LIFE SAFE-CROSSING

ACTION C1. INSTALLATION OF INNOVATIVE AVC PREVENTION SYSTEMS AND ACCOMPANYING MEASURES

BRIEF TECHNICAL REPORT – DEADLINE August 2023

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

NATURA 2000

Contents

1. Introduction

The LIFE SAFE-CROSSING (LIFE17NAT/IT/464) project aimed at implementing actions to reduce the impact of roads on some priority species in four European countries: Apennine brown bear (Ursus arctos marsicanus) and wolf (Canis lupus) in Italy, Iberian lynx (Lynx pardinus) in Spain, and Brown bear (Ursus arctos) in Greece and Romania. The main actions carried out were:

- Installation of Animal-Vehicle Collision Prevention Systems on most critical road segments;
- Adaptation of crossing structures to enhance connectivity for the target species;
- Development of activities to increase the attention of drivers about the risk of collisions with the target species.

The goal of Action C1 was the installation of 27 Animal vehicle prevention system (AVC-PS) and 34 Km of virtual fence.

This brief technical report presents the functioning of the AVC-PS and the virtual fence, the technical characteristics of these two mitigation measures and the activities carried out in the different project countries for their installation. The maps and the photos of the devices installed in the frame of the project are shown in the Annex of this report.

2. Animal vehicle collisions prevention system (AVC-PS)

The AVC-PS is an innovative electronic system to prevent wildlife vehicle collisions. This system was firstly developed in the LIFE STRADE project and then improved in the frame of the LIFE SAFE-CROSSING project.

The system acts on wildlife and drivers simultaneously and functions as follows (fig. 1): a set of passive infrared sensors (PIR) (1) and/or a thermal camera register the presence of an animal near the road and send the information to the electronic control unit (2). The control unit triggers an alert signal for drivers (3), inviting them to slow down. A radar Doppler sensor (4) measures whether the car actually slows down to the fixed threshold speed (50 Km/h). If it does, the system stops to act. Otherwise, the radar sends a signal back to the control unit. This activates an acoustic scaring device (5), to prevent animal crossing.

All the components of the system are connected through a WIFI network and a modem sends an email each time a component is triggered, as well as their proper functioning

A specific software has been developed in order to store and classify all this type of information, as well as an App through which is possible to control the system in real time.

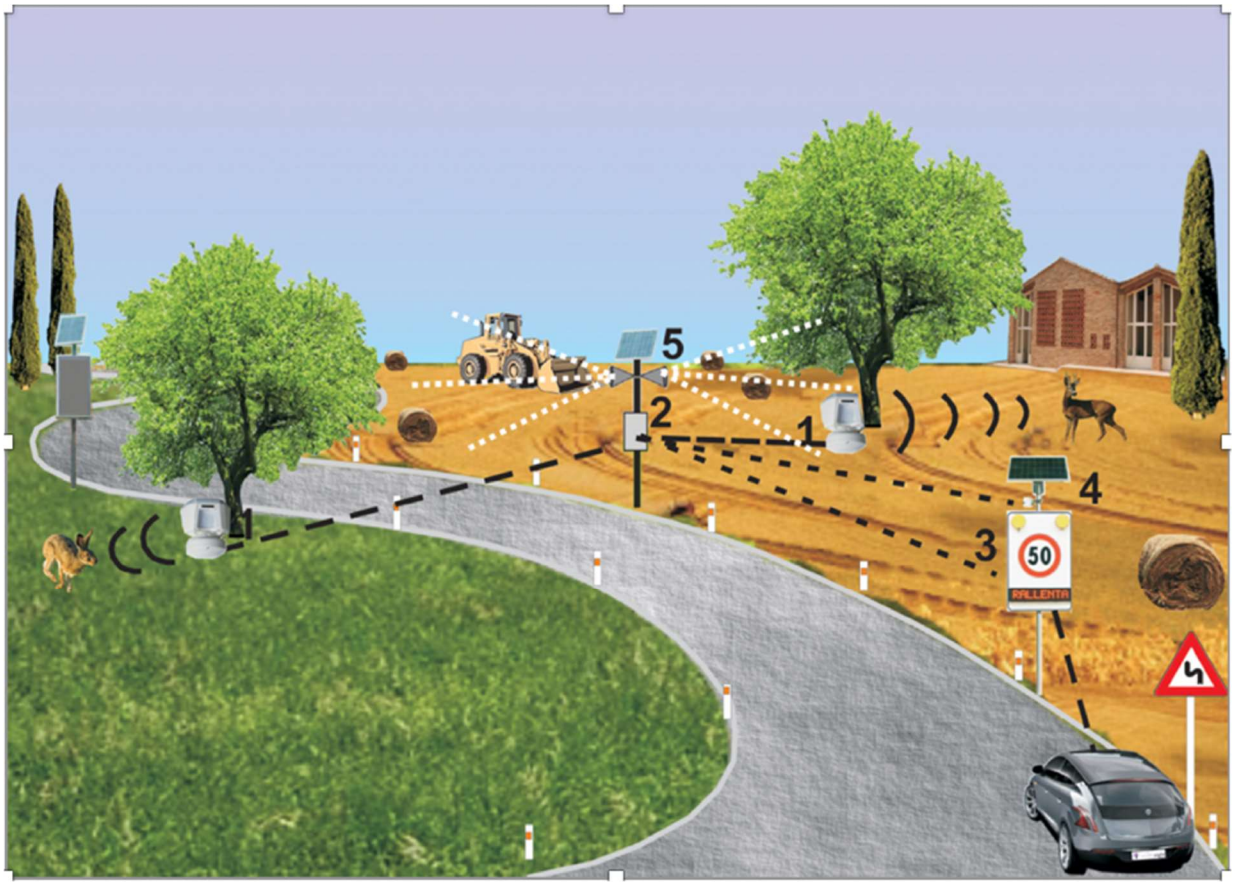

Figure 1. Scheme of the functioning of the AVC-PS

Central unit

The control unit is the core of the system because through a microprocessor sends and receives information from the other components. The control unit is contained in an electronic box installed on a steel pole of a diameter of 90 mm and a height of 4,5 m. The control unit is powered by a battery of 55 Ah charged by a

solar panel of 200 Watt. The router and modem as well as receivers for the PIR sensors are also inside the control unit box (fig. 2, 3, 4 and 5).

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Figure 2. The central unit of the AVC-PS (PNM on the left, Romania on the right).

Figure 3. The central unit of the AVC-PS in Spain.

Figure 4. The central unit of the AVC-PS installed in PNALM

Figure 5. The central unit of the AVC-PS installed in GREECE

PIR sensors

The PIR sensors are used to detect the animals near the road. These sensors are installed along the trails or paths used by animals to approach the road (fig. 6, and 7). They can be installed directly on a tree or on a pole.

The PIR sensors have the following characteristics:

- Detection range: max 12 m; Angle 90°;
- Standby time can be programmed: 5 sec or 120 sec;
- Power supply: Lithium battery of 9 Volt
- They can be installed at a maximum distance of 200 m from the central unit

Figure 6. PIR sensor used to detect the presence of the animals approaching the road in PNALM.

Figure 7. PIR sensor used to detect the presence of the animals approaching the road in PNM.

The thermal camera

Thermal camera is another device that can be used to detect the animals approaching the road. The detection area of the thermal camera can be programmed also considering the direction of movements of the animals (fig 8). For each activation the thermal camera sends 3 snapshots and register a video. The thermal camera is located in the electrical box of the central units and has two lenses one optical and one thermal.

The technical characteristics are the followings:

- Detection range: around 100 m;
- Field of view: H 87,8° V 63,8°

Figure 8. Thermal camera installed in the electrical box of the central unit and programming of the detection area (PNM).

Panels for drivers and radar doppler

The panels for drivers are installed on both sides of the road. They have a size of 60x90 with the traditional wildlife crossing sign and two flashing lights. Above these panel there is another one with alphanumeric writings (20x40 cm). Both panels are installed on a steel pole of 60 mm of diameter and height of 4 m. The panels are powered by a battery of 55 Ah charged by a solar panel of 100 Watt. On the steel pole above the flashing light panels there is a radar Doppler to measure the speed of the approaching vehicles. Depending on the size of the vehicle the detection distance of the radar Doppler is around 100-200 m (fig. 9). Behind the flashing light panel there Is an electrical box where the battery, a receiver and transmitter signal for communicating with the central unit are located.

Once the PIR sensors or the thermal camera are activated firstly the writing “Animal on the road” appears on the alphanumeric panel, when the Coppler register the presence of a vehicle the lights of the panel start to flash and the writing begin to switch continuously from “animal on the road” to “slow down”.

Figure 9. Flashing light panel and alphanumeric writing to alert drivers (PNM).

Acoustic deterrent

In order to prevent wildlife road crossing if there is a vehicle proceeding at too high-speed tracks of different nature are activated. An MP3 player is located in the electrical box of the central unit and the sounds are diffused by two loud speakers of 30 Watt installed on the top steel pole of the central unit (fig. 10).

The track sounds are chosen randomly in order to avoid possible habituation by wildlife, and the sounds are triggered for each vehicle detected in the 3 minutes after the activation of the PIR sensors or the thermal camera.

Figure 10. Loudspeakers above the electrical box of the central unit (Terni Province).

Software

The activations of the system are stored in a software that classify the email sent by the modem. The data collected are:

- System switch-on;
- System switch-off;
- Activation of the PIR sensors;
- Activation of the thermal camera with attached the snapshot;
- Activation of the mp3 player;
- Speed reduction

There data can be exported as an excel file and can be visualized as a table on hourly basis or in a graph format (fig 11).

The activation of the PIR sensors and the ones of the thermal camera represent the times when the presence of an animal near the road has been detected, while the activation of the mp3 player means the passage of a vehicle proceeding at more than 50 Km/h in the 3 minutes after the detection of an animal.

Speed reduction is measured as the decrease of 20Km/h after 4 seconds its first detection when the flashing light panels and alphanumeric writings are triggered.

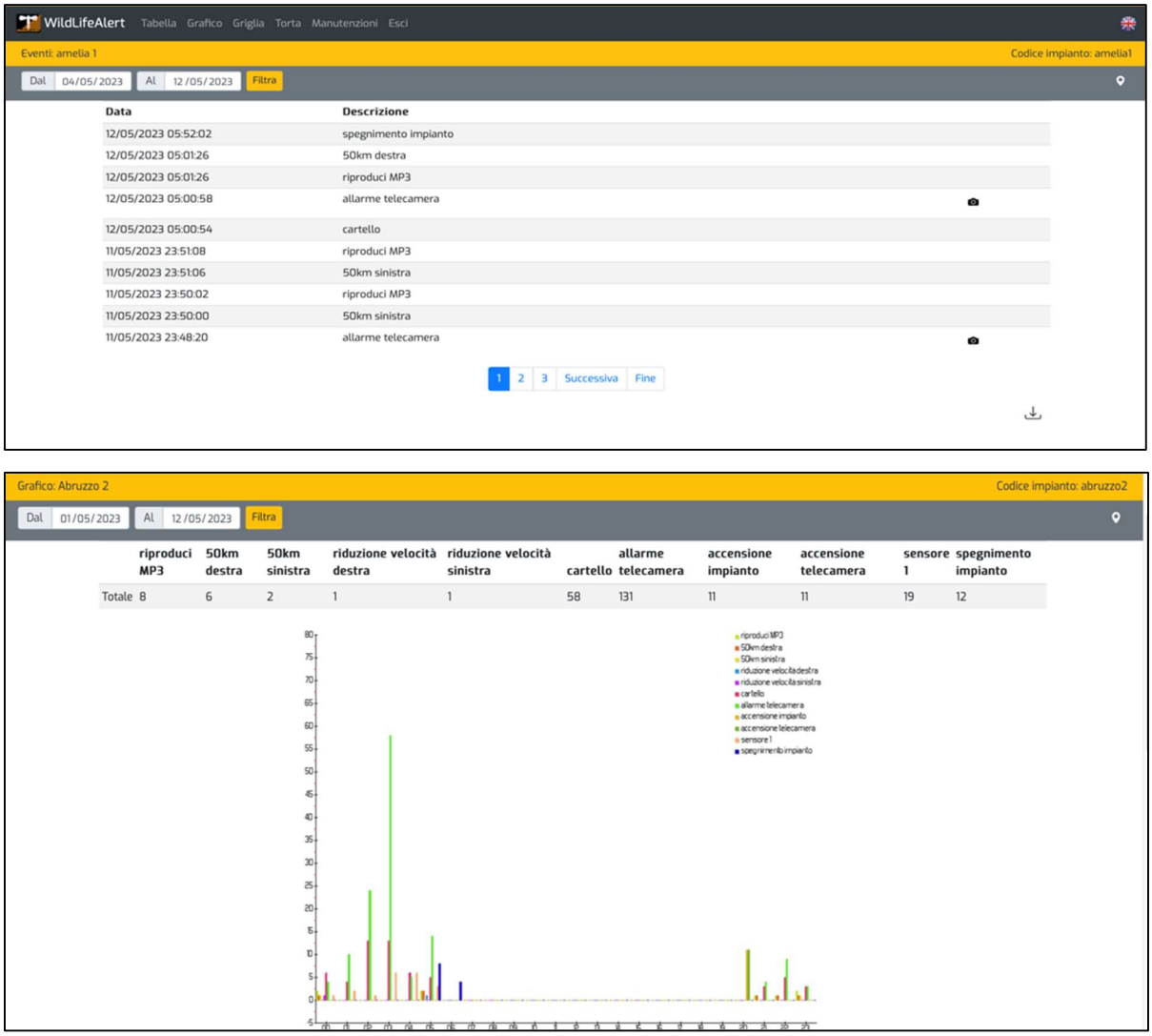


Figure 11. Screenshots of the software to analayze the activations of the AVC-PS

App

The functioning of the AVC-PS can be controlled in real time through an App with which it's possible to check if the system is properly working as well as to programme the operating time of the system and to have access to the thermal camera (fig. 12 and 13).

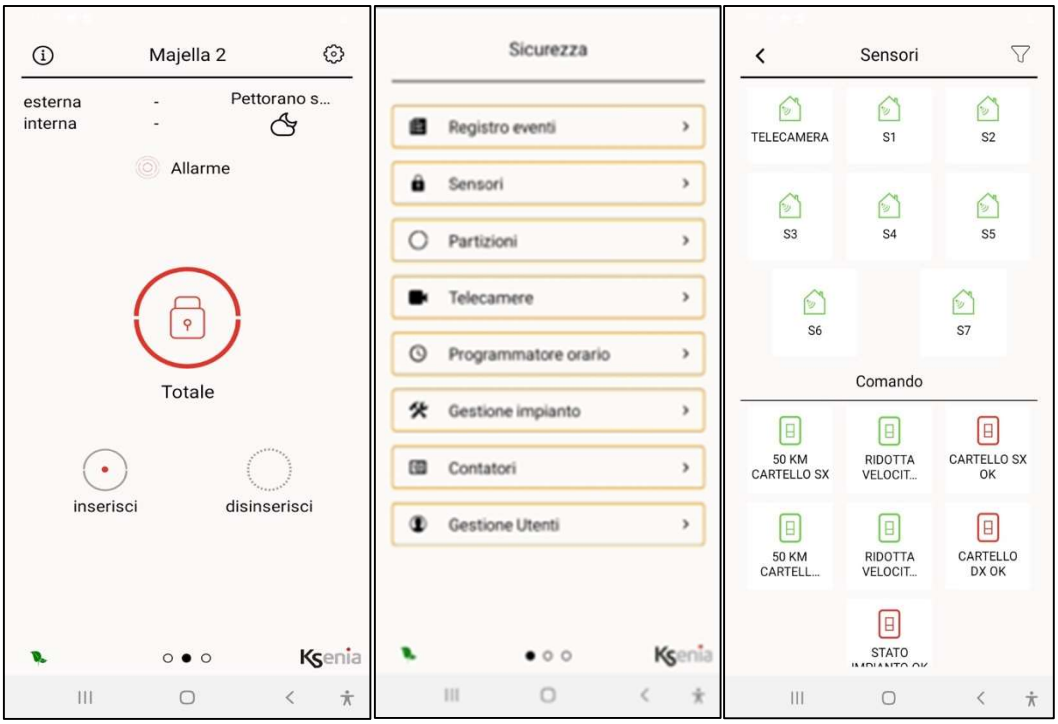


Figure 12. Screenshots of the APP illustrating AVC-PS settings

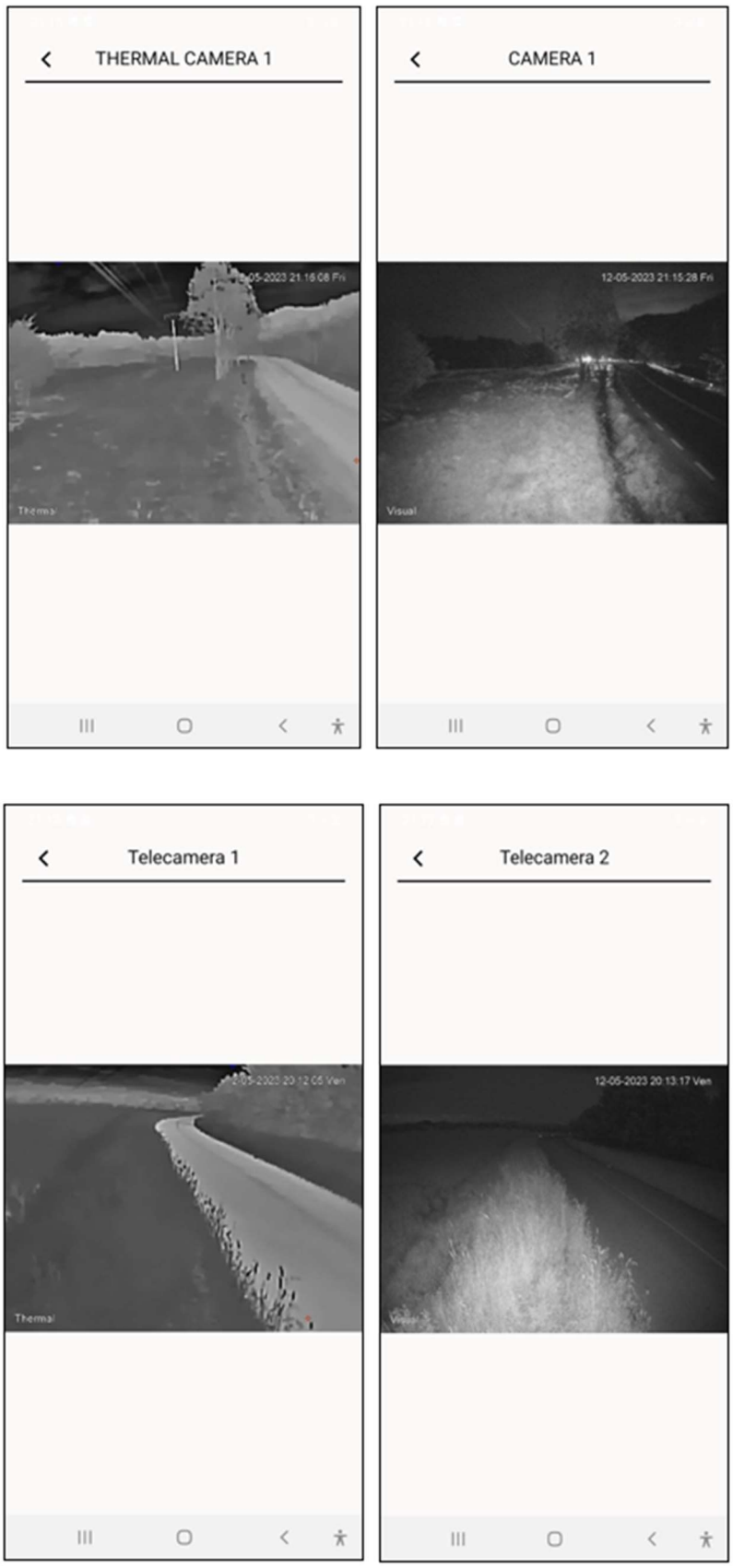


Figure 13. Real time control of the thermal camera through the App (AVC-PS Romania2 above and AVC-PS in terni Province below). Optical and thermal mode of the detection area.

3. Virtual fence

The virtual fence (VF) consists in a series of electronic devices installed on the road posts on both sides of the road (fig. 14). These devices, powered by a lithium battery charged by a solar cell, generate sound and light stimuli when activated by the headlights of approaching vehicles to avoid wildlife road crossings.
Each unit has strobing LEDs, which emit blue and amber light, and two sound settings, one for rural areas and a higher frequency for residential areas.
The main feature of the 'virtual fence' is that it actively emits light in response to a vehicle's lights, rather than reflecting the vehicles' light as wildlife warning reflectors do, therefore the units of the virtual fence are called wildlife active warning reflectors. This is possible because each unit has a sensor that once is hit by the headlights of the vehicles triggers the sound and light stimuli.
The units are aligned so that the sound and light they emit are directed away from the road surface and towards the roadside verge.
In the PNM area a new type of devices has also been installed. These devices are wireless connected so when the first one is activated, it triggers the following devices, this can be particular useful in the road segments with many curves. Each chain of devices wireless connected is composed by 12 units.

Figure 14. Unit of the virtual fence installed on a road post in Spain.

The units are generally spaced 50 meters from each other along the same side of the road, it means that generally 40 devices are mounted in 1 Km of road (fig. 15).
The installation on the road posts is very easy, because the devices are attached to the post using simple screws (fig. 16).
In Romania the units were mounted on poles specifically installed for this purpose (fig. 17)

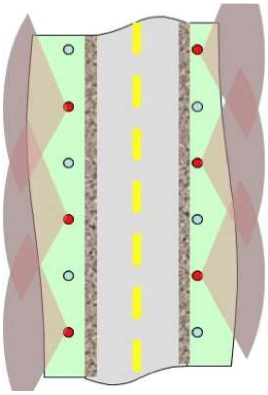


Figure 15 Positioning scheme of the devices (red dot) of the virtual fence.

Figure 16. Installation of the VF unit on the road post in PNM on the left and in PNALM on the right.

Figure 17. Installation of the VF fence in Romania

Besides on the road posts, the devices can be installed also on the guardrails (fig. 18) and on a concrete wall (fig. 19) or using specific mounting accessories as was made in PNM project area.

Figure 18 Installation of the VF device on guardrail in PNM.

Figure 19. Installation of the VF device on a concrete wall in PNM.

4. Installation of AVC-PS in the project area

In the frame of the project 26 AVC-PS were installed: 10 in Italy (5 in PNM, 3 in PNALM, and 2 in the Terni Province), 5 in Romania, 4 in Spain and 6 in Greece. In Romania one of the foreseen AVC-PS was replaced by 2 Km of virtual fence because a new critical area appeared during 2022, and there the installation of the AVC-PS was not possible.

On the results of Action A3 and A5, the AVC-PS and the virtual fence were installed in the areas at highest risk (hotspots) considering the road mortality data, the crossing points used by the target species, and the characterization of the road segments, and last but not least the ecological importance of the areas for the target species.

Once the site was selected, field inspections were made to define the position of the different components of the system.
In each road segment the installation of the AVC-PS was authorized by the local road management authority.
The installation of the AVC-PS requested a huge amount of work not only from a technical point of view but also from the administrative ones.
The administrative procedures for the purchase and installation of the AVC-PS were complex because in the tender we had to specify all the components to be installed, and especially in Romania, Greece and Spain it was very difficult to find a local company that was able to install such kind of system. Moreover, during the project implementation, a part from the problems related to the pandemic of Covid 19, there was a huge amount of price that requested several budget shifts.
The details of the components of each of the 26 AVC-PS installed are presented in the following paragraphs, while all the photos and the maps of all the installed AVC-PS are in the Annex 1.
For each AVC-PS there is a table specifying all the components of the system, while in the text we reported the number and type of components used to detect the animals approaching the road, because the other components, central unit and flashing light panels, are always included in all the AVC-PS.

Italy

The installation of AVC-PS in Italy was carried out by the Maiella National Park, the Abruzzo Lazio e Molise National Park and the Terni Province.

PNM

In the project area 5 AVC-PS were installed in 4 sites, because in one of them a double system was installed.
The administrative procedure to purchase the AVC-PS started in June 2020. The company I.S.E. Snc won the tender, however, at the beginning of November 2020 this company communicated that they were not able to respect the signed contract. Therefore, PNM signed a new contract with the second company selected by the original tender.
4 AVC-PS were installed on the national road SS17, and 1 on the road SS 487 (tab. 1).
The installation of the devices was authorized by ANAS, because all the road segments are under their responsibility.

AVC-PS code	Road code	Municipality	Date of installation	Components
Maiella 1	SS 487	Caramanico Terme	19/01/2021	1 Central unit 2 flashing light panels+ alphanumeric signals 7 PIR sensors
Maiella 2	SS 17	Pettorano sul Gizio	15/12/2020	1 Central unit; 2 flashing light panels+ alphanumeric signals 1 thermal camera and 8 PIR sensors
Maiella 3	SS 17	Rocca Pia	15/12/2021	1 Central unit 2 flashing light panels+ alphanumeric signals 2 thermal cameras
Maiella 4*	SS 17	Corfinio	03/03/2021	2 Central units 4 flashing light panels+ alphanumeric signals 1 thermal camera and 7 PIR sensors

Table 1. AVC-PS installed by the Maiella National Park.

* Maiella 4 is a double system

Maiella 1

The installation on the SS 487 road started the 19/01/2021.7 PIR sensors were installed to cover the paths used by the wildlife to approach the road, already identified in the frame of Action A5. In June 2021 one thermal camera was also added in order to record videos of the animal passages, but due to problems related to battery consumption, and the difficulty to record the videos related to the environmental characteristics of the site, we decided to turn off the thermal camera and to move it to another AVC-PS.

Maiella 2

The installation of the AVC-PS started the 15/12/2020 on SS17 in the territory of Pettorano sul Gizio. The system includes one thermal camera and 8 PIR sensors. The thermal camera is used to cover the open area on one site of the road while in the other side, due to presence of bushes and trees we used PIR sensors. At the beginning 5 PIR sensors were installed and 3 more were added in March 2022 to cover other paths used by wildlife to approach the road.

Maiella 3

The installation of the AVC-PS started the 15/12/2020 on SS17 road in the territory of Rocca Pia. The system includes two thermal cameras, because the area is completely open and then the thermal camera represents the best option in this condition. At the beginning only one camera was installed, then another one was added in September 2021 in order to increase the detection area.

Maiella 4

The installation of this double system started the 3/03/2023 on SS17 road in the territory of the municipality of Corfinio. This double system includes one thermal camera 7PIR sensors, 2 central units and 4 flashing light panels plus alphanumeric signals. The choice to install 2 AVC-PS in the same road segment was made because paths used by wildlife to cross the road were identified in a long road stretch, too long to be covered by 1 system. Therefore 4 flashing panels (2 for each road side) rather than 2 were installed as well as 2 central units, both of which equipped with the acoustic deterrence device.

PNALM

In the project area 3 AVC-PS were installed, 2 on the SS83 road and 1 on the SS17 road (tab. 2).

The installation of the devices was authorized by ANAS, because all the road segments are under their responsibility.

AVC-PS code	Road code	Municipality	Date of installation	Components
Abruzzo 1	SS 83	Pescasseroli	27/04/2021	1 Central unit 2 flashing light panels+ alphanumeric signals 2 thermal cameras and 4 PIR sensors
Abruzzo 2	SS 83	Barrea	31/05/2021	1 Central unit; 2 flashing light panels+ alphanumeric signals 1 thermal camera and 1 PIR sensor
Abruzzo 3	SS 17	Castel di Sangro	07/04/2021	1 Central unit 2 flashing light panels+ alphanumeric signals 1 thermal camera

Table 2. AVC-PS installed by the Abruzzo Lazio e Molise National Park.

Abruzzo 1

The installation of the AVC-PS started the 31/05/2021 on SS 83 road in the territory of the municipality of Pescasseroli. The system includes 2 thermal cameras and 4 PIR sensors. The second thermal camera was added in February 2022 to better cover the area used by animals to approach the road.

Abruzzo 2

The installation of the AVC-PS started the 31/05/2021 on SS 83 road in the territory of the municipality of Barrea. The system includes 1thermal camera and 1 PIR sensors.

Abruzzo 3

The installation of the AVC-PS started the 07/04/2021 on SS 83 road in the territory of the municipality of Castel di Sangro. The system includes only 1 thermal camera because it was possible to check both sides of the road. In this area, in October 2022, we started the installation of a fence on both side of the road (Action C2) therefore this system was moved to a new area in July 2023.

The new site of installation is located on SS83 in the territory of the municipality of Pescasseroli, where one AVC clusters were identified in the frame of Action A3.

Terni Province

In the project area 2 AVC-PS were installed, 1 on SP 38 road and 1 on SR 205 road (tab. 3).
No specific authorization was needed, because both rod segments are under the responsibility of the province.

AVC-PS code	Road code	Municipality	Date of installation	Components
Amelia 1	SP 38	Montecastrilli	09/02/2022	1 Central unit 2 flashing light panels+ alphanumeric signals 2 thermal cameras
Amelia 2	SR 205	Amelia	09/05/2022	1 Central unit; 2 flashing light panels+ alphanumeric signals 11 PIR sensors

Table 3. AVC-PS installed by the Terni Province.

Amelia 1

The installation of the AVC-PS started the 09/02/2022 on SP38 in the territory of the municipality of Montecastrilli. The system includes 2 thermal cameras. The second thermal camera was installed on a different pole from the central unit with the other camera. This was made to cover a longer stretch of the area used by animals to approach the road. The pole with the second thermal camera included another acoustic deterrence device.

Amelia 2

The installation of the AVC-PS started the 09/05/2022 on SR 205 in the territory of the municipality of Amelia. The system includes 11 PIR sensors to cover the main paths used by wildlife to approach the road.

Romania

The installation of AVC-PS in Romania was carried out by INCDS in cooperation with Fundatia Carpati.

5 AVC-PS were installed 2 on the following roads: 2 on DN1 road, 1 on DN 1A, 1 on DN 13 and 1 on DN 73A (tab. 4). The

The installation of the devices was authorized by the national road management authority.

AVC-PS code	Road code	Municipality	Date of installation	Components
Romania 1	DN 1	Timisul de Jos	24/11/2022	1 Central unit 2 flashing light panels 1 thermal camera
Romania 2	DN 73A	Parau Race	09/12/2022	1 Central unit 2 flashing light panels 1 thermal camera
Romania 3	DN 1A	Babarunca	09/12/2022	1 Central unit 2 flashing light panels 1 thermal camera
Romania 4	DN 13	Padurea Bogatii	8/12/2022	1 Central unit 2 flashing light panels 1 thermal camera
Romania 5	DN 1	Persani	8/12/2022	1 Central unit 2 flashing light panels 1 thermal camera

Table 4. AVC-PS installed in Romania.

Romania 1

The installation started the 24/11/2022 on the road DN 1 in the territory of the municipality of Timisul de Jos. The system includes 1 thermal camera.

Romania 2

The installation started the 09/12/2022 on the road DN 73 A in the territory of the municipality of Paraul Race. The system includes 1 thermal camera.

Romania 3

The installation started the 09/12/2022 on the road DN 1A in the territory of the municipality of Babarunca. The system includes 1 thermal camera.

Romania 4

The installation started the 08/12/2022 on the road DN 13 in the territory of the municipality of Padurea Bogatii. The system includes 1 thermal camera.

Romania 5

The installation started the 08/12/2022 on the road DN 1 in the territory of the municipality of Persani The system includes 1 thermal camera.

Spain

In the project area 5 AVC-PS were installed in 4 sites, because in one of them, two devices were installed on the same road segment. 2 systems were installed in Donana area while 3 in Sierra Morena (tab. 5).

All the road segments are under the responsibility of the regional government therefore no specific authorization is needed because the Junta de Andalucia is an associated beneficiary of the project.

The installation was supervised by the technical staff of AMAYA.

AVC-PS code	Road code	Municipality	Date of installation	Components
Spain 1	A 301	Vilches	19/04/2023	1 Central unit 2 flashing light panels+ alphanumeric signals 6 PIR sensors
Spain 2	A 481	Hinojos	18/04/2023	1 Central unit 2 flashing light panels+ alphanumeric signals 5 PIR sensors
Spain 3	A 481	Villamanrique	18/04/2023	1 Central unit; 1 audio repeater 2 flashing light panels+ alphanumeric signals 6 PIR sensors
Spain 4*	CO 3102	Adamuz	19/04/2023	2 Central units 4 flashing light panels+ alphanumeric signals; 6 PIR sensors

**Spain 4 is a double system*

Table 5. AVC-PS installed in Spain.

Spain 1

The installation started the 19/04/2023 on the road A 301 in the territory of the municipality of Vilches. The system includes 6 PIR sensors.

Spain 2

The installation started the 18/04/2023 on the road A 481 in the territory of the municipality of Hinojos. The system includes 5 PIR sensors.

Spain 3

The installation started the 19/04/2023 on the road A 481 in the territory of the municipality of Villamanrique. The system includes 6 PIR sensors.

Spain 4

The installation of this double system started the 19/04/2023 on the road CO 3102 in the territory of the municipality of Adamuz. This double system includes 2 central units, 6 PIR sensors, and 4 flashing light panels plus alphanumeric signals (2 for each side of the road). As was the case in Maiella 4, the choice to install 2 AVC-PS in the same road segment was related to the fact that paths used by wildlife to cross the road were dispersed on a long road section not possible to be covered by 1 AVC PS.

Greece

In the project area 6AVC-PS were installed in 5 sites, because in one of them, a double system was installed in the same road segment (tab. 6).

The installation of the devices was authorized by the regional road management authority.

Greece 1

The installation started the 7/08/2023 on the Old national road Ptolemaida – Florina in the territory of the municipality of Amyntaio. In this road segment, as we did in Italy in PNM and in Spain, we installed a double system. This double system includes 6 PIR sensors, 1 thermal camera 2 central units, and 2 flashing light panels. Thermal camera was installed to cover one area while the other one was covered by PIR sensors.

Greece 2

The installation started the 7/8/2023 on the road New national road Ptolemaida - Florina in the territory of the municipality of Amyntaio The system includes 16 PIR sensors because there were a lot of paths to be monitored.

Greece 3

The installation started the 7/8/2023 on the New national road Ptolemaida – Florina in the territory of the municipality of Amyntaio. The system includes 7 PIR sensors.

Greece 4

The installation started the 7/8/2023 on the County road Amyntaio-Kastoria in the territory of the municipality of Amyntaio. The system includes 6 PIR sensors and 2 central unit. The second central unit was necessary because there were two separate areas mainly used by animal to cross the road, then we had to activate the acoustic deterrence in the area farthest from the central unit. This AVC-PS could be considered as another double system

Greece 5

The installation of this system started the 7/8/2023 on the County road Metamorfosi Fotini Lithia in the territory of the municipality of Kastoria. The system includes 7PIR sensors.

AVC-PS code	Road code	Municipality	Date of installation	Components
Greece 1*	Old national road Ptolemaida - Florina	Amyntaio	7/8/2023	2 Central units 2 flashing light panels 1 thermal camera 6 PIR sensors
Greece 2	New national road Ptolemaida - Florina	Amyntaio	7/8/2023	1 Central unit 2 flashing light panels 16 PIR sensors
Greece 3	New national road Ptolemaida - Florina	Amyntaio	7/8/2023	1 Central unit 2 flashing light panels 7 PIR sensors
Greece 4	County road Amyntaio-Kastoria	Amyntaio	7/8/2023	2 Central units 2 flashing light panels 6 PIR sensors
Greece 5	County road Metamorfosi-Fotini-Lithia	Kastoria	7/8/2023	1 Central unit 2 flashing light panels 7 PIR sensors

**Greece 1 is a double system*

Table 6. AVC-PS installed in Greece.

5. Check of the AVC-PS functionality

The functioning of the AVC-PS was constantly monitored remotely through the APP and regular field inspections were made to check the proper functioning of the components.

During these field inspections we checked the PIR sensors and the thermal camera in order to see if they were triggered when a person entered in the detection area.

Once the PIR sensors and the thermal camera were activated, we checked the functioning of the flashing light panels as well as the alphanumeric signs and then the proper activation of the acoustic scaring device.

In the setup phase of the systems in order to evaluate the position and the functioning of the PIR sensors, it was very useful the installation of camera traps to see if the passage of animals detected by the cameras were recorded by the PIR sensors (fig. 18 and 19).

This was particularly useful to understand if the PIR sensors were installed at the right height above the ground and which species were detected.

We made several tests also with dog of small-medium size to better evaluate the detection of small mammals by PIR sensors (fig. 20).

For the same purpose, the set up of the thermal camera, after the installation, was evaluated analysing the 3 snapshots of each activation and the downloaded of the videos.

This analysis was made to understand if the thermal camera was well oriented and the detection area well designed, or some adjustments were necessary.

The videos collected through the use of camera traps as well the activations of the thermal camera were analyzed in the frame of Action D1.

During project implementation we have to face different technical problem

The most common problems and the attention points are:

- Battery charge:

During winter months especially in mountain areas, in case of prolonged bad weather, the solar panel struggled to charge the battery of the central unit, especially where two thermal cameras were installed. In this case the system was not able to complete the daily cycle, and it stopped to function before the fixed hour. To solve the problems the battery of the central unit was replaced with a new performing one.

- Cable corrosions

Cables corrosion occurred where salt was used to clean the roads after the snow-falls, and in areas with a high humidity rate. The problem was localized at the junction of the cables. This problem was solved inserting the cables directly in the electrical box, avoiding to have a junction outside the box.

- Internet connection

In some sites in Italy (PNALM-Abruzzo1, and Terni province-Amelia 1), we had problems in data transmission, due to a bad internet coverage. This was probably related to the national transition to 5 G, that caused problems in the data flow. We replaced the modem, trying different models, but in Abruzzo 1 the problem persisted and it was programmed the change of the central unit.

- Video downloading

The video downloading from the thermal camera in the AVC-PS in Italy was not always possible remotely, because the internet connection wasn't always able to support the download of the videos.

In Romania and Greece, the use of a more powerful SD card of the thermal camera improved the situation, and this model was already programmed to be installed in Italy.

Figure 18. Camera trap and PIR sensor in PNM.

Figure 19 Camera trap and PIR sensor in Terni province.

Figure 20. Test to check the functioning of the PIR sensors of the AVC-PS using a dog in PNM.

6. Installation of Virtual fence in the project area

In the frame of the project 36,5 Km of virtual fence were installed: 7 Km in Romania, 25 Km in Italy (20 PNM; 5 PNALM) and 4,5 in Spain. The installation of the virtual fence was not foreseen in Greece and in the Terni Province.

In each country the installation of virtual fence was authorized by the road management authority.

Italy

PNALM

The total length of the virtual fence installed, as was foreseen in the project proposal, was 5 Km.

The installation started on 11/05/2021 on the SP 17, and the following days on two road segments of the road SS 83. A total of 163 units of VF were installed on SP 17, while 17 and 22 in two test sites along the SS 83. In March 2022 all the devices of the VF installed on the SS83 were moved to SP 17, because on the SS 83 some devices were stolen and few were damaged, therefore it was decided that was more useful and effective to concentrate all of them in one single area. In PNALM all the devices were mounted on the posts already present on the road sides.

PNM: The total length of the virtual fence, as was foreseen in the project proposal was 20 Km.

The preparatory phase of this intervention was very complex, because the units had to be installed, not only on the posts already present on the road sides, but also on concrete walls, guard rails and snow poles, therefore in these cases special mounting accessories were needed, and they had to be exactly included in the tendering procedures. This implied that the road segments were surveyed meter by meter in order to assess the type of barriers present on the road sides.

The installation of VF started on June 2022 and in October the installation of ~12,5 Km of VF was finalized. The remaining ~7,5 Km of VF were installed in spring 2023, due to the delay caused by ANAS and extensively explained in the dedicated section of the Final Report.

In PNM the VF was installed on the SS487 (4,4 Km), on the SS17 (9,7 Km) and on SS 5 (5,3 Km).

On the SS 487 the VF was installed on two road stretches, one of 3,2 Km was equipped with 100 units regular and wireless devices in June 2022, the other of 1,2 Km, to complement the AVC-PS Majella 1, was equipped with 40 units always a mix of regular and wireless devices in October 2022.

On the SS 17 the first 6 Km of VF were installed to complement the AVC-PS Maiella 2; A total of 200 regular units were used to cover this segment. The other 1,4 Km of VF, using 40 regular units, was installed in October 2022 in the area of the double AVC-PS Maiella 4. The installation of VF on SS17 was than concluded in Spring 2023 when 2,30 Km of VF were installed in the area between the AVC PS Maiella 2 and Maiella 3.

On the SS5, in Spring 2023, three road stretches were equipped with VF, one of 1,3 Km wit 50 regular units, the second of 1,7 Km with 50 regular and wireless units and the remaining one of 2,3 Km with 60 regular and wireless units.

The only change respect to what was planned was the impossibility to install the VF on the SS17 in the area of Altopiano delle Cinquemiglia where AVC-PS Maiella 1 was already installed.

Overall, the action was successfully implemented and VF was installed on 4 AVC “high sureness” clusters and 1 AVC cluster identified in Action A3 and complemented 4 out of 5 AVC-PS installed by PNM.

It’s also important to underline that PNM is the only project partner that installed the wireless connected devices, special chain of VF units, where only the first (or the last) device needs to be activated by the

headlights of the car, while the devices in the middle are triggered through the wireless connection. These special chains are specifically designed to maximize the VF activation and functioning in curvy road segments where activation of the regular device is affected by nonoptimal angles between the device and car lights and then the timing of the activation of the units.

Romania

The total length of the virtual fence installed was 7 Km respect to 5 foreseen in the project proposal.

The first 2 Km of virtual fence was installed on DN1 road, in the municipality of Timisul de Jos (sector Romania 1), on 20/07/2020, while another 1 Km was installed on 13/06/2022 to increase the area covered by this prevention tool. Overall 75 regular units of VF were mounted along this road stretch. The VF was installed in the same road segment where in 2023 we installed the AVC-PS Romania 1

In the municipality of Persani, on the E68, DN1 Brasov-Vladeni road (sector Romania 5) 2 Km of virtual fence (56 regular units) were installed the 24/03/2022. The VF was installed in the same road segment where in 2023 we installed the AVC-PS Romania 5

In relation to the number of road kills registered on the DN 11 road in the municipality of Prejmer, 30 roe deer and 5 bears road killed from 1/01/2022 to 1/01/2023, we decided to install there, on the 27/07/2023, an additional 2 km of virtual fence. A total of 56 regular units of VF were installed. These 2 Km of virtual fence replaced 1 AVC-PS originally foreseen in the project proposal.

In Romania the installation of the devices requested the installation of specific poles, because on the roads there weren't posts where to attach the unit. At the beginning and at the end of the road section where the virtual fence was installed, two panels explaining the intervention were placed on the device posts (fig. 13).

Spain

The total length of the virtual fence installed was 4,5 Km respect to 4 foreseen in the project proposal. The installation was made on 9/09/2022 on A 312 road in the municipality of Vilches. The 160 regular devices were mounted on the posts already present on the road sides. This road segment was not originally included in the project proposal, but the expansion of the Iberian lynx has led to new areas of conflict, where it's important to reduce the risk of road mortality. This was the case of A 312, where in the period 04/2018-09/2022 6 iberyan linxes were rod killed., therefore this road segment was selected for the installation of the VF.

7. Check of the of the virtual fence functionality

In each country area the VF was regularly monitored to check the proper functioning of the units.

The road segments where virtual fence was installed were travelled on a weekly basis or 1 time per months in order to control if the units were triggered by the headlight of the vehicles. This survey was undertaken in darkness, by a team of at least two persons, one driving along the section, the other walking along the road verge to verify the emission of light and sound. In cases of malfunctioning, we came back to the site during the day to verify if the problem was the battery charge or an electrical fault which required assistance from the manufacturer. Only fewer units of VF were stolen in PNALM and Romania.
During the project implementation the percentage of malfunctioning units didn't exceed 5-10% of those installed. The malfunctioning devices or the stolen ones were promptly replaced. In PNALM we found some devices with the solar cell broken, probably during the work carried out by the province to clean the road verges.

The reaction of animals to the triggering of the devices was monitored through the installation of camera traps (fig. 21). This was done in PNALM in the test sites along the SS83, in Spain and in PNM, where camera traps were installed also prior the installation of the VF in order to understand if the VF modified the behaviour of animals.

Figure 21. Camera trap installed to monitor the VF in PNM.

In Romania several observation sessions were carried out with thermal camera. Observations were undertaken by one or two observers from dusk to down to try to record animal behaviour in response to the activation of VF.

The analysis of these data is included in the deliverable of Action D1.

8. General considerations

The installation of the AVC-PS and the VF was successfully implemented in each project country.
In Greece Spain and Romania the installation of AVC-PS was delayed respect to what was foreseen in the project proposal. The delay was related to several reasons, exhaustively explained in the final report. The tendering procedures were complex and it was not easy to find local companies capable of carrying out the installation (the initially foreseen procedure). The main problems were related to the general increase of prices of the materials, as well as the procurement and availability of materials due to the COVID-19 pandemics and the war in Ukraine. These problems affected the economy throughout Europe and their impact on project implementation can't be neglected. Due to the increase of prices of the materials, several budget adjustments had to be made. This delayed the launch of the tendering procedures because we had to review the components to be included. Furthermore, after the tenders were concluded the difficulty in finding materials significantly delayed the delivering of the systems from Italy, where AVC-PS was produced, to the purchasing countries.
Despite this delay, all the AVC-PS were installed in Romania, Spain and Greece, and the check of the systems benefitted from the experience gained in Italy.
In Italy the installation was made according to the time table of the project. In PNM all the 5 AVC-PS were installed within March 2021 and a huge work was done in the set up of the systems. In PNALM the installation was finalized within May 2021 and in Terni Province the 2 AVC PS were in place in May 2022.

From a technical point of view, the functioning of the AVC-PS was generally satisfactory and the technical problems encountered were solved and didn't affect the implementation of the action.
The maintenance of the systems installed in the frame of LIFE SAFE-CROSSING project will be ensured after the end of the project as it is specified in the after-life plan.
The system showed to be suitable to reduce animal-vehicle collisions in the riskiest hotspots, because the range of its effectiveness is limited. An optimal solution was the combination of the AVC-PS with VF.
The VF allowed to cover long road segments, and its installation was easy and didn't required specific technical knowledge. Only minor problems occurred in the functioning of the units of VF.
The wireless connected devices installed in PNM showed to be very useful in those road segments with many curves. In PNM project area the units were mounted not only on road post but also on concrete walls or on guard rails and other types of barriers demonstrating the adaptability of the VF to different situations present on the road sides.

Overall, the experience gained in installation of the AVC PS and VF has generated great interest as evidenced by the replication cases already implemented.

ANNEX

Maps and photos of the interventions carried out in each project area

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

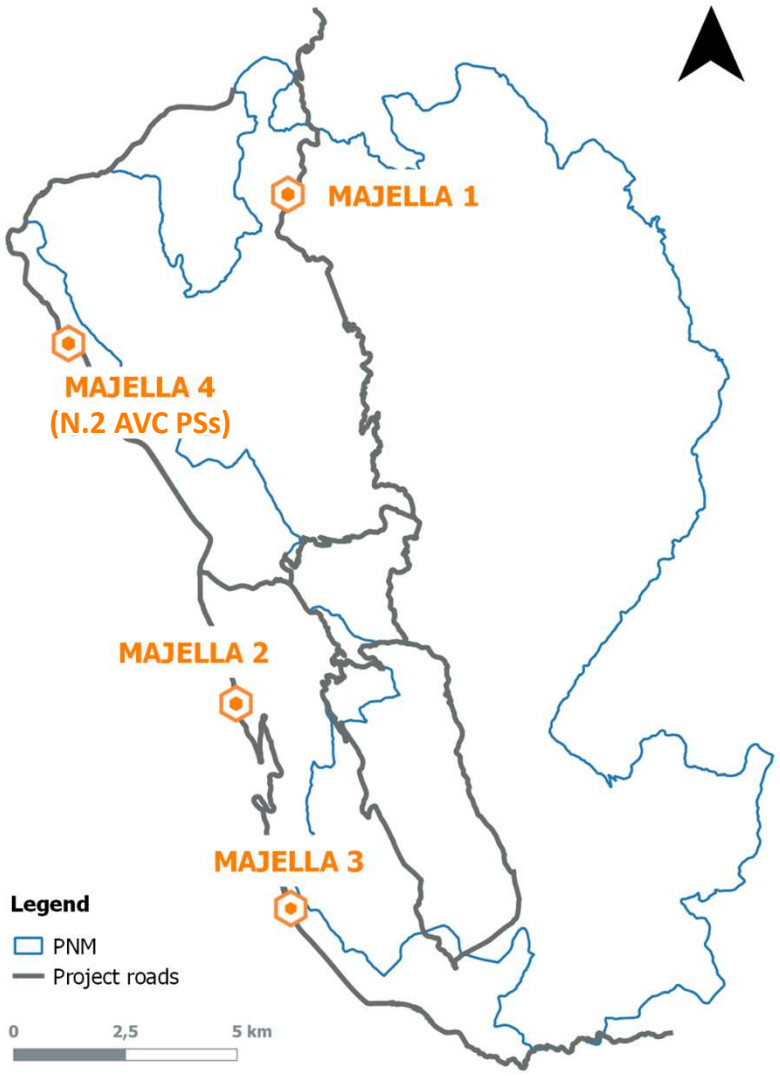
PHOTOS OF INSTALLED AVC PS

Action C1

PNM

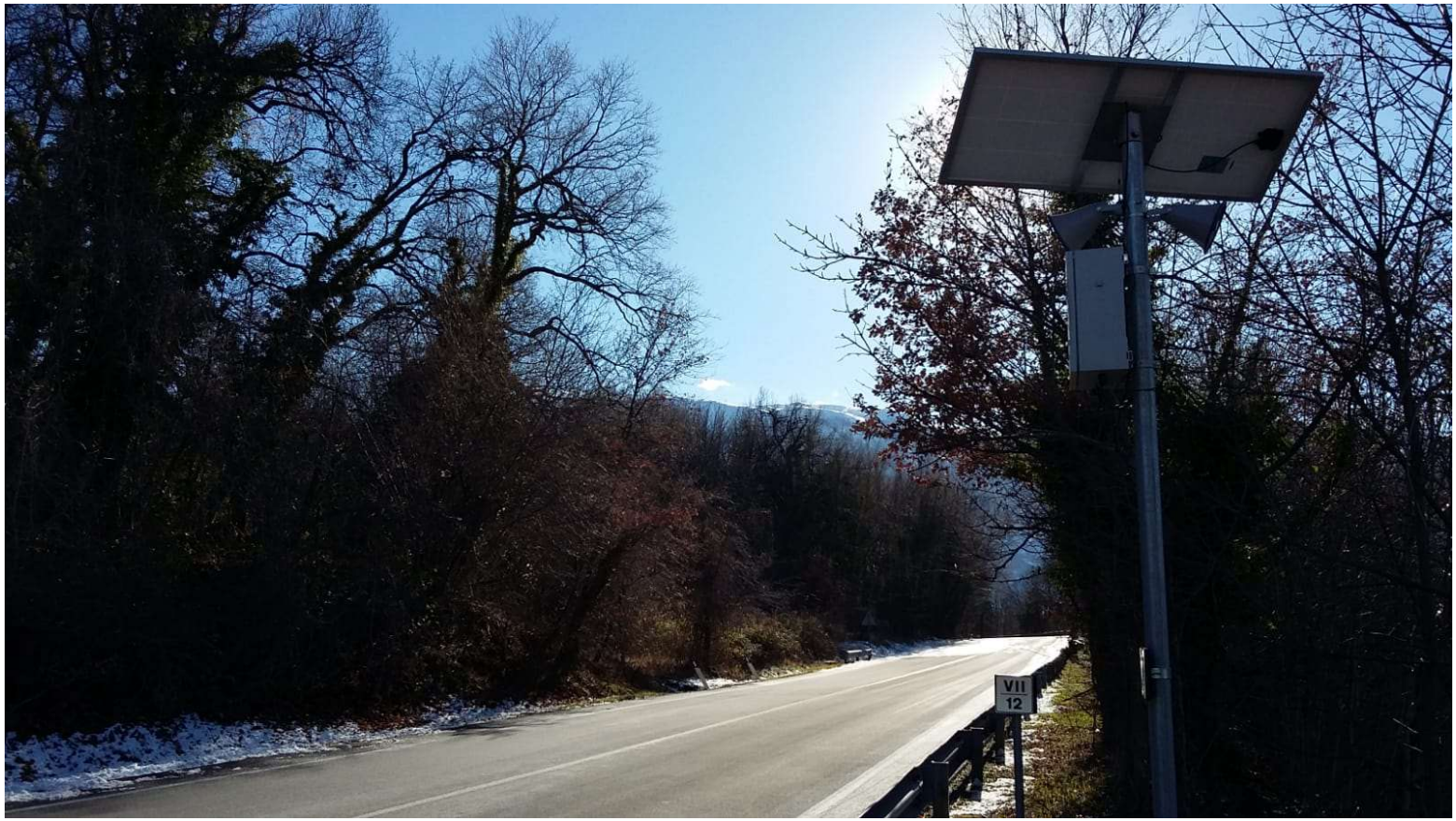
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed AVC PS



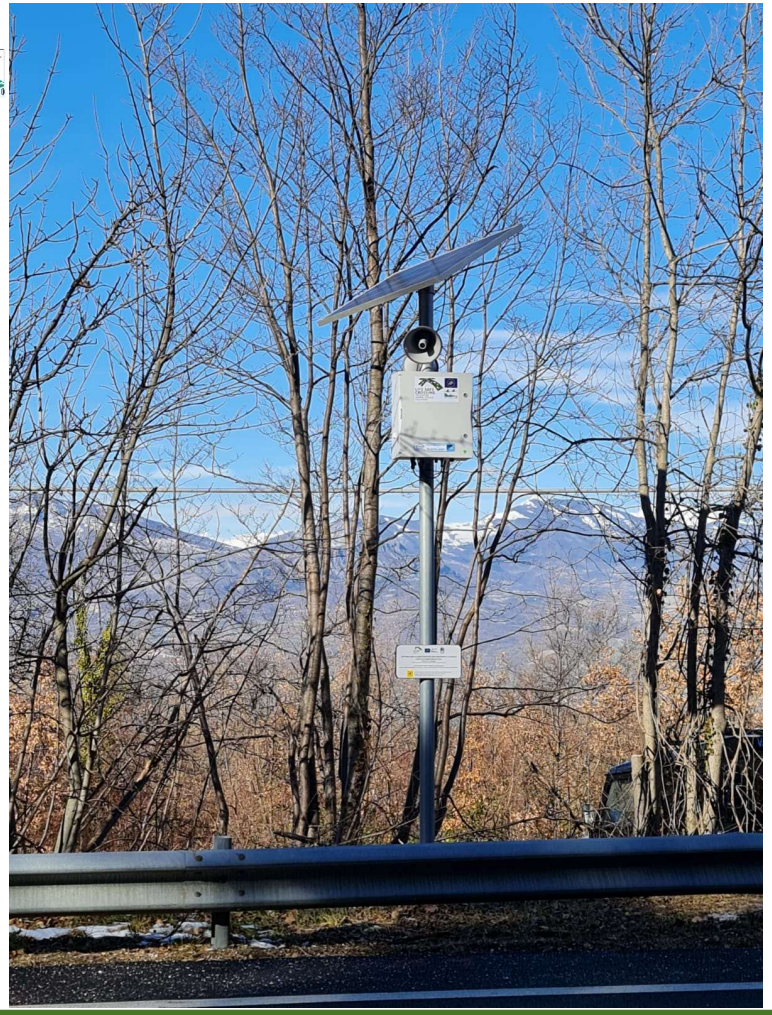
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 1 (CARAMANICO TERME SS487), 19/01/2021



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 1 (CARAMANICO TERME SS487), 19/01/2021



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 2 (PETTORANO S.G. SS17), 15/12/2020

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 2 (PETTORANO S.G. SS17), 15/12/2020

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 3 (ROCCA PIA SS17), 15/12/2020

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 4 (CORFINIO SS17), 03/03/2021

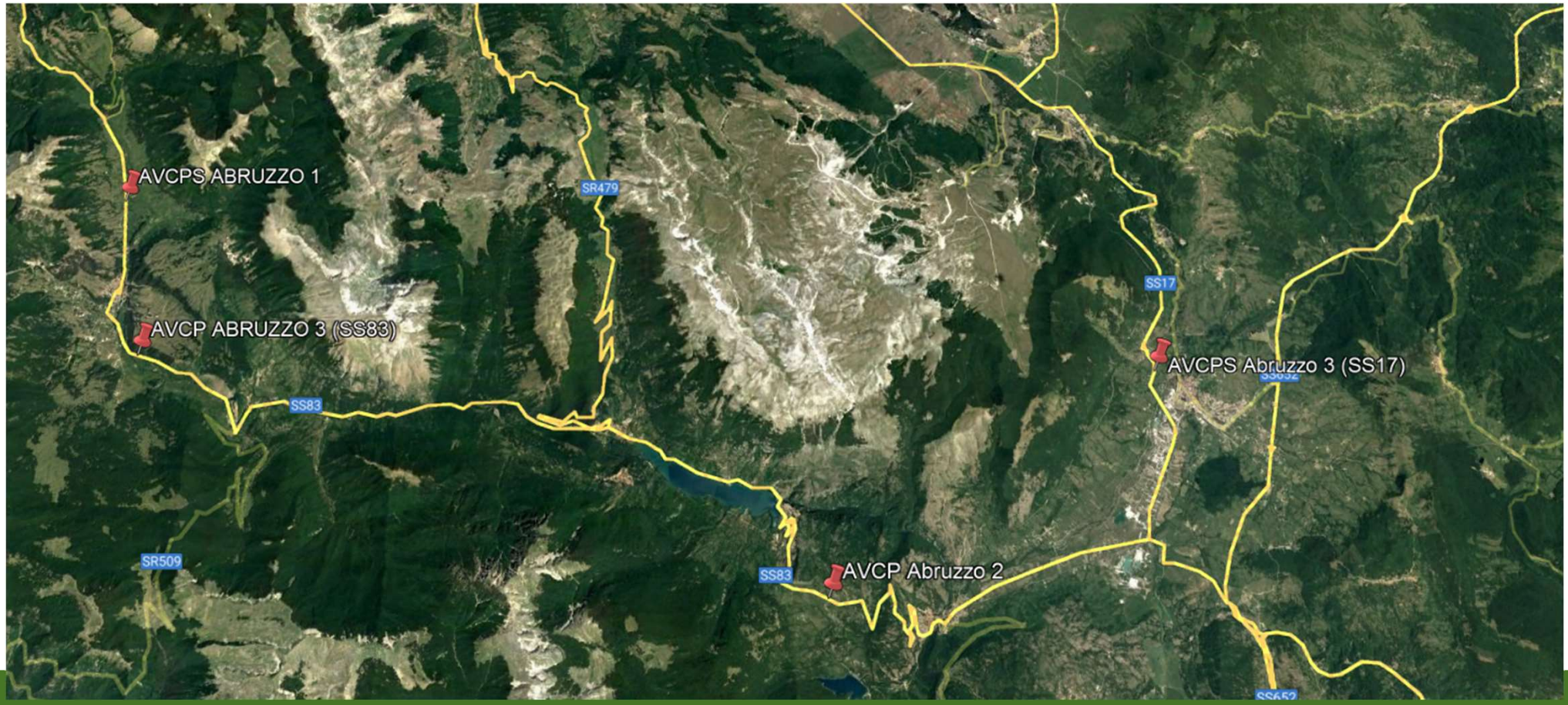
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

MAJELLA 4 (CORFINIO SS17), 03/03/2021

PNALM

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed AVC PS



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

ABRUZZO 1 (PESCASSEROLI SS83), 27/04/2021

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

ABRUZZO 2 (BARREA SS83), 31/05/2021

ABRUZZO 2 (BARREA SS83), 31/05/2021

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

ABRUZZO 3 (CASTEL DI SANGRO SS17), 07/04/2021

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

ABRUZZO 3 (PESCASSEROLI SS83), 12/07/2023
Moved from SS 17

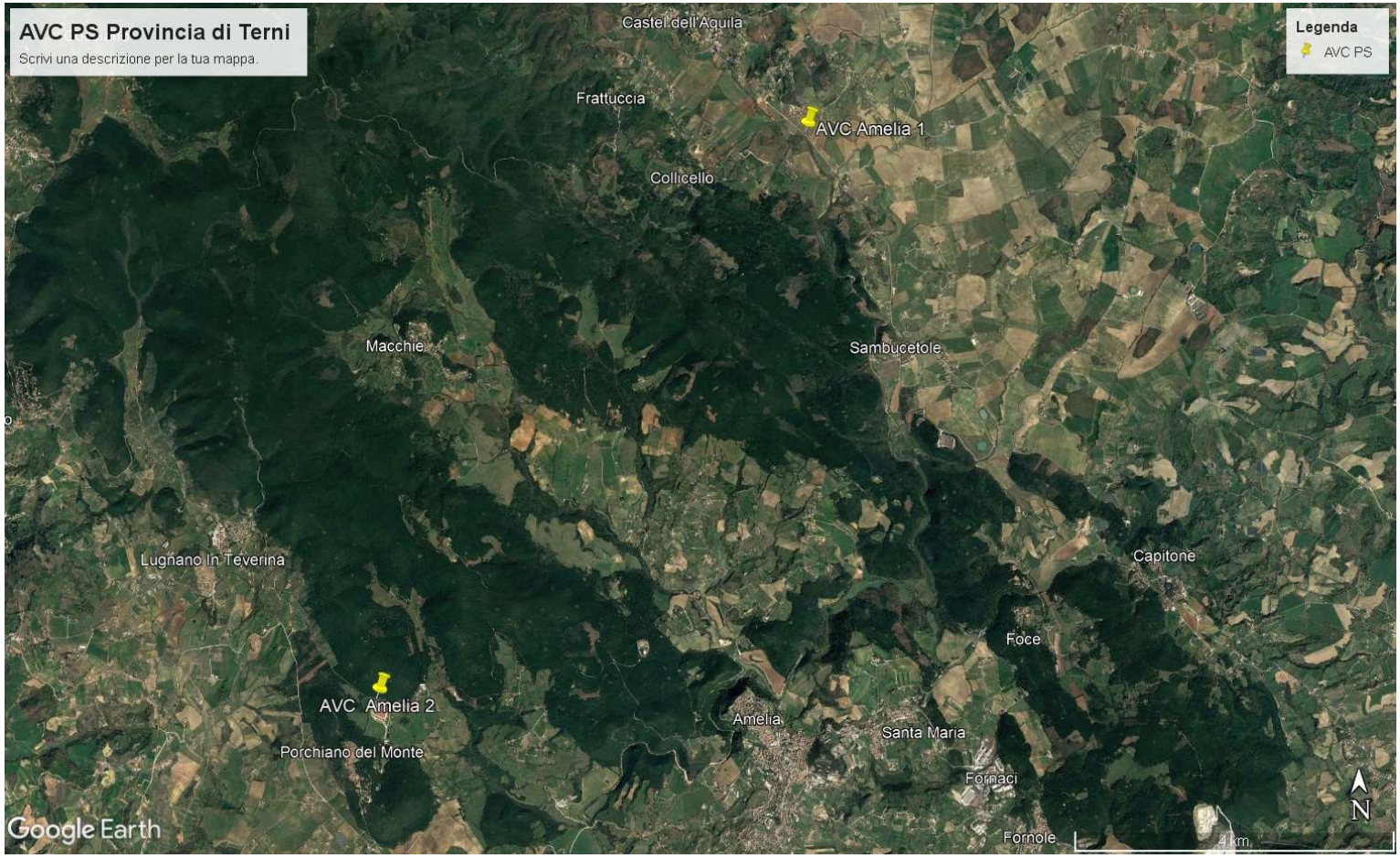
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

ABRUZZO 3 (PESCASSEROLI SS83), 12/07/2023
Moved from SS 17

PROVINCIA DI TERNI

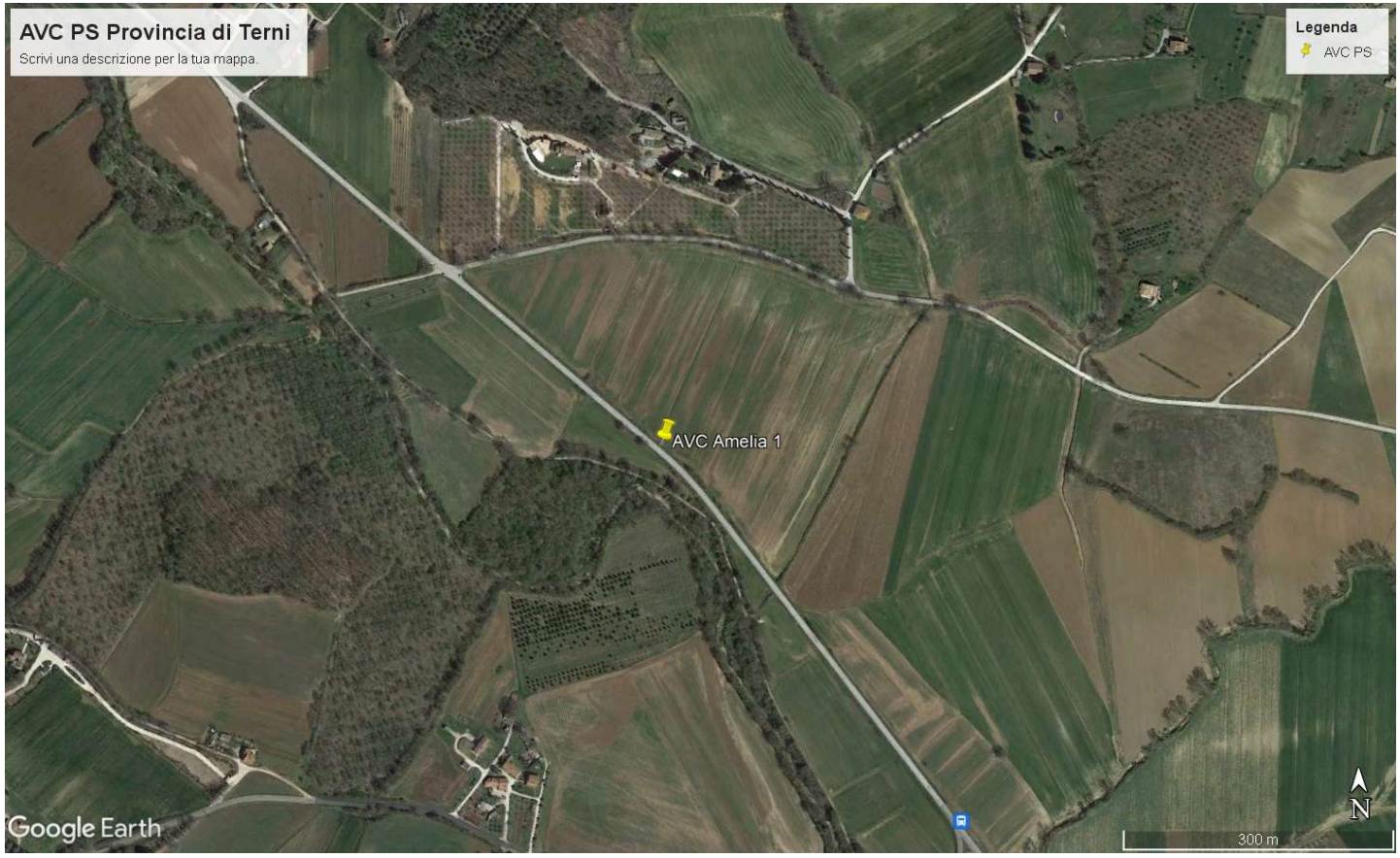
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

AVC-PS installed in Terni Province



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

AVC-PS installed in Terni Province on the SP 38

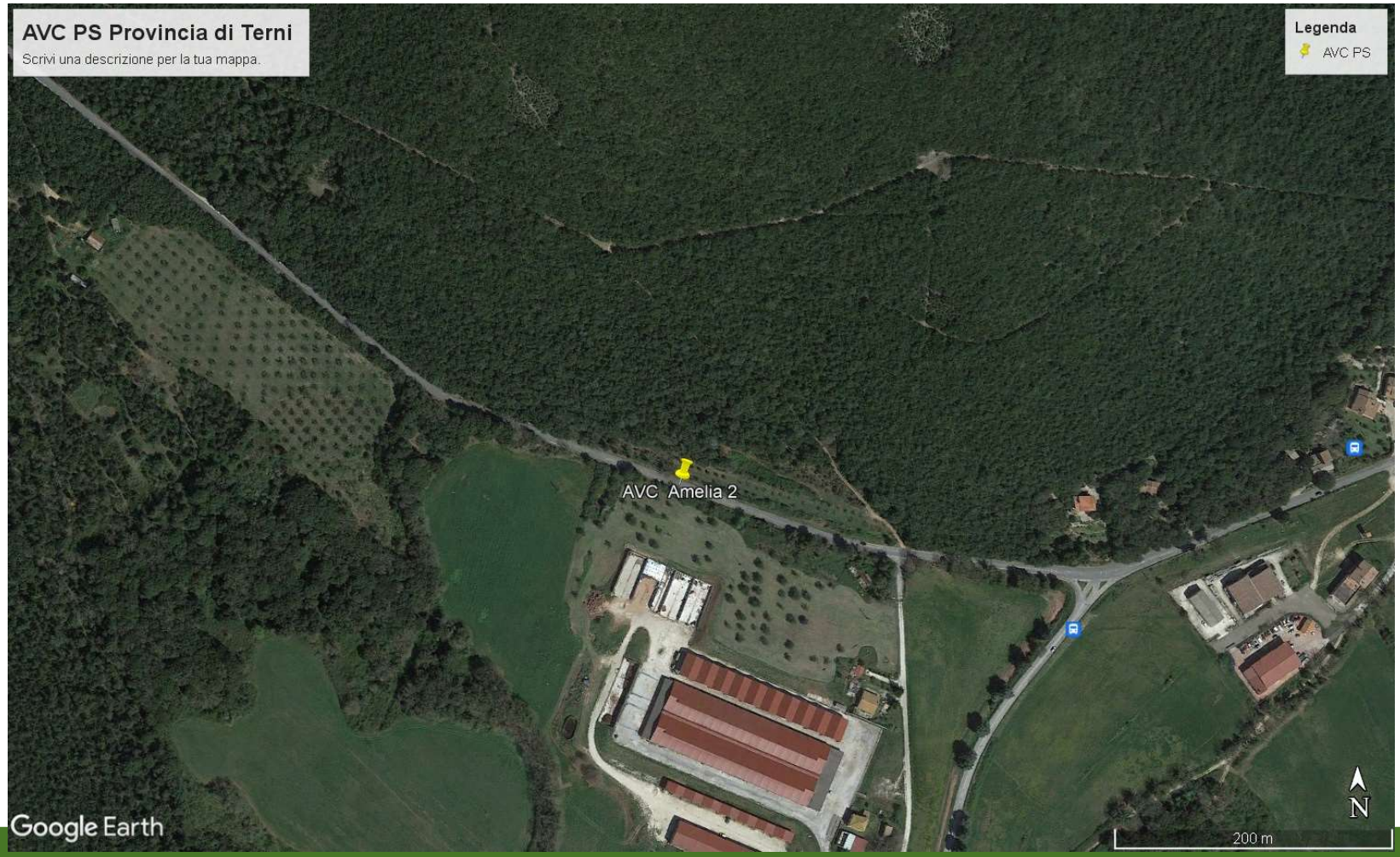


LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

AVC-PS Amelia 1- SP 38

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

AVC-PS installed in Terni Province on the SR 205

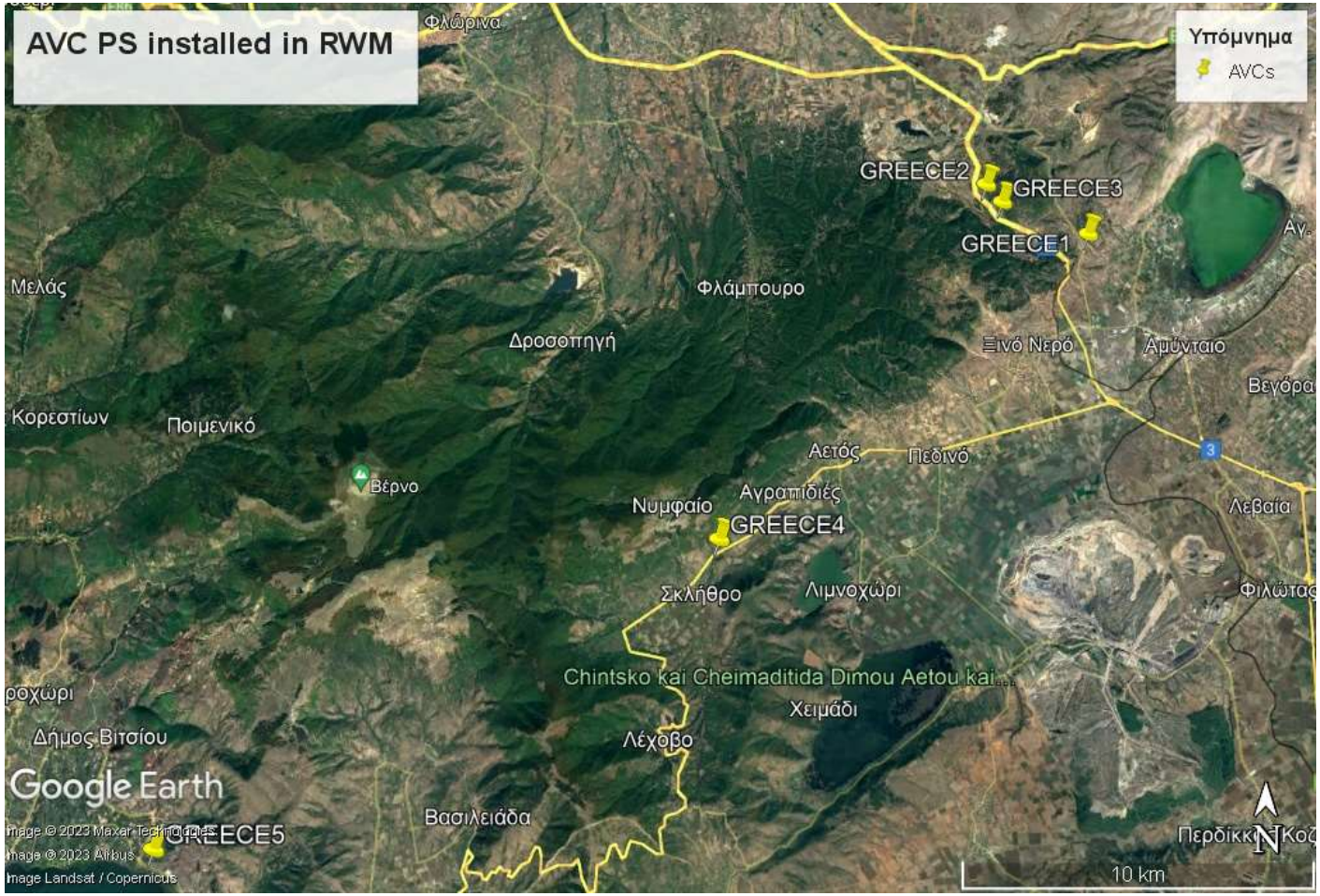


LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

AVC-PS Amelia 2- SR 205

GREECE

Map of installed AVC PS



Greece 1.Old road Ptolemaida-Florina-PJ9V+2R3 Aminteo(40.7175174,21.6445436)-Thermal Installation date:7-8-2023 DOUBLE SYSTEM

Greece 2.New road Ptolemaida Florina-PJJ4+GXG Aminteo(40.7313161,21.6074584) Installation date:7-8-2023

Greece 3.New road Ptolemaida Florina-PJG7+F66 Aminteo(40.7261533,21.6130049) Installation date:8-8-2023

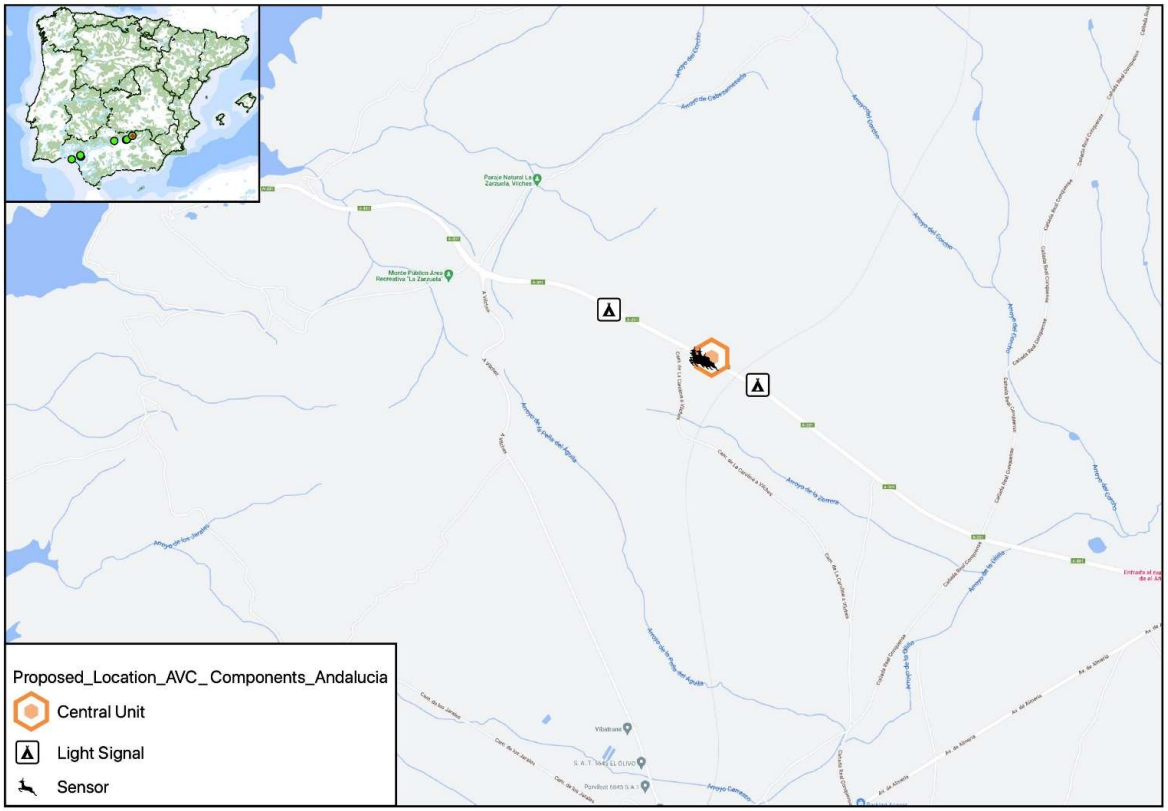
Greece 4.Road Aminteo-Kastoria-JGJ5+PP3 Sklithro(40.6317558,21.5092875) Installation date:8-8-2023

Greece 5.Road Dispilio-Sidirochori (Fotini)-H829+GX7 Fotini(40.5512759,21.3199125) Installation date:9-8-2023

SPAIN

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed AVC PS Spagna 1

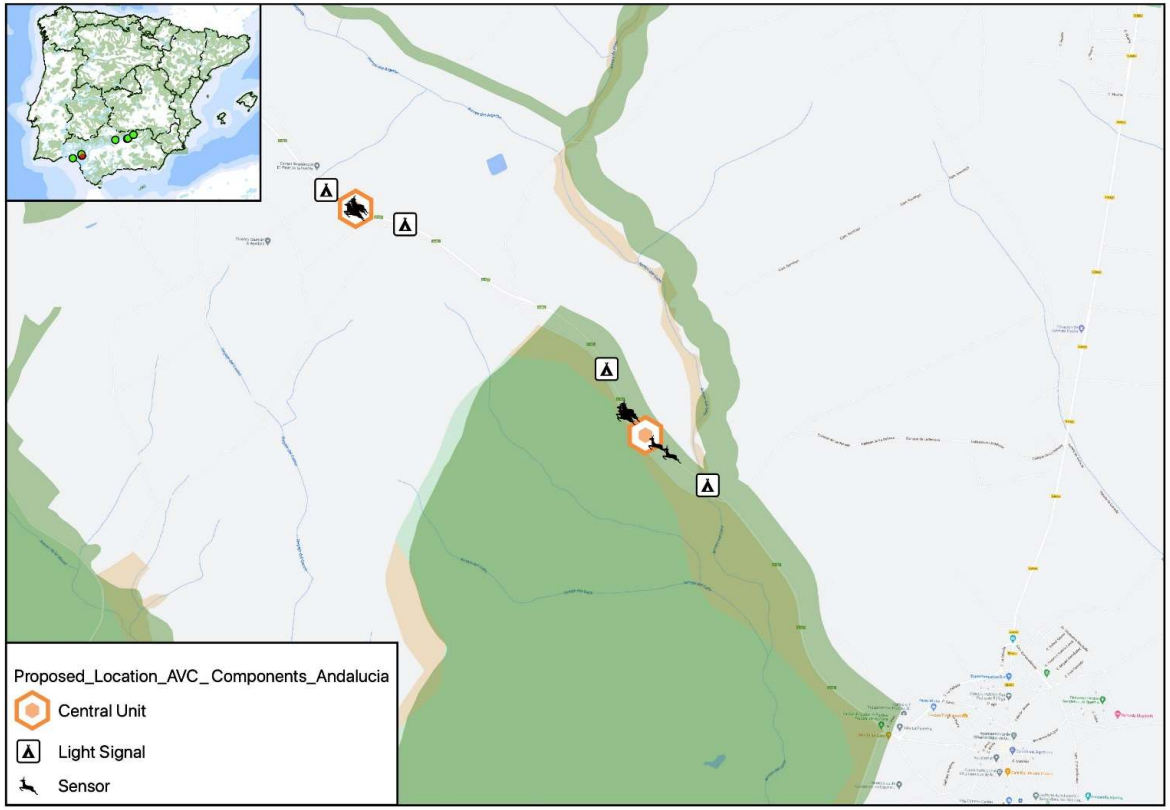


LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Spagna 1: Vilches, road A301, date of installation: 19/04/2023 (20/07/2023)*.

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

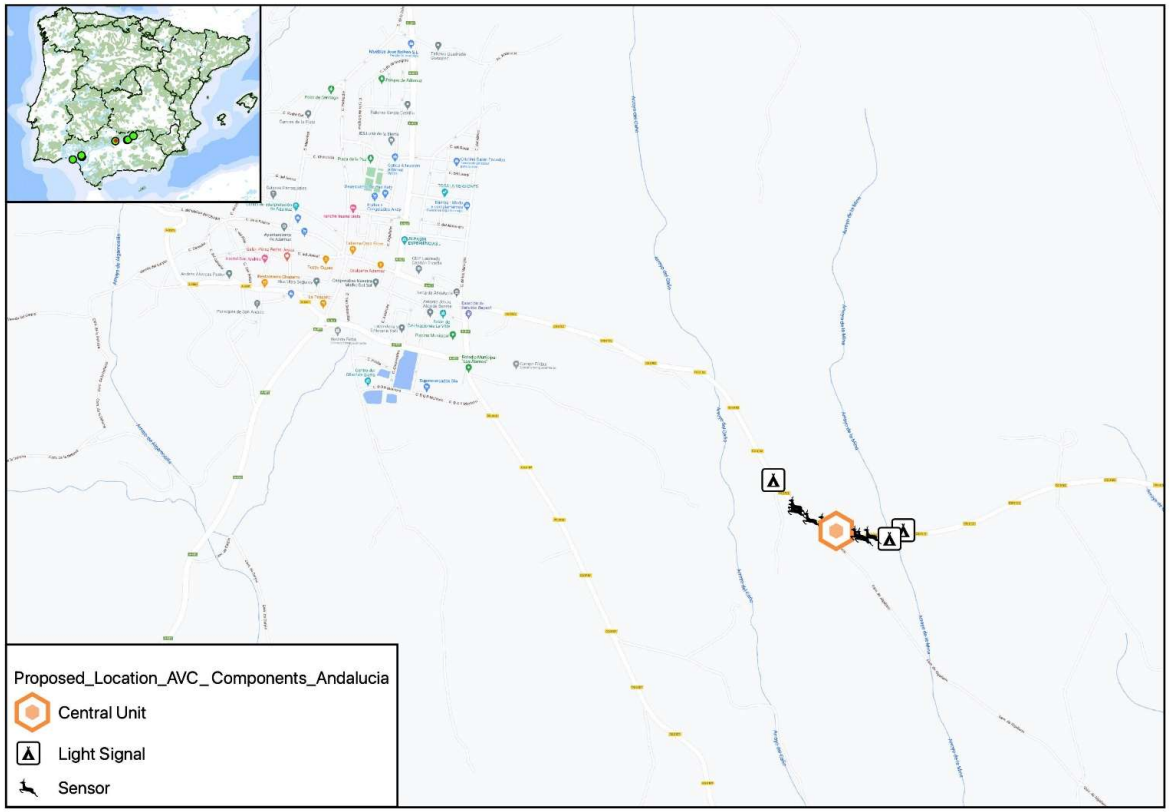
Map of installed AVC PS Spagna 2 and 3



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Spagna 2 , Hinojos A-481
Date of installation: 20/04/2023 (04/05/2023)
Spagna 3, Villamanrique de la Condesa A-481.
Date of installation: 04/05/2023 (23/05/2023)

Map of installed AVC PS Spagna 4 (Double AVC)



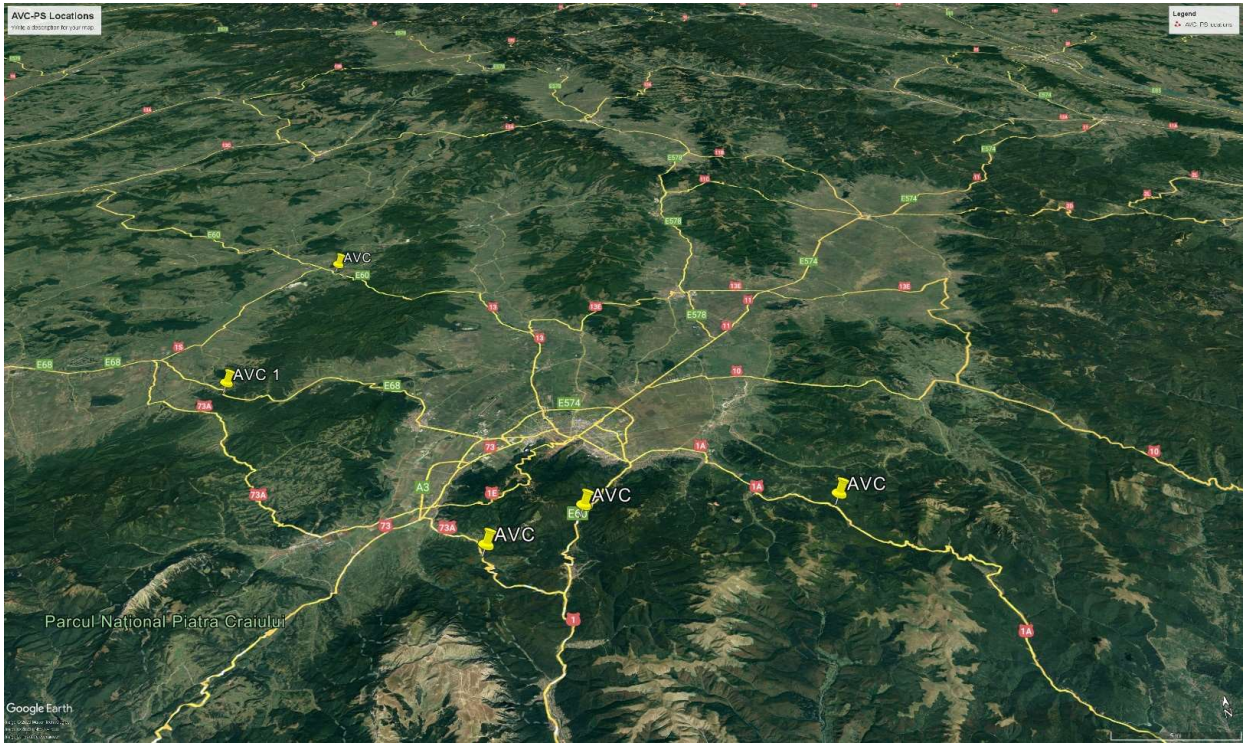
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Spagna 4, Adamuz CO-3102
date of installation: 05/05/2023 (31/05/2023)

ROMANIA

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed AVC PS



Location	Road Name
Timis	DN1
Paraul Rece	DN73A
Persani	DN1
Babarunca	DN1A
Padurea Bogatii	DN13

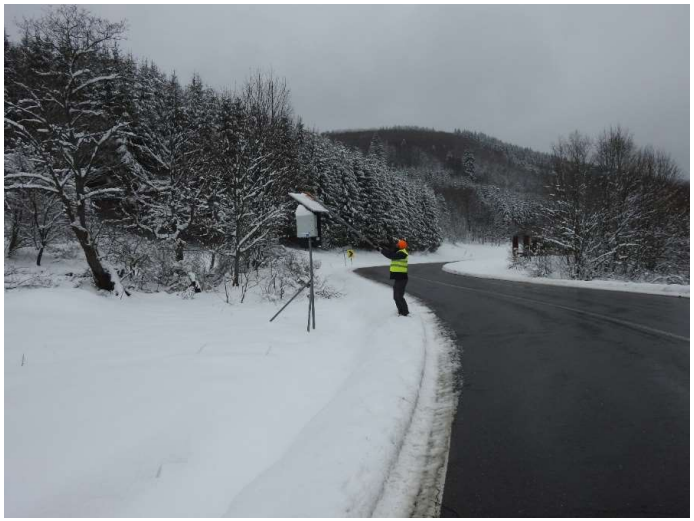
Timis DN1 – Romania 1, 07.11.2022

Paraul Rece DN73A – Romania 2, 07.11.2022

Persani DN1 – Romania 5, 07.11.2022

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Babarunca DN1A – Romania 3, 07.11.2022



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Padurea Bogatii DN13 – Romania 4, 07.11.2022

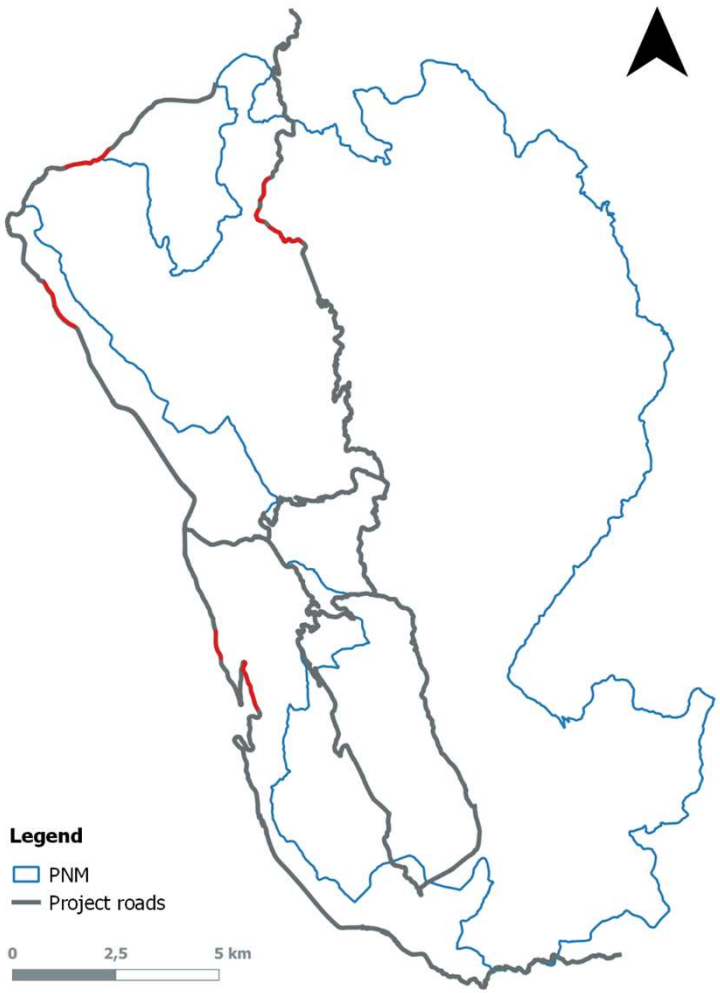
PHOTOS OF VIRTUAL FENCE

Action C1

PNM

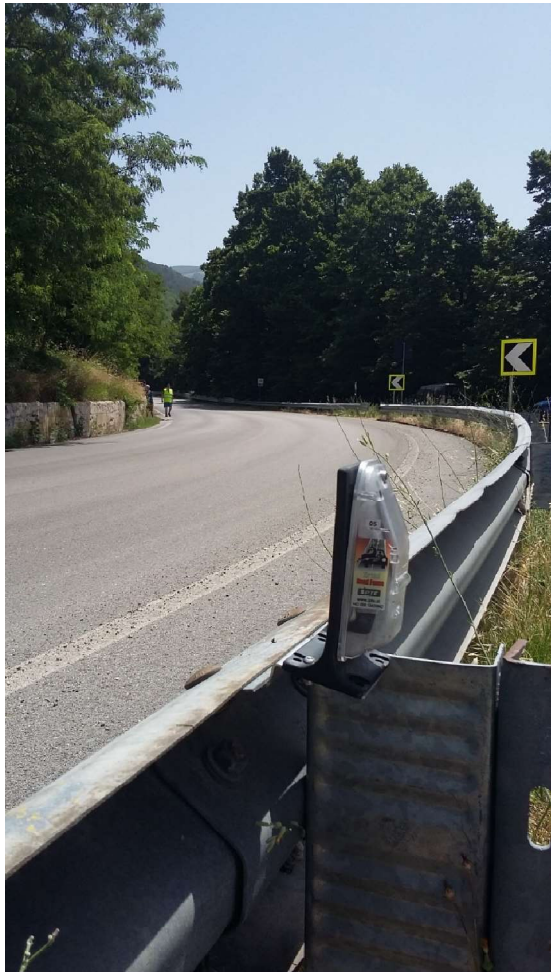
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed Virtual Fence



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Eliporto, 1.9 Km, SS487



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

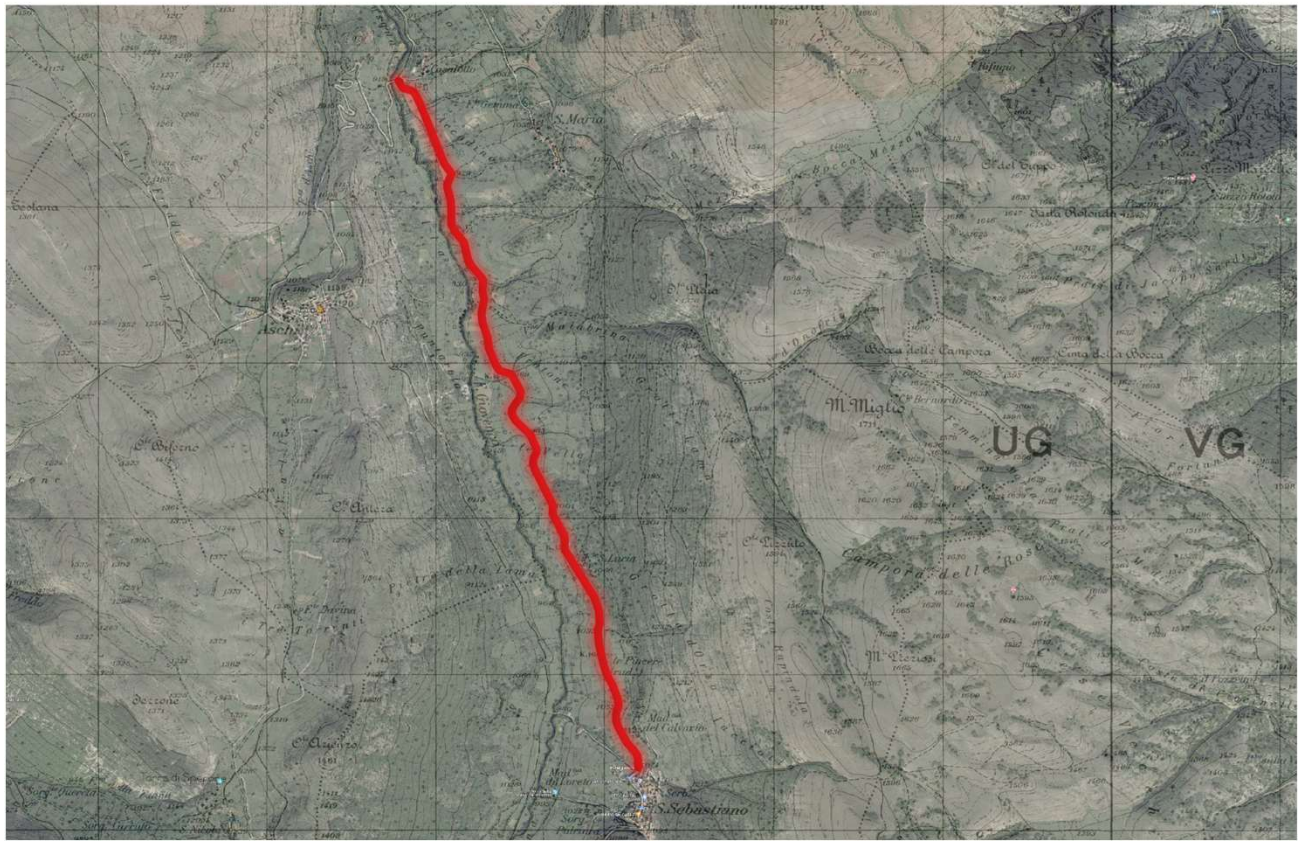
AVC PS Majella 2, 1.3 Km, SS17

ALTRE FOTO???

PNALM

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed Virtual Fence
SP 17 5 Km



LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

SP 17 5 Km

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

SP 17 5 Km

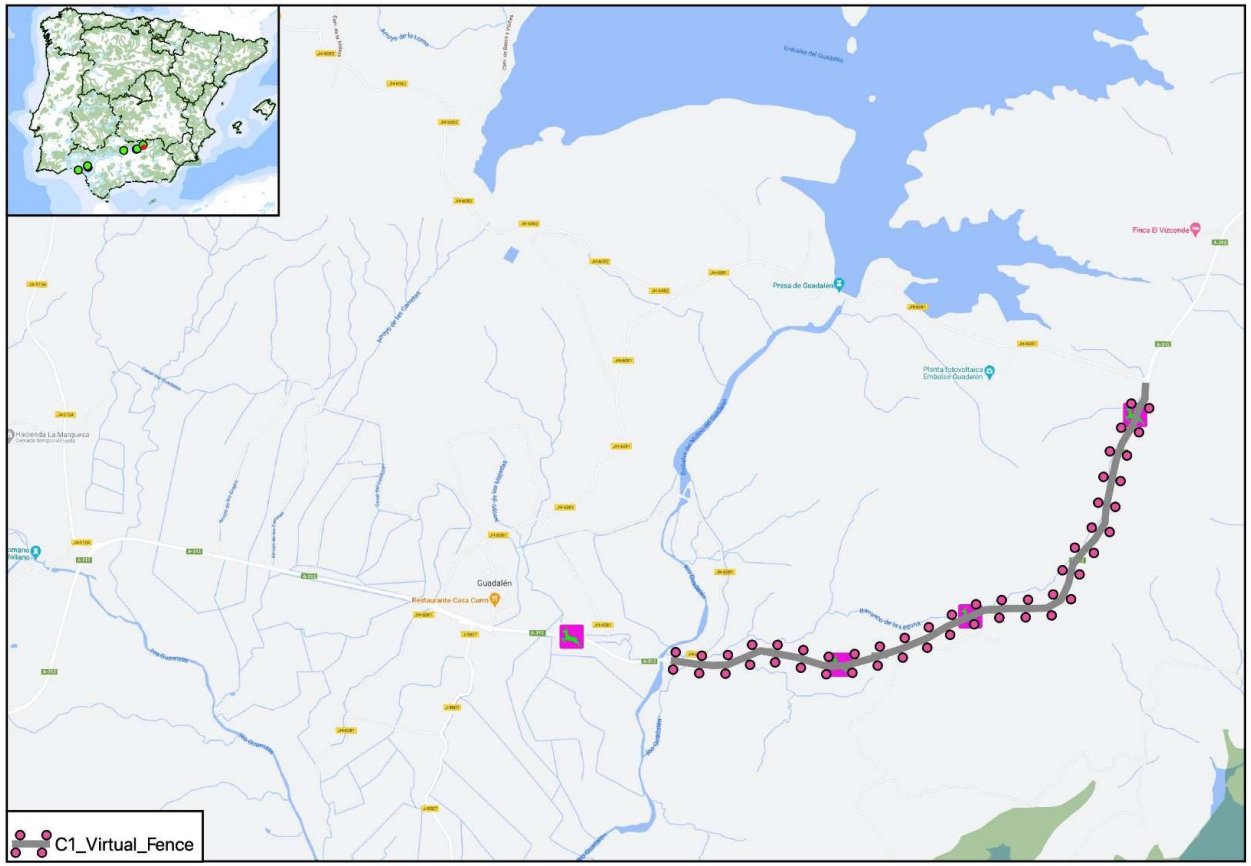
LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

SP 17 5 Km

SPAIN

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed Virtual Fence



A-312 (Vilches Arquillo),
Lenght: 4,5 Km, Installation: September 2022

ROMANIA

LIFE SAFE CROSSING
PREVENTING ANIMAL-VEHICLE COLLISIONS

Map of installed Virtual Fence

Summary table of road segments

DATE OF INSTALLATION	ROAD CODE	ROAD NAME	TOTAL LENGHT (KM)
20.07.2020	DN1	Timisu de Jos/DN1	2
13.04.2022	DN1	Timisu de Jos/DN1	1
24 03 2022	DN1	Persani/DN1	2
27.07.2023	DN11	Padurea Prejmer/DN11	2

Timisu de Sus DN1, 3 km


Timisu de Sus DN1, 3 km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Timisu de Sus DN1, 3 km


Timisu de Sus DN1, 3 km

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Timisu de Sus DN1, 3 km (the installation of the last 1 km)

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PREVENTING ANIMAL-VEHICLE COLLISIONS

Persani DN1, 2 km

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PREVENTING ANIMAL-VEHICLE COLLISIONS

Padurea Prejmer DN11, 2 km