

# 9 DEFENSIVE ARCHITECTURE OF THE MEDITERRANEAN

Anna MAROTTA, Roberta SPALLONE (Eds.)





PROCEEDINGS of the International Conference on Modern Age Fortification of the Mediterranean Coast  
FORTMED 2018

DEFENSIVE ARCHITECTURE OF THE MEDITERRANEAN  
Vol. IX

Editors  
Anna Marotta, Roberta Spallone  
Politecnico di Torino. Italy

POLITECNICO DI TORINO

Series *Defensive Architectures of the Mediterranean*

General editor  
Pablo Rodríguez-Navarro

The papers published in this volume have been peer-reviewed by the Scientific Committee of FORTMED2018\_Torino

© editors  
Anna Marotta, Roberta Spallone

© papers: the authors

© 2018 edition: Politecnico di Torino

ISBN: 978-88-85745-12-4



FORTMED - Modern Age Fortification of the Mediterranean Coast, Torino, 18th, 19th, 20th October 2018

## Organization and Committees

### Organizing Committee

Anna Marotta. (Chair). Politecnico di Torino. Italy  
Roberta Spallone. (Chair). Politecnico di Torino. Italy  
Marco Vitali. (Program Co-Chair and Secretary). Politecnico di Torino. Italy  
Michele Calvano. (Member). Politecnico di Torino. Italy  
Massimiliano Lo Turco. (Member). Politecnico di Torino. Italy  
Rossana Netti. (Member). Politecnico di Torino. Italy  
Martino Pavignano. (Member). Politecnico di Torino. Italy

### Scientific Committee

Alessandro Camiz. Girne American University. Cyprus  
Alicia Cámara Muñoz. UNED. Spain  
Andrea Pirinu. Università di Cagliari. Italy  
Andreas Georgopoulos. Nat. Tec. University of Athens. Greece  
Andrés Martínez Medina. Universidad de Alicante. Spain  
Angel Benigno González. Universidad de Alicante. Spain  
Anna Guarducci. Università di Siena. Italy  
Anna Marotta. Politecnico di Torino. Italy  
Annalisa Dameri. Politecnico di Torino. Italy  
Antonio Almagro Gorbea. CSIC. Spain  
Arturo Zaragoza Catalán. Generalitat Valenciana. Castellón. Spain  
Boutheina Bouzid. Ecole Nationale d'Architecture. Tunisia  
Concepción López González. UPV. Spain  
Faissal Cherradi. Ministerio de Cultura del Reino de Marruecos. Morocco  
Fernando Cobos Guerra. Arquitecto. Spain  
Francisco Juan Vidal. Universitat Politècnica de València, Spain  
Gabriele Guidi. Politecnico di Milano. Italy  
Giorgio Verdiani. Università degli Studi di Firenze. Italy  
Gjergji Islami. Universiteti Politeknik i Tiranës. Albania  
João Campos, Centro de Estudos de Arquitectura Militar de Almeida. Portugal  
John Harris. Fortress Study Group. United Kingdom  
Marco Bevilacqua. Università di Pisa. Italy  
Marco Vitali. Politecnico di Torino. Italy  
Nicolas Faucherre. Aix-Marseille Université – CNRS. France  
Ornella Zerlenga. Università degli Studi della Campania 'Luigi Vanvitelli'. Italy  
Pablo Rodríguez-Navarro. Universitat Politècnica de València. Spain  
Per Cornell. University of Gothenburg. Sweden  
Philippe Bragard. Université catholique de Louvain. Belgium  
Rand Eppich. Universidad Politècnica de Madrid. Spain  
Roberta Spallone. Politecnico di Torino. Italy  
Sandro Parrinello. Università di Pavia. Italy  
Stefano Bertocci. Università degli Studi di Firenze. Italy  
Stefano Columbu, Università di Cagliari. Italy  
Teresa Gil Piqueras. Universitat Politècnica de València. Spain  
Víctor Echarri Iribarren. Universitat d'Alacant. Spain

**Note**

The Conference was made in the frame of the R & D project entitled "SURVEILLANCE AND DEFENSE TOWERS OF THE VALENCIAN COAST. Metadata generation and 3D models for interpretation and effective enhancement" reference HAR2013-41859-P, whose principal investigator is Pablo Rodríguez-Navarro. The project is funded by National Program for Fostering Excellence in Scientific and Technical Research, national Sub-Program for Knowledge Generation, Ministry of Economy and Competitiveness (Government of Spain).

## Organized by



**POLITECNICO  
DI TORINO**

Dipartimento di  
Architettura e Design

## Partnerships



UNIVERSITAT  
POLITÈCNICA  
DE VALÈNCIA



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE



Universitat d'Alacant  
Universidad de Alicante

## Patronages



CITTA' DI TORINO



unione  
italiana  
disegno



FONDAZIONE  
DELL'ORDINE DEGLI  
INGEGNERI  
DELLA PROVINCIA DI  
TORINO





## Table of contents

<b>Preface</b> .....	XV
<b>Contributions</b>	
DIGITAL HERITAGE	
<i>Quivi surgeva nel lido estremo un sasso: la torre dell'Arma</i> .....	925
<i>M. Abbo, F. L. Buccafurri</i>	
Il Castello di Gorizia, analisi geometrica e rilievo con tecnologie avanzate.....	933
<i>G. Amoroso, P. Cochelli, V. Riavis</i>	
“Turris ad nocturnum navigantibus lumen”.....	941
<i>M. Arena, F. Fatta</i>	
Dalla dismissione alla valorizzazione: progetti e interventi per il Forte di Exilles (To) negli anni 1978-2018.....	949
<i>C. Bartolozzi, F. Novelli</i>	
Rilievo digitale dell'area archeologica costiera della Rocca di San Silvestro.....	957
<i>S. Bertocci, A. Lumini</i>	
New tools for the valorization and dissemination of the results of TOVIVA project.....	965
<i>S. Bertocci, P. Rodriguez-Navarro, M. Bercigli</i>	
Sperimentazioni cinquecentesche dei Sangallo verso le fortificazioni toscane. Il caso del Forte Sangallo a Nettuno.....	973
<i>D. Calisi, M. G. Cianci</i>	
Dalla nuvola di punti al progetto di restauro. L'estrazione di dati per la valorizzazione dell'antica fortificazione di Casertavecchia.....	981
<i>V. Cera, L. A. Garcia</i>	
Da castello a castello, il problema della difesa della costa ionica: i casi delle fortificazioni di Catania e Aci Castello.....	989
<i>G. Di Gregorio</i>	
Las torres vigías artilladas de Felipe II en la Región del Murcia. Representación tridimensional virtual de la Torre Navidad.....	997
<i>J. García León, P. E. Collado Espejo, M. Ramos Martínez, L. Cipriani, F. Fantini</i>	

Rappresentando il Forte di Gavi: ieri, oggi, domani.....	1005
<i>A. Marotta, V. Cirillo, O. Zerlenga</i>	
Rappresentazione sincronica e ricostruzioni diacroniche della Rocca di Senigallia. Un approccio di conoscenza integrato.....	1013
<i>A. Meschini, E. Petrucci</i>	
I sotterranei dei castelli di Otranto e di Gallipoli: dal rilievo laser scanner 3D all'analisi Strutturale.....	1021
<i>G. Muscatello, A. Quarta, C. Mitello</i>	
Rilievo tridimensionale del palazzo fortificato di Entella.....	1029
<i>R. Netti</i>	
Torri costiere nella Sicilia sud-orientale: il rilievo per la conoscenza e la messa in valore delle emergenze architettoniche.....	1037
<i>G. Nicastro</i>	
Sistemi fortificati dell'Adriatico centrale: indagini storiche, rappresentazioni contemporanee e ricostruzioni digitali.....	1045
<i>C. Palestini, A. Basso</i>	
Augmented Iconography. AR applications to the fortified Turin in the <i>Theatrum Sabaudiae</i> .....	1053
<i>V. Palma, M. Lo Turco, R. Spallone, M. Vitali</i>	
Il rilievo della torre degli Appiani a Marciana Marina.....	1061
<i>G. Pancani</i>	
Nuvole di punti per l'accessibilità universale del patrimonio storico: il caso studio del castello di Francolise.....	1067
<i>L. M. Papa, S. D'Auria</i>	
La Documentazione delle mura di Verona Rilievo, analisi e schedatura delle fortificazioni veronesi.....	1075
<i>S. Parrinello, P. Becherini</i>	
Sul limitare del Mediterraneo: Antonelli e la fortificazione di Gibilterra.....	1083
<i>S. Parrinello, F. Picchio, R. De Marco, A. Dell'Amico</i>	
Rappresentare l'architettura militare. Il bastione di Santa Croce a Cagliari in epoca sabauda.....	1091
<i>A. Pirinu, N. Contini, M. Utzeri</i>	
Il castello di Popolonia: dal rilievo alla documentazione visuale.....	1097
<i>P. Puma, A. Guidi</i>	
Método para el levantamiento del patrimonio construido mediante técnicas digitales: Puerta de la Colada de la muralla de Ciudad Rodrigo (Salamanca).....	1101
<i>A. Sánchez Corrochano, A. Greco, D. Besana, E. Martínez Sierra</i>	

Un navigatore per monumenti: proposta di applicazione software per valorizzare i monumenti culturalmente e storicamente con soluzioni informatiche, GIS e GPS.....1109  
*L. Serra*

Partimonio costruito e BIM: il palazzo di Francesco de' Medici nella Fortezza Vecchia di Livorno fa un secondo passo nell'epoca digitale.....1117  
*G. Verdiani, V. Donato, L. Pianigiani, F. Marsugli*

Cannons, galleries, ruins and Digital Survey: a first report about the “Molo Cosimo” after seventy years of abandon.....1125  
*G. Verdiani, A. Frasconi*

#### CULTURE AND MANAGEMENT

Il castello normanno di Ginosa (TA). Progetto di salvaguardia e valorizzazione di una memoria.....1133  
*A. Albanese, F. Allegretti, C. Castellana, A. Colamonico, F. Fiorio, M. Marasciulo*

The fortification system on the Elba Island: analysis of the strategic evolution and the military technologies.....1141  
*G. Baldi, A. Mancuso, A. Pasquali, M. Pucci*

Un percorso virtuale nel Forte di Fenestrelle tra memoria e attualità.....1149  
*O. Bucolo, D. Miron, R. Netti*

La fruizione multimediale del Castello di Lecce.....1157  
*G. Cacudi*

Some aspect of relationships of old and new in moroccan fortification.....1165  
*M. Cherradi*

Tutela, recupero, valorizzazione delle torri costiere come parte integrante di sistemi territoriali complessi. La “nuova vita” della Torre di Cerrano (Abruzzo, Italia).....1171  
*A. Colecchia*

Estudio integral de la Torre Navidad, en Cartagena (España), para su correcta conservación, puesta en valor y musealización.....1179  
*P. E. Collado Espejo, J. García León, J. F. García Vives*

Fortified architecture in Spanish chain Paradores de Turismo. 90 years of heritage management for touristic purposes.....1187  
*P. Cupeiro López*

Difendere la Terra d’Otranto. Le torri di avvistamento della Serie di Nardò.....1195  
*G. Danesi, A. Gagliardi*

Il castello Ursino a Catania: la costa scostata.....1203  
*G. Di Gregorio, F. Condorelli*

Conservation of Martinengo Bastion, Famagusta, Cyprus.....	1209
<i>R. Eppich, M. Pittas, M. Zubiaga de la Cal</i>	
Paesaggi sublimi: un parco ecomuseale per valorizzare il patrimonio paesaggistico militare delle colline del Golfo della Spezia.....	1217
<i>E. Falqui, D. Reitano, L. Marinaro</i>	
Il parco multimediale delle mura di Padova: valorizzazione di paesaggi e percorsi culturali in un'ottica creativa e innovativa.....	1223
<i>A. Ferrighi</i>	
Paesaggi militari della Sardegna tra XVIII e XX secolo. Scenari di riconversione e di riuso integrato.....	1229
<i>D. R. Fiorino, S. M. Grillo, E. Pilia, M. Porcu, M. Vargiu</i>	
Conoscenza e approccio architettonico per la conservazione del Castello di Mirto Crosia in Calabria (Italy).....	1237
<i>C. Gattuso</i>	
Le fortezze della famiglia Ruffo in Calabria (Italia).....	1245
<i>C. Gattuso, P. Gattuso</i>	
Accessibilità integrata per architetture inaccessibili. I castelli della Sardegna (XIV-XV sec.).....	1253
<i>C. Giannattasio, A. Pinna, V. Pintus, M. S. Pirisino</i>	
Lungo le Mura del Cassaro di Palermo. Studi e rilievi architettonici e proposte per il turismo culturale.....	1261
<i>G. Girgenti</i>	
Atlante delle Opere Fortificate: un progetto ambizioso applicato alle opere fortificate alpine della Val Pellice.....	1269
<i>L. Grande, S. Pons</i>	
"Rodi antica, medievale e cavalleresca": exemplary restoration of a Walled City during the Italian Colonialism.....	1277
<i>M. M. Grisoni</i>	
Esclusione – Inclusion. Eptapyrgio, la fortezza di Salonico.....	1285
<i>S. Gron, E. Gkrimpa</i>	
Attraversare paesaggi, collegare il patrimonio: trasformazioni militari in Liguria secondo il pensiero e i progetti di Napoleone.....	1293
<i>L. Marinaro, P. Granara, S. Di Grazia</i>	
Por un plan autonómico para la gestión de los castillos en la Comunidad Valenciana (España).....	1301
<i>J. A. Mira Rico</i>	
La musealización del patio y el almacén del Palau del Castell de Castalla (Alicante, España): nuevas aportaciones para el contexto de la provincia de Alicante.....	1309
<i>J. A. Mira Rico, M. Bevià i Garcia, J. R. Ortega Pérez</i>	

Archeologia della distruzione: i seicenteschi “Castelli del Mare” presso Castelfranco, a Finale Ligure (SV). Individuazione del tracciato e dei resti di una delle più imponenti fortezze del Ponente, contributo per la salvaguardia e la valorizzazione di un sito fragile e dimenticato.....	1317
<i>G. Pertot</i>	
Impronte del passato, forme del futuro: la valorizzazione dei siti fortificati attraverso l’arte Contemporanea.....	1325
<i>S. Pons</i>	
Programme to capitalize the fortified cultural heritage in Europe Research-Tourism-Marketing-Networking.....	1331
<i>D. Röder</i>	
Memoria dell’antico in alcune fortificazioni microasiatiche.....	1335
<i>E. Romeo</i>	
Una verifica nella gestione della conservazione programmata dei castelli recetto della Valtenesi a dieci anni dalle prime azioni: valutazioni, esiti e nuovi indirizzi.....	1341
<i>B. Scala</i>	
Il patrimonio fortificato della Repubblica di Venezia: per un’ipotesi di riformulazione della candidatura UNESCO.....	1349
<i>E. Zanardo</i>	
MISCELLANY	
Fortificación del siglo XX en la orilla norte del estrecho de Gibraltar.....	1357
<i>A. Atanasio-Guisado, A. Martínez-Medina</i>	
Fortificazioni nel Mediterraneo: disegni di ambito spagnolo nella seconda metà del XVI secolo.....	1365
<i>P. Davico</i>	
Geometria e rappresentazione nell’architettura militare e civile a Malta.....	1373
<i>A. Mollicone</i>	
El 'aura' del 'residuo': aproximación estética y fenomenológica en torno a la ruina militar Moderna.....	1379
<i>R. Nicolau Tejedor, A. Martínez-Medina</i>	
L’opera di Punta Rossa, Caprera. Strategie di conoscenza e di progetto per un patrimonio costruito militare e il suo paesaggio.....	1387
<i>S. Pieri</i>	
Protection of a UNESCO transnational site: three different legislations for the "Venetian Works of Defence between the 16th and 17th Centuries: Stato da Terra – Western Stato da Mar”.....	1395
<i>S. Rocco</i>	

## **Cannons, galleries, ruins and Digital Survey: a first report about the “Molo Cosimo” after seventy years of abandon.**

**Giorgio Verdiani<sup>a</sup>, Anna Frascari<sup>b</sup>**

<sup>a</sup>Università degli studi di Firenze - DIDA, Firenze, Italy, giorgio.verdiani@unifi.it, <sup>b</sup>Università degli studi di Firenze - DIDA, Firenze, Italy, annafrascari@hotmail.it

### **Abstract**

Livorno, in Tuscany represent the main harbor in this part of the Mediterranean coast. With the establishment of the Free Port, in 1676, the arrival of merchants was favored and the demand for warehouses, capable of accumulating goods in the port of transit, increased considerably. For this reason, the system of fortifications was strengthened towards the sea and modernized by Cosimo III. Along with the modifications of the fortifications of the city, the project of a fort at the extremity of the “Molo di Cosimo” was also entrusted to the Grand-Ducal Architect Pier Maria Baldi in 1684. General Alessandro Dal Borro chose the design model and supervised the construction of the fort, which began in 1688 at the tip of the “Molo Cosimo”. The complex could control both the interior of the port and the open sea. The main function assigned by the authorities to this fortress was to bomb ships that intended to violate the neutrality declared in 1646, becoming, in fact, a peaceful observatory that, even in moments of tension, did not fire a shot to attack. Thus, it was equipped with an extended system of tunnels to allow the safe movement of people, ammunitions and cannons in case of a battle. This war machine is now in a quite complex state of abandon with a serious loss of architectural identity, mined by fragmented architectures growth all around the fortifications and with the galleries filled with the ruins remained around after the World War II bombings. In 2017-2018 for the first time after 70 years, the Port Authority of Livorno, operated the full removal of the ruins fitted in the galleries, allowing a complete digital survey of an architecture finally brought back to have a chance or revitalization. In this paper it will be presented the products of this research, showing the accurate and unedited representation of this long-lost fortress.

**Keywords:** Cosimo’s Pier, Fortress, Livorno, Digital survey, Harbour.

### **1. Introduction**

In Livorno, the “Forte del Molo” was, for many centuries, the most extreme fortress guarding the port towards the sea.

This complex, however, is not a solitary defensive architecture but is one of the key elements of the articulated and historically stratified defensive system of the free port city, and considering it together with the other elements of this system (“Fortezza Vecchia”, “Fortezza Nuova”, “Torre della Meloria”, “Fanale”, and the water system called the “Fossi”) it is possible to understand the strength of this complex organization. The architecture of the fort has a strong military character and a fundamental importance for the safety of the port,

moreover it is the first area of the city that sees the boats entering the port so it has a strong visual and representative impact to define the image of the city-port structure. The survey here presented has been realized by the will of the Port Authority of Livorno, in collaboration with Area3D Srl, using a 3D laser scanner unit, taking care about the whole system of walls, piers, banks and about the two main buildings, nowadays granted in use to various associations and services of the port. This intervention takes also the survey -it is possible to say “for the first time”- of the spaces of the “Capponiera”, a system of walled tunnels once supporting and hosting gunports and cannons, this part of the fortress from the middle

of the XX century until today was not accessible because filled with the rubble left by the bombing of World War II and now it is made accessible thanks to the great commitment of the Port Authority.

The comparison of this new survey with the historical representations of the area and the documented written sources (mostly from the “Archivio di Stato di Firenze”, “Mediceo del Principato”) will be useful to reconstruct the stratification of the building with the aims of increasing the knowledge of this complex and of using this analysis for the development of an appropriate recovery plan for the area.

### **1.1. The port of Livorno, brief historical overview**

In 1406 the Florentines conquered Pisa and treated with the French until 1413 when they managed to buy it. The “Porto Pisano” was, in this period, impracticable and was placed under the jurisdiction of the port of Livorno on which the investments of the following years were going to be concentrated. In 1421, the Florentines decided to build the Marzocco’s tower and, later, in 1465-95 they built docks to improve the efficiency of the port of Livorno completing the walls and adding new fortifications.

The port of Livorno began to assume commercial importance in the mid-sixteenth century when, with the Medici domination over the area, the city gained importance both at a political and at a military level. The Medici family tried to develop commercial traffic in the city through various public works, legal and economic reforms.

The work on the construction of the “Fortezza Vecchia” began in 1519 on a design by Antonio da Sangallo the Elder and ended in 1534, under Alessandro de’ Medici. Later the *Granduca* Ferdinando I de’ Medici decided to build the current “Darsena Vecchia” (the “Old basin”), the Medici’s interventions on the city had, nevertheless, respected the initial urban project of Bernardo Buontalenti. All the works concerning urban and port development have been carried out towards the sea, filling various areas of the land promenade and consolidating them with piling works.

The Granduca Cosimo II, to strengthen the military stronghold, built the “Molo Cosimo”, a long artificial pier that greatly extended the receptivity of the port. The “Molo Cosimo”, whose bold protruding for 525 meters on the open sea, was a source of admiration for the contemporaries because it was the most distinctive and significant structure of the new great port.

Shortly after, in 1625, the urbanization of some small islands created by the sedimentation of sand along the coast began to be planned in order to realize the project of a new district significantly called Venice. The defense of the Port remained, however, essentially entrusted to the “Fortezza Vecchia”. The fortification system, devoid of any purpose of attack, presented itself as a machine to guarantee the peace and neutrality of the port and the mercantile city.

With the establishment of the Free Port, in 1676, it was favoured the arrival of merchants and the demand for warehouses increased, they must be capable of accumulating goods in the port of transit. For this reason the system of fortifications was strengthened towards the sea and modernized by Cosimo III. The Granduca gave new impetus to the institutions of the Port and to the growth of the city and its defensive system.

The Governor Alessandro Dal Borro<sup>1</sup> supervised the works that were designed by the grand-ducal Architect Pier Maria Baldi<sup>2</sup>. Together with the modifications of the fortifications, the project of a fort on the end of the “Molo Cosimo” was also entrusted in 1684. The construction of the fort, according to the letters at the “Archivio di Stato di Firenze” (Mediceo del Principato), began only in 1688, and had a boost the following year when General Dal Borro gave the orders to concentrate here all workers to finish the fort. The different alternative designs for the fort and the drawings of the realized project, designed by Baldi, are unfortunately not survived to the present day. The first plan representation of this important modifications is represented, for the first time, in the drawings of Benedetto Guerini<sup>3</sup>, a grand-ducal engineer who created, in 1703, an Atlas in which he designed new fortified walls and proposed further extensions towards the sea (Archivio di



Fig. 1- Drawing by Benedetto Guerini, 1703, (Archivio di Stato di Firenze)

Stato di Firenze, Miscellanea Medicea 716). The first plan representation of this important modifications is represented, for the first time, in the drawings of Benedetto Guerini<sup>3</sup>, a grand-ducal engineer who created, in 1703, an Atlas in which he designed new fortified walls and proposed further extensions towards the sea (Archivio di Stato di Firenze, Miscellanea Medicea 716).

In his drawings the "Forte della Punta del Molo" is in the foreground: the end of the pier appears strengthened and enlarged with a large platform separated by the sea from the pier and defended from the storms by the presence of a cliff. On the platform there is a multi-level structure supporting the battery of the cannons.

On the side of the Port there are two trapezoidal buildings incorporating a previous structure, already present in 1675, with a walkway placed on a high wall, in this way it shows a fortified architecture clearly developed to be able in controlling both the port and the open sea.

In 1716 it was necessary to restore the structures, a very severe winter brought a series of damages caused by copious snow and ice, in this occasion Cosimo III decided to increase the "Forte del Molo". The project was entrusted to Giovanni Maria del Fantasia, at the time superintendent of the fortresses and factories of

Livorno. In a letter (Archivio di Stato di Firenze, Mediceo del Principato, dated May 27, 1716) some news are given about the characteristics of the enlargement: the "capponiera" (which housed the shooting positions with muskets) was built at that time while above this structure a platform was set up for heavy artillery. A vaulted cistern was also built to collect water from the roof of a building made to accommodate a good number of soldiers.

In the second half of the eighteenth century the Fort, together with the "Fanale" and the "Fortezza Vecchia", was a visual reference point and a recurring theme in the prints and engravings made by the dock of the "Darsena Vecchia" and by the sea. In many prints it is reproduced with emphasis, enhancing its dimensions to underline the symbolic meaning of this fort.

The structure, completed in 1718, remains intact in the following decades and it is possible to find it well represented in the work of Giuseppe Maria Terreni "Veduta della città e porto di Livorno presa dalla cima del Fanale" dated 1781 (Vaccari, 2002). In this representation it is easy to recognize the windows of the "capponiera" below the platform for the cannons and the canopy supported by pillars that connects the two buildings. It is also represented the building



dedicated to the guardhouse, now named “Palazzina Piloti”, which controlled the small canal, separating the Fort from the pier, equipped with a drawbridge.

## 1.2. The fort between nineteenth and twentieth century

The first known metric drawings of the fort were made by the will and with the commitment of the Napoleonic engineers through surveys made in 1810 by Garin and the cadet Contri and can be consulted at the “Istituto storico e di cultura dell’arma del genio di Roma” (ISCAG) and include the plan of the gallery of the “capponiera”, the plan of the main floor of the complex as well as two sections.



Fig. 2- The “capponiera” with the tower of maritime control service (Anna Frascari, 2018)

A few years later (1825) Mellini designed a perspective section of the Fort (ISCAG Ref. F 1197), it clearly illustrates, in detail, the internal space of the fort which is still substantially unchanged compared to the view of Giuseppe Maria Terreni. Observing these survey, although not always metrically correct, we can detect the important network of galleries that lies beneath the courtyard and that is connected to the “capponiera”. These vaulted galleries constituted the entry point to the “capponiera” thanks to two staircases inside the courtyard which were later demolished and no longer exist.

After the restoration the new plans to modernize the port were reduced due to the economic crisis. In 1853 the Lorraine government launched the project, then partially executed, with the construction of the curved port breakwater to remedy the problem of low draft of the harbour responding to the new requirements due to the use

of larger ships. The “Molo Cosimo” became a dock for the smaller cargo ships, its area was enlarged and became known as “Spianata”.

The “Spianata” was the part of the pier between “Forte di Porta Murata” and the “Forte della Punta del Molo” and, after the abolition of the free port decreed by the Regno d’Italia, was sold by the State Property to the Municipality of Livorno that could rent it for storage and various activities. With the end of military use this area of the pier underwent a transformation that made it more easily accessible than before, due to its military functions, access was prevented by barriers and gates.

During the period of the Second World War, for its industrial and harbor facilities, the city of Livorno, and -in particular- the port, were heavily bombed by French, British and American planes and then systematically destroyed by the German army during their retreat. In fact, the Germans blew up the docks using mines, while 130 ships were sunk to block the entrances to the port. They also furiously attacked the city for a week with artillery destroying many facilities and reducing the city in worse conditions.

In 1944 the Allies found the port facilities so much damaged that they declared the port as unusable. After the liberation of the city and the demining operations, the US Army occupied the port and only reconstructed strictly necessary piers and binaries for military operations while they held most of handling operations of goods by trucks and mobile cranes.

The restoration took place more slowly than for other Italian ports for the prolonged US occupation returned gradually the various areas of the port (southern area in March '46, September '46 a part of the industrial port and the last areas in '47).

The civil engineering in Livorno concentrated the interventions only on some priorities: the reconstruction of the quays in the deep seabed areas of the old port and the repair of existing structures, improving them from a functional point of view.

The fort was the subject of a restoration completed in 1968 and curated by the Tuscan architect

Pierluigi Spadolini who was also a well-known yacht designer and a founding member of the Yacht Club Livorno (Vaccari, 2002) which has its headquarters, still today, inside the fort.

Nowadays, the fort is not well recognizable in its constructive unity, this also because of some important interventions such as the construction of the tower of maritime control service.



Fig. 3- The internal court of the fort viewed from the “Palazzina Piloti” (Anna Frascari, 2018)

## 2. The digital survey campaign

A general 3D laser scanner survey was made for the entire area and the whole space inside the fort was completely covered in order to acquire all the possible information about the geometry of the site. In fact, for such complex series of structures, the use of 3D laser scanning technology is a very efficient solution, while, at the same time, it allows to create complete and rich dataset, with a clear documentation of the material and an accurate rendition of all the geometrical aspects, a useful base for answering the questions about the architectonic story of this pier.

The survey was planned through two fundamental tools: the historical research (both of existing iconography and of the previous surveys) and the inspections of the site. Historical research has been useful to clarify the areas where it was necessary to deepen the survey in order to study better the historical buildings while the inspections have given the opportunity to notice all the peculiar problems of the surveyed area. The area is characterized by a particular conformation; it is located at the end of the pier so it is surrounded by water, a reflecting element that can create problems in the quality of the scans, with the generation of unwanted artefacts and noise, influencing the

alignment of the final dataset. The shape of the area also creates a potential imbalance of the scans since all the scan stations taken along the piers may have almost a half of the 360° scanning field of view not usable for alignments or further representations. To facilitate the survey operations, the surrounding vegetation, which come very close to the structure, have been removed or pruned to minimize the problems that can creates in the scans (occlusion spaces, presence of “ghosts” and problems in automatic registration). Before carrying out the survey it has been necessary to program the movement of the boats positioned on the seaside pier and placed very close to the wall of the “cajoniera” which would have created large occlusions in the scanning of this front.

The survey operations were carried out by a team of Area3D s.r.l. Livorno in collaboration with the Dipartimento di Architettura, they were held on different days depending on the availability of space. The laser scanner in use for the survey was a Cam/2 Faro Focus<sup>3D</sup> X330 with a maximum working distance of 330 meters and an accuracy up to 2 millimeters at 10 meters of distance standard reflective materials.

To enhance the quality and speed of the following alignment process, a system of targets was placed temporarily around each scanning station, both planar and spherical targets were used according to the articulation of the spaces.

## 3. Processing and results

The resulting 420 scans, in original FLS format, were initially checked and filtered using the Cam/2 Faro Scene software and then registered with Autodesk Recap 360 Pro. This software offers the possibility to automatically register the scans but this was operated only for some parts (interiors, open spaces with architectural elements) because the software is not able to register all the scan independently. During the registration process, the model has been continuously verified, checking for possible misalignments and inaccuracies caused by the presence of altered data (reflections, noisy area, ghost elements) influencing the quality of the result. The final aligned 3D point cloud was checked visually, using the “box” command to limit the view area and controlling any possible

trouble, in this way it was possible approve the registration as a fully reliable final model. Once the alignment operations have been completed, an optimized version of the total point cloud has been produced, exported in Autodesk Recap format for the subsequent operations. One of the key points of the documentation operations of the fort is, in fact, the realization of classical two-dimensional documents (plans, elevations and sections) useful for facilitate the later phases of maintenance of the complex.

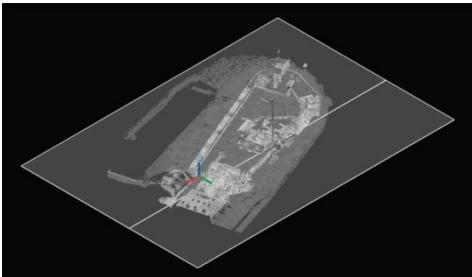


Fig. 4- AutoCAD 2018 screenshot with a section plane (Anna Frascari, 2018)

Through the tools of visualization for the pointclouds integrated into Autodesk AutoCAD 2018, which allows to move the section planes and change the display settings of the point cloud, it is possible to draw in more comprehensive and integrated way the elaborates. This software also allows to view the pointclouds in intensity or false colors (hue) or grayscale (grayscale) and to use a plane shaders to display different color planes along the axes or a vector.

To facilitate all the drawing operations of complex details and articulated signs, it has been used a Wacom Cintiq graphic tablet (model 13HD) that allowing the direct drawing on the display through graphic pen with extremely accurate control, has positively speed up and enhanced the quality of the final set of drawings.

#### 4. Conclusions

The first digital survey of this fortress, operated in the occasion of the removal of the rubble filling the "capponiera" allowed to produce an operative base, made of 3D models and technical drawings,

connecting all the parts of this architecture, giving a start to its possible future. Site inspection, survey, and documentation of the current state of this particular built heritage, are the first stage of a research project on "Forte della Punta del Molo" that will include a comparison between its current state, the historical drawing sources and the previous available surveys. This comparison may help in finding elements that no longer exist, and whose existence could not be imagined by those who walk along the pier today.



Fig. 5- Autodesk Recap 2018 screenshot of the general pointcloud (Anna Frascari, 2018)

A complex process of cultural dissemination can create an appropriate base for new studies and research to enhance the knowledge and understanding of this element of the complex system of the fortifications of the "Porto Mediceo" a precious patrimony often under evaluated and treated in inappropriate ways. The aim of this work, still in its initial phase, will be a comprehensive understanding of this complex, a process that may confer at the "Forte della Punta del Molo" the importance it deserves, contributing to a possible future restoration project aimed to change the use of this place and making it an active component of the cultural tourist route. An intervention possibly recovering the suggestive space of the "capponiera" into a public space, accessible and capable to communicate the sense of this structure, giving it back the long-lost unity and making it clearly a part of the large and fortified system of the Livorno Port. An important challenge in the try of balancing historical value and new needs of the port.

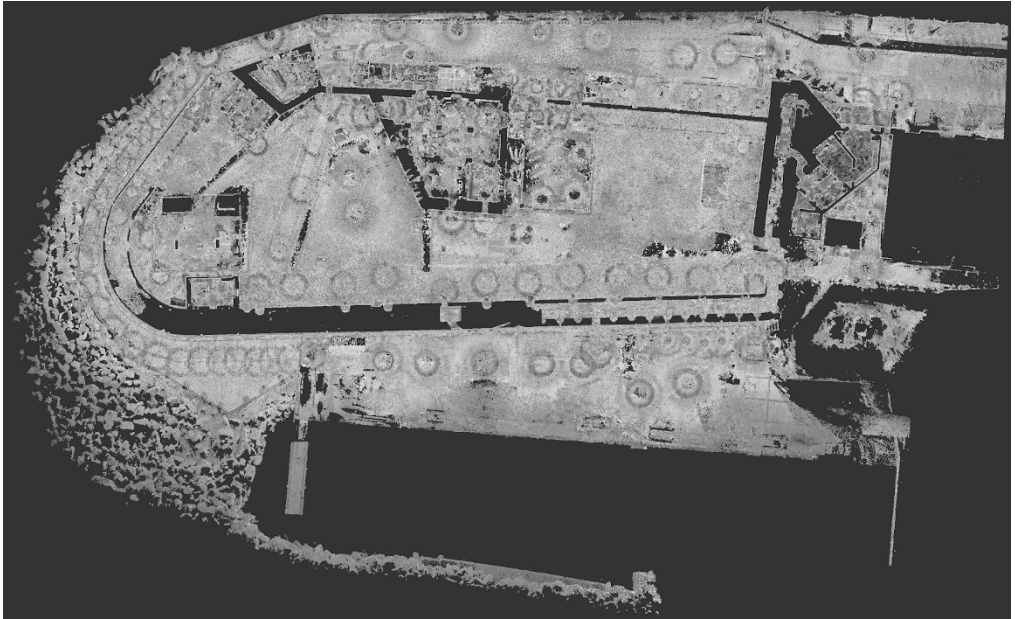


Fig. 6- Plan of the principal level of the fort (Anna Francari, 2018)

### Acknowledgments

The survey operations for the Autorità Portuale Livorno were conducted by Area3D s.r.l. Livorno in collaboration with the Dipartimento di Architettura, Università degli Studi di Firenze. Responsible for operations for the Port Authority: Maria Grazia Lodde – Coordination for Area3D: Massimo Gualandi and Alessandro Peruzzi. Scientific Coordinator for the Dipartimento di Architettura: Giorgio Verdiani. Photogrammetric surveys: Sistema DiDALabs, Dipartimento di Architettura, Laboratorio Fotografico Architettura, Paolo Formaglini, Filippo Giansanti. Digital survey operating group: Alessandro Peruzzi, Massimo Gualandi, Giorgio Verdiani, Anna Francari, Data treatment: Alessandro Peruzzi and

Anna Francari, Post processing and graphic processing: Anna Francari.

### Notes

1. Governor of Livorno from 1678 to 1701. Under his administration there was the expansion of the Livorno district of "Venezia Nuova".
2. In the years 1668-1669 Baldi entered into the service of Cosimo de' Medici (Cosimo III). He remained at his service for a long time; we find him as "supervisor" of the grand-ducal factories in Pisa and Livorno.
3. Grand-ducal engineer, in a report for Cosimo III sent in 1703, he had annexed a series of tables in which he presented various projects to strengthen and enlarge the city's defense system.

### References

- Guarducci, A., Piccardi M. & Rombai L. (2012) *Atlante della Toscana tirrenica. Cartografia, Storia, Paesaggi, Architetture*. Livorno, Debate Editore.
- Guarducci A., Piccardi M. & Rombai L. (2014) *Torri e fortezze della Toscana tirrenica. Storia e beni culturali*. Livorno, Debate Editore.
- Martigli, W. (1980) L'Arcano del mare di Robert Dudley. In: AA. VV. *Livorno. Progetto e storia di una città tra il 1500 e il 1600*. Pisa, Pacini, pp. 191-197.
- Papi, M. L. & Vernassa, M. (2015) (eds.) *L'ammiraglio Napoleone: Atti della Giornata internazionale di studi, Auditorium della Camera di commercio, 20 marzo 2015, Livorno*. Firenze, Edizioni Polistampa.

- Principe, I., (1988) *Fortificazioni e città nella Toscana lorenese*. Vibo Valentia, Edizioni Monograf.
- Piancastelli Politi-Nencini, G. (ed.) (1995) *La Fortezza Vecchia difesa e simbolo di Livorno*. Livorno, Cassa di Risparmio di Livorno.
- Rodríguez-Navarro, P. (ed.) (2015) *Defensive Architecture of the Mediterranean XV to XVIII Centuries. Voll. 1-2: Proceedings of FORTMED – Modern Age Fortification of the Western Mediterranean Coast, 15-17 October 2015, València*. València, Editorial Universitat Politècnica de València.
- Vaccari, O. (2002) *Il Molo Mediceo e il suo Forte, Immagini e storie del porto di Livorno*. Livorno, Debatte Editore.
- Rodríguez-Navarro P. ed. 2015. *Defensive Architecture of the Mediterranean XV to XVIII centuries, volume 1*. Valencia: UPV Press.
- Verdiani, G. (ed.) (2016) *Defensive Architecture of the Mediterranean XV to XVIII Centuries. Voll. 3-4: Proceedings of FORTMED – Modern Age Fortification of the Mediterranean Coast, 10-12 November 2016, Firenze*. Firenze, Didapress.
- Verdiani, G. (2017) Fortifications and documentation: the case of Fortezza Vecchia in Livorno. State of the digital survey 2017. In: Gonzáles Avilés, A. (ed.) *Defensive Architecture of the Mediterranean XV to XVIII Centuries. Vol. 6: Proceedings of FORTMED – Modern Age Fortification of the Mediterranean Coast, 26-28 October, Alicante*. Alicante, Universitat d'Alacant, pp. 311-318.