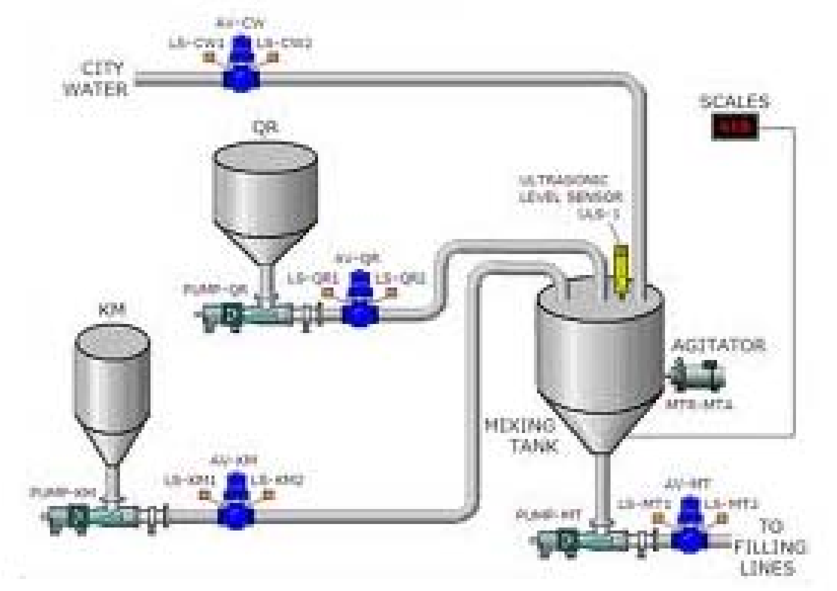
INSTITUTO SUPERIOR DE ENGENHARIA DE LISBOA

Área Departamental de Engenharia de Sistemas de Potência e Automação



Study on influence of the new CoDeSys V3.0 on the existing CoDeSys discipline of the Mind8 Engineering Center

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(Bacharel em Engenharia Electrotécnica)

Dissertação para a obtenção do grau de Mestre em
Engenharia Electrotécnica – ramo de Automação e Electrónica Industrial

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Ph.D. Acácio Galhardo

Júri:
Presidente:
Vogais:

Mês de Ano

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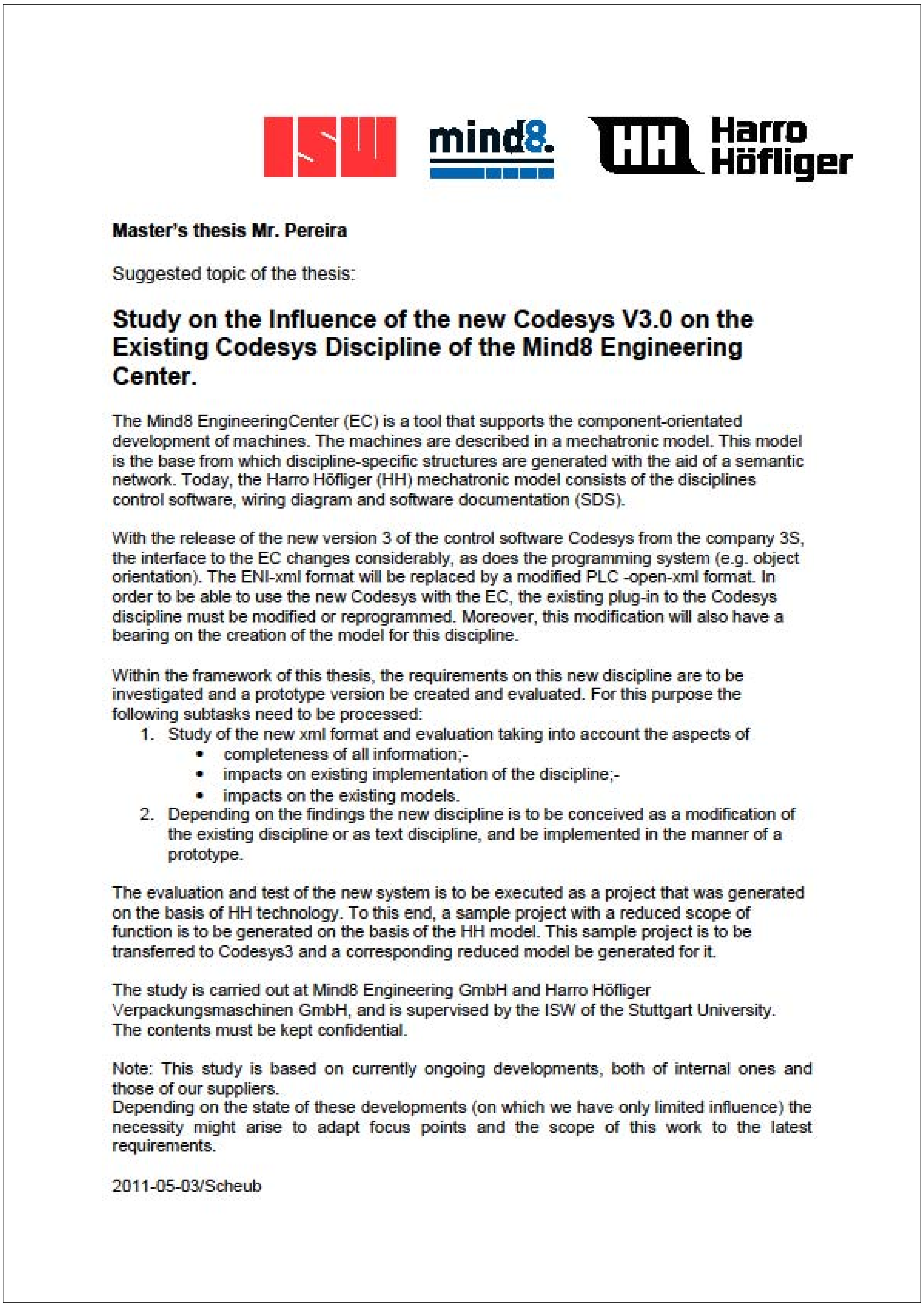
Special thanks for my friend and college Rui Figueiredo for all the friendship and company he gave to me, after all, we are the only two Portuguese in the Stuttgart University Campus. Finally, I want to most specially thanks to my parents and my girlfriend, Carla, for all the support in this time that I have been away.

Stuttgart, July 2012



Master's thesis Mr. Pereira

Suggested topic of the thesis:

Study on the Influence of the new Codesys V3.0 on the Existing Codesys Discipline of the Mind8 Engineering Center.

The Mind8 EngineeringCenter (EC) is a tool that supports the component-orientated development of machines. The machines are described in a mechatronic model. This model is the base from which discipline-specific structures are generated with the aid of a semantic network. Today, the Harro Höfliger (HH) mechatronic model consists of the disciplines control software, wiring diagram and software documentation (SDS).

With the release of the new version 3 of the control software Codesys from the company 3S, the interface to the EC changes considerably, as does the programming system (e.g. object orientation). The ENI-xml format will be replaced by a modified PLC -open-xml format. In order to be able to use the new Codesys with the EC, the existing plug-in to the Codesys discipline must be modified or reprogrammed. Moreover, this modification will also have a bearing on the creation of the model for this discipline.

Within the framework of this thesis, the requirements on this new discipline are to be investigated and a prototype version be created and evaluated. For this purpose the following subtasks need to be processed:

1. Study of the new xml format and evaluation taking into account the aspects of
   - completeness of all information;-
   - impacts on existing implementation of the discipline;-
   - impacts on the existing models.
2. Depending on the findings the new discipline is to be conceived as a modification of the existing discipline or as text discipline, and be implemented in the manner of a prototype.

The evaluation and test of the new system is to be executed as a project that was generated on the basis of HH technology. To this end, a sample project with a reduced scope of function is to be generated on the basis of the HH model. This sample project is to be transferred to Codesys3 and a corresponding reduced model be generated for it.

The study is carried out at Mind8 Engineering GmbH and Harro Höfliger Verpackungsmaschinen GmbH, and is supervised by the ISW of the Stuttgart University. The contents must be kept confidential.

Note: This study is based on currently ongoing developments, both of internal ones and those of our suppliers.
Depending on the state of these developments (on which we have only limited influence) the necessity might arise to adapt focus points and the scope of this work to the latest requirements.

2011-05-03/Scheub

III Table of Contents

IV Abbreviations

Abbreviation	**Meaning**
FDB	Function Block Diagram
SFC	Sequential Function Chart
LD	Ladder Diagram
ST	Structure Text
IL	Instruction List
IEC	International Electrotechnical Commission
PLC	Programmable Logic Controller
CPU	Central Processor Unit
POU	Program Organization Unit
XML	Extensible Markup Language
EEC	Eplan Engineering Center
I/O	Inputs/Output
TC	Technical Committees
HH	Harro Höfliger
OOP	Objects Oriented Programming

1 Abstract

CoDeSys "Controller Development Systems" is a development environment for programming in the area of automation controllers. It is an open source solution completely in line with the international industrial standard IEC 61131-3. All five programming languages for application programming as defined in IEC 61131-3 are available in the development environment. These features give professionals greater flexibility with regard to programming and allow control engineers have the ability to program for many different applications in the languages in which they feel most comfortable.

Over 200 manufacturers of devices from different industrial sectors offer intelligent automation devices with a CoDeSys programming interface. In 2006, version 3 was released with new updates and tools.

One of the great innovations of the new version of CoDeSys is object oriented programming. Object oriented programming (OOP) offers great advantages to the user for example when wanting to reuse existing parts of the application or when working on one application with several developers. For this reuse can be prepared a source code with several well known parts and this is automatically generated where necessary in a project, users can improve then the time/cost/quality management.

Until now in version 2 it was necessary to have hardware interface called “Eni-Server” to have access to the generated XML code. Another of the novelties of the new version is a tool called Export PLCopenXML. This tool makes it possible to export the open XML code without the need of specific hardware. This type of code has own requisites to be able to comply with the standard described above. With XML code and with the knowledge how it works it is possible to do component-oriented development of machines with modular programming in an easy way. Eplan Engineering Center (EEC) is a software tool developed by Mind8 GmbH & Co. KG that allows configuring and generating automation projects. Therefore it uses modules of PLC code. The EEC already has a library to generate code for CoDeSys version 2. For version 3 and the constant innovation of drivers by manufacturers, it is necessary to implement a new library in this software. Therefore it is important to study the XML export to be then able to design any type of machine. The purpose of this master thesis is to study the new version of the CoDeSys XML taking into account all aspects and impact on the existing CoDeSys V2 models and libraries in the company Harro Höfliger Verpackungsmaschinen GmbH. For achieve this goal a small sample named “Traffic light” in CoDeSys version 2 will be done and then, using the tools of the new version it there will be a project with version 3 and also the EEC implementation for the automatically generated code.

2 Basics

2.1 Packaging Machinery

Packaging is the technology for protection and storage of products. To do the packaging of products fast and with high reliability usually very sophisticated machines are used often with the latest know-how and technology.
The company Harro Höfliger Verpackungsmaschinen GmbH is exclusively dedicated to the design and construction of machinery for packaging production primarily for the medical market. The technology introduced on these machines makes them able to produce any product for this sector. To automate these devices the company uses programmable logic controllers (PLC) from the brand ELAU. This brand was recently acquired by Schneider Electric Company.

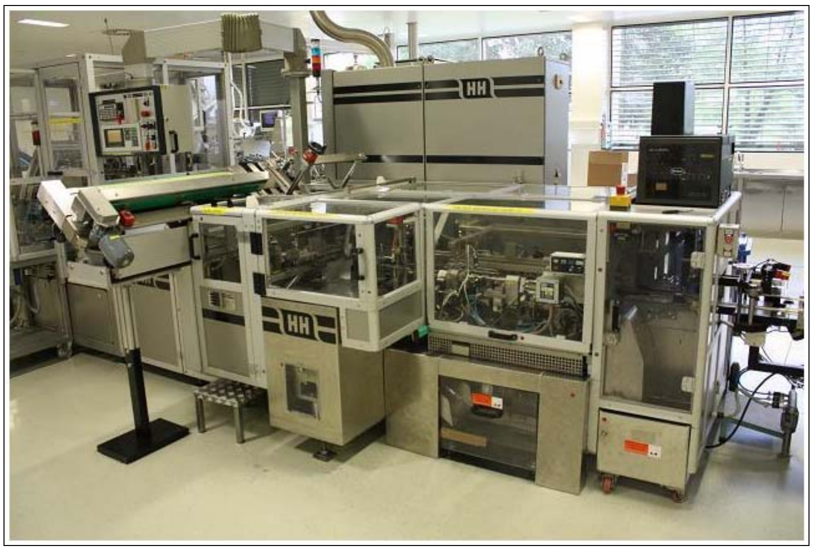


Figure 1 - Machinery for packaging production for the medical sector

One of big difficulties that existed in the past in the design of these machines was the programming of automation devices like drives or cylinders and how this task was performed. Each PLC programmer used to do his own way of programming which meant that there was no standardization of code in any of the machines that were produced.
All PLCs were and still are programmed until today in CoDeSys version 2 Software with Epas-4 (Elau). This is done to ensure that the standard "IEC 61131-3 Program Controllers, Programming Languages" is fully accomplished.

As already mentioned, Harro Höfliger Verpackungsmaschinen GmbH produced machines in the past without a harmonization of parameters for the programming of their machines. To improve this situation there was adopted software called "Eplan Engineering Center" developed by the German company Mind8 GmbH & Co. KG. This software uses libraries of components based on mechatronic machine segments. These are once developed and then many times used for the construction of a new model. All the code necessary to program the machine is drawn into fragments for the various blocks and components, using hierarchies among them. At the end of construction of the whole new machine, the PLC code is generated using the CoDeSys library. This library contains all the code for implementing the specific PLC code of Harro Höfliger.

Today, the Harro Höfliger mechatronic model consists of the disciplines control software, wiring diagram and software documentation (SDS). In short, libraries with standardized code fragments corresponding to mechatronic components are created in the software EEC. The PLC code implementation of a new machine is then not more than joining several pieces of mechatronic components with included code and adjusting various parameters to customer defined requirements that will be present on the machine.

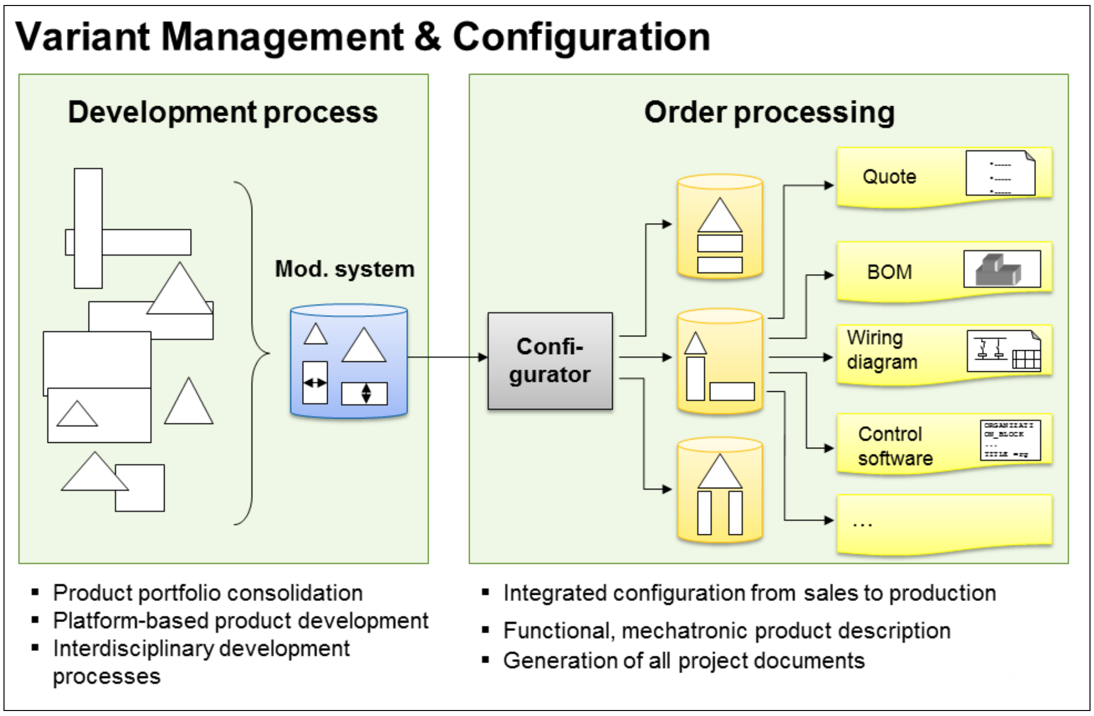

Variant Management & Configuration
Development process
Mod. system
Order processing
Confi-gurator
Quote
BOM
Wiring diagram
Control software
...
Product portfolio consolidation
Platform-based product development
Interdisciplinary development processes
Integrated configuration from sales to production
Functional, mechatronic product description
Generation of all project documents

Figure 2 – Eplan Engineering Center variant management and configuration

Therefore, when creating a code for a new machine, the user does more than build a machine using a graphical model which contains all the components that constitute it. This ensures then that all the code is constructed and approved in advance and thereafter is consistently used the same pattern.

The purpose of this master thesis is to create a new library for the software "Eplan Engineering Center" so that the code is generated according to the new version 3 of CoDeSys (Epas-5 from Elau). Besides of that, all the generated code in version 3 must be in accordance with the standards of quality of machines produced by the company Harro Höfliger. The influence on the new code generated by "Eplan Engineering Center" should also be analyzed; it should be verified that all parameters of IEC 61131-3 are covered.

2.2 PLC – Programmable Logic Controller

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many industries and machines.
Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory.
A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result. [12]
The first PLC was made in the 70´s with a simplified programming language and limited to meet demand in place of industrial control systems based on relays. Over the years various functions have been incorporated into the controller, such as treatment of analog variables, and complex arithmetic algorithms, not limited only to discrete logic (I/O).

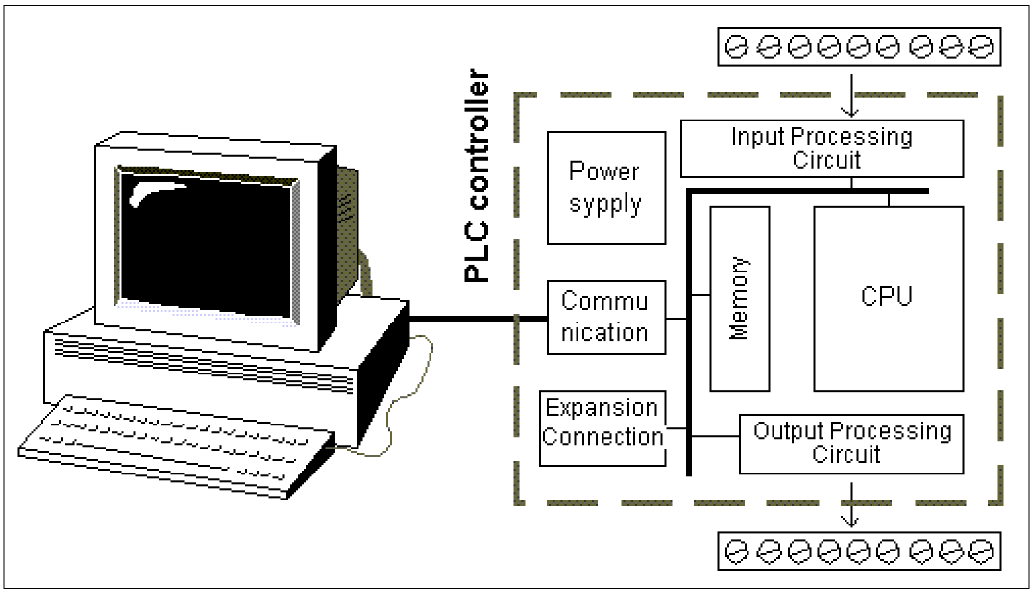


Figure 3 – PLC System Overview

All PLCs have three physical parts (*hardware*) for your basic operating: CPU (*Central Processing Unit*), memory unit and Inputs and outputs (*I/O*), all communicating via a bus communication. The CPU coordinates all tasks and executes the PLC program control stored in memory.

The actual states of the process are monitored and sampled by the drive I/O. All programming is done through an engineering station (computer) in which the program is compiled and loaded into the CPU to be stored in memory using local area network (LAN).

The PLC allows monitoring of inputs and outputs in real time using the engineering workstation, while the program is running.
The company Harro Höfliger uses controllers from the brand Elau with the software Epas-4. Controllers and software use CoDeSys version 2 interface.

Figure 4 – Elau Programmable Logic Controller

2.3 Standard IEC 61131-3

IEC 61131-3 is a programming language standard, independent and standardized for the industrial automation sector. This standard was established by the International Electrotechnical Commission (IEC), an organization of creating global standards at the level established in 1906 and recognized worldwide by industry standards that elaborate. Applying a standard programming language has a positive impact on the life cycle of a software requisite that includes analysis, design, construction, testing (validation), installation, operation and maintenance. IEC 61131-3 provides support of multiple languages within one control program. The user / programmer can select the language that is most suitable for a particular task, thereby increasing his productivity. Ladder Diagram (LD) and Instruction List (IL) are fairly simple, so appropriate mainly for small applications. Function Block Diagram (FBD), Structure Text (ST) and Sequential Function Chart (SFC) are recommended for medium or large scale projects. [1]

IEC 61131-3 is a modular standard because with the FBD language it is possible to create libraries of small modular programs allowing the creation of complete functions. These functions can be used as often as necessary in new machines.

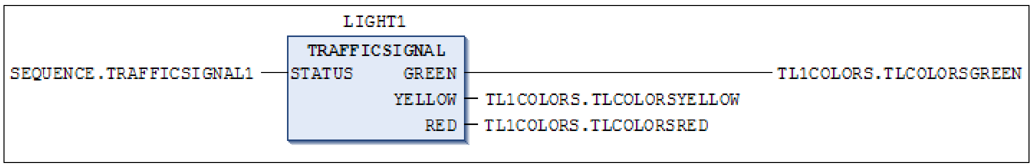


Figure 5 – Traffic Light Function Block Diagram

With a standardized programming interface that is completely independent of the hardware platform (PLC), users can greatly reduce the maintenance cost and the training on these automation application programs. The ability to migrate automation solutions from one to another platform is given in PLC applications, which are offering users and programmers reuse systems with levels never before available.
IEC 61131-3 increases efficiency and speed of implementation of new automation solutions using available control components developed in other projects by other developers.

2.3.1 Configuration, Resources and Tasks

At the highest level, the software needed to solve a particular problem of control can be formulated as a setting. The configuration is specific to a particular type of control system and includes the arrangement of the hardware (processing resources, memory addresses for I/O channels, and system capabilities). Within a configuration, you can define resources. Within a resource, one or more tasks can be defined. [6]
Tasks control the execution of a set of programs and / or function blocks. These can be run periodically or the occurrence of a specific event.

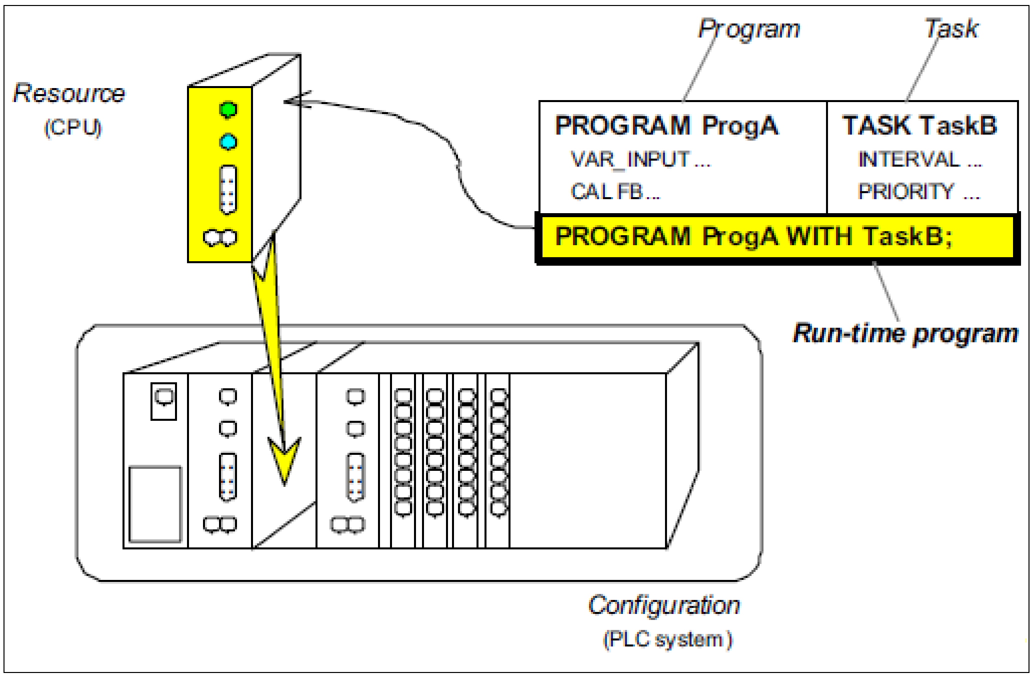


Figure 6 – Physic software model

- **Configuration**

A configuration includes at least one and usually several resources. A resource in turn defines several tasks and programs to be executed by these tasks. Global variables common to all resources are specified in the configuration. Access variables to be used for communication with other configurations are also specified at the configuration level. Global variables are also declared at resource level and are accessible to all the programs within the resource. [6]

- **Resource**

A resource generally corresponds to a device that can execute IEC Programs and is defined within a configuration using an identifier and the processor on which the resource will be loaded. A resource contains Global variable declarations, Access variables that permit remote access to named variables, External variable declarations, Program declarations and task definitions. [6]

- **Tasks**

One of the main requirements in a large process control system is the ability to execute different parts of the control program at different rates depending on the process requirements. For example, a system may contain components with large inertia in its parameters, say a boiler furnace whose temperature can only vary slowly in view of the large thermal time constant and as a result, the function block which controls the furnace temperature may execute once in say 10 seconds. On the other hand, a turbine will have a very fast speed response and the over speed monitoring function block will have to execute at a much faster rate.
An interlocking logic of a fast moving process line may require even faster execution. Tasks achieve this type of control by triggering programs and function blocks at specified time periods. The standard provides for allocation of specific programs and function blocks to specific tasks, which execute at predefined intervals and priority rates (0 for the highest priority and 1, 2, 3 etc. in decreasing order). When multiple tasks are declared within a resource, they need to be scheduled. The scheduler decides the exact moment that a task has to execute. [6]

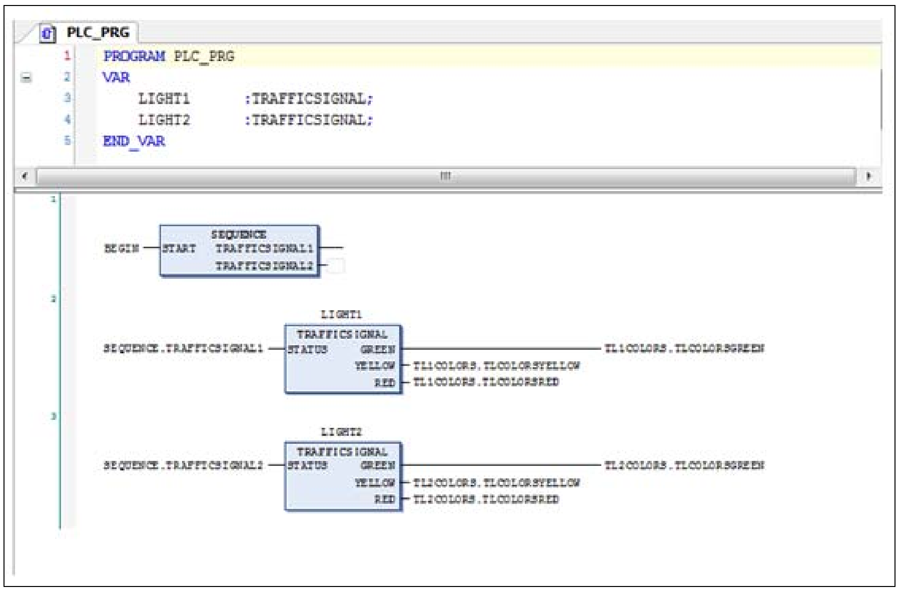
- **Program Organization Units (POU)**

Within IEC 61131-3, programs, function blocks and functions are called program organization units or POUs. IEC 61131-3 standard feature set includes cases, including ADD, ABS, SQRT, SIN, COS, and the user can also create a custom function block and use that function block several times.
Function blocks are software objects that represent a more detailed level of control. They can contain data as well as an algorithm. Software as objects, they have a well-defined interface and hide.

This creates a clear line between the different levels of programs. With these features, functions and function blocks reflect good practice and principles embraced by object-oriented programming.

Function blocks can be written in any of the IEC languages and, in most cases, even using C basic building blocks. Sequential Function Charts or SFCs are used to control the behavior of a sequential control program and support synchronization and concurrency.

One program organization unit may be as to its type: Program, Function Block or Function and may be as to its implementation language: Instruction List, Structure Text, Sequential Function Chart, Function Block Diagram and Ladder Diagram. [8]


PLC_PRG

```
PROGRAM PLC_PRG
VAR
    LIGHT1      :TRAFFICSIGNAL;
    LIGHT2      :TRAFFICSIGNAL;
END_VAR
```

Figure 7 – Program organization unit sample

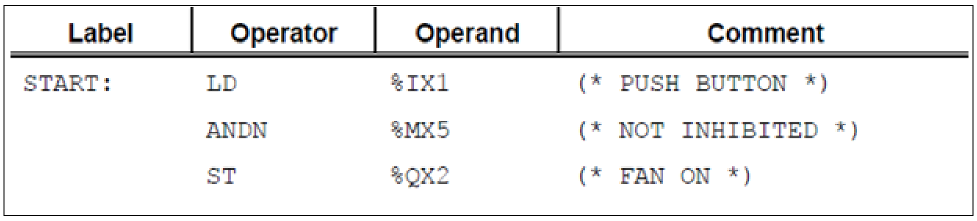
2.3.2 Programming Languages

In this standard, five programming languages are defined. This means that their syntax and semantics have been defined.

- Instruction List, IL (Textual language);
- Structured Text, ST (Textual language);
- Ladder Diagram, LD (Graphical language);
- Function Block Diagram, FBD (Graphical language);
- Sequential Function Chart, SFC (Organization structure).

Instruction List (IL)

Low-level machine-oriented language offered by most of the programming systems. It’s a language very similar with assembler. Single accumulator based execution model. Only one operation such as storing a value in the accumulator register is allowed per line.

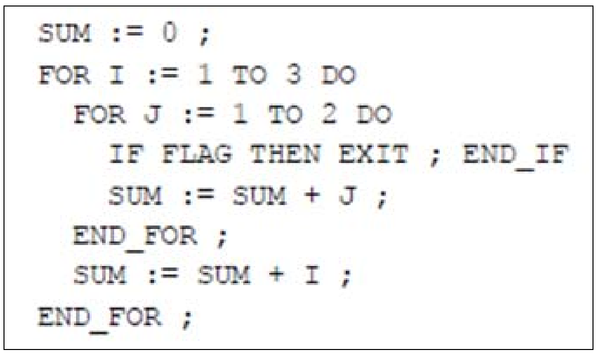


Label	Operator	Operand	Comment
START:	LD	%IX1	(* PUSH BUTTON *)
	ANDN	%MX5	(* NOT INHIBITED *)
	ST	%QX2	(* FAN ON *)

Figure 8 – Instruction list code sample

Structure Text (ST)

Is a high-level language very powerful, with roots in Ada, Pascal and "C". Contains all the essential elements of a modern programming language, including conditional (IF-THEN-ELSE and CASE OF) and iteration (FOR, WHILE and REPEAT).
This language is excellent for the definition of complex functional blocks, which can be used in any other language IEC. [6]



```
SUM := 0 ;
FOR I := 1 TO 3 DO
  FOR J := 1 TO 2 DO
    IF FLAG THEN EXIT ; END_IF
    SUM := SUM + J ;
  END_FOR ;
  SUM := SUM + I ;
END_FOR ;
```

Figure 9 – Structure text code sample

Ladder Diagram (LD)

POUs written in LD are divided into sections known as networks. LD networks are bounded on the left and right by power rails Graphical connections of Boolean variables (contacts and coils), geometrical view of a circuit similar to earlier relay controls.
A Ladder diagram program enables the controller to test and modify data by means of standardized graphic symbols. [6]

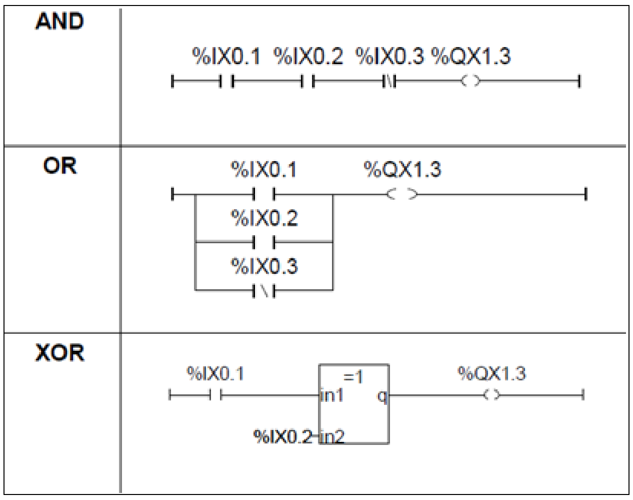


Figure 10 – Ladder diagrams samples

Function Block Diagram (FDB)

In the process industry graphical language is intensive used. This language allows programs elements which appear as blocks to be “wired” together in a form analogous to a circuit diagram.
Elements of the FBD language shall be interconnected by signal flow lines. Outputs of function blocks shall not be connected together. [6]

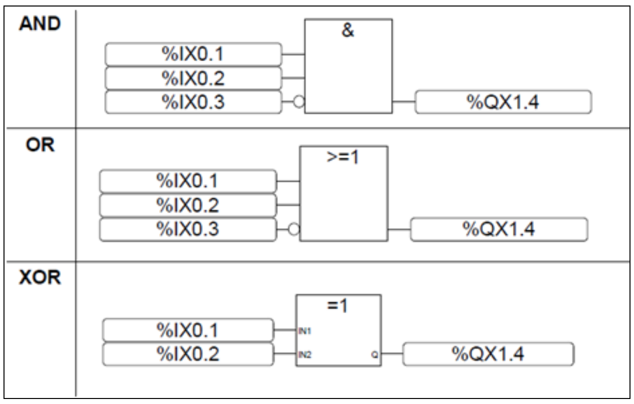


Figure 11 – Functions blocks diagram samples

Sequential Function Chart (SFC)

In order to divide control task into parts which can be executed sequentially and in parallel, as well as for controlling their overall execution, we have sequential functions charts. SFC very clearly describes the program flow by defining which actions of the controlled process will be enabled, disabled or terminated at any one time. [6]

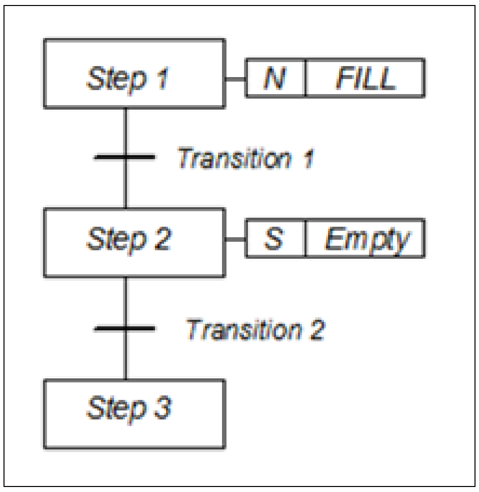


Figure 12 – Sequential function chart samples

The SFC representation indicates the following in respect of an industrial process or machinery:

- Main phases of the process;
- In the case of machinery, the main states;
- Behavior of action blocks pertaining to each phase or state;
- Conditions for change from one phase to the next phase.

An SFC consists of a sucession of steps, with each step representing a stage of a process. The change over from one step to the next is decided by transitions, which follow a step. It is to be stressed here that a SFC need not necessarily show an entire process.
A complex process can be split into several SFCs each representing a part of the process. A Function block can itself be defined using a SFC. As in the case of other graphical IEC languages such as the FBD or the LD, the Sequential Function Chart can also be represented in full graphic or semi-graphic form.

Steps

We learnt about the use of steps in the previous section. There are essentially two types of steps.

- *Initial Step* - The START step in the SFC is an initial step represented by a rectangle with double vertical lines. An SFC can have only one initial step and this is the step which will be activated first when a PLC is started;

- *Normal Step* - All the other steps in the SFC are normal steps and are represented by plain rectangles.

Transitions

Transition conditions can be expressed using any of the other IEC standard languages. In the examples, the most common is they represented on the SFC, using structured text. But, the same can be represented using Ladder diagram or Function block diagram as well.

Actions

Each step of an SFC represents a particular state of a machine or a process. When a set of conditions is fulfilled, a transition occurs and a sequence of actions is initiated to achieve the process condition defined for the concerned step. In the SFC graphic representation, this is shown as a rectangular box within which the actions corresponding to the step are indicated using any of the IEC standard languages. [8]

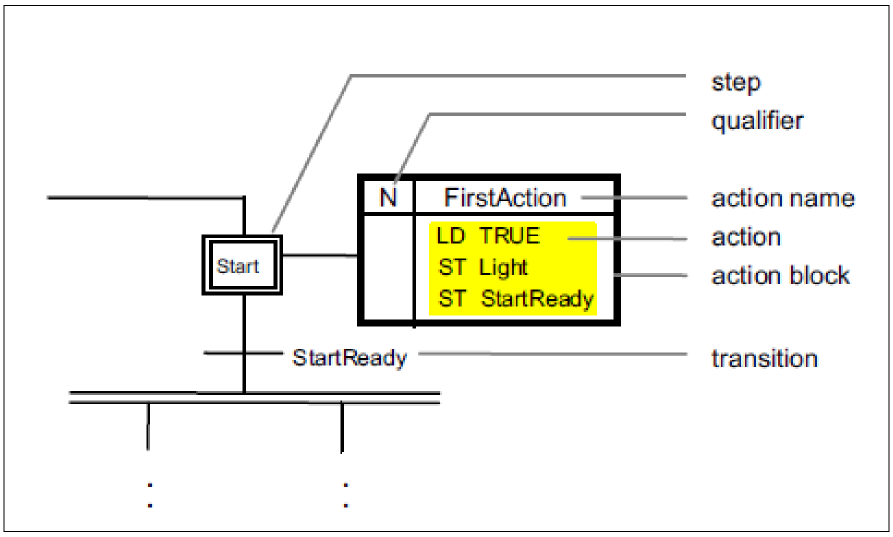


Figure 13 – SFC initial step extended with a (non-Boolean) action block for step Start

2.4 PLCopen

PLCopen is an independent international organization. Many PLC manufacturers, software houses and independent institutions in Europe and overseas are members of the organization. Coming from different industry sectors, the members are focused on the harmonization of controller programming and the development of applications and software interfaces in the IEC 61131-3 environment.
In order to reduce the costs in industrial engineering, uniform specifications and implementation guidelines have been devised. These efforts resulted, for example, in standardized libraries for different application fields, the specification of a conformity level for programming languages, and interfaces for an enhanced exchange of software. The PLCopen expert members are organized in technical committees and define these open standards in cooperation with final users. Since the release of the IEC 61131-3 standard, users are able to exchange their programs, libraries and projects between all the available development environments. [3]

PLCopen has several Technical Committees, but the most important for this thesis is the TC6. TC6 defines XML schemes for the description of IEC 61131-3 application programs and projects in XML. This includes the textual and graphical languages, variable declaration, and configuration. The specification supports:

- The exchange of blocks between systems;
- The interface to other software packets such as documentation, simulation, or verification tools.

PLCopen XML standard is the representation of the complete project within the IEC 61131-3 environment based on current XML technologies. In PLCopen XML can be found the common elements with Sequential Function Chart (SFC), the two textual languages Structured Text (ST) and Instruction List (IL), and the two graphical languages Function Block Diagram (FBD), and Ladder Diagram (LD). The formats are specified through a corresponding XML scheme. This is an independent file, with the .xsd extension, and as such part of this specification.

A scheme (xsd file) is defined as a formal specification of element names that indicates which elements are allowed in an XML document, and in which combinations. It also defines the structure of the document: which elements are child elements of others, the sequence in which the child elements can appear, and the number of child elements. It defines whether an element is empty or can include text.

The scheme can also define default values for attributes. A scheme also provides extended functionality such as data typing, inheritance, and presentation rules.

In the exported XML file all information is made available. The intelligence is in the importing function. Vendor specific information and attributes can be included in the export file and deleted during import, if applicable. [3]

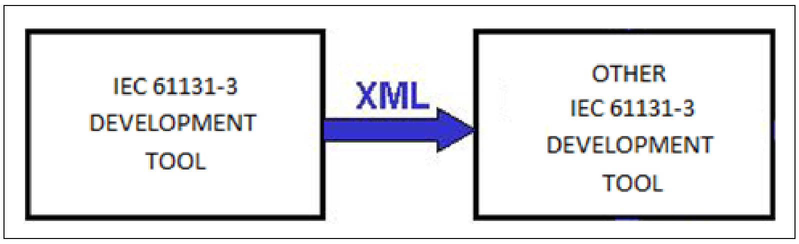


Figure 14 – PLCopenXML tool

2.5 Eplan Engineering Center (EEC)

The company Mind8 GmbH & Co. KG, headquartered in Stuttgart, was founded in late 2000. Since early 2004, this company has collaborated with the company Eplan Software & Service. Since 2007 it is part of the Friedhelm Loh Group.

Mind8 is specialized in mechatronic variant management, reducing the complexity of products and processes. The software tool Eplan Engineering Center (EEC) is developed by Mind8. It is based on a combination of long experience in the areas of modularization and reuse of mechatronics engineering of plant and machinery as well as in-depth knowledge of standard IT systems.

Eplan Engineering Center is a technical software based on Java language with an eclipse environment. This software is used for the construction of various items including machinery and production of technical documentation for the same.

Based on object oriented blocks it is very simple to configure a machine and to produce the source code for the controller and datasheets of all components forming part of the project.

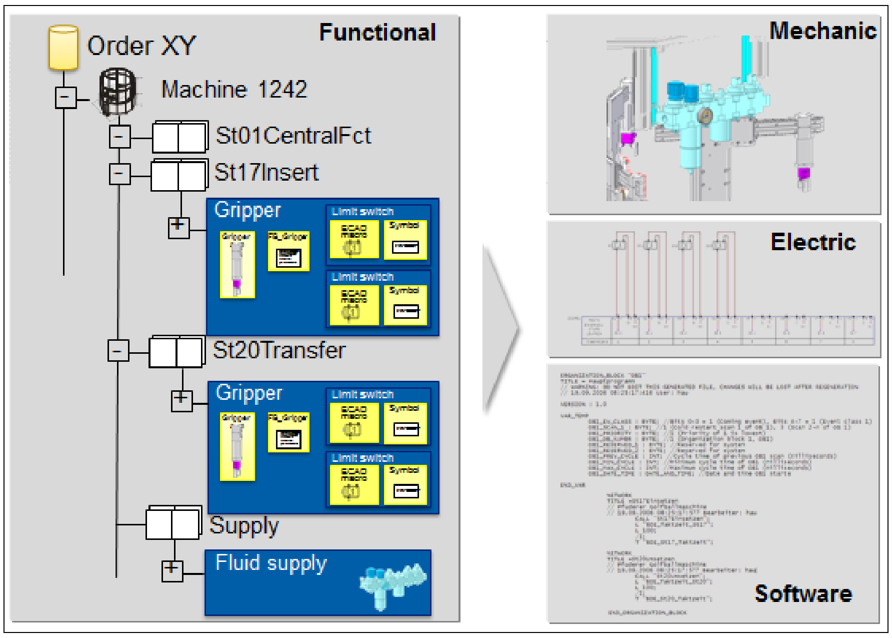


Figure 15 – Eplan Engineering Center generation of documents out of the mechatronic model

As can be seen in figure 16, for each gripper inserted in different variants in machine 1242, mechanical, electrical and software diagrams will be changed according to the characteristics and functions predefined for the gripper inserted.

3 Traffic Light Sample

For this investigation a schedule of mile stones was elaborated. An achieved mile stone will allow a consistent way forward to the next step and thus successfully complete the work that was originally proposed.

1	***SAMPLES (PHASE I)***
1.1	CODESYS V2 (EPAS-4) SAMPLE
1.2	CODESYS V3 (EPAS-5) SAMPLE
1.3	CODESYS V2 (EPAS-4) PLC TESTING
1.4	CODESYS V3 (EPAS-5) PLC TESTING
2	***TEMPLATES (PHASE II)***
2.1	CODESYS V2 (EPAS-4) TEMPLATE – EEC RESOURCES
2.2	CODESYS V3 (EPAS-5) TEMPLATE – EEC RESOURCES
3	***CODESYS / TEXT DISCIPLINE (PHASE III)***
3.1	EEC MECHATRONIC MODEL – V2 CODESYS DISCIPLINE
3.2	EEC MECHATRONIC MODEL – V3 TEXT DISCIPLINE
4	***TESTINGS (PHASE III)***
4.1	EEC CODESYS V2 DISCIPLINE TESTING
4.2	EEC CODESYS V3 DISCIPLINE (TEXT DICSCIPLINE) TESTING

Table 1 – EEC CoDeSys version 3 implementation structure

In the first phase a project in CoDeSys version 2 Epas-4 called "Traffic Light" was created. Once compiled, this project has been imported by the new version of CoDeSys software through the Epas-5. This will be a very important analysis because there are already many functions and programs written in Epas-4 and with this information it is possible to see if the update for the new version can be done. In this way many functions and reusable codes can be easily exported to the latest CoDeSys version and then take advantage of the latest improvements. During the first phase both projects were compiled and tested with PLCs specific for each version.

3.1 Creation of CoDeSys Version 2 Project

- **Controlling a Traffic Signal Unit**

For a simple traffic signal unit which is supposed to control two traffic signals at an intersection. The red/green phases of both traffic signals alternate and, in order to avoid accidents, it will be insert yellow or yellow/red transitional phases. The latter will be longer than the former. In this example is possible to see how time dependent programs can be shown with the language resources of the IEC 61131-3 standard, how one can edit the different languages of the standard with the help of Epas-4. [10]

- **Create a POU**

In the dialog box which appears, the first POU has already been given the default name PLC_PRG. The type of POU should definitely be a program. Each project needs a program with this name. In this case may be chosen as the language of this POU the Continuous Function Chart Editor (CFC). Now three more objects will be create with the command "Project" "Object Add" with the menu bar or with the context menu. A program in the language Sequential Function Chart (SFC) named SEQUENCE, a function block in the language Function Block Diagram (FBD) named TRAFFICSIGNAL, along with a POU WAIT, also of the type function block, which we want to program as an Instruction List (IL). [10]

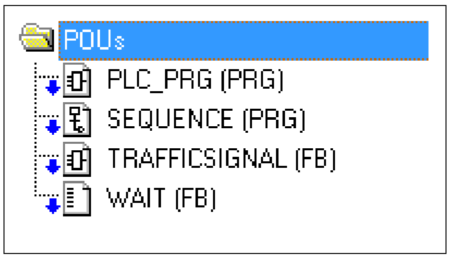
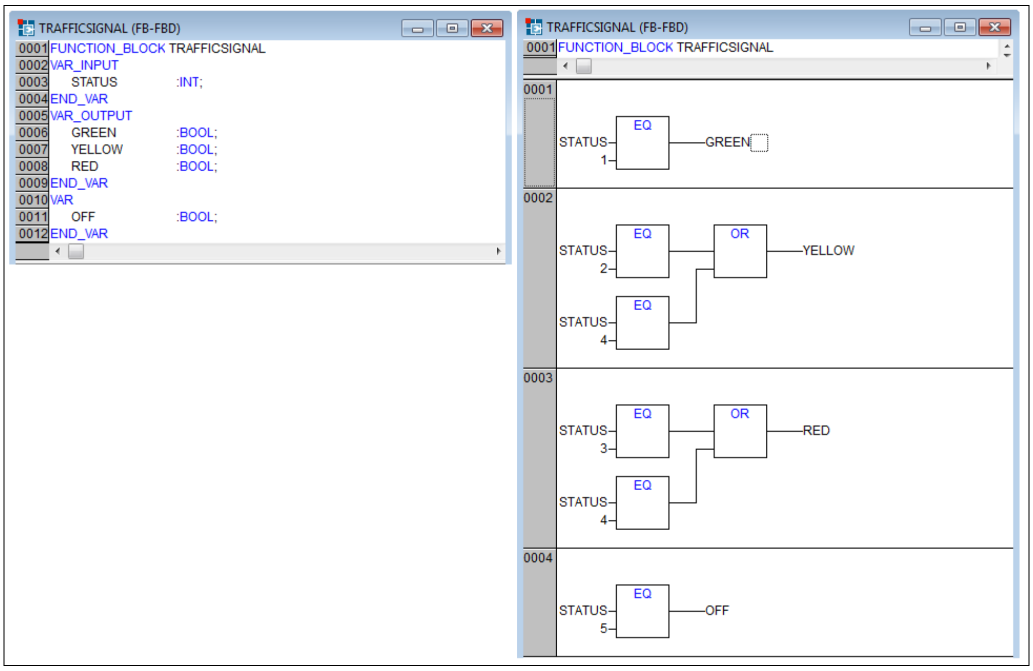


Figure 16 – POU folder

- **Pou Trafficsignal**

In the POU TRAFFICSIGNAL will be assign the individual traffic signal phases to the lights, and has to be ensure that the red light is lit red in the red phase and in the yellow/red phase, the yellow light in the yellow and yellow/red phases, etc. [10]

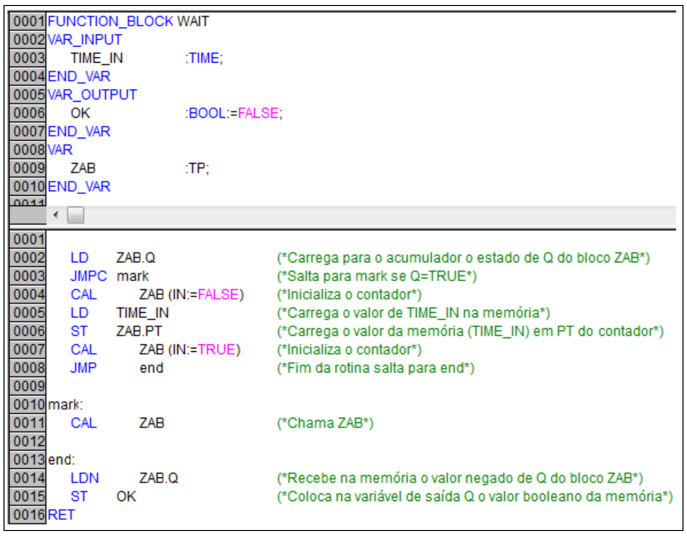


```
FUNCTION_BLOCK TRAFFICSIGNAL
VAR_INPUT
    STATUS          :INT;
END_VAR
VAR_OUTPUT
    GREEN           :BOOL;
    YELLOW          :BOOL;
    RED             :BOOL;
END_VAR
VAR
    OFF             :BOOL;
END_VAR
```

Figure 17 – Trafficsignal POU

- **Pou Wait**

In WAIT POU program a simple timer which as input will receive the length of the phase in milliseconds, and as output will produce TRUE as soon as the time period is finished. [10]



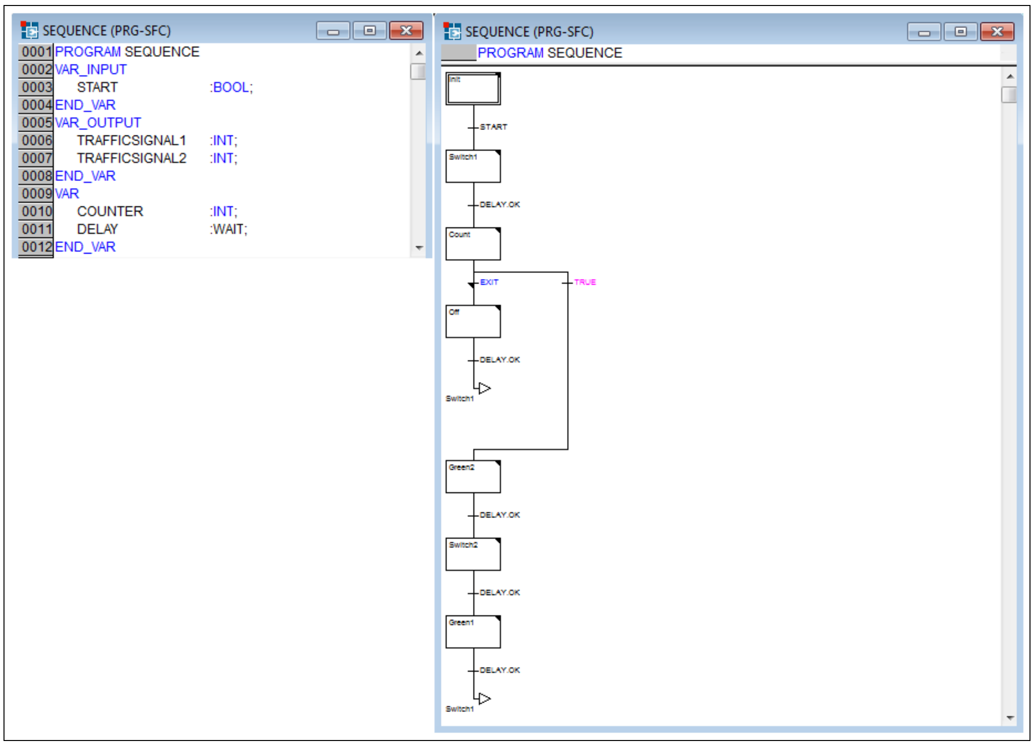
```
FUNCTION_BLOCK WAIT
VAR_INPUT
    TIME_IN             :TIME;
END_VAR
VAR_OUTPUT
    OK                  :BOOL:=FALSE;
END_VAR
VAR
    ZAB                 :TP;
END_VAR
```

```

    LD    ZAB.Q               (*Carrega para o acumulador o estado de Q do bloco ZAB*)
    JMPC  mark                (*Salta para mark se Q=TRUE*)
    CAL      ZAB (IN:=FALSE)  (*Inicializa o contador*)
    LD    TIME_IN             (*Carrega o valor de TIME_IN na memória*)
    ST    ZAB.PT              (*Carrega o valor da memória (TIME_IN) em PT do contador*)
    CAL      ZAB (IN:=TRUE)   (*Inicializa o contador*)
    JMP      end              (*Fim da rotina salta para end*)

mark:
    CAL      ZAB              (*Chama ZAB*)

end:
    LDN      ZAB.Q            (*Recebe na memória o valor negado de Q do bloco ZAB*)
    ST    OK                  (*Coloca na variável de saída Q o valor booleano da memória*)
RET
```

Figure 18 – Wait POU

- **Pou Sequence**

In SEQUENCE all is combined so that the right light lights up at the right time for the desired time period. [10]



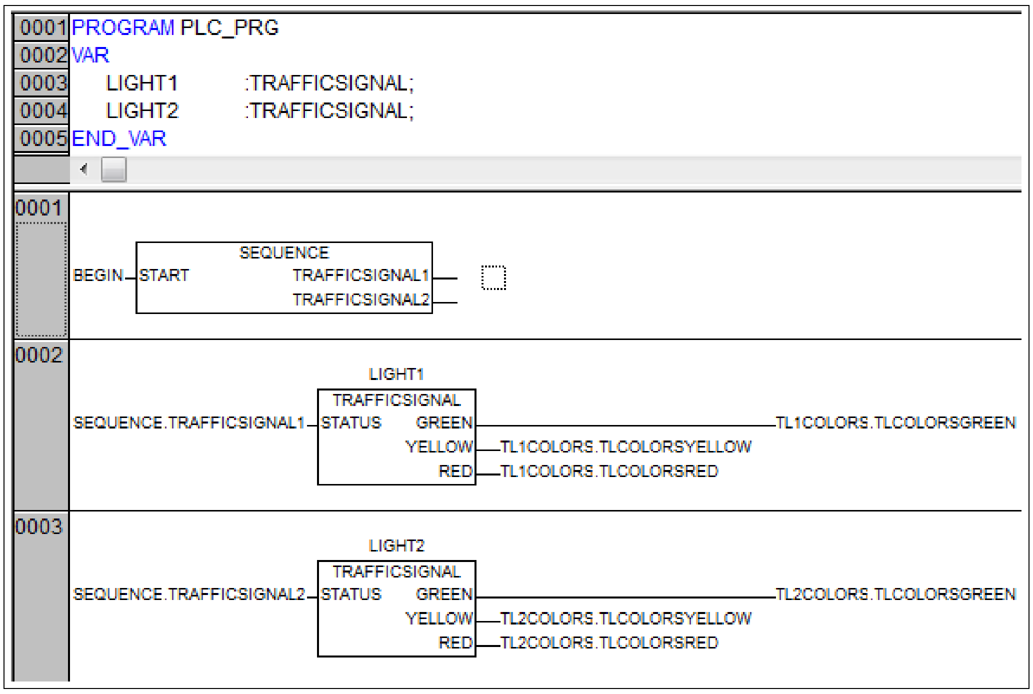
```
PROGRAM SEQUENCE
VAR_INPUT
    START              :BOOL;
END_VAR
VAR_OUTPUT
    TRAFFICSIGNAL1     :INT;
    TRAFFICSIGNAL2     :INT;
END_VAR
VAR
    COUNTER            :INT;
    DELAY              :WAIT;
END_VAR
```

Figure 19 – Sequence POU

The steps presented have associated actions that will be performed when the steps are initiated. These actions also might be easily edited, and the code automatically generated by EEC.

- Pou PLC_PRG

In PLC_PRG the input start signal is connected to the traffic lights sequence and the "color instructions" for each lamp are provided as outputs. [10]



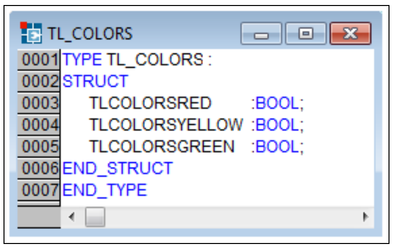
```
PROGRAM PLC_PRG
VAR
    LIGHT1        :TRAFFICSIGNAL;
    LIGHT2        :TRAFFICSIGNAL;
END_VAR
```

Figure 20 – PLC_PRG POU

This POU will be the most important for the implementation of the CoDeSys v3 library in EEC software. Each intersection will have two traffic lights identified by this POU, "LIGHT1" and "LIGHT2". If the project developer chooses to introduce another Intersection the code will automatically generate two additional FDB as shown in Figure 20.

- Data Type

In the section Data Types can define specific variables in our program. One can use standard data types or user-defined types. Each identifier is assigned to a data type that determines the amount of memory space will be reserved and what kind of values it stores.

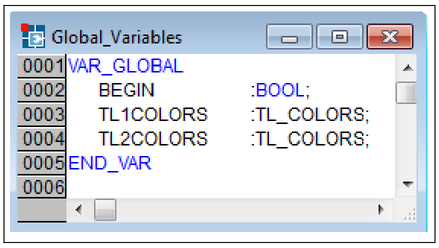


```
TYPE TL_COLORS :
STRUCT
    TLCOLORSRED       :BOOL;
    TLCOLORSYELLOW :BOOL;
    TLCOLORSGREEN   :BOOL;
END_STRUCT
END_TYPE
```

Figure 21 – Data Types "TL_COLORS"

- Global Variables

Are constants or variables that are common to the whole project can be declared as global variables, but also network variables that are then used to exchange data with subscribers of other networks.

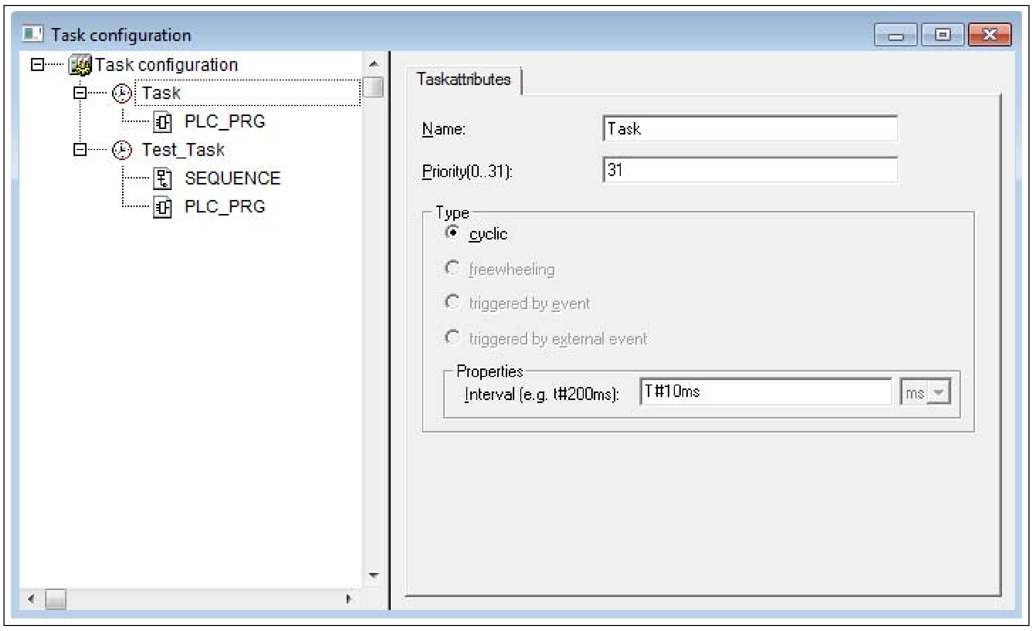


```
VAR_GLOBAL
    BEGIN        :BOOL;
    TL1COLORS    :TL_COLORS;
    TL2COLORS    :TL_COLORS;
END_VAR
```

Figure 22 – Global Variables

- Tasks

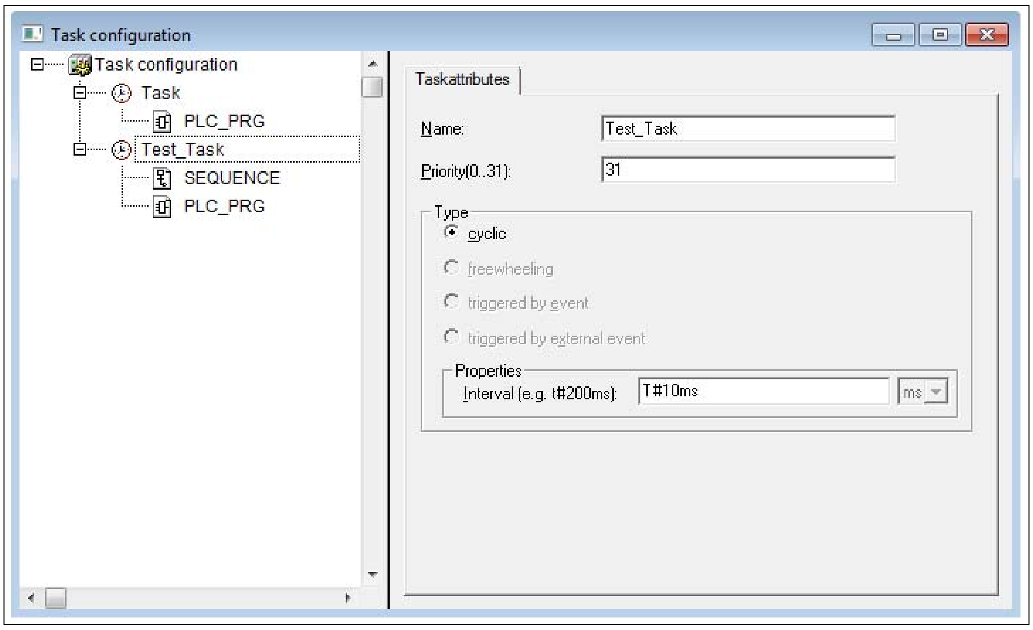
To also test whether the tasks will be imported correctly, two tasks will be created in the project as shown in the following two figures.



Name: Task
Priority(0..31): 31
Type
(● cyclic) freewheeling / triggered by event / triggered by external event
Properties
Interval (e.g. t#200ms): T#10ms ms

Figure 23 – Task configuration, Task

Parameter	Value
Name	Test
Priority	31
Type	Cyclic
Interval	10ms
Program Call	PLC_PRG



Name: Test_Task
Priority(0..31): 31
Type
[✓ cyclic]
freewheeling
triggered by event
triggered by external event
Properties
Interval (e.g. t#200ms): T#10ms ms

Figure 24 – Task configuration, Test_Task

Parameter	Value
Name	Test_Task
Priority	31
Type	Cyclic
Interval	10ms
Program Call	PLC_PRG, SEQUENCE

- **Visualization**

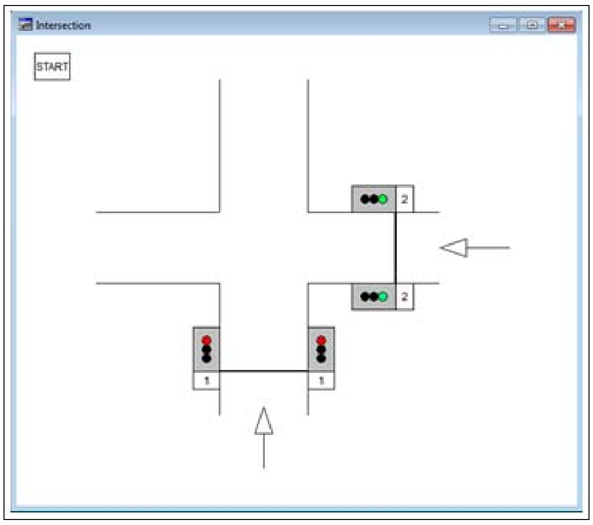


Figure 25 – Traffic light Visualization

The program was tested with the appropriate hardware and the intersection traffic light gain live in the visualization showed in figure 25.

3.2 Project XML Output – Eni-Server

The XML project just performed can be analyzed only with Eni-Server interface. This interface is responsible for "translating" the draft prepared by Epas-4 software in XML code. Currently Eni-Server works together with EEC software for creating real-time code in Harro Höfliger Company.

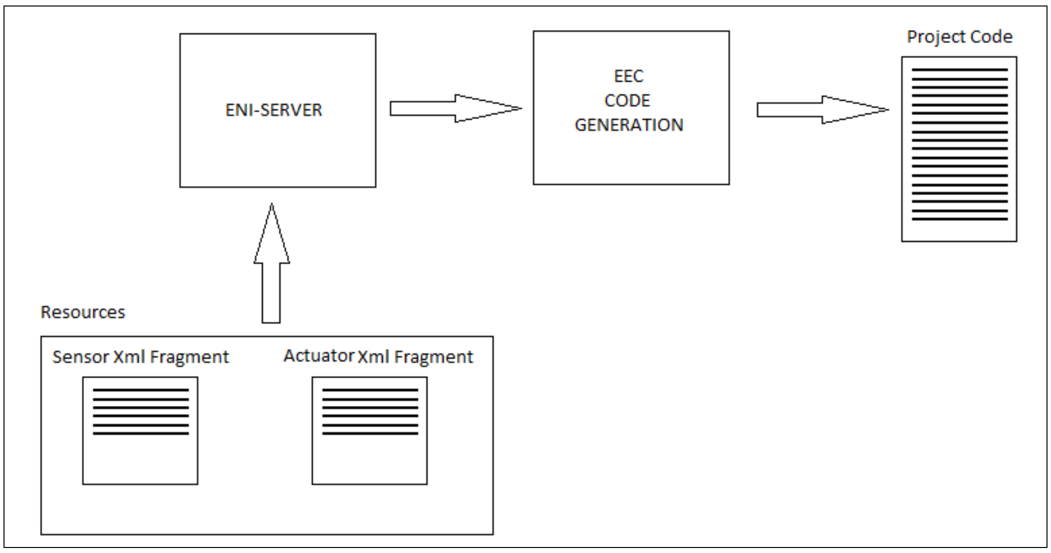
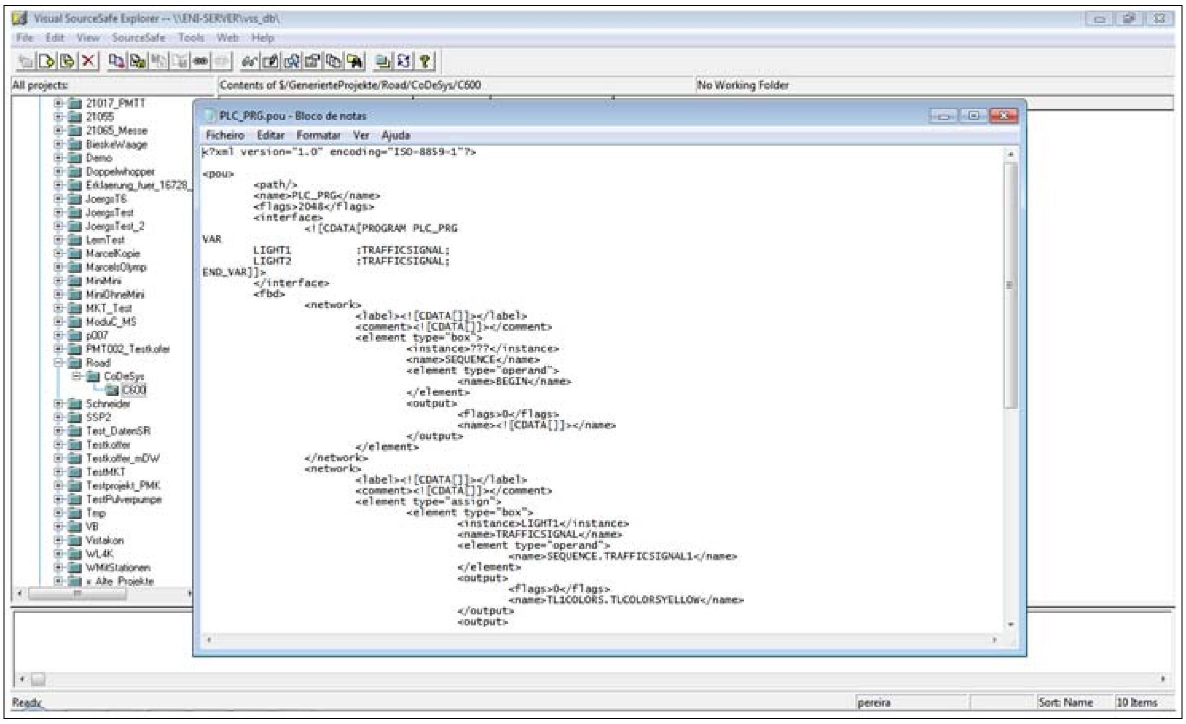


Figure 26 – Scheme of XML output, connection Eni-Server with EEC



```
<?xml version="1.0" encoding="ISO-8859-1"?>

<pou>
        <path/>
        <name>PLC_PRG</name>
        <flags>2048</flags>
        <interface>
                <![CDATA[PROGRAM PLC_PRG
VAR
        LIGHT1          :TRAFFICSIGNAL;
        LIGHT2          :TRAFFICSIGNAL;
END_VAR]]>
        </interface>
        <fbd>
                <network>
                        <label><![CDATA[]]></label>
                        <comment><![CDATA[]]></comment>
                        <element type="box">
                                <instance>???</instance>
                                <name>SEQUENCE</name>
                                <element type="operand">
                                        <name>BEGIN</name>
                                </element>
                                <output>
                                        <flags>0</flags>
                                        <name><![CDATA[]]></name>
                                </output>
                        </element>
                </network>
                <network>
                        <label><![CDATA[]]></label>
                        <comment><![CDATA[]]></comment>
                        <element type="assign">
                                <element type="box">
                                        <instance>LIGHT1</instance>
                                        <name>TRAFFICSIGNAL</name>
                                        <element type="operand">
                                                <name>SEQUENCE.TRAFFICSIGNAL1</name>
                                        </element>
                                        <output>
                                                <flags>0</flags>
                                                <name>TL1COLORS.TLCOLORSYELLOW</name>
                                        </output>
                                        <output>
```

Figure 27 – PLC_PRG code visualization with Eni-Server

Now with the release of CoDeSys version 3, users can take advantage of PLCopenXML tool. Unlike Eni-Server this tool is completely open source and eliminates the need to have a server to translate automation projects in XML format.

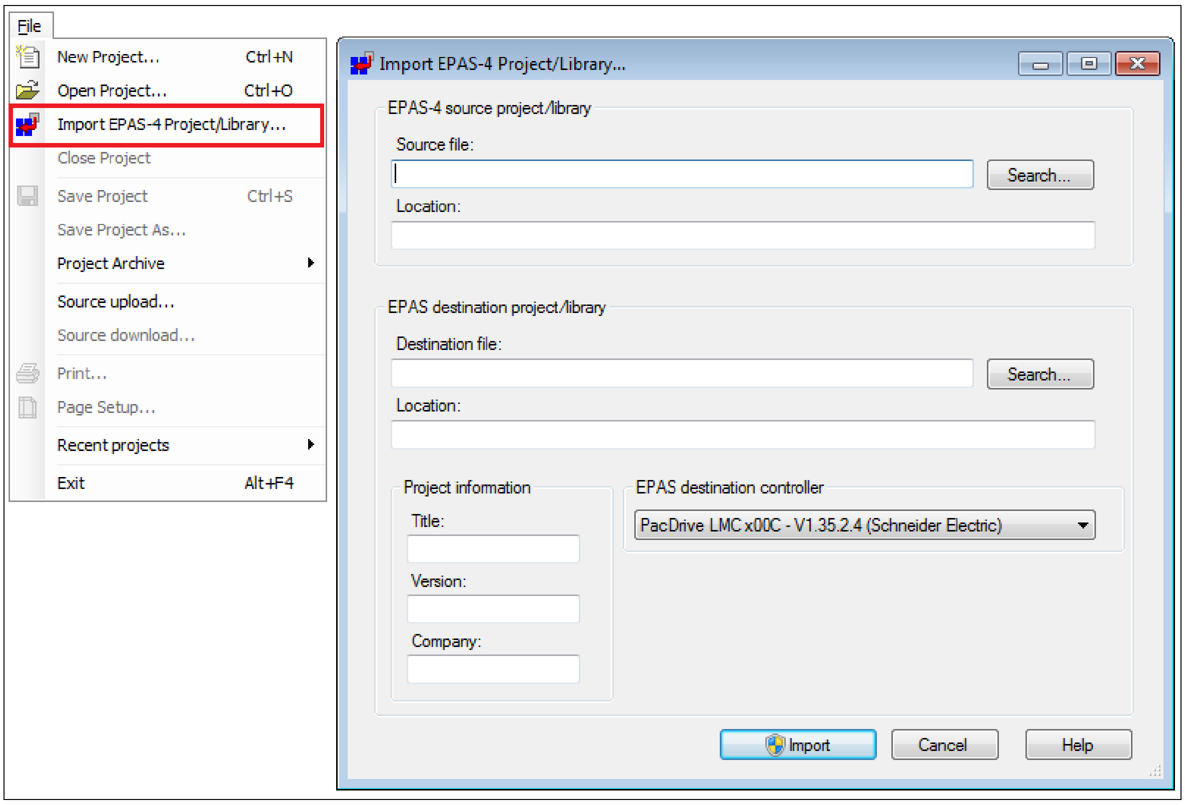
In the next picture is possible to visualize a small part of the code of the PLC_PRG POU. Later in this document it will be done a comparison with the same part but in PLCopenXML code, CoDeSys version 3.

```
<network>
        <label><![CDATA[]]></label>
        <comment><![CDATA[]]></comment>
        <element type="assign">
                <element type="box">
                        <instance>LIGHT1</instance>
                        <name>TRAFFICSIGNAL</name>
                        <element type="operand">
                                <name>SEQUENCE.TRAFFICSIGNAL1</name>
                        </element>
                        <output>
                                <flags>0</flags>
                                <name>TL1COLORS.TLCOLORSYELLOW</name>
                        </output>
                        <output>
                                <flags>0</flags>
                                <name>TL1COLORS.TLCOLORSRED</name>
                        </output>
                </element>
                <output>
                        <flags>0</flags>
                        <name>TL1COLORS.TLCOLORSGREEN</name>
                </output>
        </element>
</network>
```

Figure 28 – PLC_PRG code sample

3.3 Import of the Traffic Light Sample into CoDeSys Version 3 and adding of an object oriented function block

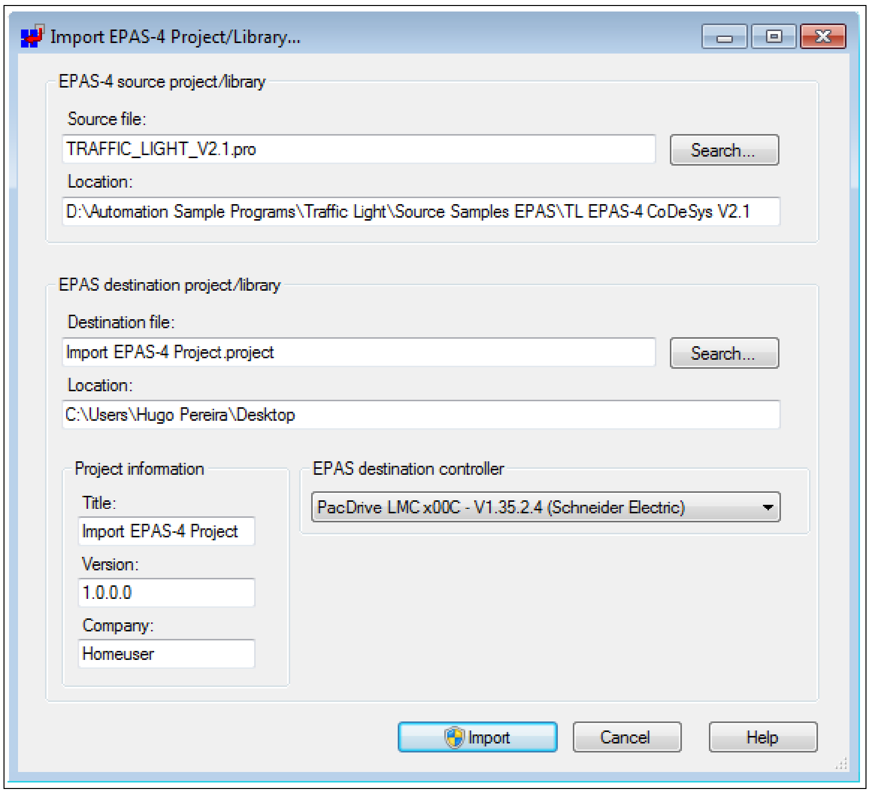
To implement the sample project in CoDeSys version 3 was used a new tool available in this software. This tool is called "Import Epas-4 Project/Library" and easily the draft version 2 is updated to the latest version. Will be analyzed and discussed in this section what kind of problems a user may find when performing this data transport and whether all mandatory requirements will be met.



EPAS destination controller: PacDrive LMC x00C - V1.35.2.4 (Schneider Electric)

Figure 29 – Import Epas-4 Project/Library

The user must fill in all fields such as where is the source file (version 2), the name of the new project or which Elau controller will be used to execute this project.



Import EPAS-4 Project/Library...

EPAS-4 source project/library

Source file: TRAFFIC_LIGHT_V2.1.pro

Location: D:\Automation Sample Programs\Traffic Light\Source Samples EPAS\TL EPAS-4 CoDeSys V2.1

EPAS destination project/library

Destination file: Import EPAS-4 Project.project

Location: C:\Users\Hugo Pereira\Desktop

Project information

Title: Import EPAS-4 Project

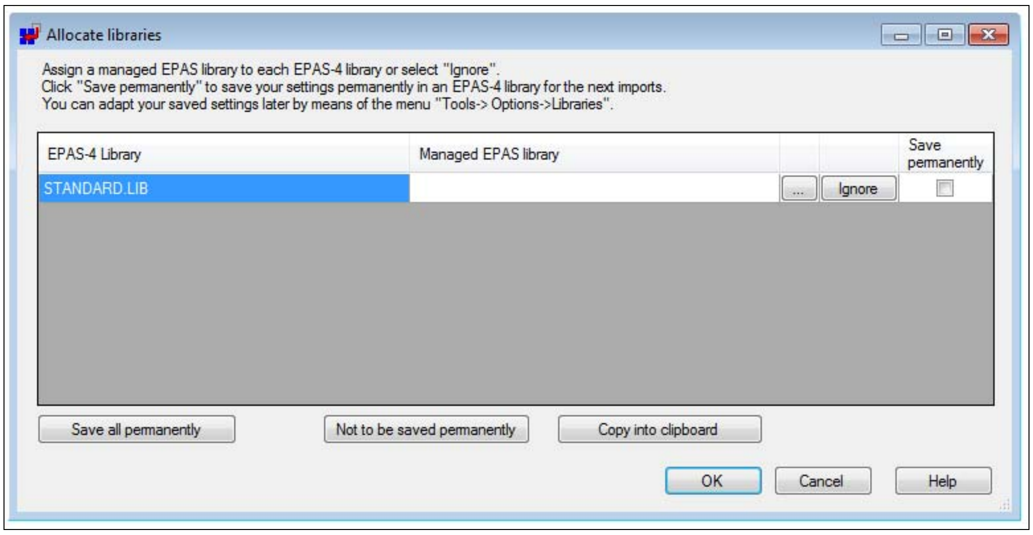
Version: 1.0.0.0

Company: Homeuser

EPAS destination controller: PacDrive LMC x00C - V1.35.2.4 (Schneider Electric)

Figure 30 – Import Epas-4 Project/Library

The system identifies the library “STANDARD.LIB” is being used by the project in version 2 and the user is asked if he also wishes that this library is imported. If the library is imported it is guaranteed that the whole project will work exactly as in version 2.

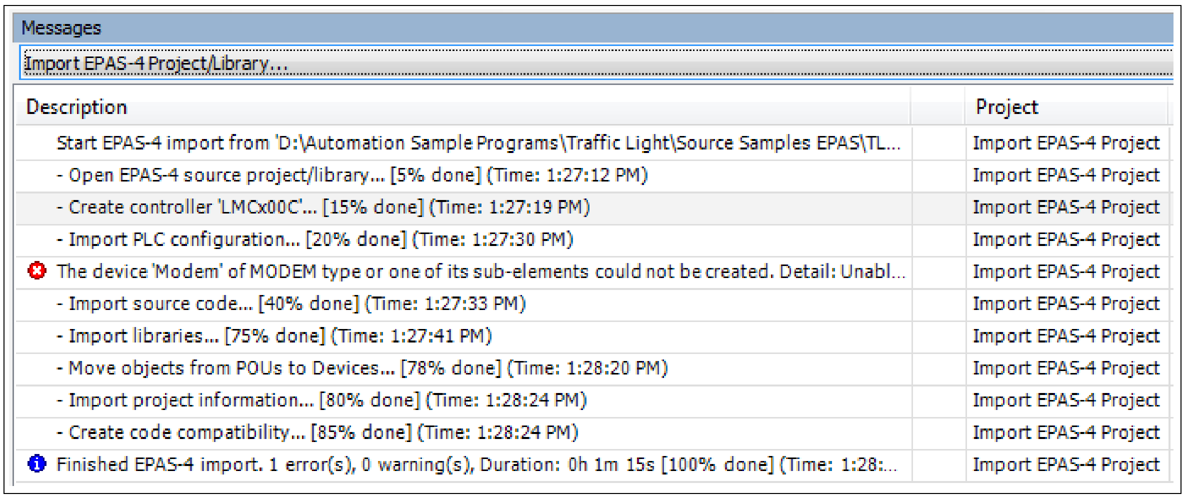


Allocate libraries

Assign a managed EPAS library to each EPAS-4 library or select "Ignore".
Click "Save permanently" to save your settings permanently in an EPAS-4 library for the next imports.
You can adapt your saved settings later by means of the menu "Tools-> Options->Libraries".

EPAS-4 Library	Managed EPAS library			Save permanently
STANDARD.LIB		...	Ignore	☐

Figure 31 – Import Epas-4 Project/Library – Allocate libraries



Messages

Import EPAS-4 Project/Library...

Description	Project
Start EPAS-4 import from 'D:\Automation Sample Programs\Traffic Light\Source Samples EPAS\TL...	Import EPAS-4 Project
- Open EPAS-4 source project/library... [5% done] (Time: 1:27:12 PM)	Import EPAS-4 Project
- Create controller 'LMCx00C'... [15% done] (Time: 1:27:19 PM)	Import EPAS-4 Project
- Import PLC configuration... [20% done] (Time: 1:27:30 PM)	Import EPAS-4 Project
The device 'Modem' of MODEM type or one of its sub-elements could not be created. Detail: Unabl...	Import EPAS-4 Project
- Import source code... [40% done] (Time: 1:27:33 PM)	Import EPAS-4 Project
- Import libraries... [75% done] (Time: 1:27:41 PM)	Import EPAS-4 Project
- Move objects from POUs to Devices... [78% done] (Time: 1:28:20 PM)	Import EPAS-4 Project
- Import project information... [80% done] (Time: 1:28:24 PM)	Import EPAS-4 Project
- Create code compatibility... [85% done] (Time: 1:28:24 PM)	Import EPAS-4 Project
Finished EPAS-4 import. 1 error(s), 0 warning(s), Duration: 0h 1m 15s [100% done] (Time: 1:28:...	Import EPAS-4 Project

Figure 32 – Epas-5 Messages

After finishing the imported project there is shown only one error regarding to the modem device. It is an hardware settings error, the parameters of the new modem driver section do not coincide with the equipment available in the previous version. This error is not influential in the successful implementation of the program. After this step is carried out an
build and the project do not have any errors.
Another new feature of the new version is a controller simulation tool. It is now possible run projects without any connection to any hardware. The project is then simulated by this tool and it works as it worked in version 2.

The next section will be analyzed the POUs folder. Will be checked if this files have all the parameters and requisites are in accordance with the project prepared in CoDeSys version 2.

- **Program Organizations Units**

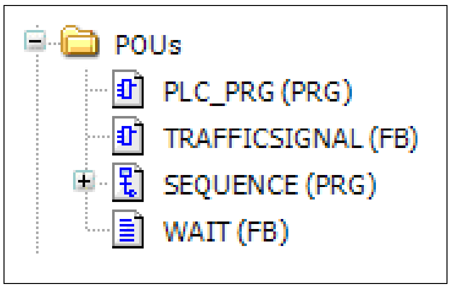
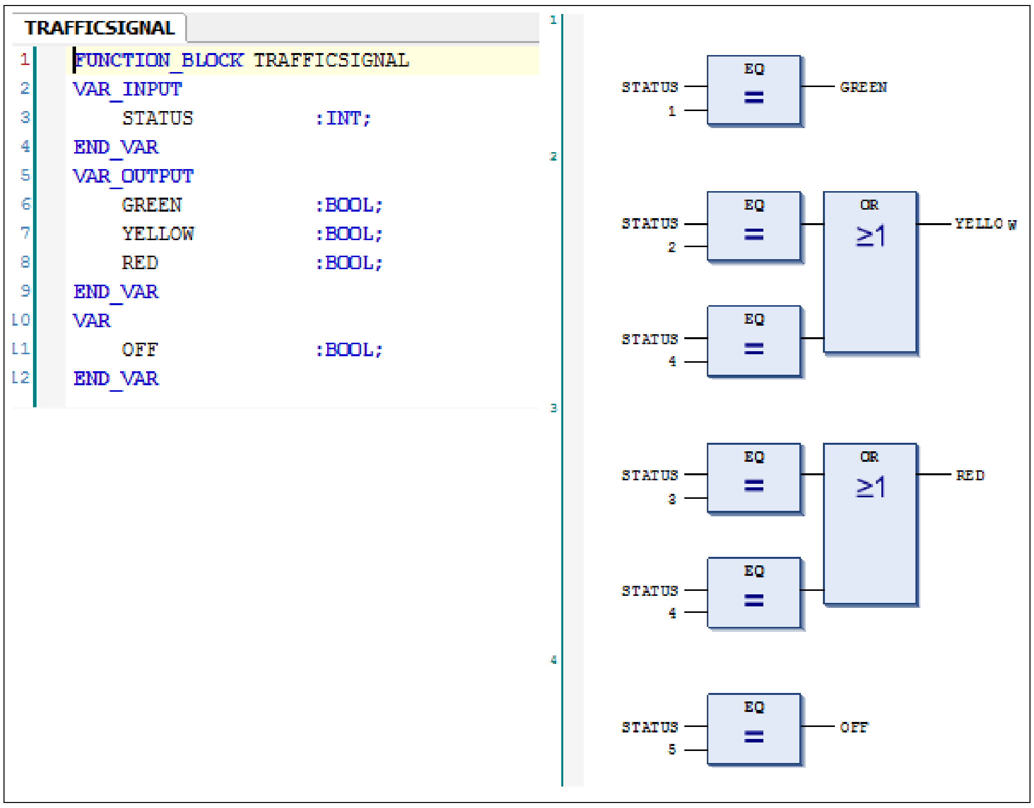


Figure 33 – POU folder

Pou Trafficsignal

After the project importation from Epas-4 the POU Trafficsignal from the type “Function Block” and the language “Function Block Diagram” remains with the same aspect from the previous version.

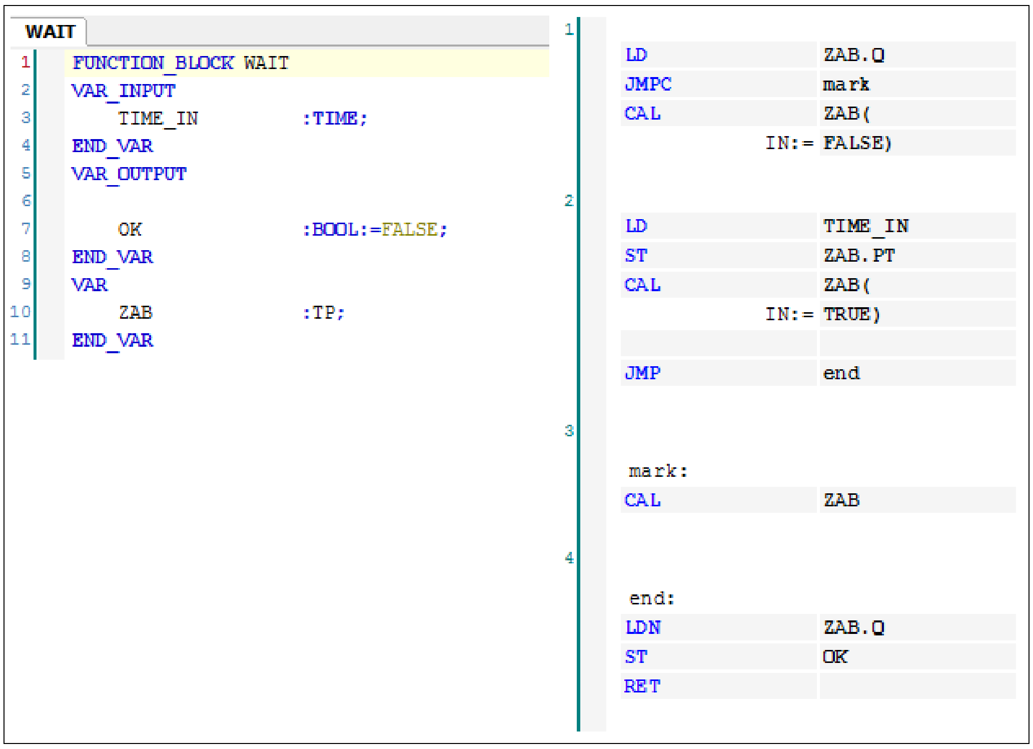

TRAFFICSIGNAL

```
FUNCTION_BLOCK TRAFFICSIGNAL
VAR_INPUT
    STATUS          :INT;
END_VAR
VAR_OUTPUT
    GREEN           :BOOL;
    YELLOW          :BOOL;
    RED             :BOOL;
END_VAR
VAR
    OFF             :BOOL;
END_VAR
```

Figure 34 – Pou Trafficsignal declaration and body sections

Pou Wait

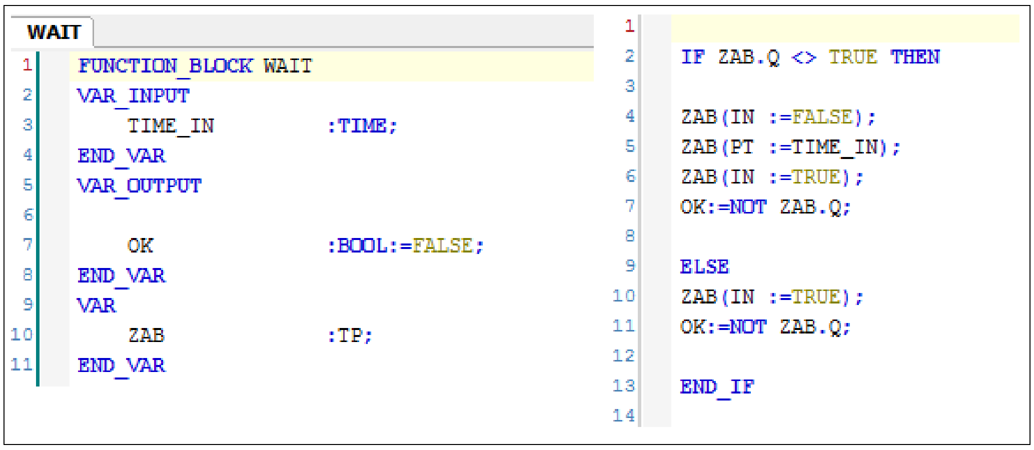
This Pou is from type “Function Block” and the language of body section is “Instruction List”. The program is the same as in Epas-4 but in the current version of Epas-5 (V1.35.15.0) it is not possible to export the instruction list language with the PLCopenXML tool. This problem will be mentioned further.



```
WAIT
FUNCTION_BLOCK WAIT
VAR_INPUT
    TIME_IN         :TIME;
END_VAR
VAR_OUTPUT

    OK              :BOOL:=FALSE;
END_VAR
VAR
    ZAB             :TP;
END_VAR
```

```
1
LD          ZAB.Q
JMPC        mark
CAL         ZAB(
        IN:= FALSE)

2
LD          TIME_IN
ST          ZAB.PT
CAL         ZAB(
        IN:= TRUE)

JMP         end

3

mark:
CAL         ZAB

4

end:
LDN         ZAB.Q
ST          OK
RET
```

Figure 35 – Pou Wait declaration and body sections (Instruction List language)



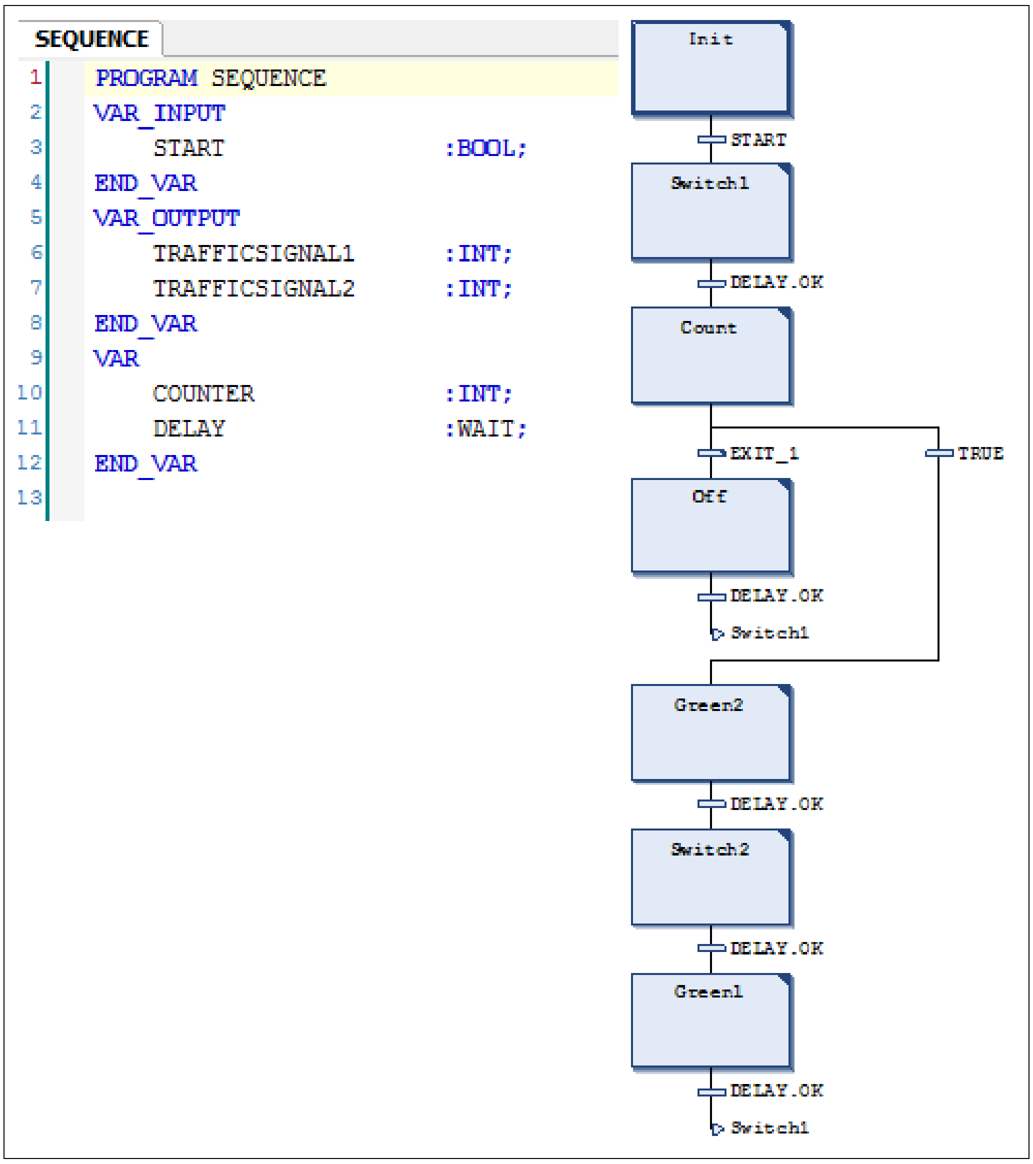
```
WAIT
FUNCTION_BLOCK WAIT
VAR_INPUT
    TIME_IN         :TIME;
END_VAR
VAR_OUTPUT

    OK              :BOOL:=FALSE;
END_VAR
VAR
    ZAB             :TP;
END_VAR
```

```

IF ZAB.Q <> TRUE THEN

ZAB(IN :=FALSE);
ZAB(PT :=TIME_IN);
ZAB(IN :=TRUE);
OK:=NOT ZAB.Q;

ELSE
ZAB(IN :=TRUE);
OK:=NOT ZAB.Q;

END_IF

```

Figure 36 – Pou Wait declaration and body sections (Structure Text language)

To eliminate this error then became necessary to change all “Instruction List” code to “Structured Text”. It was changed the code of POU wait and all actions of the POU Sequence.

Pou Sequence

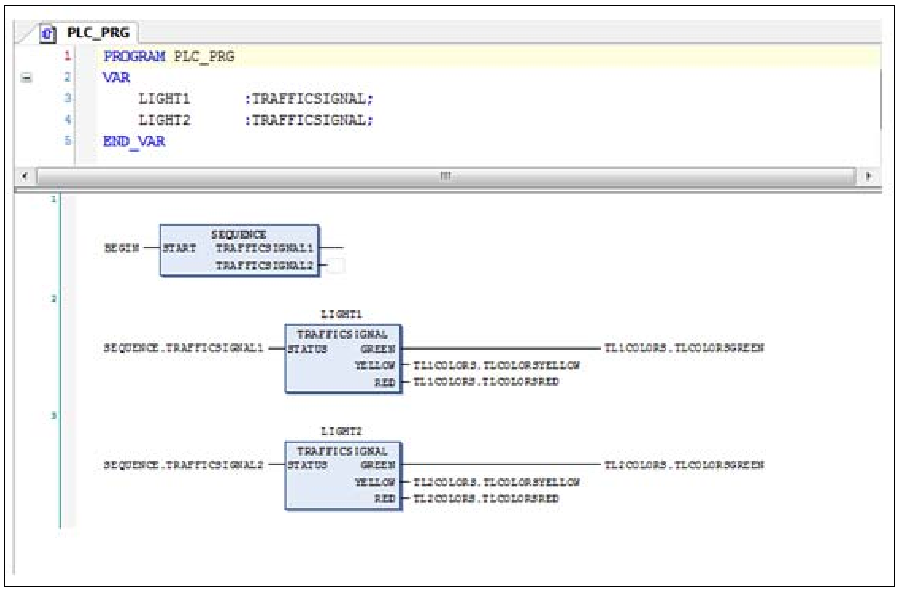


```
SEQUENCE
PROGRAM SEQUENCE
VAR_INPUT
        START                :BOOL;
END_VAR
VAR_OUTPUT
        TRAFFICSIGNAL1       :INT;
        TRAFFICSIGNAL2       :INT;
END_VAR
VAR
        COUNTER              :INT;
        DELAY                :WAIT;
END_VAR
```

Figure 37 – Pou Sequence declaration and body sections

Pou PLC_PRG

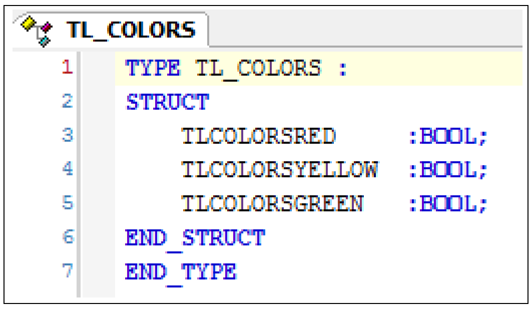
This POU was imported successfully and all requirements were covered.


PLC_PRG

```
PROGRAM PLC_PRG
VAR
    LIGHT1      :TRAFFICSIGNAL;
    LIGHT2      :TRAFFICSIGNAL;
END_VAR
```

Figure 38 – Pou PLC_PRG declaration and body sections

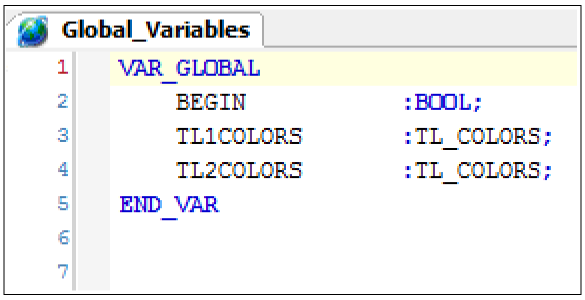
Data Types


TL_COLORS

```
TYPE TL_COLORS :
STRUCT
    TLCOLORSRED      :BOOL;
    TLCOLORSYELLOW   :BOOL;
    TLCOLORSGREEN    :BOOL;
END_STRUCT
END_TYPE
```

Figure 39 – Data Types

Global Variables


Global_Variables

```
VAR_GLOBAL
    BEGIN           :BOOL;
    TL1COLORS       :TL_COLORS;
    TL2COLORS       :TL_COLORS;
END_VAR
```

Figure 40 – Global variables

- **Tasks**

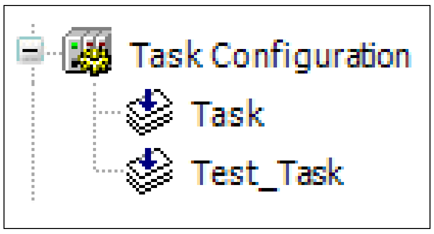
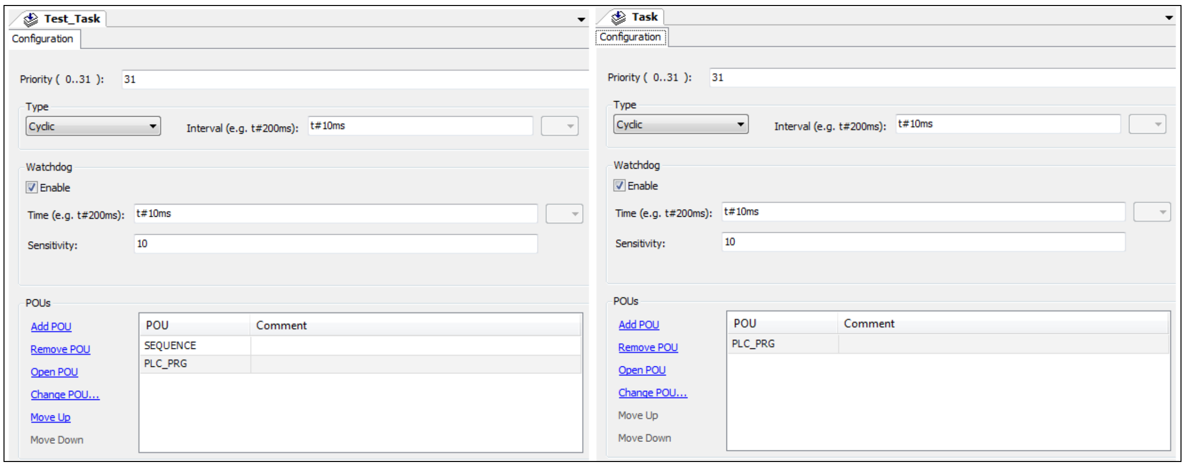


Figure 41 – Task Configuration parameter

Both tasks of the project were imported and both are in agreement with the data entered in the previous version.


Test_Task

Configuration

Priority (0..31): 31

Type

Cyclic

Interval (e.g. t#200ms): t#10ms

Watchdog

☑ Enable

Time (e.g. t#200ms): t#10ms

Sensitivity: 10

POUs

Add POU

Remove POU

Open POU

Change POU...

Move Up

Move Down

POU	Comment
SEQUENCE	
PLC_PRG	

Task

Configuration

Priority (0..31): 31

Type

Cyclic

Interval (e.g. t#200ms): t#10ms

Watchdog

☑ Enable

Time (e.g. t#200ms): t#10ms

Sensitivity: 10

POUs

Add POU

Remove POU

Open POU

Change POU...

Move Up

Move Down

POU	Comment
PLC_PRG	

Figure 42 – Task Configuration parameter

- **Visualization**

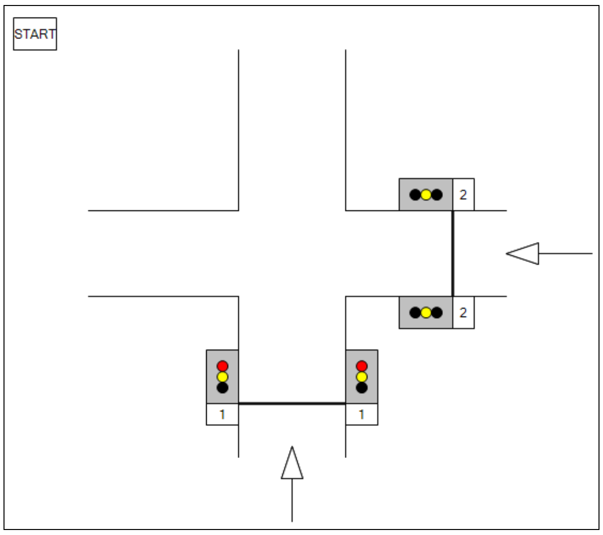


Figure 43 – Epas-5 Visualization

- **Object-Oriented Programming and Inheritance**

To introduce the greatest number of instances for the EEC implementation is as complete as possible in this project was introduced an interface, a method unit to a function block named PEDESTRIANLIGHT. This function block illuminates the walkways in the intersection during the night period. With these units it can be possible speak of objects programming software CoDeSys version 3.

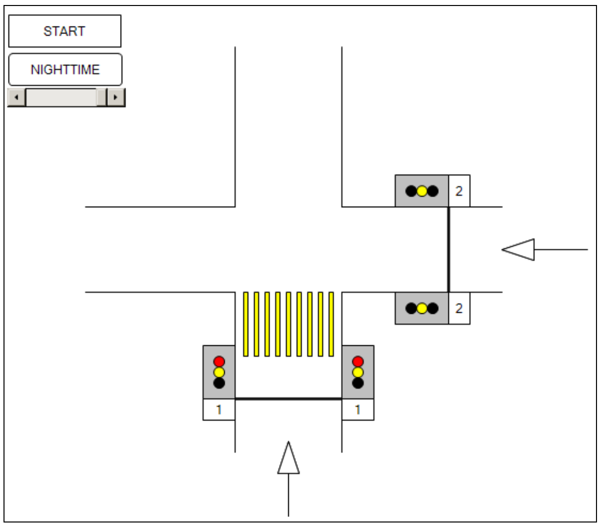


Figure 44 – Project visualization with object oriented programming

This language constructs in the IEC 61131-3 allow the user to program one application with object-oriented methods in the languages of the IEC standard. Object-oriented functionality is optional, meaning it is left up to you to choose between classic or object-oriented programming or combine both philosophies.

Definitions of terms used in Object Oriented Programming (OOP):

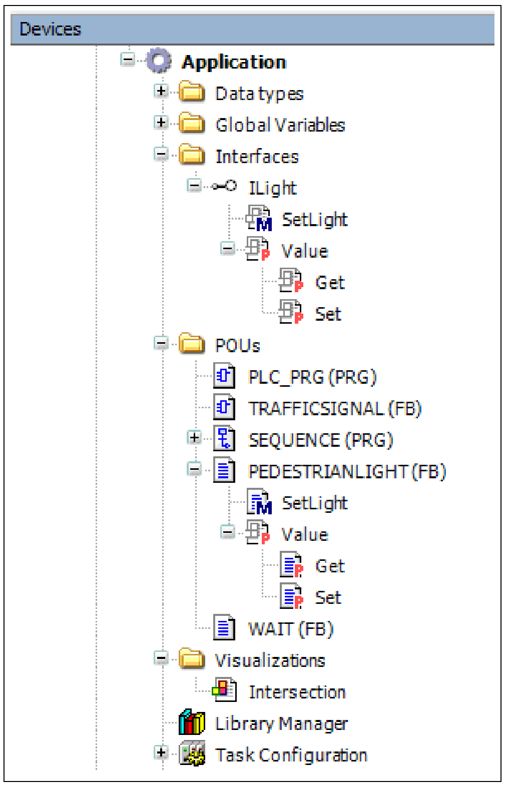
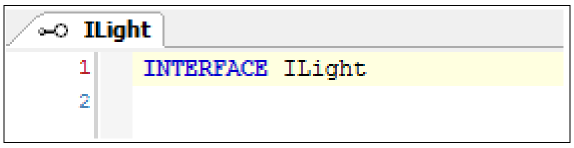


Figure 45 – Project Tree visualization with object oriented programming

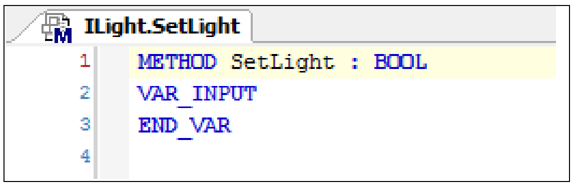
In sample project it was used an Interface called ILight with a Method and one Property:



```
INTERFACE ILight
```

Figure 46 – ILight Interface

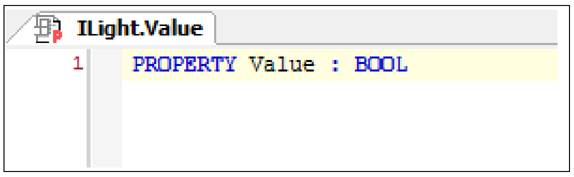
An interface possesses a set of methods and defines the required variables of the methods. The body of the method is then programmed in the class the interface is implemented into. Objects are instances of function blocks (classes).



```
METHOD SetLight : BOOL
VAR_INPUT
END_VAR
```

Figure 47 – Method in Interface

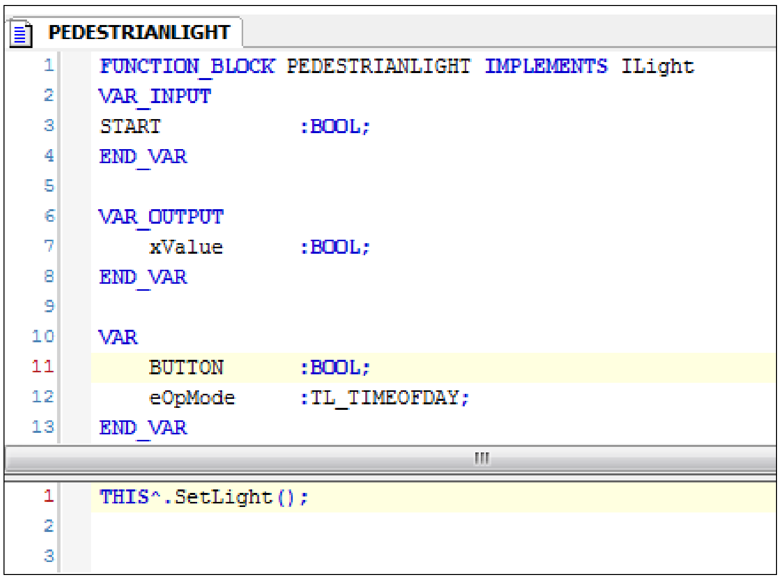
Methods are routines which are firmly assigned to a function block or an interface. They operate with the data of the function block but can, just like IEC functions; have I/O variables or local variables.


ILight.Value

```
PROPERTY Value : BOOL
```

Figure 48 –Interface property

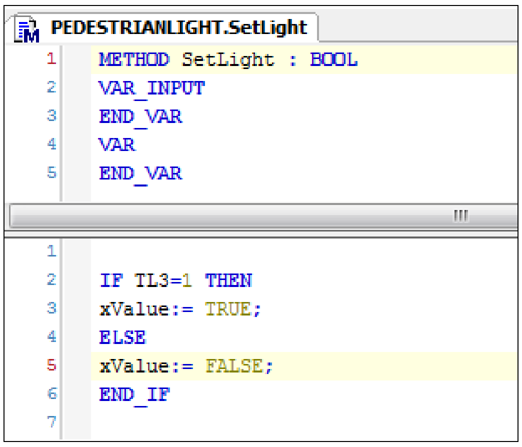
It's also used a function block called PEDESTRIANLIGHT. A function block is a class with exactly one method. With the extension to full class functionality, methods and interfaces with their methods can be implemented in one function block.
A function block implements an interface with the keyword IMPLEMENTS. Therefore, all methods of the interface have to be realized in the function block. A function block can extend a class with the keyword EXTENDS and then inherits the data and the methods of the class. Which implementation of a method is actually executed when a method is called via its interface is decided at runtime. This functionality is called polymorphism. [10]


PEDESTRIANLIGHT

```
FUNCTION_BLOCK PEDESTRIANLIGHT IMPLEMENTS ILight
VAR_INPUT
START           :BOOL;
END_VAR

VAR_OUTPUT
    xValue      :BOOL;
END_VAR

VAR
    BUTTON      :BOOL;
    eOpMode     :TL_TIMEOFDAY;
END_VAR
```

```
THIS^.SetLight();
```

Figure 49 – Function Block with Implements of the Interface


PEDESTRIANLIGHT.SetLight

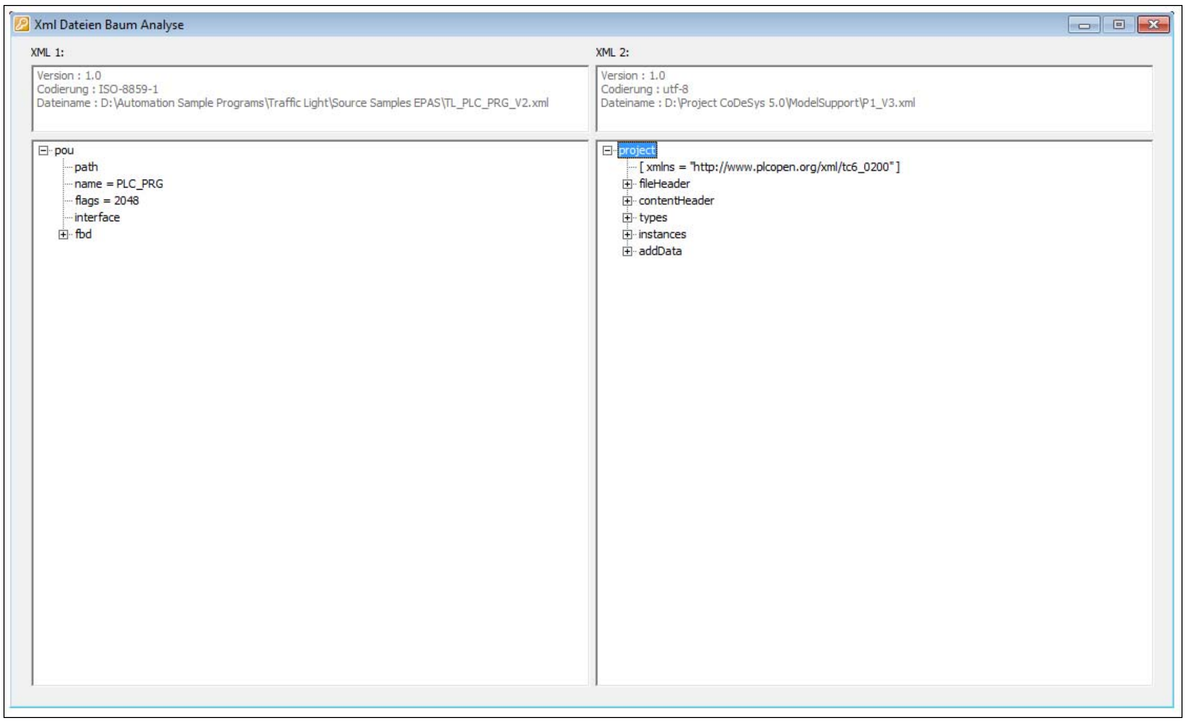
```
METHOD SetLight : BOOL
VAR_INPUT
END_VAR
VAR
END_VAR
```

```

IF TL3=1 THEN
xValue:= TRUE;
ELSE
xValue:= FALSE;
END_IF

```

Figure 50 – Method aggregate at function block

3.4 XML Comparison of CoDeSys Version 2 and Version 3

This chapter aims to compare two XML tags of the two versions of CoDeSys. This analysis will serve to assess whether the user can directly export code fragments from one version to another, and if these will be used by version 3. To better analyze the code it was created for this investigation a comparison tool called "Xml Dateien Baum Analyse" which is a program that brings together two xml codes.


Xml Dateien Baum Analyse

XML 1:

Version : 1.0
Codierung : ISO-8859-1
Dateiname : D:\Automation Sample Programs\Traffic Light\Source Samples EPAS\TL_PLC_PRG_V2.xml

```
⊟ pou
    path
    name = PLC_PRG
    flags = 2048
    interface
  ⊞ fbd
```

XML 2:

Version : 1.0
Codierung : utf-8
Dateiname : D:\Project CoDeSys 5.0\ModelSupport\P1_V3.xml

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊞ instances
  ⊞ addData
```

Figure 51 – Xml Dateien Baum Analyse, comparison

As shown in Figure above, codes of XML projects from both CoDeSys versions are not identical and there are many differences between them. The existing codes for version 2 may not be used in version 3. It then becomes necessary to perform an export project from older version to the latest. CoDeSys version 3 has a tool that automatically allows importing projects and libraries from the previous version. This new feature was analyzed in chapter 3.2.1.

It is also possible to analyse a small part of the codes. These chosen parts must do the same thing in the project. The first traffic light of Trafficsignal POU is been chosen.

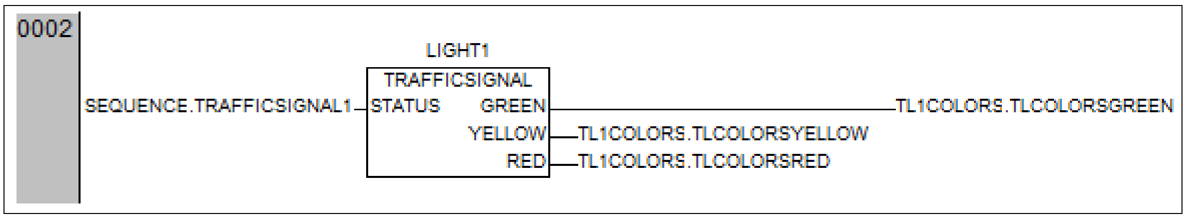
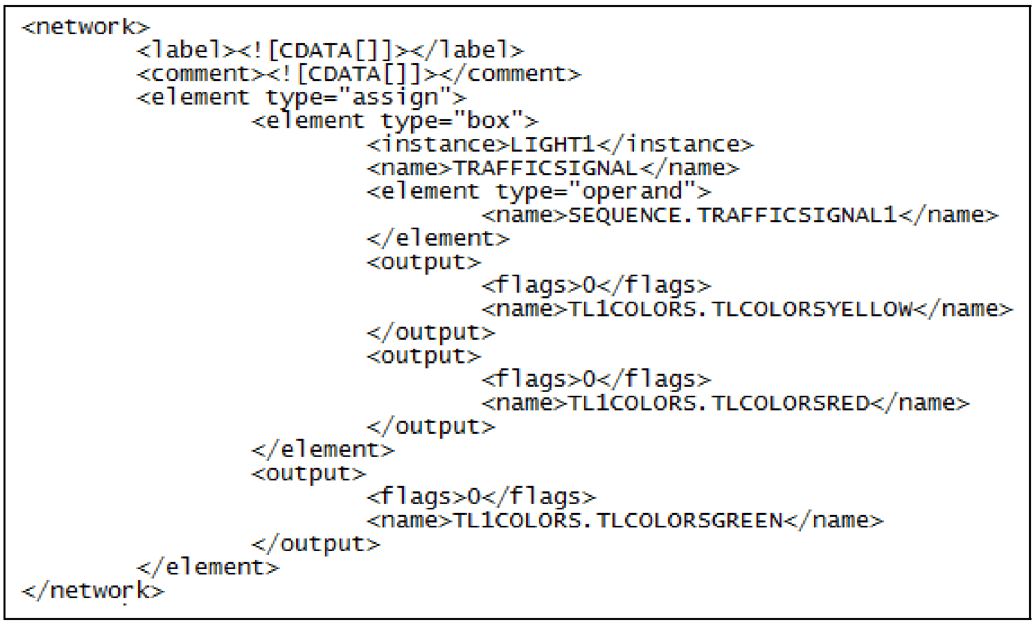
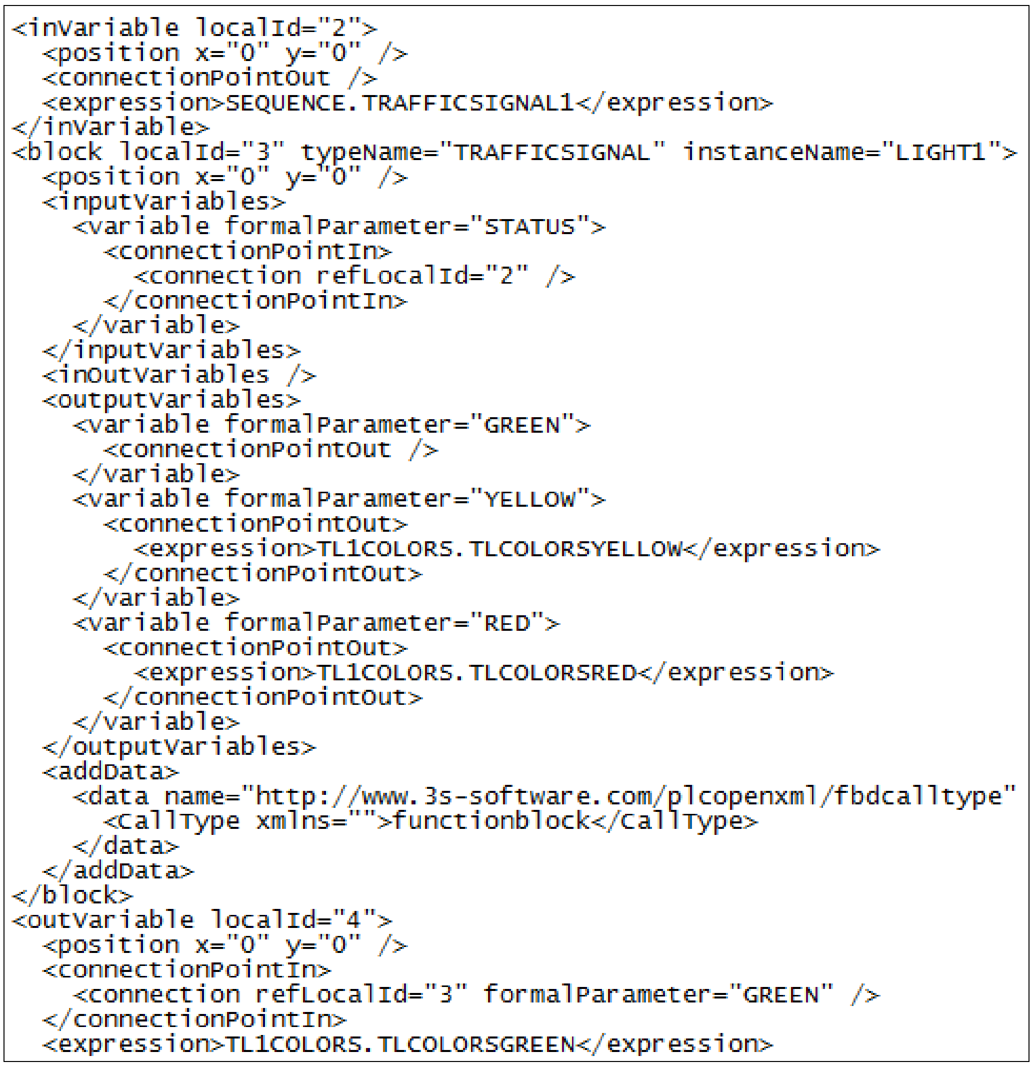


Figure 52 – Traffic Light Function Block Diagram



```
<network>
        <label><![CDATA[]]></label>
        <comment><![CDATA[]]></comment>
        <element type="assign">
                <element type="box">
                        <instance>LIGHT1</instance>
                        <name>TRAFFICSIGNAL</name>
                        <element type="operand">
                                <name>SEQUENCE.TRAFFICSIGNAL1</name>
                        </element>
                        <output>
                                <flags>0</flags>
                                <name>TL1COLORS.TLCOLORSYELLOW</name>
                        </output>
                        <output>
                                <flags>0</flags>
                                <name>TL1COLORS.TLCOLORSRED</name>
                        </output>
                </element>
                <output>
                        <flags>0</flags>
                        <name>TL1COLORS.TLCOLORSGREEN</name>
                </output>
        </element>
</network>
```

Figure 53 – CoDeSys version 2 Eni-Server



```
<inVariable localId="2">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>SEQUENCE.TRAFFICSIGNAL1</expression>
</inVariable>
<block localId="3" typeName="TRAFFICSIGNAL" instanceName="LIGHT1">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="STATUS">
      <connectionPointIn>
        <connection refLocalId="2" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="GREEN">
      <connectionPointOut />
    </variable>
    <variable formalParameter="YELLOW">
      <connectionPointOut>
        <expression>TL1COLORS.TLCOLORSYELLOW</expression>
      </connectionPointOut>
    </variable>
    <variable formalParameter="RED">
      <connectionPointOut>
        <expression>TL1COLORS.TLCOLORSRED</expression>
      </connectionPointOut>
    </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
      <CallType xmlns="">functionblock</CallType>
    </data>
  </addData>
</block>
<outVariable localId="4">
  <position x="0" y="0" />
  <connectionPointIn>
    <connection refLocalId="3" formalParameter="GREEN" />
  </connectionPointIn>
  <expression>TL1COLORS.TLCOLORSGREEN</expression>
```

Figure 54 – CoDeSys version 3 PLCopenXML

It is possible to observe that the codes are quite different. In Epas-4 through the Eni-Server it seems an individualized programming across networks while in the PLCopenXML structure programming is closer to a graphic language where localId have a special importance.

4 Analysis of Epas-5 XML-Import/Export-Scheme

In this chapter is described the analysis of the compliance of traffic light Epas-5 PLCopenXML sample with the PLCopenXML Scheme (according IEC 61131-3).

This analysis is necessary to see if the Epas Scheme is completely in compliance with PLCopenXML standard. This is a important knowledge because implementation on EEC will use the Epas-5 XML output and then in EEC only one implementation is necessary to generate all CoDeSys PLC-systems and also other systems which use the PLCopenXML scheme.

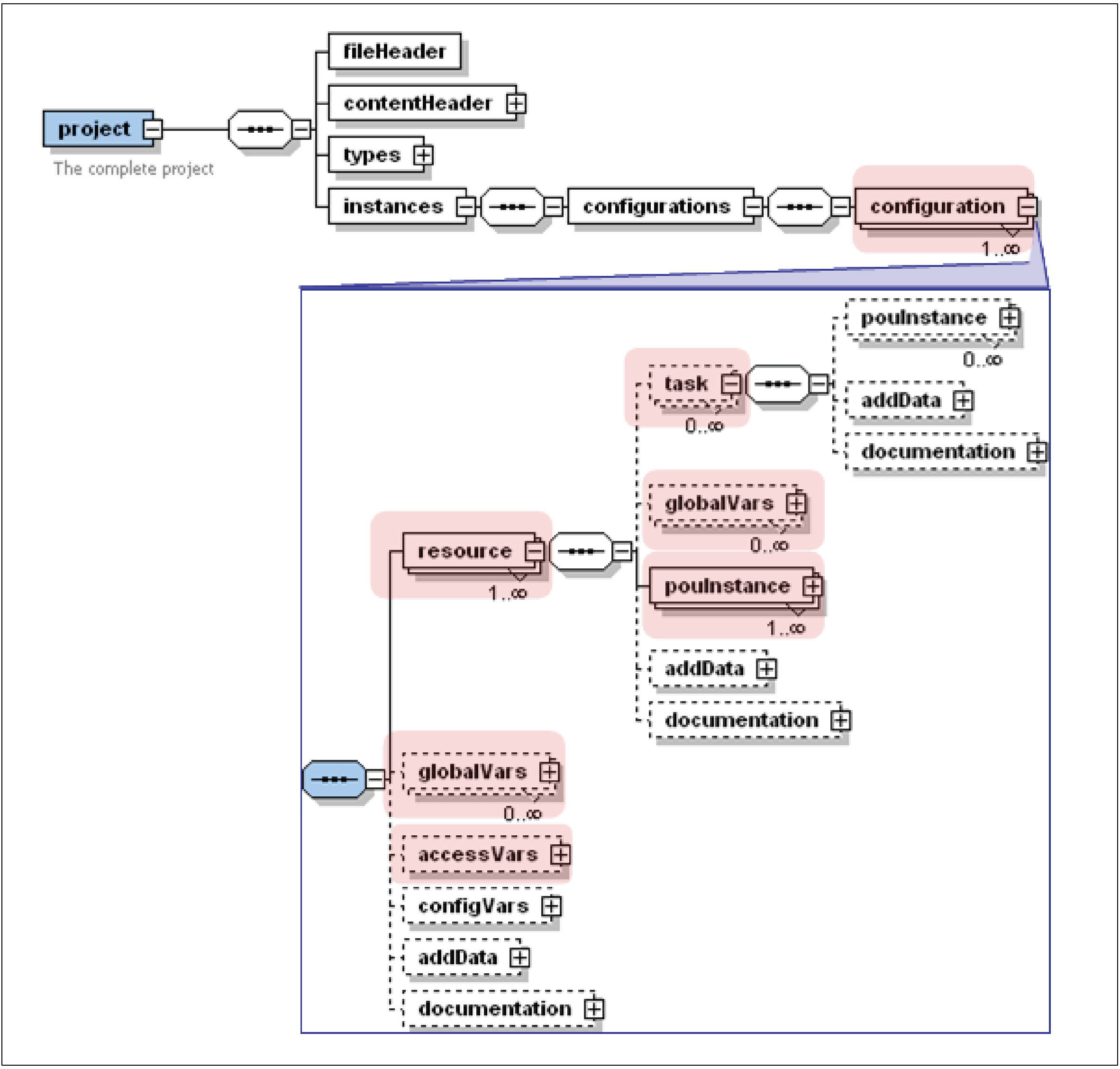
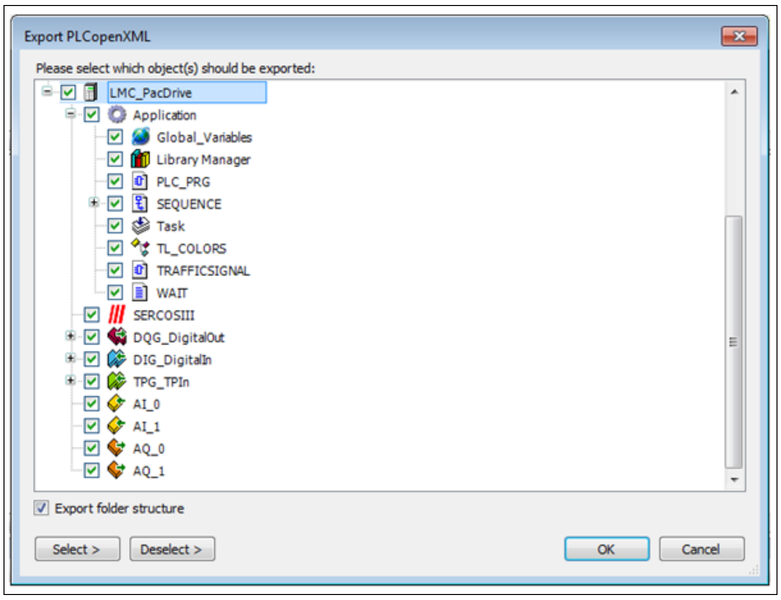


Figure 55 – Automation project structure check

For this analyses it was used a software named “XMLSpy” and another already mention named “Xml Dateien Baum Analyse”. The first one analyses the compliance with the standard and the second is only for visual analyses. It was used also “eclipse” software for generate a blank XML file from the PLCopenXML scheme file and “Notepad++” for reading all XML files. For CoDeSys environment was used the program Epas-5 version 1.35.15.0.
The next conformance level checks if an automation project is formed at least by a configuration containing one or more resources in which the source code (program instances) is going to be downloaded. In order to check if the automation project follows this architectural style, multiplicity constraints have been added to the PLCopen XML scheme, as illustrated in the next figure.
The elements of any automation project structure have been highlighted and in particular the multiplicity of configurations and resources has been modified. [5]

4.1 Export/Import PLCopenXML Tool

Currently, many software programs that are in accordance with IEC 61131-3 standard, as CoDeSys version 3 or Epas version 5 (which implements CoDeSys version 3), use a tool that allows export or import an entire project. This tool will allow the exchange of projects between different kinds of software.
The file created with this tool is in XML format and is standardized by the international company called PLCopen. In short, A project can be create in IEC 61131-3 compiler, create an XML file with all the project information’s and it can be open it with another compiler that possesses this export import tool, then this project will work in a different PLC brand.
Is with this XML file that the CoDeSys version 3 in EEC integration can be done.
An automation project can be create using the existing libraries of EEC and this software can generate the project in XML code. As this is standard XML we can work with it in any type of controller that obeys to IEC 61131-3.


Export PLCopenXML

Please select which object(s) should be exported:

- ☑ LMC_PacDrive
  - ☑ Application
    - ☑ Global_Variables
    - ☑ Library Manager
    - ☑ PLC_PRG
    - ☑ SEQUENCE
    - ☑ Task
    - ☑ TL_COLORS
    - ☑ TRAFFICSIGNAL
    - ☑ WAIT
  - ☑ SERCOSIII
  - ☑ DQG_DigitalOut
  - ☑ DIG_DigitalIn
  - ☑ TPG_TPIn
  - ☑ AI_0
  - ☑ AI_1
  - ☑ AQ_0
  - ☑ AQ_1

☑ Export folder structure

Figure 56 – Export/Import PLCopenXML tool

4.2 Comparison of Schemes

The XML export/import tool from Epas-5 software will now be tested and compared with the PLCopen standard scheme. As already mentioned this scheme is consistent with standard IEC61131-3 and is therefore ensured that all the requirements are met.

The purpose of this analysis is also to understand the PLCopenXML scheme to perform a compliance implementation in EEC. The XML output of this software must be completely consistent with this scheme and then it can be opened in any automation application.

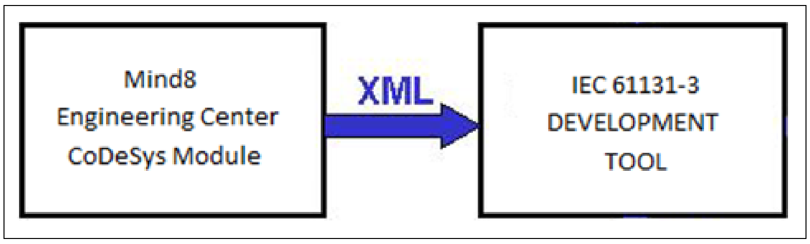


Figure 57 – EEC XML generate code

1 - Project

This element shows the main tree of the project.

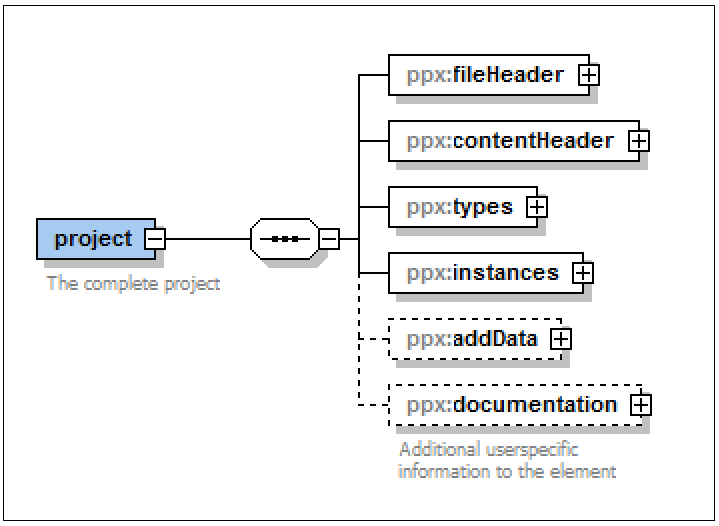


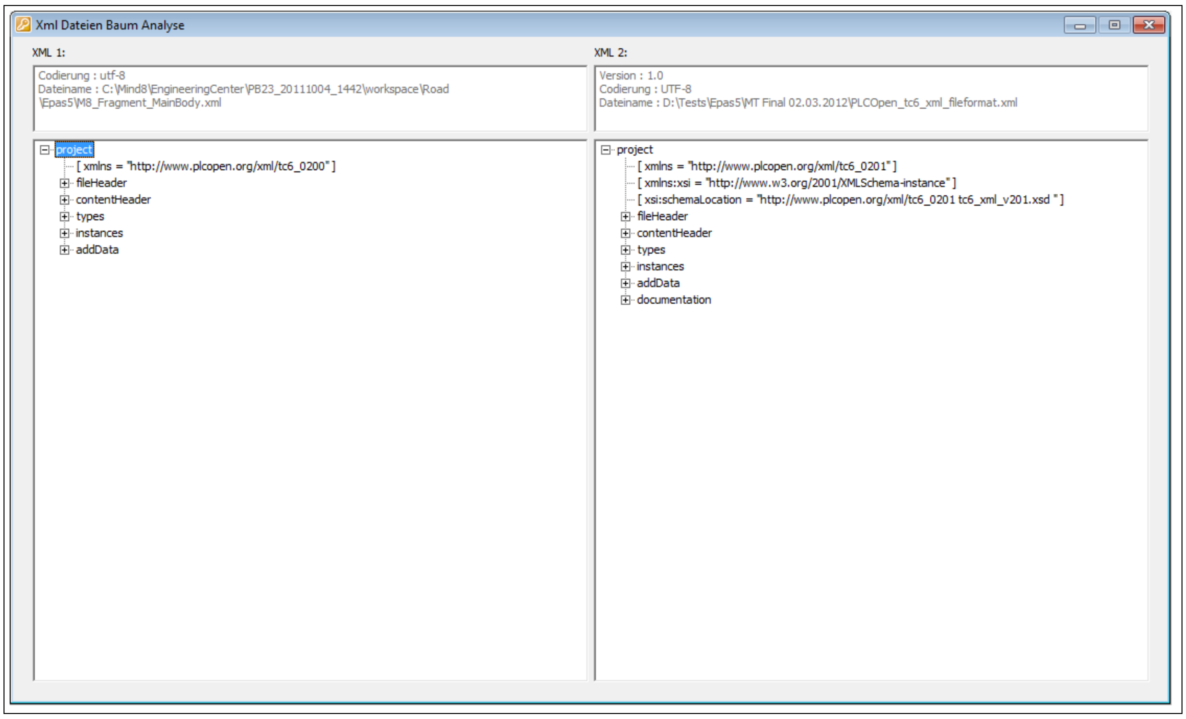
Figure 58 – project diagram

- *<u>Header information of an XML file</u>*

The file header and content header information originates from the publicly available specification of the IDA consortium and was specifically developed for usage in a context, where XML exchange files are generated from different tools of the same or of different vendors.

Looking at the differences between standard diagram PLCopen and Epas-5 XML export tool software it appears that this software does not use the element "documentation". This element is not a required element and the export tool does not show unconformities with the PLCopen standard.

One difference is that the export tool is in the PLCopen version 2.0 as showed in parameter targetNamespace (xmlns) in figure 59. This version is not the latest. The latest version is PLCopen version 2.01 released in August 2008. [11]



```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml

⊟ project
   [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊞ instances
  ⊞ addData
```

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml

⊟ project
   [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
   [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
   [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊞ instances
  ⊞ addData
  ⊞ documentation
```

Figure 59 – project diagram

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

Epas-5 XML

```
<?xml version="1.0" encoding="utf-8"?>
<project xmlns="http://www.plcopen.org/xml/tc6_0200">
```

PLCopen Scheme

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://www.plcopen.org/xml/tc6_0201"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd ">
```

Table 2 – project diagram XML

1.1 - File Header

The “FileHeader” element is used to provide information concerning the creation of the export / import file.

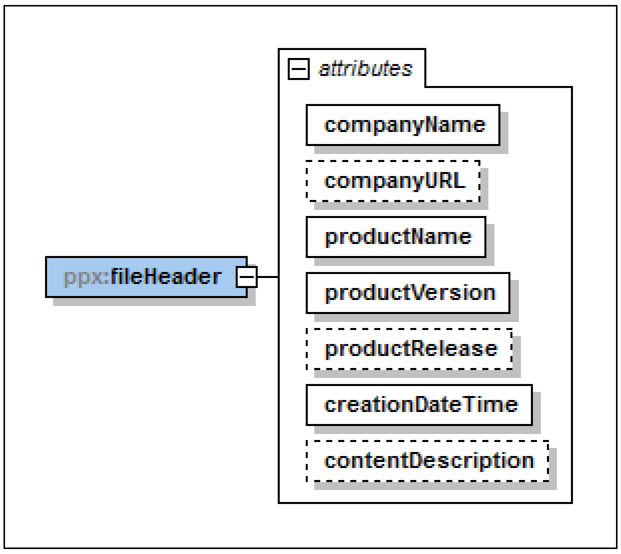
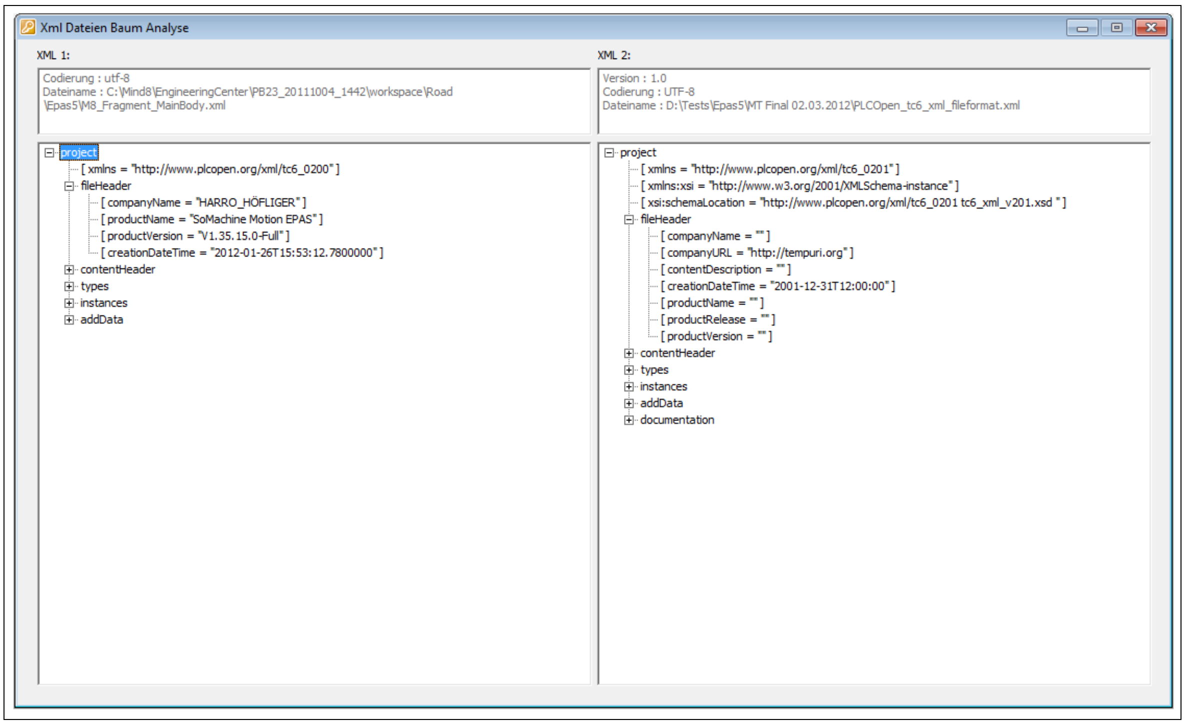


Figure 60 – fileHeader diagram



XML 1:

```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml
```

```
project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
    fileHeader
        [ companyName = "HARRO_HÖFLIGER" ]
        [ productName = "SoMachine Motion EPAS" ]
        [ productVersion = "V1.35.15.0-Full" ]
        [ creationDateTime = "2012-01-26T15:53:12.7800000" ]
    contentHeader
    types
    instances
    addData
```

XML 2:

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml
```

```
project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
    [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
    [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
    fileHeader
        [ companyName = "" ]
        [ companyURL = "http://tempuri.org" ]
        [ contentDescription = "" ]
        [ creationDateTime = "2001-12-31T12:00:00" ]
        [ productName = "" ]
        [ productRelease = "" ]
        [ productVersion = "" ]
    contentHeader
    types
    instances
    addData
    documentation
```

Figure 61 – fileHeader diagram
Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

Epas-5 XML
`<fileHeader companyName="" productName="SoMachine Motion EPAS" productVersion="V1.35.15.0-Full" creationDateTime="2012-02-24T09:21:46.6371239" />`
PLCopen Scheme
`<fileHeader companyName="" companyURL="http://tempuri.org" contentDescription="" creationDateTime="2001-12-31T12:00:00" productName="" productRelease="" productVersion=""/>`

Table 3 – fileHeader structure XML

The Epas-5 export tool only has the required attributes “companyName”, “productName”, “productVersion” and “creationDateTime”. With those attributes the tool is in conformance with PLCopen standard.

1.2 - Content Header

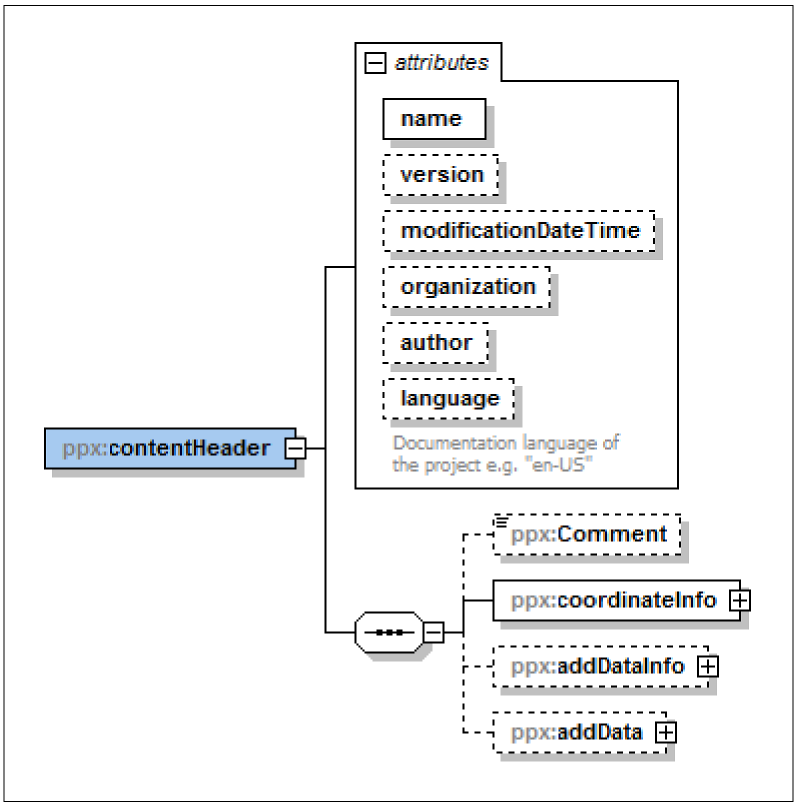
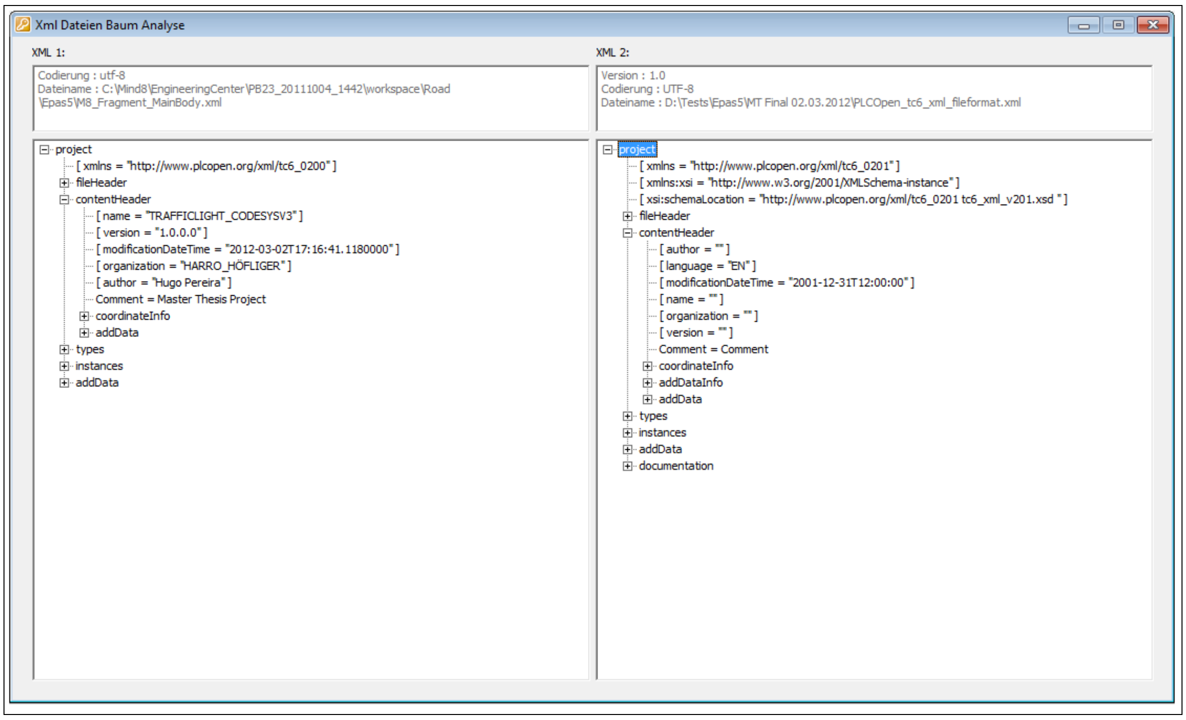


Figure 62 – contentHeader diagram

The “contentHeader” element is used to provide overview information concerning the actual content of the export / import file. The "name" attribute is required. In case of exporting this attribute is set to the project name. The other attributes correspond to the equally named attributes of the "VersionInfo" element as defined in IEC 61499-2. The "comment" element corresponds to the "Remarks" attribute of the "VersionInfo" element. The attribute “language” is intended to specify the used language in the definition of the project. The “comment’ element consists of a string. The element “coordinateInfo” contains the information for the mapping of the coordinate system. [11]



XML 1:

```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊟ contentHeader
      [ name = "TRAFFICLIGHT_CODESYSV3" ]
      [ version = "1.0.0.0" ]
      [ modificationDateTime = "2012-03-02T17:16:41.1180000" ]
      [ organization = "HARRO_HÖFLIGER" ]
      [ author = "Hugo Pereira" ]
      Comment = Master Thesis Project
    ⊞ coordinateInfo
    ⊞ addData
  ⊞ types
  ⊞ instances
  ⊞ addData
```

XML 2:

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
    [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
    [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  ⊞ fileHeader
  ⊟ contentHeader
      [ author = "" ]
      [ language = "EN" ]
      [ modificationDateTime = "2001-12-31T12:00:00" ]
      [ name = "" ]
      [ organization = "" ]
      [ version = "" ]
      Comment = Comment
    ⊞ coordinateInfo
    ⊞ addDataInfo
    ⊞ addData
  ⊞ types
  ⊞ instances
  ⊞ addData
  ⊞ documentation
```

Figure 63 –contentHeader structure

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

Epas-5 XML

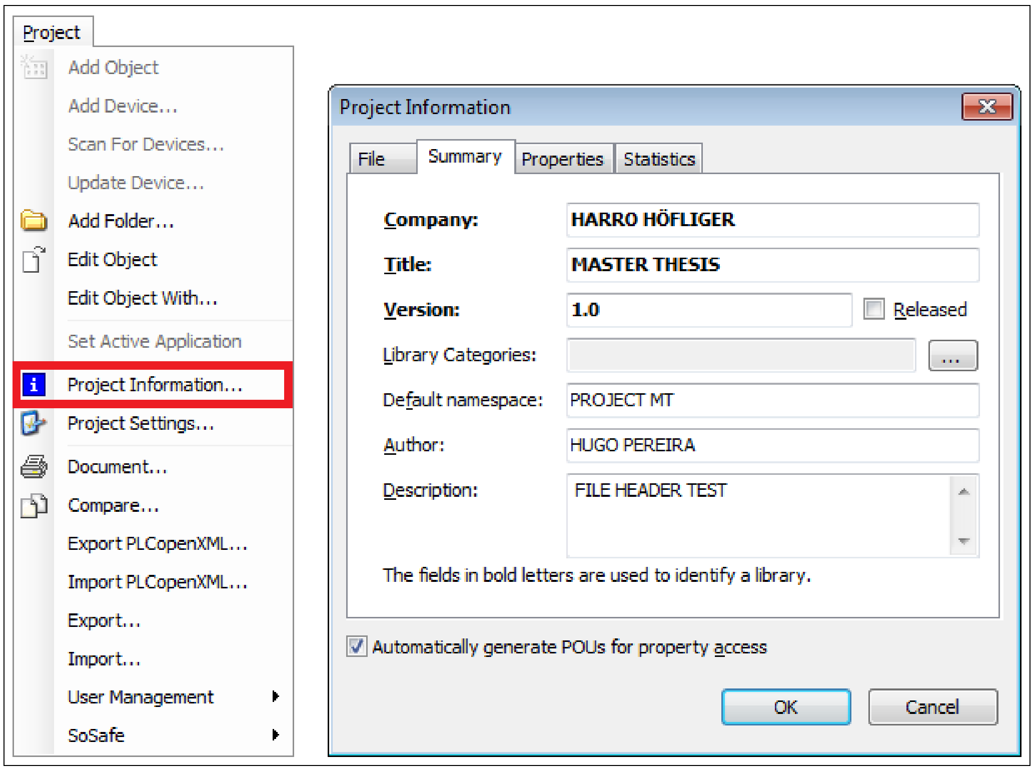
```
<contentHeader name="MASTER THESIS" version="1.0"
modificationDateTime="2012-02-06T09:39:35.6393348"
organization="HARRO HÖFLIGER" author="HUGO PEREIRA">
  <Comment>FILE HEADER TEST</Comment>
```

PLCopen Scheme

```
<contentHeader author="" language="EN"
modificationDateTime="2001-12-31T12:00:00"
name="" organization="" version="">
  <Comment>Comment</Comment>
```

Table 4 – contentHeader structure XML

In Epas-5 the parameters of contentHeader can be change. The user can choose the menu “Project” and then “Project Information” section Summary.



Company:	**HARRO HÖFLIGER**
Title:	**MASTER THESIS**
Version:	**1.0** ☐ Released
Library Categories:	
Default namespace:	PROJECT MT
Author:	HUGO PEREIRA
Description:	FILE HEADER TEST

The fields in bold letters are used to identify a library.

☑ Automatically generate POUs for property access

Figure 64 –contentHeader project parameters in Epas-5

1.2.1 – Coordinate Info

This parameter is responsible for positions and coordinates of inputs, outputs and blocks positions manly use for graphical information.

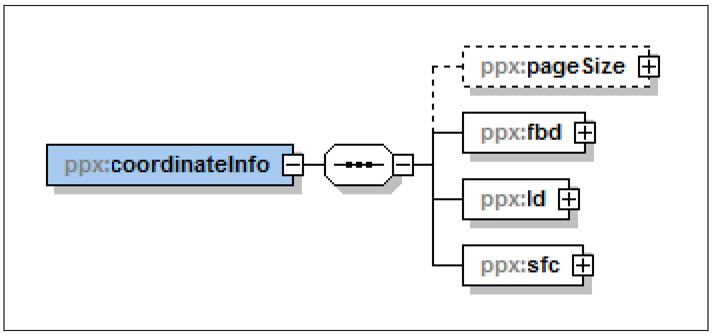
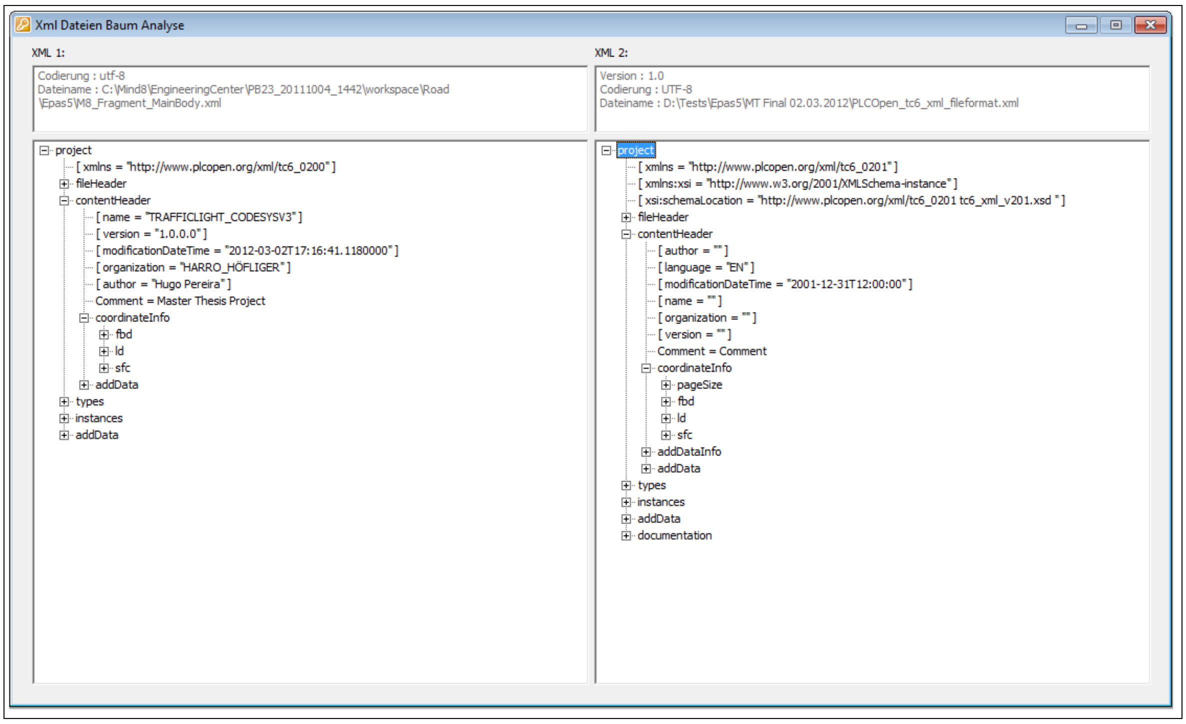


Figure 65 – coordinateInfo diagram



XML 1:

```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊟ contentHeader
      [ name = "TRAFFICLIGHT_CODESYSV3" ]
      [ version = "1.0.0.0" ]
      [ modificationDateTime = "2012-03-02T17:16:41.1180000" ]
      [ organization = "HARRO_HÖFLIGER" ]
      [ author = "Hugo Pereira" ]
      Comment = Master Thesis Project
    ⊟ coordinateInfo
      ⊞ fbd
      ⊞ ld
      ⊞ sfc
    ⊞ addData
  ⊞ types
  ⊞ instances
  ⊞ addData
```

XML 2:

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
    [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
    [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  ⊞ fileHeader
  ⊟ contentHeader
      [ author = "" ]
      [ language = "EN" ]
      [ modificationDateTime = "2001-12-31T12:00:00" ]
      [ name = "" ]
      [ organization = "" ]
      [ version = "" ]
      Comment = Comment
    ⊟ coordinateInfo
      ⊞ pageSize
      ⊞ fbd
      ⊞ ld
      ⊞ sfc
    ⊞ addDataInfo
    ⊞ addData
  ⊞ types
  ⊞ instances
  ⊞ addData
  ⊞ documentation
```

Figure 66 – coordinateInfo structure

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

Epas-5 XML

```
<coordinateInfo>
   <fbd>
     <scaling x="1" y="1" />
   </fbd>
   <ld>
     <scaling x="1" y="1" />
   </ld>
   <sfc>
     <scaling x="1" y="1" />
   </sfc>
 </coordinateInfo>
```

PLCopen Scheme

```
<coordinateInfo>
  <pageSize x="0.0" y="0.0"/>
  <fbd>
    <scaling x="0.0" y="0.0"/>
  </fbd>
  <ld>
    <scaling x="0.0" y="0.0"/>
  </ld>
  <sfc>
    <scaling x="0.0" y="0.0"/>
  </sfc>
</coordinateInfo>
```

Table 5 – contentHeader structure XML

Analyzing the figure 66 and the table 5 it is possible conclude that Epas-5 export tool is in conformance with PLCopen in this parameter although in standard PLCopen has an optional attribute named “pageSize”.

- *coordinateInfo / fdb / scaling*

In this element is defined the scales x and y for the language Function Diagram Blocks.

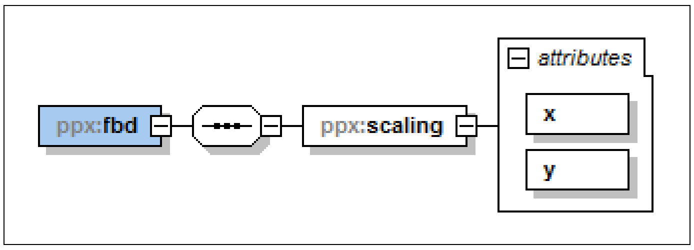


Figure 67 – fdb/scaling diagram

- *coordinateInfo / ld / scaling*

In this element is defined the scales x and y for the language Ladder Diagram.

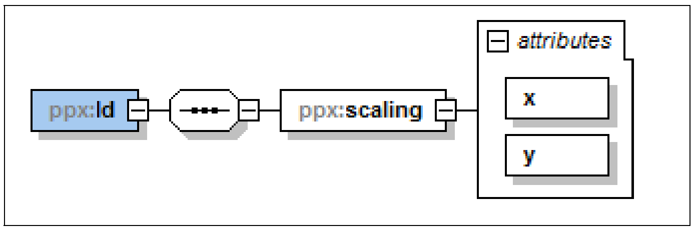


Figure 68 – ld/scaling diagram

- *coordinateInfo / sfc / scaling*

In this element is defined the scales x and y for the language Sequential Function Chart.

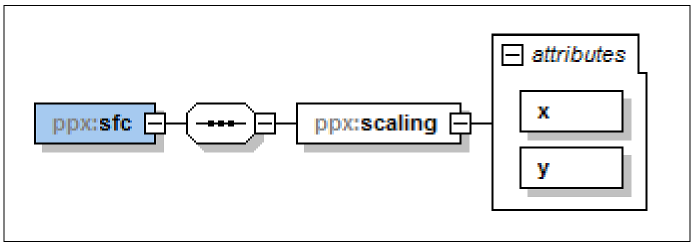
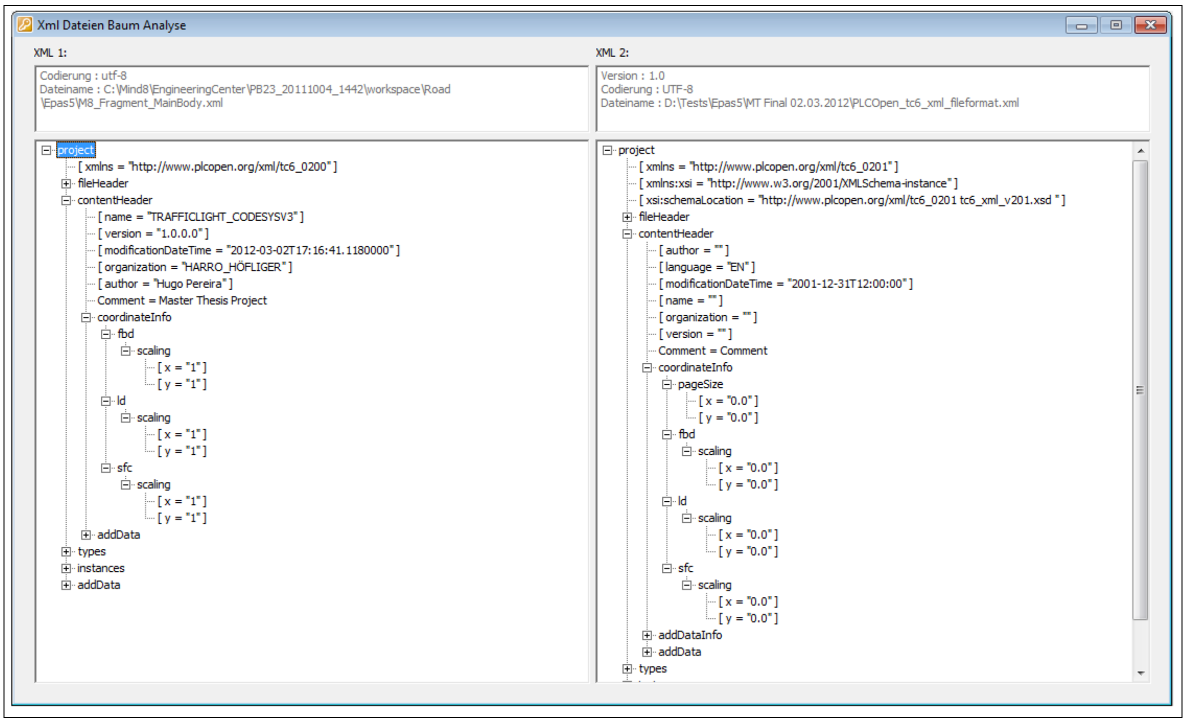


Figure 69 – sfc/scaling diagram



XML 1:

```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊟ contentHeader
      [ name = "TRAFFICLIGHT_CODESYSV3" ]
      [ version = "1.0.0.0" ]
      [ modificationDateTime = "2012-03-02T17:16:41.1180000" ]
      [ organization = "HARRO_HÖFLIGER" ]
      [ author = "Hugo Pereira" ]
      Comment = Master Thesis Project
    ⊟ coordinateInfo
      ⊟ fbd
        ⊟ scaling
            [ x = "1" ]
            [ y = "1" ]
      ⊟ ld
        ⊟ scaling
            [ x = "1" ]
            [ y = "1" ]
      ⊟ sfc
        ⊟ scaling
            [ x = "1" ]
            [ y = "1" ]
    ⊞ addData
  ⊞ types
  ⊞ instances
  ⊞ addData
```

XML 2:

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
    [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
    [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  ⊞ fileHeader
  ⊟ contentHeader
      [ author = "" ]
      [ language = "EN" ]
      [ modificationDateTime = "2001-12-31T12:00:00" ]
      [ name = "" ]
      [ organization = "" ]
      [ version = "" ]
      Comment = Comment
    ⊟ coordinateInfo
      ⊟ pageSize
          [ x = "0.0" ]
          [ y = "0.0" ]
      ⊟ fbd
        ⊟ scaling
            [ x = "0.0" ]
            [ y = "0.0" ]
      ⊟ ld
        ⊟ scaling
            [ x = "0.0" ]
            [ y = "0.0" ]
      ⊟ sfc
        ⊟ scaling
            [ x = "0.0" ]
            [ y = "0.0" ]
    ⊞ addDataInfo
    ⊞ addData
  ⊞ types
```

Figure 70 – fdb, ld, sfc scaling

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

The Epas-5 export tool is in conformance with PLCopen in element coordinateInfo.

1.2.2 – add Data and add Data Info

For the project and certain objects in the XML file the vendor can include additional data. Such additional data is vendor-specific. The data itself is given in an addData object. Additionally in the addDataInfo an URI (uniform resource identifier) is given for the corresponding addData to uniquely identify the additional data element content. In this name the vendor domain shall be included to ensure unique names. Using this name the importing tool may process the addData. The vendor shall specify the behavior of the importing tool in case the name is not known by the importing tool especially regarding a later export from this tool. [11]

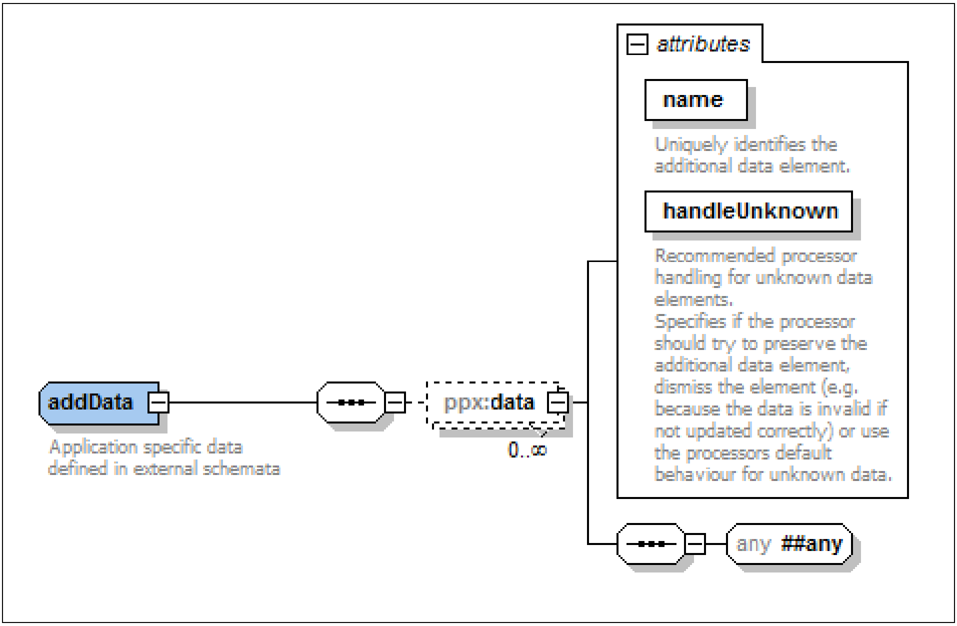

attributes
name
Uniquely identifies the additional data element.
handleUnknown
Recommended processor handling for unknown data elements. Specifies if the processor should try to preserve the additional data element, dismiss the element (e.g. because the data is invalid if not updated correctly) or use the processors default behaviour for unknown data.
addData
Application specific data defined in external schemata
ppx:data
0..∞
any ##any

Figure 71 – addData with child data diagram

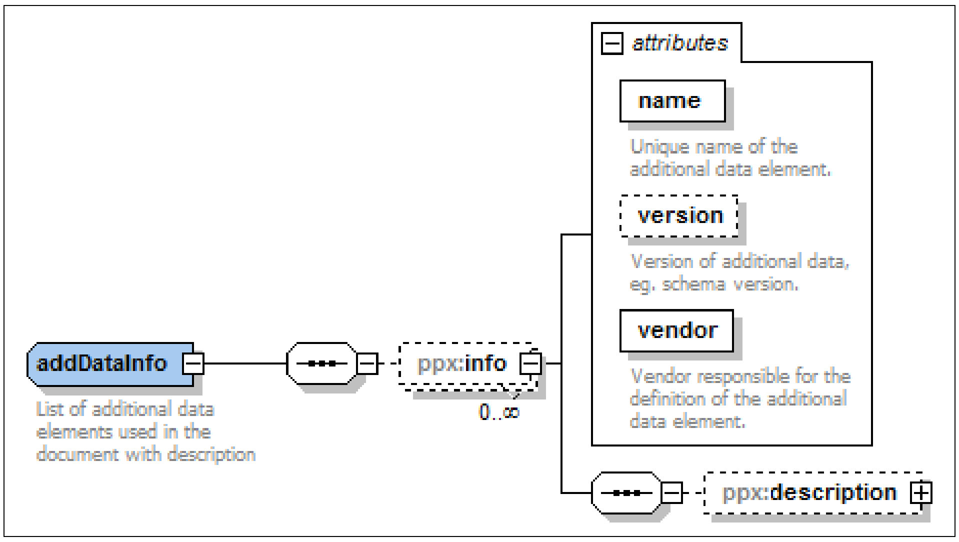
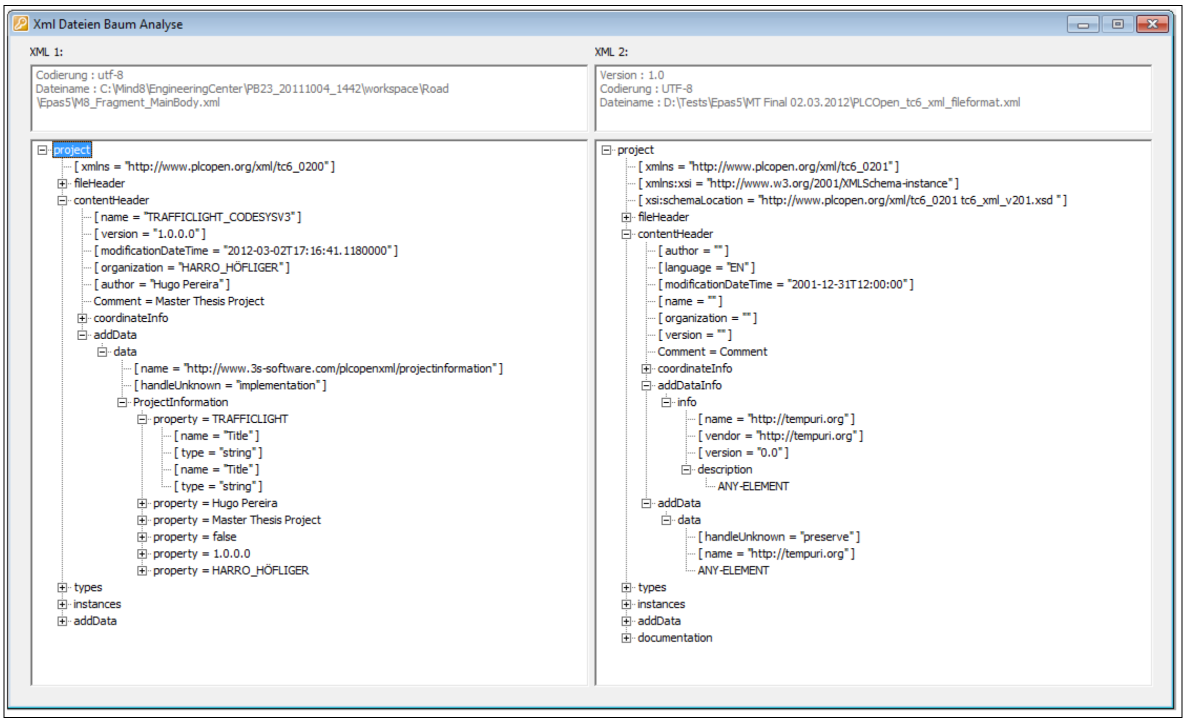

attributes
name
Unique name of the additional data element.
version
Version of additional data, eg. schema version.
vendor
Vendor responsible for the definition of the additional data element.
addDataInfo
List of additional data elements used in the document with description
ppx:info
0..∞
ppx:description

Figure 72 – addDataInfo with child info diagram



XML 1:

```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml
```

```
project
  [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  fileHeader
  contentHeader
    [ name = "TRAFFICLIGHT_CODESYSV3" ]
    [ version = "1.0.0.0" ]
    [ modificationDateTime = "2012-03-02T17:16:41.1180000" ]
    [ organization = "HARRO_HÖFLIGER" ]
    [ author = "Hugo Pereira" ]
    Comment = Master Thesis Project
    coordinateInfo
    addData
      data
        [ name = "http://www.3s-software.com/plcopenxml/projectinformation" ]
        [ handleUnknown = "implementation" ]
        ProjectInformation
          property = TRAFFICLIGHT
            [ name = "Title" ]
            [ type = "string" ]
            [ name = "Title" ]
            [ type = "string" ]
          property = Hugo Pereira
          property = Master Thesis Project
          property = false
          property = 1.0.0.0
          property = HARRO_HÖFLIGER
  types
  instances
  addData
```

XML 2:

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml
```

```
project
  [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
  [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
  [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  fileHeader
  contentHeader
    [ author = "" ]
    [ language = "EN" ]
    [ modificationDateTime = "2001-12-31T12:00:00" ]
    [ name = "" ]
    [ organization = "" ]
    [ version = "" ]
    Comment = Comment
    coordinateInfo
    addDataInfo
      info
        [ name = "http://tempuri.org" ]
        [ vendor = "http://tempuri.org" ]
        [ version = "0.0" ]
        description
          ANY-ELEMENT
    addData
      data
        [ handleUnknown = "preserve" ]
        [ name = "http://tempuri.org" ]
        ANY-ELEMENT
  types
  instances
  addData
  documentation
```

Figure 73 – addData and addDataInfo structure

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

Epas-5 XML

```xml
<addData>
  <data name="http://www.3s-software.com/plcopenxml/projectinformation"
  handleUnknown="implementation">
   <ProjectInformation>
      <property name="Author" type="string">HUGO PEREIRA
      </property>
      <property name="Title" type="string">MASTER THESIS
      </property>
      <property name="DefaultNamespace" type="string">PROJECT MT
      </property>
      <property name="Version" type="version">1.0
      </property>
      <property name="Project" type="string">TL_Epas5_V1.35.15.00_Original
      </property>
      <property name="Description" type="string">FILE HEADER TEST
      </property>
      <property name="Company" type="string">HARRO HÖFLIGER
      </property>
    </ProjectInformation>
  </data>
</addData>
```

PLCopen Scheme

```xml
<addData>
  <data handleUnknown="preserve" name="http://tempuri.org">
    <ANY-ELEMENT/>
  </data>
</addData>


<addDataInfo>
  <info name="http://tempuri.org"
  vendor="http://tempuri.org" version="0.0">
    <description>
      <ANY-ELEMENT/>
    </description>
  </info>
</addDataInfo>
```

Table 6 – contentHeader/addData addDataInfo structure XML

The Epas-5 export tool is in conformance with PLCopen in element addData.

1.3 - Instances

Instances can contain a “configurations” element, which consists of zero or more elements “configuration”.

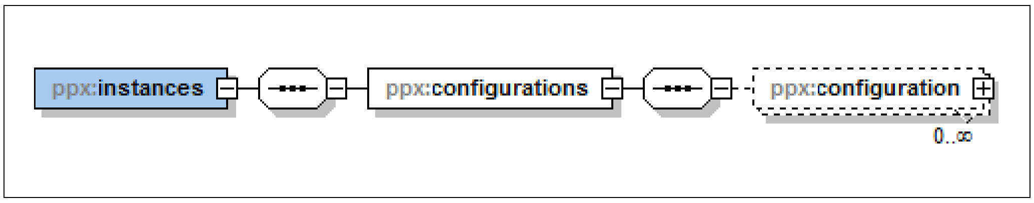


Figure 74 – Instances diagram

1.3.1 - Configurations

Configuration represents a group of resources and global variables. It is identified by a required name. Configuration is for example A PLC system, e.g. a controller in a rack with multiple (interconnected) CPUs, controlling a cell of machines. In configuration we have:

- Definition of global variables (valid within this configuration);
- Combination of all resources of a PLC system;
- Definition of access paths between configurations;
- Declaration of directly represented (global) variables.

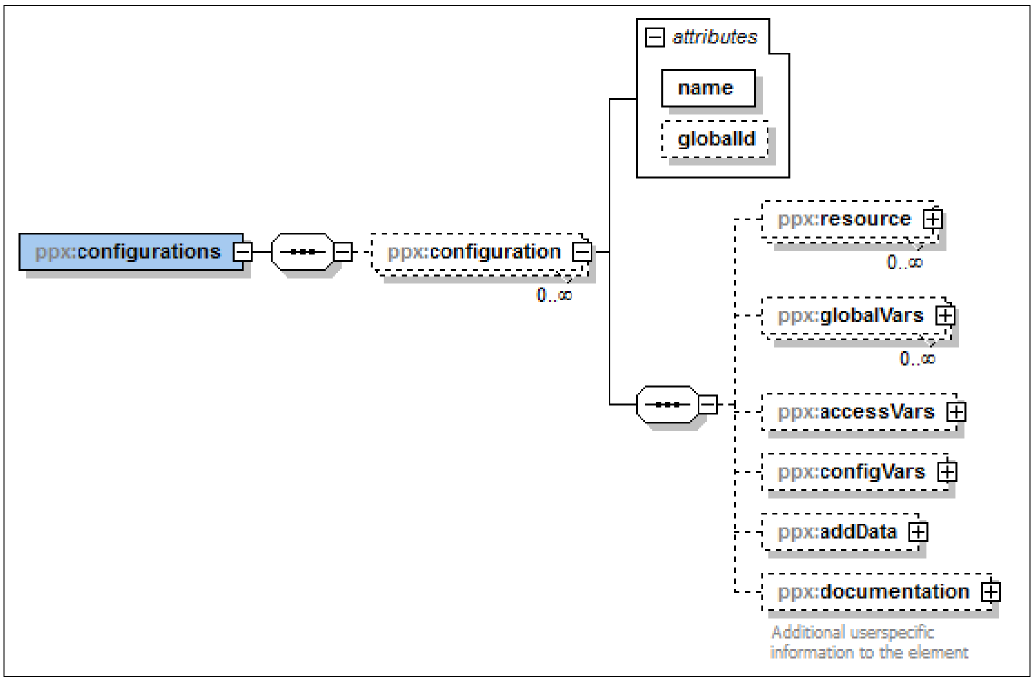
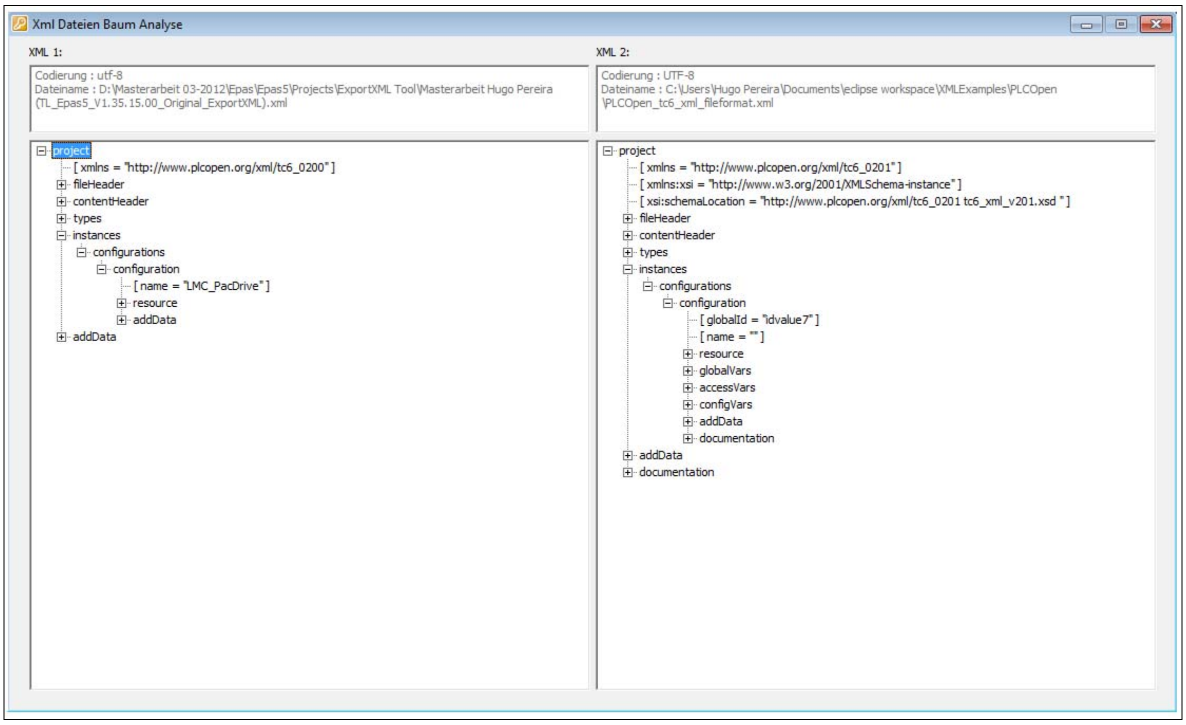


Figure 75 – configurations/configuration diagram



Xml Dateien Baum Analyse

XML 1:

Codierung : utf-8
Dateiname : D:\Masterarbeit 03-2012\Epas\Epas5\Projects\ExportXML Tool\Masterarbeit Hugo Pereira (TL_Epas5_V1.35.15.00_Original_ExportXML).xml

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊟ instances
    ⊟ configurations
      ⊟ configuration
          [ name = "LMC_PacDrive" ]
        ⊞ resource
        ⊞ addData
  ⊞ addData
```

XML 2:

Codierung : UTF-8
Dateiname : C:\Users\Hugo Pereira\Documents\eclipse workspace\XMLExamples\PLCOpen \PLCOpen_tc6_xml_fileformat.xml

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
    [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
    [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊟ instances
    ⊟ configurations
      ⊟ configuration
          [ globalId = "idvalue7" ]
          [ name = "" ]
        ⊞ resource
        ⊞ globalVars
        ⊞ accessVars
        ⊞ configVars
        ⊞ addData
        ⊞ documentation
  ⊞ addData
  ⊞ documentation
```

Figure 76 – Instances structure

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

The name of the configuration is “LMC_PacDrive” as it´s possible to see in the figure. Configuration elements are typically declared in textual form. The standard provides a definition for a graphical representation of a TASK, but the graphical representation of all other configuration elements is left to the programming system and is therefore implementation-dependent. [11]

Epas-5 XML

```xml
<instances>
  <configurations>
    <configuration name="LMC_PacDrive">
      <resource name="Application">
        <task name="Task" interval="PT0.01S" priority="31">
          <pouInstance name="PLC_PRG" typeName="">
            <documentation>
              <xhtml xmlns="http://www.w3.org/1999/xhtml" />
            </documentation>
```

Table 7 – contentHeader/addData addDataInfo structure XML

1.3.2 - Resources

Resource represents a group of programs, tasks and global variables. It is identified by a required name.
A resource is defined in order to assign TASKs to the physical resources of a PLC system.
In a resource we have:

- Definition of global variables (valid within this resource);
- Assignment of tasks and programs to a resource;
- Invocation of run-time programs with input and output parameters;
- Declaration of directly represented (global) variables.

The resource name assigns a symbolic name to a CPU in a PLC. The types and numbers of the resources in a PLC system (individual CPU designations) are provided by the programming system and checked to ensure that they are used correctly. Global variables, which are permissible at resource level, can be used for managing the data that are restricted to one CPU. [11]

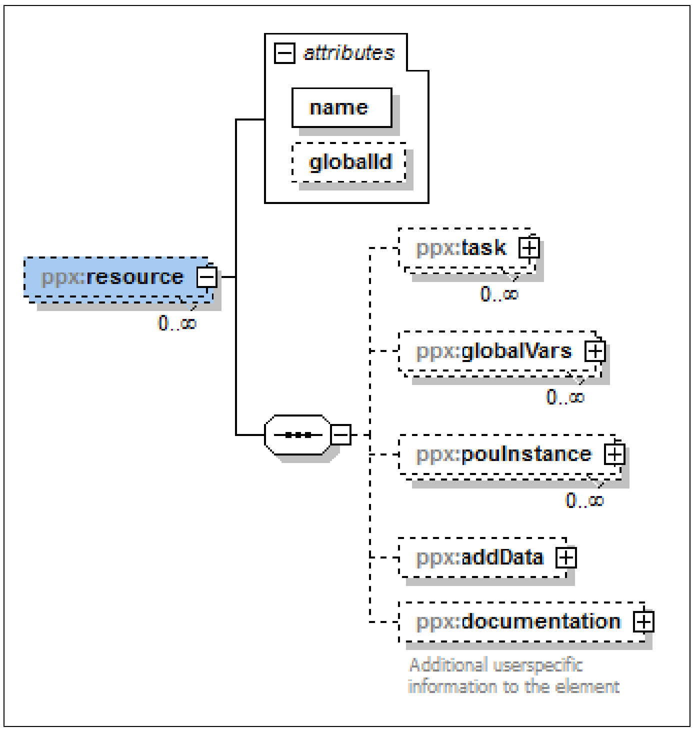
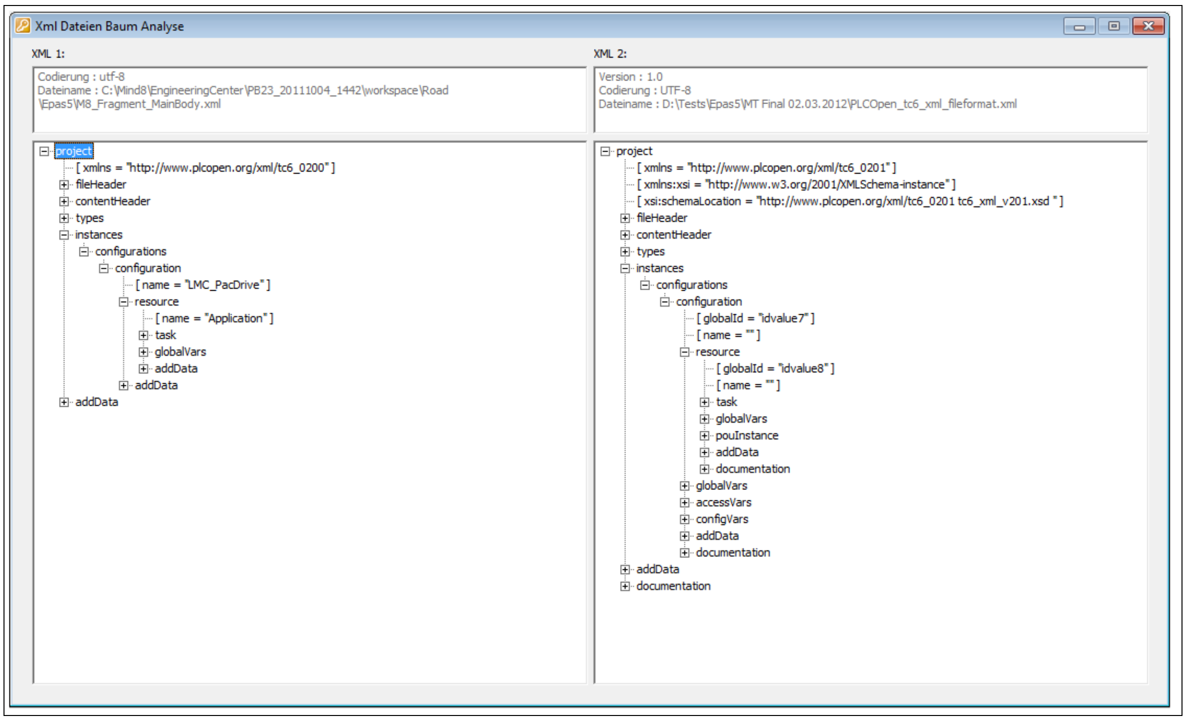


Figure 77 – resource diagram



Xml Dateien Baum Analyse

XML 1:

```
Codierung : utf-8
Dateiname : C:\Mind8\EngineeringCenter\PB23_20111004_1442\workspace\Road
\Epas5\M8_Fragment_MainBody.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊟ instances
      ⊟ configurations
          ⊟ configuration
              [ name = "LMC_PacDrive" ]
              ⊟ resource
                  [ name = "Application" ]
                  ⊞ task
                  ⊞ globalVars
                  ⊞ addData
              ⊞ addData
  ⊞ addData
```

XML 2:

```
Version : 1.0
Codierung : UTF-8
Dateiname : D:\Tests\Epas5\MT Final 02.03.2012\PLCOpen_tc6_xml_fileformat.xml
```

```
⊟ project
    [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
    [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
    [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  ⊞ fileHeader
  ⊞ contentHeader
  ⊞ types
  ⊟ instances
      ⊟ configurations
          ⊟ configuration
              [ globalId = "idvalue7" ]
              [ name = "" ]
              ⊟ resource
                  [ globalId = "idvalue8" ]
                  [ name = "" ]
                  ⊞ task
                  ⊞ globalVars
                  ⊞ pouInstance
                  ⊞ addData
                  ⊞ documentation
              ⊞ globalVars
              ⊞ accessVars
              ⊞ configVars
              ⊞ addData
              ⊞ documentation
  ⊞ addData
  ⊞ documentation
```

Figure 78 – resources

Epas-5 XML code (Left) and PLCopenXML Scheme (Right)

1.3.2 - Tasks

In a task a definition of run-time properties can be done. Task represents a periodic or triggered task and consists of a group of program and / or function block instances. It is defined by a required priority, an optional single, and an optional interval time.
A task definition according to IEC 61131-3 enables these program features to be formulated explicitly and vendor-independently. This makes program documentation and maintenance easier. [11]

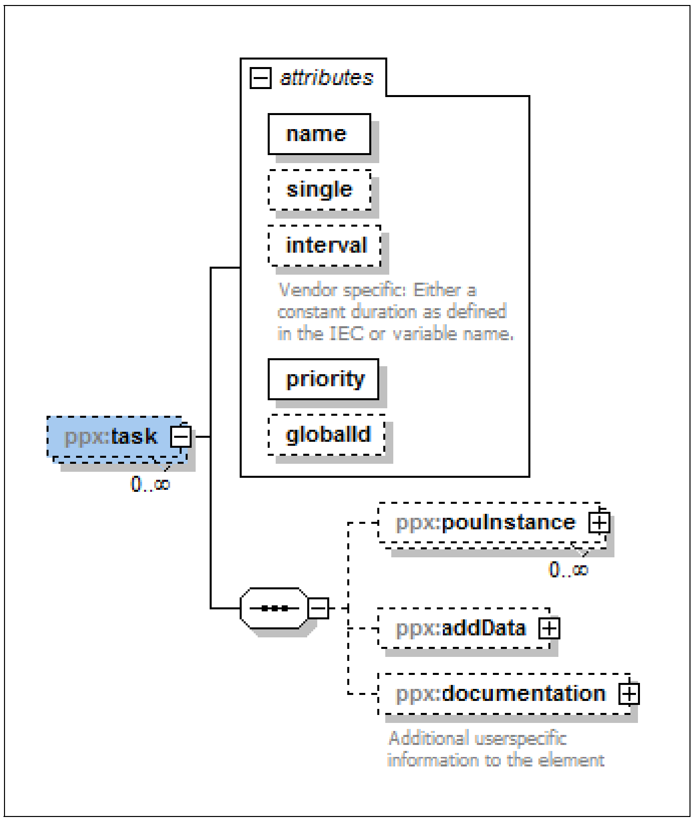
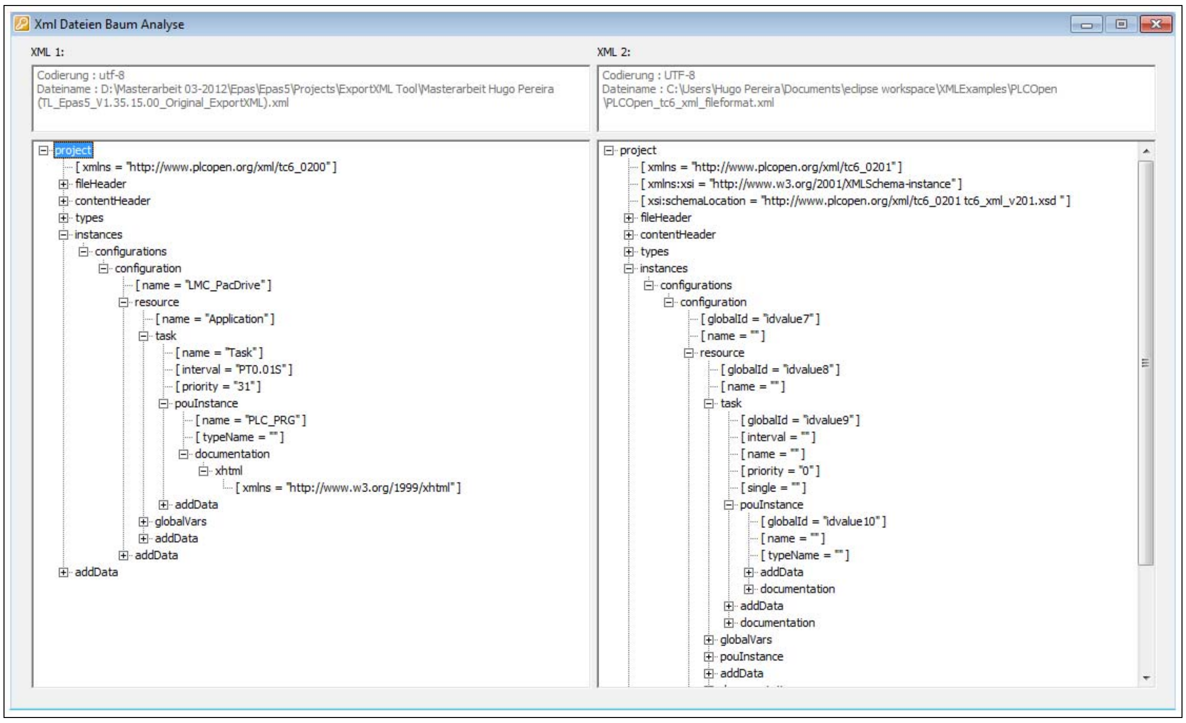

attributes
name
single
interval
Vendor specific: Either a constant duration as defined in the IEC or variable name.
priority
globalId
ppx:task
0..∞
ppx:pouInstance
0..∞
ppx:addData
ppx:documentation
Additional userspecific information to the element

Figure 79 – task diagram



```
XML 1:
Codierung : utf-8
Dateiname : D:\Masterarbeit 03-2012\Epas\Epas5\Projects\ExportXML Tool\Masterarbeit Hugo Pereira
(TL_Epas5_V1.35.15.00_Original_ExportXML).xml

project
  [ xmlns = "http://www.plcopen.org/xml/tc6_0200" ]
  fileHeader
  contentHeader
  types
  instances
    configurations
      configuration
        [ name = "LMC_PacDrive" ]
        resource
          [ name = "Application" ]
          task
            [ name = "Task" ]
            [ interval = "PT0.01S" ]
            [ priority = "31" ]
            pouInstance
              [ name = "PLC_PRG" ]
              [ typeName = "" ]
              documentation
                xhtml
                  [ xmlns = "http://www.w3.org/1999/xhtml" ]
            addData
          globalVars
          addData
        addData
  addData
```

```
XML 2:
Codierung : UTF-8
Dateiname : C:\Users\Hugo Pereira\Documents\eclipse workspace\XMLExamples\PLCOpen
\PLCOpen_tc6_xml_fileformat.xml

project
  [ xmlns = "http://www.plcopen.org/xml/tc6_0201" ]
  [ xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance" ]
  [ xsi:schemaLocation = "http://www.plcopen.org/xml/tc6_0201 tc6_xml_v201.xsd " ]
  fileHeader
  contentHeader
  types
  instances
    configurations
      configuration
        [ globalId = "idvalue7" ]
        [ name = "" ]
        resource
          [ globalId = "idvalue8" ]
          [ name = "" ]
          task
            [ globalId = "idvalue9" ]
            [ interval = "" ]
            [ name = "" ]
            [ priority = "0" ]
            [ single = "" ]
            pouInstance
              [ globalId = "idvalue10" ]
              [ name = "" ]
              [ typeName = "" ]
              addData
              documentation
            addData
            documentation
          globalVars
          pouInstance
          addData
```

Figure 80 – resource/task

Epas-5 XML code (Left) and PLCopen XML Scheme (Right)

Epas-5 XML

```xml
<task name="Task" interval="PT0.01S" priority="31">
  <pouInstance name="PLC_PRG" typeName="">
    <documentation>
      <xhtml xmlns="http://www.w3.org/1999/xhtml" />
    </documentation>
  </pouInstance>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/tasksettings"
    handleUnknown="implementation">
      <TaskSettings KindOfTask="Cyclic" Interval="t#10ms" IntervalUnit="ms"
      WithinSPSTimeSlicing="true">
        <Watchdog Enabled="true" Time="PT0.01S" Sensitivity="10" />
      </TaskSettings>
    </data>
  </addData>
</task>
```

PLCopen Scheme

```xml
<task globalId="idvalue9" interval="" name="" priority="0" single="">
  <pouInstance globalId="idvalue10" name="" typeName="">
    <addData>
      <data handleUnknown="preserve" name="http://tempuri.org">
        <ANY-ELEMENT/>
      </data>
    </addData>
    <documentation>
      <ANY-ELEMENT/>
    </documentation>
  </pouInstance>
  <addData>
    <data handleUnknown="preserve" name="http://tempuri.org">
      <ANY-ELEMENT/>
    </data>
  </addData>
  <documentation>
    <ANY-ELEMENT/>
  </documentation>
</task>
```

Table 8 – task structure XML

After this analysis it was found that the extracted XML from software Epas-5 is in compliance with the PLCopen scheme. In this section, only some parameters were analyzed. A more detailed study than can be seen in the appendix to this document.

5 Creation of the Eplan Engineering Center Model

For this work to be understood more simply was conceived a project of a Road for automobile traffic. For this project could be modular on this road the user can introduce one or more intersections. Each intersection has two traffic lights for each direction of intersection.

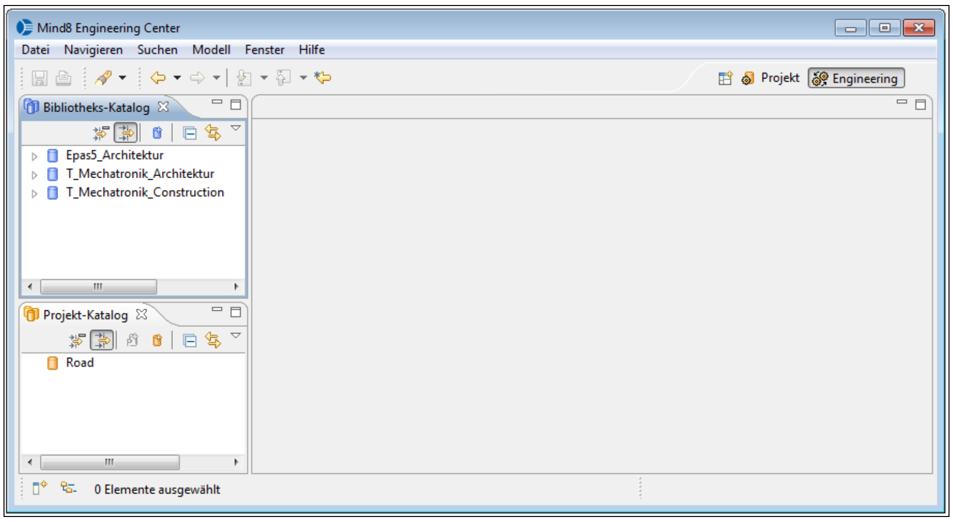


Figure 81 – Eplan Engineering Center Road project

The aim of this project is to demonstrate that it is possible to generate CoDeSys version 3 PLC code. It is possible extrapolate this small example project to a machine with components as a modular sensor or actuator. In this case was created a main road project and the user can put as many intersections he want. In addition to the modular component "Intersection" it is possible to put n modular components, but the goal is to be simple and perceptible by all.

5.1 Mechatronic Architecture Library Creation

First it is necessary to split the project and put all the components by levels of functionality and structure. The levels of structure will be:

- Station (Machine);
- Stationcomponent (Component of the machine);
- Component.

Later, the design of each component will be referred to those elements described.

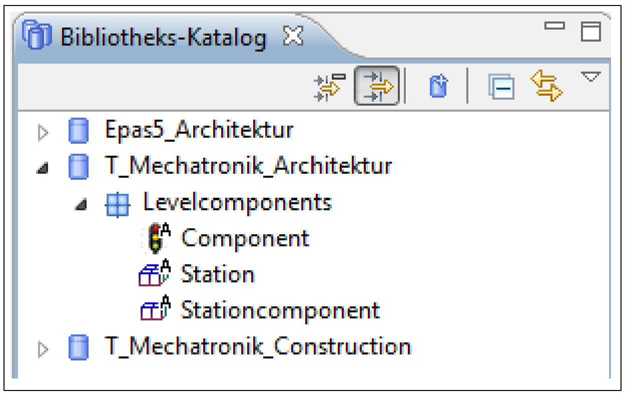


Figure 82 – T_Mechatronik_Architektur construction

In this library it will be used one pre-defined base-library called Engineering.

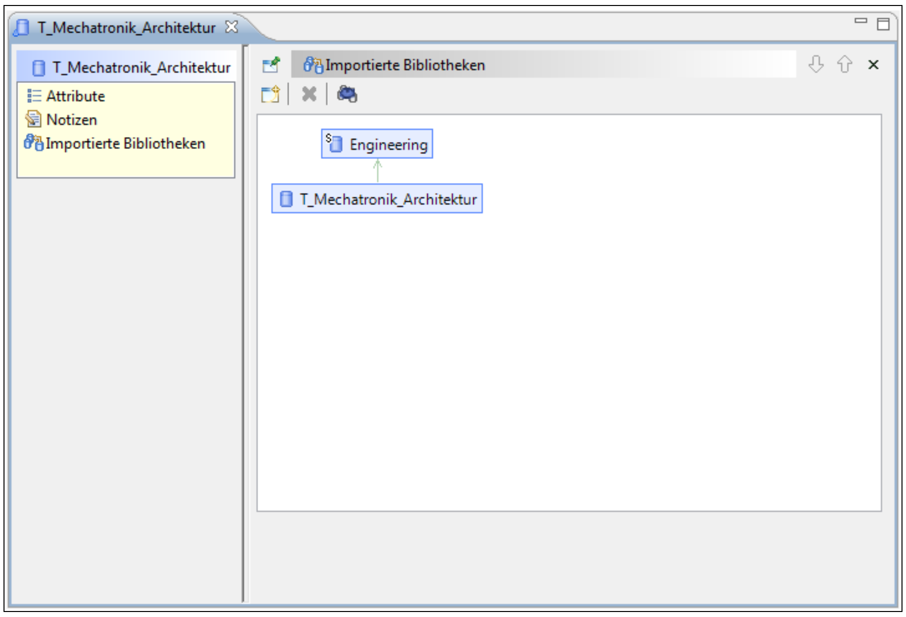

T_Mechatronik_Architektur
T_Mechatronik_Architektur
Attribute
Notizen
Importierte Bibliotheken
Importierte Bibliotheken
Engineering
T_Mechatronik_Architektur

Figure 83 – T_Mechatronik_Architektur library

5.2 Epas-5 Architecture Library Creation

This library is the main responsible for the CoDeSys version 3 code generate

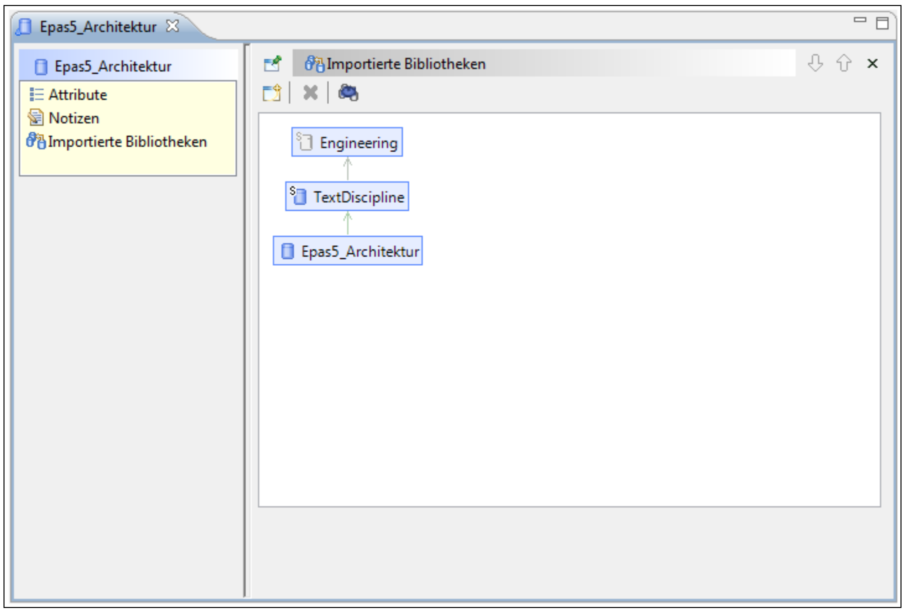
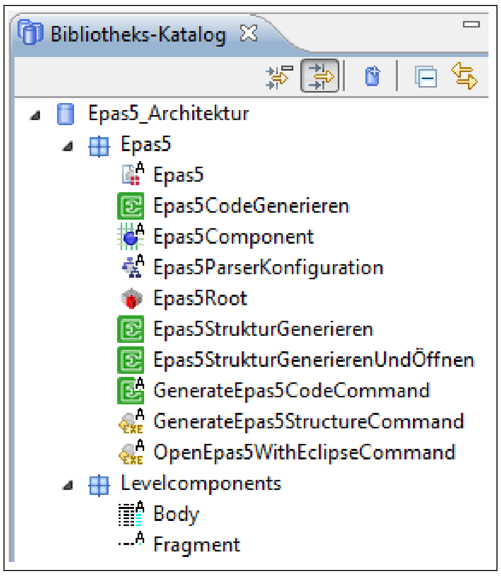


Figure 84 – Epas-5 _Architektur library

TextDiscipline is a pre-defined library. This library is capable from the functional configuration of a mechatronik system generate an element of text (source code).

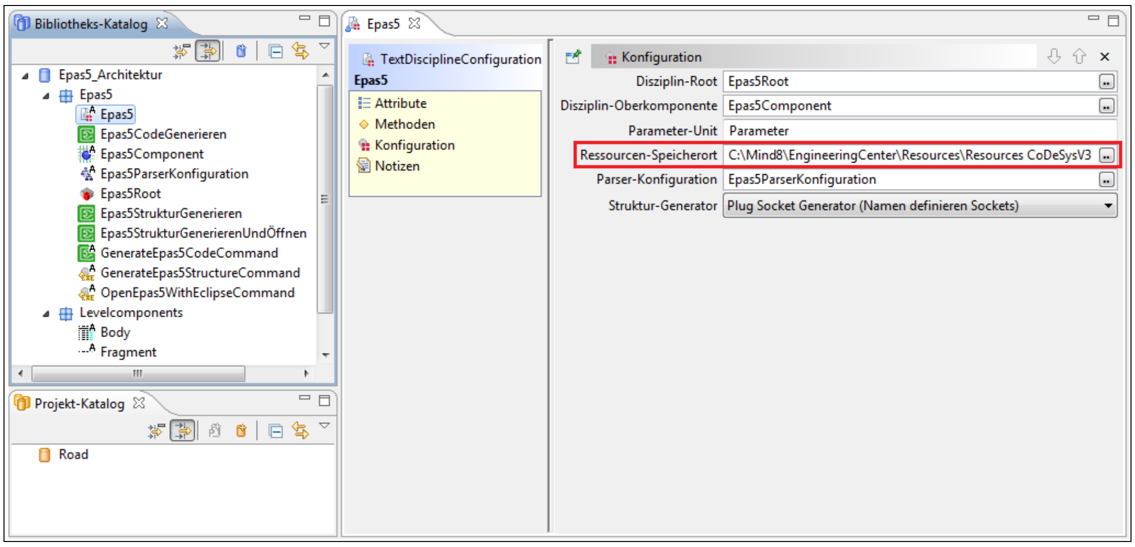


Epas5_Architektur
- Epas5
  - Epas5
  - Epas5CodeGenerieren
  - Epas5Component
  - Epas5ParserKonfiguration
  - Epas5Root
  - Epas5StrukturGenerieren
  - Epas5StrukturGenerierenUndÖffnen
  - GenerateEpas5CodeCommand
  - GenerateEpas5StructureCommand
  - OpenEpas5WithEclipseCommand
- Levelcomponents
  - Body
  - Fragment

Figure 85 – Epas5 _Architektur tree view

The library “Epas5_Architekture” has two main folders, “Epas5” with the text discipline library and “levelcomponents” with the components that will be used later in the creation of the source code fragments.

In Epas5 folder user can define the entire library for example, where is the text source that will be used to generate the code source for PLC project (resources).



Disziplin-Root	Epas5Root
Disziplin-Oberkomponente	Epas5Component
Parameter-Unit	Parameter
Ressourcen-Speicherort	C:\Mind8\EngineeringCenter\Resources\Resources CoDeSysV3
Parser-Konfiguration	Epas5ParserKonfiguration
Struktur-Generator	Plug Socket Generator (Namen definieren Sockets)

Figure 86 – Epas5 _Architektur path to resources of the project

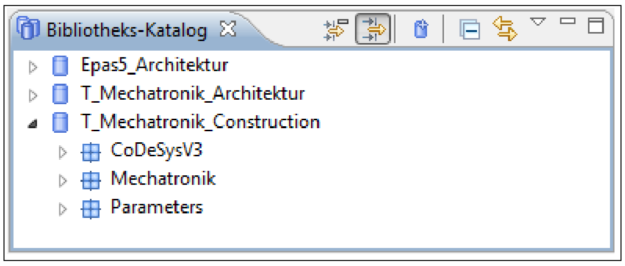
In “Levelcomponents” The “Body” level object is the hull for the main Epas-5 code, with other words it will contain the PLCopenXML output from the project constructed in Epas-5 (CoDeSys version 3) for the Road project like we have seen in previous chapter. The “Fragment” level object is the hull for fragments of little codes that we introduce in the main code depending of the construction of the project.

Just to remember these two objects are just hulls and they will be used further in this chapter.

5.3 Mechatronic Construction Library Creation

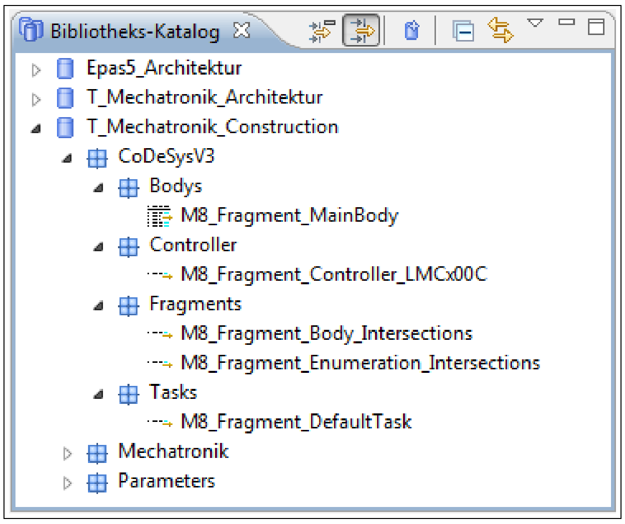
The "T_Mechatronik_Construction" library will be the working library of the project Road. In this library are three main folders:

- CoDeSysV3 – this folder contains the body and the fragments for the generation of XML code.
- Mechatronik – Is defined the Mechatronik structure.
- Parameters – All the parameters for the project will be save in this folder.



```
Bibliotheks-Katalog
▷ Epas5_Architektur
▷ T_Mechatronik_Architektur
◢ T_Mechatronik_Construction
    ▷ CoDeSysV3
    ▷ Mechatronik
    ▷ Parameters
```

Figure 87 – T_Mechatronik_Construction tree view

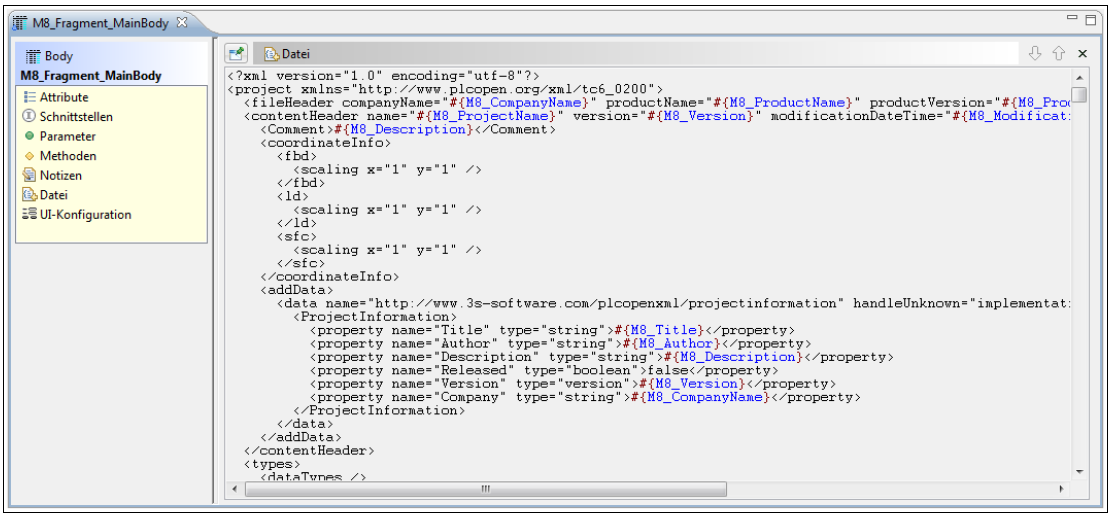


```
Bibliotheks-Katalog
▷ Epas5_Architektur
▷ T_Mechatronik_Architektur
◢ T_Mechatronik_Construction
    ◢ CoDeSysV3
        ◢ Bodys
            M8_Fragment_MainBody
        ◢ Controller
            M8_Fragment_Controller_LMCx00C
        ◢ Fragments
            M8_Fragment_Body_Intersections
            M8_Fragment_Enumeration_Intersections
        ◢ Tasks
            M8_Fragment_DefaultTask
    ▷ Mechatronik
    ▷ Parameters
```

Figure 88 – T_Mechatronik_Construction tree view

CoDeSysV3 Folder:

CoDeSysV3 contains the folder “Bodys” which contain the main body text file of the ExportPLCopenXML of Epas-5 Road project, called “M8_Fragment_MainBody”.

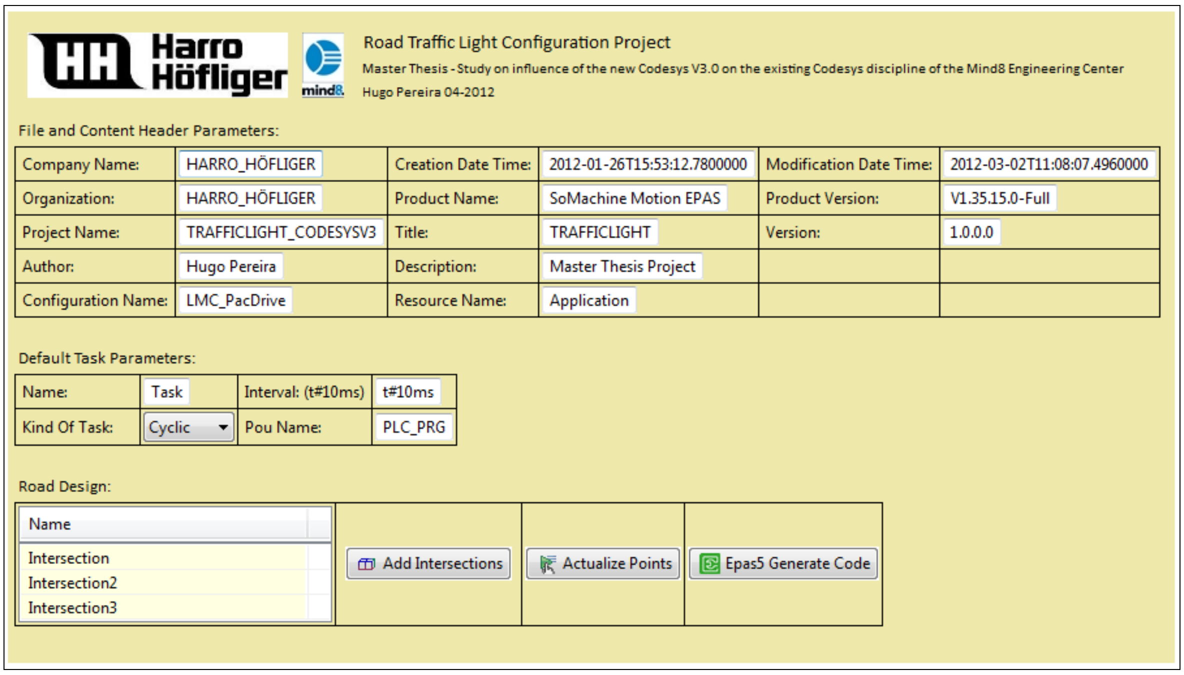


```
<?xml version="1.0" encoding="utf-8"?>
<project xmlns="http://www.plcopen.org/xml/tc6_0200">
  <fileHeader companyName="#{M8_CompanyName}" productName="#{M8_ProductName}" productVersion="#{M8_Proc
  <contentHeader name="#{M8_ProjectName}" version="#{M8_Version}" modificationDateTime="#{M8_Modificat:
    <Comment>#{M8_Description}</Comment>
    <coordinateInfo>
      <fbd>
        <scaling x="1" y="1" />
      </fbd>
      <ld>
        <scaling x="1" y="1" />
      </ld>
      <sfc>
        <scaling x="1" y="1" />
      </sfc>
    </coordinateInfo>
    <addData>
      <data name="http://www.3s-software.com/plcopenxml/projectinformation" handleUnknown="implementat:
        <ProjectInformation>
          <property name="Title" type="string">#{M8_Title}</property>
          <property name="Author" type="string">#{M8_Author}</property>
          <property name="Description" type="string">#{M8_Description}</property>
          <property name="Released" type="boolean">false</property>
          <property name="Version" type="version">#{M8_Version}</property>
          <property name="Company" type="string">#{M8_CompanyName}</property>
        </ProjectInformation>
      </data>
    </addData>
  </contentHeader>
  <types>
    <dataTypes />
```

Figure 89 – M8_Fragment_MainBody Data

In Datei (Data) user can visualize all the XML from the Road original project. The letters in blue color are parameters we can change in EEC. In fileHeader section we can change “Company Name” and the parameter is called “M8_CompanyName” and so on. These features allow the user to personalize each machine for each customer. The main code is the same for the same kind of machines but they are never equals.

For the simple introducing of these parameters it is possible to create a user friendly user interface in EEC software like the next figure.


Road Traffic Light Configuration Project
Master Thesis - Study on influence of the new Codesys V3.0 on the existing Codesys discipline of the Mind8 Engineering Center
Hugo Pereira 04-2012

File and Content Header Parameters:

Company Name:	HARRO_HÖFLIGER	Creation Date Time:	2012-01-26T15:53:12.7800000	Modification Date Time:	2012-03-02T11:08:07.4960000
Organization:	HARRO_HÖFLIGER	Product Name:	SoMachine Motion EPAS	Product Version:	V1.35.15.0-Full
Project Name:	TRAFFICLIGHT_CODESYSV3	Title:	TRAFFICLIGHT	Version:	1.0.0.0
Author:	Hugo Pereira	Description:	Master Thesis Project		
Configuration Name:	LMC_PacDrive	Resource Name:	Application		

Default Task Parameters:

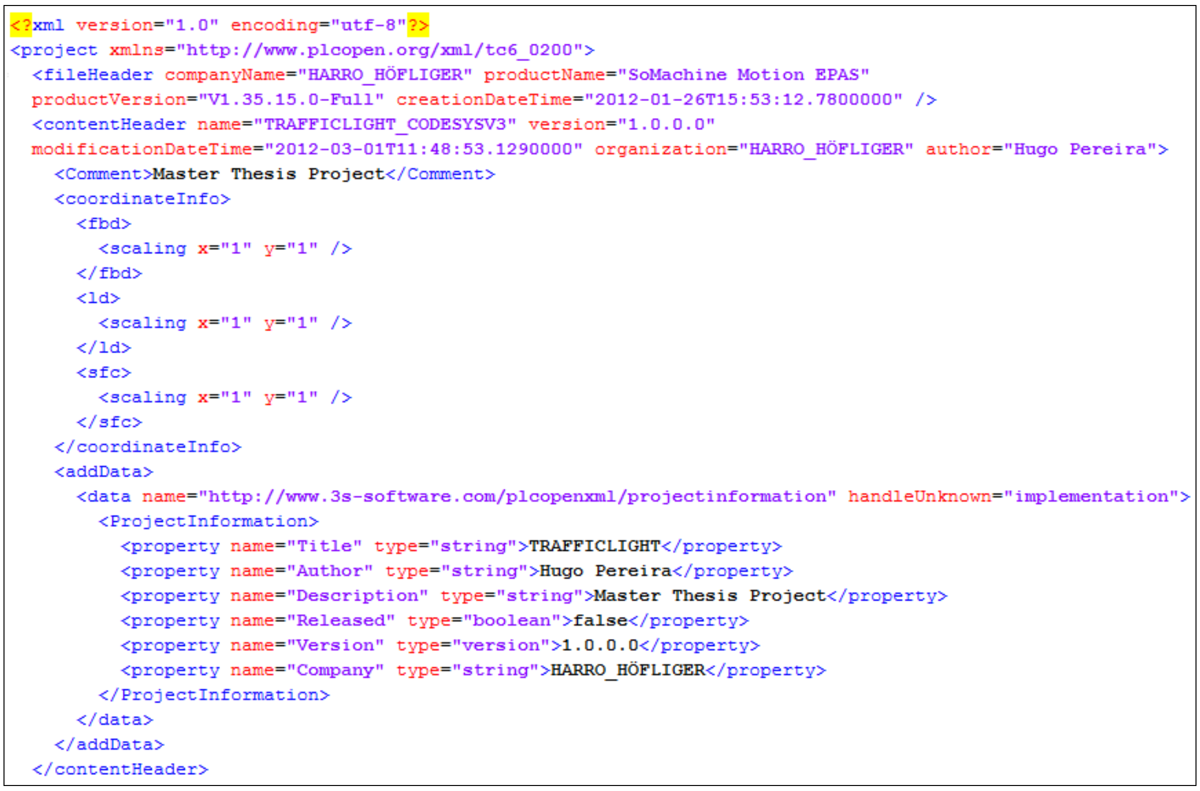
Name:	Task	Interval: (t#10ms)	t#10ms
Kind Of Task:	Cyclic	Pou Name:	PLC_PRG

Road Design:

Name
Intersection
Intersection2
Intersection3

Figure 90 – Road traffic light configuration project form, File and Content Header Parameters

The PLCopenXML output from EEC is in the next figure and as we can see all parameters are with the complete information of the previous form.

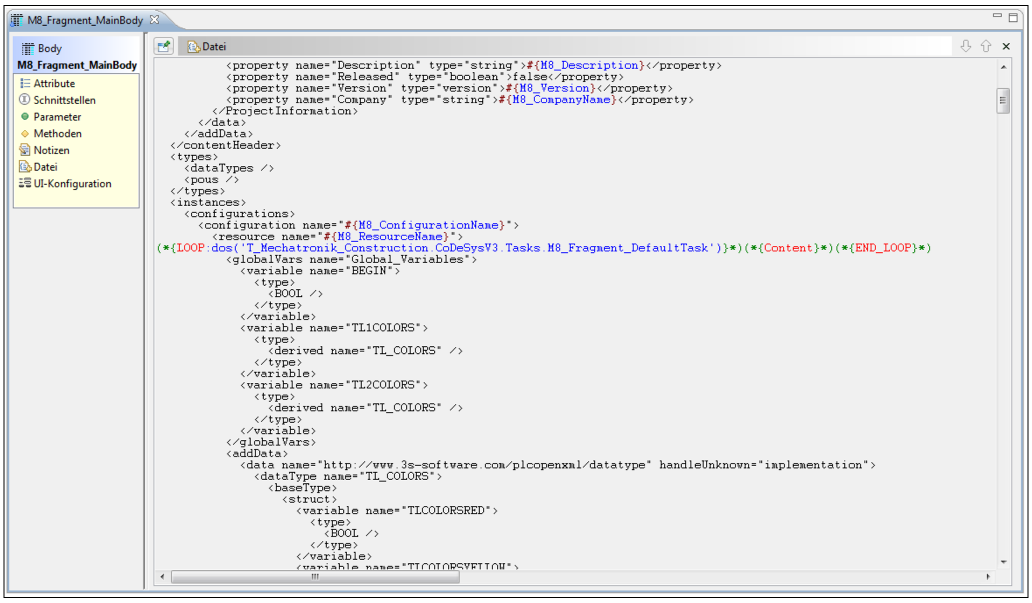


```
<?xml version="1.0" encoding="utf-8"?>
<project xmlns="http://www.plcopen.org/xml/tc6_0200">
  <fileHeader companyName="HARRO_HÖFLIGER" productName="SoMachine Motion EPAS"
  productVersion="V1.35.15.0-Full" creationDateTime="2012-01-26T15:53:12.7800000" />
  <contentHeader name="TRAFFICLIGHT_CODESYSV3" version="1.0.0.0"
  modificationDateTime="2012-03-01T11:48:53.1290000" organization="HARRO_HÖFLIGER" author="Hugo Pereira">
    <Comment>Master Thesis Project</Comment>
    <coordinateInfo>
      <fbd>
        <scaling x="1" y="1" />
      </fbd>
      <ld>
        <scaling x="1" y="1" />
      </ld>
      <sfc>
        <scaling x="1" y="1" />
      </sfc>
    </coordinateInfo>
    <addData>
      <data name="http://www.3s-software.com/plcopenxml/projectinformation" handleUnknown="implementation">
        <ProjectInformation>
          <property name="Title" type="string">TRAFFICLIGHT</property>
          <property name="Author" type="string">Hugo Pereira</property>
          <property name="Description" type="string">Master Thesis Project</property>
          <property name="Released" type="boolean">false</property>
          <property name="Version" type="version">1.0.0.0</property>
          <property name="Company" type="string">HARRO_HÖFLIGER</property>
        </ProjectInformation>
      </data>
    </addData>
  </contentHeader>
```

Figure 91 – Road traffic light PLCopenXML EEC output

Beyond these parameters in “M8_Fragment_MainBody” user have to introduce another function called “LOOP”. This function is called to repeat the text fragments many times as selected by the user or simply to replace the main body in the places where this function is referred to the text fragments released by the parameters listed on the form. Normally this function is placed in the Epas-5 code where the original text to be replaced is located. In this project we have four functions “LOOP”, they are:

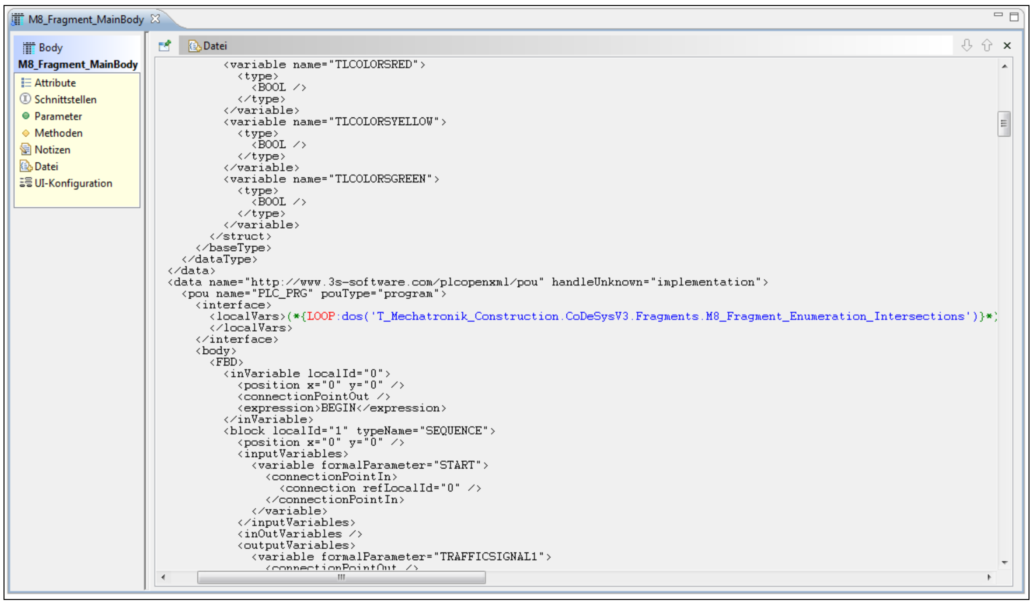
- Loop for replace default task with parameters edit by user;



```
          <property name="Description" type="string">#{M8_Description}</property>
          <property name="Released" type="boolean">false</property>
          <property name="Version" type="version">#{M8_Version}</property>
          <property name="Company" type="string">#{M8_CompanyName}</property>
        </ProjectInformation>
      </data>
    </addData>
  </contentHeader>
  <types>
    <dataTypes />
    <pous />
  </types>
  <instances>
    <configurations>
      <configuration name="#{M8_ConfigurationName}">
        <resource name="#{M8_ResourceName}">
(*{LOOP:dos('T_Mechatronik_Construction.CoDeSysV3.Tasks.M8_Fragment_DefaultTask')}*)(*{Content}*)(*{END_LOOP}*)
          <globalVars name="Global_Variables">
            <variable name="BEGIN">
              <type>
                <BOOL />
              </type>
            </variable>
            <variable name="TL1COLORS">
              <type>
                <derived name="TL_COLORS" />
              </type>
            </variable>
            <variable name="TL2COLORS">
              <type>
                <derived name="TL_COLORS" />
              </type>
            </variable>
          </globalVars>
          <addData>
            <data name="http://www.3s-software.com/plcopenxml/datatype" handleUnknown="implementation">
              <dataType name="TL_COLORS">
                <baseType>
                  <struct>
                    <variable name="TLCOLORSRED">
                      <type>
                        <BOOL />
                      </type>
                    </variable>
                    <variable name="TLCOLORSYELLOW">
```

Figure 92 – M8_Fragment_MainBody Loop for Default Task code

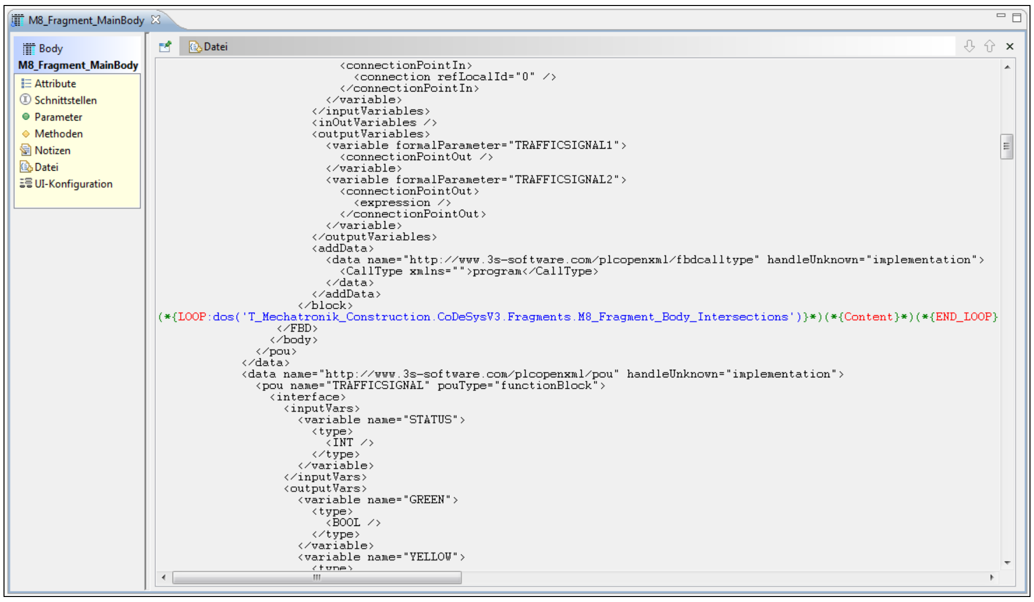
- Loop for enumeration intersection code replace with parameters edited by user;



```
          <variable name="TLCOLORSRED">
            <type>
              <BOOL />
            </type>
          </variable>
          <variable name="TLCOLORSYELLOW">
            <type>
              <BOOL />
            </type>
          </variable>
          <variable name="TLCOLORSGREEN">
            <type>
              <BOOL />
            </type>
          </variable>
        </struct>
      </baseType>
    </dataType>
  </data>
  <data name="http://www.3s-software.com/plcopenxml/pou" handleUnknown="implementation">
    <pou name="PLC_PRG" pouType="program">
      <interface>
        <localVars>(*{LOOP:dos('T_Mechatronik_Construction.CoDeSysV3.Fragments.M8_Fragment_Enumeration_Intersections')}*)
        </localVars>
      </interface>
      <body>
        <FBD>
          <inVariable localId="0">
            <position x="0" y="0" />
            <connectionPointOut />
            <expression>BEGIN</expression>
          </inVariable>
          <block localId="1" typeName="SEQUENCE">
            <position x="0" y="0" />
            <inputVariables>
              <variable formalParameter="START">
                <connectionPointIn>
                  <connection refLocalId="0" />
                </connectionPointIn>
              </variable>
            </inputVariables>
            <inOutVariables />
            <outputVariables>
              <variable formalParameter="TRAFFICSIGNAL1">
                <connectionPointOut />
```

Figure 93 – M8_Fragment_MainBody Loop for Enumeration Intersections code

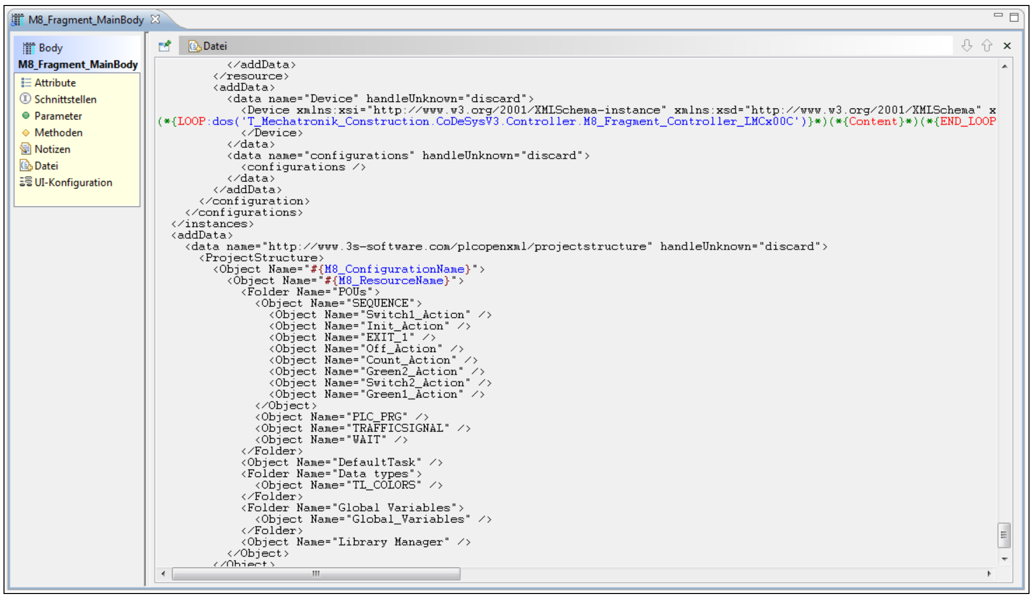
- Loop for body intersection code replace with parameters edited by user;



```
                    <connectionPointIn>
                      <connection refLocalId="0" />
                    </connectionPointIn>
                  </variable>
                </inputVariables>
                <inOutVariables />
                <outputVariables>
                  <variable formalParameter="TRAFFICSIGNAL1">
                    <connectionPointOut />
                  </variable>
                  <variable formalParameter="TRAFFICSIGNAL2">
                    <connectionPointOut>
                      <expression />
                    </connectionPointOut>
                  </variable>
                </outputVariables>
                <addData>
                  <data name="http://www.3s-software.com/plcopenxml/fbdcalltype" handleUnknown="implementation">
                    <CallType xmlns="">program</CallType>
                  </data>
                </addData>
              </block>
(*{LOOP:dos('T_Mechatronik_Construction.CoDeSysV3.Fragments.M8_Fragment_Body_Intersections')}*)(*{Content}*)(*{END_LOOP}
            </FBD>
          </body>
        </pou>
      </data>
      <data name="http://www.3s-software.com/plcopenxml/pou" handleUnknown="implementation">
        <pou name="TRAFFICSIGNAL" pouType="functionBlock">
          <interface>
            <inputVars>
              <variable name="STATUS">
                <type>
                  <INT />
                </type>
              </variable>
            </inputVars>
            <outputVars>
              <variable name="GREEN">
                <type>
                  <BOOL />
                </type>
              </variable>
              <variable name="YELLOW">
                <type>
```

Figure 94 – M8_Fragment_MainBody Loop for Body Intersections code

- Loop for hardware devices code replace;

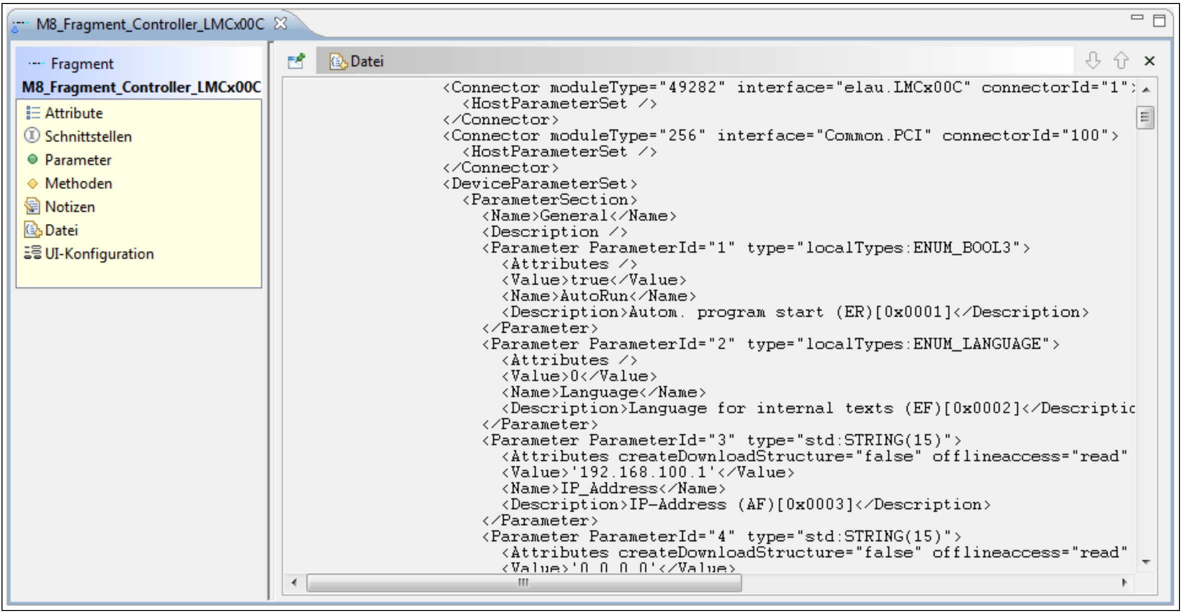


```
          </addData>
        </resource>
        <addData>
          <data name="Device" handleUnknown="discard">
            <Device xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema" x
(*{LOOP:dos('T_Mechatronik_Construction.CoDeSysV3.Controller.M8_Fragment_Controller_LMCx00C')}*)(*{Content}*)(*{END_LOOP
            </Device>
          </data>
          <data name="configurations" handleUnknown="discard">
            <configurations />
          </data>
        </addData>
      </configuration>
    </configurations>
  </instances>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/projectstructure" handleUnknown="discard">
      <ProjectStructure>
        <Object Name="#{M8_ConfigurationName}">
          <Object Name="#{M8_ResourceName}">
            <Folder Name="POUs">
              <Object Name="SEQUENCE">
                <Object Name="Switch1_Action" />
                <Object Name="Init_Action" />
                <Object Name="EXIT_1" />
                <Object Name="Off_Action" />
                <Object Name="Count_Action" />
                <Object Name="Green2_Action" />
                <Object Name="Switch2_Action" />
                <Object Name="Green1_Action" />
              </Object>
              <Object Name="PLC_PRG" />
              <Object Name="TRAFFICSIGNAL" />
              <Object Name="WAIT" />
            </Folder>
            <Object Name="DefaultTask" />
            <Folder Name="Data types">
              <Object Name="TL_COLORS" />
            </Folder>
            <Folder Name="Global Variables">
              <Object Name="Global_Variables" />
            </Folder>
            <Object Name="Library Manager" />
          </Object>
        </Object>
```

Figure 95 – M8_Fragment_MainBody Loop for devices code

<u>*Controller folder:*</u>

For example user can create a fragment or several fragments for several PLC devices in project and then he can introduce or replace in main body of code the fragment belong to the device we will use. Maybe if you need more inputs or outputs in a specific machine than the usual, it is possible to replace the code from the source code to a “larger” PLC and for that he only have to choose which PLC he want to implement in the project. The replace text file is called “M8_Fragment_Controller_LMCx00C”.



```
<Connector moduleType="49282" interface="elau.LMCx00C" connectorId="1":
  <HostParameterSet />
</Connector>
<Connector moduleType="256" interface="Common.PCI" connectorId="100">
  <HostParameterSet />
</Connector>
<DeviceParameterSet>
  <ParameterSection>
    <Name>General</Name>
    <Description />
    <Parameter ParameterId="1" type="localTypes:ENUM_BOOL3">
      <Attributes />
      <Value>true</Value>
      <Name>AutoRun</Name>
      <Description>Autom. program start (ER)[0x0001]</Description>
    </Parameter>
    <Parameter ParameterId="2" type="localTypes:ENUM_LANGUAGE">
      <Attributes />
      <Value>0</Value>
      <Name>Language</Name>
      <Description>Language for internal texts (EF)[0x0002]</Descriptic
    </Parameter>
    <Parameter ParameterId="3" type="std:STRING(15)">
      <Attributes createDownloadStructure="false" offlineaccess="read"
      <Value>'192.168.100.1'</Value>
      <Name>IP_Address</Name>
      <Description>IP-Address (AF)[0x0003]</Description>
    </Parameter>
    <Parameter ParameterId="4" type="std:STRING(15)">
      <Attributes createDownloadStructure="false" offlineaccess="read"
      <Value>'0.0.0.0'</Value>
```

Figure 96 – M8_Fragment_Controller_LMCx00C Data

<u>*Fragments folder:*</u>

In this folder are introduced all fragments for the modular parts of the machine (Road). In Road project the only modular part sample is a intersection. For each intersection introduce in project is considered two kinds of fragments:

- Enumerations intersections;
- Body intersections.

The user can edit the project introducing in this sample more intersections with the form of the Road traffic light configuration project. If he clicks the “Add Intersections” button the table at the right will be increased with one more intersection line and in XML output the POU “PLC_PRG” will have another incremental text code.

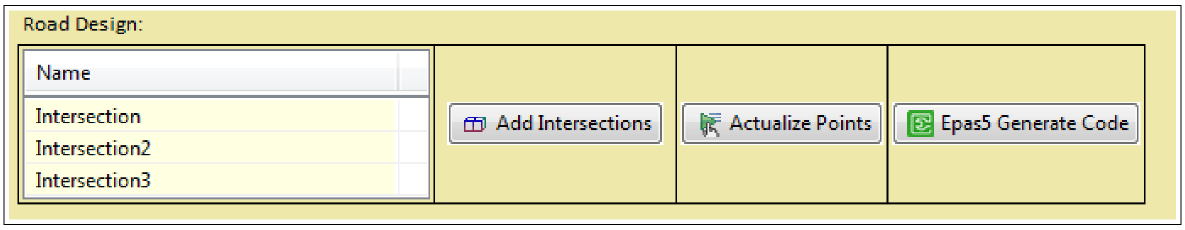
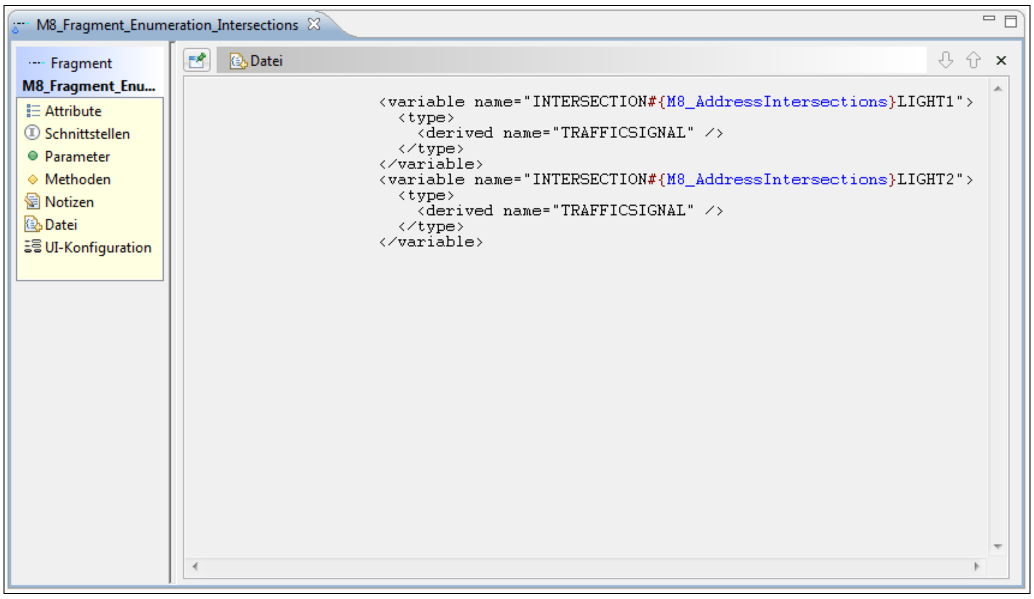


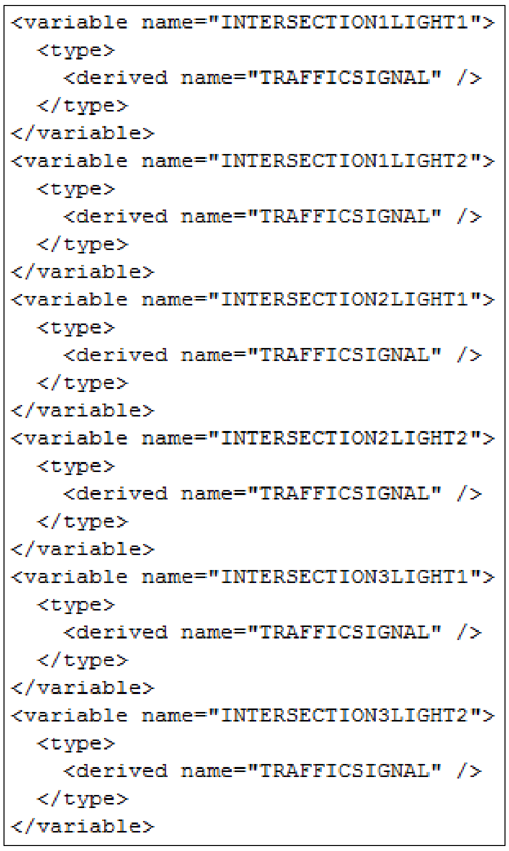
Figure 97 – Road traffic light configuration project form, Road Design

In “M8_Fragment_Enumeration_Intersections” text fragment is enounce the variables of each intersection. In the next figure is possible to see that each intersection has an intersection number light1 and light2. Light1 and light2 are the two traffic lights for each intersection. The parameter “M8_AdressIntersections” will be replaced by the index of each intersection. In figure 102 is possible to see a sample for three intersections.



```
<variable name="INTERSECTION#{M8_AddressIntersections}LIGHT1">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
<variable name="INTERSECTION#{M8_AddressIntersections}LIGHT2">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
```

Figure 98 – M8_Fragment_Enumeration_Intersections Data

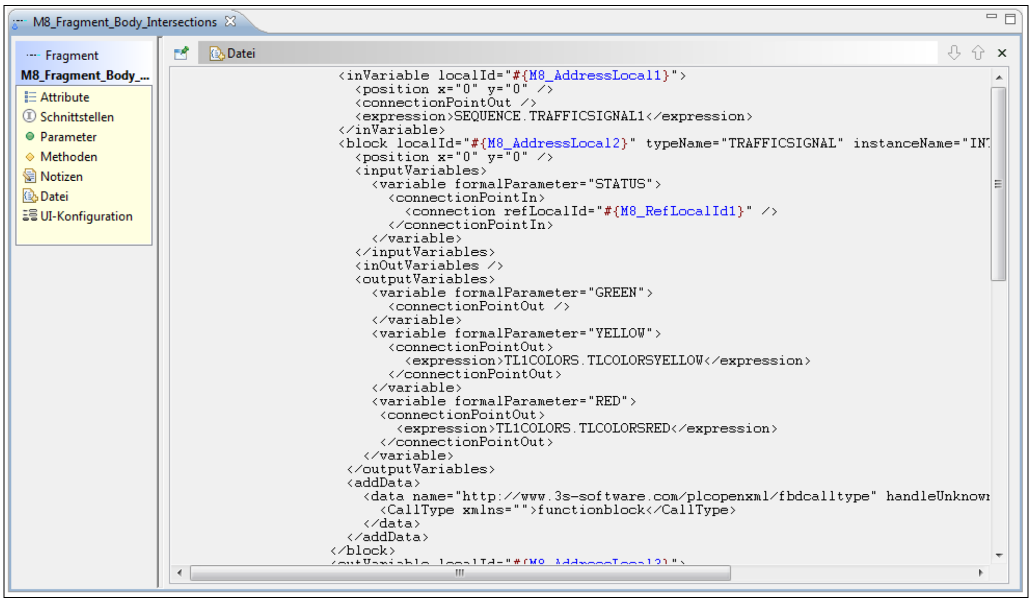


```
<variable name="INTERSECTION1LIGHT1">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
<variable name="INTERSECTION1LIGHT2">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
<variable name="INTERSECTION2LIGHT1">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
<variable name="INTERSECTION2LIGHT2">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
<variable name="INTERSECTION3LIGHT1">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
<variable name="INTERSECTION3LIGHT2">
  <type>
    <derived name="TRAFFICSIGNAL" />
  </type>
</variable>
```

Figure 99 – Enumeration intersection PLCopenXML Eplan EC output

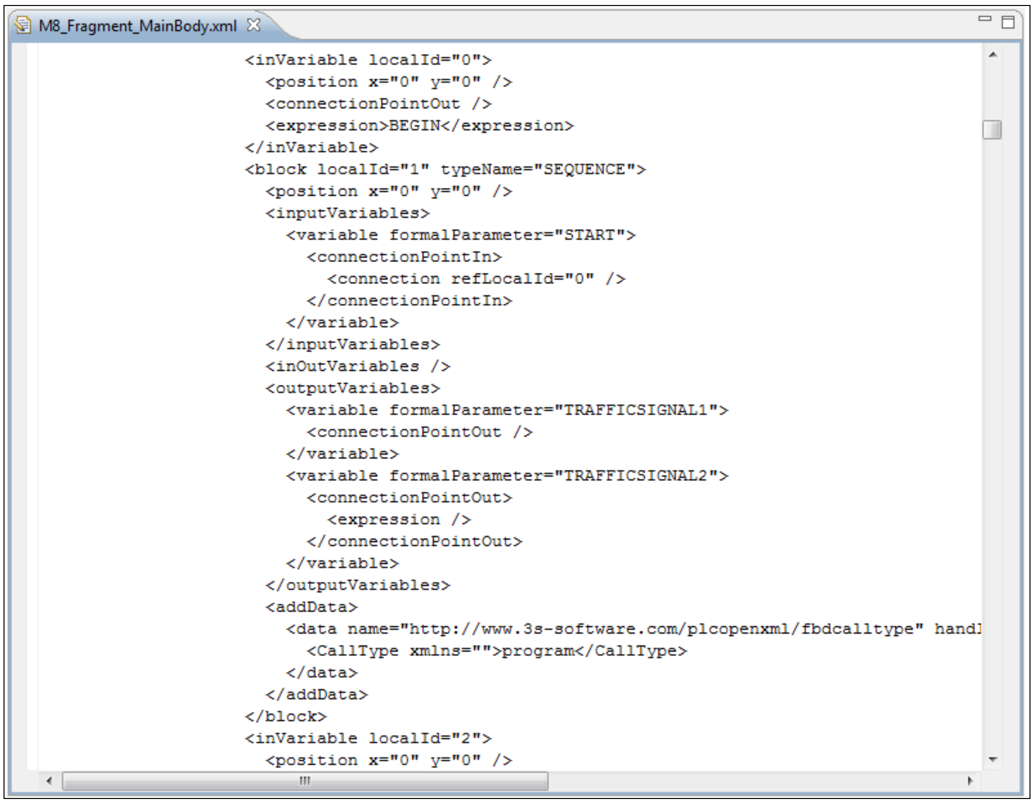
The second part of intersection (Body intersections) is responsible for the rest of the code for “PLC_PRG” program unit organization.

As can be seen in the next figure the parameters “M8_AddressLocal” and “M8_RefLocalId” are indexes and they are responsible for the positions and coordinates of inputs, outputs and blocks for Epas-5 software and PLC graphical information.



```
<inVariable localId="#{M8_AddressLocal1}">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>SEQUENCE.TRAFFICSIGNAL1</expression>
</inVariable>
<block localId="#{M8_AddressLocal2}" typeName="TRAFFICSIGNAL" instanceName="IN
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="STATUS">
      <connectionPointIn>
        <connection refLocalId="#{M8_RefLocalId1}" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="GREEN">
      <connectionPointOut />
    </variable>
    <variable formalParameter="YELLOW">
      <connectionPointOut>
        <expression>TL1COLORS.TLCOLORSYELLOW</expression>
      </connectionPointOut>
    </variable>
    <variable formalParameter="RED">
     <connectionPointOut>
       <expression>TL1COLORS.TLCOLORSRED</expression>
     </connectionPointOut>
   </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype" handleUnknown
      <CallType xmlns="">functionblock</CallType>
    </data>
  </addData>
</block>
<outVariable localId="#{M8_AddressLocal3}">
```

Figure 100 – M8_Fragment_Body_Intersections data

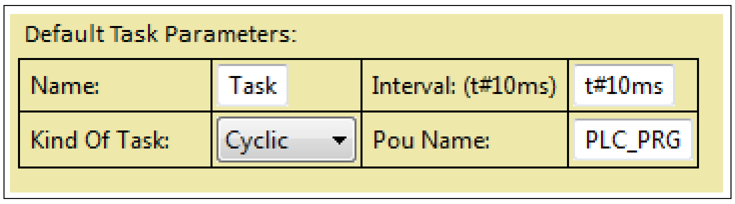


```
<inVariable localId="0">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>BEGIN</expression>
</inVariable>
<block localId="1" typeName="SEQUENCE">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="START">
      <connectionPointIn>
        <connection refLocalId="0" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="TRAFFICSIGNAL1">
      <connectionPointOut />
    </variable>
    <variable formalParameter="TRAFFICSIGNAL2">
      <connectionPointOut>
        <expression />
      </connectionPointOut>
    </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype" handl
      <CallType xmlns="">program</CallType>
    </data>
  </addData>
</block>
<inVariable localId="2">
  <position x="0" y="0" />
```

Figure 101 – Main Body PLCopenXML EEC output

Tasks folder:

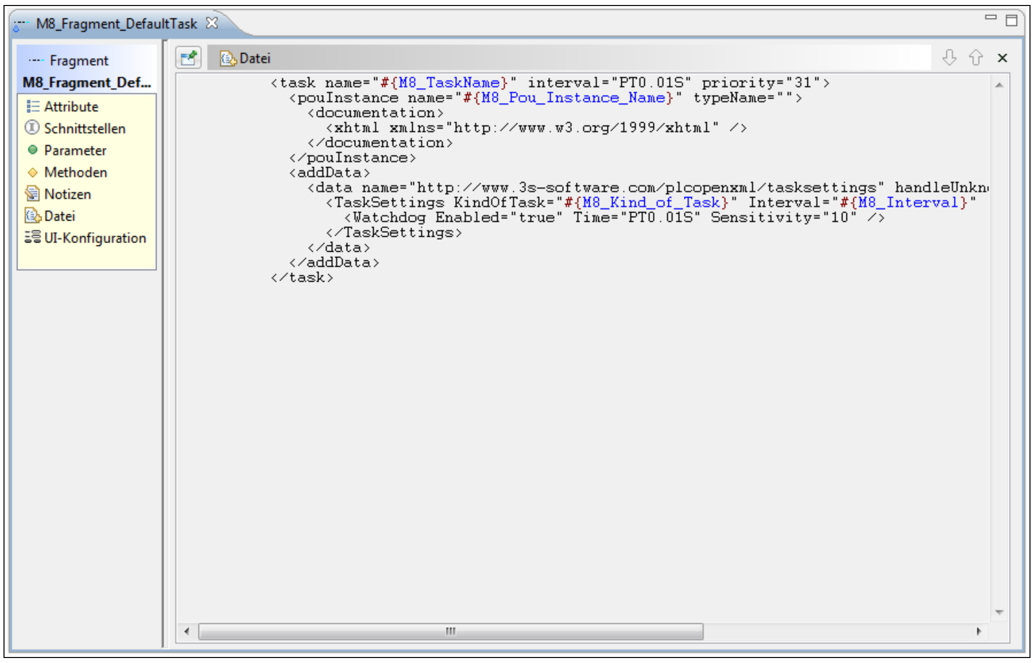
In tasks folder it was introduced the text file “M8_Fragment_DefaultTask”. This text file is responsible for the default task of the project. This means that it is possible to create or change some parameters of the tasks inside a project. Editing the task is possible in the Road form like showed in the next figure. Each project requires at least one task but user can introduce as many as he want, depending of the complexity of the machine. In this sample the number of tasks was not modular because this is a sample project and the modular parameterization is always reach with the intersections. In default task we can change “Name”, “Kind Of Task”, “Interval” and the “Pou Name” that is the name of the Pou called when the task is executed.



Default Task Parameters:

Name:	Task	Interval: (t#10ms)	t#10ms
Kind Of Task:	Cyclic	Pou Name:	PLC_PRG

Figure 102 – Road traffic light configuration project form, Default Task Parameters



```
<task name="#{M8_TaskName}" interval="PT0.01S" priority="31">
  <pouInstance name="#{M8_Pou_Instance_Name}" typeName="">
    <documentation>
      <xhtml xmlns="http://www.w3.org/1999/xhtml" />
    </documentation>
  </pouInstance>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/tasksettings" handleUnkn
      <TaskSettings KindOfTask="#{M8_Kind_of_Task}" Interval="#{M8_Interval}"
        <Watchdog Enabled="true" Time="PT0.01S" Sensitivity="10" />
      </TaskSettings>
    </data>
  </addData>
</task>
```

Figure 103 – M8_Fragment_DefaultTask data

Mechatronik Folder:

In this folder is saved the mechatronics parts of the project. Subfolders are the elements of the "T_Mechatronik_Architektur", Stations, Stationcomponents and Components.

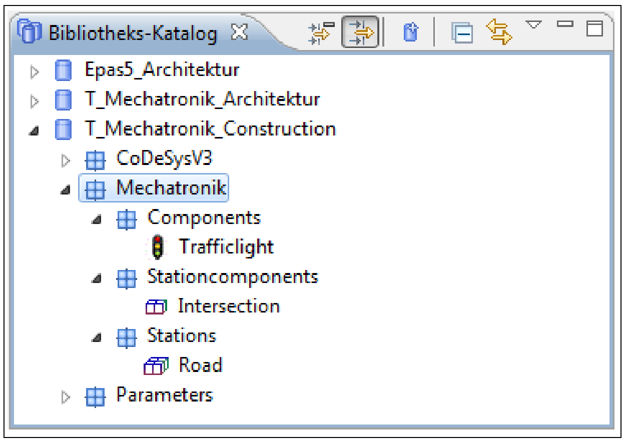
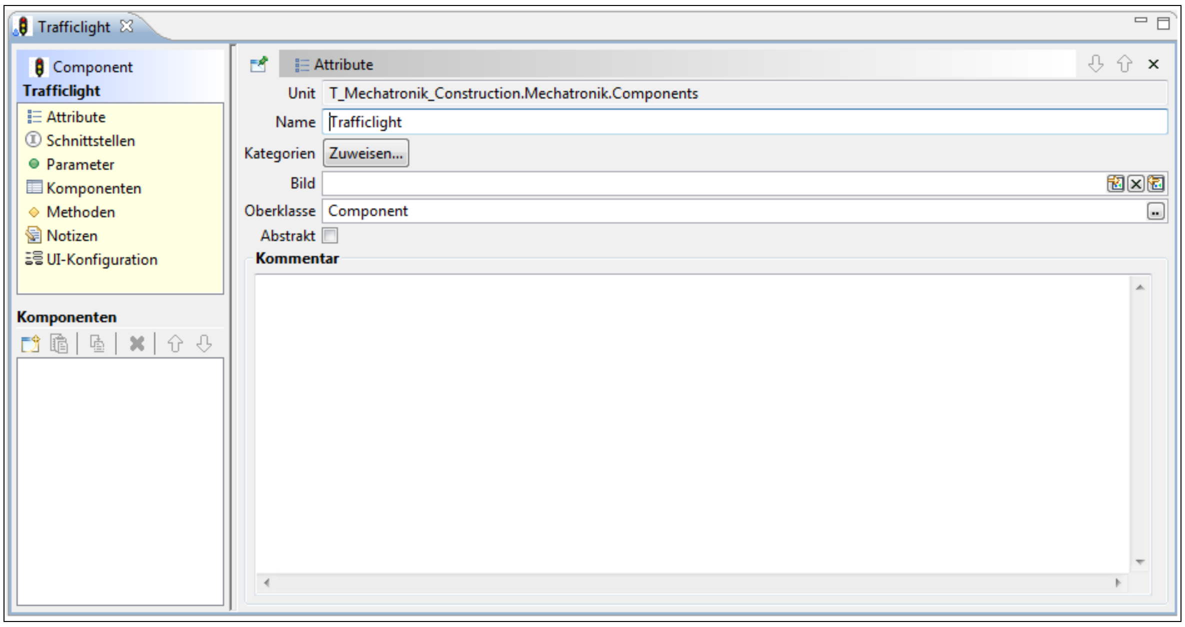


Figure 104 – T_Mechatronik_Construction Mechatronik tree view

Components folder:

This folder contains the lowest value element "TrafficLight". This element is from the type "Component" enounced in the library "T_Mechatronik_Architektur".

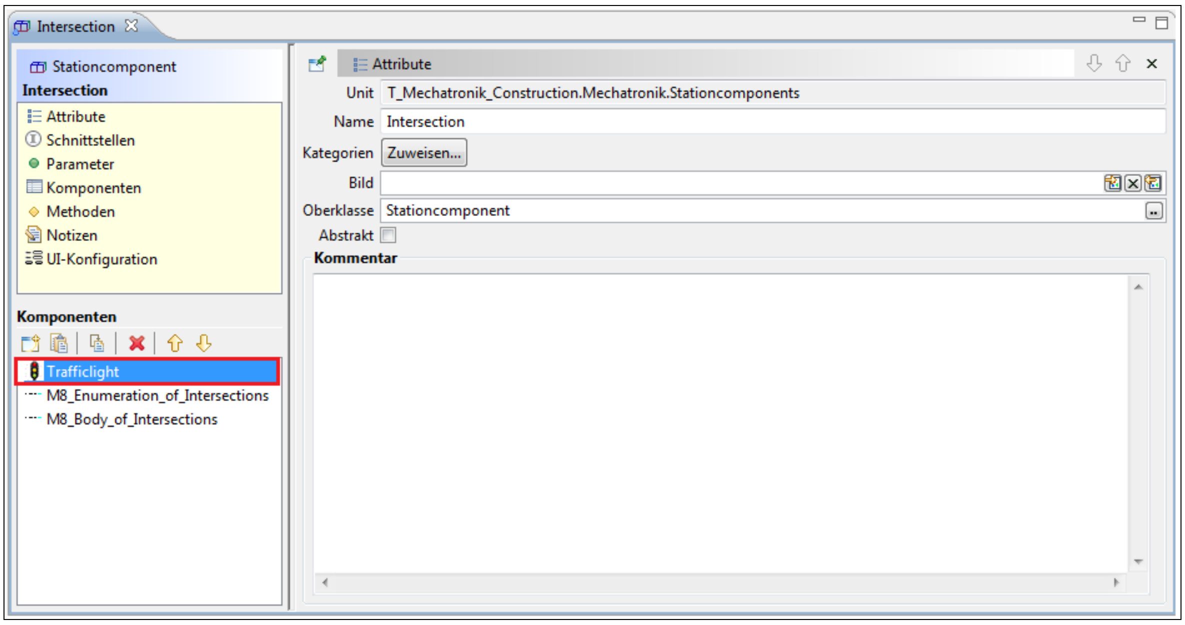


Unit T_Mechatronik_Construction.Mechatronik.Components
Name Trafficlight
Bild
Oberklasse Component
Abstrakt ☐

Figure 105 – T_Mechatronik_Construction Traffic Light

Stationcomponents folder:

This folder contains the medium value element “Intersection”. This element is from the type “Sationcomponent” enounced in the library “T_Mechatronik_Architektur”. The Intersection element will be the only modular element of the Road project.
In figure below one “Intersection” has in the “Komponenten” section one “TrafficLight”. This is the way to define compositions..


Intersection

Stationcomponent
Intersection

- Attribute
- Schnittstellen
- Parameter
- Komponenten
- Methoden
- Notizen
- UI-Konfiguration

Komponenten

- Trafficlight
- M8_Enumeration_of_Intersections
- M8_Body_of_Intersections

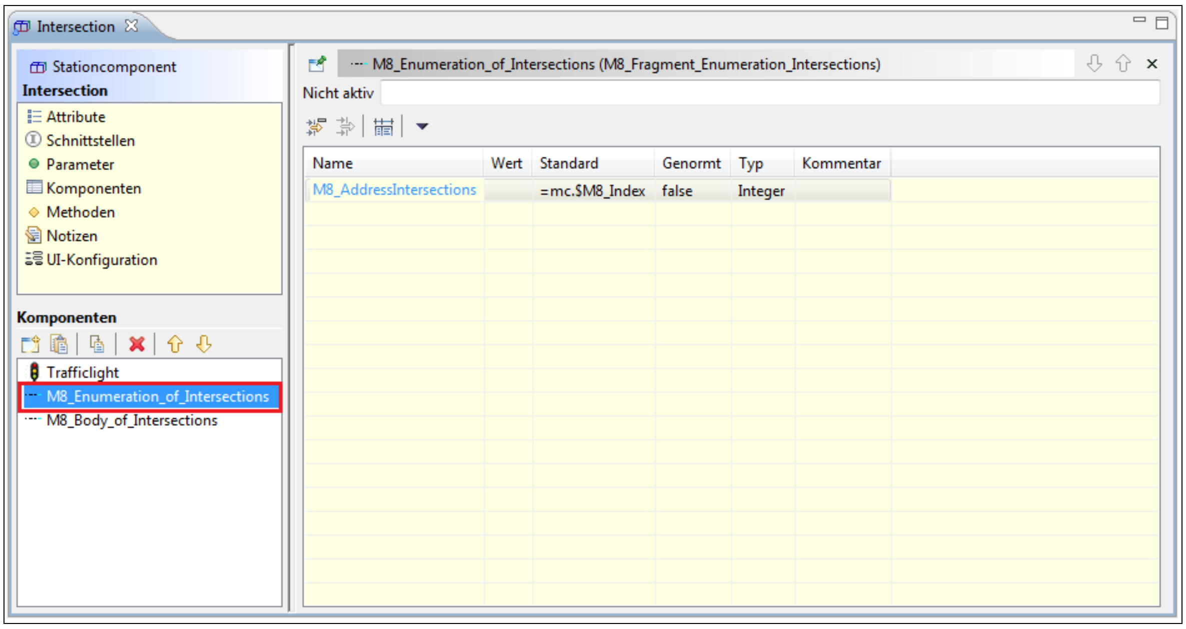
Attribute

Unit	T_Mechatronik_Construction.Mechatronik.Stationcomponents
Name	Intersection
Kategorien	Zuweisen...
Bild	
Oberklasse	Stationcomponent
Abstrakt	☐

Kommentar

Figure 106 – T_Mechatronik_Construction Intersection

In the next figure it is sign now the “M8_Enumeration_of_Intersecions”. This fragment is responsible for input the variables of one intersection. This fragment has just one parameter “M8_AddressIntersection” and is responsible to give the index for each intersection. The formula to calculate this index is programed in Standard column “m8_AddressIntersections = mc.$M8_Index”. “M8_Index” is an index that represents the number of intersections of a Road. “mc” means mechatronic components (mechatronic father of this component) and the all formula means that for one Intersection the project have one “M8_AddressIntersections”. The project has as many “M8_AddressIntersections” parameters as Intersections it has.



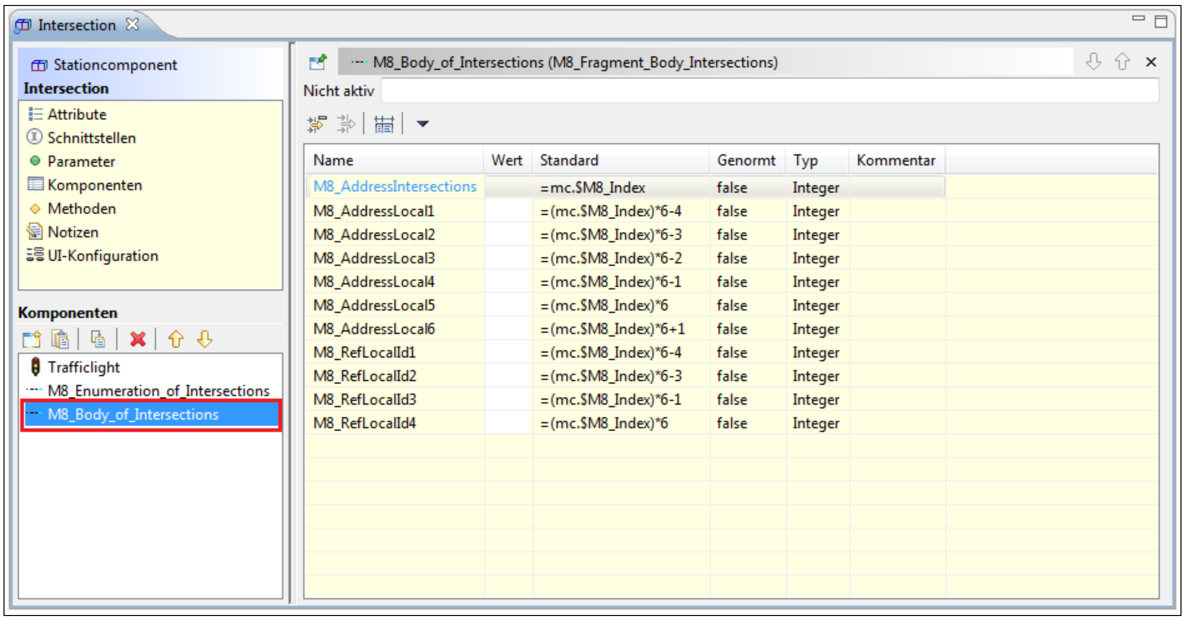
M8_Enumeration_of_Intersections (M8_Fragment_Enumeration_Intersections)

Nicht aktiv

Name	Wert	Standard	Genormt	Typ	Kommentar
M8_AddressIntersections		=mc.$M8_Index	false	Integer	

Figure 107 – T_Mechatronik_Construction Intersection

The object intersection also has another fragment called “M8_Body_of_Intersection”. In the next figure it is possible to see the several parameters of this fragment. They are responsible for all the addresses of the text. These addresses are not constants and that’s the reason we have to use formulas, depending on the number of intersections the indexes of these addresses will change according the formulas presents in parameters.



M8_Body_of_Intersections (M8_Fragment_Body_Intersections)

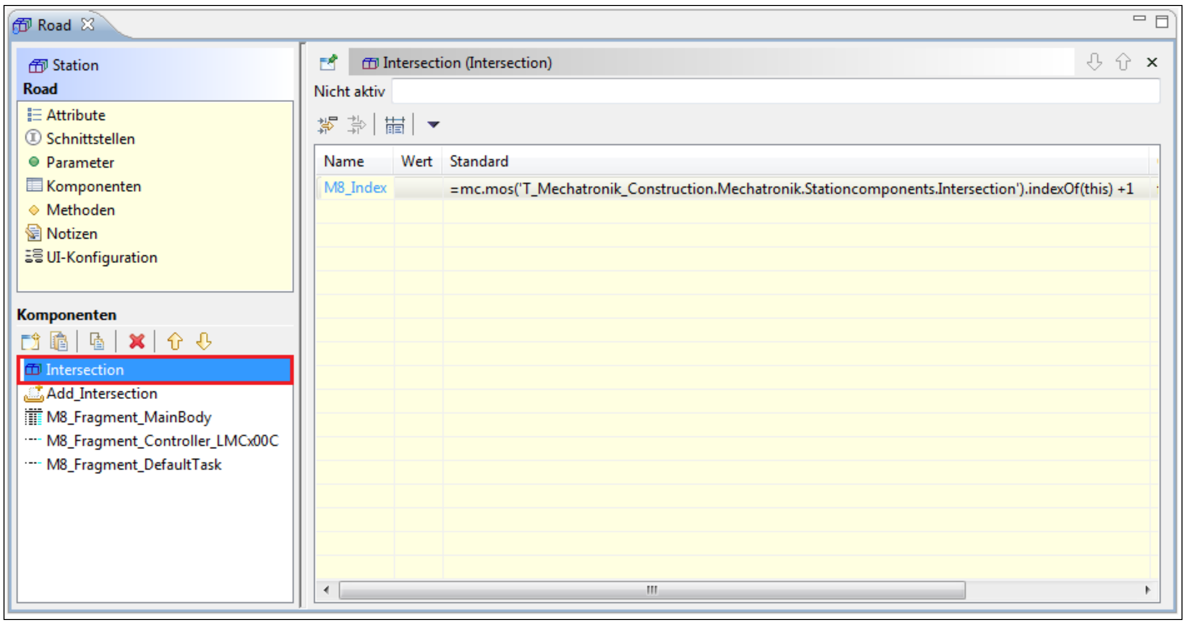
Nicht aktiv

Name	Wert	Standard	Genormt	Typ	Kommentar
M8_AddressIntersections		=mc.$M8_Index	false	Integer	
M8_AddressLocal1		=(mc.$M8_Index)*6-4	false	Integer	
M8_AddressLocal2		=(mc.$M8_Index)*6-3	false	Integer	
M8_AddressLocal3		=(mc.$M8_Index)*6-2	false	Integer	
M8_AddressLocal4		=(mc.$M8_Index)*6-1	false	Integer	
M8_AddressLocal5		=(mc.$M8_Index)*6	false	Integer	
M8_AddressLocal6		=(mc.$M8_Index)*6+1	false	Integer	
M8_RefLocalId1		=(mc.$M8_Index)*6-4	false	Integer	
M8_RefLocalId2		=(mc.$M8_Index)*6-3	false	Integer	
M8_RefLocalId3		=(mc.$M8_Index)*6-1	false	Integer	
M8_RefLocalId4		=(mc.$M8_Index)*6	false	Integer	

Figure 108 – T_Mechatronik_Construction Intersection

Station folder:

This folder contains the main project “Road”. This element is from the type “Station” enounced in the library “T_Mechatronik_Architektur”.


Road

Station
Road

- Attribute
- Schnittstellen
- Parameter
- Komponenten
- Methoden
- Notizen
- UI-Konfiguration

Komponenten

- Intersection
- Add_Intersection
- M8_Fragment_MainBody
- M8_Fragment_Controller_LMCx00C
- M8_Fragment_DefaultTask

Intersection (Intersection)

Nicht aktiv

Name	Wert	Standard
M8_Index		=mc.mos('T_Mechatronik_Construction.Mechatronik.Stationcomponents.Intersection').indexOf(this) +1

Figure 109 – T_Mechatronik_Construction Road

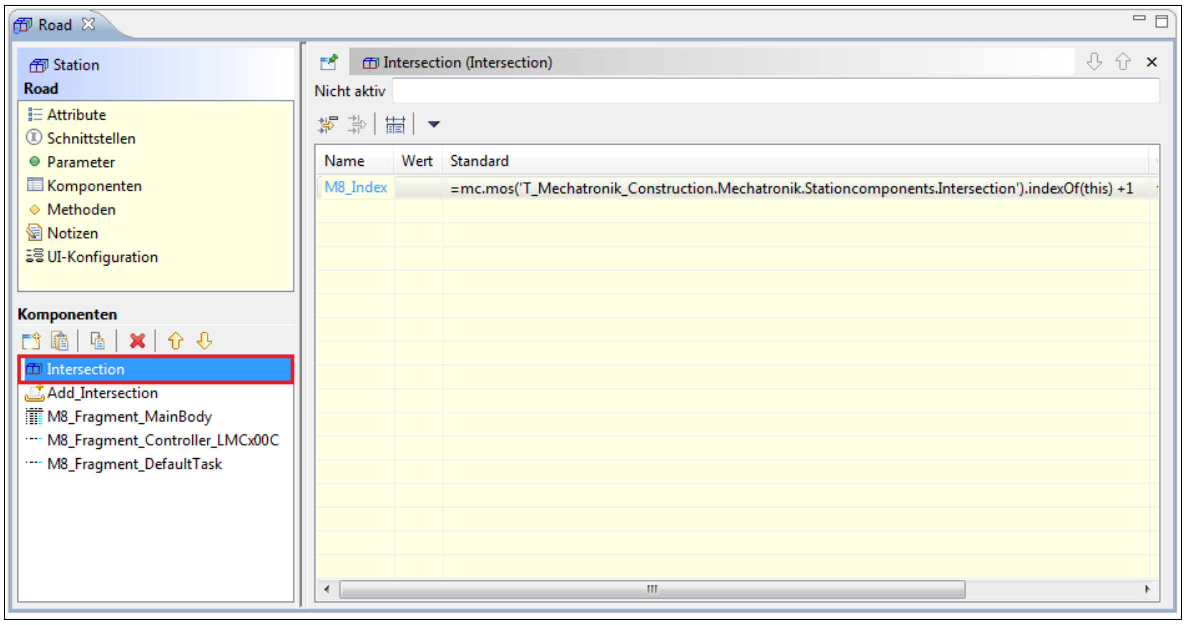
Inside the project Road we have as components:

- Intersection;
- Add_Intersection;
- M8_Fragment_MainBody;
- M8_Fragment_Controller_LMCx00C;
- M8_Fragment_DefaultTask.

Intersection:

The picture below shows the Intersection parameters. The formula means that it will exist many "M8_Index" as many intersections the user add to the main Road project.
The name "mc" means mechatronic father object and "mos" means mechatronic child objects

"M8_Index =mc.mos('T_Mechatronik_Construction.Mechatronik.Stationcomponents.Intersection').indexOf(this) +1"

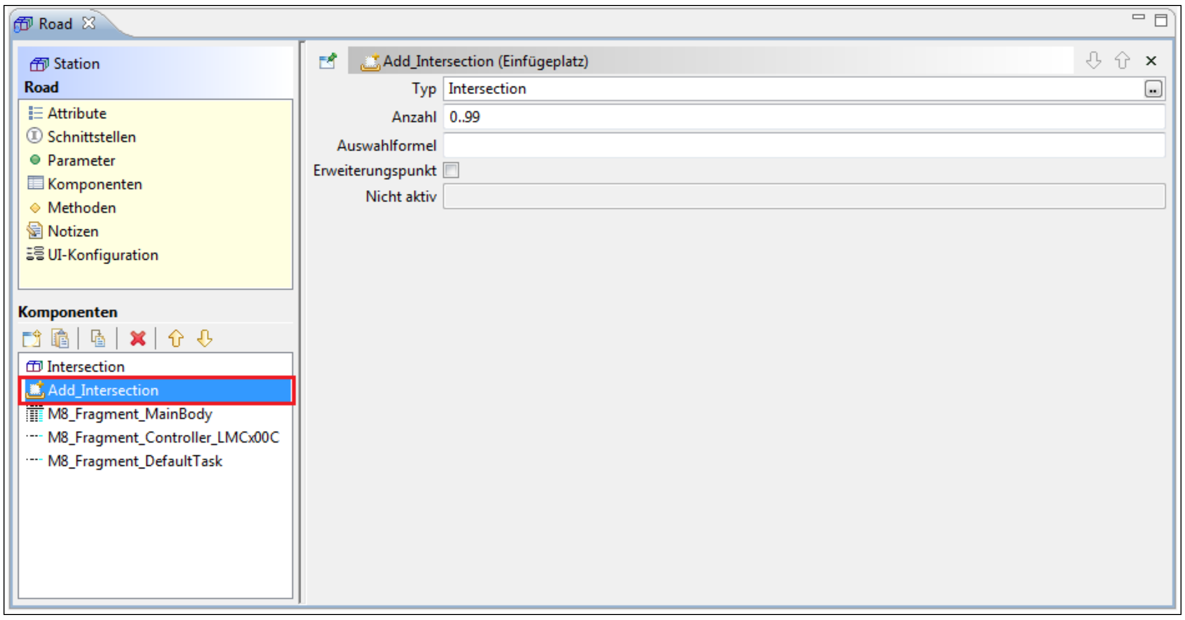


Name	Wert	Standard
M8_Index		=mc.mos('T_Mechatronik_Construction.Mechatronik.Stationcomponents.Intersection').indexOf(this) +1

Figure 110 – T_Mechatronik_Construction Road - Intersection

Add_Intersection:

This is a EEC function and means "addition points" to project. In these case is the function that turns possible the adding of intersections to the project.



Road

Station
Road
Attribute
Schnittstellen
Parameter
Komponenten
Methoden
Notizen
UI-Konfiguration

Komponenten
Intersection
Add_Intersection
M8_Fragment_MainBody
M8_Fragment_Controller_LMCx00C
M8_Fragment_DefaultTask

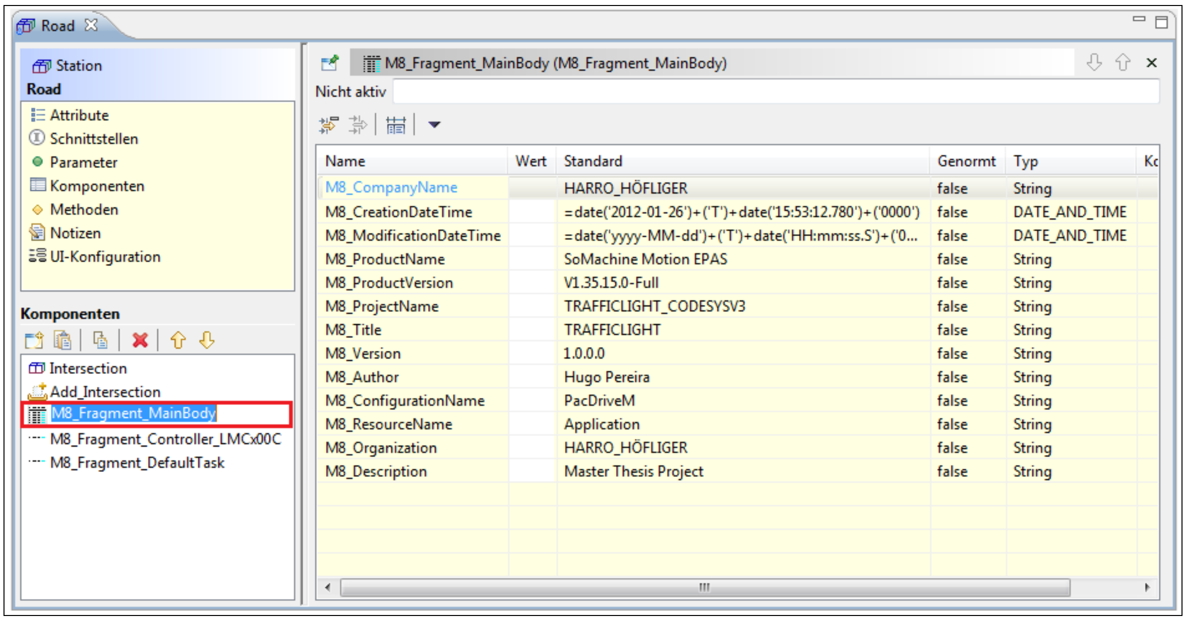
Add_Intersection (Einfügeplatz)

Typ	Intersection
Anzahl	0..99
Auswahlformel	
Erweiterungspunkt	☐
Nicht aktiv	

Figure 111 – T_Mechatronik_Construction Road – Add_Intersection

M8_Fragment_MainBody:

Including this fragment text to the Road project means that when the user generate the XML code this text will have the most of the line of code. Is inside this code that loops functions will be introduced for replacing and editing the lines of XML code.



Road

Station
Road
Attribute
Schnittstellen
Parameter
Komponenten
Methoden
Notizen
UI-Konfiguration

Komponenten
Intersection
Add_Intersection
M8_Fragment_MainBody
M8_Fragment_Controller_LMCx00C
M8_Fragment_DefaultTask

M8_Fragment_MainBody (M8_Fragment_MainBody)

Nicht aktiv

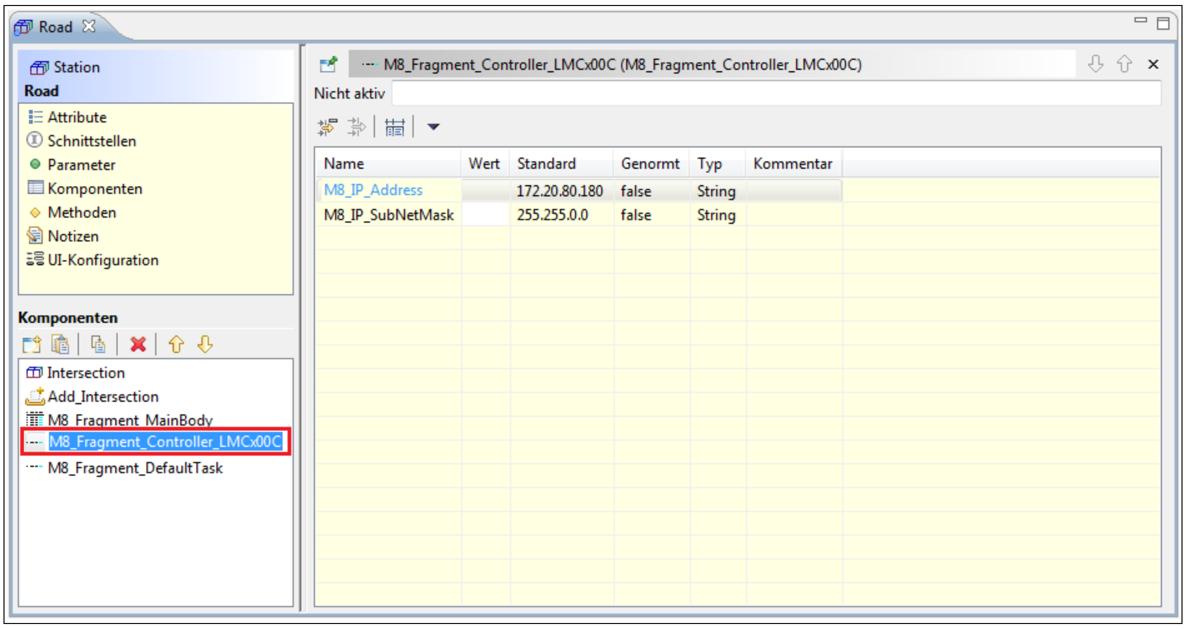
Name	Wert	Standard	Genormt	Typ	Kc
M8_CompanyName		HARRO_HÖFLIGER	false	String	
M8_CreationDateTime		=date('2012-01-26')+('T')+date('15:53:12.780')+('0000')	false	DATE_AND_TIME	
M8_ModificationDateTime		=date('yyyy-MM-dd')+('T')+date('HH:mm:ss.S')+('0...	false	DATE_AND_TIME	
M8_ProductName		SoMachine Motion EPAS	false	String	
M8_ProductVersion		V1.35.15.0-Full	false	String	
M8_ProjectName		TRAFFICLIGHT_CODESYSV3	false	String	
M8_Title		TRAFFICLIGHT	false	String	
M8_Version		1.0.0.0	false	String	
M8_Author		Hugo Pereira	false	String	
M8_ConfigurationName		PacDriveM	false	String	
M8_ResourceName		Application	false	String	
M8_Organization		HARRO_HÖFLIGER	false	String	
M8_Description		Master Thesis Project	false	String	

Figure 112 – T_Mechatronik_Construction Road - M8_Fragment_MainBody

It is possible to see in the parameters section of this fragment all variables that are presents in this element of text. In the Standard column are the initial values of these parameters. The user can change all of them.

M8_Fragment_Controller_LMCx00C:

In this parameter the user can change the code for the hardware (PLC) called devices. If the user has a several numbers of PLC XML Fragments he can choose in an appropriate form which PLC he will use in the project. In this case the used device was which is the most common in ELAU projects.

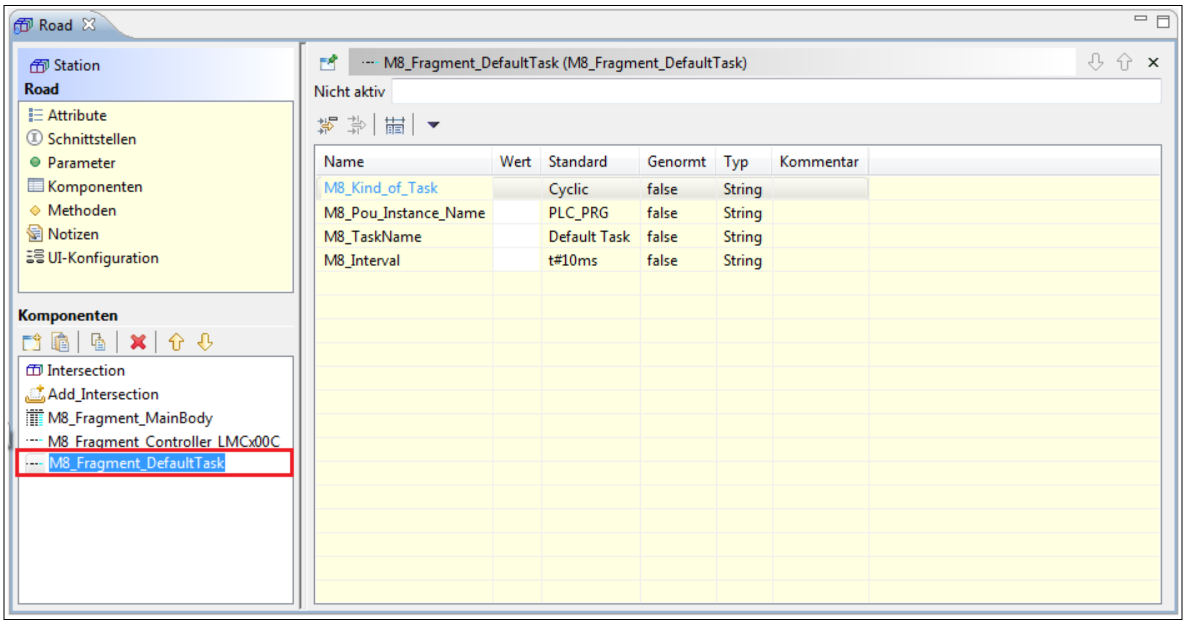


Name	Wert	Standard	Genormt	Typ	Kommentar
M8_IP_Address		172.20.80.180	false	String	
M8_IP_SubNetMask		255.255.0.0	false	String	

Figure 113 – T_Mechatronik_Construction Road - M8_Fragment_Controller_LMCx00C

M8_Fragment_DefaultTask:

This fragment of text will replace or create tasks in the project. There are four possible variables in this fragment. The user can have many tasks saved and he can use the most appropriate one.


Road

Station
Road
- Attribute
- Schnittstellen
- Parameter
- Komponenten
- Methoden
- Notizen
- UI-Konfiguration

Komponenten
- Intersection
- Add_Intersection
- M8_Fragment_MainBody
- M8_Fragment_Controller_LMCx00C
- M8_Fragment_DefaultTask

M8_Fragment_DefaultTask (M8_Fragment_DefaultTask)

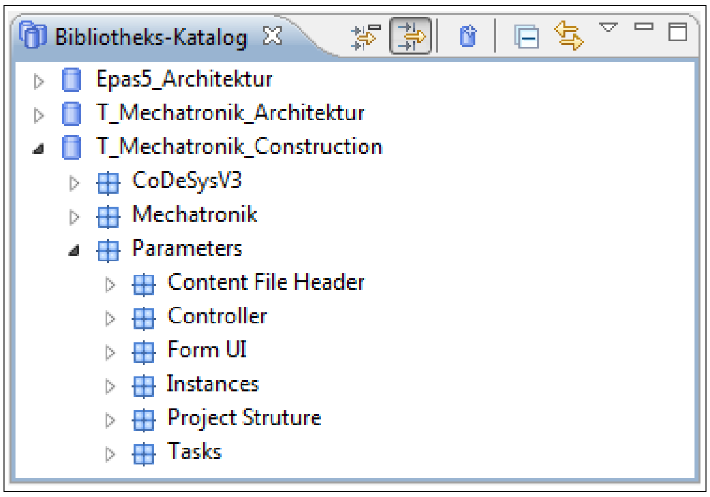
Nicht aktiv

Name	Wert	Standard	Genormt	Typ	Kommentar
M8_Kind_of_Task		Cyclic	false	String	
M8_Pou_Instance_Name		PLC_PRG	false	String	
M8_TaskName		Default Task	false	String	
M8_Interval		t#10ms	false	String	

Figure 114 – T_Mechatronik_Construction Road - M8_Fragment_DefaultTask

<u>Parameters Folder:</u>

All parameters will be saved in parameters folder. This folder has six subfolders for better organize the elements. Each subfolder contains the parameter of that specific fragment.

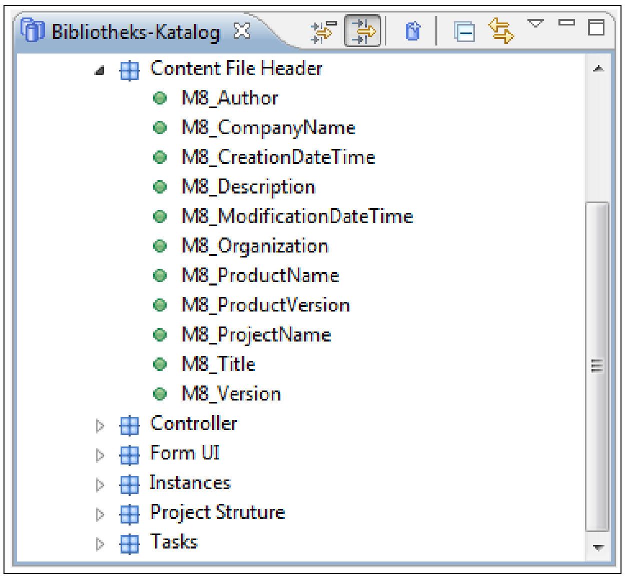

Bibliotheks-Katalog

- Epas5_Architektur
- T_Mechatronik_Architektur
- T_Mechatronik_Construction
  - CoDeSysV3
  - Mechatronik
  - Parameters
    - Content File Header
    - Controller
    - Form UI
    - Instances
    - Project Struture
    - Tasks

Figure 115 – T_Mechatronik_Construction Parameters tree view

Content File Header folder:

This folder contains the parameters of the XML “Content Header” and “File Header”. All of them are informative parameters.


Bibliotheks-Katalog
Content File Header
- M8_Author
- M8_CompanyName
- M8_CreationDateTime
- M8_Description
- M8_ModificationDateTime
- M8_Organization
- M8_ProductName
- M8_ProductVersion
- M8_ProjectName
- M8_Title
- M8_Version

Controller
Form UI
Instances
Project Struture
Tasks

Figure 116 – Parameters Content File Header tree view

Controller and Form UI folder:

In the figure below the parameters in folder “Controller” and “Form UI” are showed. “Controller” contains the parameters for the device. “Form UI” contains some parameters only for organize the form user friendly and those variables don´t have anything to do with the really project.

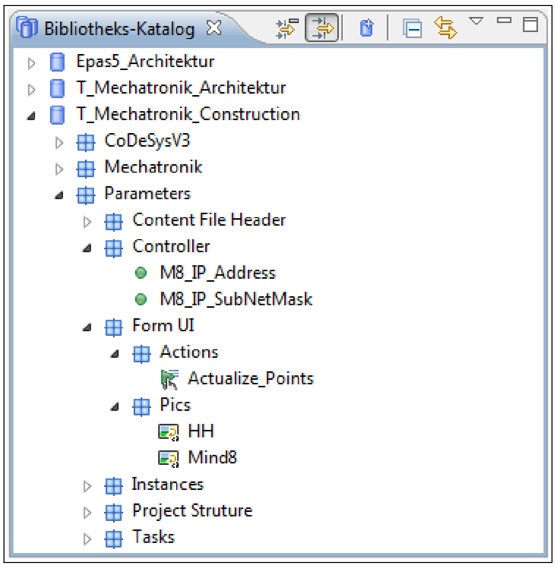

Bibliotheks-Katalog
Epas5_Architektur
T_Mechatronik_Architektur
T_Mechatronik_Construction
CoDeSysV3
Mechatronik
Parameters
Content File Header
Controller
M8_IP_Address
M8_IP_SubNetMask
Form UI
Actions
Actualize_Points
Pics
HH
Mind8
Instances
Project Struture
Tasks

Figure 117 – Parameters Controller and Form UI tree view

Instances folder:

Variables configuration name and resource name can be change also by the user and they are saved under the subfolder “instances”.

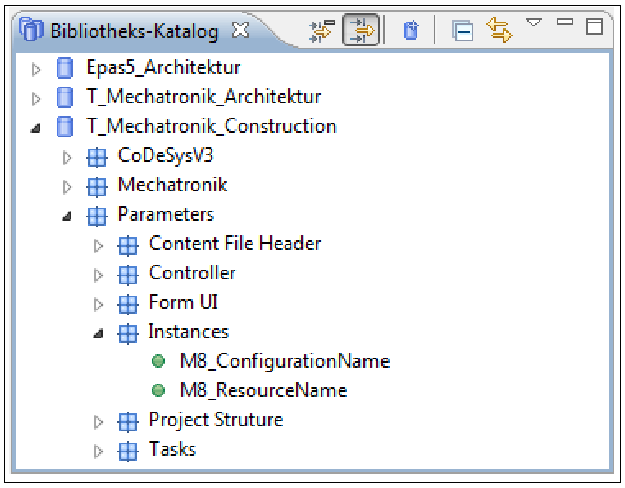


Figure 118 – Parameters Instances tree view

Project Structure folder:

All project structure variables are under this folder. They are specially indexes variables for coordinates of blocks for function blocks diagrams.

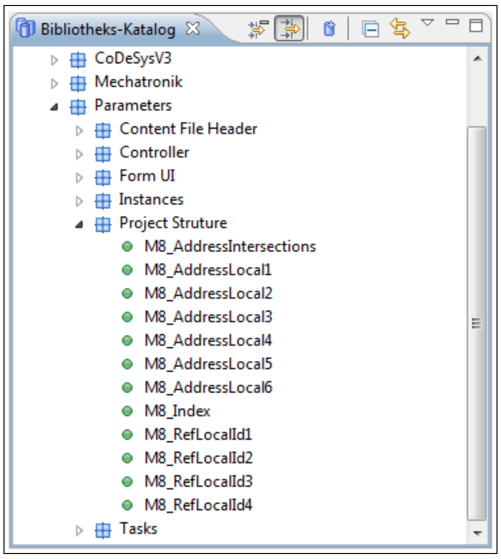
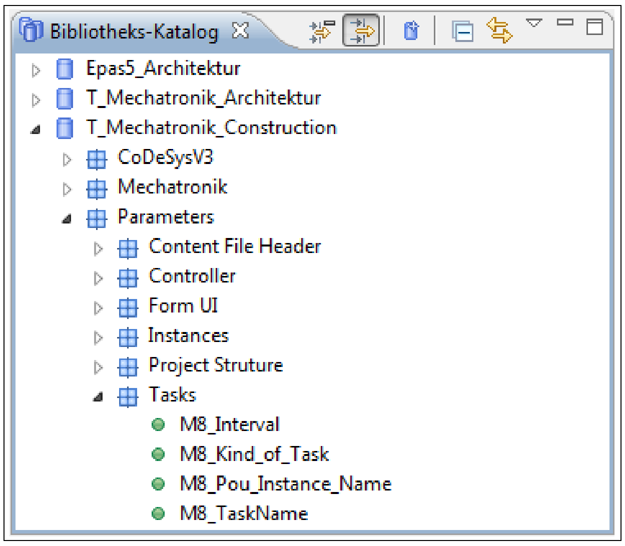


Figure 119 – Parameters Project Structure tree view

Tasks folder:

The folder “Tasks” contains the four variables that user can change in project tasks.

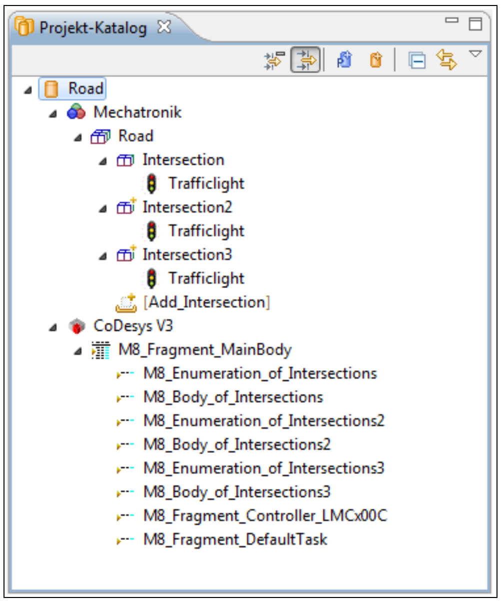

Bibliotheks-Katalog

- Epas5_Architektur
- T_Mechatronik_Architektur
- T_Mechatronik_Construction
  - CoDeSysV3
  - Mechatronik
  - Parameters
    - Content File Header
    - Controller
    - Form UI
    - Instances
    - Project Struture
    - Tasks
      - M8_Interval
      - M8_Kind_of_Task
      - M8_Pou_Instance_Name
      - M8_TaskName

Figure 120 – Parameters Tasks tree view

5.4 Road Project Construction

Under the Project Katalog window the project will be constructing and in the end is possible to have a structure like the figure below.


Projekt-Katalog

- Road
  - Mechatronik
    - Road
      - Intersection
        - Trafficlight
      - Intersection2
        - Trafficlight
      - Intersection3
        - Trafficlight
      - [Add_Intersection]
  - CoDesys V3
    - M8_Fragment_MainBody
      - M8_Enumeration_of_Intersections
      - M8_Body_of_Intersections
      - M8_Enumeration_of_Intersections2
      - M8_Body_of_Intersections2
      - M8_Enumeration_of_Intersections3
      - M8_Body_of_Intersections3
      - M8_Fragment_Controller_LMCx00C
      - M8_Fragment_DefaultTask

Figure 121 – Project tree view

The main project is called Road and it has a mechatronik folder with the Road "machine". A Road contains in this case three intersections and each intersection one traffic light set. The user has also the possibility for adding more intersections to the project. Users have also the folder for the XML code created with text discipline library. It can be seen in the figure 121 "M8_Fragment_MainBody" as the father of all others fragments. In this project there are three intersections so the project will have three "M8_Enumeration_of_Intersections" and also three "M8_Body_of_Intersection". To generate the XML code just choose "Generate Structure and open file" in Mechatronik and all the code will be processed.

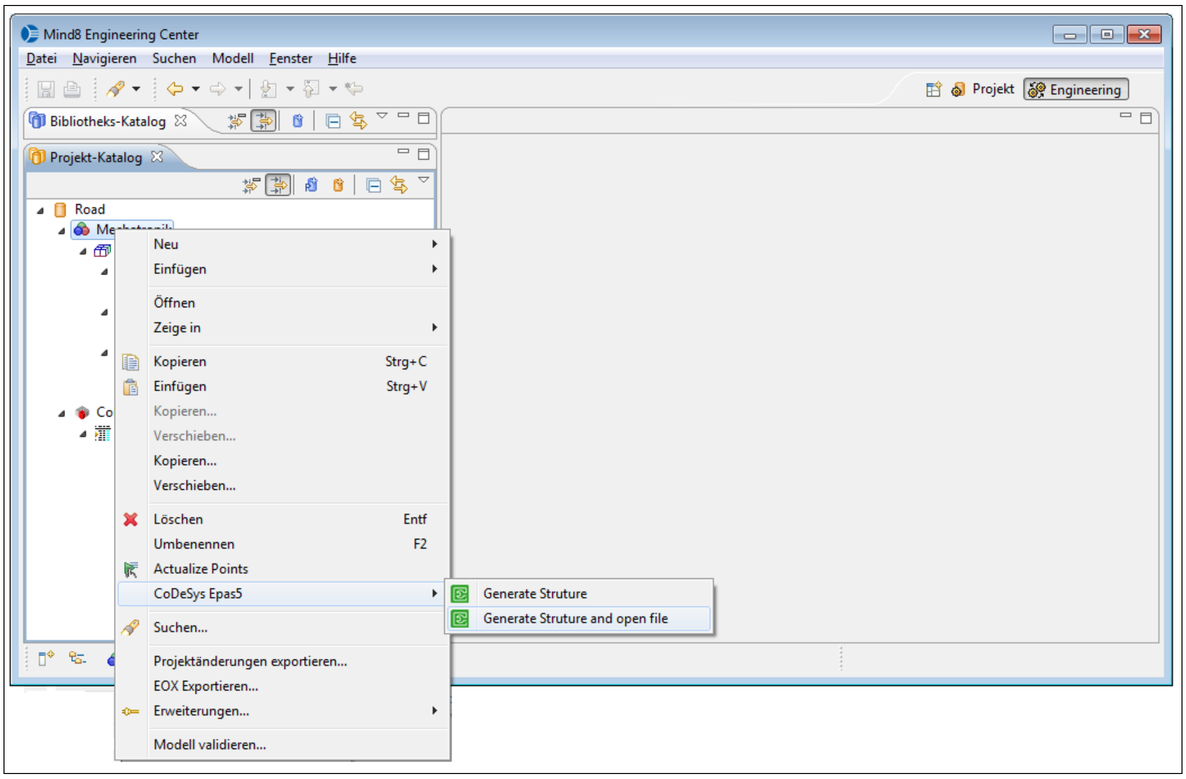
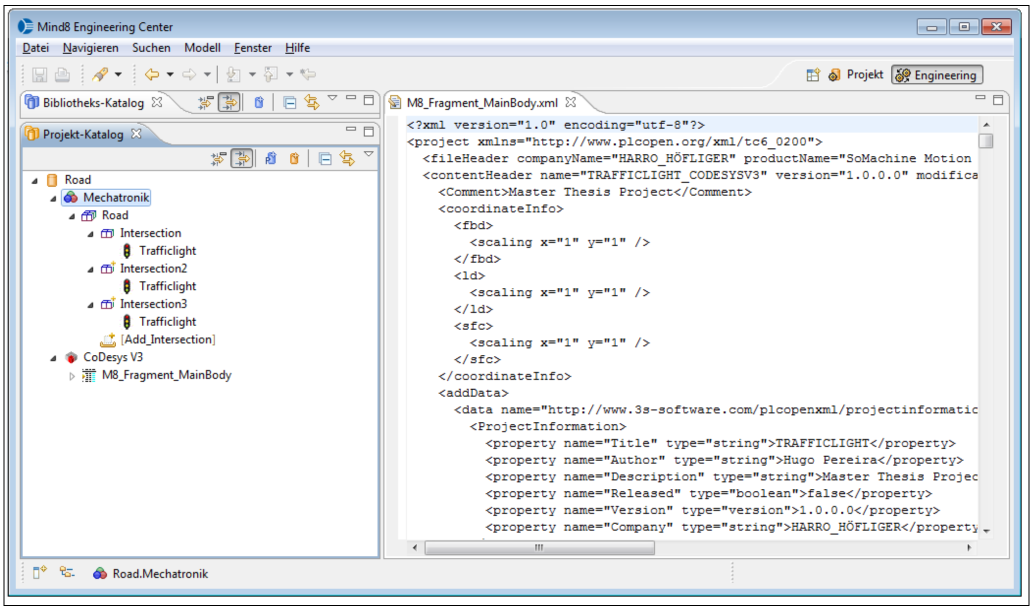


Figure 122 – Generate XML code



```
<?xml version="1.0" encoding="utf-8"?>
<project xmlns="http://www.plcopen.org/xml/tc6_0200">
  <fileHeader companyName="HARRO_HÖFLIGER" productName="SoMachine Motion
  <contentHeader name="TRAFFICLIGHT_CODESYSV3" version="1.0.0.0" modifica
    <Comment>Master Thesis Project</Comment>
    <coordinateInfo>
      <fbd>
        <scaling x="1" y="1" />
      </fbd>
      <ld>
        <scaling x="1" y="1" />
      </ld>
      <sfc>
        <scaling x="1" y="1" />
      </sfc>
    </coordinateInfo>
    <addData>
      <data name="http://www.3s-software.com/plcopenxml/projectinformatic
        <ProjectInformation>
          <property name="Title" type="string">TRAFFICLIGHT</property>
          <property name="Author" type="string">Hugo Pereira</property>
          <property name="Description" type="string">Master Thesis Projec
          <property name="Released" type="boolean">false</property>
          <property name="Version" type="version">1.0.0.0</property>
          <property name="Company" type="string">HARRO_HÖFLIGER</property
```

Figure 123 – Generate XML code

After few moments the code appears in the window and it's ready for testing in PLC. For appropriate test the output code of EEC the Epas-5 software is open and then one new project is create and "Import PLCopenXML". Then, the entire project will be constructing with all the structure that we have defined in the project design.

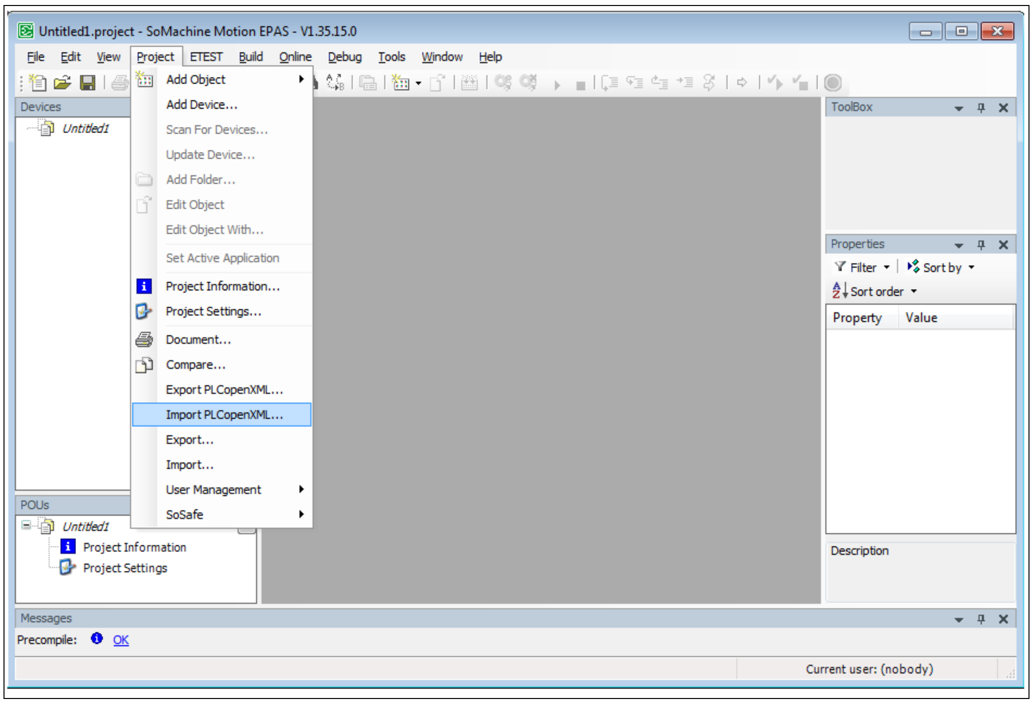
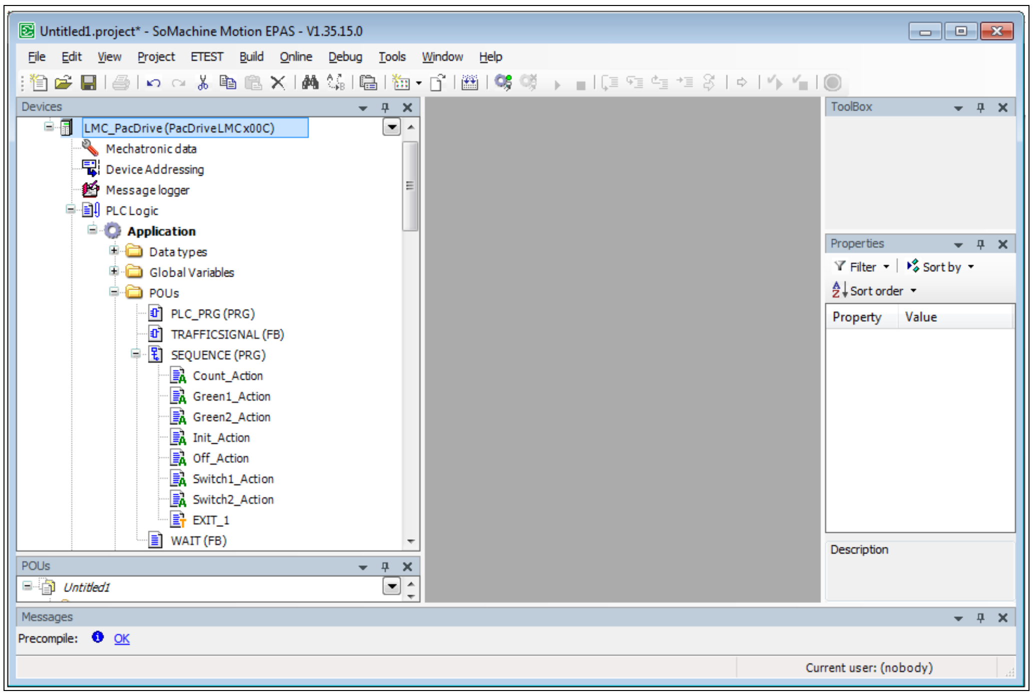


Figure 124 – Epas-5 Import PLCopenXML

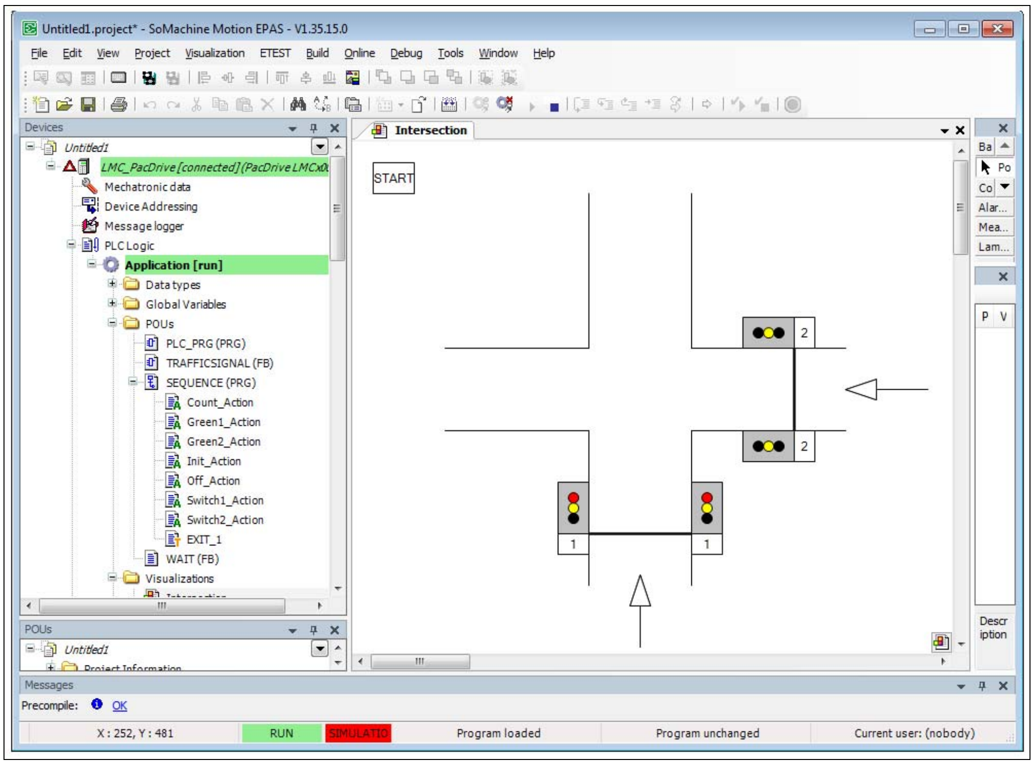


Precompile: OK

Current user: (nobody)

Figure 125 – Epas-5 Project Structure

Now it´s possible trying the program with the simulate tool of Epas-5 and everything works fine like planned.

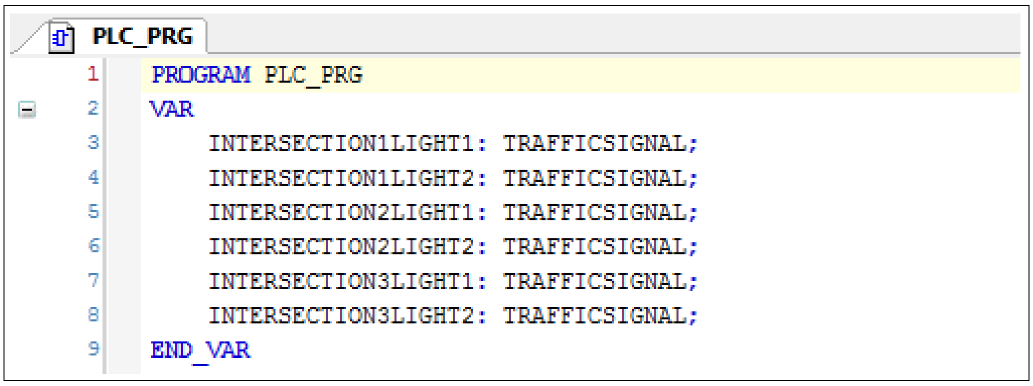


Precompile: OK

X : 252, Y : 481 | RUN | SIMULATIO | Program loaded | Program unchanged | Current user: (nobody)

Figure 126 – Epas-5 Project running

In this project it was projected a Road with three Intersecions. After open the project in Epas-5 tool it is possible to check the POU PLC_PRG which contains all the Intersections of the Road and see if they really exists three Intersections.



```
PROGRAM PLC_PRG
VAR
    INTERSECTION1LIGHT1: TRAFFICSIGNAL;
    INTERSECTION1LIGHT2: TRAFFICSIGNAL;
    INTERSECTION2LIGHT1: TRAFFICSIGNAL;
    INTERSECTION2LIGHT2: TRAFFICSIGNAL;
    INTERSECTION3LIGHT1: TRAFFICSIGNAL;
    INTERSECTION3LIGHT2: TRAFFICSIGNAL;
END_VAR
```

Figure 127 – Road PLC_PRG Declaration section

In the declaration part of PLC_PRG POU it is possbible see three Intersection declared. Each Intersection have two traffic Light. The label of those Epas-5 variables are like the introduced label in EEC software, on M8_Fragment_Enumeration_Intersections. The code above is based in PLCopenXML and represents one intersection. This fragment will be repeat many times, as many Intersections the project will have.

```
        <variable name="INTERSECTION#{M8_AddressIntersections}LIGHT1">
<type>
        <derived name="TRAFFICSIGNAL" />

        <variable name="INTERSECTION#{M8_AddressIntersections}LIGHT2">
<type>
        <derived name="TRAFFICSIGNAL" />
```

The next figure represents the body section of the PLC_PRG POU. It can be seen the six FDB for the three Intersections in the Road project.

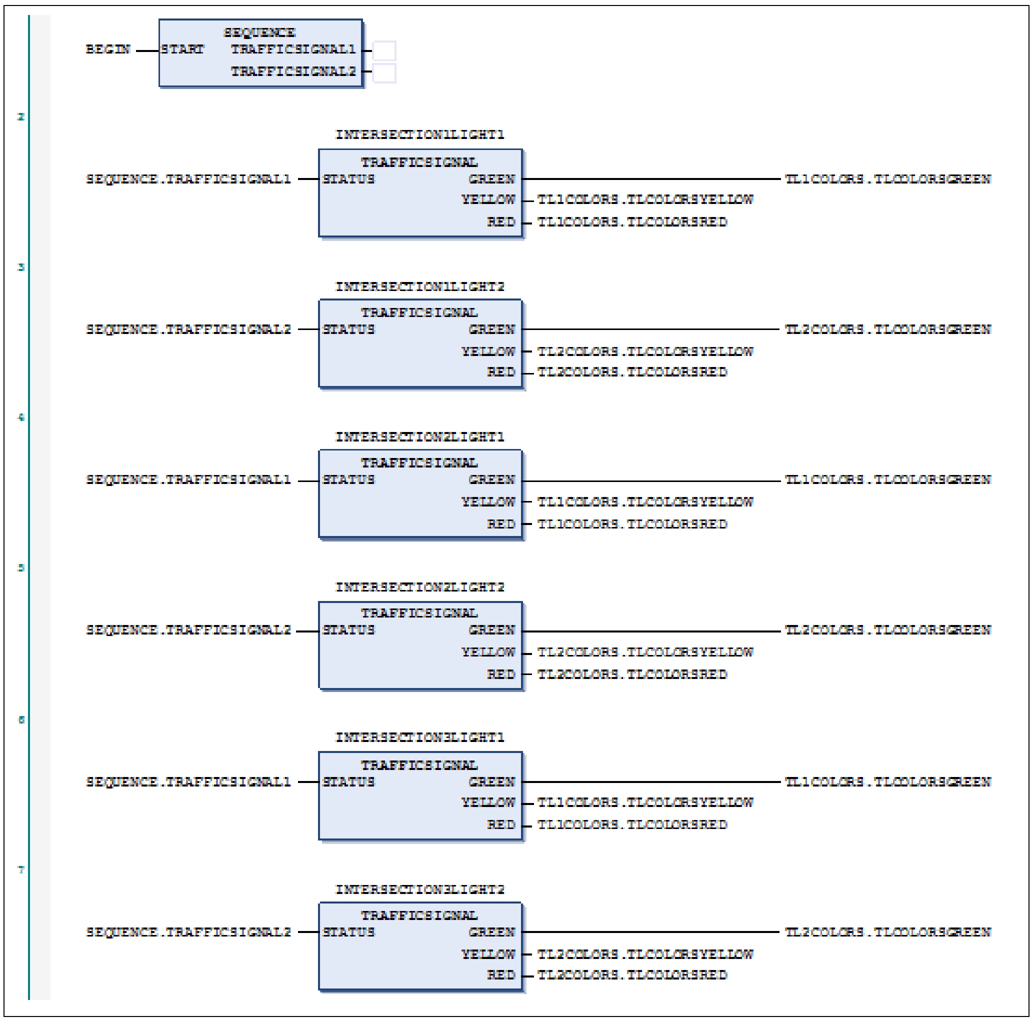


Figure 128 – Road PLC_PRG Body section

6 Summary of Results

Once completed the CoDeSys version 3 implementation work in EEC software, the program of this project has been tested several times but there was some errors in the PLCopenXML export import Epas-5 tool. To achieve and certificate if the XML code is correctly organized “Sequence” program organization unit was bypassed and manually imported because the current version of Epas-5 does not support sequential function chart language.

The program organization unit “Wait” was programmed in structure text language because instruction list language was not recognized by Epas-5. That’s another “bug” in this latest update. The mains errors found in Elau Epas-5 Export/Import PLCopen were:

- The XML scheme not update (v2.00);
- Doesn’t support IEC 61131-3 standard instruction list language;
- Doesn’t support IEC 61131-3 standard sequential function chart language;
- When interfaces and implements are introduced in the project, the PLCopenXML Import does not work.
- Problems with PLCopenXML Import/Export comments;

Although this errors, was guaranteed that the text fragment extracted from the software EEC works in general and has been proved that the implementation of CoDeSys version 3 in EEC is possible and was well successful.

The main objective of this work was to study all the requirements necessary for the introduction of the new discipline CoDeSys in EEC software. With these results the company Harro Höfliger can build a process to create control software to automate their machines, as it already does with CoDeSys version 2.

A small project in both versions of CoDeSys was built. In this project the following items were analyzed:

- Main software environment differences between the both versions of CoDeSys;
- CoDeSys version 2, Eni-Server XML format;
- CoDeSys version 3 and PLCopen XML format;
- Update Projects with CoDeSys version 3 import tool (version 2 to version 3)
- PLCopenXML Export/Import Projects;
- Analyze errors with Epas5 PLCopenXML Export/Import tool.

With this small project was also possible to develop the “Text Discipline” model to implement the new version 3 discipline in EEC software. It is possible to conclude that are many differences between two versions of XML code extracted from Elau-4 and Elau-5. These codes do not have a structure or a similar semantic which makes it impossible to reuse the blocks of all existing code in Harro Höfliger Company. Nevertheless all the code could be analyzed and imported but not directly.

When the projects are update to the latest version they can be exported with PLCopen XML and then the integration in the future EEC discipline will be possible. The migration of Harro Höfliger library projects can be made now, but should be considered that Epas-5 software is still evolving and is not now completely stabilized. This migration should be initiated with small projects so as to be easily detected some errors that may occur during the import. After this migration all projects should be tested in PLC's version 3 to ensure everything is parameterized. New projects may also be inserted in the new discipline of EEC soon as it is released by Mind8 GmbH & Co. KG.

Here some recommendations for the creation of the new library in EEC:

Initial conditions

- Software Epas-5 stable;
- CoDeSys V3 Library implement in Eplan Engineering Center;
- New server for store all new version data with a copy of Eni-Server;

Import V2 resources

- With Epas-5 import one simple project with a fragment to new version;
- PLCopenXML for generate XML code;
- Construct the structure in EEC;
- Generate code and test project in PLC for checking eventual errors;
- Organize the disk structure;
- Iniciate the migration of the data folow the steps above;

7 Future Prospects

In this document it was demonstrated that IEC 61131-3 standard is very important for nowadays automation. Besides that international standard the PLCopen standard is also crucial for standardizes machines and softwares. Summarizing it will be very good if we all talk the same automation language, and for that we must adopt definitely the two standards above.

It was demonstrated also that the implementation on EEC will be successful and very helpful for create new processes and methods. I´m very satisfied for can contribute for the development on such important automation tool.

Eplan Engineering Center is an important tool for working with high quality and fastness. These kinds of tools use one fast constructing projects and parameterizing without any “heavy” programming.

CoDeSys version 3 is important and very useful upgrade software. It brings to automation world some new enhancements that will surely make a big difference in the way you envision designs and implements automation projects.

Combining all these tools it will be possible to create a great process to develop and design automated structures. If all procedures are complied with the standards and get the maximum leverage this tool can actually be a universal tool easy to use with maximum quality and high standards.

V List of Figures

VI List of Tables

VII References

[1] International Electrotechnical Commission. IEC International Standard IEC 61131 3:2003, Programmable Controllers, Part 3: Programming Languages, 2003.

[2] XML Formats for IEC 61131-3 version 2.01, PLCopen Technical Committee 6, Technical Paper.

[3] PLCopen home-page: http://www.plcopen.org.

[4] XML, available at: http://www.w3.org/XML.

[5] E. Estévez, M. Marcos, E. Irisarri "Analysis of IEC 61131-3 Compliance through PLCopen XML Interface".

[6] Karl-Heinz John y Michael Tiegelkamp, "IEC 61131-3: Programming Industrial Automation Systems", Second edition. Springer. 2001.

[7] Edouard Tisserant, Laurent Bessard, and Mário de Sousa "An Open Source IEC 61131-3 Integrated Development Environment".

[8] IDC Technologies Industrial Programming using IEC 61131-3 for PLCs.

[9] 3S Software home page: http://www.3s-software.com.

[10] Elau, Epas version 4 and version 5 Help menu.

[11] Technical Paper PLCopen Technical Committee 6 XML Formats for IEC 61131-3 version 2.01 – Official Release.

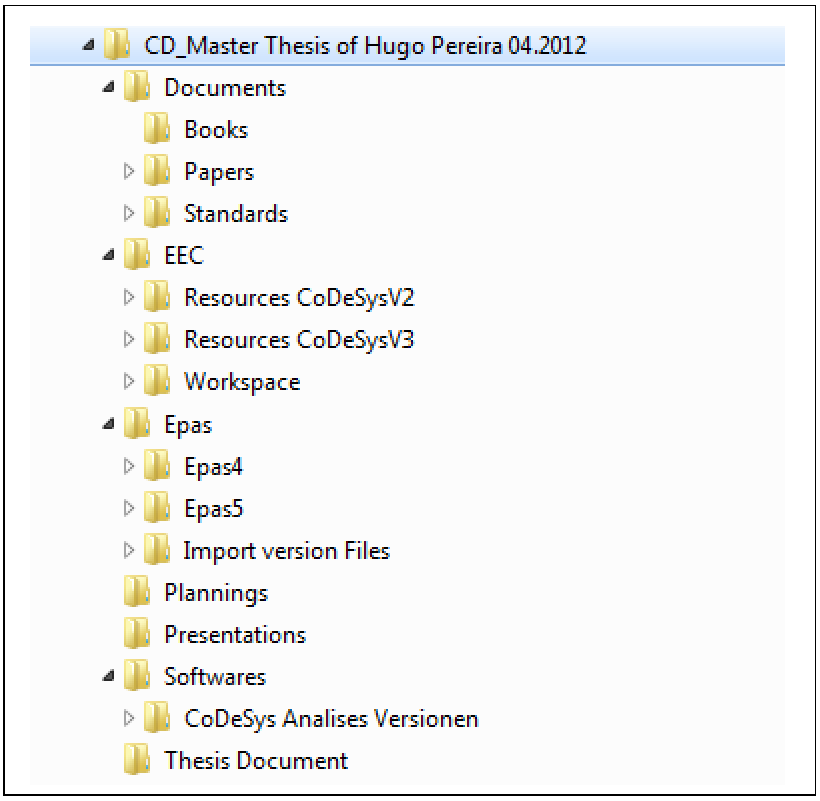
[12] Wikipedia the free encyclopedia home-page: http://en.wikipedia.org.

VIII Appendix

- **Epas-5 / PLCopen XML**

a) Analyses of Export PLCopenXML Road Project

- **Structure of the CD_Master Thesis of Hugo Pereira 04.2012**



- CD_Master Thesis of Hugo Pereira 04.2012
  - Documents
    - Books
    - Papers
    - Standards
  - EEC
    - Resources CoDeSysV2
    - Resources CoDeSysV3
    - Workspace
  - Epas
    - Epas4
    - Epas5
    - Import version Files
  - Plannings
  - Presentations
  - Softwares
    - CoDeSys Analises Versionen
  - Thesis Document

a) Analyses of Export PLCopenXML Road Project

After doing the project, must be analyzed the Export code PLCopenXML from the Road project. This analysis will be used to refer all objects that make up the XML. Then will serve for the implementation of the CoDeSys software EEC.

The most important objects in this analysis are:

- POUs;
- Interfaces;
- Actions;
- Methods;
- Properties;
- Transitions;
- Global variables;
- Data types;
- Tasks;
- Devices;
- Applications;
- Project information.

These objects may for example be easily edited, deleted or duplicated in software EEC. For this reason it is important to know the exact location of them.

1 – Header Information

```
<?xml version="1.0" encoding="utf-8"?>
<project xmlns="http://www.plcopen.org/xml/tc6_0200">
```

Epas-5 XML code (project structure)

Here we have the main project and information about the PLCopenXML version used.

2 – File Header

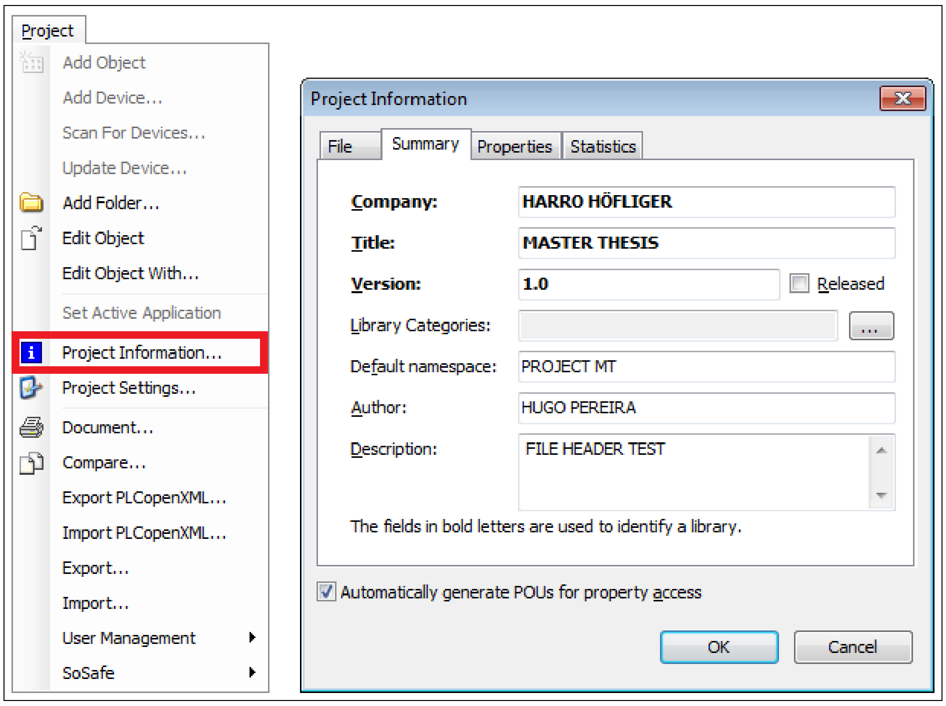
```
<fileHeader companyName="" productName="SoMachine Motion EPAS"
productVersion="V1.35.15.0-Full"
creationDateTime="2012-02-24T09:21:46.6371239" />
```

Epas-5 XML code (fileHeader structure)

Here we have the information’s about the project and the user.

3 – Content Header

Here we have the information’s about the project and the user. In Epas-5 we can change the parameters of contentHeader. We can choose the menu “Project” and then “Project Information” section Summary.



Company:	HARRO HÖFLIGER
Title:	MASTER THESIS
Version:	1.0 ☐ Released
Library Categories:	...
Default namespace:	PROJECT MT
Author:	HUGO PEREIRA
Description:	FILE HEADER TEST

The fields in bold letters are used to identify a library.

☑ Automatically generate POUs for property access

contentHeader project parameters in Epas-5

```
<contentHeader name="MASTER THESIS" version="1.0"
modificationDateTime="2012-02-06T09:39:35.6393348"
organization="HARRO HÖFLIGER" author="HUGO PEREIRA">
  <Comment>FILE HEADER TEST</Comment>
```

Epas-5 XML code (contentHeader structure)

3.1 – Coordinate Info

```
<coordinateInfo>
   <fbd>
     <scaling x="1" y="1" />
   </fbd>
   <ld>
     <scaling x="1" y="1" />
   </ld>
   <sfc>
     <scaling x="1" y="1" />
   </sfc>
 </coordinateInfo>
```

Epas-5 XML code (coordinateInfo)

The element “coordinateInfo” contains the information for the mapping of the coordinate system

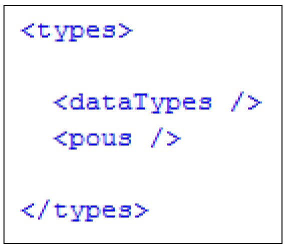
3.2 – Add Data

For the project and certain objects in the XML file the vendor can include additional data.

```
<addData>
  <data name="http://www.3s-software.com/plcopenxml/projectinformation
  handleUnknown="implementation">
    <ProjectInformation>
      <property name="Author" type="string">HUGO PEREIRA
      </property>
      <property name="Title" type="string">MASTER THESIS
      </property>
      <property name="DefaultNamespace" type="string">PROJECT MT
      </property>
      <property name="Version" type="version">1.0
      </property>
      <property name="Project" type="string">TL_Epas5_V1.35.15.00_Method
      </property>
      <property name="Description" type="string">FILE HEADER TEST
      </property>
      <property name="Company" type="string">HARRO HÖFLIGER
      </property>
    </ProjectInformation>
  </data>
</addData>
```

Epas-5 XML code (addData)

4 – Types

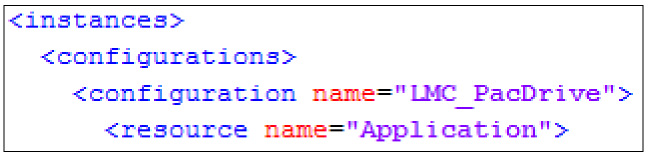


```
<types>

  <dataTypes />
  <pous />

</types>
```

Epas-5 XML code (dataTypes/ dataType structure)

5 – Instances

5.1 – configurations / configuration / resource



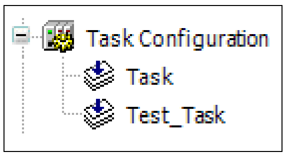
```
<instances>
  <configurations>
    <configuration name="LMC_PacDrive">
      <resource name="Application">
```

Epas-5 XML code (instances)

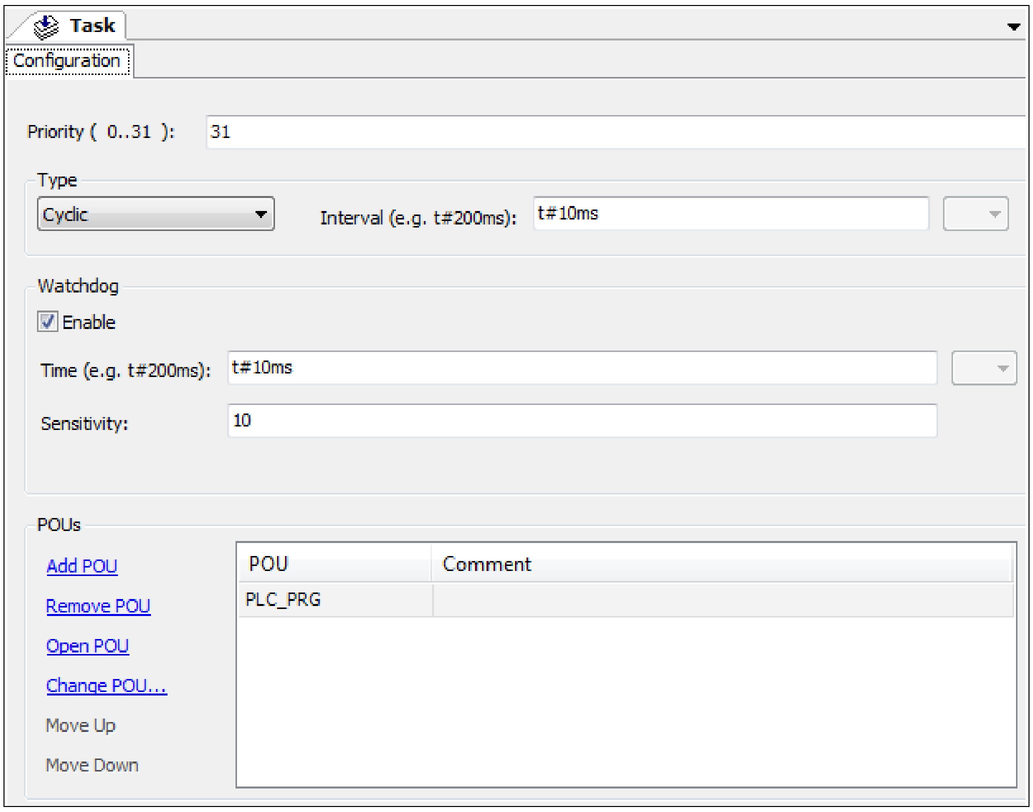
5.1.2 – Tasks

Tasks control the execution of a set of programs and/or function blocks. These can either be executed periodically or upon the occurrence of a specified trigger, such as the change of a variable:

In next figure we have the tasks tree view of EPAS-5 Intersection project. This project has two tasks, “Task” and “Test_Task”. The first one is the main task of project and “Test_Task” is only for testing the XML output.



Epas-5 Tree view project



Priority (0..31): 31

Type

Cyclic

Interval (e.g. t#200ms): t#10ms

Watchdog

☑ Enable

Time (e.g. t#200ms): t#10ms

Sensitivity: 10

POUs

POU	Comment
PLC_PRG	

Epas-5 “Task” configuration form

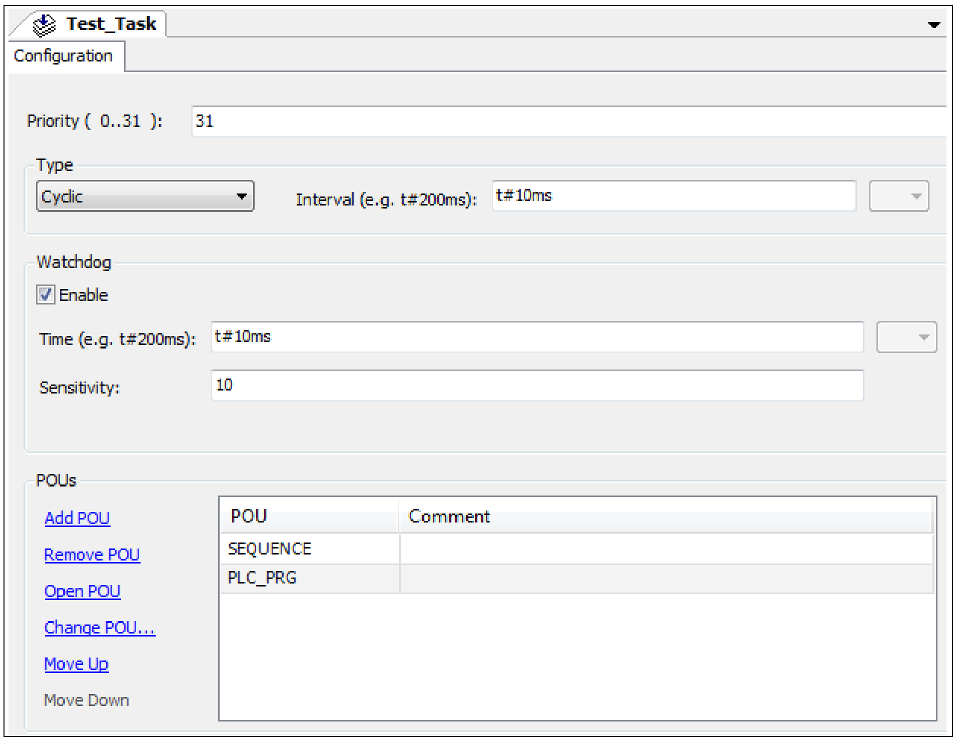
```xml
<task name="Task" interval="PT0.01S" priority="31">
  <pouInstance name="PLC_PRG" typeName="">
    <documentation>
      <xhtml xmlns="http://www.w3.org/1999/xhtml" />
    </documentation>
  </pouInstance>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/tasksettings"
    handleUnknown="implementation">
      <TaskSettings KindOfTask="Cyclic" Interval="t#10ms" IntervalUnit="ms"
      WithinSPSTimeSlicing="true">
        <Watchdog Enabled="true" Time="PT0.01S" Sensitivity="10" />
      </TaskSettings>
    </data>
  </addData>
</task>
```

Epas-5 XML code (Task XML output)

Inside a task can be defined:

- POUs for execute;
- Priority;
- Type of Task, Interval and Interval unit;
- Enable/disable Watchdog, Time and Sensitivity;

If user look closely the form of the task and its xml code we can conclude that we can fully configure a task just by changing the xml code. Thus with the implementation in software EEC can create and edit tasks in a project.



Test_Task

Configuration

Priority (0..31): 31

Type

Cyclic

Interval (e.g. t#200ms): t#10ms

Watchdog

[✓] Enable

Time (e.g. t#200ms): t#10ms

Sensitivity: 10

POUs

Add POU

Remove POU

Open POU

Change POU...

Move Up

Move Down

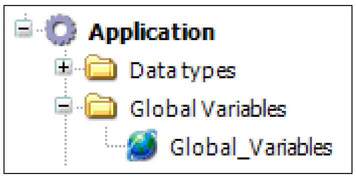
POU	Comment
SEQUENCE	
PLC_PRG	

Epas-5 “Test_Task” configuration form

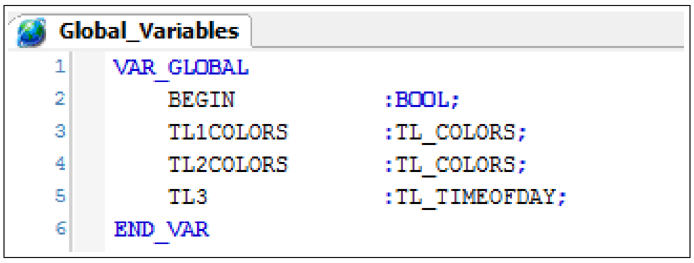
```
<task name="Test_Task" interval="PT0.01S" priority="31">
  <pouInstance name="SEQUENCE" typeName="">
    <documentation>
      <xhtml xmlns="http://www.w3.org/1999/xhtml" />
    </documentation>
  </pouInstance>
  <pouInstance name="PLC_PRG" typeName="">
    <documentation>
      <xhtml xmlns="http://www.w3.org/1999/xhtml" />
    </documentation>
  </pouInstance>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/tasksettings"
    handleUnknown="implementation">
      <TaskSettings KindOfTask="Cyclic" Interval="t#10ms" IntervalUnit="ms"
      WithinSPSTimeSlicing="true">
        <Watchdog Enabled="true" Time="PT0.01S" Sensitivity="10" />
      </TaskSettings>
    </data>
  </addData>
</task>
```

Epas-5 XML code (Test_Task XML output)

5.1.3 – Global Variables



Epas-5 Tree view project (Global variables)

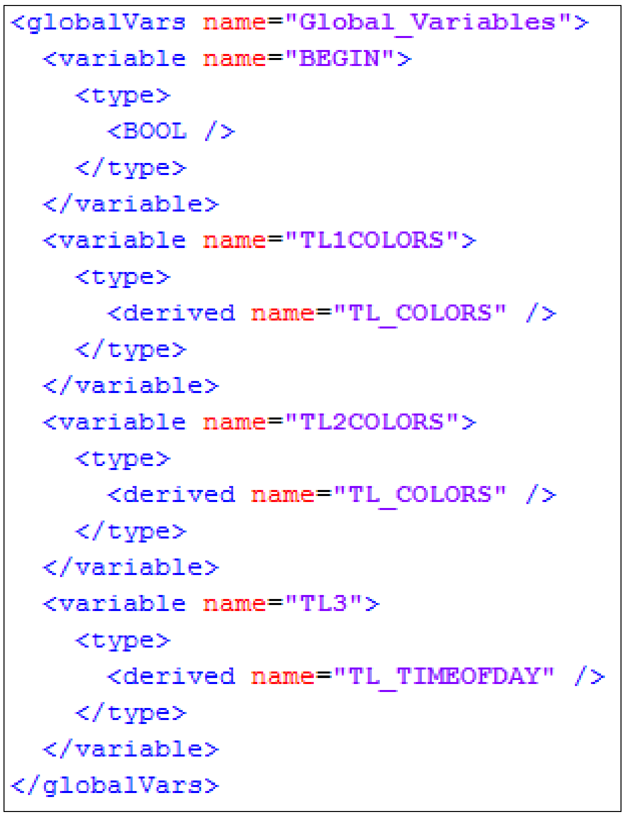


Global_Variables

```
VAR_GLOBAL
    BEGIN           :BOOL;
    TL1COLORS       :TL_COLORS;
    TL2COLORS       :TL_COLORS;
    TL3             :TL_TIMEOFDAY;
END_VAR
```

Epas-5 Global variables declaration

In these variables we have three derived variables data type and one generic data type variable.



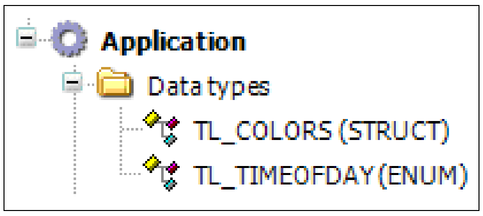
```xml
<globalVars name="Global_Variables">
  <variable name="BEGIN">
    <type>
      <BOOL />
    </type>
  </variable>
  <variable name="TL1COLORS">
    <type>
      <derived name="TL_COLORS" />
    </type>
  </variable>
  <variable name="TL2COLORS">
    <type>
      <derived name="TL_COLORS" />
    </type>
  </variable>
  <variable name="TL3">
    <type>
      <derived name="TL_TIMEOFDAY" />
    </type>
  </variable>
</globalVars>
```

Epas-5 XML code (Global variables XML output)

Like the Task configuration we can fully configure global variables just by just changing the xml code. Thus with the implementation in software Mind8 can create and edit global variables in a project.

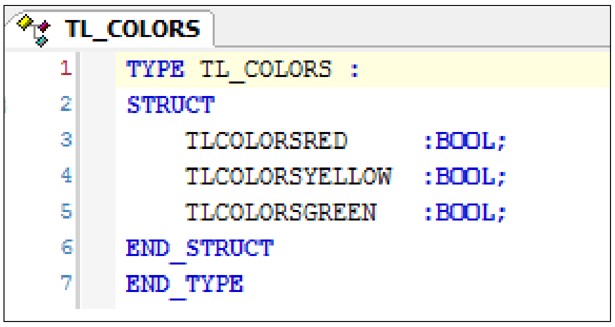
5.1.4 – Add Data

5.1.4.1 – Data Types



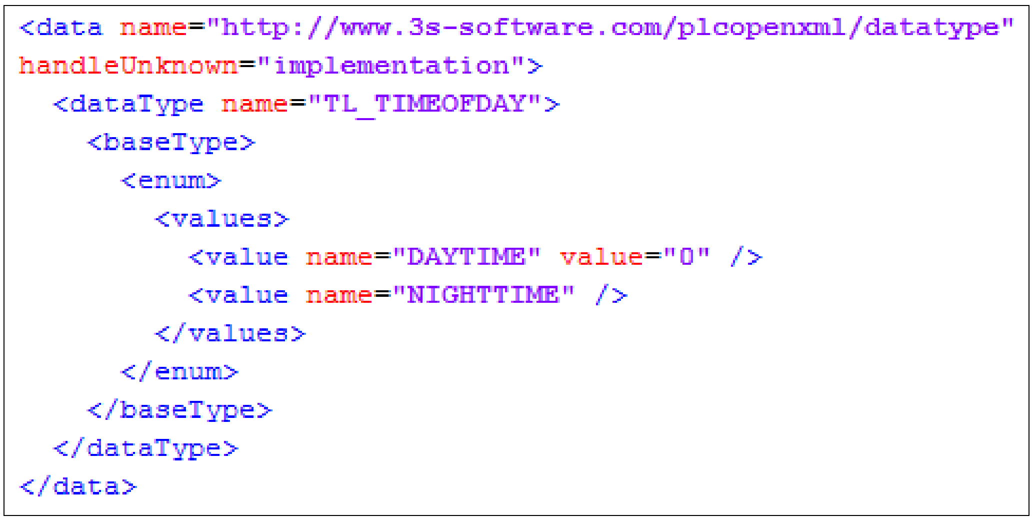
```
Application
  Data types
    TL_COLORS (STRUCT)
    TL_TIMEOFDAY (ENUM)
```

Epas-5 Tree view project (Data types)



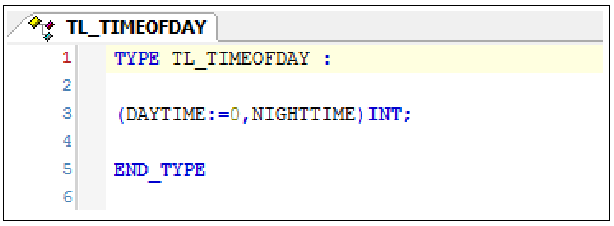
```
TYPE TL_COLORS :
STRUCT
    TLCOLORSRED      :BOOL;
    TLCOLORSYELLOW   :BOOL;
    TLCOLORSGREEN    :BOOL;
END_STRUCT
END_TYPE
```

Epas-5 Data types “TL_COLORS” declaration



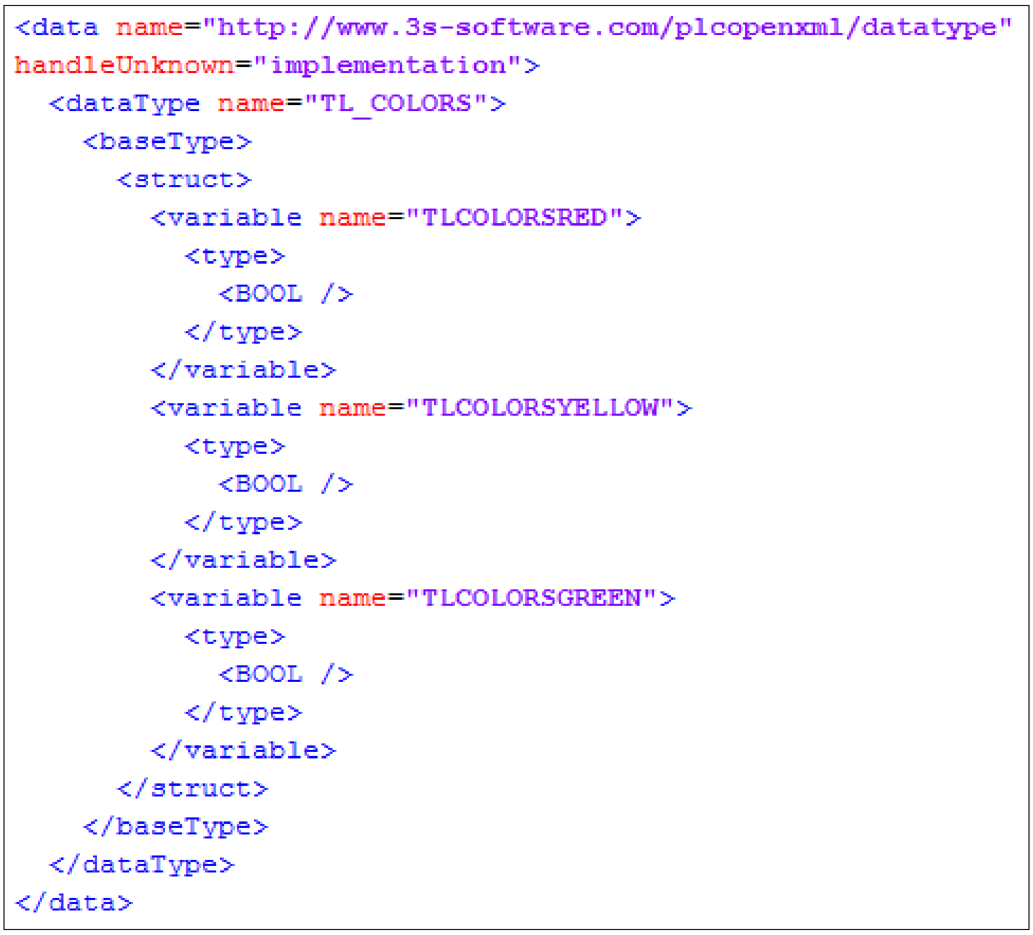
```
<data name="http://www.3s-software.com/plcopenxml/datatype"
handleUnknown="implementation">
  <dataType name="TL_TIMEOFDAY">
    <baseType>
      <enum>
        <values>
          <value name="DAYTIME" value="0" />
          <value name="NIGHTTIME" />
        </values>
      </enum>
    </baseType>
  </dataType>
</data>
```

Epas-5 XML code (Data type “TL_TIMEOFDAY” XML output)



```
TYPE TL_TIMEOFDAY :

(DAYTIME:=0,NIGHTTIME)INT;

END_TYPE
```

Epas-5 Data types “TL_TIMEOFDAY” declaration



```
<data name="http://www.3s-software.com/plcopenxml/datatype"
handleUnknown="implementation">
  <dataType name="TL_COLORS">
    <baseType>
      <struct>
        <variable name="TLCOLORSRED">
          <type>
            <BOOL />
          </type>
        </variable>
        <variable name="TLCOLORSYELLOW">
          <type>
            <BOOL />
          </type>
        </variable>
        <variable name="TLCOLORSGREEN">
          <type>
            <BOOL />
          </type>
        </variable>
      </struct>
    </baseType>
  </dataType>
</data>
```

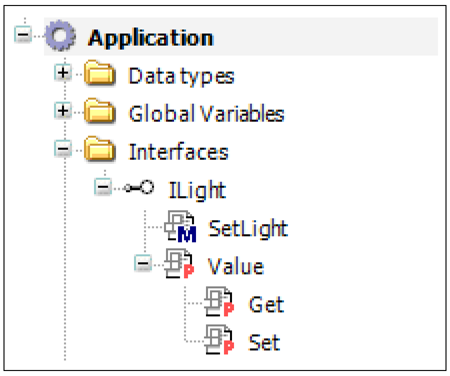
Epas-5 XML code (Data type “TL_COLORS” XML output)

Again we can fully configure Data Types just by just changing the xml code. Thus with the implementation in software Mind8 can create and edit Data Types in a project.

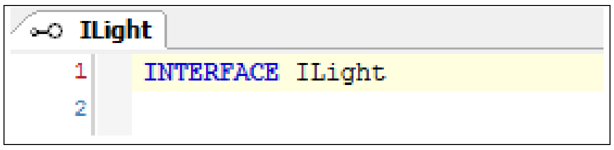
5.1.4.2 – Interface

Interfaces can be used to organize methods which are used by function blocks. An "Interface" is a POU describing a collection of method-prototypes. "Prototype" means that just declarations but no implementation is contained. A function block can implement one or several interfaces which mean that basically all methods of the interface(s) are available in the function block.

The advantage: The method calls are defined and thus unique for all function blocks implementing the same interface. Within a function block the methods have to be filled with implementation code.

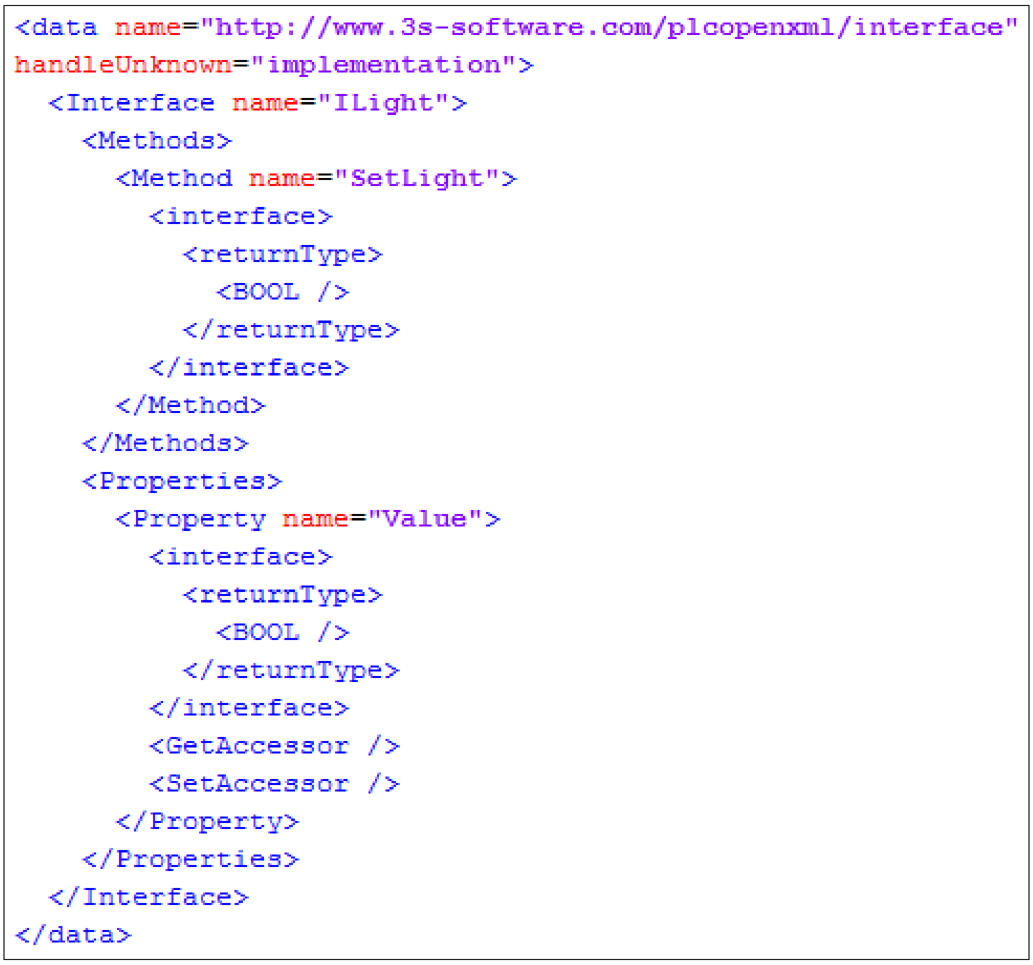


Epas-5 Tree view project (Interfaces)



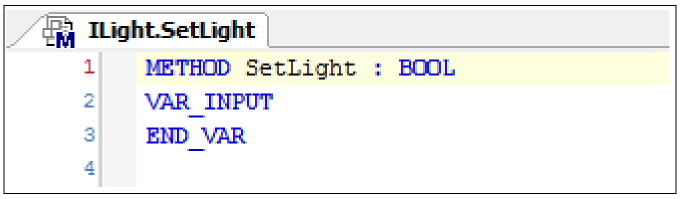
```
INTERFACE ILight

```

Epas-5 Interface “ILight” declaration



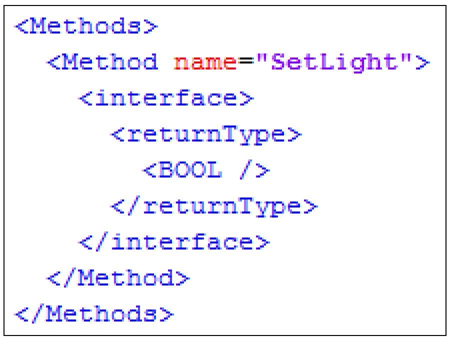
```
<data name="http://www.3s-software.com/plcopenxml/interface"
handleUnknown="implementation">
  <Interface name="ILight">
    <Methods>
      <Method name="SetLight">
        <interface>
          <returnType>
            <BOOL />
          </returnType>
        </interface>
      </Method>
    </Methods>
    <Properties>
      <Property name="Value">
        <interface>
          <returnType>
            <BOOL />
          </returnType>
        </interface>
        <GetAccessor />
        <SetAccessor />
      </Property>
    </Properties>
  </Interface>
</data>
```

Epas-5 XML code (Interface “ILight” XML output)



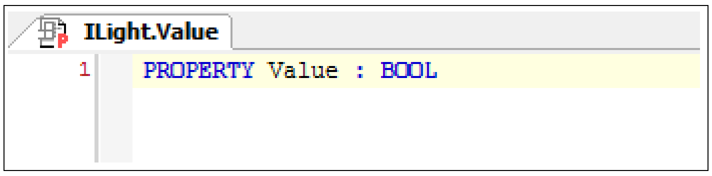
```
METHOD SetLight : BOOL
VAR_INPUT
END_VAR
```

Epas-5 Method “SetLight” declaration



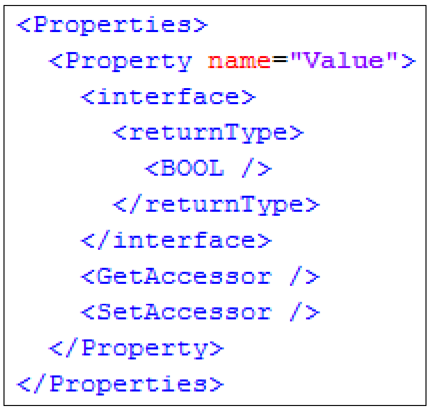
```
<Methods>
  <Method name="SetLight">
    <interface>
      <returnType>
        <BOOL />
      </returnType>
    </interface>
  </Method>
</Methods>
```

Epas-5 XML code (Method “SetLight” XML output)



```
PROPERTY Value : BOOL
```

Epas-5 Property “Value” declaration



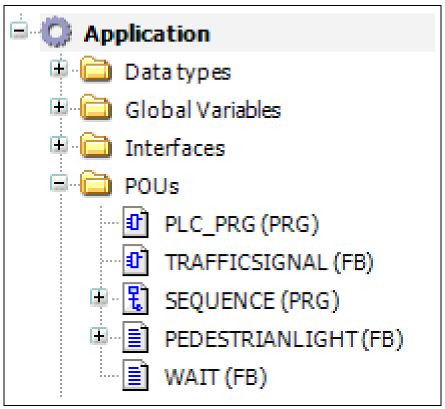
```
<Properties>
  <Property name="Value">
    <interface>
      <returnType>
        <BOOL />
      </returnType>
    </interface>
    <GetAccessor />
    <SetAccessor />
  </Property>
</Properties>
```

Epas-5 XML code (Properties “Value” XML output)

5.1.4.3 – Pou / PLC_PRG

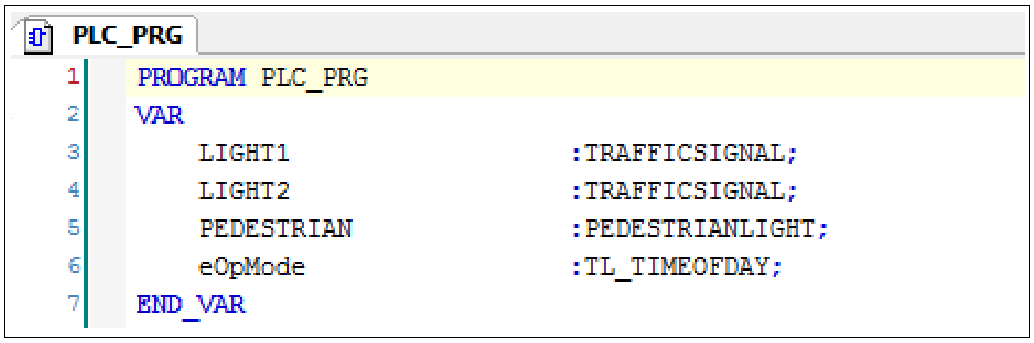
Interface / Local variables:

Here is defined all variables of the PLC_PRG program organization unit declaration.



```
Application
  Data types
  Global Variables
  Interfaces
  POUs
    PLC_PRG (PRG)
    TRAFFICSIGNAL (FB)
    SEQUENCE (PRG)
    PEDESTRIANLIGHT (FB)
    WAIT (FB)
```

Epas-5 Tree view project (POUs)


PLC_PRG

```
PROGRAM PLC_PRG
VAR
    LIGHT1              :TRAFFICSIGNAL;
    LIGHT2              :TRAFFICSIGNAL;
    PEDESTRIAN          :PEDESTRIANLIGHT;
    eOpMode             :TL_TIMEOFDAY;
END_VAR
```

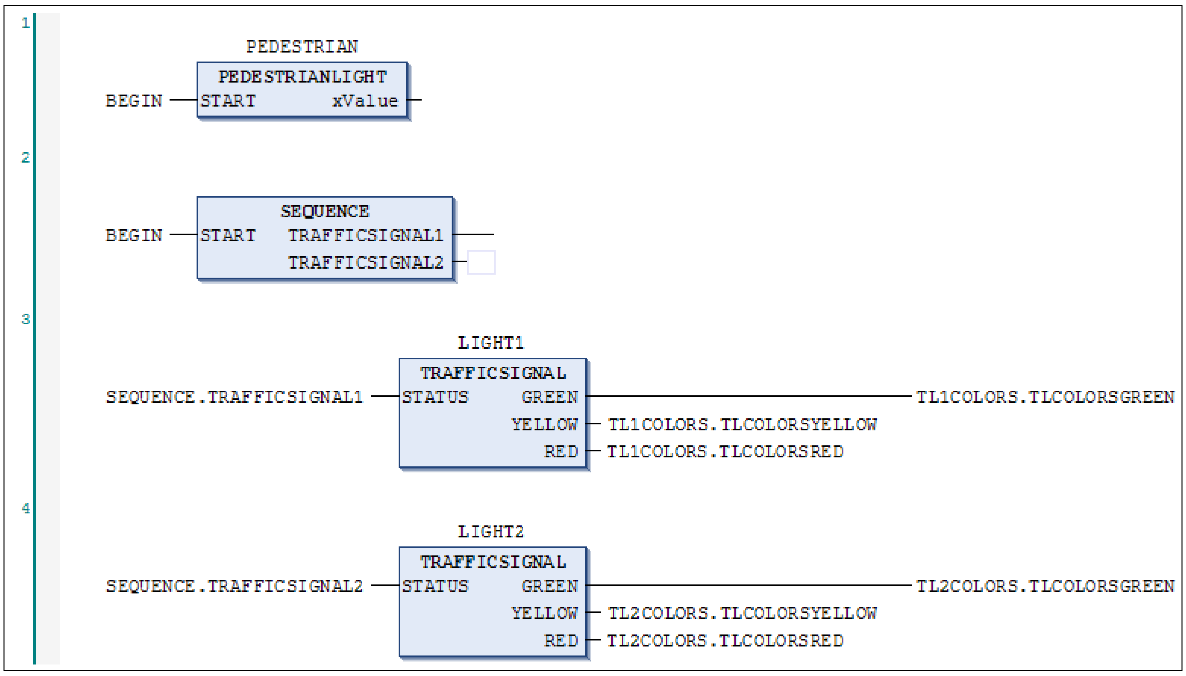
Epas-5 POU “PLC_PRG” declaration

```
<data name="http://www.3s-software.com/plcopenxml/pou"
handleUnknown="implementation">
  <pou name="PLC_PRG" pouType="program">
    <interface>
      <localVars>
        <variable name="LIGHT1">
          <type>
            <derived name="TRAFFICSIGNAL" />
          </type>
        </variable>
        <variable name="LIGHT2">
          <type>
            <derived name="TRAFFICSIGNAL" />
          </type>
        </variable>
        <variable name="PEDESTRIAN">
          <type>
            <derived name="PEDESTRIANLIGHT" />
          </type>
        </variable>
        <variable name="eOpMode">
          <type>
            <derived name="TL_TIMEOFDAY" />
          </type>
        </variable>
      </localVars>
    </interface>
```

Epas-5 XML code (POU “PLC_PRG” variables XML output)

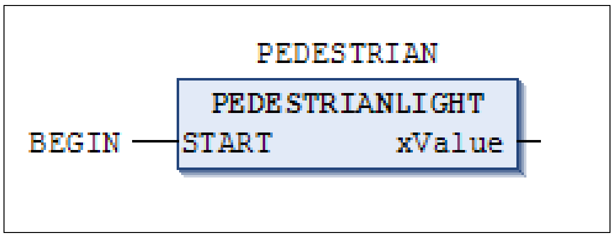
Body / FDB:

In this section it will be analyze the POUs body XML. This part of XML is mainly with coordinate factors.



Epas-5 POU “PLC_PRG” Body

- PedestrianLight



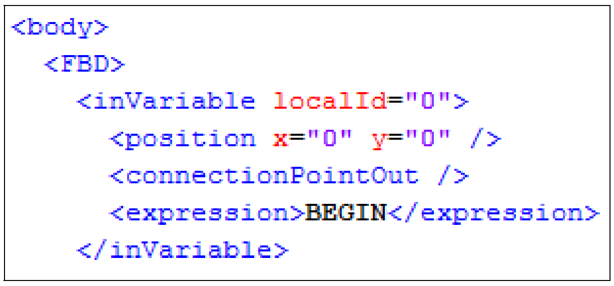
Epas-5 PEDESTRIANLIGHT block

SVG is a vector graphics format that follows the XML grammar. It defines three types of graphical objects: vector graphical objects, such as lines, ellipses, rectangle, etc. that can be grouped, formatted, transformed and composed.
Related to the IEC 61131-3 graphical languages and, in particular, to the FBD language, a limited set of SVG elements are needed, as illustrated in Fig. 4 along with its expression in SVG language.

Besides the common characteristics, it is necessary to add to each element the specific characteristics, as defined by the standard as well as the specific graphical information, such as position, width and height.

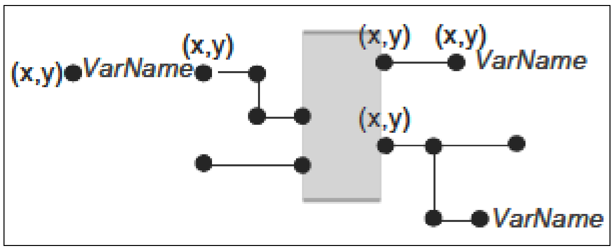
The information needed for generating the SVG of a graphical POU, written in FBD, can be extracted from a XML file that follows the grammar, as it not only contain the networks and lines by network, but also the relative position of blocks in a line (order attribute).

Only filters the information about block instances and input/output variables, but it also can apply the processing algorithms in order to generate the picture (as any PLC programming tool does). In this sense, making use of a XSL stylesheet, it is possible to generate the SVG corresponding to each graphical POU.



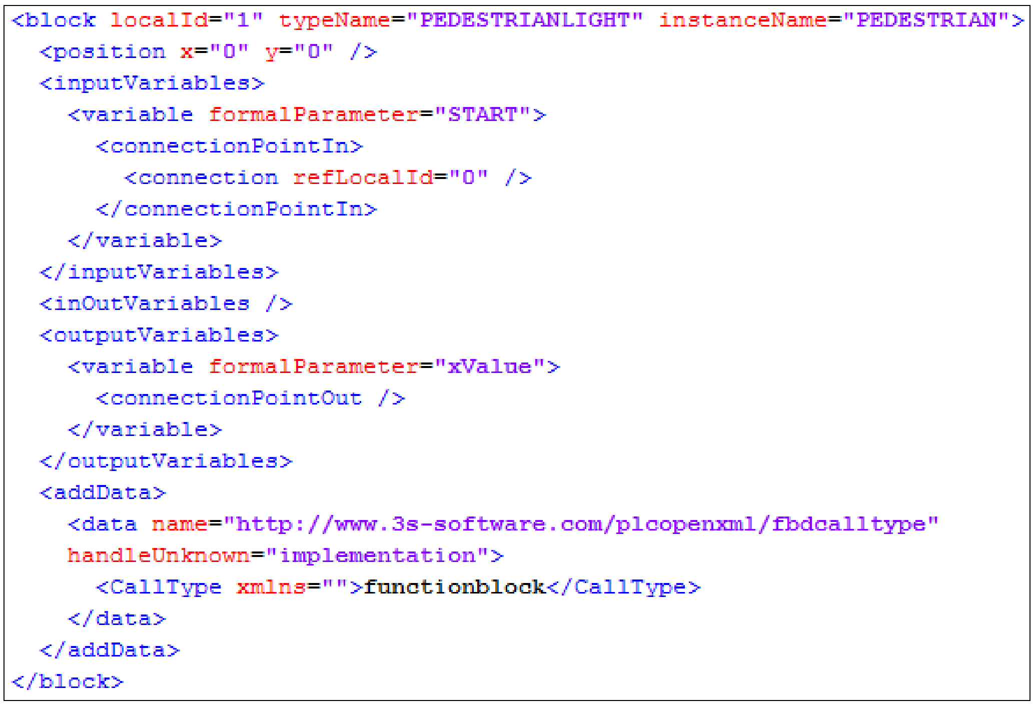
```
<body>
  <FBD>
    <inVariable localId="0">
      <position x="0" y="0" />
      <connectionPointOut />
      <expression>BEGIN</expression>
    </inVariable>
```

Epas-5 XML code (Input BEGIN PedestrianLight FB XML)



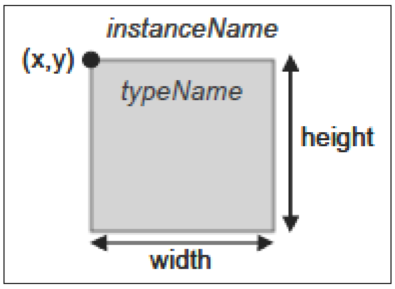
Xml variable coordinate Structure for graphic elements (Inputs and Outputs)

The “LocalId” for the BEGIN “inVariable” is “0”. This object get a local number as identification by the generating system, and shall be unique within this POU code body. “inVariable” means that the code above is relative to an input variable.



```
<block localId="1" typeName="PEDESTRIANLIGHT" instanceName="PEDESTRIAN">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="START">
      <connectionPointIn>
        <connection refLocalId="0" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="xValue">
      <connectionPointOut />
    </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">functionblock</CallType>
    </data>
  </addData>
</block>
```

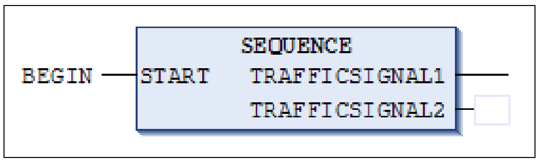
Epas-5 XML code (PEDESTRIAN Block)



Xml block coordinate Structure for graphic elements (Blocks)

In this XML part we define the all inside block with the instance name “PEDESTRIAN”. First is defined the “typeName” and the “instanceName”, then the coordinate of the block and the input variable “Start”. The parameter “refLocalId” is “0”. Next the “outputVariables” “xValue” is announced. Finally we have the type of POU “functionblock” in the parameter “callType”.

- *Sequence*



Epas-5 SEQUENCE block

```
<inVariable localId="2">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>BEGIN</expression>
</inVariable>
```

Epas-5 XML code (Input BEGIN SEQUENCE FB XML)

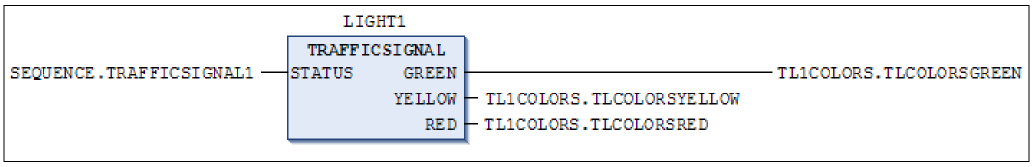
The “localId” of this object has the number “2”, because the number “0” is already been used by a “inVariable” and the number “1” by the previous block.

```
<block localId="3" typeName="SEQUENCE">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="START">
      <connectionPointIn>
        <connection refLocalId="2" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="TRAFFICSIGNAL1">
      <connectionPointOut />
    </variable>
    <variable formalParameter="TRAFFICSIGNAL2">
      <connectionPointOut>
        <expression />
      </connectionPointOut>
    </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">program</CallType>
    </data>
  </addData>
</block>
```

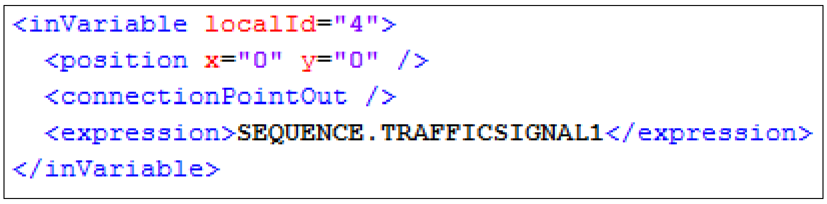
Epas-5 XML code (SEQUENCE Block)

The parameter “refLocalId” increase one unit when we change of block. In the parameter “callType” we have the type of POU “program”.

- Trafficsignal Light1

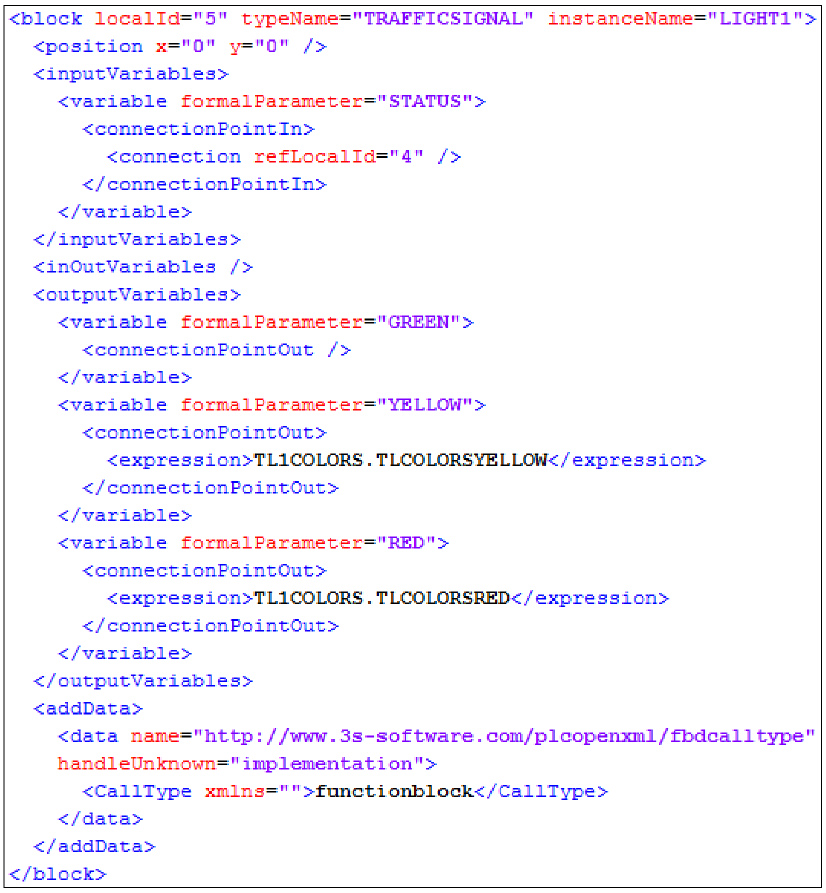


TRAFFICSIGNAL LIGHT1 block



```xml
<inVariable localId="4">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>SEQUENCE.TRAFFICSIGNAL1</expression>
</inVariable>
```

Epas-5 XML code (Input SEQUENCE.TRAFFICSIGNAL1 XML)



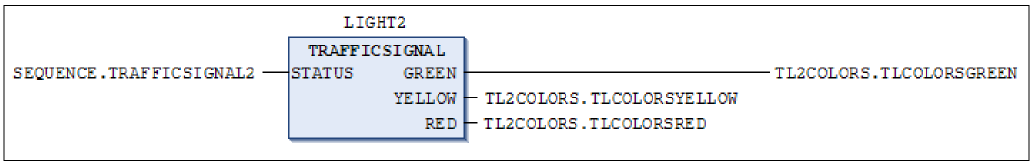
```xml
<block localId="5" typeName="TRAFFICSIGNAL" instanceName="LIGHT1">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="STATUS">
      <connectionPointIn>
        <connection refLocalId="4" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="GREEN">
      <connectionPointOut />
    </variable>
    <variable formalParameter="YELLOW">
      <connectionPointOut>
        <expression>TL1COLORS.TLCOLORSYELLOW</expression>
      </connectionPointOut>
    </variable>
    <variable formalParameter="RED">
      <connectionPointOut>
        <expression>TL1COLORS.TLCOLORSRED</expression>
      </connectionPointOut>
    </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">functionblock</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL LIGHT1 Block)

```xml
<outVariable localId="6">
  <position x="0" y="0" />
  <connectionPointIn>
    <connection refLocalId="5" formalParameter="GREEN" />
  </connectionPointIn>
  <expression>TL1COLORS.TLCOLORSGREEN</expression>
</outVariable>
```

Epas-5 XML code (output TL1COLORS.TLCOLORSGREEN XML)

- Trafficsignal Light2



TRAFFICSIGNAL LIGHT2 block

```xml
<inVariable localId="7">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>SEQUENCE.TRAFFICSIGNAL2</expression>
</inVariable>
```

Epas-5 XML code (Input SEQUENCE.TRAFFICSIGNAL2 XML)

```xml
<block localId="8" typeName="TRAFFICSIGNAL" instanceName="LIGHT2">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="STATUS">
      <connectionPointIn>
        <connection refLocalId="7" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="GREEN">
      <connectionPointOut />
    </variable>
    <variable formalParameter="YELLOW">
      <connectionPointOut>
        <expression>TL2COLORS.TLCOLORSYELLOW</expression>
      </connectionPointOut>
    </variable>
    <variable formalParameter="RED">
      <connectionPointOut>
        <expression>TL2COLORS.TLCOLORSRED</expression>
      </connectionPointOut>
    </variable>
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">functionblock</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL LIGHT2 Block)

```xml
    <outVariable localId="9">
      <position x="0" y="0" />
      <connectionPointIn>
        <connection refLocalId="8" formalParameter="GREEN" />
      </connectionPointIn>
      <expression>TL2COLORS.TLCOLORSGREEN</expression>
    </outVariable>
  </FBD>
</body>
```

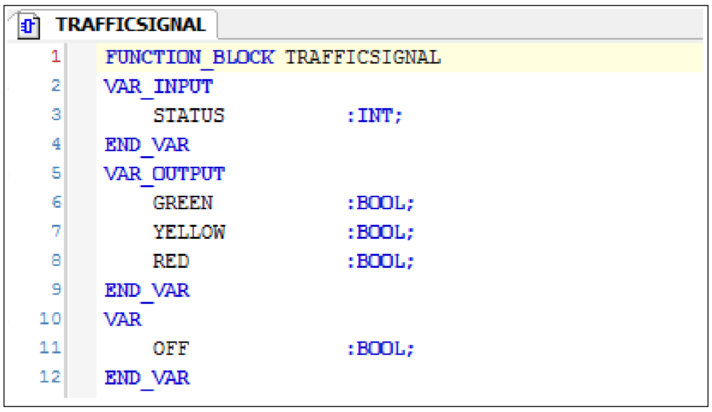
Epas-5 XML code (output TL2COLORS.TLCOLORSGREEN XML)

With the closing of “FDB and “body” we finish the graphical information for this POU.

5.1.4.4 – Pou / TRAFFICSIGNAL

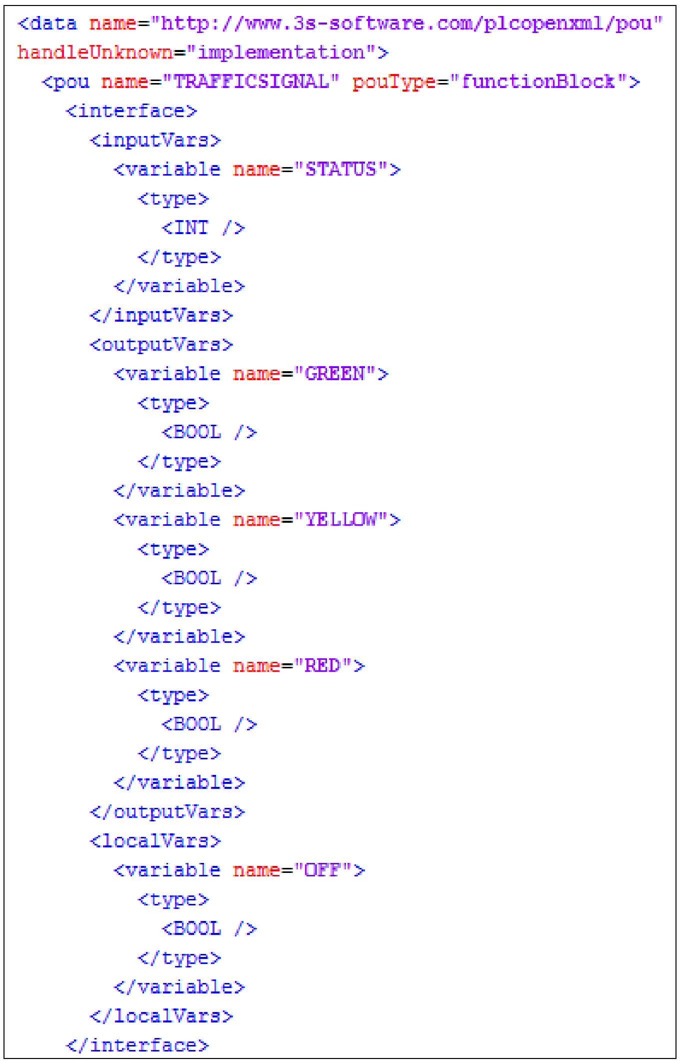
Interface / Local variables:

Here is defined all variables of the TRAFFICSIGNAL program organization unit declaration.



```
TRAFFICSIGNAL
FUNCTION_BLOCK TRAFFICSIGNAL
VAR_INPUT
    STATUS          :INT;
END_VAR
VAR_OUTPUT
    GREEN           :BOOL;
    YELLOW          :BOOL;
    RED             :BOOL;
END_VAR
VAR
    OFF             :BOOL;
END_VAR
```

Epas-5 POU “TRAFFICSIGNAL” declaration

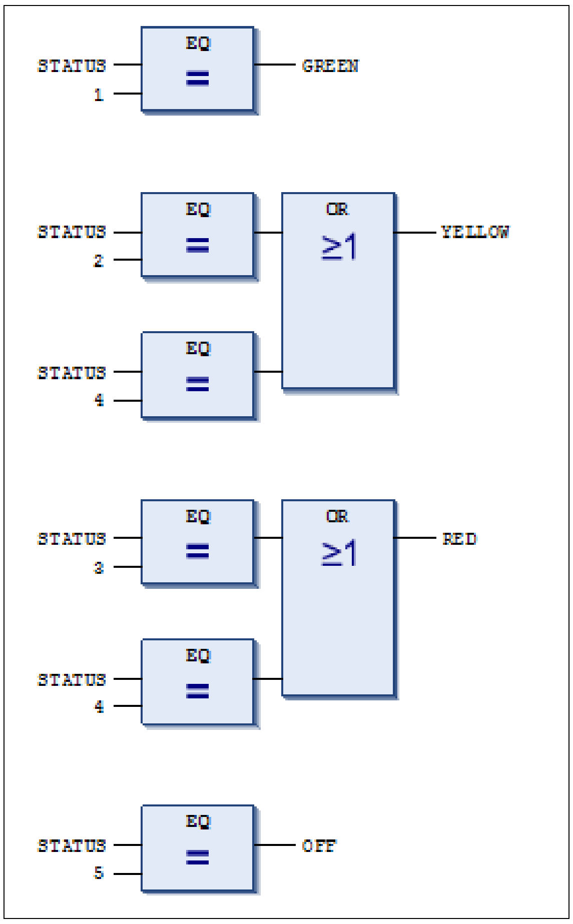


```
<data name="http://www.3s-software.com/plcopenxml/pou"
handleUnknown="implementation">
  <pou name="TRAFFICSIGNAL" pouType="functionBlock">
    <interface>
      <inputVars>
        <variable name="STATUS">
          <type>
            <INT />
          </type>
        </variable>
      </inputVars>
      <outputVars>
        <variable name="GREEN">
          <type>
            <BOOL />
          </type>
        </variable>
        <variable name="YELLOW">
          <type>
            <BOOL />
          </type>
        </variable>
        <variable name="RED">
          <type>
            <BOOL />
          </type>
        </variable>
      </outputVars>
      <localVars>
        <variable name="OFF">
          <type>
            <BOOL />
          </type>
        </variable>
      </localVars>
    </interface>
```

Epas-5 XML code (POU TRAFFICSIGNAL variables XML output)

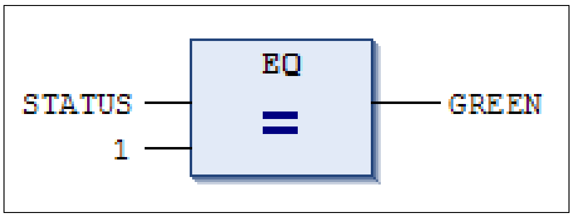
Body / FDB:

In this section it will be analyze the POUs body XML.

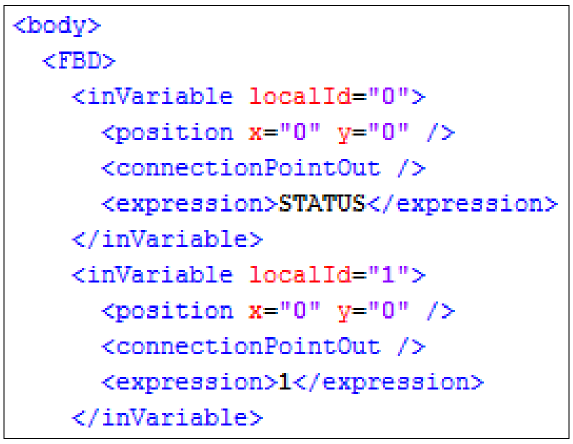


Epas-5 POU “TRAFFICSIGNAL” Body

- *Network1:*

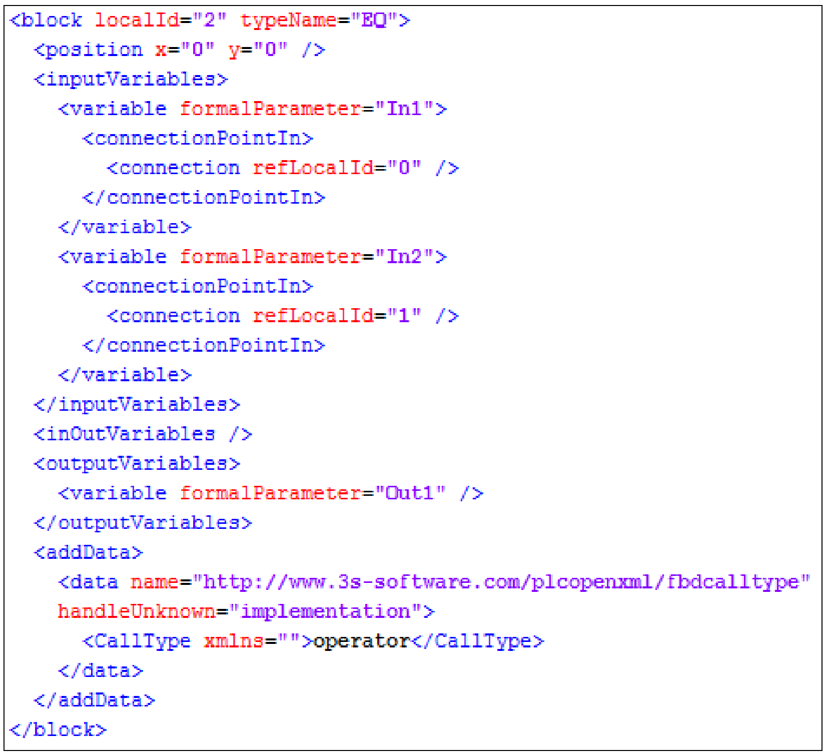


Epas-5 POU “TRAFFICSIGNAL” Block 1



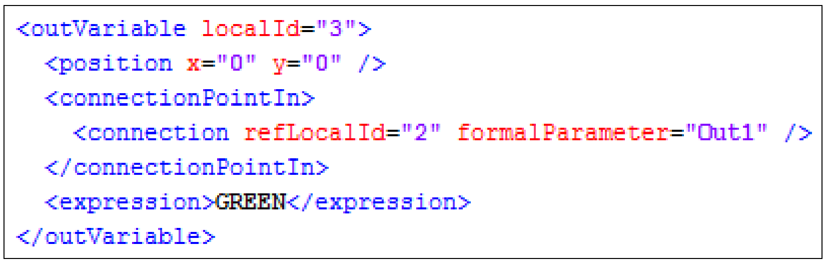
```xml
<body>
  <FBD>
    <inVariable localId="0">
      <position x="0" y="0" />
      <connectionPointOut />
      <expression>STATUS</expression>
    </inVariable>
    <inVariable localId="1">
      <position x="0" y="0" />
      <connectionPointOut />
      <expression>1</expression>
    </inVariable>
```

Epas-5 XML code (Inputs STATUS and “1” XML)



```xml
<block localId="2" typeName="EQ">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="0" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="1" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

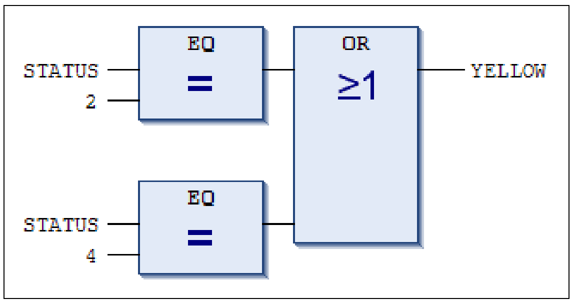
Epas-5 XML code (TRAFFICSIGNAL Block 1)



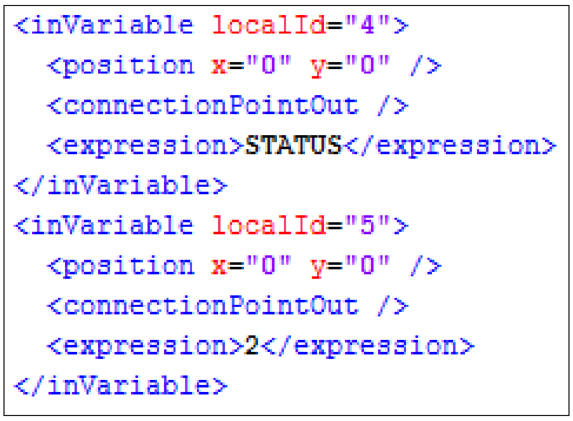
```xml
<outVariable localId="3">
  <position x="0" y="0" />
  <connectionPointIn>
    <connection refLocalId="2" formalParameter="Out1" />
  </connectionPointIn>
  <expression>GREEN</expression>
</outVariable>
```

Epas-5 XML code (output GREEN XML)

- *Network2:*

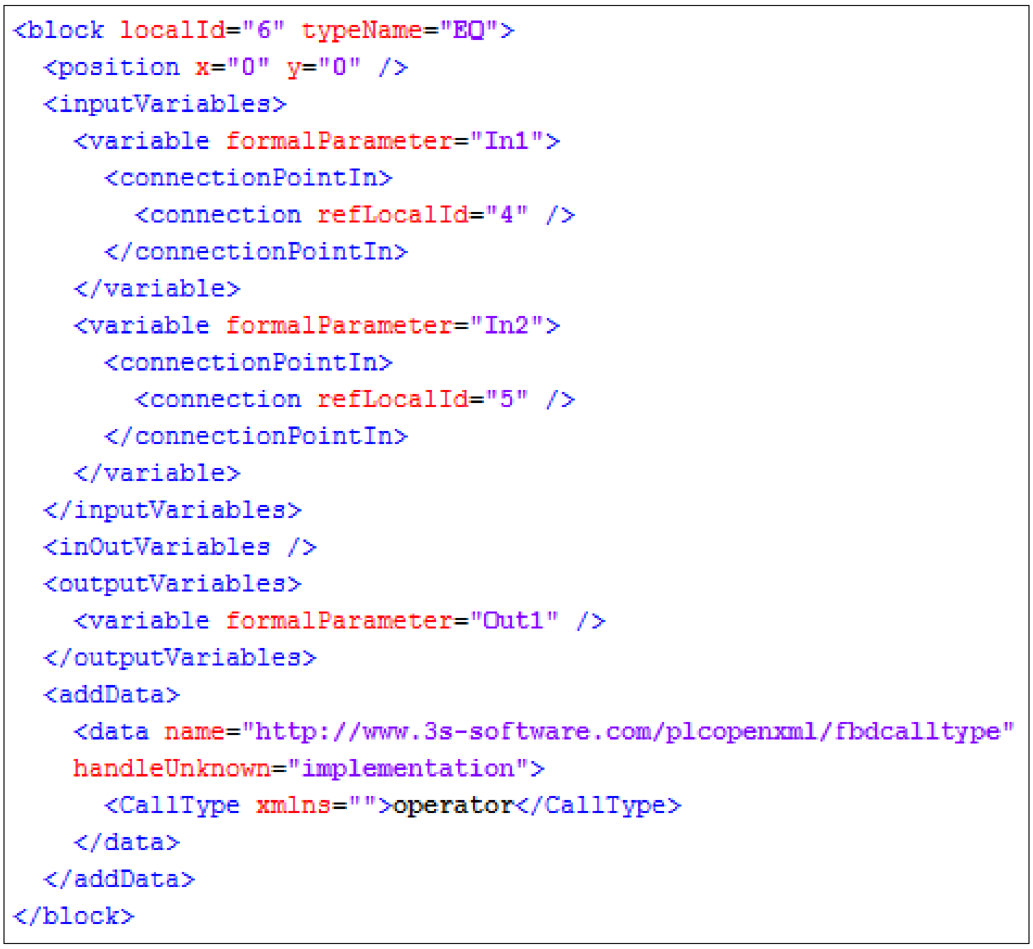


Epas-5 POU “TRAFFICSIGNAL” Network 2



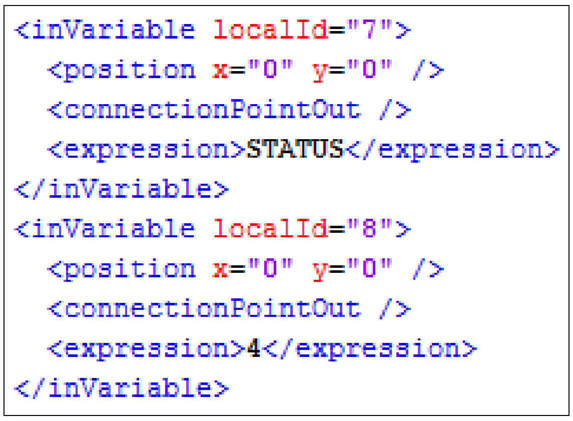
```
<inVariable localId="4">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>STATUS</expression>
</inVariable>
<inVariable localId="5">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>2</expression>
</inVariable>
```

Epas-5 XML code (Inputs STATUS and “2”)



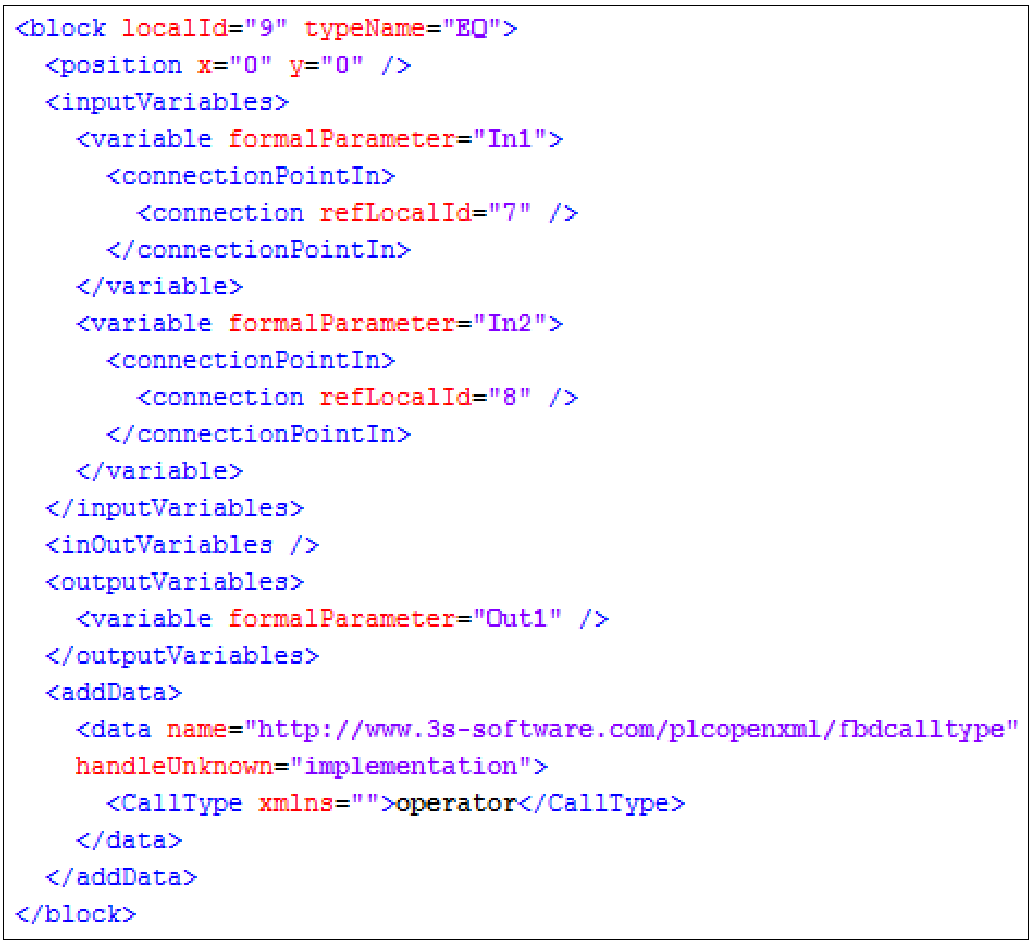
```
<block localId="6" typeName="EQ">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="4" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="5" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL Network 2 Block “EQ”)



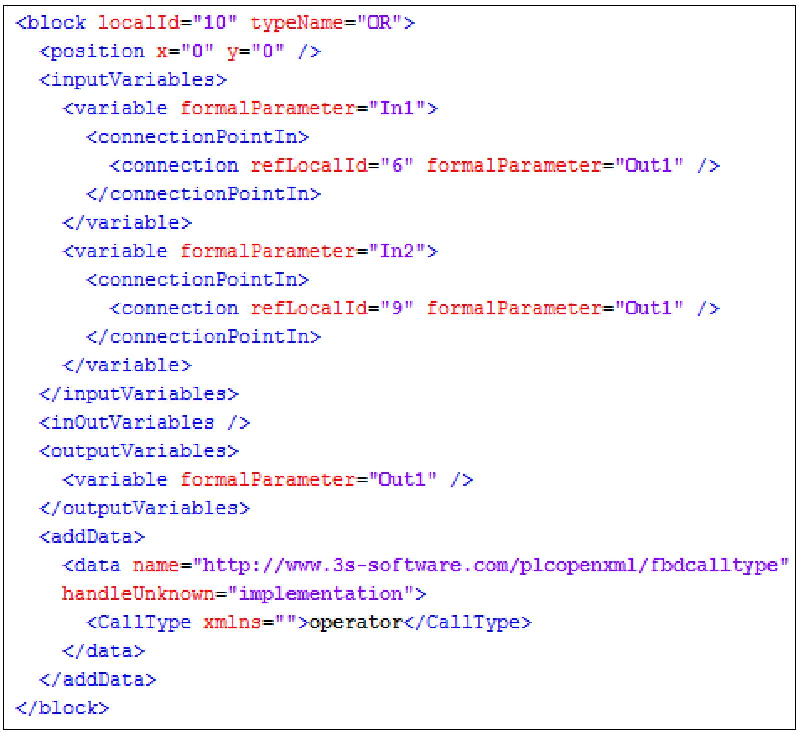
```
<inVariable localId="7">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>STATUS</expression>
</inVariable>
<inVariable localId="8">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>4</expression>
</inVariable>
```

Epas-5 XML code (Inputs STATUS and “4”)



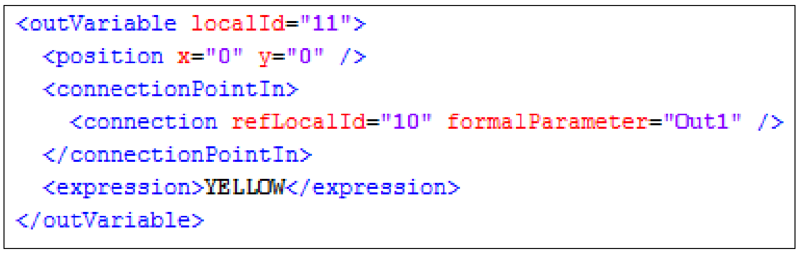
```xml
<block localId="9" typeName="EQ">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="7" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="8" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL Network 2 Block “EQ”)



```
<block localId="10" typeName="OR">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="6" formalParameter="Out1" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="9" formalParameter="Out1" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

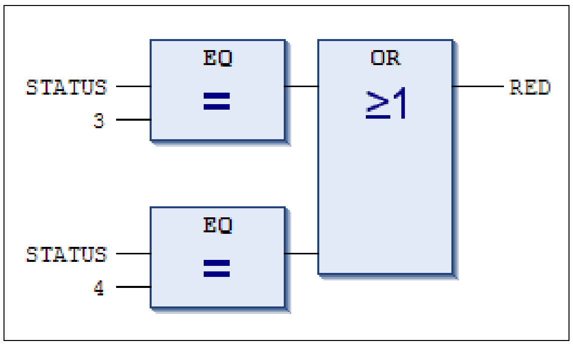
Epas-5 XML code (TRAFFICSIGNAL Network 2 Block “OR”)



```
<outVariable localId="11">
  <position x="0" y="0" />
  <connectionPointIn>
    <connection refLocalId="10" formalParameter="Out1" />
  </connectionPointIn>
  <expression>YELLOW</expression>
</outVariable>
```

Epas-5 XML code (output YELLOW XML)

- *Network3:*



Epas-5 POU “TRAFFICSIGNAL” Network 3

```
<inVariable localId="12">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>STATUS</expression>
</inVariable>
<inVariable localId="13">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>3</expression>
</inVariable>
```

Epas-5 XML code (Inputs STATUS and “3”)

```
<block localId="14" typeName="EQ">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="12" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="13" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL Network 3 Block “EQ”)

```
<inVariable localId="15">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>STATUS</expression>
</inVariable>
<inVariable localId="16">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>4</expression>
</inVariable>
```

Epas-5 XML code (Inputs STATUS and “4”)

```
<block localId="17" typeName="EQ">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="15" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="16" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL Network 3 Block “EQ”)

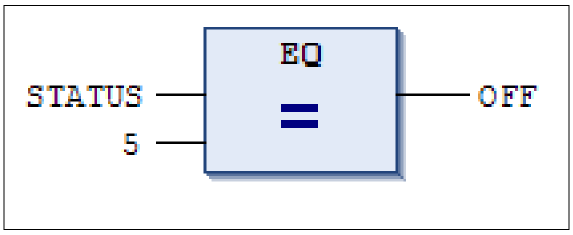
```
<block localId="18" typeName="OR">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="14" formalParameter="Out1" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="17" formalParameter="Out1" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL Network 3 Block “OR”)

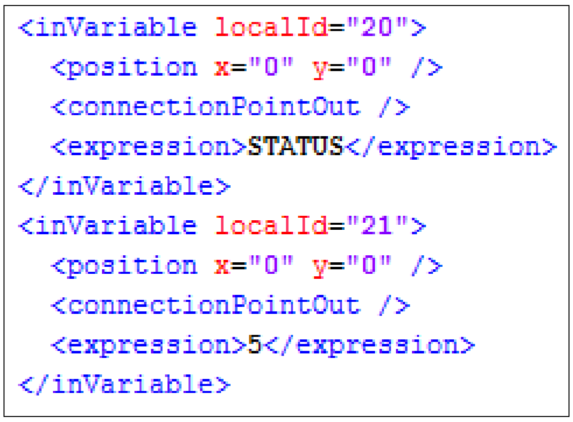
```
<outVariable localId="19">
  <position x="0" y="0" />
  <connectionPointIn>
    <connection refLocalId="18" formalParameter="Out1" />
  </connectionPointIn>
  <expression>RED</expression>
</outVariable>
```

Epas-5 XML code (output RED XML)

- *Network4:*

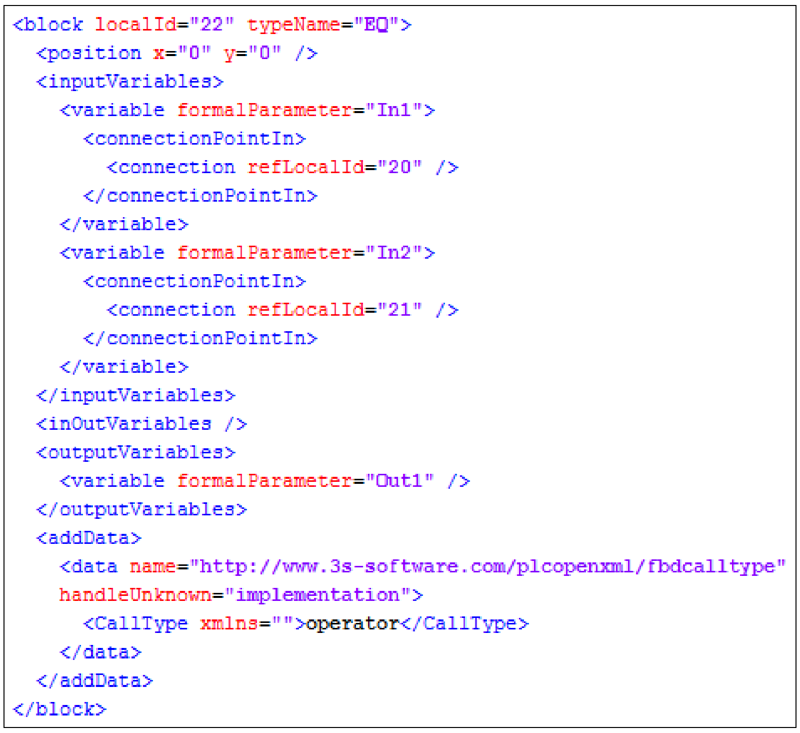


Epas-5 POU “TRAFFICSIGNAL” Network 4



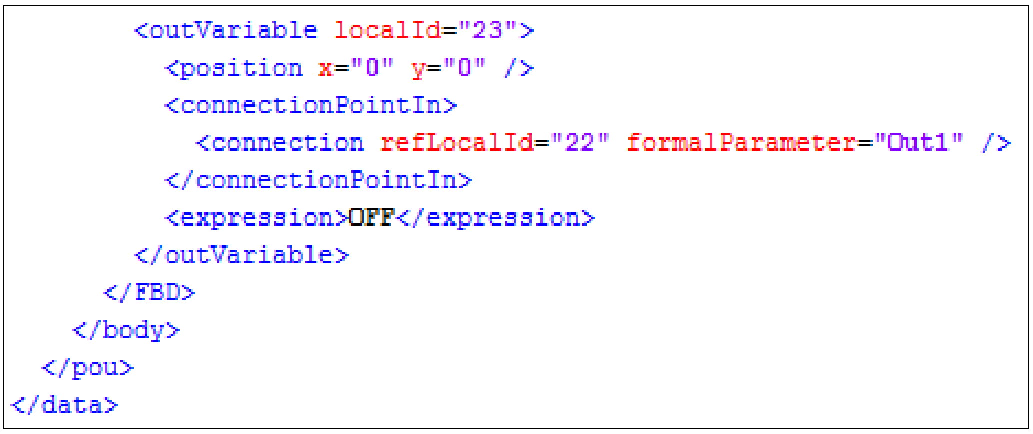
```xml
<inVariable localId="20">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>STATUS</expression>
</inVariable>
<inVariable localId="21">
  <position x="0" y="0" />
  <connectionPointOut />
  <expression>5</expression>
</inVariable>
```

Epas-5 XML code (Inputs STATUS and “5”)



```xml
<block localId="22" typeName="EQ">
  <position x="0" y="0" />
  <inputVariables>
    <variable formalParameter="In1">
      <connectionPointIn>
        <connection refLocalId="20" />
      </connectionPointIn>
    </variable>
    <variable formalParameter="In2">
      <connectionPointIn>
        <connection refLocalId="21" />
      </connectionPointIn>
    </variable>
  </inputVariables>
  <inOutVariables />
  <outputVariables>
    <variable formalParameter="Out1" />
  </outputVariables>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/fbdcalltype"
    handleUnknown="implementation">
      <CallType xmlns="">operator</CallType>
    </data>
  </addData>
</block>
```

Epas-5 XML code (TRAFFICSIGNAL Network 4)

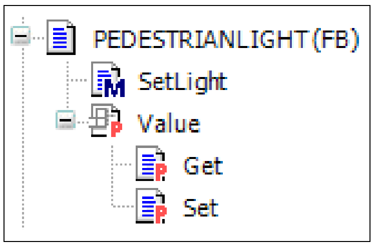

```
        <outVariable localId="23">
          <position x="0" y="0" />
          <connectionPointIn>
            <connection refLocalId="22" formalParameter="Out1" />
          </connectionPointIn>
          <expression>OFF</expression>
        </outVariable>
      </FBD>
    </body>
  </pou>
</data>
```

Epas-5 XML code (output OFF)

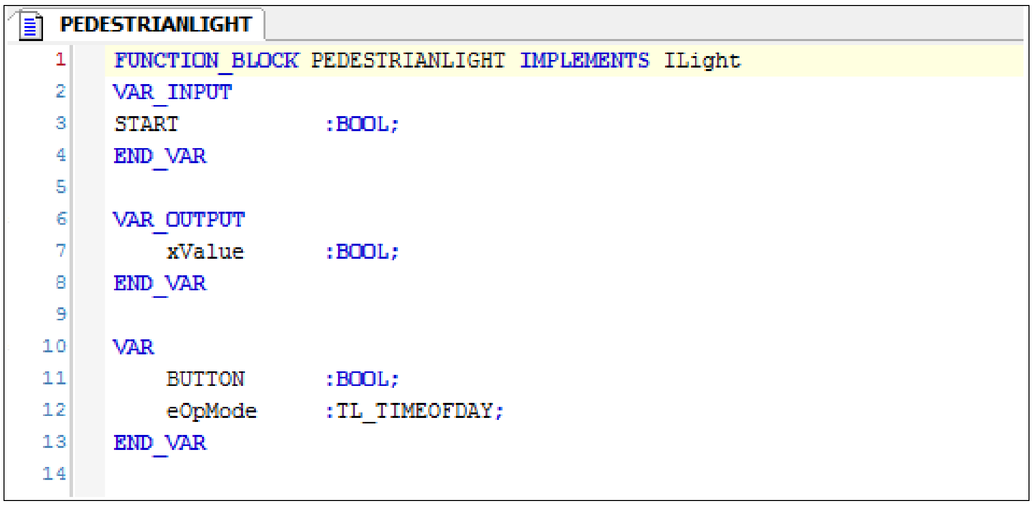
5.1.4.4 – Pou / PEDESTRIANLIGHT

Interface / Local variables:

Here is defined all variables of the PEDESTRIANLIGHT program organization unit declaration.

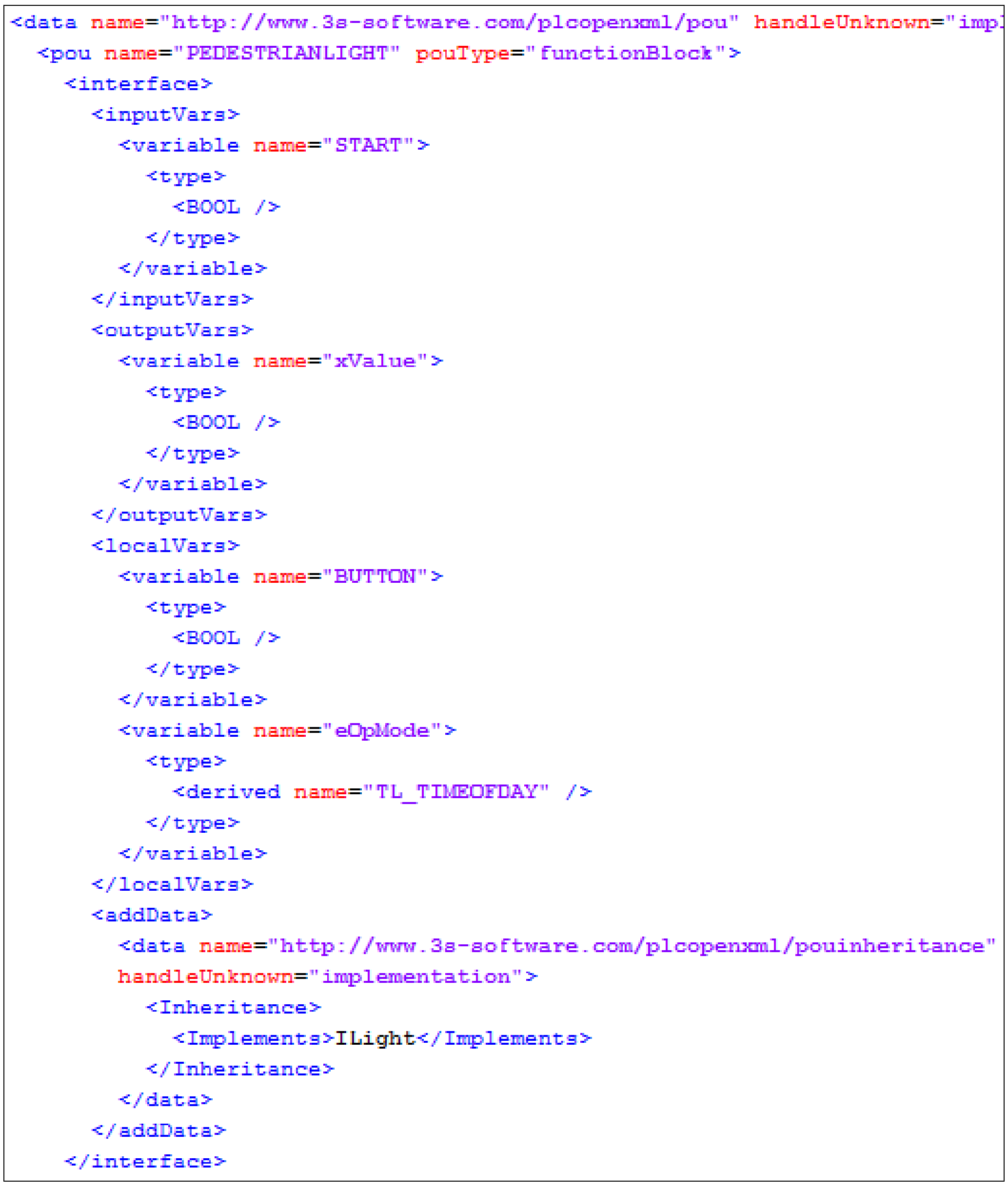


Epas-5 Tree view project (PEDESTRIAN POU)


PEDESTRIANLIGHT

```
FUNCTION_BLOCK PEDESTRIANLIGHT IMPLEMENTS ILight
VAR_INPUT
START           :BOOL;
END_VAR

VAR_OUTPUT
    xValue      :BOOL;
END_VAR

VAR
    BUTTON      :BOOL;
    eOpMode     :TL_TIMEOFDAY;
END_VAR

```

Epas-5 POU “PEDESTRIANLIGHT” declaration

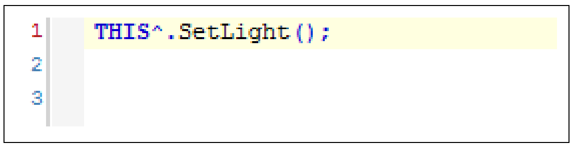


```xml
<data name="http://www.3s-software.com/plcopenxml/pou" handleUnknown="imp
  <pou name="PEDESTRIANLIGHT" pouType="functionBlock">
    <interface>
      <inputVars>
        <variable name="START">
          <type>
            <BOOL />
          </type>
        </variable>
      </inputVars>
      <outputVars>
        <variable name="xValue">
          <type>
            <BOOL />
          </type>
        </variable>
      </outputVars>
      <localVars>
        <variable name="BUTTON">
          <type>
            <BOOL />
          </type>
        </variable>
        <variable name="eOpMode">
          <type>
            <derived name="TL_TIMEOFDAY" />
          </type>
        </variable>
      </localVars>
      <addData>
        <data name="http://www.3s-software.com/plcopenxml/pouinheritance"
        handleUnknown="implementation">
          <Inheritance>
            <Implements>ILight</Implements>
          </Inheritance>
        </data>
      </addData>
    </interface>
```

Epas-5 XML code (POU PEDESTRIANLIGHT variables XML output and Inheritance)

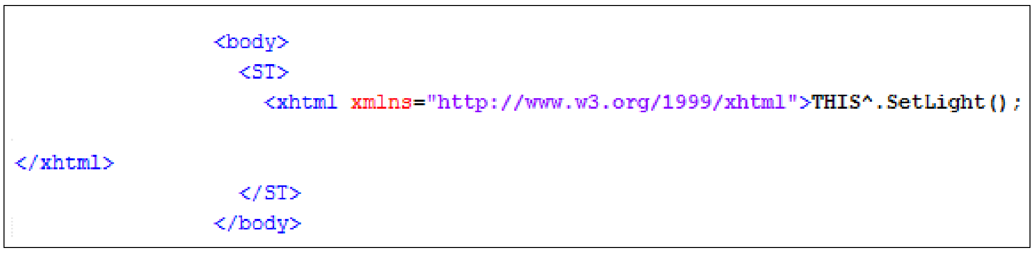
Body / ST:

In this section it will be analyze the POUs body XML.



```
THIS^.SetLight();
```

Epas-5 POU “PEDESTRIANLIGHT” Body

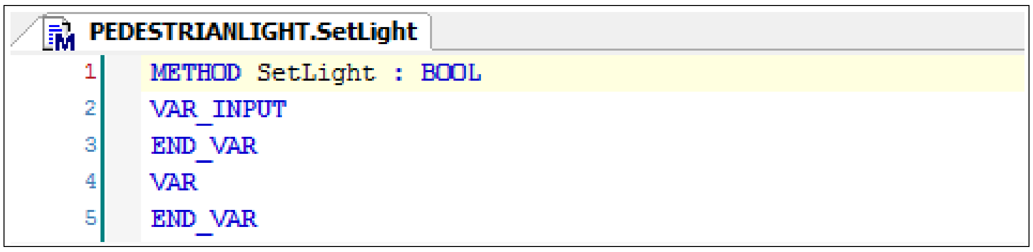


```
                <body>
                  <ST>
                    <xhtml xmlns="http://www.w3.org/1999/xhtml">THIS^.SetLight();
</xhtml>
                  </ST>
                </body>
```

Epas-5 XML code (PEDESTRIANLIGHT Body)

Add Data / Data:

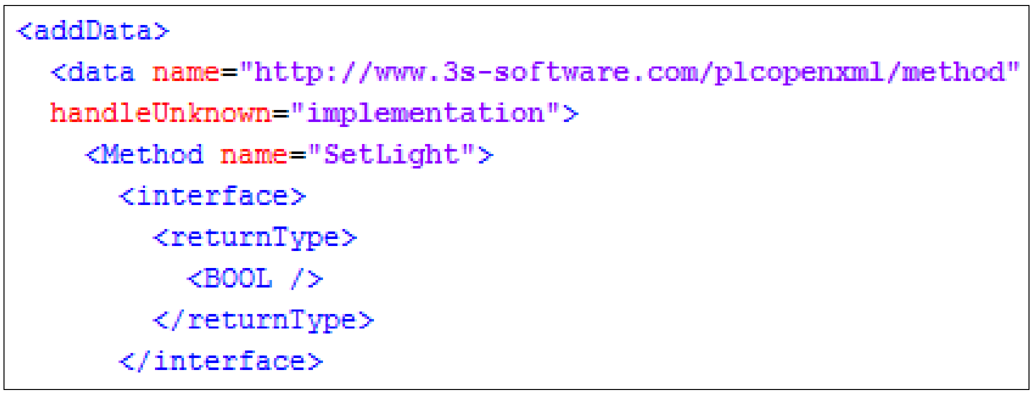
- *Method Interface:*



PEDESTRIANLIGHT.SetLight

```
METHOD SetLight : BOOL
VAR_INPUT
END_VAR
VAR
END_VAR
```

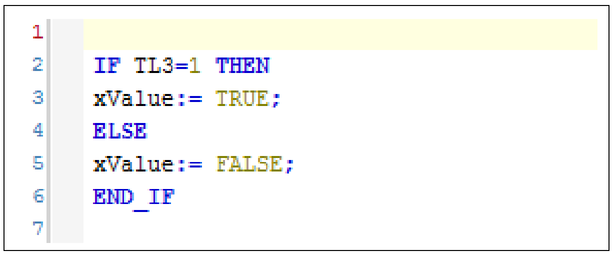
Epas-5 POU Method “SetLight” declaration



```
<addData>
  <data name="http://www.3s-software.com/plcopenxml/method"
  handleUnknown="implementation">
    <Method name="SetLight">
      <interface>
        <returnType>
          <BOOL />
        </returnType>
      </interface>
```

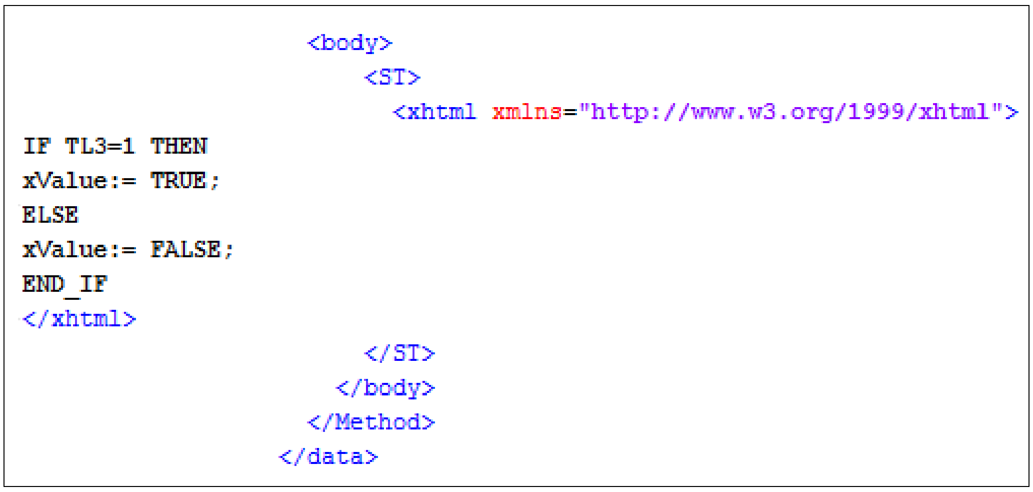
Epas-5 XML code (Method SetLight declaration)

- *Method Body / ST:*



```
IF TL3=1 THEN
xValue:= TRUE;
ELSE
xValue:= FALSE;
END_IF
```

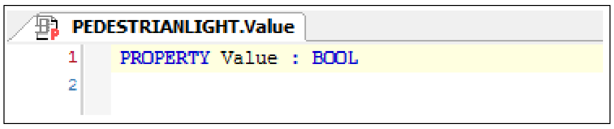
Epas-5 POU Method “SetLight” body



```
                        <body>
                            <ST>
                              <xhtml xmlns="http://www.w3.org/1999/xhtml">
IF TL3=1 THEN
xValue:= TRUE;
ELSE
xValue:= FALSE;
END_IF
</xhtml>
                            </ST>
                          </body>
                        </Method>
                      </data>
```

Epas-5 XML code (Method SetLight body)

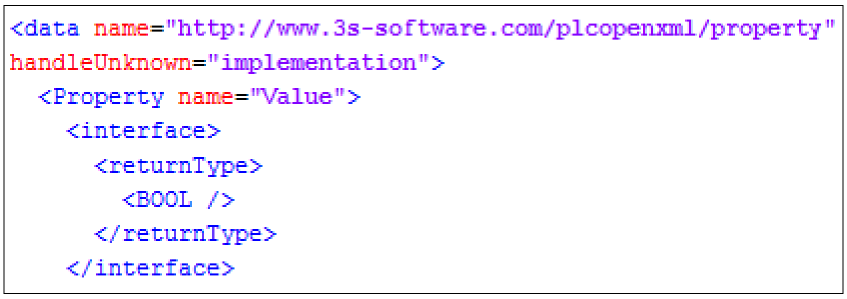
- *Property Value:*



PEDESTRIANLIGHT.Value

```
PROPERTY Value : BOOL
```

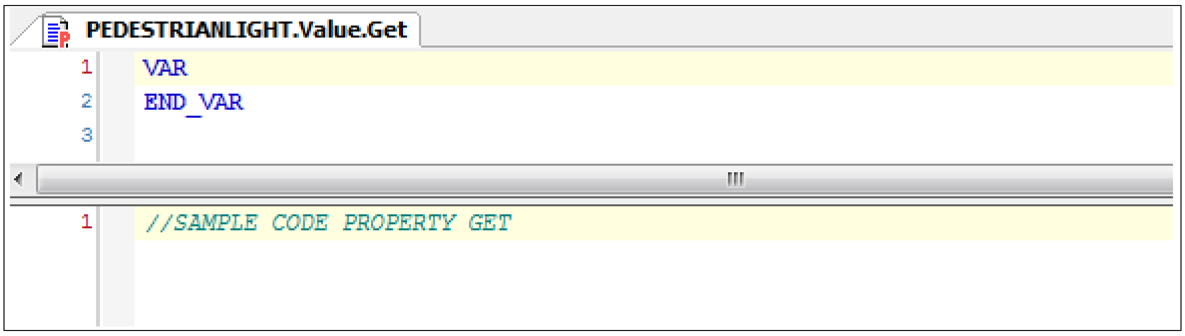
Epas-5 POU Property “Value”



```
<data name="http://www.3s-software.com/plcopenxml/property"
handleUnknown="implementation">
  <Property name="Value">
    <interface>
      <returnType>
        <BOOL />
      </returnType>
    </interface>
```

Epas-5 XML code (Property Value)

- *Property Value GetAccessor:*



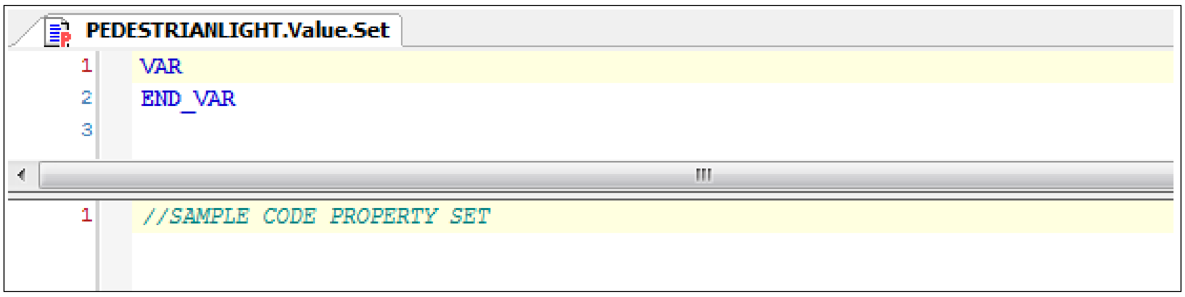
PEDESTRIANLIGHT.Value.Get

```
VAR
END_VAR

//SAMPLE CODE PROPERTY GET
```

Epas-5 Method Property "Value" GetAcessor

```
<GetAccessor>
  <interface>
    <addData>
      <data name="http://www.3s-software.com/plcopenxml/attributes"
      handleUnknown="implementation">
        <Attributes>
          <Attribute Name="hide" Value="" />
        </Attributes>
      </data>
    </addData>
  </interface>
 <body>
    <ST>
      <xhtml xmlns="http://www.w3.org/1999/xhtml">//SAMPLE CODE PROPERTY GET</xhtml>
    </ST>
  </body>
</GetAccessor>
```

Epas-5 XML code (Property Value GetAccessor)



PEDESTRIANLIGHT.Value.Set

```
VAR
END_VAR

//SAMPLE CODE PROPERTY SET
```

Epas-5 Method Property "Value" SetAccessor

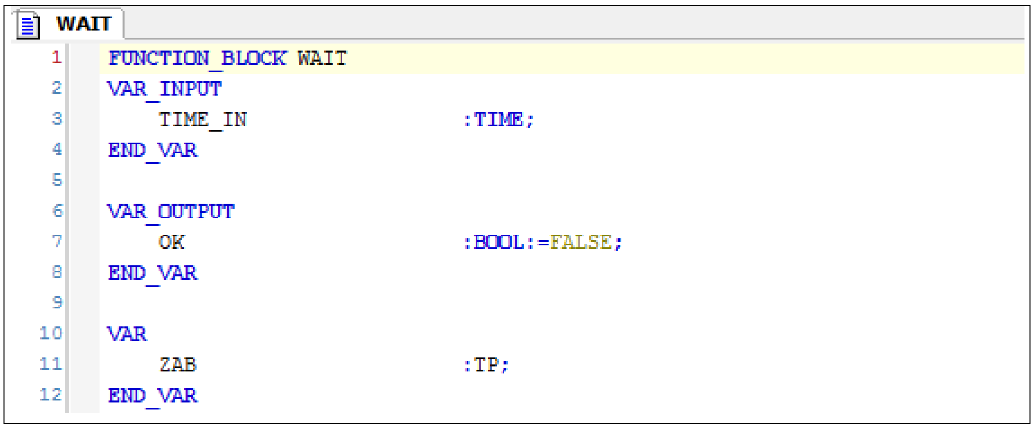
```
          <SetAccessor>
            <interface>
              <addData>
                <data name="http://www.3s-software.com/plcopenxml/attributes"
                handleUnknown="implementation">
                  <Attributes>
                    <Attribute Name="hide" Value="" />
                  </Attributes>
                </data>
              </addData>
            </interface>
            <body>
              <ST>
                <xhtml xmlns="http://www.w3.org/1999/xhtml">//SAMPLE CODE PROPERTY SET</xhtml>
              </ST>
            </body>
          </SetAccessor>
        </Property>
      </data>
    </addData>
  </pou>
</data>
```

Epas-5 XML code (Property Value SetAccessor)

5.1.4.5 – *Pou / WAIT*

Interface:

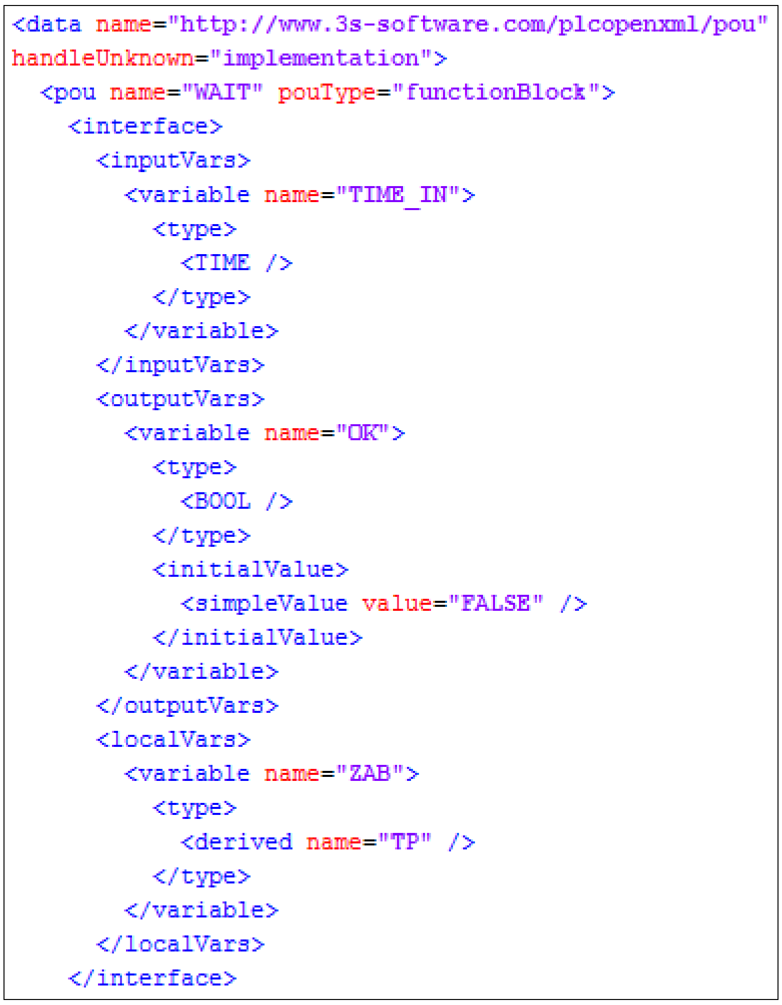
Here is defined all variables of the WAIT program organization unit declaration.



WAIT

```
FUNCTION_BLOCK WAIT
VAR_INPUT
    TIME_IN                 :TIME;
END_VAR

VAR_OUTPUT
    OK                      :BOOL:=FALSE;
END_VAR

VAR
    ZAB                     :TP;
END_VAR
```

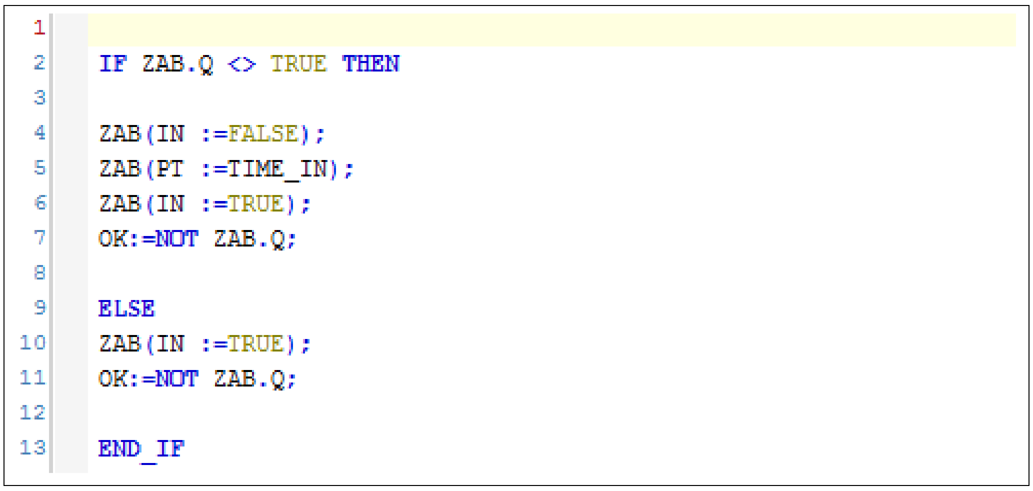
Epas-5 POU “WAIT” declaration



```xml
<data name="http://www.3s-software.com/plcopenxml/pou"
handleUnknown="implementation">
  <pou name="WAIT" pouType="functionBlock">
    <interface>
      <inputVars>
        <variable name="TIME_IN">
          <type>
            <TIME />
          </type>
        </variable>
      </inputVars>
      <outputVars>
        <variable name="OK">
          <type>
            <BOOL />
          </type>
          <initialValue>
            <simpleValue value="FALSE" />
          </initialValue>
        </variable>
      </outputVars>
      <localVars>
        <variable name="ZAB">
          <type>
            <derived name="TP" />
          </type>
        </variable>
      </localVars>
    </interface>
```

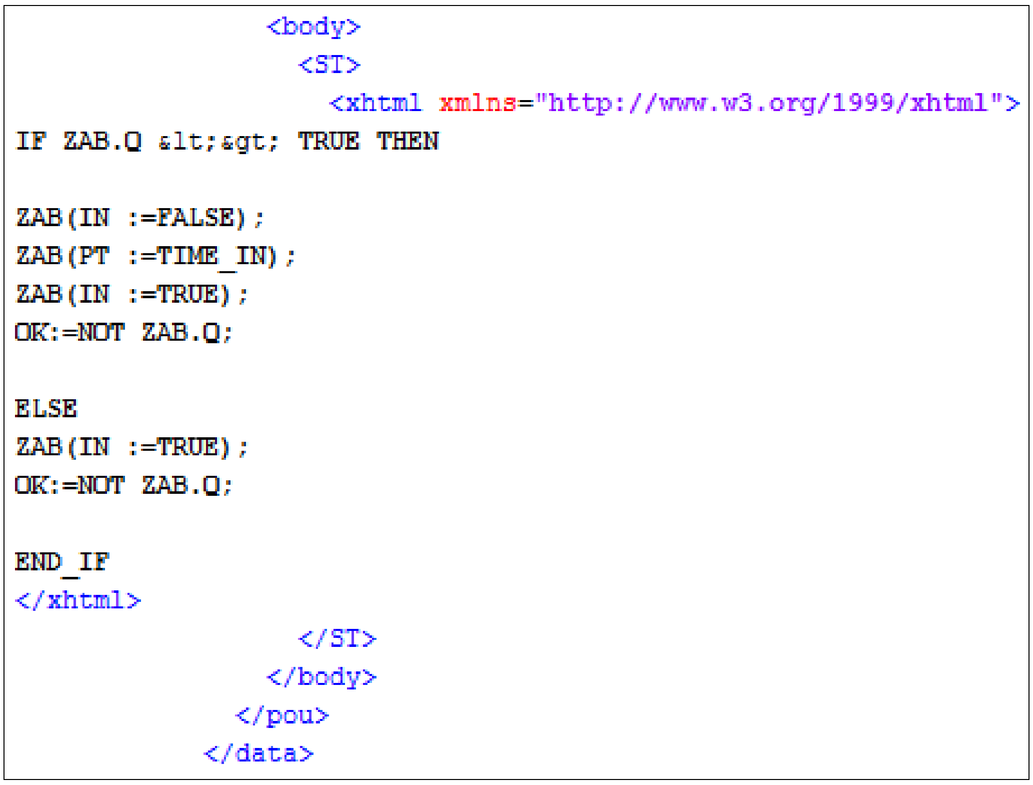
Epas-5 XML code (POU WAIT variables XML)

Body / ST:



```

IF ZAB.Q <> TRUE THEN

ZAB(IN :=FALSE);
ZAB(PT :=TIME_IN);
ZAB(IN :=TRUE);
OK:=NOT ZAB.Q;

ELSE
ZAB(IN :=TRUE);
OK:=NOT ZAB.Q;

END_IF
```

Epas-5 POU WAIT body

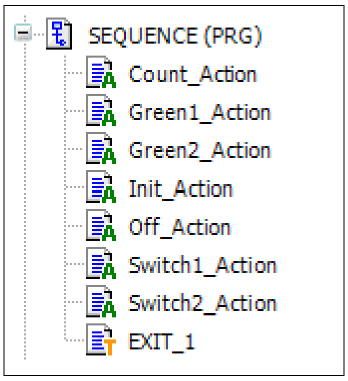


```
                        <body>
                          <ST>
                            <xhtml xmlns="http://www.w3.org/1999/xhtml">
IF ZAB.Q &lt;&gt; TRUE THEN

ZAB(IN :=FALSE);
ZAB(PT :=TIME_IN);
ZAB(IN :=TRUE);
OK:=NOT ZAB.Q;

ELSE
ZAB(IN :=TRUE);
OK:=NOT ZAB.Q;

END_IF
</xhtml>
                          </ST>
                        </body>
                      </pou>
                    </data>
```

Epas-5 XML code (POU WAIT body)

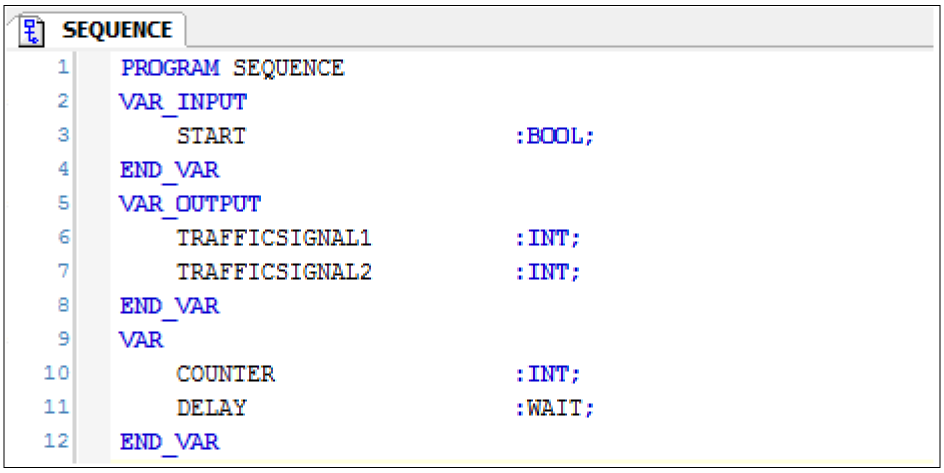
5.1.4.5 – Pou / SEQUENCE

Interface:



```
SEQUENCE (PRG)
    Count_Action
    Green1_Action
    Green2_Action
    Init_Action
    Off_Action
    Switch1_Action
    Switch2_Action
    EXIT_1
```

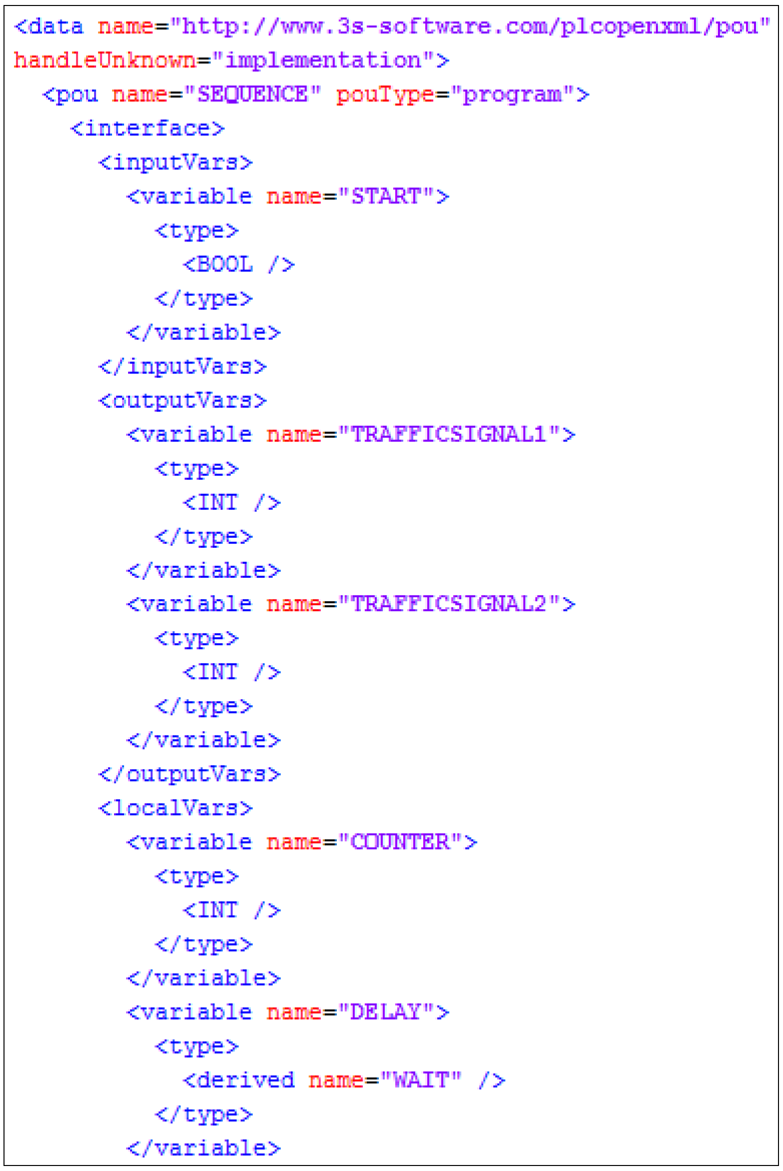
Epas-5 Tree view project (SEQUENCE POU)



SEQUENCE

```
PROGRAM SEQUENCE
VAR_INPUT
    START                   :BOOL;
END_VAR
VAR_OUTPUT
    TRAFFICSIGNAL1          :INT;
    TRAFFICSIGNAL2          :INT;
END_VAR
VAR
    COUNTER                 :INT;
    DELAY                   :WAIT;
END_VAR
```

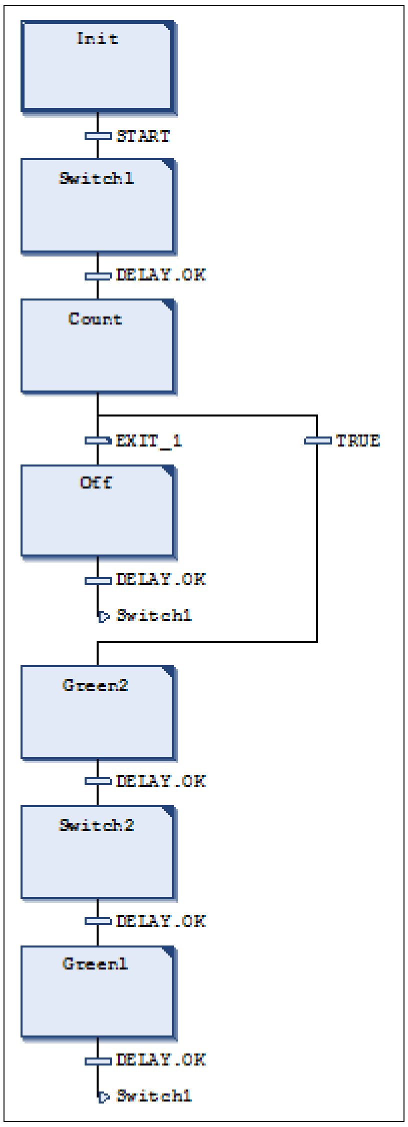
Epas-5 POU SEQUENCE declaration



```
<data name="http://www.3s-software.com/plcopenxml/pou"
handleUnknown="implementation">
  <pou name="SEQUENCE" pouType="program">
    <interface>
      <inputVars>
        <variable name="START">
          <type>
            <BOOL />
          </type>
        </variable>
      </inputVars>
      <outputVars>
        <variable name="TRAFFICSIGNAL1">
          <type>
            <INT />
          </type>
        </variable>
        <variable name="TRAFFICSIGNAL2">
          <type>
            <INT />
          </type>
        </variable>
      </outputVars>
      <localVars>
        <variable name="COUNTER">
          <type>
            <INT />
          </type>
        </variable>
        <variable name="DELAY">
          <type>
            <derived name="WAIT" />
          </type>
        </variable>
```

Epas-5 XML code POU SEQUENCE declaration

Body / SFC:



Epas-5 POU SEQUENCE body section in SFC language

```
<variable name="Init">
  <type>
    <derived name="SFCStepType" />
  </type>
  <initialValue>
    <structValue>
      <value member="_x">
        <simpleValue value="TRUE" />
      </value>
    </structValue>
  </initialValue>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/attributes"
    handleUnknown="implementation">
      <Attributes>
        <Attribute Name="Name" Value="Init" />
        <Attribute Name="MainAction" Value="Init_Action" />
        <Attribute Name="hide" Value="" />
        <Attribute Name="InitStep" Value="TRUE" />
        <Attribute Name="sfc-variable" Value="" />
      </Attributes>
    </data>
  </addData>
</variable>
```

Epas-5 XML code Init Step

```
<variable name="Switch1">
  <type>
    <derived name="SFCStepType" />
  </type>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/attributes"
    handleUnknown="implementation">
      <Attributes>
        <Attribute Name="Name" Value="Switch1" />
        <Attribute Name="MainAction" Value="Switch1_Action" />
        <Attribute Name="hide" Value="" />
        <Attribute Name="sfc-variable" Value="" />
      </Attributes>
    </data>
  </addData>
</variable>
```

Epas-5 XML code Switch1 Step

```
<variable name="Count">
  <type>
    <derived name="SFCStepType" />
  </type>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/attributes"
    handleUnknown="implementation">
      <Attributes>
        <Attribute Name="Name" Value="Count" />
        <Attribute Name="MainAction" Value="Count_Action" />
        <Attribute Name="hide" Value="" />
        <Attribute Name="sfc-variable" Value="" />
      </Attributes>
    </data>
  </addData>
</variable>
```

Epas-5 XML code Count Step

```
<variable name="Off">
  <type>
    <derived name="SFCStepType" />
  </type>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/attributes"
    handleUnknown="implementation">
      <Attributes>
        <Attribute Name="Name" Value="Off" />
        <Attribute Name="MainAction" Value="Off_Action" />
        <Attribute Name="hide" Value="" />
        <Attribute Name="sfc-variable" Value="" />
      </Attributes>
    </data>
  </addData>
</variable>
```

Epas-5 XML code Off Step

```xml
<variable name="Green2">
  <type>
    <derived name="SFCStepType" />
  </type>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/attributes"
    handleUnknown="implementation">
      <Attributes>
        <Attribute Name="Name" Value="Green2" />
        <Attribute Name="MainAction" Value="Green2_Action" />
        <Attribute Name="hide" Value="" />
        <Attribute Name="sfc-variable" Value="" />
      </Attributes>
    </data>
  </addData>
</variable>
```

Epas-5 XML code Green2 Step

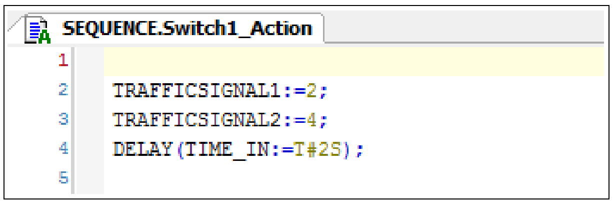
```xml
<variable name="Switch2">
  <type>
    <derived name="SFCStepType" />
  </type>
  <addData>
    <data name="http://www.3s-software.com/plcopenxml/attributes"
    handleUnknown="implementation">
      <Attributes>
        <Attribute Name="Name" Value="Switch2" />
        <Attribute Name="MainAction" Value="Switch2_Action" />
        <Attribute Name="hide" Value="" />
        <Attribute Name="sfc-variable" Value="" />
      </Attributes>
    </data>
  </addData>
</variable>
```

Epas-5 XML code Switch2 Step

```
    <variable name="Green1">
      <type>
        <derived name="SFCStepType" />
      </type>
      <addData>
        <data name="http://www.3s-software.com/plcopenxml/attributes"
        handleUnknown="implementation">
          <Attributes>
            <Attribute Name="Name" Value="Green1" />
            <Attribute Name="MainAction" Value="Green1_Action" />
            <Attribute Name="hide" Value="" />
            <Attribute Name="sfc-variable" Value="" />
          </Attributes>
        </data>
      </addData>
    </variable>
  </localVars>
</interface>
```

Epas-5 XML code Green1 Step

Actions:

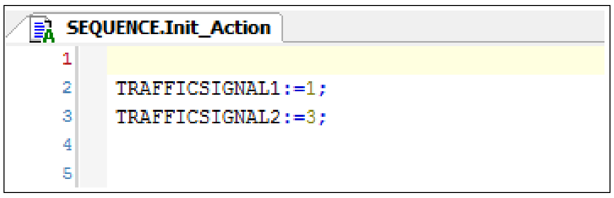


```

TRAFFICSIGNAL1:=2;
TRAFFICSIGNAL2:=4;
DELAY(TIME_IN:=T#2S);

```

Epas-5 Action Switch1

```
                <actions>
                  <action name="Switch1_Action">
                    <body>
                      <ST>
                        <xhtml xmlns="http://www.w3.org/1999/xhtml">

TRAFFICSIGNAL1:=2;
TRAFFICSIGNAL2:=4;
DELAY(TIME_IN:=T#2S);
</xhtml>
                      </ST>
                    </body>
                  </action>
```

Epas-5 XML code Action Switch1

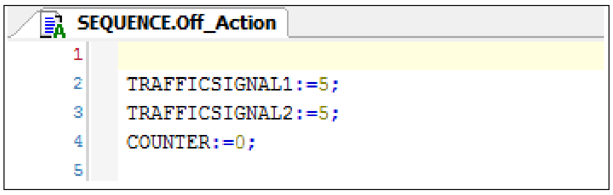

SEQUENCE.Init_Action

```
TRAFFICSIGNAL1:=1;
TRAFFICSIGNAL2:=3;
```

Epas-5 Action Init

```
                    <action name="Init_Action">
                      <body>
                        <ST>
                          <xhtml xmlns="http://www.w3.org/1999/xhtml">

TRAFFICSIGNAL1:=1;
TRAFFICSIGNAL2:=3;
</xhtml>
                        </ST>
                      </body>
                    </action>
```

Epas-5 XML code Action Init

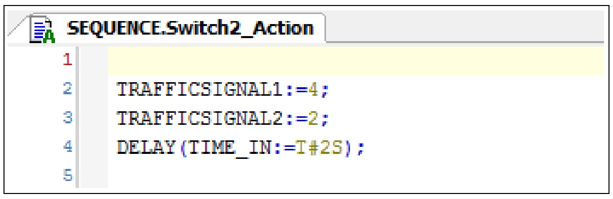

SEQUENCE.Off_Action

```
TRAFFICSIGNAL1:=5;
TRAFFICSIGNAL2:=5;
COUNTER:=0;
```

Epas-5 Action Off

```
                    <action name="Off_Action">
                      <body>
                        <ST>
                          <xhtml xmlns="http://www.w3.org/1999/xhtml">

TRAFFICSIGNAL1:=5;
TRAFFICSIGNAL2:=5;
COUNTER:=0;
</xhtml>
                        </ST>
                      </body>
                    </action>
```

Epas-5 XML code Action Off



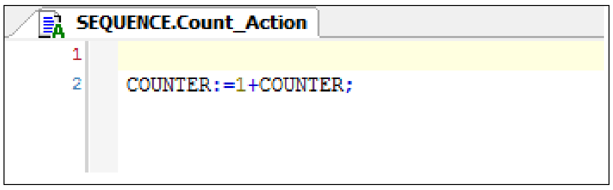
SEQUENCE.Switch2_Action

```

TRAFFICSIGNAL1:=4;
TRAFFICSIGNAL2:=2;
DELAY(TIME_IN:=T#2S);

```

Epas-5 Action Switch2

```
                                   <action name="Switch2_Action">
                                     <body>
                                       <ST>
                                         <xhtml xmlns="http://www.w3.org/1999/xhtml">
TRAFFICSIGNAL1:=4;
TRAFFICSIGNAL2:=2;
DELAY(TIME_IN:=T#2S);
</xhtml>
                                       </ST>
                                     </body>
                                   </action>
```

Epas-5 XML code Action Switch2



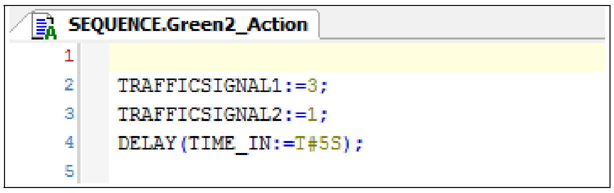
SEQUENCE.Count_Action

```

COUNTER:=1+COUNTER;
```

Epas-5 Action Count

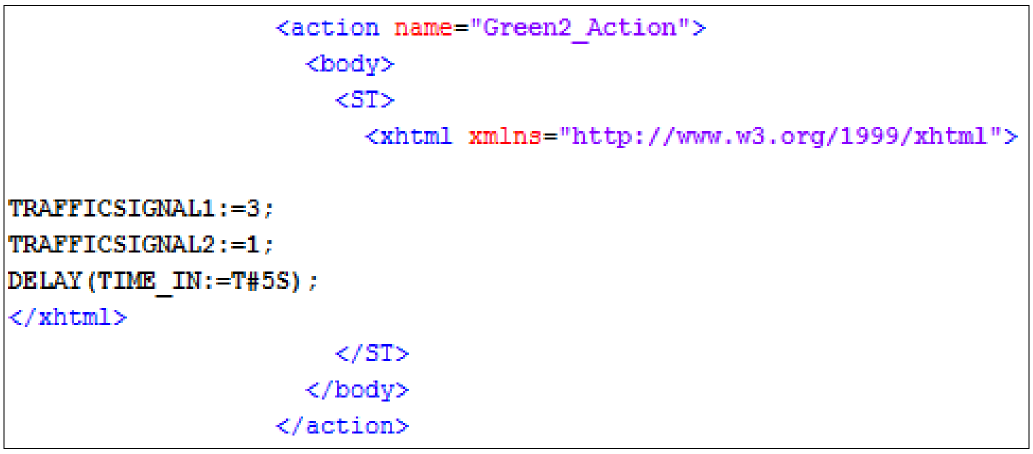
```
                                   <action name="Count_Action">
                                     <body>
                                       <ST>
                                         <xhtml xmlns="http://www.w3.org/1999/xhtml">
COUNTER:=1+COUNTER;
</xhtml>
                                       </ST>
                                     </body>
                                   </action>
```

Epas-5 XML code Action Count


SEQUENCE.Green2_Action

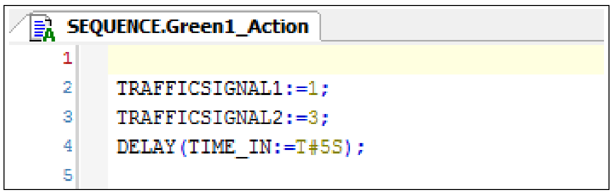
```

TRAFFICSIGNAL1:=3;
TRAFFICSIGNAL2:=1;
DELAY(TIME_IN:=T#5S);

```

Epas-5 Action Green2



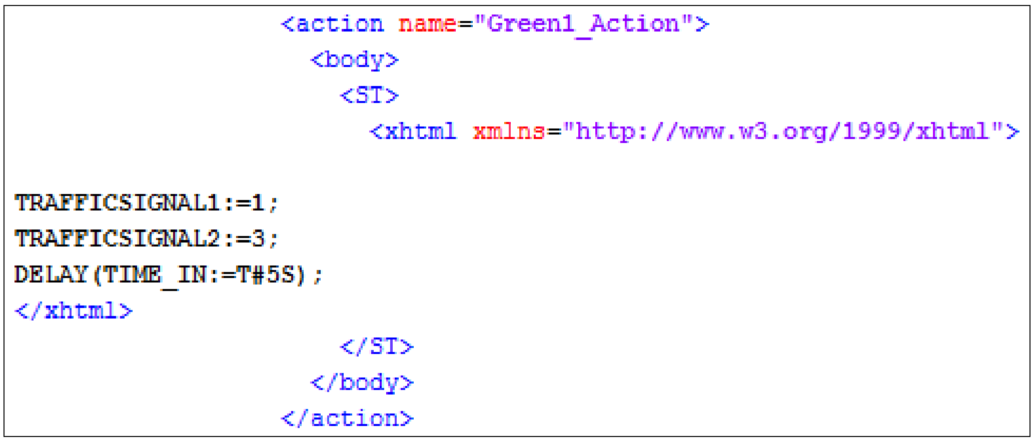
```
                  <action name="Green2_Action">
                    <body>
                      <ST>
                        <xhtml xmlns="http://www.w3.org/1999/xhtml">

TRAFFICSIGNAL1:=3;
TRAFFICSIGNAL2:=1;
DELAY(TIME_IN:=T#5S);
</xhtml>
                      </ST>
                    </body>
                  </action>
```

Epas-5 XML code Action Green2


SEQUENCE.Green1_Action

```

TRAFFICSIGNAL1:=1;
TRAFFICSIGNAL2:=3;
DELAY(TIME_IN:=T#5S);

```

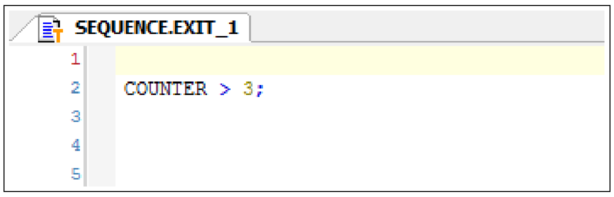
Epas-5 Action Green1



```
                  <action name="Green1_Action">
                    <body>
                      <ST>
                        <xhtml xmlns="http://www.w3.org/1999/xhtml">

TRAFFICSIGNAL1:=1;
TRAFFICSIGNAL2:=3;
DELAY(TIME_IN:=T#5S);
</xhtml>
                      </ST>
                    </body>
                  </action>
```

Epas-5 XML code Action Green1

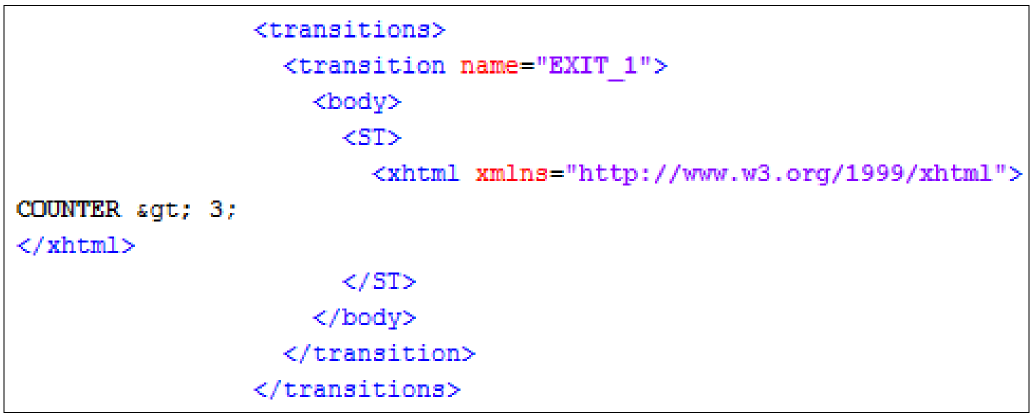
Transitions:



SEQUENCE.EXIT_1

```

COUNTER > 3;


```

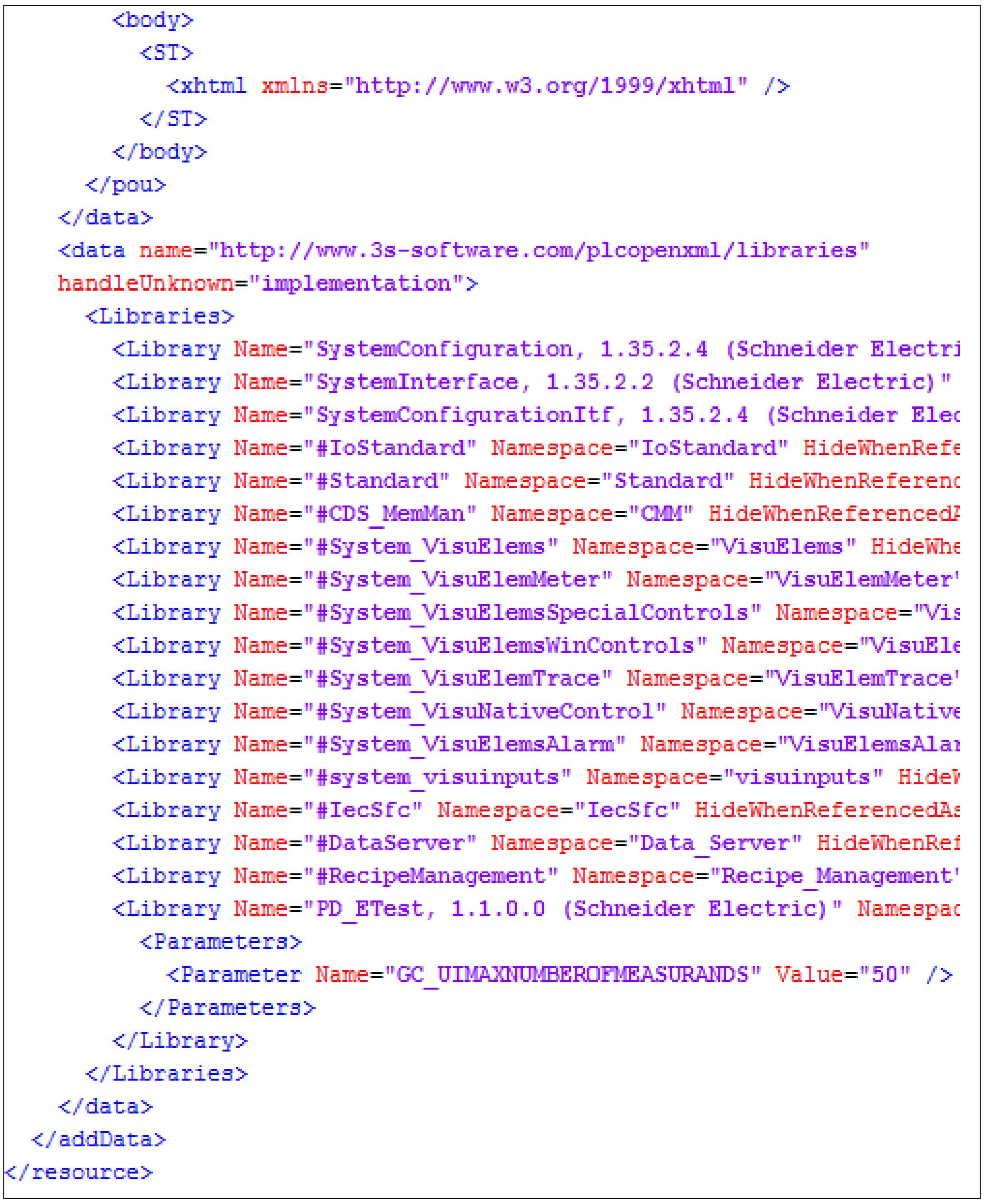
Epas-5 Transition EXIT_1



```
                        <transitions>
                          <transition name="EXIT_1">
                            <body>
                              <ST>
                                <xhtml xmlns="http://www.w3.org/1999/xhtml">
COUNTER &gt; 3;
</xhtml>
                              </ST>
                            </body>
                          </transition>
                        </transitions>
```

Epas-5 XML code Transition EXIT_1

<u>*Libraries:*</u>



```
        <body>
          <ST>
            <xhtml xmlns="http://www.w3.org/1999/xhtml" />
          </ST>
        </body>
      </pou>
    </data>
    <data name="http://www.3s-software.com/plcopenxml/libraries"
    handleUnknown="implementation">
      <Libraries>
        <Library Name="SystemConfiguration, 1.35.2.4 (Schneider Electri
        <Library Name="SystemInterface, 1.35.2.2 (Schneider Electric)"
        <Library Name="SystemConfigurationItf, 1.35.2.4 (Schneider Elec
        <Library Name="#IoStandard" Namespace="IoStandard" HideWhenRefe
        <Library Name="#Standard" Namespace="Standard" HideWhenReferenc
        <Library Name="#CDS_MemMan" Namespace="CMM" HideWhenReferencedA
        <Library Name="#System_VisuElems" Namespace="VisuElems" HideWhe
        <Library Name="#System_VisuElemMeter" Namespace="VisuElemMeter'
        <Library Name="#System_VisuElemsSpecialControls" Namespace="Vis
        <Library Name="#System_VisuElemsWinControls" Namespace="VisuEle
        <Library Name="#System_VisuElemTrace" Namespace="VisuElemTrace'
        <Library Name="#System_VisuNativeControl" Namespace="VisuNative
        <Library Name="#System_VisuElemsAlarm" Namespace="VisuElemsAla
        <Library Name="#system_visuinputs" Namespace="visuinputs" HideW
        <Library Name="#IecSfc" Namespace="IecSfc" HideWhenReferencedAs
        <Library Name="#DataServer" Namespace="Data_Server" HideWhenRef
        <Library Name="#RecipeManagement" Namespace="Recipe_Management'
        <Library Name="PD_ETest, 1.1.0.0 (Schneider Electric)" Namespac
          <Parameters>
            <Parameter Name="GC_UIMAXNUMBEROFMEASURANDS" Value="50" />
          </Parameters>
        </Library>
      </Libraries>
    </data>
  </addData>
</resource>
```

Epas-5 XML code Libraries used in Project

5.2 – configurations / configuration / addData

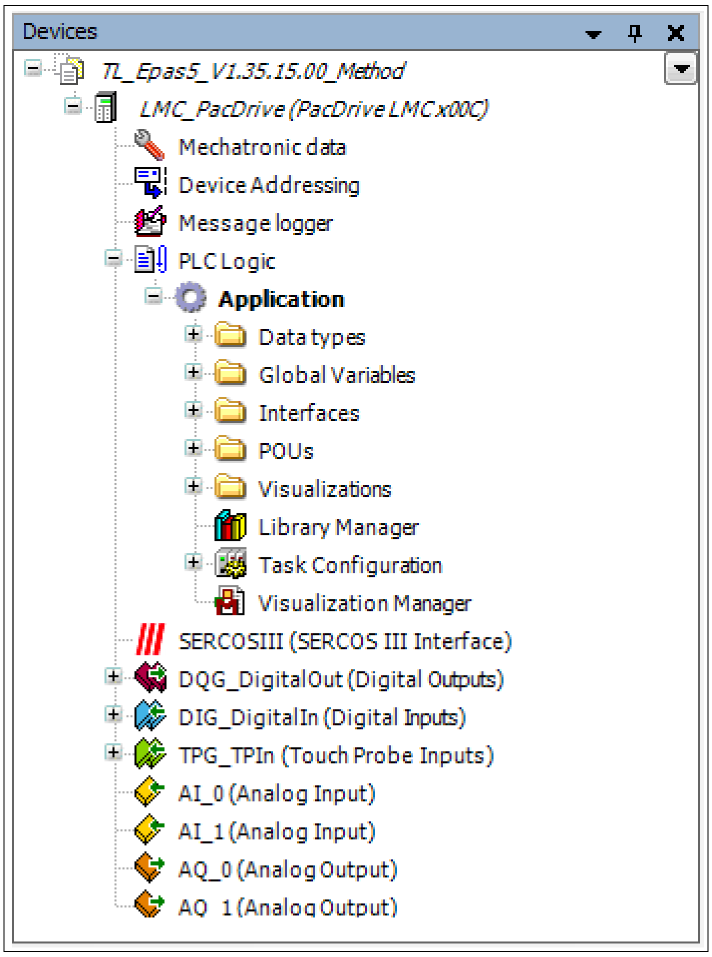
In this parameter is defined the configurations for PLC hardware.

```
<addData>
  <data name="Device" handleUnknown="discard">
    <Device xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns="">
      <DeviceType>
        <DeviceIdentification>
```

Epas-5 XML code Hardware, devices

6 – Add Data

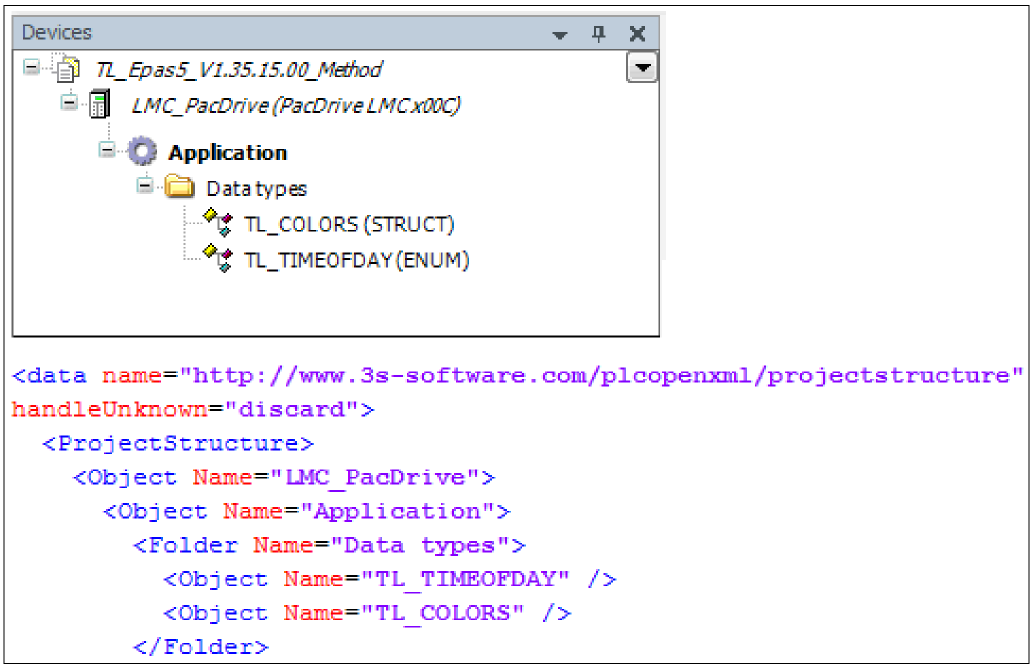
In this section XML print the project structure of all project. Is it showed the tree view for the IEC 61131-3 project.



```
Devices
TL_Epas5_V1.35.15.00_Method
  LMC_PacDrive (PacDrive LMC x00C)
    Mechatronic data
    Device Addressing
    Message logger
    PLC Logic
      Application
        Data types
        Global Variables
        Interfaces
        POUs
        Visualizations
        Library Manager
        Task Configuration
        Visualization Manager
    SERCOSIII (SERCOS III Interface)
    DQG_DigitalOut (Digital Outputs)
    DIG_DigitalIn (Digital Inputs)
    TPG_TPIn (Touch Probe Inputs)
    AI_0 (Analog Input)
    AI_1 (Analog Input)
    AQ_0 (Analog Output)
    AQ_1 (Analog Output)
```

Epas-5 Project tree view

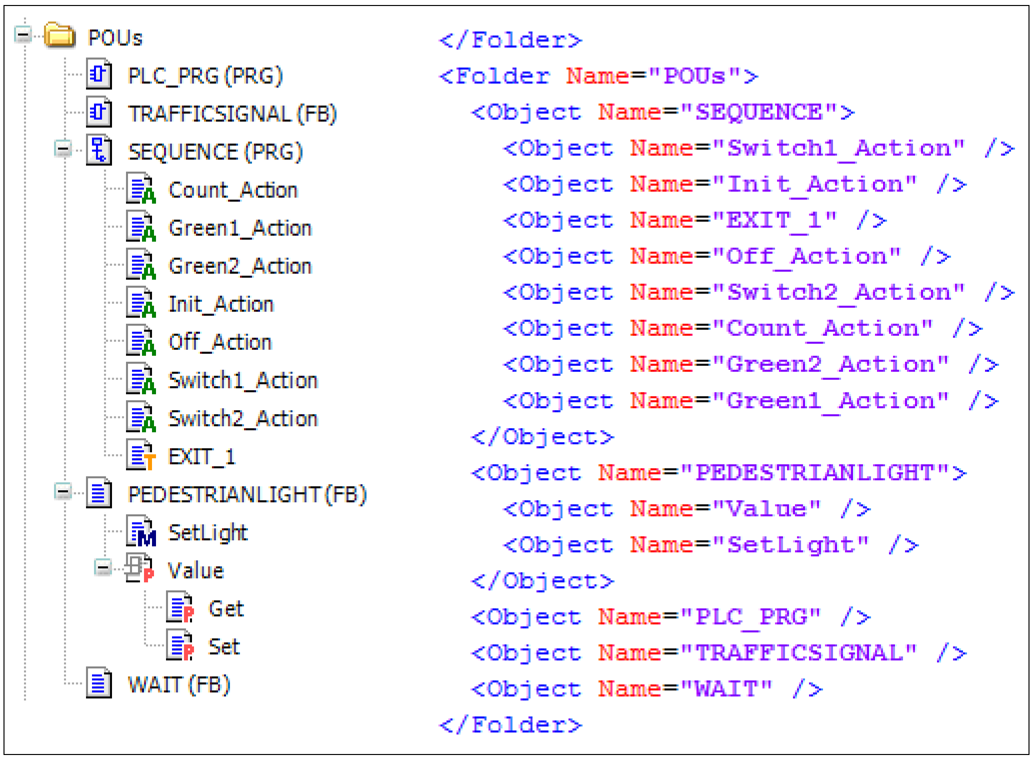
Application and Data Types folder:



```
<data name="http://www.3s-software.com/plcopenxml/projectstructure"
handleUnknown="discard">
  <ProjectStructure>
    <Object Name="LMC_PacDrive">
      <Object Name="Application">
        <Folder Name="Data types">
          <Object Name="TL_TIMEOFDAY" />
          <Object Name="TL_COLORS" />
        </Folder>
```

Epas-5 Project tree view Application and Data types

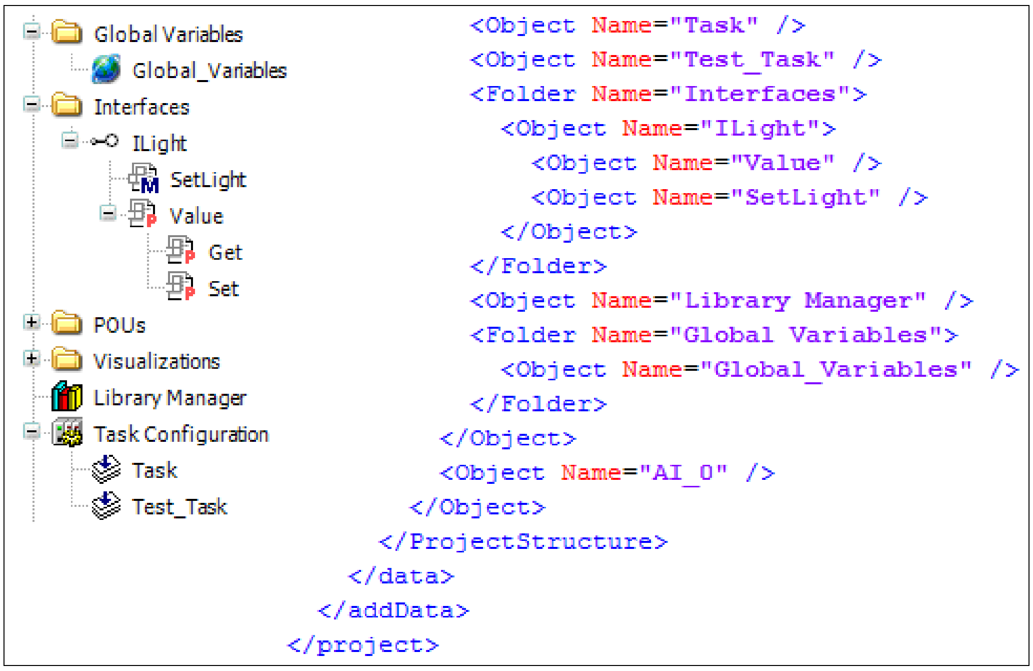
POUs folder:



```
</Folder>
<Folder Name="POUs">
  <Object Name="SEQUENCE">
    <Object Name="Switch1_Action" />
    <Object Name="Init_Action" />
    <Object Name="EXIT_1" />
    <Object Name="Off_Action" />
    <Object Name="Switch2_Action" />
    <Object Name="Count_Action" />
    <Object Name="Green2_Action" />
    <Object Name="Green1_Action" />
  </Object>
  <Object Name="PEDESTRIANLIGHT">
    <Object Name="Value" />
    <Object Name="SetLight" />
  </Object>
  <Object Name="PLC_PRG" />
  <Object Name="TRAFFICSIGNAL" />
  <Object Name="WAIT" />
</Folder>
```

Epas-5 Project tree view POUs folder

Global variables, Interfaces and Task configuration:



```
            <Object Name="Task" />
            <Object Name="Test_Task" />
            <Folder Name="Interfaces">
              <Object Name="ILight">
                <Object Name="Value" />
                <Object Name="SetLight" />
              </Object>
            </Folder>
            <Object Name="Library Manager" />
            <Folder Name="Global Variables">
              <Object Name="Global_Variables" />
            </Folder>
          </Object>
          <Object Name="AI_0" />
        </Object>
      </ProjectStructure>
    </data>
  </addData>
</project>
```

Epas-5 Project tree view folders

With the closing of the element “project” the ExportPLCopenXML code is finish.