Webcams and two (2) tide gauge stations implemented, tested and data recorded

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INTRODUCTION

As part of Activity 5.2. Emilia Romagna coast, the partner PP9 Marche Region was commited to implement and test webcams and 2 tide gauge stations, as well as record relevant data. Regional observational network will be integrated with tide gauges that will be used for model validation, monitoring of sea level trend during sea storms and for the estimation of the critical thresholds.

CHAPTER 1 - Webcam network: CamERa

The project consists of the installation, setting up, archiving, processing and data publication of eight video monitoring fixed stations along the Emilia-Romagna regional coast. Stations (webcams) able to acquire, process, transmit and publish images compose the coastal CamERa network aiming at the monitoring of the beaches and shorelines. Real-time monitoring of beach conditions is the main goal which allows for the acquisition of long datasets that will support decision-making processes for the management and planning of the marine-coastal zones. The list of the webcam locations is presented in Figure 1.

An installation height of about 8m above the ground provides adequate framing of the coastline for image processing and product creation. The stations allow the acquisition of video streams and images at constant intervals, even for consecutive periods of at least 20 minutes, as well as local archiving, processing and transmission of the resulting products with the relevant metadata to the archive of the Arpae Functional Centre. It is also possible to remotely access the individual video surveillance stations to use the local data, check their operation, modify the settings and carry out the necessary software updates (including firmware).

Each station consists of the following basic elements:

- A fixed industrial camera for image and video acquisition, easily available on the market from primary manufacturers and suitable for use in aggressive environments such as coastal environments, to provide a consistent basis for the overall reliability of the system;
- Processing and control unit capable of automatically acquiring, at configurable intervals, the streams or images from the connected camera(s), processing them using specific algorithms (free software) to produce timex, timestack, snapshot, shoreline and orthorectified images, and recording them in a local archive (30-day depth);
- 220 Vac power supply module with uninterruptible power supply (UPS);
- 3G/4G/LTE communication module, complete with antenna, for the transmission of products with metadata resulting from processing to the Arpae Functional Centre with configurable frequency (typically 30 minutes);

- Ethernet communication/transmission provision;

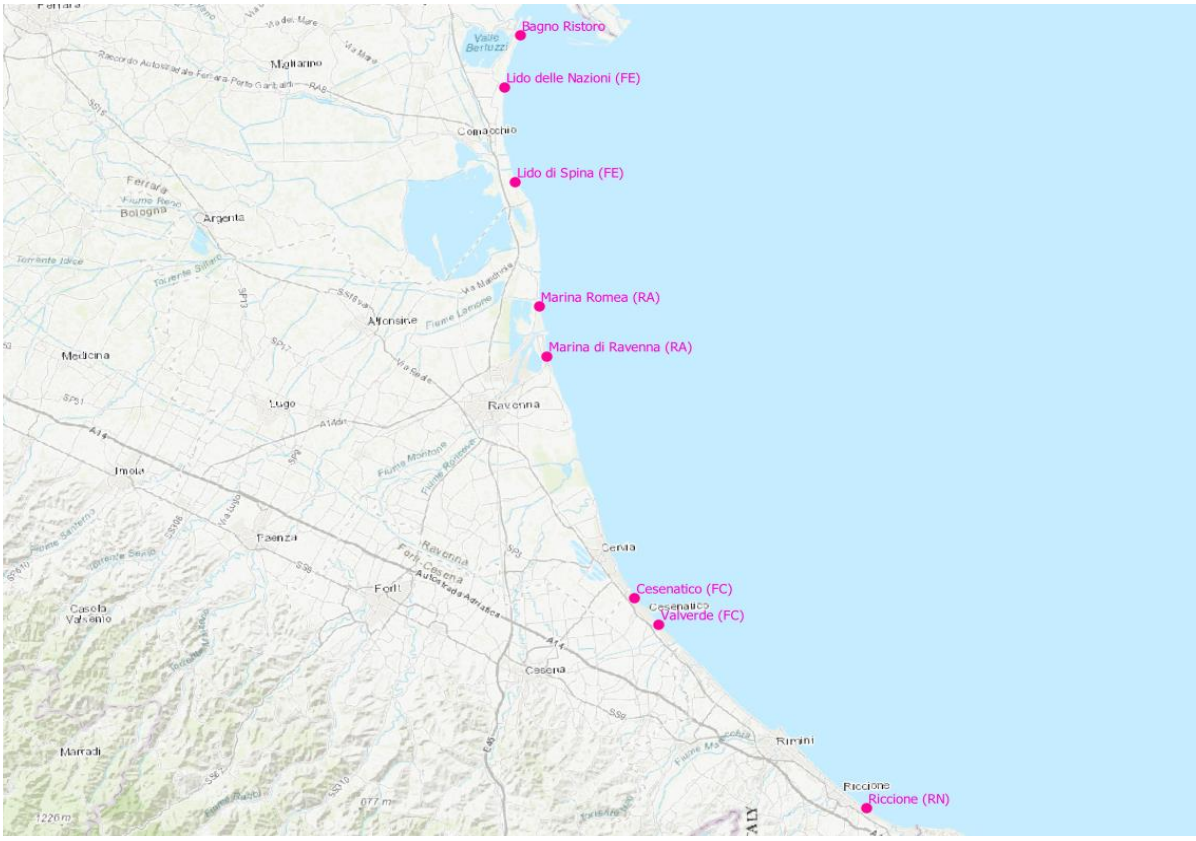


Figure 1. Webcam locations along the Emilia-Romagna coast

Given the characteristics of the Emilia-Romagna coast, two types of stations have been identified:

- Type A: host structures with a low height above ground level (3 m) and located in beach establishments, on average, close to the shore;
- Type B: host structures with a height above ground level > 8 m.

Type A sites are designed to be as non-invasive as possible, avoiding, for example, drilling holes in the roof to fix the mast. By analyzing the observation sites, the height of the camera mast has been evaluated with the aim of guaranteeing the acquisition of significant images at any time of the year (in fact, during the winter a containment dune will be built, which must not affect the view of the coastline).
The camera characteristics:

- 3 Mpx resolution
- 2 Hz frame rate
- 200m shoreline viewing distance
- Day and night operation
- Weather resistant marine housing

- PoE power supply
- Face masking function and sensitive data
- Illuminator for night vision
- Transmission interface via proprietary and open standard protocol (GigE Vision)

Two of the webcams installed can be seen in Figures 2 (Riccione) and 3 (Valverde). In the Annexes, it is possible to see the pictures of other webcams installed along the coast as well as steps of the calibration process performed in order to correctly set up the system.

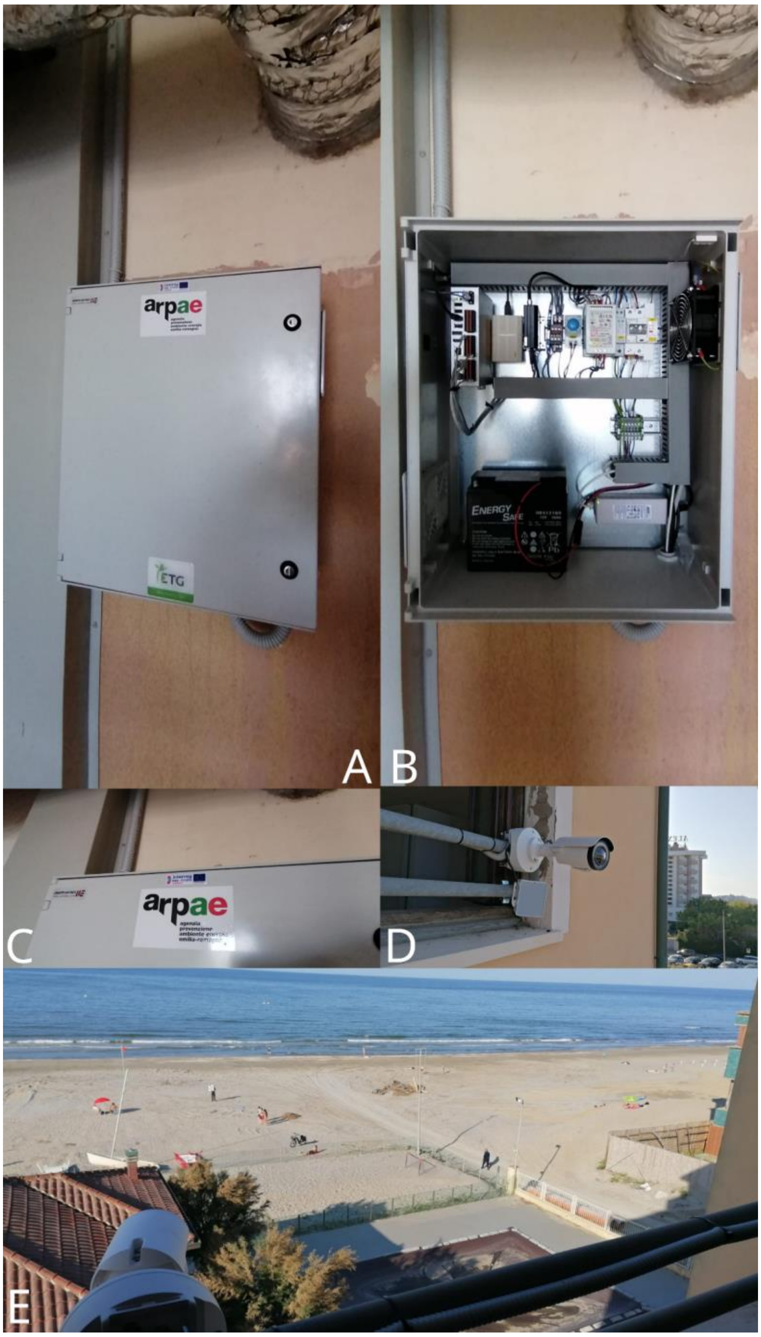


Figure 2. A, B, C) device installed which stores and initially processes the webcam data before sending to the other Arpae servers. D, E) Webcam installed in Riccione and Webcam view towards the Adriatic Sea, respectively.

Figure 3. Webcam installed in Valverde

System architecture

Given the availability of a virtual environment within the Arpae infrastructure, this is the natural location for the web visualization platform of the products resulting from the video surveillance network. The raw images and videos acquired by the camera are stored in order to limit the traffic to the center to processed products only.

As visible in Figure 4, the remote stations process the data coming from the cameras (1), generate the products and send them to the FTP server provided by Arpae using the FTPS protocol. The data present here are then transferred both to the Arpae database (Arkimet) and the local memory (data module of the APP ETG). The proposed web platform (2) represents the "shop window" of the project and allows to access the data, through two different areas of the application; one with anonymous access, for consultation only, and another with access authenticated by credentials (AUTH module), which allows to intervene in the configuration and to request the raw data as if directly connected to the web server of the remote site.

The web application developed for the project will be created following the directives available on https://docs.italia.it/italia/design/lg-design-servizi-web/it/versione-corrente/index.html, which are a guarantee of a development “compliant with accessibility regulations”.

Image acquisition, processing and transmission unit

The design of the image acquisition and processing system is based on reliability and performance requirements. The literature on coastal video surveillance, such as Picoastal (https://github.com/caiostringari/picoastal), considers the use of objects with limited computing capacity; the ambitious nature of this project, which aims to increase performance and use higher resolution video systems, is the direct consequence of the need for greater computing power. An embedded industrial PC with a high-performance CPU, 8 GB of RAM and a high-speed SSD hard disk is used, equipped with the Ubuntu 22.04 Linux operating system. This choice not only guarantees a proven and more stable system, but also promotes better performance with the same hardware resources. Linux systems provide users with a high degree of customizability, enabling users to fine-tune and optimize performance according to their specific preferences.

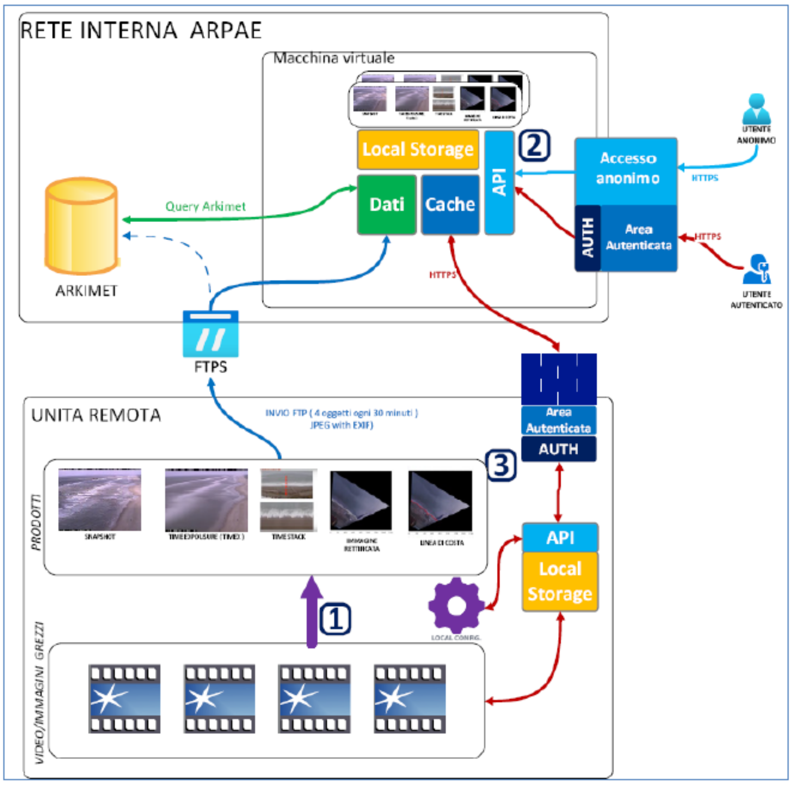


Figure 4. System architecture

CHAPTER 2 – TIDE GAUGE STATIONS

The coastal environmental monitoring network managed by Arpae has been upgraded with the installation of 2 tide gauges and 2 GNSS stations. Two tide gauges have been installed: one in the tourist port of Cattolica (RN) and another one in Cervia (RA), as indicated in Figure 5. Each station has also been equipped with a GNSS station (two in total).

The installation guarantees a complete monitoring of the sea level with respect to the coast, also taking into account the geodynamics of the territory itself, especially in areas subject to a significant phenomenon of natural and anthropogenic subsidence, as in the case of the Emilia-Romagna coast. For this purpose, the stations have been equipped with a permanent GNSS to monitor the geodesy of the site. GNSS monitoring allows detection of the altimetric variations of the territory in order to separate the real component of the variation of the mean sea level (eustatism) from other vertical movements, such as the lowering of the territory due to the phenomenon of subsidence.

Figure 5. Location of the tide gauges installed along the Emilia-Romagna coast. In addition to that, other equipment (e.g. wave buoy - Boa ondametrica + correntometro) purchased and installed recently are also shown.

Both tide gauge stations are equipped with two different technology of sea level sensors:

1. a radar sea level sensor
2. a pressure sea level sensor

The depth gauge (or pressure hydrometer), see Figure 6, performs the same functions as the ultrasonic hydrometer, but uses a different operating technology that makes it particularly suitable for measuring the level of streams and underground aquifers, the variations of which are linked to hydrogeological risks (landslides and mudslides).

The all-electronic PLM10 level sensor identifies the level of the liquid body in which it is immersed by measuring its differential pressure: from the total pressure detected, the sensor subtracts the pressure of the column of air weighing on the liquid body, giving the net measurement of fluid pressure. The sensor responds to the stress derived from the fluid pressure by emitting an electrical signal which is decoded by the acquisition unit and converted into meters of depth.

Figure 6. Pressure hydrometer

The radar level sensor (TDR10), visible in Figure 7, is a non-contact, continuous level measurement sensor that guarantees maximum reliability and safety even in the presence of rough surfaces, foam or particularly critical environmental conditions. The TDR10 measurement system uses the Time of Flight (ToF) or Time Domain Reflectometry (TDR) method to measure the distance from the probe reference point to the water surface: in particular, the device sends high-frequency pulses into a probe and through the probe, then the pulses are reflected by the water surface, detected by the processing unit and converted into level data. The reflected pulses are transmitted from the probe to the electronic instrumentation. Here a microprocessor analyzes the signals and identifies the level of echo caused by the reflection of the high-frequency pulses from the product surface.

Figure 7. Radar level sensor

The GNSS station consists of a Leica GM30 receiver (Figure 8), designed for continuous operation in a variety of monitoring scenarios. It includes on-board data logging software, making it completely autonomous. Its low power consumption, highly redundant communication capabilities and ability to withstand harsh environmental conditions make it ideal for use in stand-alone and maritime environments, such as a tide gauge station.

Figure 8. GNSS station (Leica GM30 receiver)

Cervia Tide gauge

The Mareographic station of Cervia (Figures 9-11) has been equipped with the following elements:

1) <u>Mareographic monitoring installation components:</u>

- n°1 Datalogger Compact Plus by CAE: the acquisition unit which is responsible for all the important management activities of the "station" system.
- 1 LTE Gemalto PLS62T-W cellular modem and relative external antenna;
- n°1 Power system consisting of n°1 solar panels of 50W and n°1 battery of 100 Ah;
- n°1 guided wave radar level sensor model TDR10 3m rod,
- n°1 pressure sensor model PLM10 in Titanium;
- n°1 316 stainless steel container;
- n°1 automatic door opening signaling device;
- n°1 pole 2 m;
- n°1 2m tide gauge in AISI 316 stainless steel, 3 mm thick, 156 mm wide, 2 mm resolution and 8 mm side edge, equipped with a 6 mm thick black polyethylene display panel and stainless steel nuts and bolts.
- n°1 topographic stronghold.

2) GNSS tracking installation components:
    - n°1 GNSS LEICA model GN30 with Antenna;
    - 1 NB800 Router;
    - n°1 AISI 316L stainless steel containers;
    - Power supply with 1 buffer battery;
    - n°1 automatic door opening signaling device.
    - n°1 CVT/PT and electrical panel;

Continuous and automatic signal tracing produces RINEX data at different sampling intervals sent to the control center server via FTP.

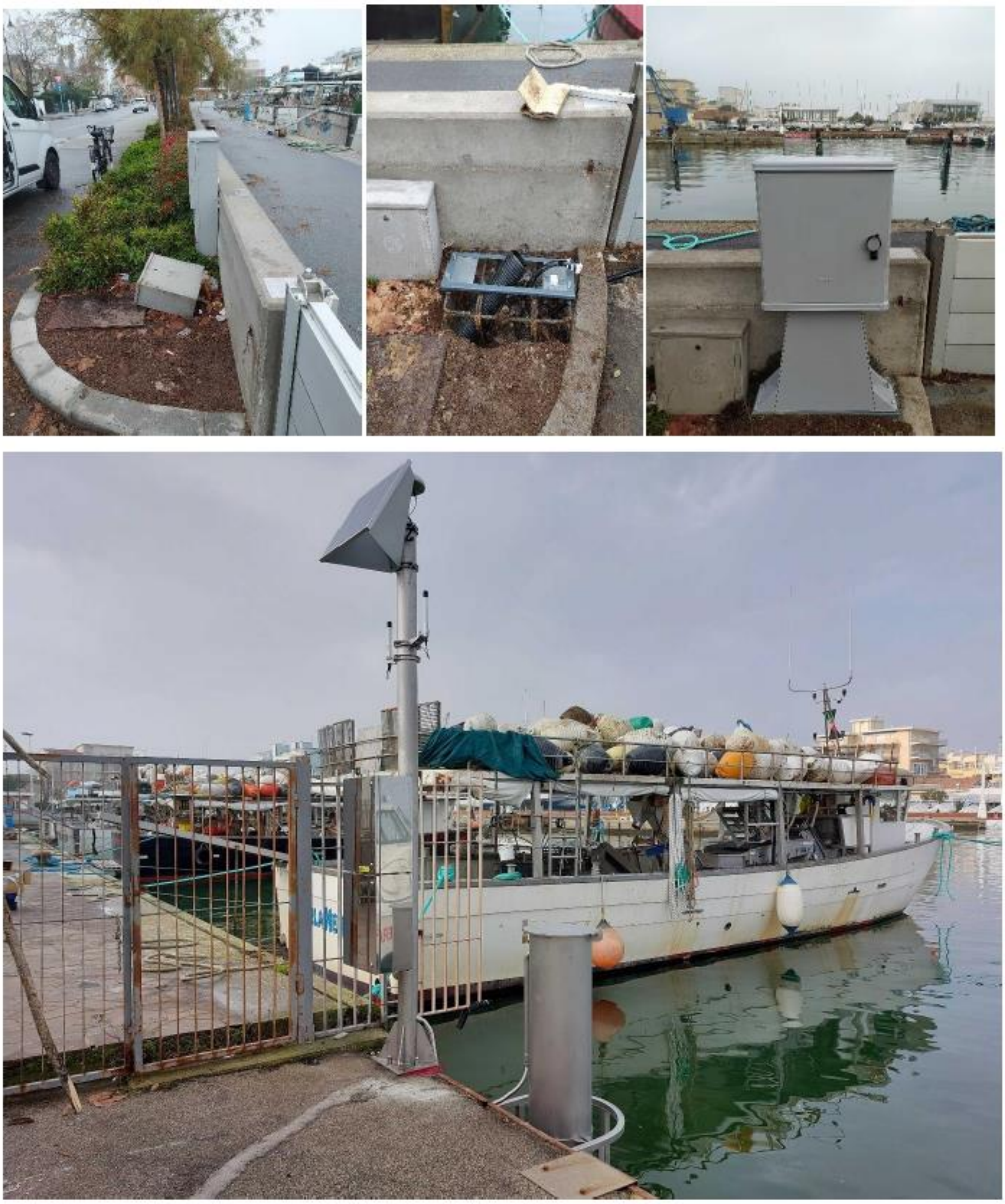


Figure 9. Pictures of the tide gauge installed in Cervia (RA)

Figure 10. Pictures of the tide gauge installed in Cervia (RA)

Figure 11. Picture of the tide gauge installed in Cervia (RA) with the logo

Cattolica tide gauge

The tidal station of Cattolica (Figures 12-15) has been equipped with the following elements:

1) Mareographic monitoring installation components:

- n°1 Datalogger Compact Plus by CAE: the acquisition unit which is responsible for all the important management activities of the "station" system.
- 1 LTE Gemalto PLS62T-W cellular modem and relative external antenna;
- n°1 Power system consisting of n°1 solar panels of 50W and n°1 battery of 100 Ah;
- n°1 guided wave radar type level sensor model TDR10, 5mt rod
- n°1 pressure sensor model PLM10 in Titanium;
- n°1 316 stainless steel container;
- n°1 automatic door opening signaling device;
- n°1 pole 2 m;
- n°1 4m tide gauge in AISI 316 stainless steel, 3mm thick, 156mm wide, 2mm resolution and 8mm side edge, equipped with a 6mm thick black polyethylene display panel and stainless steel bolts.
- n°1 topographic stronghold.

2) GNSS tracking installation components:

- n°1 GNSS LEICA model GN30 with Antenna;
- 1 NB800 Router;
- n°1 AISI 316L stainless steel containers;
- Power supply with 1 buffer battery;
- n°1 automatic door opening signaling device.
- n°1 CVT/PT and electrical panel;
- Continuous and automatic signal tracing produces RINEX data at different sampling intervals sent to the control center server via FTP.

Figure 12. Pictures of the tide gauge installed in Cattolica (RN)

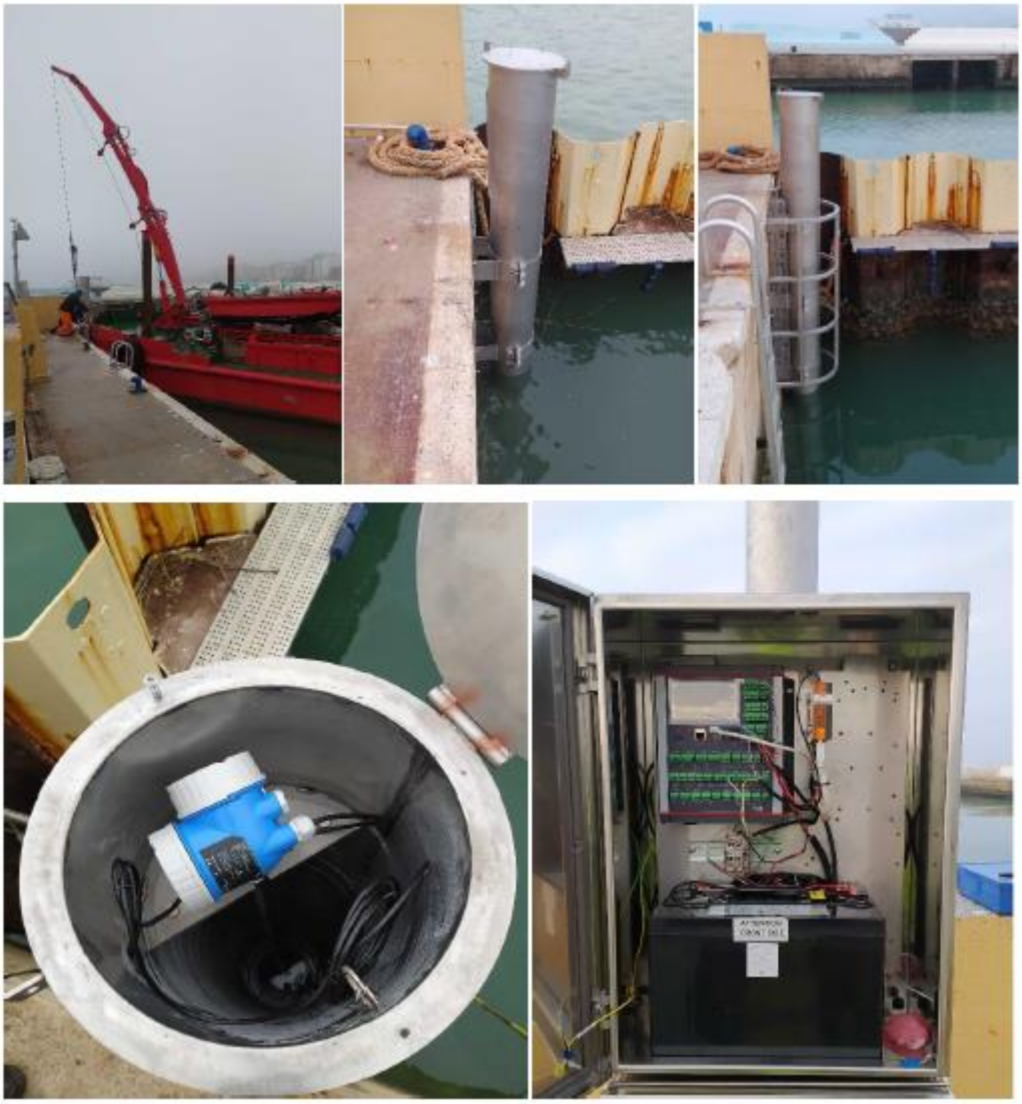


Figure 13. Pictures of the tide gauge installed in Cattolica (RN)

Figure 14. Picture of the tide gauge installed in Cattolica (RN) with the logo

Figure 15. Cattolica tide gauge and GNSS station (RN)

Sea level data measured by the two stations (Cervia and Cattolica) are archived in Arpae's database (available for the public download at https://simc.arpae.it/dext3r/) and visualized in Arpae's public website within the meto-marine monitoring network (https://www.arpae.it/it/temi-ambientali/mare/dati-e-indicatori/rete-di-monitoraggio-meteo-marina - as shown in Figure 16).

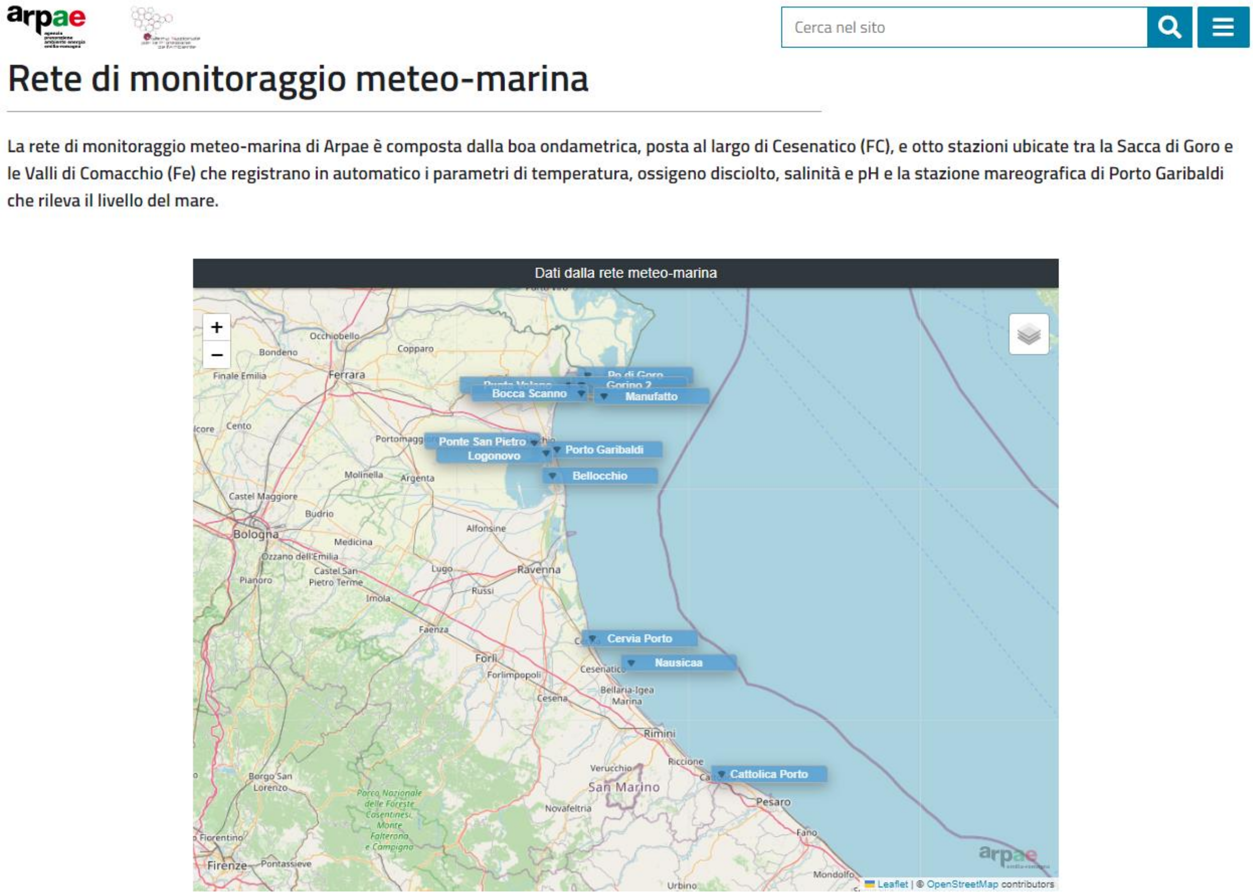


Figure 16. Data visualization on the Arpae pèublic website within the regional meteo-marine monitoring network.

For each station, sea level variations (both radar and pressure sensors) are visualized in a time-variation graph as presented in Figure 17.

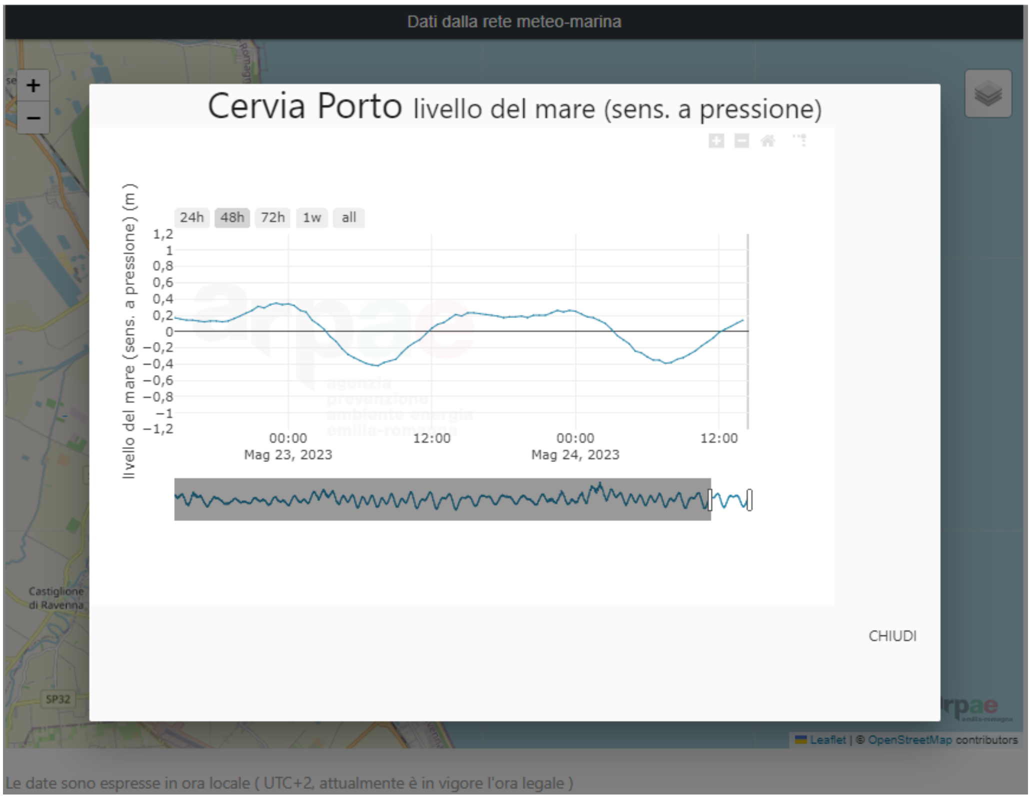


Figure 17. Sea level time series visualized on the Arpae public website

CONCLUSION

Activity 5.2 was completed successfully and produced satisfying results for the project. Regarding D.5.2.2., the processing of webcam images datasets was done by UNIVPM and used to define and identify coastal risk thresholds, as well as to estimate the coastline evolution. Regional observational network will be integrated with tide gauges that will be used for model validation, monitoring of sea level trend during sea storms and for the estimation of the critical thresholds. The regional observing network of the Emilia-Romagna Region was updated with the installation of two tide gauges located in Cattolica and Cervia. Moreover, Arpae intensively worked on the installation of a coastal regional network of webcams with the purpose to improve the environmental monitoring of the coasts through the video monitoring of shoreline evolution.

ANNEXES

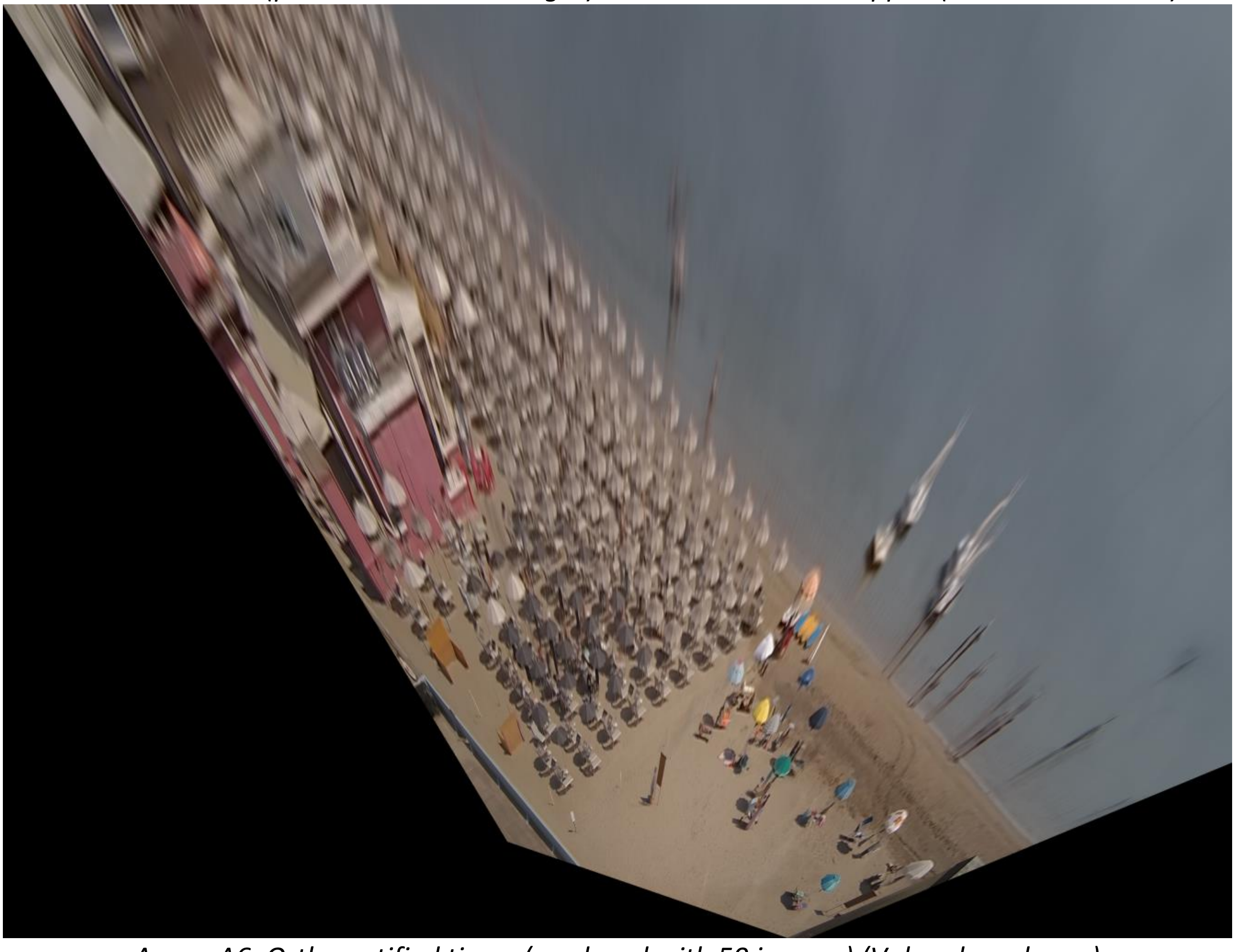
Annex A1. Raw, distorted image collected with the Valverde webcam

Annex A2. Corrected A1 image with rectified dimensions and only valid pixels

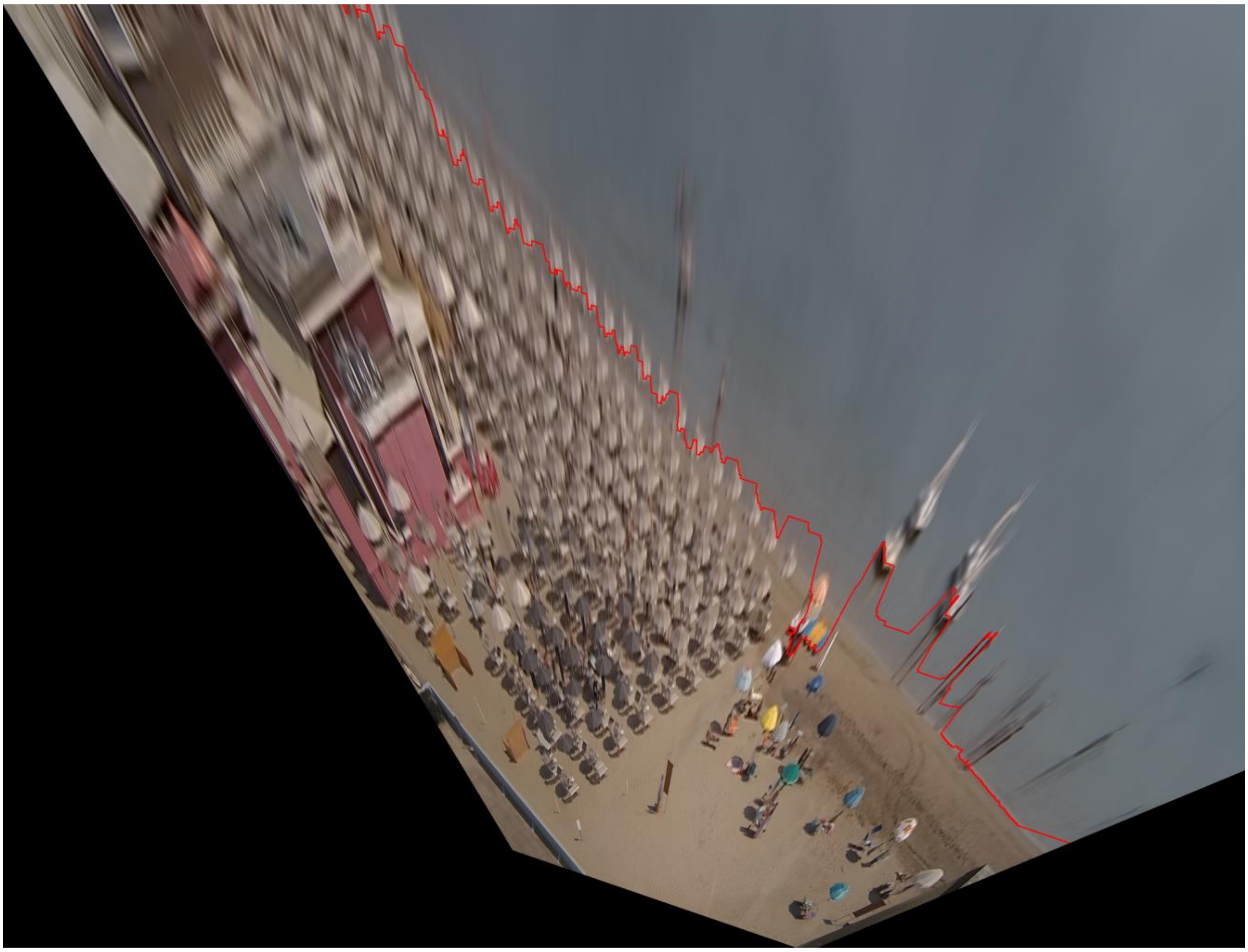
Annex A3. Corrected A1 image with rectified dimensions and all pixels being shown (the invalid pixels are filled in this image, contrary to what happens in image A2 in which the pixels are deleted from the image).

Annex A4. Non distorted timex (produced with 50 images) in one of the calibration steps (Valverde webcam)

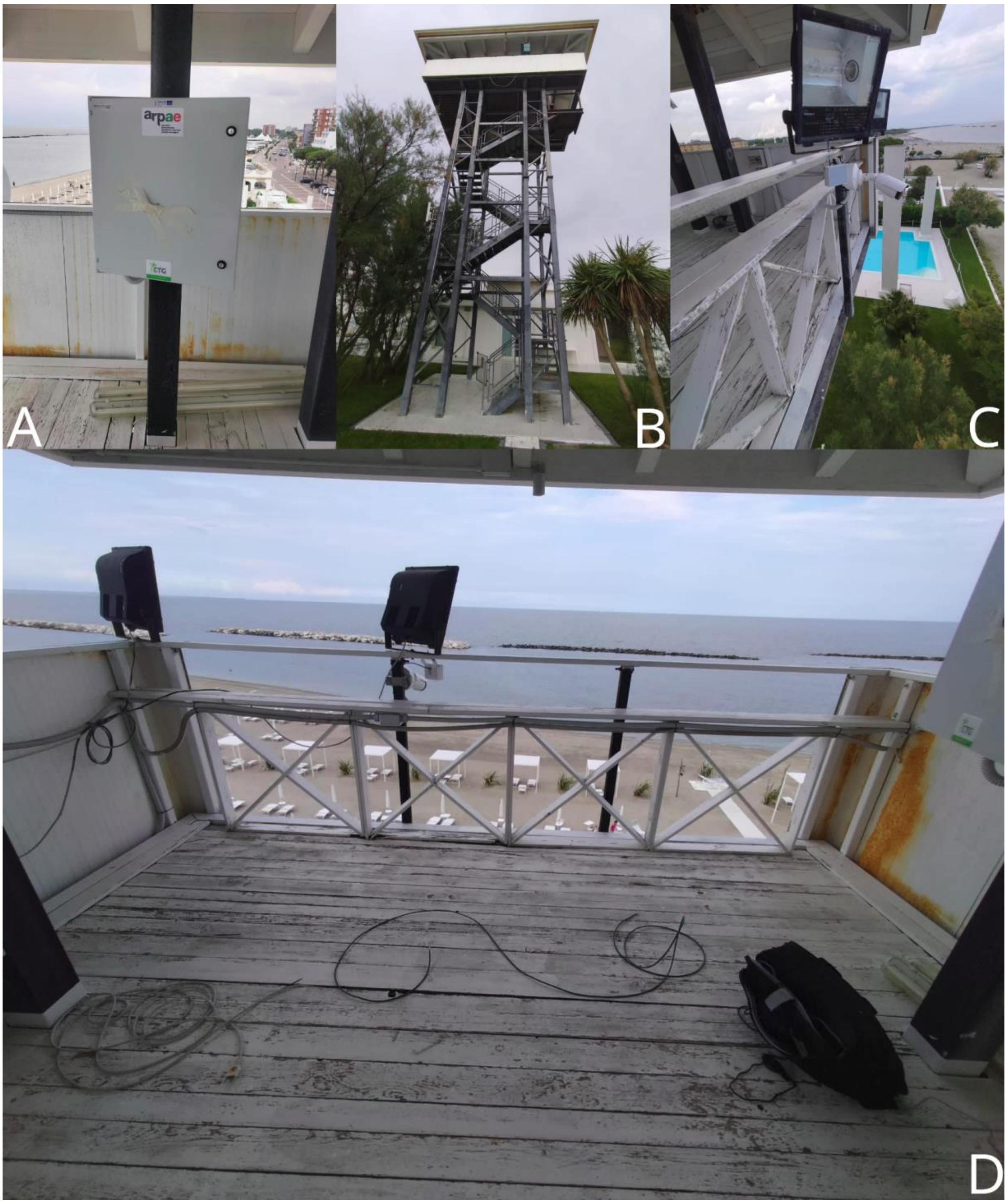
Annex A5. Timex (produced with 50 images) with the shoreline mapped (Valverde webcam)



Annex A6. Orthorectified timex (produced with 50 images) (Valverde webcam)



Annex A7. Orthorectified timex (produced with 50 images) and shoreline mapped (Valverde webcam)



Annex A8. Webcam installed in Lido delle Nazioni (Bagno Prestige)

Annex A9. Webcam installed in Cesenatico (Soleè)