Cultural Heritage Through Time

Project Deliverable

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0	Gabriele Guidi	Document framework setup	January 10, 2017
1	Gabriele Guidi	Delivery of finalized report	February 5, 2017
2	Gabriele Guidi	Delivery of report updated after review	March 30, 2017
3			
4			

day stresses, for example tourism, urban development and natural hazards, making the Wall an ideal case study for the CHT2 project.

The CHT2 case study focusses on three different study sites: Beckfoot, Corbridge and Birdoswald (Fig. 9), that characterise natural hazard phenomena facing the Wall in the 21st Century. The fort, civilian settlement and cemetery at Beckfoot (https://historicengland.org.uk/listing/the-list/list-entry/1007170), located to the south-west of the main Wall, has been subject to significant coastal erosion over recent centuries, with archaeology buried under sand dunes being frequently exposed by coastal processes. Birdoswald (https://historicengland.org.uk/listing/the-list/list-entry/1010994) is one of the best preserved of the 16 forts located along the Wall, but, together with the nearby milecastle at Harrows Scar, is at critical risk to landslides instigated by fluvial erosion from the River Irthing to the south of the site. Finally, the modern day settlement of Corbridge (https://historicengland.org.uk/listing/the-list/list-entry/1006611) marks the site of the most northerly town in the Roman Empire, but is subject to fluvial flood hazard from the River Tyne to the south.

Figure 9 –Location map of CHT2 UK study sites overlaid on Google maps.

As the primary aim of CHT2 is to merge heterogeneous information in order to deliver enhanced 4D heritage digital products, a variety of methods were used including historic mapping, archival aerial imagery, Unmanned Aerial Vehicle (UAV) sorties, airborne laser scanning (ALS) and geophysical surveys. Accurate new data acquisition took place at Beckfoot (UAV survey, archaeology and geophysical survey) and Corbridge (geophysical survey).

a *b* *c*

Figure 10 – Dense clouds taken from the different sites with various technologies: a) 2016 dense point cloud generated by SfM from UAV NIR imagery of Beckfoot; b) 2008 airborne laser scan of Birdoswald Roman Fort and surrounds; c) 1946 dense point cloud of Corbridge landscape generated by SfM from archive photographs supplied by Historic England / English Heritage.

Amongst other datasets, In each of the three case studies this has resulted in a heterogeneous timeline of disparate data streams that require reconciliation to be meaningful. For example, at Beckfoot, English Heritage archival aerial imagery from 1948 and 1991 has been digitised, augmented with ALS data from the UK's Environment Agency for 2009, 2010, 2013 and supplemented by 2016 UAV (both RGB and NIR imagery were captured), as well as geophysics survey. Core data for the Birdoswald and Corbridge study sites include similarly multifarious episodic surveys over similar time spans.
Data for all study sites were processed following the CHT2 designated workflow, mentioned in WP2.
3D data for each individual epoch shown in Fig. 10, were fused using various approaches, including surface matching and ICP routines, to ensure rigorous registration from epoch to epoch, thereby generating spatially consistent 3D time series for subsequent cultural heritage analysis.
In order to maximise the value of research outcomes by promoting their transfer to individuals and organisations, CHT2 is also considering ways to best visualise and disseminate results. An example of such a visualisation from the Corbridge dataset is given in Figure 11. Material from the project is also feeding into a Newcastle University Massive Online Open Course (MOOC), entitled Hadrian's Wall: Life on the Roman Frontier. This free to participate MOOC is available at https://www.futurelearn.com/courses/hadrians-wall.

Figure 11 – Visualisation of 2016 Corbridge landscape generated from archive photographs supplied by Historic England / English Heritage.

4.3.1.3.4 POLIMI

The case study covers the south-west area of the city centre of Milan that corresponds to the Roman Circus area. On this zone, it's possible to see several traces of the different historical periods from ancient times until the densely urbanized structure of the present days. According to some archaeological finds, Milan was inhabited since the V century BC in the area corresponding to the current Via Meravigli, Via Valpetrosa, Piazza del Duomo. In this zone, some protostoric tracks converge, with traces of the following Roman roads still recognizable in the city plan. Such roads connected Milan with some towns and villages in its northwestern neighbourhoods belonging initially to the Golasecca culture, a prehistoric civilization who lived in the Ticino River area from the Bronze Age until the 1st century BC. The route towards Vercelli crosses the area studied within this research and corresponds to the current Corso Magenta. In II-I centuries. B.C. excavation works and levelling have been made, in order to adapt the ground to the Roman urban model. At that time, a first urban planning was conceived, probably maintaining the Golasecca road network. The entire settlement occupied an area 80 hectares, with a spatial organization influenced by differences in height, watercourses and by the existing routes. In the second half of the I century. B.C. the Romanization of the territory was completed. With the arrival of the Romans and their culture, the investigated area was first dedicated to housing and productive activities.

In the area, now occupied by the Archaeological Museum, recent excavations have revealed the presence of a domus belonging to various pre-imperial times. At the end of the I century BC, good quality residences and production activities should have been present, probably related to the metal extraction from the sediments of the Nirone river (then diverted to leave space to the Circus and city Walls), and the related processing. A subsequent domus must have been built in the I and II centuries AD, later transformed in a prestigious domus in the III century AD. For none of these buildings, unfortunately, a complete plan is known.

In the 286 AD, with the tetrarchic subdivision, Milan became the capital of the Western Roman Empire, under the emperor Maximian. During the imperial period, up to 402 AD, the area has been modified by the construction of major buildings such as the imperial palace, the circus and the defensive walls.

The Circus was the open-air venue for chariot and horse races, or rather the place dedicated to the celebration of the Emperor's greatness and for this reason it was generally located near the Imperial Palace. The Milan's circus was also adjacent the defensive walls with which shared the western part with it. This particular location has probably resulted in a number of peculiarities, such as the absence of the arc of Triumph on the apex of the curve. Although the circus of Milan was one of the most important of the empire, today only few traces are still visible: a tower of the city walls, a tower of the Carceres reused as a bell tower (formerly belonging to the Monastero Maggiore), and some sections of the walls or foundations in the private properties nearby, sometimes hidden in their interiors or in the basements.

Historical sources report the existence of the circus until the Longbard's era. From that period, as happened to other monuments in Milan, the materials of the roman structures were used in other buildings construction. Archaeological studies were conducted mostly at the beginning of the '900 and after World War II, during the reconstruction of some private and public buildings, when it was possible to see the several archaeological remains. Many questions are still open about the building's elevation and its relation to the surrounding area: the imperial palace and the town fortification walls.

The area of the circus includes the Church of San Maurizio, whose nucleus is of early Christian origin and was built in the form we know today at the beginning of '500. The church was connected to Monastero Maggiore in Milan, one of the most important female monastery of the Benedictine order, active since the Carolingian age.

The convent, among the largest and richest of the city, had its greatest extent in the '700, until it was abolished by decree of the Cisalpine Republic in 1798. After this event, it was used for laic purposes (barracks, female school, military hospital).

During the'800, the main cloister and the buildings connected to the opening of two new roads (Via Luini and Via Anasperto) were shot down. Other serious damage occurred, moreover, following the bombings of august 1943, during the World War II. Nowadays, unfortunately, only small portions of the monument remain visible and a lot of historical documentation has been lost in a fire during World War II. In the '60s of last century, the area of the complex was used as headquarters of the Archeological Museum of the Municipality of Milan (Civico Museo Archeologico di Milano) that still takes care to preserve the memory of the various eras represented in this part of town.

The rest of the area occupied by the ancient Roman Circus is instead almost entirely occupied by residential buildings and small remains of the circus are still visible in the basements of modern buildings in that area.

Figure 12 – Plan of Milan Circus according to archaeological studies conducted by De Capitani D'Arzago. Legend: full red pattern: foundations of visible walls or put into light; obliquely red dashed line pattern: identified masonry foundations; red dashed lines pattern: supposed masonry foundations.

The first kind of source taken in to account are the bibliographic resources to document the history of the city and the monument of the area. In particular, historical texts were considered, from which it is possible to infer useful information about life, state of the monument and reports of past and contemporary archaeological excavations.

Especially important for the study of the monument it was the text of the archaeologist De Capitani D'Arzago that the late '30s of last century has thoroughly studied the circus theme, confirming the existence, location and essential size of them thanks to discovery of the parallel walls, some portion of the foundations and a large part of the curve. In Fig. 12 the positioning of all the recognized portion of the walls of the roman circus and in Fig. 13 the plan reconstruction of the monument.

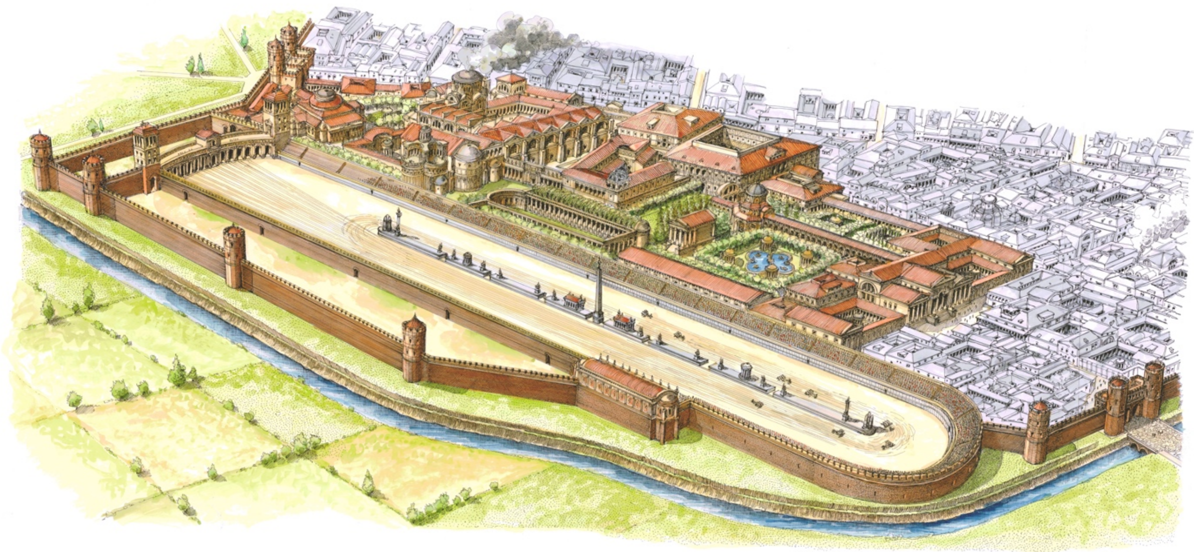

Figure 13 – Reconstructive drawing of the Circus and the Imperial Palace by F. Corni.

The literature search was also conducted in relation to other examples of imperial-era monuments and preimperial-era domus; so it is possible make up with references to other historical cases to any missing information on the area under analysis.

Another step of the work was a collection of maps, drawings and images concerning the various topics covered in the research. Drawings and historical paintings are fundamental to get information no longer available today. When possible data for individual monuments are searched. If these are not available, as in the case of the search area, historical representations of elements of the same typology and age are searched.

This kind of approach is useful to have typological indications and to validate the reconstructive hypotheses proposed by scholars. In our case, for example, we have been researched sources regarding: (i) domus of pre-imperial era; (ii) Roman circuses built in the Empire in the same period; (iii) monasteries of the Benedictine order. Unfortunately, in the case of Milan have come to us poor graphical representations of the monuments concerned during their period of use. Regarding more recent times, we have been collected all the drawings of survey campaigns carried out in the area. In the post war period, many buildings destroyed by bombing were rebuilt. In this phase the excavations for the foundations of the buildings have, in some cases, revealed archaeological finds that were sometimes enhanced in the same building while other times covered. In the latter case the survey drawings made during excavations are fundamental to get information about archaeological remains today no longer accessible. Then a depth iconographic research was carried out collecting also different maps from various periods that can highlight the urban structure of the area. About 60 city maps represented in different historical periods have been identified, at the Civica Raccolta delle Stampe Achille Bertarelli, and analyzed to study the evolution of the urban area.

Another type of data taken into account are the photographs. Images of artefact or urban area from different points of view and about two or more different periods are a valuable support for the three-dimensional reconstruction work. Specifically, a research in the photographic archive at the Superintendence's office was performed and with regard to the area of interest, about a thousand images have been found, of which about 100 were selected. This selection regards artefacts visible on construction sites or inspections of the superintendent. These images are a valuable documentary heritage because many artefacts are no longer visible, embedded in the foundations of modern buildings.

Starting from a detailed map of the circus made in the late '30 of the last century, the work is verifying the accurate current position of all the remains of the walls of the structure. This part of the work dealt also with a capillary search, in connection with the inspectors of the Superintendence of Milan, of all the street numbers of the actual buildings in which basements are still visible the remains. During this search, it was also stated that all the cadastral units interested by archaeological findings are under restrictions but, given the period in which this limitation were produced, most of them are brief and not clear. Hence, it was difficult to identify the single structures, their position and their extension.

Another stage of the work regards the 3D survey with reality-based techniques of all the remains still visible in order to have a starting point for the reconstruction.

Currently survey works of the visible portions of the monument have been performed only at the archaeological museum in Milan where the access was obtained rather easily for the friendly cooperation of the archology superintendence and the museum direction.

Afterwards, along with the superintendent, all areas subjected to archaeological restrictions have been screened in order to assess the actual presence of remains, their state of conservation and the opportunity to perform a three-dimensional survey.

This part of the work, dealing with a massive archaeological remain underneath the city, has been much longer than expected and is still in progress.

Figure 14 – Example of photographic material available through the archives: some of the remains visible in the area of the ancient roman circus in Milan shot in the '50s, when the area in the city centre was excavated for restoration works after the damages of WW2

4.3.2 Deliverables/output

TABLE 4.3.2: Deliverables							
Deliver-able number	**Deliverable name**	**Brief description of deliverable**	**Lead partner (country)**	**Planned delivery date**	**Date delivered**	**Actual/ forecast delivery date**	**Comments**
D2.2	Guidelines for 4D landscape analysis	Multidisciplinary approach for analysing time evolution (3D+T) of landscapes	USAL (Spain)	M10	June 30, 2016		*For the sake of simplicity the two topics have been treated in a single physical document of 25 pages entitled "Methodology definition", where both scales are considered*
D2.3	Guidelines for 4D urban and architectural analysis	Multidisciplinary approach for analysing time evolution (3D+T) of buildings and urban areas	USAL (Spain)	M10	June 30, 2016		

4.3.3 Contribution to JPI-CH

TABLE 4.3.3: Contribution to JPI-CH visibility and the priorities and challenges of its SRA			
Contribution to		**Contribution by (deliverable number (s))**	**Brief description of what is contributed and how**
General JPI-CH visibility			
SRA challenges	Developing reflective society	D2.2, D2.3	CHT2, aiming at reconstructing the changes through time of important Cultural Heritage in four different countries, has a strong impact in understanding how the environment and cities are changing. The possibility to highlight the temporal modifications of European Cultural Heritage permits to identify the strong connection between the past and the modern time and allows understanding which agents (environmental or human) caused the changes and sometimes the disappearance of Heritage.
	Connecting people with heritage	D2.2, D2.3	It is always difficult for non-experts to understand completely a Cultural Site without proper explanations, and even so, sometimes this information is not enough. The correlation between texts and images can occasionally help in understanding, but if the Heritage is complex or not fully visible, it is almost impossible to make it understandable. For comprehending our past, one of the most important factor is to safeguard it and it is mandatory to provide the best tools to non-professionals. The methodology provided by the CHT2 project helps to give back to the ancient structures selected as test cases their past splendour making their understanding more accessible, especially regarding the roman circus of Milan, which is completely hidden below modern buildings. In this case, the 4D reconstruction is a helpful tool to make aware the citizens about the history of their city.
	Creating knowledge	D2.2, D2.3	In cities that have a long past and are still living on ancient remains, it is required to have a proper mapping of the archaeological risk, in order to avoid the destruction of remains. Maps like this can also help in understanding why the modern city or landscape has developed in a way instead of another and can be a support to decision-makers who have to deal with the normal management of the infrastructures. Products like the ones given by the CHT2 project helps in finding innovative approaches able to combine the safeguarding of our Cultural Heritage, forming the basis for any kind of decision regarding intervention on Cultural Heritage, helping assess the risks and issues involved.
	Safeguarding cultural heritage resource	D2.2, D2.3	The inclusion of the time factor in the survey of a cultural heritage asset allows to do predictive analysis that may help in taking proper countermeasures against for example pollution or natural events that might represent a threat for a specific heritage asset (e.g. the coastline changes minacing the Hadrian Wall)

4.3.4 *Future activities*

- Three of the four partners of the CHT2 project (NCL, SSSA and POLIMI) will orient their efforts in finalizing the 3D models corresponding to different ages and link them in a 4D reconstruction of the different sites
- In particular, POLIMI aims at 3D surveying all the circus remains still available in the basements of several private houses, sorting out the authorization issues with the archaeological superintendence of Milan. This survey will be then oriented in a georeferenced coordinate system that will allow to precisely reference the current state of the city with the buried remains of the Roman circus. However, this specific step, will be available only if the needed funds will be paid by the Italian funding agency (MIUR) before April 2017, otherwise, even with a delayed payment, the remaining time would not be enough for completing the work.
- USAL has done most of the planned work, therefore will not produce further data
- SSSA will spend more efforts that in the last year for the activities related to WP5

4.4 PROJECT MEETINGS AND INTERNAL COLLABORATION

<table>
<tr><th colspan="5">TABLE 4.4: Project internal collaboration and meetings</th></tr>
<tr><td colspan="5">List of internal meetings</td></tr>
<tr><td>Date</td><td>Location</td><td>Participants</td><td colspan="2">Weblink to periodic reports/minutes (if applicable)</td></tr>
<tr><td>Jul 16, 2016</td><td>Prague</td><td>POLIMI, NCL, USAL, SSSA</td><td colspan="2">http://cht2-project.eu/2016/07/16/second-cht2-meeting/</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="5">Collaboration / communication amongst consortium member</td></tr>
<tr><td colspan="3">Type of exchange * (choose from list of options below)</td><td>Type of organizations involved</td><td>Countries involved</td></tr>
<tr><td colspan="3">joint publications</td><td>Universities and Associations</td><td>Italy, UK, Spain, Poland</td></tr>
</table>

4.5 IMPACT: DISSEMINATION, NETWORKING AND KNOWLEDGE TRANSFER

4.5.1 Networking activities (external) and stakeholder involvement

TABLE 4.5.1: Networking and stakeholder involvement					
Brief description of **networking activity / how stakeholders have been involved** in the project	Please indicate whether the activity is **open to any interested stakeholder** *(yes/no)* *	**Stakeholders** involved *(more than one category is allowed)*	Indicate the **outcome / impact / opportunity for (transnational) collaboration**	Indicate the **number of stakeholders** reached in each category	Indicate the number of stakeholders reached, that are based **outside the EU, for** each category*
Contribution is creating 4D digital models with the CHT2 methodology	yes	Cultural Heritage institutions	Documentation about previous studies supporting the decision, on top of which start the CHT2 activity	5	0

4.5.2 List of scientific publications

TABLE 4.5.2 Scientific publications										
Peer reviewed publications *(starting with the most important ones)*										
Number	**Title**	**Main author**	**Title of journal or series**	**Issue number, date or frequency**	**Publisher**	**Place of publication**	**Year of publication**	**Relevant pages**	**Permanent identifiers** [1]	**Open access** [2] **publication** ***(yes/no)***
1	4D reconstruction and visualization of cultural heritage: analyzing our legacy through time	Pablo Rodríguez-González	Proceedings of 3DARCH 2017	Bi-annual	ISPRS	Hannover, Germany	2017	not yet defined	not yet assigned	yes
2	Interdisciplinary data fusion for diachronic 3d reconstruction of historic sites	Laura Micoli	Proceedings of 3DARCH 2017	Bi-annual	ISPRS	Hannover, Germany	2017	not yet defined	not yet assigned	yes
3	Cultural Heritage Through Time: a case study of Hadrian's Wall	Karolina D. Fieber	Proceedings of 3DARCH 2017	Bi-annual	ISPRS	Hannover, Germany	2017	not yet defined	not yet assigned	yes
4	Diachronic 3D reconstruction of historical sites in urban context	Gabriele Guidi	Proceedings of CAA 2017	Annual	CAA	Atlanta (GA), USA	2017 (expected)	not yet defined	not yet assigned	yes
5	Mobile LiDAR System: New Possibilities for the Documentation and Dissemination of Large Cultural Heritage Sites	Pablo Rodríguez-González	Remote Sensing	Monthly	MDPI	Basel, Switzerland	Still under peer-review	not yet defined	Still under peer-review	yes

4.5.3 List of other scientific outputs

TABLE 4.5.3 Other scientific output							
Type of output *(choose from list of options below)*	Brief description of **type of output and focus/ topic**	**Date** ***(mm/yy)***	**Authors/ developers** *(organizations and, if relevant, persons)*	**Country(ies involved)**	**(end)users/ target group**	**Open access** [1] **publication** ***(yes/no)*** *	**Issuing institute and/or code** *(if applicable)*
training or educational instruments, workshops, courses/modules, summerschools	CHT2 contributed to the production of the MOOC entitled "Hadrian's Wall: Life on the Roman Frontier", by providing aerial time-varying images of the Hadrian Wall		Ian Haynes; Karolina Fieber	UK	University students; common public	yes	

4.1.1 Dissemination and knowledge transfer

TABLE 4.5.4: Dissemination and knowledge transfer activities and tools				
Type *(choose from list of options below)* *	Brief description of **medium and topic**	Brief description of **overall impact/benefit**	**Stakeholders and audience** (direct stakeholders, private sector, public sector, the general public etc)	Estimation of **number of persons** reached

websites	cht2-project.org (project website)	Description of the general project purposes and periodical updates through a "news" section, where the partners publish their advancements	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	1000
logos	Project logo summarizing graphically the aim of CHT2	Quick visual explanation of the project purpose	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	1000
ONLINE PRESENTATIONS (youtube movie, TED talk, webinar etc)	Production of a TV program for a Spanish TV channel by the University of Salamanca	Communication of the project progress to a broad audience	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	5000
ONLINE PRESENTATIONS (youtube movie, TED talk, webinar etc)	Twitter: communication of second project meeting from the account @Nexus6it specialized in 3D tech & Cultural Heritage	Communication of the project progress to a selected audience	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	1000

ONLINE PRESENTATIONS (youtube movie, TED talk, webinar etc)	Posts on the CHT2 blog about “Digging into archives for reconstructing the Roman Circus of Milan”	Communication of the project progress to a selected audience	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	1000
ONLINE PRESENTATIONS (youtube movie, TED talk, webinar etc)	Posts on the CHT2 blog about “Collection of archival images of the Circus of Milan”	Communication of the project progress to a selected audience	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	1000
ONLINE PRESENTATIONS (youtube movie, TED talk, webinar etc)	Posts on the CHT2 blog about “Archaeological remains of the circus on the modern topography of Milan”	Communication of the project progress to a selected audience	Academic and industrial users of technology for cultural heritage preservation and improvement, private and public sector, general public	1000

5 FINANCIAL SUMMARY FOR THE REPORTING PERIOD

5.1 FUNDS RECEIVED DURING THE REPORTING PERIOD

Date of grant (tranche)	Partner	Funding agency + country	Amount (€)
	POLIMI (Project leader)	MIUR, Italy	€ -
	NCL (Partner 1)	AHRC, UK	€ 73.289,00
	USAL (Partner 2)	MEC, Spain	€ 12.225,00
	SSSA (Partner 3)	MNSW, Poland	€ 27.744,99
Total of funds received by project during reporting period			**€ 113.258,99**
Total of funds received by project up until reporting date (from the start onwards)			**€ 167.683,89**

Regarding this table, please note that for an error last year €60k was reported as received by the Spanish unit USAL. Actually the unit received €60k by their university, but only €30k by the Spanish Ministry of Economy, Industry and Competitiveness (MINECO). The other €30k were anticipated by the university and so they should not have been reported.

Therefore, the total funds received by whole project from start onwards, is the total reported last year (€ 84.424,90) minus the amount erroneously reported (€ 30.000,00), corresponding to € 54.424,90, plus the total received this year (€ 113.258,99).

5.2 SUMMARY EXPENDITURE STATEMENT FOR THE PERIOD

TABLE 5.2: Expenditure	
Item description	**Amount (€)**
Project Employment costs	**€ 174.707,68**
POLIMI (Project leader)	€ 85.109,85
NCL (Partner 1)	€ 38.011,00
USAL (Partner 2)	€ 29.338,17
SSSA (Partner 3)	€ 22.365,92
Project Equipment costs	**€ -**
POLIMI (Project leader)	€ -
NCL (Partner 1)	€ -
USAL (Partner 2)	€ -
SSSA (Partner 3)	€ -
Project publications costs	**€ -**
POLIMI (Project leader)	€ -
NCL (Partner 1)	€ -
USAL (Partner 2)	€ -
SSSA (Partner 3)	€ -
Project Travelling costs	**€ 3.265,93**
POLIMI (Project leader)	€ 1.645,93
NCL (Partner 1)	€ 1.620,00
USAL (Partner 2)	€ -
SSSA (Partner 3)	€ -
Project Other costs	**€ 426,69**
POLIMI (Project leader)	€ -
NCL (Partner 1)	€ -
USAL (Partner 2)	€ -
SSSA (Partner 3)	€ 426,69
Project Overheads Financial, Scientific, Administrative Support Fee (if applicable)	**€ 76.212,93**
POLIMI (Project leader)	€ 42.554,93
NCL (Partner 1)	€ 33.658,00
USAL (Partner 2)	€ -
SSSA (Partner 3)	€ -
TOTAL EXPENDITURE	**€ 254.730,49**

Regarding this table, please note that for a trivial error last year POLIMI reported € 8.127,14 instead of the amount of € 20.119,75 actually spent in labour, with a difference of € 11.992,61. This involved also an increase of € 5.996,31 in the overhead. The total POLIMI employment costs reported is therefore € 73.117,24 (the actual expenditure of this year) plus € 11.992,61 not reported last year. Similarly, the overhead is increased from € 36.558,62 (amount corresponding to this year) to € 42.554,93, for keeping into account the € 5.996,31 amount not reported last year.