LIFE+10 ENV/IT/000389

INTEGREEN

Action 4: Implementation & Integration

P.4.2.1

On-board traffic monitoring unit prototype

Project Coordinating Beneficiary	Municipality of Bolzano
Project Associated Beneficiary n.2	TIS innovation park (TIS)
Project Associated Beneficiary n.3	Austrian Institute of Technology (AIT)
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[1] CO = Confidential (for members of the Consortium only, including the Commission Services)

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1 Introduction

The Implementation phase follows directly the design specification phase and it relies on the V-model approach as show here below in Figure 1.

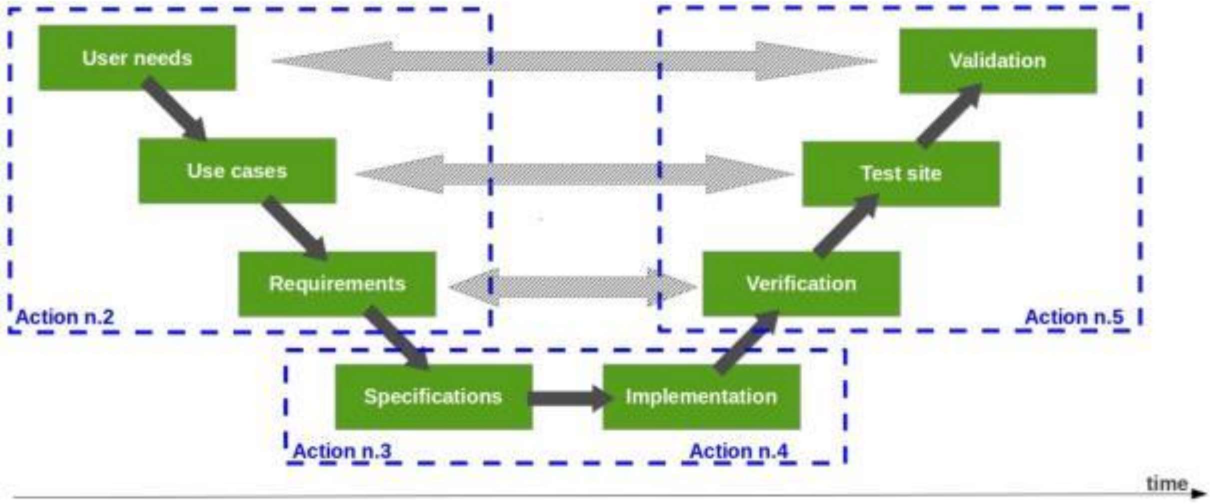

Figure 1: The V-model approach applied in the INTEGREEN project

The Implementation and Integration action aims primarily at producing the physical prototypes for the INTEGREEN Systems. It is executed after the Design phase which is the main input to this Action as it can be seen in Figure 1.

1.1 Purpose of the document

This document deliverable P.4.2.1 is one of the deliverables of Action 4: Implementation and Integration under the responsibility of AIT. AIT is the responsible beneficiary for the activities in Action 4 and directly responsible for the execution of Task 4.2 Mobile systems implementation as well as for the execution of Task 4.3 System integration. The execution of Task 4.1 Supervisory Centre component implementation is under the responsibility of TIS.

Task 4.2 is divided into four activities as follows:

- On-board traffic monitoring unit
- Environmental sensors
- On-board environmental monitoring unit
- On-board telematic unit

All the Mobile subsystems to be implemented and produced in Task 4.2 are clearly visible in Figure 2 below.

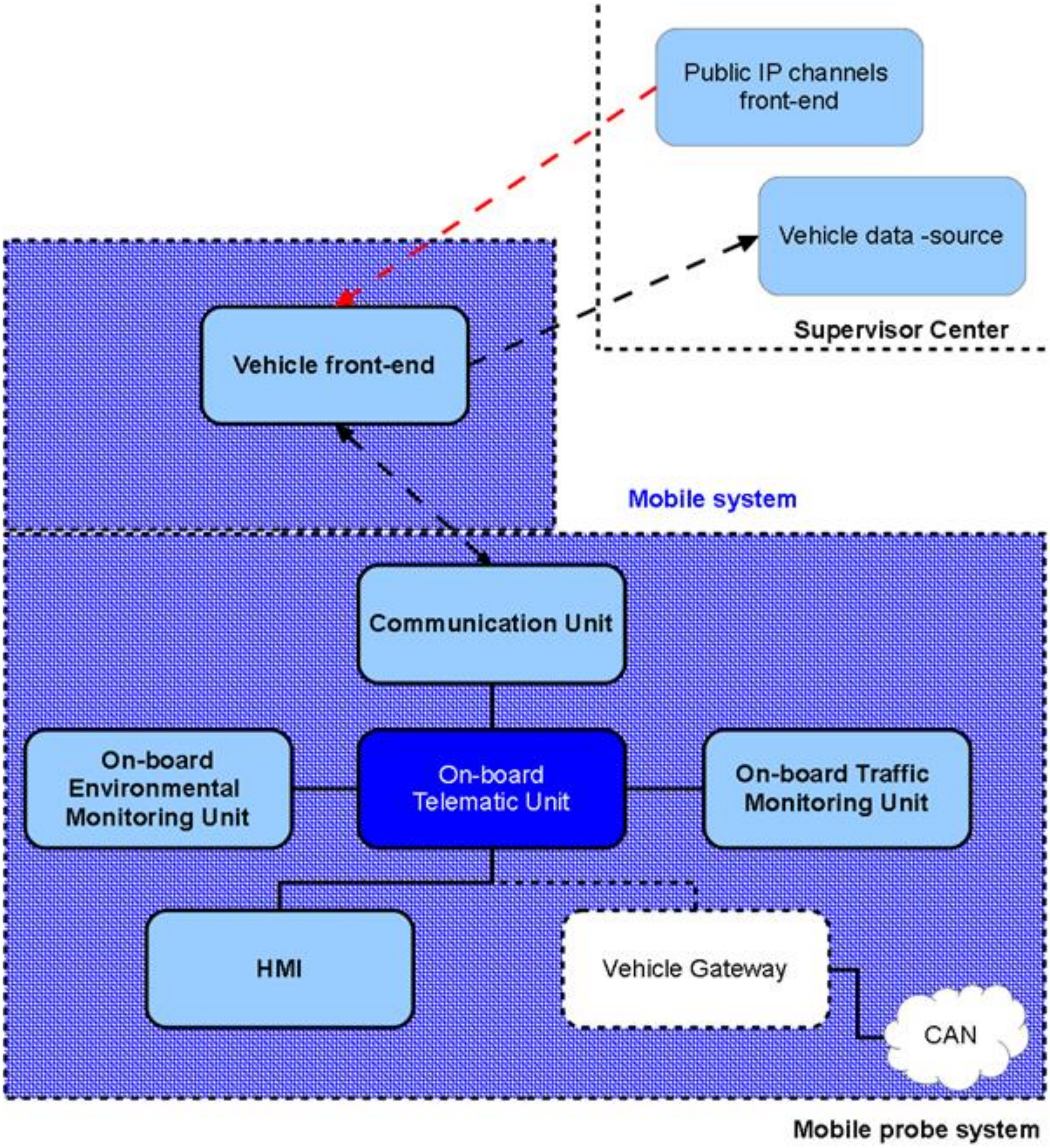

Figure 2: The reference architecture of the INTEGREEN mobile system

1.2 Mobile system implementation

The overall objective of the implementation phase has been to produce a solution based on the development of traffic and environmental monitoring units and selecting of a processing platform and components already present on the market and at the same time suitable for automotive applications. For the selection of a suitable off-the-shelf embedded platform and of the electronic components, the latest automotive standards and technological advancements have been taken into account.

Basic research and future components have not been considered as the final prototype systems will have to be suitable for commercialisation after INTEGREEN.

In Task 4.2 a complete mobile system prototype suitable for automotive application has been produced. The physical prototypes will be the input for the next Task 4.3 System integration where a mobile systems with full functionalities which will allow vehicles to have traffic and environmental detection capabilities, as well as real-time communication functionalities, in particular between the On-board telematic unit and the Vehicle front-end and subsequently to the Supervisor Center system will be integrated in vehicles and tested.

The real result in Action 4 is the production and integration of the physical prototypes. Each prototype unit consists of physical HW and SW and will have to perform the specified functionalities. The document deliverables of Action 4 are the accompanying documentation which summarise and describe the main steps needed to deliver the physical prototypes.

This document deliverable contains the first output of Task 4.2, namely a description of the on-board traffic monitoring unit prototype.

2 Implementation of the On-board traffic unit prototype

2.1 Implementation of the On-board traffic unit prototype

The design of the On-board traffic unit is already described in detail in the deliverable D.3.2.2. The structure of the on-board traffic unit is illustrated in Figure 3.

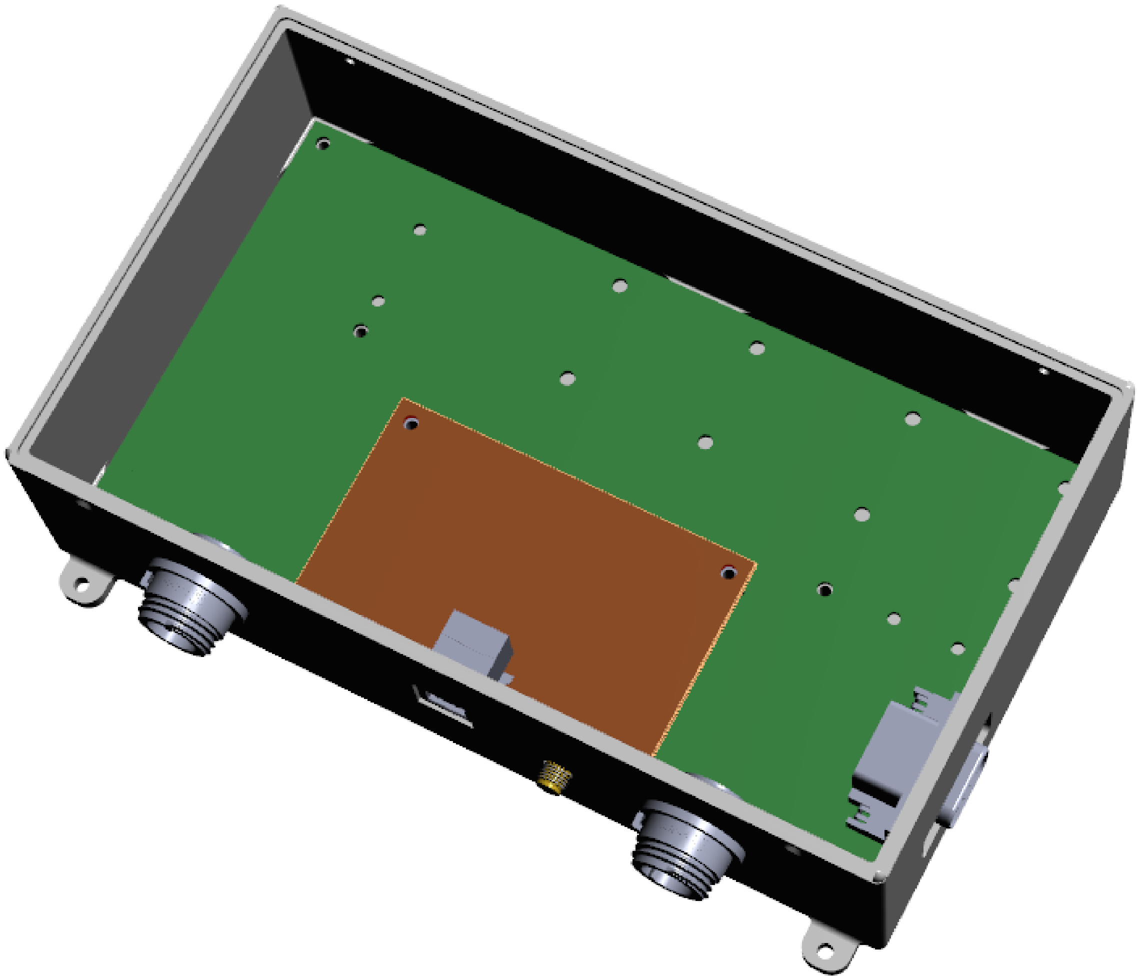

Figure 3: Model of the Traffic monitoring unit

The system is composed of the sensor-PCB (shown in green, including all electronic and mechanical components for the sensors), the MECU (Miniature Electronic Controller Unit, shown in brown colour) and the enclosure.

The high level implementation work-flow is shown in Figure 4.

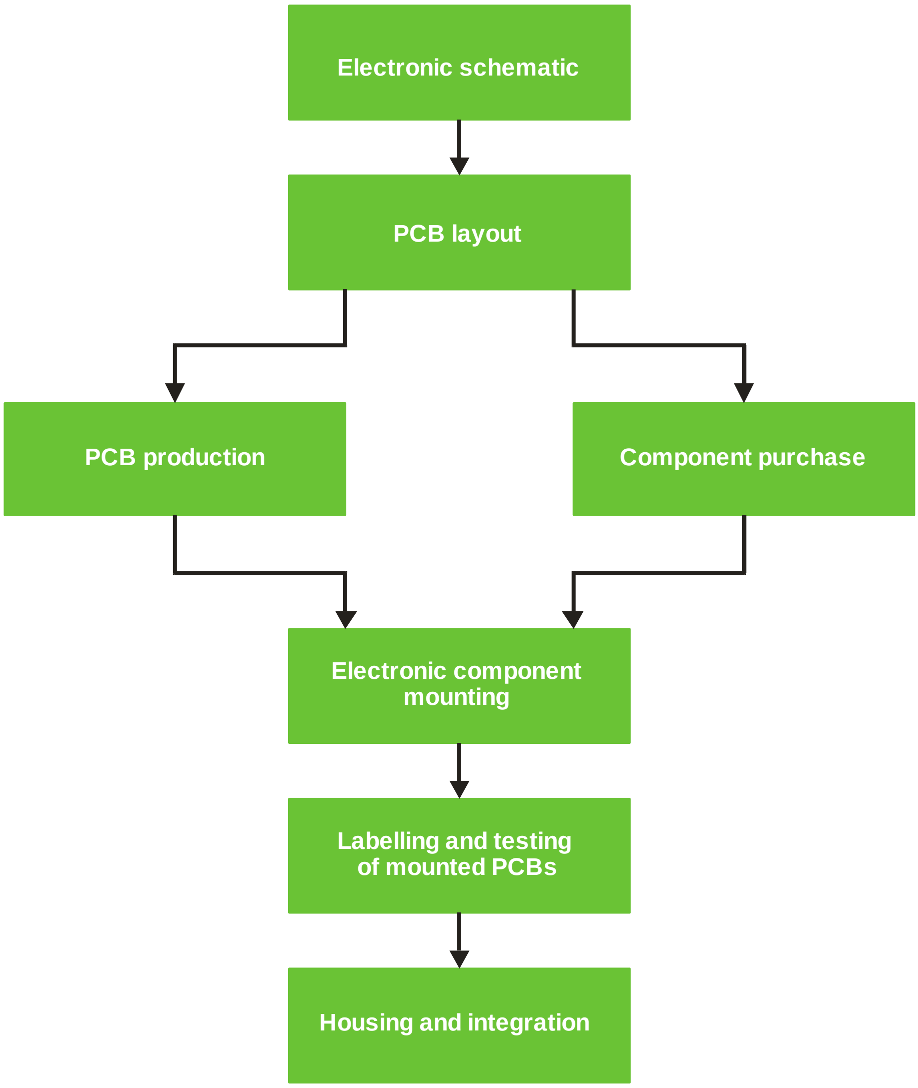

Figure 4: Implementation flow diagram

2.1.1 Electronic schematic design

The electronic design includes the selection of the right components and the design of the schematic diagram.

In the design –phase much attention was given to select components and material which are suitable for automatic assembly and therefore for mass-production.

Almost all electronic components were selected in an SMD-case version (where possible), only a few sensors and connectors are through-hole components. Consequently the automatic mounting of components can be easily fulfilled by automatic mounting devices. For passive components the case SMD0402 is the most preferable case because it is small, simple to mount for machines and also for peoples with manual work, the components are very cheap because there have been widely used in mass productions for many years and at the same time are easy to purchase.

2.1.2 PCB layout design

One of the key components in electronic design is the PCB layout. It is always an ad-hoc design. Much care must be taken in the design to fulfil the following features:

- Easy and economic production of the PCB
- Electrical characteristics (current rating, cross-talk, characteristic impedances…)
- EMV characteristics

In order to design an industrial PCB many years of experience are necessary. AIT develops complex PCBs since more than ten years in partnership with an external and specialised industrial PCB-designer. Therefore the PCB design phase has been always a success at the first time.

2.1.3 PCB production

The PCB production is done by specialised external companies. Attention must be paid in the selection of the companies in the following points:

- Initial cost: The initial costs can be very high, perhaps much higher than the real unit price. This depends on the company type. Especially companies for mass production have very high initial costs and low unit costs for volume production.
- Delivery time: Some companies have long delivery time for the PCBs, especially companies that work with a high number of productions. In our case as the production date was near Christmas and New Year, where during this period almost all companies in Austria and Germany are closed, it has been extremely difficult and time consuming to negotiate a manufacturing slot for our low volume needed units.
- Quality, electrical test: Especially small companies can have problems with sophisticated or complex PCBs. Defects in the PCB-production are possible and sometimes very difficult to locate.

2.1.4 Component purchase

The most appropriate time to proceed with the electronic components purchase is after the completion of the PCB layout design, because the choice of final components dependents also from some layout constraints. Some components are generally only available in big numbers (like passive components on reels have typical 3000 – 5000 pieces) or the components are not in a machine mountable packaging. In our case where a low number of components are needed time and effort had to be dedicated in searching suppliers which were ready in delivering our small quantities and also suitably packaged for machine mounting. A few components have long delivery time (weeks or even month) and consequently these components have to be identified and ordered as soon as possible.

2.1.5 Electronic component mounting

The industrial mounting of electronic components on a PCB is a complex process and sophisticated machines are therefore necessary. AIT as a Research Center doesn't have this production machines in house hence an industrial mounting activity has to be done by external companies. Only for not very complex component mounting and soldering for single prototype boards the work can be done manually from internal personnel.

If a critical component (in the sense that it cannot be mounted in a simple way by hand) is not available at the programmed mounting time, then the whole mounting process has to be delayed. This is very critical because the companies that can mount the components are often inflexible in time and a new time-slot some weeks later must be negotiated and agreed.

To solve these problems for the INTEGREEN system, the smaller PCB (MECU) with complex components was mounted by an external company while the components on the bigger but simpler sensor board PCB were mounted manually internally by AIT personnel.

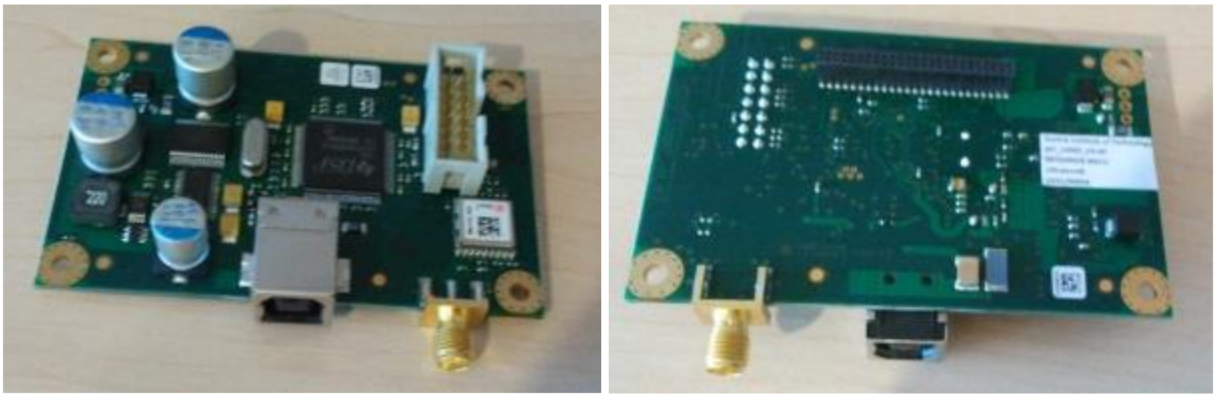

Figure 5: MECU board

2.1.6 Labelling and testing of mounted PCBs

At a first view it seems a secondary process to mark each PCB with a clear and unique label. But from our expertise in working with prototypes and near industrialised HW boards, it is a very crucial process. It happens frequently that two or more nearly identical boards will be tested. Then small SW or HW adaptations will be done on one of the HW board and after some time it is no longer clear on which of the boards the modifications were done. Also if a passive component has been modified it cannot be controlled anymore because small SMD components frequently don't have a unique label printed on the component (typically on SMD capacitors).

For the MECU of the INEGREEN project the following Labelling has been used (Figure 6):

Austria Institute of Technology
AIT_13007_V0.00
INTEGREEN MECU
Ultratronik
1351/00001

Figure 6: Label of the INTEGREEN MECU

Description of the fields:

- First field: Design company
- Second field: HW-design number and HW-Version
- Third field: Device name
- Fourth field: name of the company mounting the components on the board
- Fifth field: Production Year and Week (YYWW) plus a unique serial number

The label of the sensor board for the Traffic monitoring unit is shown in Figure 7

Austria Institute
of Technology
AIT_13021_V0.00
INTEGREEN TRAFFIC
AIT
1404/00001

Figure 7: Label of the INTEGREEN Traffic sensor board

After plugging the MECU board on the Traffic sensor board and fixing it with M3 screws the FW for the MECU is programmed in the flash-memory of the controller and the following tests are performed:

- Power consumption: this gives a good indication if the different modules are running and there is no short circuit on the boards
- Communication interface tests: USB, GPS, RS232/485, CAN-bus
- Test of the sensor outputs: all sensor outputs are tested and evaluated

2.1.7 Housing and integration

Another challenging component is the housing of the electronic boards. Certainly the housing should be as small as possible (only a little bit larger than the electronic itself.

It was not possible to find an off-the-shelf housing for the system which fits very well. So we decided to design a 3D-model of the housing and print it out internally in AIT.

In AIT there is a 3D-printer working with plastic materials. The housing was printed in 2 parts: the lower part (Figure 9) and the cover part (Figure 10).

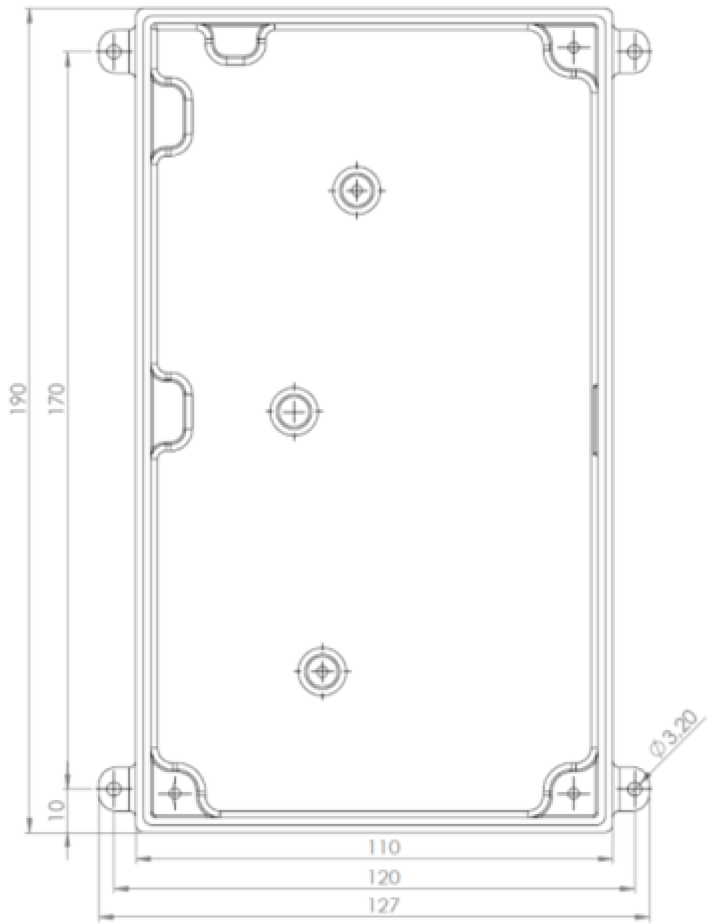

Figure 8: Dimension of the housing

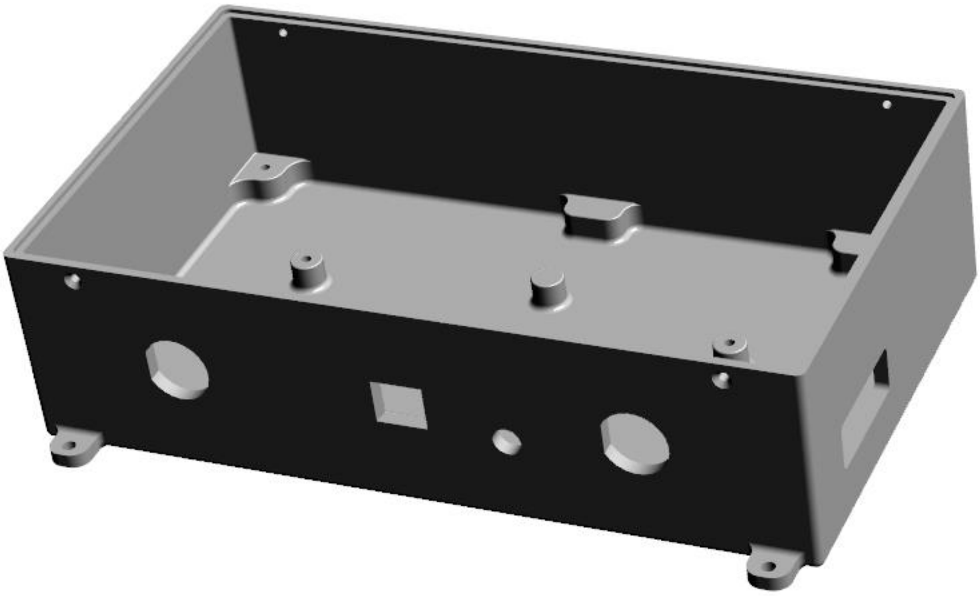

Figure 9: Lower part of the Traffic unit housing

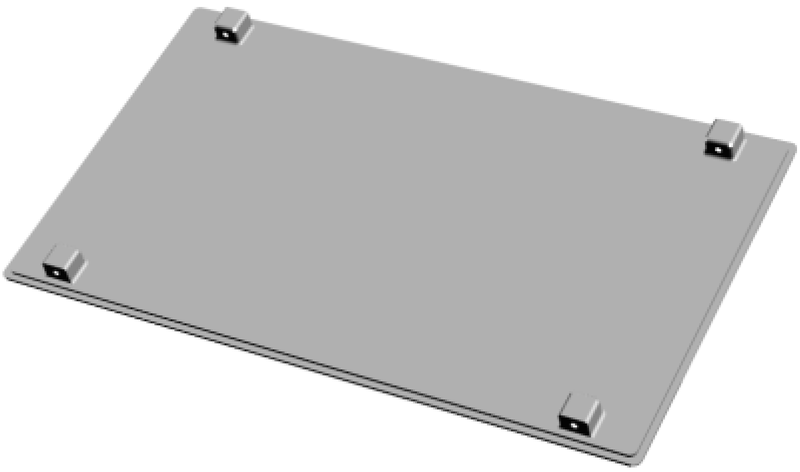

Figure 10: Cover of the Traffic unit housing

The mounting of the electronic boards is simply done from the top. The sensor board is fixed with M3 screws in the lower part of the housing. Two connectors (one for the power supply and one for the CAN-bus access) have to be mounted on the housing and connected by cables (for details see interface description in chapter 2.2). The two half transparent cylinders above the components in Figure 12 are fuse holders mounted on the cable of "12V continuous" and "+12V ignition".

Figure 11: Traffic monitoring unit prototype

Figure 12: Traffic monitoring unit without cover

2.2 Interface description of the Traffic monitoring unit

2.2.1 CAN-bus connection

The CAN-bus connector and the pin allocation are shown in the following Figure 13. The AIT test vehicle uses a write-protection circuit inside the vehicle. To activate the CAN-bus access the line +5V line write protection must be connected. In the case no extra write protection circuit is used in the vehicle then this pin can be left unconnected.

Figure 13: CAN-bus connector

2.2.2 USB connection

A standard USB type B connector is designed for connection to a hub device over a standard USB 2.0 cable.

Figure 14: USB connection to hub device

2.2.3 GPS antenna connection

For the use of an external GPS antenna a SMA connector is mounted on the Traffic monitoring unit. An active or passive GPS antenna can be used. It is recommendable to use an active antenna with an integrated amplifier, e.g. the ANN-MS-0-005-0 from the Switzerland company u-blox.

Figure 15: GPS antenna connector and external active GPS antenna

2.2.4 Power supply connection

The power supply connector is a 3-pin connector. The “+12V continuous” line should be connected to the battery supply of the vehicle and the “+12V ignition” line should be connected to a power source in the vehicle that is only active If the engine is running.

However, if the system should be powered all the time or only when the engine of the vehicle is running the two lines (“+12V ignition” and “+12V continuous”) could be connected together.

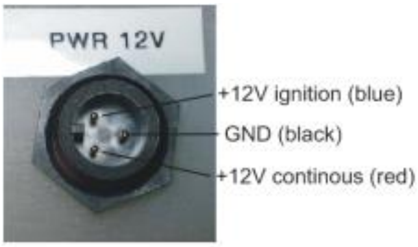

Figure 16: Power supply connector

2.2.5 External expansion connection

For expansion with other devices a standard RS232 connector is available. It can be used with small adaptations also as RS485 connection.

Figure 17: External expansion connector

2.2.6 Internal expansion connection

For expansion with other sensor in the future this internal expansion connector can be used. Here there are different power levels, free I/O pins and a serial interface.

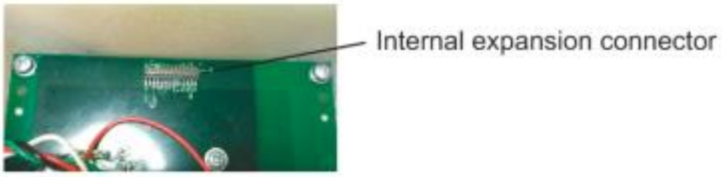

Figure 18: Internal expansion connector

2.2.7 Programming connection

To program the firmware of the controller in the flash memory a standard JTAG from Texas instruments can be used.

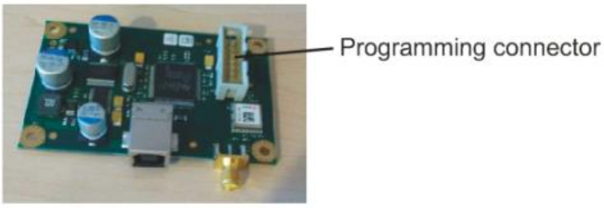

Figure 19: Programming connector

Conclusions

The overall objective of the implementation phase has been to produce a solution based on the development of traffic and environmental monitoring units as well as to select a processing platform and components already present on the market and at the same time suitable for automotive applications. For the selection of a suitable off-the-shelf embedded platform and of the electronic components, the latest automotive standards and technological advancements have been taken into account.

The results of Action 4 are the production and integration of the physical prototypes. Each prototype unit consists of physical HW and SW that will have to perform the specified functionalities. The three prototypes are the On-board traffic monitoring unit prototype, the On-board environmental monitoring unit prototype and the On-board telematic unit prototype.

The main steps of the implementation phase that are common to the three prototypes are the following:

- Electronic schematic design
- PCB layout design
- PCB production
- Component purchase
- Electronic component mounting
- Labelling and testing and of mounted PCBs
- Housing and integration
- Power supply connection
- USB connection
- Interface description unit

Specific steps for the Implementation of the On-board traffic unit prototype have been necessary, namely:

- CAN-bus connection
- GPS antenna connection

Once the three prototypes were completed the integration of the complete INTEGREEN mobile system has been executed on board of the AIT test vehicle.

Subsequently several Field Tests have been successfully executed in Vienna as well as in Bolzano where the End-to-End functionalities of the Mobile System have been verified.

Appendix A: Acronyms and Definitions

FW: Firmware

HW: Hardware

lpm: litre per minute

Pb: lead

PCB: Printed Circuit Board

SW: Software