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Innovative strategies for the management of the historical defence heritage: the italian project IMASS-CHAIN

Elisa Pilia[1][0000-0002-9072-3418] and Donatella Rita Fiorino[2][0000-0003-4481-9897]

[1] University of Cagliari, DICAAR, Cagliari, Italy
[2] University of Cagliari, DICAAR, Cagliari, Italy
elisa.pilia@unica.it
donatella.fiorino@unica.it

Abstract. Nowadays, historical defence heritage is a complex and dynamic built reality, characterised by a significant cultural value, a wide typological heterogeneity, as well as a high degree of technical specialization, high security standards, with both a centralized and distributed management. Thus, this heritage requires a challenging administration in consideration of its complexity and significance. This especially concerns: the interventions of maintenance and restoration, but also the activities required for the adaptation to new military strategies; the need to contain public and effective expenses, and the reduction of environmental impact of the buildings required by the Agenda ONU 2030; the necessity to organise the heritage information system in a certifiable, transparent, and correlated system. Furthermore, the fragmented knowledge – about technical, administrative, planning and management data - negatively affects the efficiency of interventions in terms of time and costs. All these issues have been addressed with the interdisciplinary research project entitled IMASS-CHAIN (Infrastructure Management Support System Chain) carried out by the University of Cagliari in partnership with the companies Leonardo S.p.A. and Flosslab S.r.l., and co-financed by the Italian Ministry of Defence, with the resources of the National Military Research Plan 2020. Starting from the study of the existing heterogeneous patrimony, this project aims to create an innovative 'certified' and 'protected' protocol of 'intelligent' management and governance for defence structures, arriving at functional and logistic models for different infrastructure categories, relevant in the national scale. It transforms, therefore, the information into an 'integrated knowledge' thanks to the digitalisation of the information and the creation of an innovative digital heritage file (Digital Enhanced Folder-DEF) that associates heritage building information modelling (HBIM) with the possibilities offered by digital certification processes typical of blockchain and the potential arising from intelligent predictive models.

Keywords: Military heritage; Integrated knowledge; Sustainable transition.

1 Introduction

Military historical infrastructures owned by the Ministry of Defence in Italy constitutes a dynamic and complex reality characterised by a significant historical value, vast

typological heterogeneity, as well as high degrees of specialisation, high safety standards and a governance structure that is both centralised and distributed (Bagaeen and Clark 2016, Camerin and Gastaldi 2021).

Hence, the management of such assets results to be extremely demanding. In particular, the higher is the historical-artistic value, the more complex is its governance. This is especially true when referring to the interventions connected with maintenance and restoration, but the issue is even more challenging if we refer to new performance instances such as the compliance with new military functions and demands, the rationalization strategies, budget requirements, operational costs, and environmental footprint reductions. In addition, all these aspects involve technical changes in the buildings that need to be kept certified within a transparent and effective document workflow. Dispersion and fragmentation of the – present and past – documents and related data concerning technical, administrative, programmatic, operational aspects reduce the efficiency of the interventions and impact on timing and construction costs.

The issue is particularly relevant in Sardinia as the consistency of the real estate designed for defence purposes or converted into military use over time is high both in terms of number of buildings and dimension of each architectural complex. Sardinia can be considered a dense microcosm, broadly representative of the dynamics and processes underway in the wider Italian and European context as well as outside Europe, mainly in the Mediterranean area.

With the awareness of this state-of-the-art, the research group in Restoration of the University of Cagliari has been leading for over ten years a wide range of academic studies specifically oriented to the assessment and enhancement of these assets with perspectives of conservation, restoration, re-use, and dual use[1]. Furthermore, since 2018, these studies have been included within the framework of the Collaboration Agreement between the University of Cagliari and the Ministry of Defence, specifically dedicated to the cooperation in the field of the redevelopment of military areas[2]. Thanks to this agreement, it has been possible to carry out academic studies and educational

[1] The peculiar Sardinian as well as worldwide situation has been stressed during the international conference Military Landscapes organised by the University of Cagliari (Fiorino 2017). Other studies have been conducted in the project financed by the Autonomous Region of Sardinia, Department of Local Authorities Finance and Town Planning, Italy-France Maritime cross-border cooperation programme 2014 - 2020 - "Military architectures in small islands", European project named "*ISOS - ISOle Sostenibili: Réseau d'îles pour le développement durable et la préservation des patrimoines*" - Scientific Coordinators: A.M. Colavitti and D. R. Fiorino (University of Cagliari - DICAAR). Methodological aspects in consideration of the sustainable reuse of disused state-owned cultural heritage, have been investigated into the project SOSLab - Research-action laboratories for urban sustainability, financed by Ministry of Environment and Energy Security (MITE) into the wider national research *"Bando per la promozione di progetti di ricerca a supporto dell'attuazione della Strategia Nazionale per lo Sviluppo Sostenibile. Bando Snsvs 2* | Call for the promotion of research projects to support the implementation of the National Strategy for Sustainable Development. Call Snsvs 2", principal investigators for the specific field od the research D.R. Fiorino, G. Sistu, main researcher fellows E. Pilia and A. Scalas.

[2] The Agreement has been signed on 18/09/2018 (scientific coordinator D.R, Fiorino for the University of Cagliari, and col. Pasqualino Iannotti for the Ministry of Defence - GENIODIFE).

programs on several Sardinian and National case studies based on a transdisciplinary approach. This “Synergy” with the Ministry of Defence (Fiorino 2021) has been seen not only as a two-way relationship between institutions, but also as an opportunity for sharing methodologies and scientific tools with a broader research community to define possible scenarios for the redevelopment of the military areas, both in terms of ‘cognitive protocol’ and ‘exploratory project’.

In this context, a three-year long project entitled ‘IMASS-CHAIN, Infrastructure Management Support System Chain’ has been developed and co-financed by the Ministry of Defence, with resources from the National Military Research Plan 2020. This paper illustrates the methodological approach and disseminate the results of the first stage of the research program.

2 IMASS-CHAIN project: goals and methodology (DRF)

The main goal of IMASS-CHAIN project is the codification of a governance protocol, useful for the Ministry of Defence's infrastructure assets, aimed at defining a system through which the administration's functional requirements can be compared with the technical, functional and performance characteristics of the buildings, providing support to all the strategic planning processes of intervention.

This can be possible through the construction of a network of ‘intelligent’ HBIM models called ‘Digital Enhanced Folder-DEF’, adopted as a tool for knowledge synthesis and project control. This is associated with the abilities offered by digital certification processes typical of blockchain and the potential arising from intelligent predictive models. Thanks to the possibility of comparing attributes and phenomena, and tracking behaviours and processes, IMASS-CHAIN makes it possible to extrapolate highly efficient construction standards and intervention models that can be replicated on a national scale.

In addition, IMASS-CHAIN digital platform aims at transforming the fragmentary and usually long phase of collecting information into an 'integrated knowledge' thanks to the digitalisation and the coding of the different kind of information coming from documents, technical surveys, analysis, assessment processes.

At the same time, IMASS-CHAIN intervenes - transversally to the entire project - on the complex process of protection, management, and certification of the documental heritage, operating directly on the criticality of content traceability with an innovative protocol for cataloguing digital or digitalised archival documents, and providing an important contribution in the field of 'long-term preservation' of the digital heritage. Starting from the existing heterogeneous information about the built military properties, this project aims to create an innovative 'certified' and 'protected' protocol of intelligent management and governance for defence structures, arriving at functional and logistic models for different infrastructure categories, relevant in the national scale, but in the future easily applicable to other international military contexts, such as NATO infrastructures.

This general goal is achieved by tackling the following specific objectives:

- taxonomic classification of military functions and spaces, through a detailed, organized, and hierarchical selection of the operative (historical and present) needs and of the typological and constructive characteristics of the main national military infrastructures;
- definition of the descriptors and indicators for monitoring, assessment, and comparison of technical, functional characteristics and performance aspects of the infrastructures, in order to implement efficient comparative evaluations concerning the infrastructure state of conservation and the effectiveness of the different levels of intervention (maintenance, renovation, etc.);
- design of the interoperability criteria between the information system Ge.Pa.D.D., used by the Ministry of Defence, and other information and archival systems (e.g. in use at Ministry of Culture and the Statal Archives) to fulfil the law requirements connected with document transfer;
- driving the Defence strategies concerning redevelopment processes as well as functional and performance adaptations of historical military complexes through intervention models based on predictive simulations (machine learning).

In carrying out these tasks, IMASS-CHAIN goes beyond each individual armed force and considers the whole Defence interforce infrastructures. For this reason, the pilot tests are performed on military complexes belonging to the Army, the Air Force, the Navy, and the *Carabinieri* Corp in Sardinia, and, in a subsequent phase, on similar case studies in the wider national context.

IMASS-CHIAN is planned in three phases - each consisting of several work packages (WP) (Fig.1).

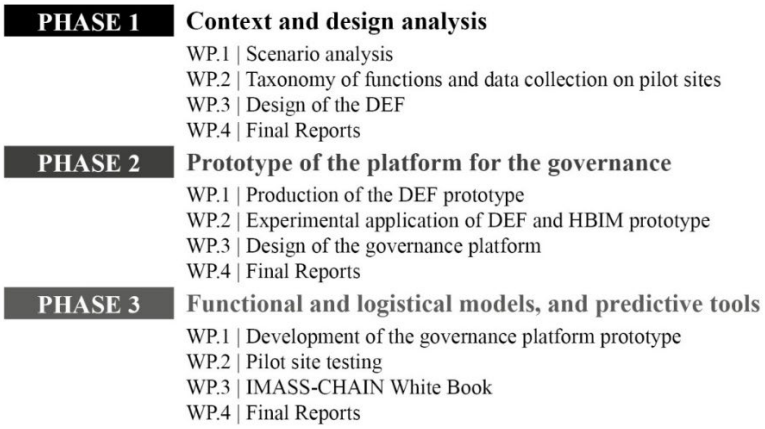

Fig. 1. Table of contents of the three stages research project IMASS-CHAIN.

The phase 1 is dedicated to the definition of the context and design analysis and it consists of three work packages. The first one includes: the analysis of the-state-of-the-art concerning the management of Defence infrastructures and the main information systems used by The Ministry of Defence and other public institutions; the recognition of the software still in use by the Defence Technical Departments and other available and

useful for the development of the demonstrator of the project platform; the selection of the pilot sites accordingly to the following criteria: significance of the site in terms of strategic military importance (historical and present), technical-constructive heterogeneity, functional requirements, availability of documental resources, dual-use potential. The second step, instead, is aimed at the collection of the data concerning the selected sites (documental databases, measurement acquisitions, instrumental analysis, diagnostics, evaluation of implemented projects) as well as the definition of the taxonomy of the military functions (e.g., standards, ranges of the parameters of the descriptors) and of the different levels of criticality, security, vulnerability. Lastly, a third step consists in: the identification of the optimal ICT tools for the construction and implementation of the Digital Enhanced Folders (DEFs); the design of the DEF structure through the organization of acquired pieces of information (physical, material, performance, etc.) and their preliminary categorization; the codification of the methodological protocol with the definition of indicators and descriptors for the artefact assessment (dating, type and constructive techniques, spatial characteristics, functional requirements, energy performances, etc.) and for the comparison and monitoring of the interventions over time. This phase was submitted at the end of the first year and the results are explored in the next chapter.

Phase 2, to be developed during the second research year, mainly consists in prototyping the governance platform. In its work packages are included: the implementation of the platform accordingly to the guidelines developed in the first phase; the test of the developed protocols on the pilot sites with the associated implementation and optimization of the DEF into an HBIM prototype; the experimental design and development of the DEF interoperability with other information systems, several of them GIS based; the monitoring and update of the data (documental, physical, but, also, related to performances, interaction with the social and natural environment) and the construction of a dynamic model for management of possible transformation processes; the design of the blockchain certification criteria. It is also considered in this step the collection of information from other national case studies, comparable with the Sardinian pilot sites, provided by the Ministry of Defence and the definition of an evaluation model to assess the performances and functional effectiveness. Lastly, during the final step of the second year, the algorithms for the comparison and evaluation of the taxonomies and descriptors will be developed and designed, with the main purpose of providing an efficient tool for the planning of maintenance, adaptation, and redevelopment projects, but also for considering disposal options.

Finally, phase 3 is strictly connected to the definition of functional and logistic models, and predictive tools through: the predictivity analysis of the developed models and the test on the pilot sites; the development of new functional and logistic model and standards at the national scale, as well as of protocols for effective interventions; the optimization, test and check of the interoperability and scalability of the developed tools.

Overall, the path outlined is an interdisciplinary protocol (Fig. 2) developed with the interaction and synergic research of five departments of the University of Cagliari: the Departments of Civil-Environmental Engineering and Architecture (DICAAR); Mathematics and computer science (DMI) for the IT aspects; Literature, Languages and

Cultural Heritage for the aspects related to archives and history; Chemical and Geological Science (DCGS) for investigations on historical natural and artificial materials; Economics and Business Sciences (DSEA), for economic assessments and financial strategies. Other partners involved are the companies Leonardo S.p.A. and Flosslab S.r.l., important components of the research group to cover the field of data management and blockchain technologies and application.

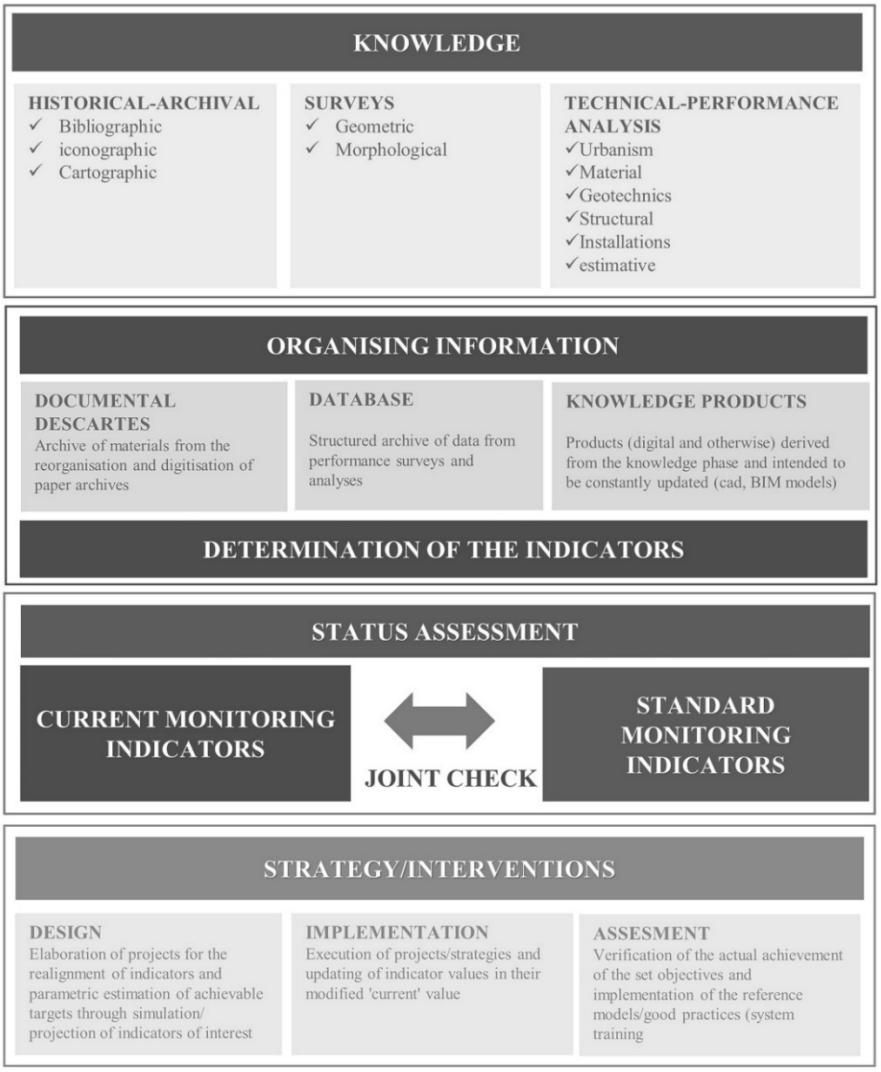

Fig. 2. Diagram of the transdisciplinary methodological protocol of the IMASS-CHAIN management model.

3 Results of phase 1 and future development (EP)

As mentioned above, the first stage of the research project, carried out for over a year, focuses on the definition of the project context and on the state-of-the-art analysis of Defence infrastructure management. The study reconsiders the complex system of institutions, authorities, and departments - internal and external to the Ministry of Defence, involved in the entire infrastructure governance cycle, and the legal framework related to the main technical-administrative procedures at the different scales of intervention on historical heritage: monitoring, maintenance - ordinary and extraordinary -, restoration, performance upgrade, and regeneration.

In general, each Armed Force, hierarchically organised[3], starting from the General Staff to the Infrastructure Departments, has special Engineer Corps (*Genio*) specialised in building management, including historical buildings, as well as urban and landscape matter. The expertise, the functioning, and the relationships among different offices are generally established by precise 'Directives for infrastructure activities', continuously updated. Therefore, when designing the DEF, this aspect has been considered, trying to set up a data structure as much as possible coherent with this institutional framework, to be effectively useful for the real Defence needs and to guarantee its stability over time.

Another important part of the research has been dedicated to the study of the available information systems and databases involved in the management processes of the Ministry of Defence's infrastructural assets. This analysis included the study of Public Institutions databases which contain data related to the military properties, including those of the MEF, the MIC[4]. In particular, the Ge.Pa.D.D.[5] information system platform (Management of the State Property of the Defence Administration), entrusted by the AID General Directorate and used to register and manage the enormous wide-ranging assets by all the Armed Forces, has been analysed and chosen as a starting model. This platform collects all the information of military infrastructures and is organised according to a precise hierarchy. The analysis starts from the ‘complex’, considered as group of artifacts included into a well codified military perimeter and identified by a unique ID code (Compendium Code). The complex contains one or more buildings - traditionally assumed – classified in the category of ‘artifacts’, while the category "structures" is associated with other minor building types such as, for example, canopies. ‘Artifacts’ are described by ‘floors’ and for each floor “units” and/or “rooms” are described, as the minimum unit composing the building. This organisation has been maintained in the

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[3] Infrastructure management involves three hierarchical levels, summarised in the directive GEN G-001 as follows: Responsible Apex Commands, Technical bodies of Armed Force, Engineer executive bodies.

[4] These include: the General Information System of the SIGEC-Web Catalogue in the more complex Networked Constraints System-VIR, the SITAP, the SICar-Web, the Land Registry, and the Territorial Bodies (SiBar).

[5] The project, currently at its 3.0 version, is born in 2011 from the re-engineering of the application software "BUDGET" of the Directorate General GENIODIFE, introduced with note of 20 September 2006, no. 0614 within the framework of the general planning of medium and long Ministry of Defence.

design of the DEF as it is essential for sharing and implementing data from the Ge.Pa.D.D. system, when available. The design of the DEF structure, supported by the highly multidisciplinary collaboration of several different scientific-disciplinary fields of research, has been based on a set of 'descriptors'[6] related to the building and its technical/functional behaviour. In summary, the thematic descriptors - organised accordingly to the levels 'complex-structures/artifacts-floor-units/room' - include the following aspects: a. historical-archival analysis and document cataloguing; b. chrono-typological analysis, study of the building phases and subsequent modifications, analysis of the historical identity and historical, artistic, testimonial, and cultural values; c. morphological and dimensional analyses; d. analysis and characterization of building elements, their consistency and performance levels; e. structural analysis; f. technical-performance analysis and hydraulic engineering; g. urban analysis; h. composition and distribution evaluation; i. estimative assessment. All the descriptors, identified and studied independently by each technical group of the interdisciplinary team, and then compared each other and optimized in their relationships, can be both structured and unstructured. Structured data include, for example, integers, decimals, strings, and Boolean values, but also structured data with a variable number of instances. Unstructured data types include, for example, large text and any objects representing images, audio, video, etc. (Tab. 1).

Table 1. Table of descriptors codification; the yellow titles indicate the part implemented by DICAAR and the green titles indicate the analysis of data conducted by DMI. For each descriptor the platform design has considered the following aspects: description, nature of data to insert (eventually the menu of possible items to select), sources, typology according to the informatic language, obligatoriness, relationship with other data.

Name	Description	Vocabularies	Sources	Typology	Obligatoriness	Constraint
Descriptors	Synthesis of the required datum.	Drop-down menu items or open field	Source of the data	Typology of data	Yes/No	Typology of relationship with other data
EXAMPLE						
Name of the building	Identify the building	Open field	Ge.Pa.D.D.	VARCHAR	Yes	ID complex

The need of testing descriptors and processes has required the identification of some pilot sites, at least one for each Armed Force, selected to be sufficiently representative of the variety of the Defence infrastructural heritage. The chosen case studies are in the vast area of Cagliari, the Sardinian capital, included among the militarily important coastal municipalities[7] (Fig. 3). Starting from the analysis of the pilot sites, UNICA-DICAAR reconstructed the more general framework of the historical infrastructure typologies and their evolution, from the period of their establishment to the recent

[6] A 'descriptor' is intended as a datum that describe an aspect of the structures, usually it is connoted by a unit of measurement.

[7] Pursuant to art. 333, c. 8 of the Code of Military Order.

typologies, extending the research also to the categories not directly due to the pilot sites. For each of these typologies, geometric-dimensional, morphological, constructional, functional and performance descriptors were defined.

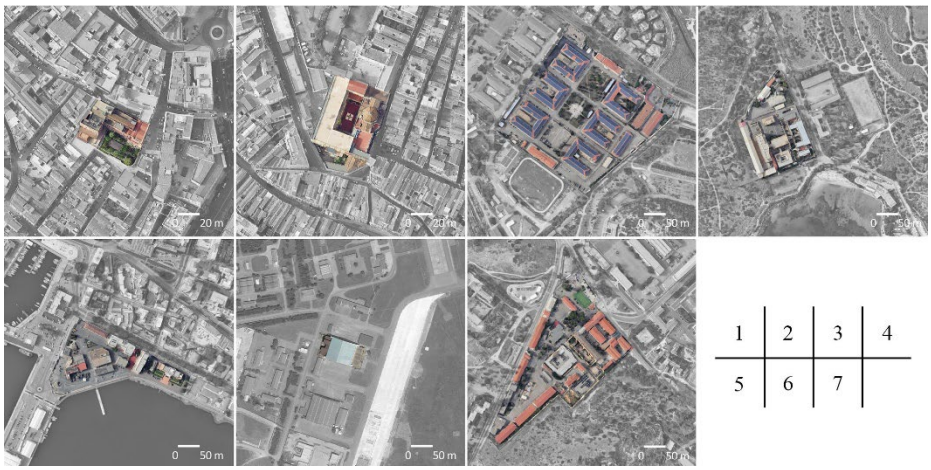

Fig. 3. Matrix of pilot sites: 1) De la Vallée Palace, Sardinia Army Headquarters; 2) De Murtas Barrack, Headquarters of the Military District of Legal Medicine in Cagliari former Military Hospital (typology of former convent, XVII-XX cent.); 3) Riva Villasanta Barracks, 14° Infrastructure Department (typology of functional pavilion barrack, XX Cent.); 4) Carlo Ederle Barracks, Military Documentary Centre (typology of military complex, XX Cent.); 5) Naval Base, Ex Maricommi, Maritime Military Commissariat Headquarters (typology of naval base, post 1860); 6) Decimomannu Air Base, Hangar PG61 (typology of 555 model, post 1954); 7) Livio Dice Barracks, Headquarters XI Battalion Carabinieri Sardinia (typology of former penal colony, XIX Cent.).

In fact, the project expects, on the one hand, to characterise the buildings by their consistency and intrinsic nature, codifying taxonomies, and, on the other hand, to collect the logistical requirements of each military function, in order to allow the DEF to carry out the joint/check between the existing heritage and the updated functions to be allocated, to support sustainable choices of maintenance, transformation, decommissioning (Tab. 2). This phase of the study has been carried out consulting literature[8] with particular attention to the recognition of historical typological models developed over time by the Military Engineers (types and profiles), in reference to which the so-called 'local variants'. The study of the functional typologies required for today's military logistics was also extended with reference to categories not present in the pilot sites, to compose an overview – as wide as possible - of the functional taxonomies, which is one of the

[8] The analysis is based on the cases study investigated and from some publications specifically concerning the national Armed Forces (Donesana 1875; Rocchi 1908, 2010; Melis 1939; Geniodife 1991; Cassi Ramelli 1996; Storelli and Turri 2014; Fiorino & Vargiu 2023) and Armed Force directives such as the *Direttiva S.M.E. Ispettorato dell'Arma del Genio, Pub. n. 6252 D.T. n.1 - Direttive per la Progettazione di accasermamenti, Roma, 26.11.1980.*

specific objectives of the project. Each functional macro-area was linked to the type of artefact according to the defined taxonomy; in addition, where possible, the study identified the relationship between typologies and Armed Force peculiarities (i.e. hangar for Air Force, Lighthouses for Navy, etc.) (Tab. 3).

Table 2. Extract from the table of typologies.

Armed Forces[9]	Typology	Sub- Type	Morphology	Description	Source
EI AM MM CC	1 | Isolated building	a) Building		An artefact that is isolated from adjacent, multi-storey structures and may contain several functions.	Ge.Pa.D.D.| Implemented by nationwide comparison case studies.
		b) Simple structure		A building isolated from adjacent structures, on a single level, also with a single hall and wide openings. It can contain several functions.	
	2 | In-line (linear) building with orthogonal wings	/		A single linear multi-storey building, completed by orthogonal wings at the ends (no longer than one third of the central body), facing a green area or the parade ground. This typology may contain all functions.	Ge.Pa.D.D.| Implemented by nationwide comparison case studies.

Table 3. Extract from the table that associates typologies and functional taxonomies.

Armed Forces	Macromere-use	Use	Sub-use	Typology artifacts	Description[10]
EI AM MM CC	Command Area	Command	Operations and logistical support unit	1| Isolated building 2 | In-line (linear) building with orthogonal wings	The Headquarters and the Guardhouse are examined together because many functions are in common; the interrelationships of use imply the traditional reciprocity and spatial proximity. The main characteristic is an office building typology: the external shell is matched by a largely flexible internal organisation using modular walls (except for sensitive areas).
			Command and control structure for land, sea and airspace		

At the same time, while identifying the typologies and the functional taxonomies, UNICA-DMI was responsible for defining the "ideal" logistical models to efficiently store data and create useful relationships among information. In detail, for each function, when possible, typological, dimensional and performance requirements have been

[9] F.A. (EI| The Army; MM| The Navy; AM| The Air Force; CC| Carabinieri).
[10] Short description from *Direttiva S.M.E. Ispettorato dell'Arma del Genio,* 1980.

defined. This task - still ongoing - of collecting and systemising the requirements of each infrastructural category considers: (a) the performance of the actual/future functions adequately and safely; b) the experience gained through the examination of the typological evolution that has occurred over time in relation to the transformation of each specific infrastructural category; c) the characteristics and prescriptions imposed in the different regulatory areas. This activity specifically involved the disciplinary fields of Restoration, Architectural Design, Building Production, Structures, Technical Architecture and Technical Environmental Physics. For each function, references to relevant literature and regulations have been specified.

Moreover, in this first phase, for each case study, a transdisciplinary protocol of investigation has been carried out, adapted to functional peculiarities of each individual Armed Force. Following the framework of descriptors, the data collection can be outlined as follows:

a) Historical-archival analysis. This has been carried out in the archives - civil and military - of Cagliari, Rome, and Turin. Various types of documents have been analysed, including all the iconographic and descriptive materials of the building, such as historical and contemporary surveys, cadastral cartographies, historical iconographies, inventories, minutes and acts of delivery, technical project documents (historical and current).

b) Chrono-typological and transformation analyses. Historical identity and memorial, artistic, testimonial, and cultural values have been studied for all the pilot sites. Furthermore, starting from bibliographic and archival investigations, the outlines of the chronological evolution of the building as well as its construction elements have been delineated, codifying the information with the "*Raumbuch*" (so called 'book of rooms'). The use of his methodology on military heritage has been widely experimented, proving to be particularly effective as a preparatory activity to the implantation of the HBIM model (Fig. 4).

c) Morphological and dimensional analysis. Topographical and photogrammetric surveys have been designed and carried out for the pilot sites with an accuracy compatible with the restoration project (1:50 and 1:20). Terrestrial laser scanner and drone's technologies have been managed for having a 3D reconstruction of the architectural complexes and then the restitutions of plans, façades, and sections.

d) Analysis and characterisation of building elements and their state of conservation. This step is the result of the synergic integration of several fields of research such as restoration, applied geophysics, technical architecture, building production and mineralogical-petrographic applications for the environment and cultural heritage. All the constructive elements of the built systems (foundations, structures, masonry, faces, floors, vertical connections, roofs, plasters, mortars, decorative elements, fixed industrial apparatus, etc.) have been in-depth investigated thanks to the protocols and tools of diagnostics. Natural and artificial materials and construction techniques - both traditional and post-industrial – have been investigated.

e) Structural analysis. The structural stability of buildings has been assessed through the identification and analysis of the general structural framework and by the study of the state of efficiency of every single component, depending on its material and

constructive technique. In fact, the survey also recorded degenerative phenomena (cracking and deformation frameworks, out-of-plumbness and asymmetries, lesions).

f) Technical-performance analyses. These include energetic, illumination, comfort, and hydraulics investigations. An essential in-depth study concerns the plant engineering sector, surveyed starting from the scanning of information included into the documentation available in the archives. This has been implemented through visual analysis and the support of some non-destructive diagnostics.

g) Urban planning analysis. The context situation and the urban planning parameters of the sites have been studied with a further in-depth analysis on the landscape aspects.

h) Compositional and distributive architectural analysis. An architectural assessment of the buildings has been carried out, including formal aspects, distribution, exposure, relationships, accessibility and, in general, all the factors ascribable to a good architectural design of spaces (interior and exterior).

i) Estimative analysis. This part of the research aims at quantifying the costs needed for the performance improvements of buildings and artefacts identified. It will therefore proceed, by means of analytical accounting techniques, to the identification of the production factors necessary for the implementation of the performance enhancement modifications of the buildings and their specific quantification and valorisation.

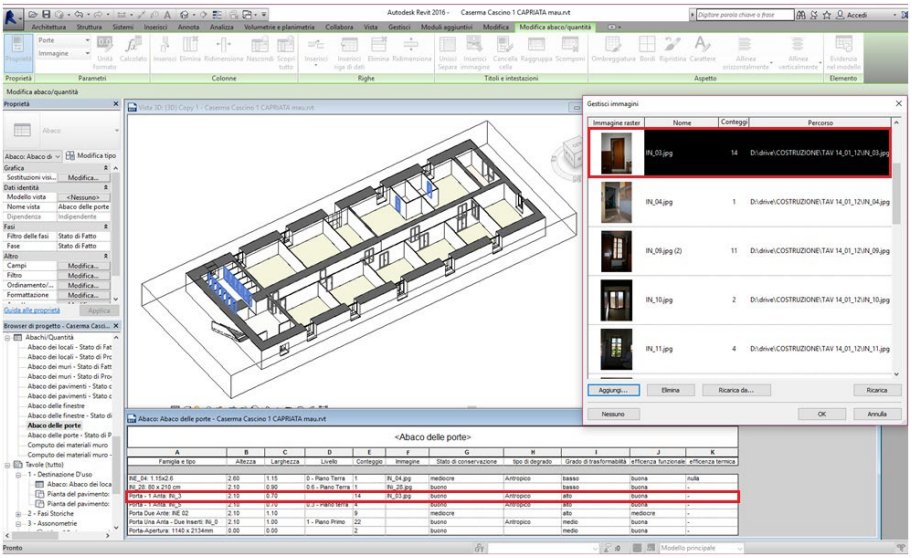

Fig. 4. Interoperability between Raumbuch and HBIM in the case study Livio Duce barracks.

Following the analysis of the pilot sites and the definition of the descriptors of the artefacts divided into thematic areas, the descriptors were selected, and the relative indicators were defined, which are useful for monitoring the transformations over time and, consequently, to represent and simulate the impact of the interventions, both in terms of technical and performance effectiveness and cost. All the knowledge acquired - in terms of data - has been then organised trough the systematisation and the

categorisation in different systems: the documental Descartes and the database DEF (Digital Enhanced Folder). Indicators can therefore coincide with parameters or be calculated by algorithms and are understood and coded as the parameters/descriptors, at the different scales of compendium, artefact, accommodation, unit, room, element.

Descriptors/indicators have also been codified with reference to the following processes of conservation/reuse:

- Monitoring and assessment of current situation | Joint check phase. This includes all indicators (possibly coinciding with parameters) that provide information on the state of conservation of the compendium/building etc. or compare the state with current regulatory requirements. The indicators, therefore, quantify the gap that needs to be connected to reach a condition of suitability with respect to current standards and how far this gap is solvable with sustainable interventions.

- Consultation and intervention hypotheses | These include indicators that can guide and predict the feasibility of an intervention. An example is the residual buildable volume: the admissible volume according to the buildability index of the urban area within which the compendium is located.

- Monitoring after the intervention | This includes indicators that provide information on the final outcomes of the intervention performed. An example may be the covered surface change (Δs) understood as the difference between the initial (pre-intervention) and final (post-intervention) covered surface area. Only after determining the list of indicators, it will be possible the joint check step, comparing the 'current monitored indicators' with the 'standard monitoring indicators'.

Generally, the IMASS-CHAIN protocol manages three types of information in relation to their sources of production: historical or historic paper-based, documentary and material; technical data from recent surveys; digital and non-derived products from the knowledge phase, intended to be constantly updated. This last category includes CAD, GIS, BIM, etc., in their editable extension and thus updatable over time. Based on the analyses, indicator values can be used for assessing the state of conservation in its current state and, furthermore, for monitoring the degree of efficiency and suitability of the building for the functions housed. Based on the adequacy or inadequacy of the 'current' indicators with respect to the regulatory standards, the nature and intensity of the corrective measures to be taken can be assessed by means of appropriate strategies. The recording of the change in the values assumed by the indicators at the end of the execution of the projects may reveal the actual effectiveness of the intervention carried out and feed the system's "training" process in a forecasting key.

4 Conclusions

In conclusion, IMASS-CHAIN consists in an innovative model for the effective management of the military infrastructures, based on the set up of a digital platform (DEF). This tool, through the methodology that conceived it, can create a virtual environment for the integrated knowledge of the historical buildings, connecting information belonging to archives with the past and present surveys, providing an always updated state-of-the-art of the buildings.

IMASS-CHAIN will allow managing documental flows (analogical or digital), certifying the immutable storage of data, tracking the information flow by means of the blockchain technology in perfect agreement with the current regulation and by creating new archive models to be adopted for the Long-Term Preservation.

In this way, operatively speaking, each military asset will have in the future its Digital Enhanced Folder. This system will operate integrating HBIM (Historical Building Information Modelling) systems and blockchain technology, defining certified intervention models with high efficiency and sustainability, based on the experience gained through the documentation of multiple interventions carried out on extensive cases of artifacts. Due to this ability, the tool would provide an important support to decision-making bodies in defining use and reuse strategies, orienting towards compatible solutions. Specifically referring to phase 1, the methodology developed in the first year of research gives answers in terms of monitoring and managing of the entire lifecycle of the infrastructures, and in terms of handling of the archive sources and controlling the entire lifecycle of the document. In fact, the methodologies and technologies involved in the project can be easily applied to other public institutions owner of large properties like the Ministry of Defence, supplying a management tool for taking informed decision within the reuse processes, constantly updatable and (blockchain) certified, connecting the documental reservoirs with the associated operative processes.

Furthermore, the outcome has a significant dual-use impact: besides the industrial research 'product', the project will develop a new 'concept' of innovative document management system as basis for an effective and efficient tool for the management and valorisation of infrastructure assets. This vision of the archive as source of 'production of the information' fully exploits the interdisciplinary nature of the document reservoirs: the archive becomes a way for the implementation of efficient, transparent, democratic, memory conservation if it is made accessible, via different levels and interfaces to the public (clearly, accordingly, to regulated level of confidentiality). Finally, it is important to highlight that studies and surveys have been carried out in constant cooperation with the military human resources, with a common and mutual training supply, sharing competencies as well as technical devices.

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