had to be performed.

The works for the harbor improving concerned the railway and road connections to the harbor which had to divert commercial traffic from downtown. Furthermore they concerned: the maintenance and completion works of the Diga della Meloria (Meloria Breakwater); some works to rationalize the Medicean Port (some quays between the Molo Elba and the Darsena Nuova, the Molo Capitaneria (Capitaneria Wharf), the extension and enlargement of the Molo Elba, the enlargement of the entrance); the construction of a new dock for tankers (Darsena Petrolì); the construction of a new quay, enlarging the Diga Rettiliena in the north side, long 750 m and deep 12,0 m, lean against to the straight breakwater; the construction of a new jetty named “S. Stefano” and later Molo Italia (Italy Warf) long 800 m and wide 150 m; the construction of a new dry dock (Bacino di Carenaggio) close to the Fanale dei Pisani. Some of these works, as best shown below, were made much later, sometimes with smaller dimensions, as for example the Molo Italia. Other works planned, as for example the extension towards East of the Diga della Vegliaia and the enlargement of the entrance of the Porto Mediceo, were never carried out.

In the following years numerous variants to the 1953 Port Plan was prepared and approved. With the first variant, approved in 1955, it was decided: to insert a draw-bridge between the Andana degli Anelli and the Molo Sgarallino (Sgarallino Wharf) close to the Fortezza Vecchia; to shorten of 110 m the Molo Italia in order to improve the maneuvering of the ships; to place the Tanker Dock (Darsena Petrolifera) 130 m far from the Molo Italia. Were also introduced some minor changes.

The development of the port traffic between the '60s and '70s was impetuous, generating an increased demand for quays and large earthworks. Evidence of the needs that arose, is the 1960 variant to the Port Plan which planned to increase both the depth of the Darsena Pisa (Pisa Dock), from  $-4,0$  m to  $-12,0$  m, allowing the exploitation of a wide area located behind the dock, and the depth of the access canal to the industrial harbor for its connection to the new turning basin.

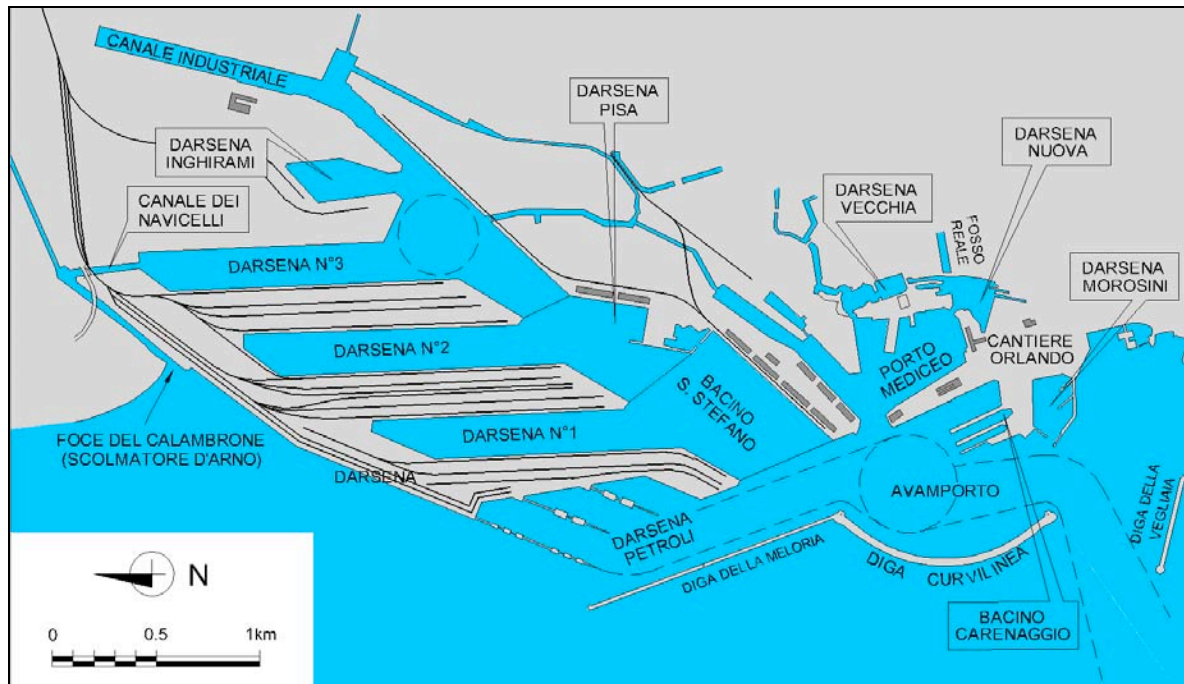


Figure 11. Final Proposal of the Committee chaired by Eng. P. Vian (1965.)

In 1965 the Chamber of Commerce of Livorno promoted the studies for a new Port Plan which were commissioned to a Committee chaired by Eng. P. Vian, famous in the maritime field. The Vian proposal (fig. 11) was an update of the Coen Cagli Plan. Vian devised the construction of four large docks: three for commercial ships wide 200 m and with a depth of  $-12,0$  m, excavated inshore and connected with the industrial canal which was to be widened; one external dock for tankers (Darsena Petroli), which had to be protected to the west by an extension of 800 m of the Diga della Meloria (Meloria Breakwater) and to the north by an offshore breakwater. Furthermore Vian proposed: a) the dredging at  $-16,0$  m of the port entrance channel; b) the construction of a second large dry-dock for ships up to 100.000 DWT to be placed close to that included by the 1953 Port Plan; c) the location of a marina in the Darsena Morosini (Morosini Dock); d) the widening of the entrance to the Porto Mediceo. The Vian Project was sharply criticized for the orientation of the docks, almost perpendiculars to the local prevailing winds coming from south-west. This aspect was always considered very carefully by all the projects presented over the years. The Committee, chaired by Vian, tried to get around this problem by changing the orientation of the docks in order to form an angle of  $56^\circ$  with the direction of south-west, angle considered acceptable for navigational purposes, and appropriately staggering the heads of the wharfs. The Vian project was never approved.

In the following years (between 1968 and 1975), the most important work that took place in the port of Livorno was the construction of a large dry dock long 350 m and wide 360 m, capable of receiving ships up to 290.000 DWT. This dry dock was included in the 1953 Port Plan, although of smaller dimensions.

The dry dock was realized at the initiative of a Consortium formed in Livorno between the Municipality, the Province, the Chamber of Commerce and the banks “Cassa di Risparmio di Livorno”, “Monte dei Paschi di Siena” and “Banco di Napoli”. The aim of the Consortium was to revitalize the local shipbuilding activity which was drastically reduced in favour of other Italian and foreign shipyards. The chosen location was undoubtedly bad, being placed close to the town, but reflected a tradition rooted in Italy to bring the job close to the workers. In fact, today many ports in Italy where the shipbuilding industry languishes, have the problem of reuse of facilities that occupy areas that are particularly attractive. Just think to the incongruous present location of several dry-docks in Genoa, located between the historical port and an exhibition area of great importance, or of the shipyards in Ancona placed in the most emblematic area of the port, in close contact with famous Roman monuments.

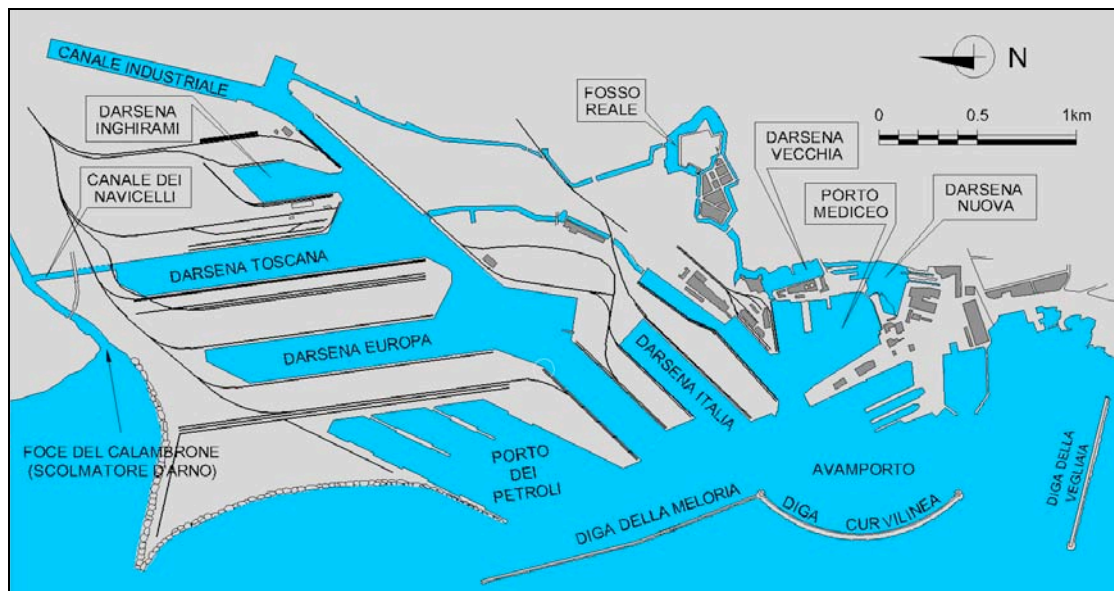


Figure 12. Port Plan proposed in 1971.

At the same time, the ship traffics continued to increase, passing from 3.000.000 t to 10.000.000 t per year between 1953 and 1970, with an interesting presence of containers, whose traffic was developing all over the world. In the meanwhile, the institutions were dedicated only to the mere maintenance of the status quo. Such an immobility and lack of initiative caused the protest of the port operators. Therefore in 1971 a new Port Plan was again prepared by the Civil Engineers Office for Maritime Works of the State, directed by Eng. G. Semiani. This Plan somehow took account of the debate arouse by the presentation of the Vian Plan. The new Plan (see Fig. 12) proposed, as a novelty compared to the previous, the construction of two docks both of them located to the north of the Diga del Marzocco. These docks, with a water depth of -13,0 m, were called Darsena Toscana (Tuscany Dock) and Darsena Europa (Europe Dock). Furthermore the Plan proposed a Porto Petroli (Petroleum Port), with a water depth of -15,0 m, located near the Diga della Meloria which had to be prolonged.

In 1973, while the new Port Plan was still in a phase of laborious approval, a variant of the in force Plan was urgently approved. The variant (fig. 13) included the realization of the Darsena Toscana strongly requested by port operators. The Dock was located along the last part of the Canale dei Navicelli (Navicelli Canal) in the stretch between “Marzocco Tower” and the confluence in the Canale Scolmatore d’Arno (Spillway Canal of the Arno) which was built between 1953 and 1971 in order to defense Pisa from river flooding (Fig. 2). The Spillway Canal followed the path of the ancient branch of the Arno, called “Arnaccio”. The dock width should be 200 m and the depth -13,0 m. Besides, in order to eliminate the entry of sediments from the Spillway of the Arno, it was planned the construction of interception works of the Canale dei Navicelli upstream of the new dock, by using the system of “vincian gates”. The new embankments had a surface of 5.000.000 m<sup>2</sup> and were provided with new road and rail connections.

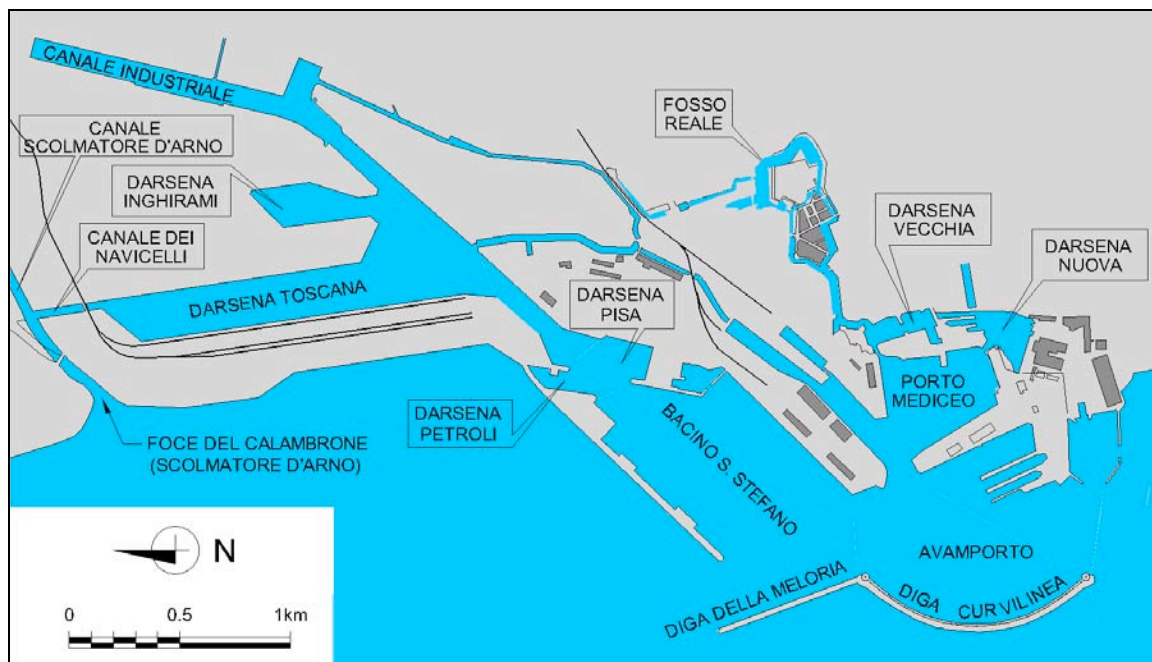


Figure 13. Variant of the 1953 Port Plan proposed in 1973.

The construction of the new dock and of the quays on both sides began in 1976 and has not yet been fully completed, reflecting the slowness with which many important works are realized in Italy. A partial justification in this case is provided by the difficulties encountered to solve the problems of letting in the Navicelli Canal. These problems involving several Administrations and without their resolution, the road and rail links could not be assured. Note that the “vincian gates” have never worked, also because the Calabrone mouth, which is the mouth of the Arno Spillway Canal, was perpetually obstructed by a sand bar and with the gates closed, there would have been an unacceptable rise in water levels in the canal. Finally there is what they wanted to avoid using the gates: the filling of Tuscany Dock with all the sediment transported by the Calabrone, with maintenance costs not negligible.

The 1971 Plan was never approved in its entirety, thus losing another opportunity to modernize the port and enable it to meet the challenges posed constantly by competing ports. The works realized in the following years, apart from the Darsena Toscana, therefore fell between those provided by the old 1953 Port Plan, partially modified through the use of simplified procedures described below.



Before the bloodless political and judicial revolution occurred in Italy around the 90s which is generally called as the passage from the "First" to the "Second" Republic, was made a last attempt to change the situation.

In 1980 a "District Committee" (composed by the municipalities of Livorno, Pisa and Collesalveti, and the Provinces and Chambers of Commerce of Livorno and Pisa), preferred to disengage from Ufficio del Genio Civile per le Opere Marittime (Civil Engineers Office for Maritime Works of the State) and entrusted to the Bonifica Company, of the Group Iri-Italstat (with semi-public features), the drafting of the new Port Plan. The situation seemed favorable also because Bonifica had an unquestionable expertise and good political supports. It should be noted here that traditionally Port Plans were carried out by the Civil Engineers Office for Maritime Works responsible for area and belonging to the State. Before World War II these offices enjoyed a large and well-deserved prestige. After the War these offices for a number of reasons, such as lack of personnel with specific training, the disaffection of the most talented graduates for a work paid little and no more prestigious, reduced stay in the seat of the holders thereof, had no culture and ability to manage a complex and multidisciplinary design as port planning.

Attempts to replace the Civil Engineers Office with structured design teams, didn't start with the Port of Livorno but always met resistance and difficulties. Only the "Cassa per il Mezzogiorno" ("Found for South") began to erode the absolute power of the local Civil Engineers Offices. The "Found for South" was a Public Authority with financial and decision-making autonomy, which was created in the mid 50's in order to solve in a unified approach the problems of southern Italy. Not by chance were devised by the "Fund" interesting works with features of modernity such as the ports of Gioia Tauro and Cagliari, which, once implemented, were successful in the containers transshipment. During those years, following the success of Gioia Tauro, it was built the port of Genoa Voltri with the contribution of private capital. The Port was planned and realized by the "Consorzio Autonomo del Porto di Genova" ("Autonomous Consortium for the Port of Genoa"), ably supported by Dutch experts.

The time therefore seemed ready for the solution of the problems of Livorno.

Following an extensive study on freight traffic and on deficiencies of the existing port, the Bonifica Company said first that any expansion of the port within the shoreline had to be excluded, due to numerous constraints that had arisen since the Coen Cagli Project. Therefore Bonifica proposed to extend the port towards the sea in the west side of the Tuscany Dock. The final solution (fig. 14) presented to the "District Committee", after a long series of meetings and discussions, included:

- the protection of the new works by an offshore breakwater rooted immediately in the north of the Calabrone mouth, with a first stretch parallel to the Marzocco Breakwater and gradually connected with a second stretch almost parallel to the coast-line;
- the creation of a large dock with the axis oriented along the northeast-southwest direction; the creation of a series of quays with an overall length of 5.000 m and with the same orientation of the dock; the creation of large embankments behind the quays, with a total area of 1.200.000 m<sup>2</sup>;
- the creation of a canal 400 m wide, located between the new offshore breakwater and the new embankments, to eliminate the entrance of the Canale dei Navicelli in the Darsena Toscana, ensuring a protected mouth to the Calabrone.

The Port Plan developed by Bonifica Company, that if implemented would certainly have contributed to rapid growth of the port, was blocked due to opposition expressed by two public authorities: the Civil Engineers Office and the Capitaneria di Porto (Harbour Office).

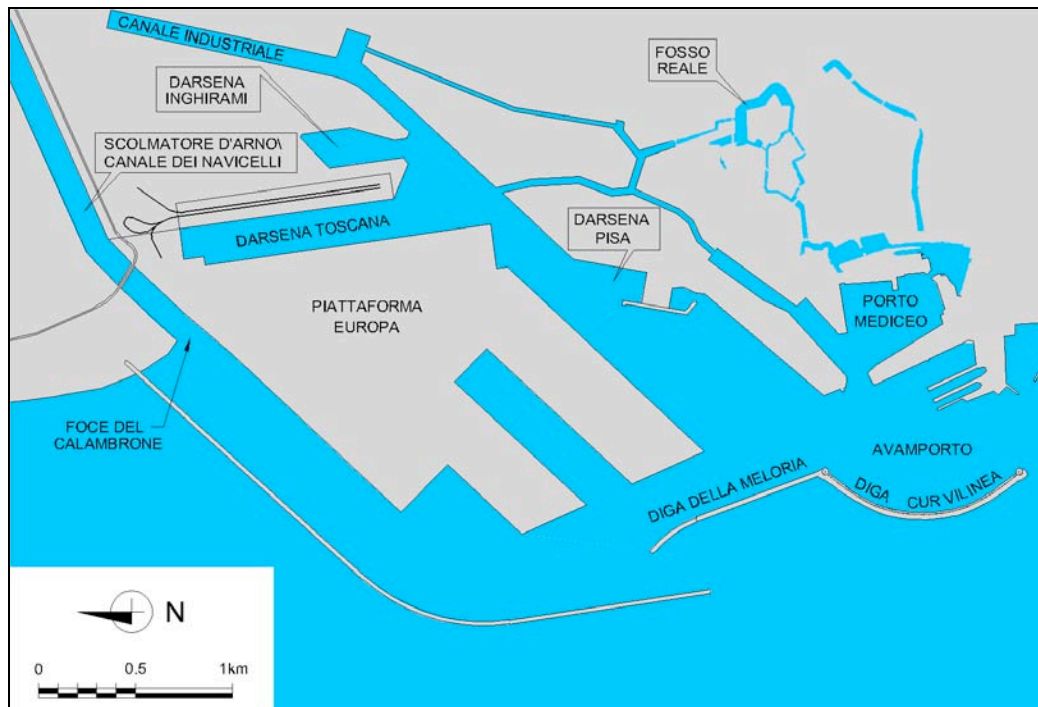


Figure 14. Port Plan proposed by Bonifica (1980).

The justifications exposed, although stated as techniques, probably arose from the fear of losing power and competencies.

Suffice it to say that the Harbour Office, whose specific expertise in the field of transport was at least questionable, raised the objection that it was necessary to follow the General Transport Plan, drawn up in those years by the Italian Government, which advocated a fairly general integrated development of transport modes by land, sea, air and waterway. This was possible, according to the Harbour Office, only by developing the port fully inside the coastline, in the nearby territory of Pisa.

In itself the idea of such a development was acceptable, but at that time many environmental groups were opposed to it. There was also the lack of the accord with the Pisa Municipality. Both factors were kept well in mind by engineers of the Bonifica Company.

In retrospect one can say that the opinions expressed by the Civil Engineering and the Harbour Office helped to give the “coupe de grace” to the initiative. You can also say that the “sinking” of the Port Plan proposed by the Company Bonifica was also the result of lack of political foresight (no shortage of opportunities for those who manage the public affairs to avoid or modify the judgments themselves) and more or less obvious contrasts between the port operators.

However it was paradoxical that after about one hundred years the discussion was always on the same topics: that is the realization of the internal or the external port and the orientation of the docks respect to the dominant wind directions. The Administrations were not aware that any decision, in compliance with modern standards for the size of channels and docks, have anyway contributed to a strong revival of the port.

The two options on the type of port were both valid. Furthermore any loss of operational time due to a suboptimal orientation of the docks, would not have affected appreciably on the functioning of the structure as a whole, as demonstrated by the acceptable operational time of the Tuscany Dock.

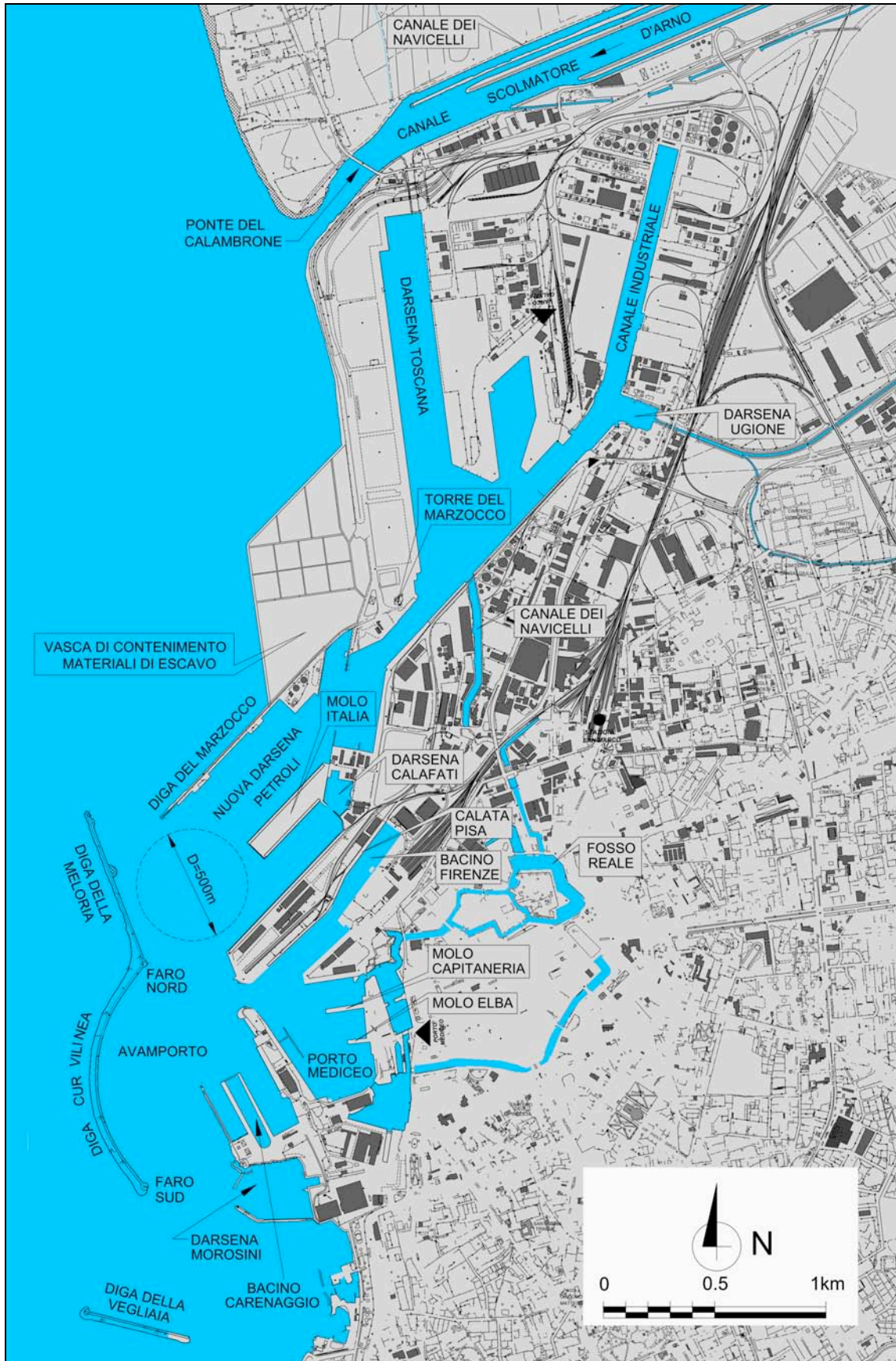


Figure 15. Present state of the Port of Livorno (2010).

In 1994, shortly after the rejection of the “Bonifica Port Plan”, it was enacted in Italy a new law on ports. This law was sought by some politicians who were finally convinced of the damage caused by many aspects of port legislation then in force, dating back to 1885. The new law also set up the Port Authority in the most important Italian ports. The Port Authority is a body composed of various public and private stakeholders, which, among other things, is responsible for preparing the new Port Plan in agreement with the municipality, or municipalities, where the port is located.

The Livorno Port Authority were still struggling with the outdated Port Plan and urgent problems to solve. Even after the enactment of new law on ports, the Port Authority made use for several years of the Italian technical-administrative tool named “adeguamento tecnico-funzionale” (“technical and functional adjustment”) in order to carry out some works. This tool was conceived by the Consiglio Superiore dei Lavori Pubblici (Italian Superior Council of Public Works) in order to simplify the implementation of works that show slight differences with the in force Port Plan. In this way some works were realized in the Port of Livorno, including: the Molo Italia; the Molo Capitaneria; the extension of the Molo Elba. This works were included in the 1953 Port Plan (see Fig. 15).

Furthermore presented an important project, not included in the in force Port Plan, for the realization of a “fill storage” (vasca di colmata), in the west side of the Darsena Toscana. It was devoted to contain the dredging material coming from some excavations to be carry out in the port. The intention of the Port Authority was to use in the future the “fill storage”, once filled, as embankment to enlarge the port in the sea and towards north. The Port Authority in fact had not given up to realize the so-called Darsena Europa envisaged by the plan developed by the Bonifica Company and which in the following the Authority proposed to call Piattaforma Europa (Europe Platform, it was also proposed the name Sun Dock).

Unfortunately, due to numerous and increasingly stringent restrictions imposed in Italy to re-use of dredged material coming from port excavations, the “reclamation tank” had to be completely waterproofed. This has prevented the natural consolidation of the dredged material. In the future it will be necessary to ensure the crowding of this material by suitable devices, such as drains, mixing with cement or similar.

In 2006 the Port Authority, died out the possibility of circumventing the regulations in force, issued a call for the award of the project for the new Port Plan. The call was awarded to a consortium of engineering companies, coordinated by Prof. Eng. Alberto Noli and formed by Modimar (group leader), Technital, Acquatecno and Sciro.

Despite the efforts to complete the work, it has often been interrupted in order to seek a prior agreement between the various institutions concerned, primarily the Region, the Province and the Municipality.

Even today, the new Port Plan in its final version has not been examined by the Ministries of Infrastructure and Environment, although all suggest that the “worst” is over as there is at least an agreement with the institutions above mentioned. The following chapter discusses the results of the obtained compromise.

#### **4. The 2010 Port Plan**

Prior to the drafting of the new Port Plan, the design team performed a series of preparatory studies, aimed at identifying: the updated oceanographic parameters; the main defects of the existing port; forecasts of future traffic and possible fields to expand the port.

The studies has clearly shown that the most interesting applications of port operators, both those already in port and those who have expressed their intention to use it in future, concerns the container traffic which is currently blocked at the levels of 1980 for insuperable physics

limits of the Tuscany Dock, and the traffic with ferries, ro-ro and ro-pax, in strong growth but hampered by lack of parking places on the ground, by distance from the port entrance to the berths and by the planimetric dispersion of berths themselves.

For container traffic it is obviously desired the possibility to receive ships of last generation (Post-Panamax up to 10.000÷12.000 TEU capacity) while for ferries, whose maximum sizes in Mediterranean Sea have stabilized in the length of 220 m, in the width of 30 m and in the draught of 7.5 m, the most pressing request concerns, in addition to the availability of appropriate spaces on the ground, the minimization of the transit time in the port, given the importance for these types of ships of savings the time elapsing between the departure from a port to the berthing in another.

Other needs that have been identified during the analysis are:

- the need to move the tanker ships in a position placed the farthest possible from the town;
- the need to prevent the direct entry of the “Navicelli Canal” in the “Tuscany Dock”;
- rationalization of functions and port activities;
- the concentration of cruise ship traffic in the vicinity of the town and its most important historic monuments.

Agreeing with the Company Bonifica on the impossibility of extending the port in the mainland territory of the municipality of Livorno due to the existing numerous constraints, it was considered necessary to plan the extension of the port in the sea, through the implementation of the just mentioned “Europe Platform” and to devote the Platform entirely to the three traffic types mentioned above (containers, ferries and tankers). Moreover, it was decided to rationalize the use of existing quays and embankments.

With reference to the Europe Platform, it have been examined many alternatives that have involved the configuration of the same platform, the configuration of the breakwaters and of the access and navigation channels. In particular it was analyzed in depth the issue of the harbor entrance, by performing a technical and economic comparison between the solution with single entrance with the solution with double entrance. Regarding the solution with single entrance, it was taken into consideration the current entrance which needs to be extended and deepened. Concerning the double entrance solution, the new entrance has been located close to the Europe Platform and for it two alternatives has been studied. They concern the new entrance orientation: the first solution has the entrance oriented along the axis north-east south-west while the second along the axis north-south.

The solution with the double entrance and access channel oriented along the northeast-southwest direction has been selected. The chosen solution is characterized by a remarkable length of offshore breakwaters, which in the case of Livorno, unlike the majority of Italian ports, are located at depths relatively low, with a favorable impact from an economic standpoint. Furthermore, most of the breakwaters are invested tangentially from extreme wave conditions. The volume of material to dig a whole is significant, amounting to approximately 10.000.000 m<sup>3</sup>. This material is largely devoted to the realization of the embankments.

For the configuration of the docks, solutions both with the berths oriented parallel to the Darsena Toscana and with the berths oriented along the direction of the dominant winds (northeast-southwest) has been studied, as it was always done in the past. The chosen configuration, represented in fig. 16, has only one large canal, wide 350 m, on whose sides face two large terminals, respectively 650 m 450 m wide.

The terminal located in the south of the canal is bordered by two opposing quays each long 1100 m. At the terminal head there is a quay which is not used for commercial activities (vessels waiting, vessels out of commission, etc.). This terminal is devoted to the containers

traffic, reserving the north side to the larger vessels (Post-Panamax) and the south side to the smaller (Panamax, generally feeder ships). It is served by a railway branch line for both the quays. On the terminal, which has a surface of 715.000 m<sup>2</sup>, it is possible to handle about 2.000.000 of TEU/year, thus meeting the target proposed by the potential users of the terminal for 2015.

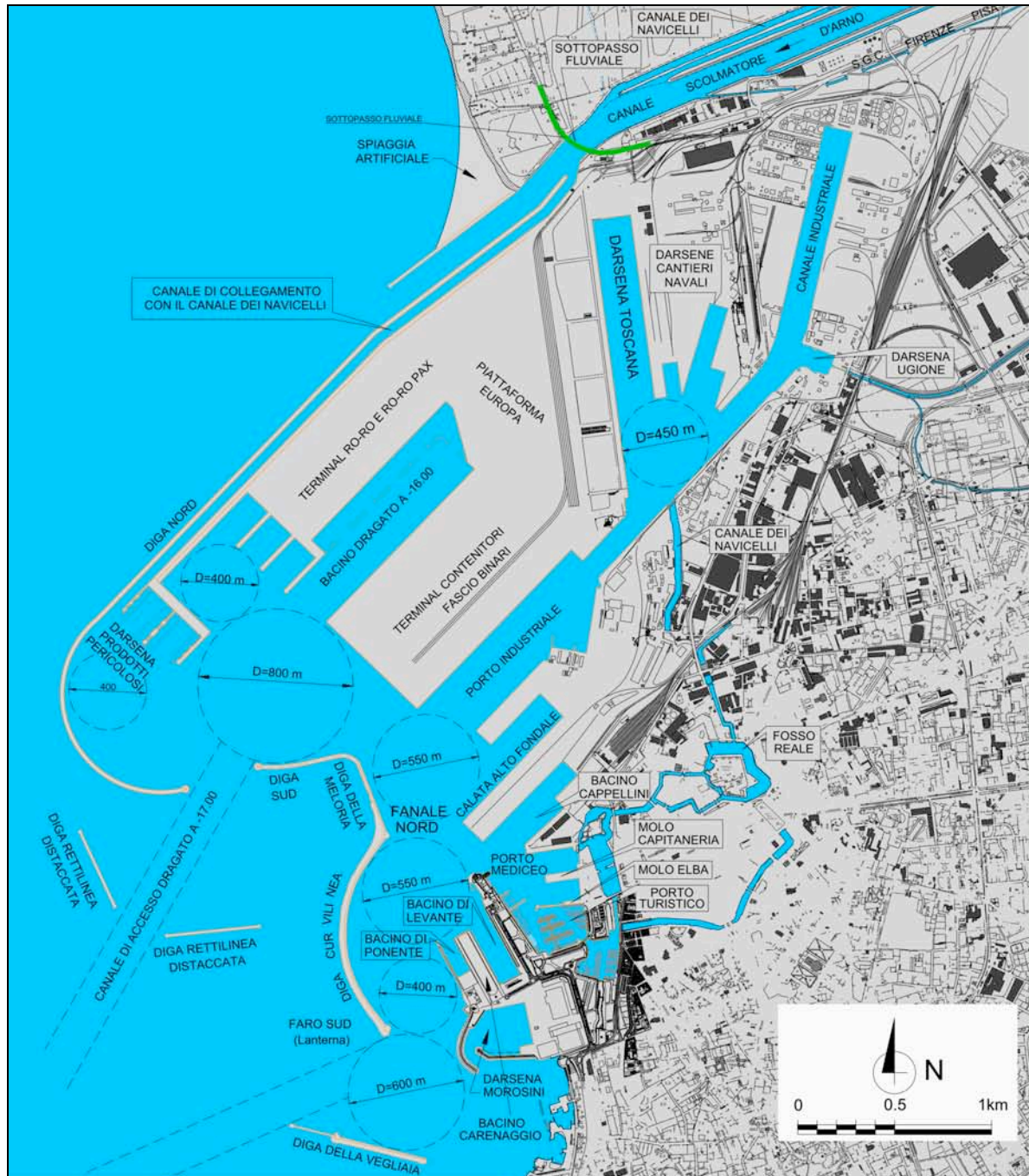


Figure 16. 2010 Port Plan being evaluated for its final approval.

The terminal located in the north of the canal is devoted to the ro-ro and ro-pax ships. It will be possible to moor the ships both along the quay located in the southeast of the terminal and to the three jetties located on the southwest side of the terminal. The moorings, which totally are

ten, besides being located very close to the harbor entrance, have very large squares, as Port Authority has been requested by all the ship owners concerned to develop the so-called "Motorways of the Sea" ("Autostrade del Mare"). The terminal is connected, by means of a road 650 m long and parallel to the new north breakwater which has a quay along the side facing the port, to an orthogonal pier not very wide, where three jetties for the moorings of tankers and gas tankers are located. Thus the oil traffic is located in an independent dock ("Darsena Prodotti Pericolosi") and far (more than 2 km) from downtown, with obvious advantages for safety and with the possibility to limit any accidental spillage, without affecting the remaining parts of the port.

One of the most important aspect of the new Port Plan is to have convinced the Authorities about the need to freely release in the sea the water coming from of the Arno Spillway Canal (Canale Scolmatore d'Arno). The canal mouth, named foce del Calambrone, has been armed in the south side with the new north breakwater of the port and in the north side with a groin about parallel to the same breakwater. The north groin reaches a depth sufficient to avoid, or at least to retard, the formation of the sand bar which gave in the past a lot of problems. The Plan includes a navigable canal which connects the Canale dei Navicelli with the Port of Livorno. This canal, which run parallel to the north breakwater, has always been requested by the users of the canal, including the NATO base of Camp Darby located in the Tombolo pine forest on the edge of the Canale dei Navicelli. The new navigable canal starts close to the Spillway Canal mouth and has a path between the new North Breakwater and the north side of the ferries terminal.

The adopted solution solves at the same time the hydraulic problems of the Arno Spillway, the sedimentation problems of the Darsena Toscana and the access problems to the Piattaforma Europa. It also allows the passage of pipes for transporting petroleum products in a location well separated from other parts of the port. Please note that today the links with the Tuscany Dock, for vehicles, rail and pipes are made by using four bridges passing over the Navicelli Canal !

During the study of the new mouth of the river Calambrone, it has examined the problem of the fixed bridge linking the town of Tirrenia and the south side of the Spillway Canal. It is desirable that this connection will be through an underpass of the canal, the depth of the underpass must be determined but it is subject to the future use of the same canal. In this regard it should be stressed that, in order to facilitate the distribution of traffics in different modes of transport, the Tuscany Region want to restore the waterway, already existing in the past, between Livorno and Pontedera, town located along the left bank of the Arno and situated about 20 km as the crow flies from Pisa. The Port Authority also support this waterway that runs through an area with many industries, making possible their waterway connection with the port. Specifically it is desirable to realize the connection with the existing interport, managed by the Port Authority and located about 8 km away, in the area named Gabicce, just along the Spillway Canal. Probably the use of the Spillway Canal only as waterway is restrictive. Indeed, the mere examination of the geographical configuration of the canal and of the surrounding area, clearly shows that it is possible to develop an inland port with the access from the mouth of the Calambrone, provided that a sufficient depth of the canal is guarantee. Obviously, such an expansion of the port should be implemented only once that the expansion planned in the sea by the Port Plan 2010, will become insufficient. This possible internal expansion of the port conflicts with the fact that the involved areas fall near an area subject to special attention by several environmental organizations.

You can also say, as was done by earlier drafters of the Livorno Port Plan, that the implementation of the "outer port" doesn't prejudice to the possibility of developing in the future an "internal port". In this perspective, although distant in time, it is important to

deepen considerably the road underpass of the canal in order to reach with the top of the cover slab a height of -18,0÷-20,0 m under the mean sea level.

Turning to consider the proposed organization for the present port, in the Port Plan 2010 it was done a reorganization of the various functions, by using the quays and embankments that become available and eliminating or changing properly some of the existing structures.

In particular it was considered necessary:

- to expand the turning basin near the entrance to the Tuscany Dock by retreating the corner between “Calata Tripoli” and “Calata Assab”;
- to eliminate the extreme stretch of the Darsena Toscana on the Calabrone side, which has a width smaller respect to the current one;
- to widen the Canale Industriale bringing the total width at 150 m;
- to remove the oil terminal (Darsena Petroli) from the Diga del Marzocco, providing it with a straight quay that delimit the new terminal container of the Piattaforma Europa, already described in the ambit of the same Platform;
- to remove the Darsena Calafati;
- to shorten the “Calata Pisa” and the “Calata Orlando” and to fill the extreme side of the Bacino Firenze in order to obtain: a larger entrance to the Bacino Mediceo (this work was proposed in vain in all previous port plans); a quay with a length sufficient to be used by big ships and located facing to the most ancient and monumental area of the harbor;
- to widen up to 30,0 m the Molo Capitaneria;
- to move the shipyards, in particular the fixed and floating dry-docs, in a new dock obtained by modification of the Darsena Inghirami.

In the matter of the areas utilization, the following general guidelines have been provided.

The industrial canal, suitably widened and deepened, will be able to play better the current functions.

The Darsena Toscana will be devoted to the general cargo traffic, to the traffic of specialized goods (e.g. cellulose and timber), to the traffic of cars which has assumed great importance for the Livorno Port. Part of the quays may be dedicated to bulk traffic.

An area of sufficient surface close to new dry-docks has been devoted to shipyards.

All the southern part of the harbor, located near the historic urban core, has been devoted to yachting. For the existing dry dock, no longer used and which is now located in a position incompatible with the intended use of the surrounding area, it is necessary to study in the future a new destination compatible with yachting.

The Porto Mediceo is partly devoted to yachting, partly to the small ferries used for connection to the islands of the Tuscan Archipelago, partly to the last generation ferries and partly to cruise ships. The cruise ships will be able to moor also to the “Calata Alti Fondali”, in the stretch not connected with the Molo Italia.

In the area located in the south of the Darsena Morosini Dock, which falls out of the ambit of the Port Authority, the Municipality has planned a new marina able to accommodate about 1.000 yachts in order to satisfy the demand coming from the same town, from the surrounding areas and also from very far places. The new marina will not interfere with the navigational requirements of the large vessels. The Municipality is actively searching for a further area where to place another port facility outside the commercial port in order to satisfy fans of yachting.

The road and rail links with the proper “commercial port”, will be all made by using the existing access branches, which have a path peripheral respect to the town. It is planned to



significantly reduce the areas devoted to fan of sidings that currently occupy vast areas within the port, practically not used and that could be used for other purposes. For the transfer of goods on trains, it will be used modern methods which avoid the tracks on the quays and favor the use of fan of sidings with a number of tracks not bigger than three-five, served by special bridge cranes.

The access to the "tourist area" and to the "Medicean Port" ("Porto Mediceo") will continue to evolve in the city, although mostly along the roads bordering with the outer edge of the ancient city walls. For the rail access it will be sufficient to keep two tracks and a small station.

## 5. Conclusions

The criteria used for the preparation of the new Livorno Port Plan have been exposed. The Port of Livorno has the characteristics to be one of the most important in Italy, being favored by its geographical position and by good existing road and rail links. It may be noted that the Port is, respect to Genoa, closer to Brenner and thus to much of the central and southern Europe. Furthermore, the development of the port involves areas far from the town and close to a wide plain.

The description is very dwells on the historical aspects of the birth and development of the port, because it seemed interesting, for those not versed in Italian affairs, to illustrate the contrast, sometimes inextricable, which exists in our nation between desire for renewal and modernization and to jealous maintenance of heritage of the past, often bordering with the preconceived ostracism towards any innovation.

Only in this way you can justify the improper delay (in the case of Livorno, the new Port Plan is expected from over 40 years!) with which certain facilities, necessary for an harmonious development of the nation, are realized.

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