TRDP

EN 50155 / IEC 60571
Railway Embedded Controller & Remote IO

Application note
TRDP communication over ETB

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Introduction

RIOM & BRIO are Ethernet-based input/output controller designed to be embedded on-board rolling stock vehicles.

RIOM & BRIO are fully compliant with the EN50155 standard for railway systems.

This application note describes the implementation of TRDP communications in the TCMS.

Following User Manuals for RIOM are available:

- ✓ User Manual "Hardware specifications" P_DOC_RIOM_001E
- ✓ User Manual "User's manual STRATON programming" P_DOC_RIOM_006E

Prerequisites

It is necessary that the user have technical knowledge in mechanical, electrical, and Ethernet networks for railway systems; following standards IEC61375-2-3, IEC61375-2-4 & IEC61375-2-5 are used for the network configuration and communication definition.

Safety instructions

Following symbols are used in this documentation in order to avoid user for potential risks:


Risk of personal injury or damage to the equipment.


Risk of an electrical hazard.

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1. Introduction

TRDP (Train Real-Time Data Protocol) is a new Ethernet communication protocol dedicated to TCMS (Train Control and Monitoring System) applications.

TRDP is defined in the IEC61375-2-3 standard: this standard specifies rules for the data exchange between consists in trains, in order to define a TCN (Train communication network) communication profile.

The objective of the communication profile is to ensure interoperability between consists of the trains with respect to the exchange of information.

This communication profile is adhered to the Ethernet Train Backbone (ETB) technology as defined in IEC 61375-2-5 standard. TRDP is also used in Ethernet Consist Network (ECN) technology as defined in IEC 61375-3-4 standard.

This application note describes TRDP communications over ETB and ECN networks.

TRDP is now available on all new Leroy Automation Ethernet devices designed for train.

1.1. Hardware Description

RIOM, acting as a VCU (Vehicle Control Unit), BRIO, acting as a remote IO, DDS (Driver Display Unit), Routers (ETBN: Ethernet Train Backbone Node) and Ethernet Switches () are units fully compliant with the EN50155 standard, and are designed to be integrated in embedded railway systems and subsystems.

Figure 2 : Leroy Automation RIOM

Figure 1 : Leroy Automation BRIO

Figure 3 : PIXY DDS

Figure 5 : VDS Ethernet Train Backbone Node

Figure 4 : VDS Consist Switch

1.2. System architecture

The system architecture is defined according to IEC61375-2-5 and IEC61375-3-4 standards.

The system described in this application note implements the following features:

- ETB line redundancy: redundant Ethernet line between each ETBN.
- 3 consists management: train inauguration process.
- Leader consist management: ECSC (ETB Control Service Client) & ECSP (ETB Control Service Provider) communication.
- TRDP communication: between RIOM (VCU) & ETBN (ETB Node), RIOM (VCU) & BRIO (remote IO).
- Process management (Doors) through the RIOM device
- DDS : monitoring of the Door & Speed process

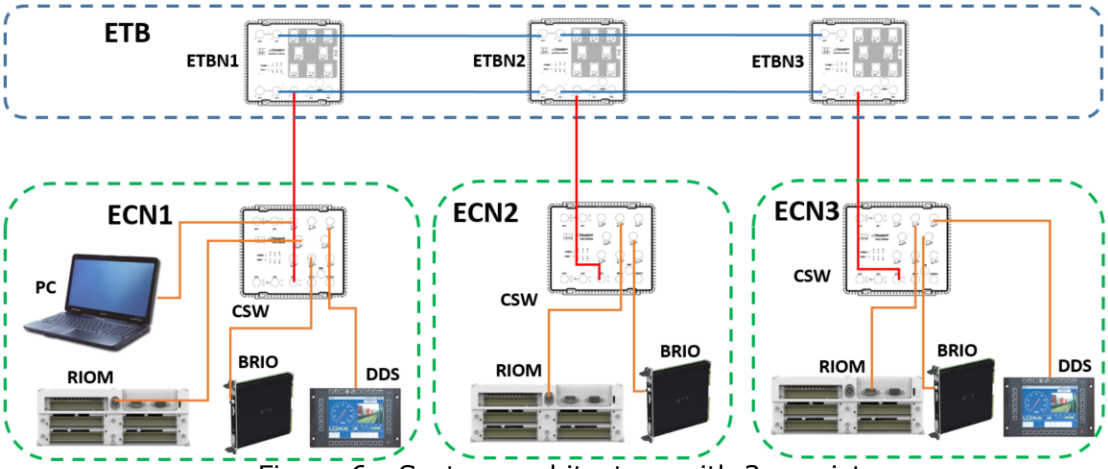


Figure 6 : System architecture with 3 consists

To increase the ECN availability, the architecture can be improved: the architecture below includes for ECN1 the following features:

- ETB-ECN line redundancy: two Ethernet lines are available between the ETB and ECN1: ETBN1 & ETBN2 are in redundancy mode.
- ECN Ethernet redundancy: two consist switches (CSW1 & CSW2) are connected together with a redundant Ethernet line.
- VCU redundancy: two RIOM (VCU) in this consist are in redundancy mode.

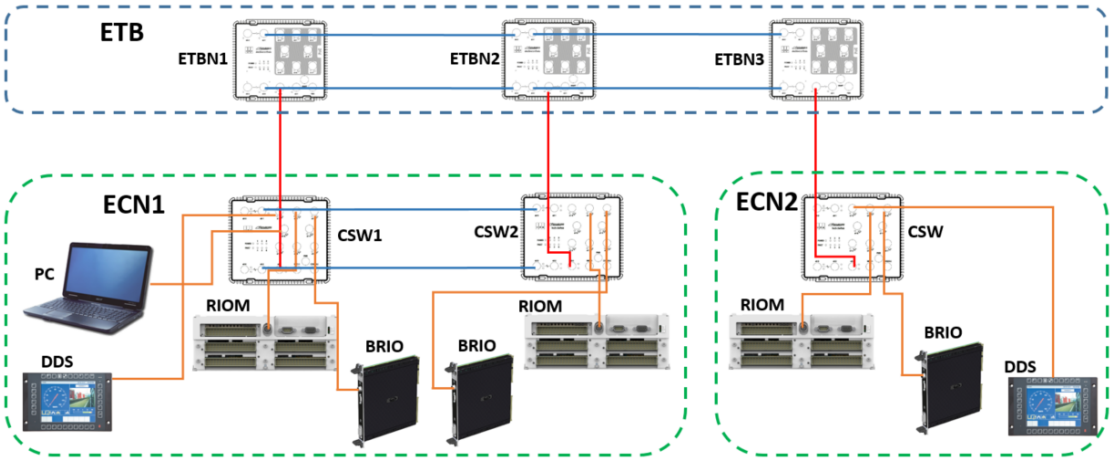


Figure 7 : System architecture with 2 consists, in

2. System implementation

2.1. Network configuration

VDS router & switches are configured with a PC software called "TTCMP Network Manager"; scripts are used in order to configure and enable the TCN and the TTDP (Train Topology Discovery Protocol) management.

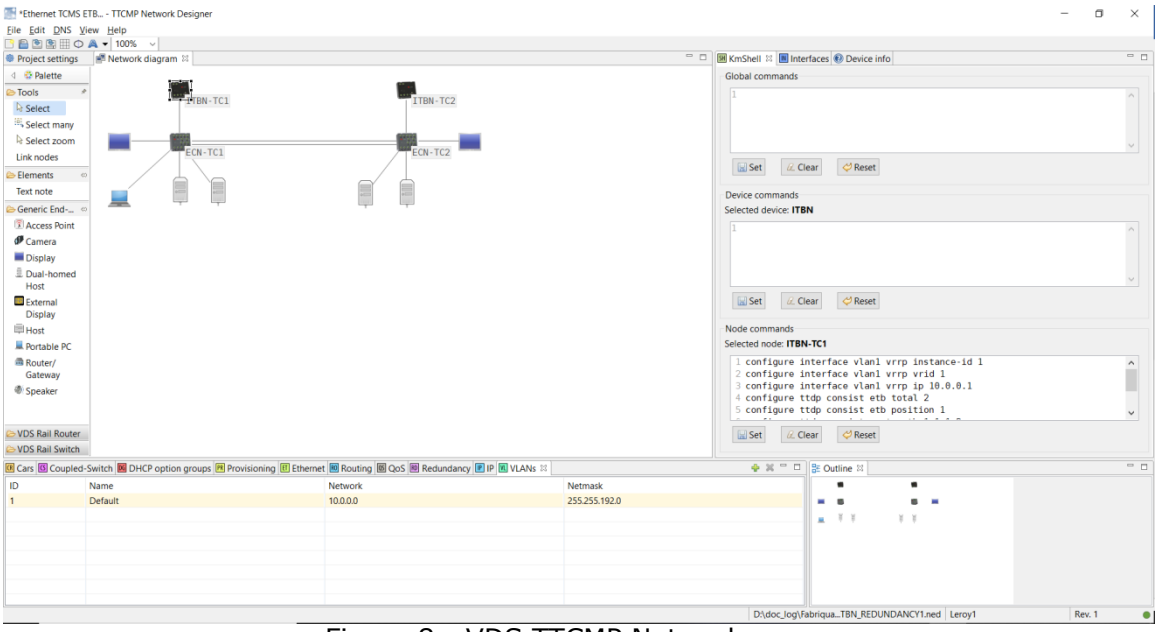


Figure 8 : VDS TTCMP Network manager

User manuals are available on request.

Deployment of the configuration in a router or a switch and all verifications are performed using VDS virtual machine called "Konfstation". Once uploaded to a router or switch, the configuration is automatically deployed to all other routers or switches in the Consist.

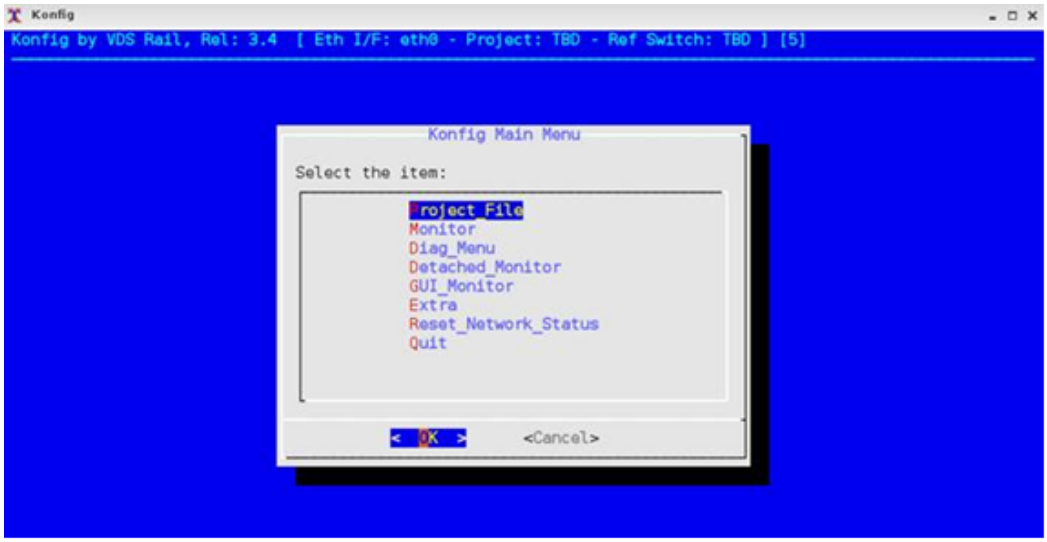


Figure 9 : VDS Konfstation virtual machine

2.2. RIOM programming

The IDE used for programming the RIOM is the **Straton** software from Copa-Data: its main features are listed below:

- Processes programming in IEC61131-3 languages
- Networks configuration through a Fieldbus editor
- Real time monitoring tools for the projects debugging

The project developed for this application note is divided in several programs each managing a process:

- Redundancy management with the second RIOM: "REDUND" program
- TRDP communication: "TRDP" program calling sub-programs located in folder "TRDP FUNCTIONS"
    - within the Local consist :
        - With remote IO : PD for the local process control
        - With the local ETBN: it is the VDS router (ECSP): standard TRDP PD and MD messages comID 100 to 131, for the train database, and the train leading control.
    - through the ETB, with the other consists:
        - With the RIOM of each other consists, TRDP PD messages, for the train process control.
- DDS communication management : "UDP_management" program
- Doors management : "DOORS" program

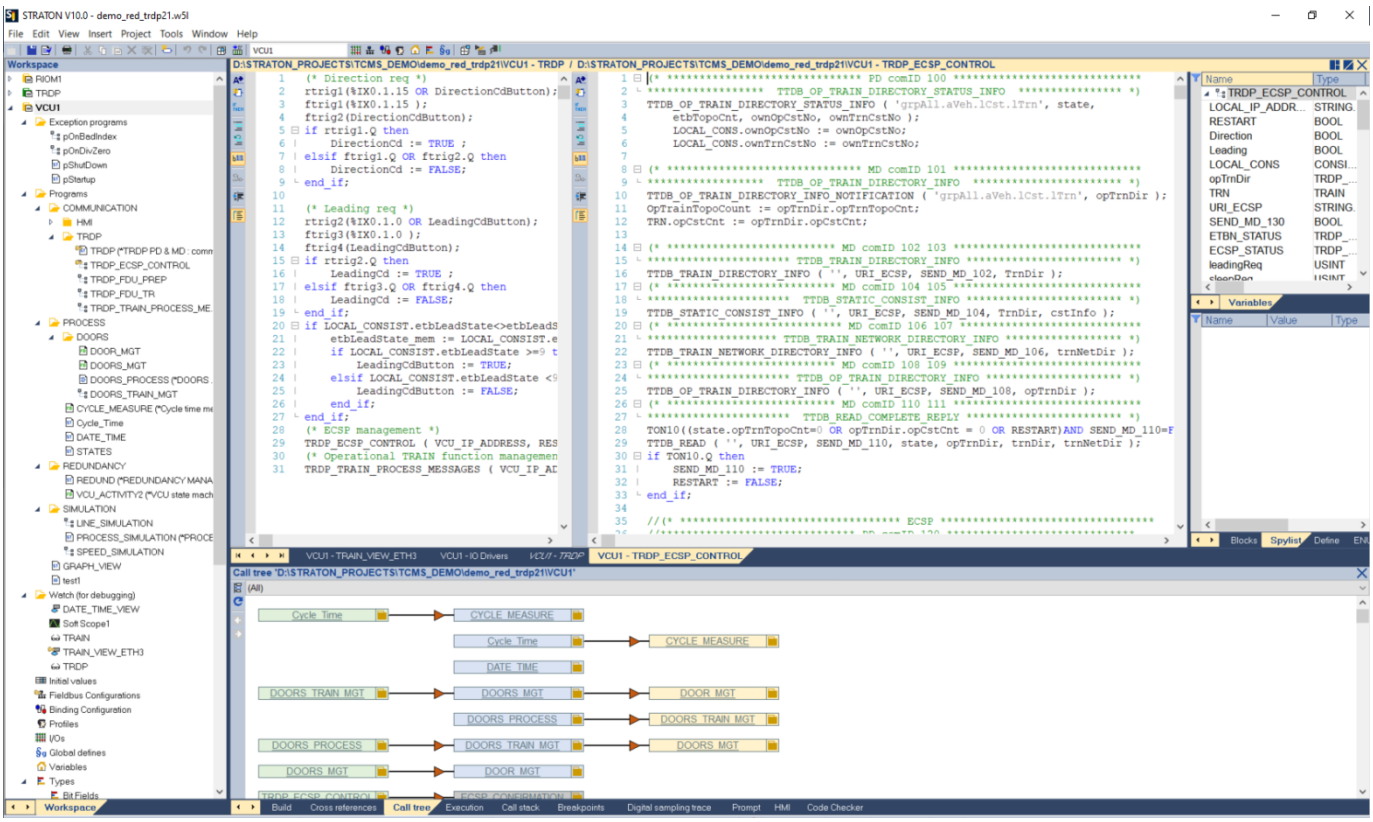


Figure 11: Straton IDE

2.2.1. Straton database

Straton allows defining variables, arrays, and structures: all the structures defined in IEC61375-2-3 are defined in the Straton library "TRDP", used by the RIOM project:

Figure 12: Straton TRDP structures definition

2.2.2. Communication with remote IO within the local consist

TRDP communication programming is available through the Straton fieldbus editor:

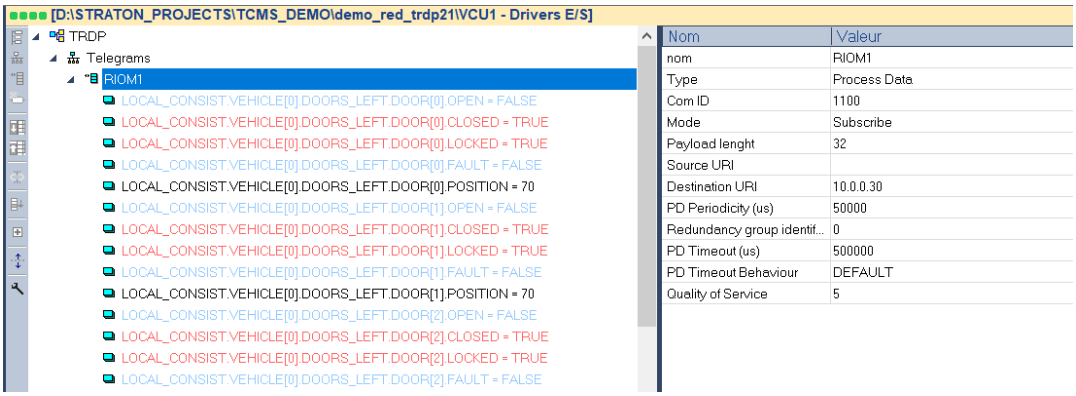


Figure 13: Straton fieldbus editor

2.2.3. Communication with the local ETBN:

A specific sub program "TRDP_ESCP_CONTROL" manages the communication with the ECSP (ETB Control Service Provider) that is provided by the ETBN:

```
(* ECSP management *)
TRDP_ECSP_CONTROL ( VCU_IP_ADDRESS, Restart, DirectionCd, LeadingCd, LOCAL_CONSIST, opTrainDir, TRN );
```

The RIOM act as the ECSC (ETB Control Service Client).
This sub program manages the following MD and PD:

- PD ComID 100: TTDB_OP_TRAIN_DIRECTORY_STATUS_INFO
- MD ComID 101: TTDB_OP_TRAIN_DIRECTORY_INFO
- MD ComID 110 & 111: TTDB_READ_COMPLETE_REPLY
- PD comID 120: ECSP control telegram
- PD comID 121: ECSP status telegram
- MD comID 122: ECSP confirmation/correction telegram
- MD comID 123: ECSP confirmation/correction reply data

The complete TTDB will then be acquired by the RIOM with message ComID 111.

The ECSP control telegram allows to change the state of the local consist, from follower state to Leader state.

2.2.4. Communication with other consists

The RIOM, VCU in Leader consist, will send PD command messages to other VCU in follower consists, as defined in IEC 61375-2-4:

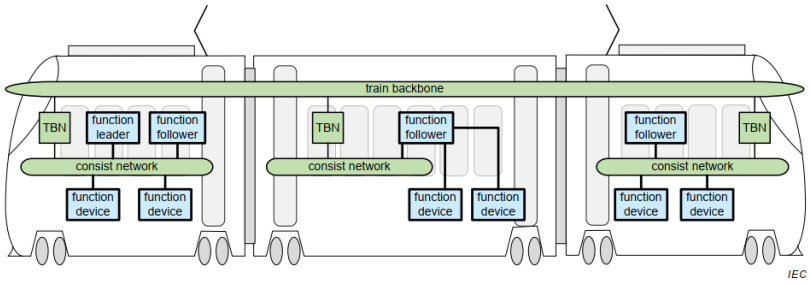


Figure 14 : communication with other consists

A specific sub program "TRDP_TRAIN_PROCESS_MESSAGES" manages all PD messages over the ETB: those PD messages depend on the local consist state, follower or leader:

Those PD are managed dynamically at each TTDB change detection.

Each VCU in follower consist sends its function states to the VCU in leader consist.

The VCU in leader consist sends the function commands to each VCU in follower consist.

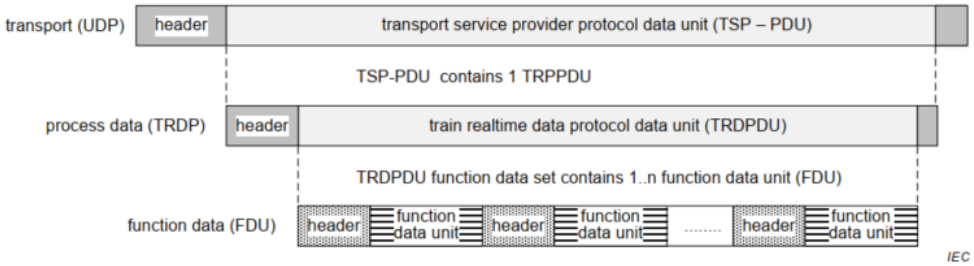


Figure 15: Function Data Unit definition

FDUs are automatically managed in the "TRDP_TRAIN_PROCESS_MESSAGES" sub program.

In this project, the following functions are managed: External doors, Driving and brake controls, and Interior lighting equipment. Function Id and SubId are compliant with UIC556.

```
(**********  FDU PREPARATION FOR SENDING COMMANDS TO FOLLOWER CONSISTS  **********)
// Doors management
// Left Doors
FDU_SEND_LEADER[0].Header.FunctionId := 16#92 ; // External doors
FDU_SEND_LEADER[0].Header.FunctionSubId := 0 ; // External doors
FDU_SEND_LEADER[0].Header.ChannelId := 0;
FDU_SEND_LEADER[0].Header.InstanceInfo := 1;// Left Doors
FDU_SEND_LEADER[0].Header.ControlInfo := 0; //
FDU_SEND_LEADER[0].Header.LifeSign := LifeSign;
FDU_SEND_LEADER[0].Header.DataLength := 3; //
FDU_SEND_LEADER[0].DataSet[0] := ANY_TO_USINT(TRN.CONSIST[CST_INDEX].DOORS_LEFT.CD_LOCK);
FDU_SEND_LEADER[0].DataSet[1] := ANY_TO_USINT(TRN.CONSIST[CST_INDEX].DOORS_LEFT.CD_CLOSE);
FDU_SEND_LEADER[0].DataSet[2] := ANY_TO_USINT(TRN.CONSIST[CST_INDEX].DOORS_LEFT.CD_OPEN);
```

Figure 16: Function Data Unit application

2.3. DDS programming

The PIXY touch screen is programed with PIXY PAD software: it allows to define screens, configure the communication and to program action on events.
Ethernet communication is only with the VCU within the consist.

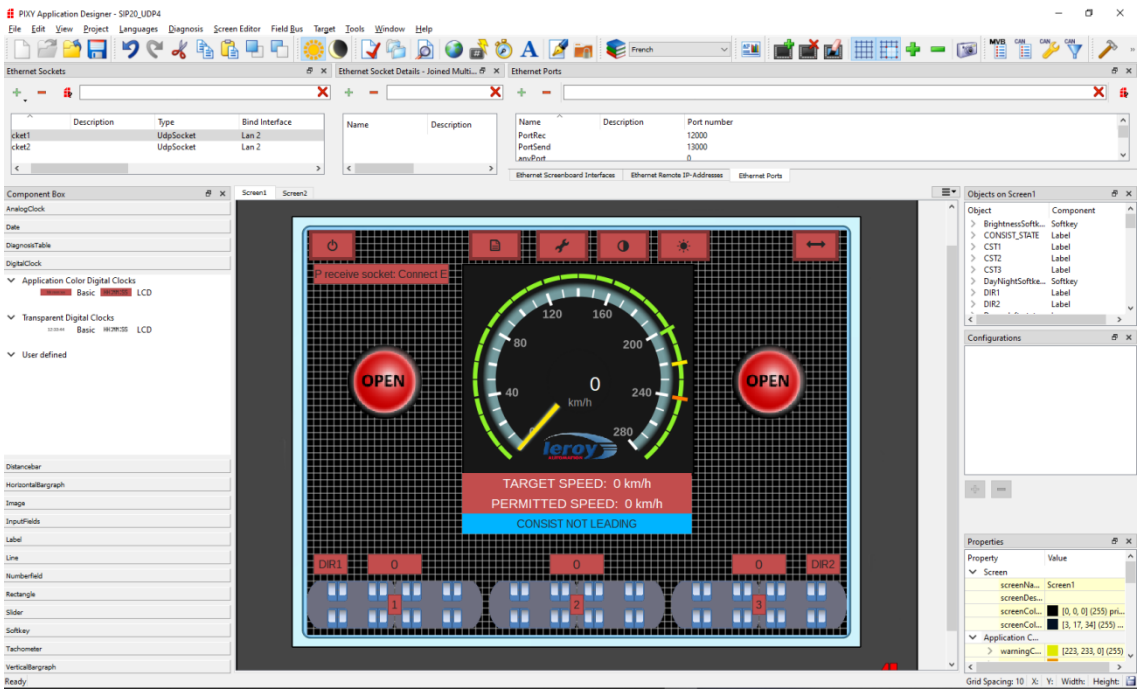


Figure 17 : PIXY PAD software

Event/Action editor:

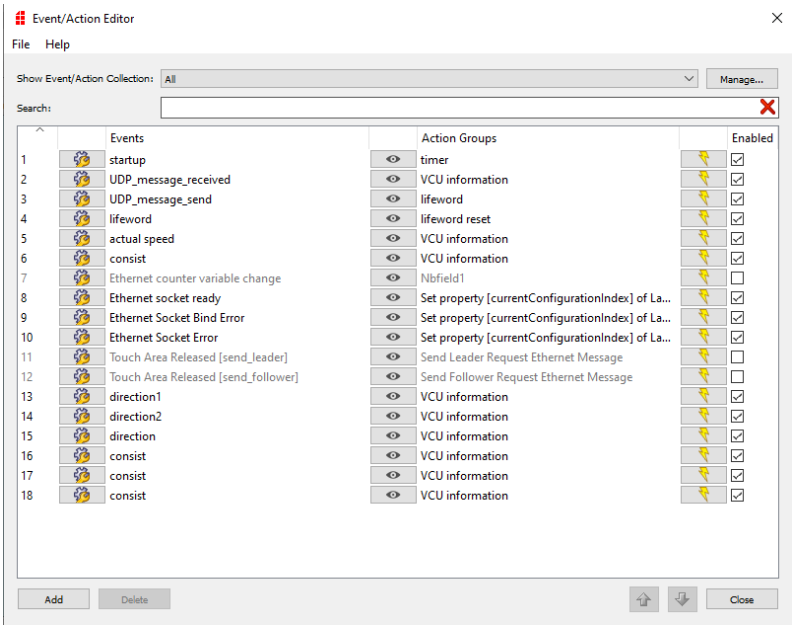


Figure 18: Pixy PAD event/action editor

2.4. System test

At startup, after inauguration step, all consists are enumerated and in the Follower state.

2.4.1. Consist 1 Leader state case

VCU in consist 1 sends a Leader request to the local ETBN in order to change the local consist state from Follower to Leader.

Result: Consist 1 becomes Leader and consist 2 & 3 remain as Followers: all the train programmed functions are driven by the VCU in Consist 1: Doors commands, Traction commands, Light commands.

VCU in consist 1 sends a Follower request to the local ETBN: Consist 1 returns to the Follower state.

2.4.2. Consist 3 Leader state case

VCU in consist 3 sends a Leader request to the local ETBN in order to change the local consist state from Follower to Leader.

Result: Consist 2 becomes Leader and consist 1 & 2 remain as Followers: all the train programmed functions are driven by the VCU in Consist 3: Doors commands, Traction commands, Light commands.

VCU in consist 3 sends a Follower request to the local ETBN: Consist 3 returns to the Follower state.

2.4.3. Straton Monitoring, Debugging & list view

Straton in "Online" mode allows to animate any edition view with real values defined in the Straton project:

Straton graphic views allow to define process animated views:

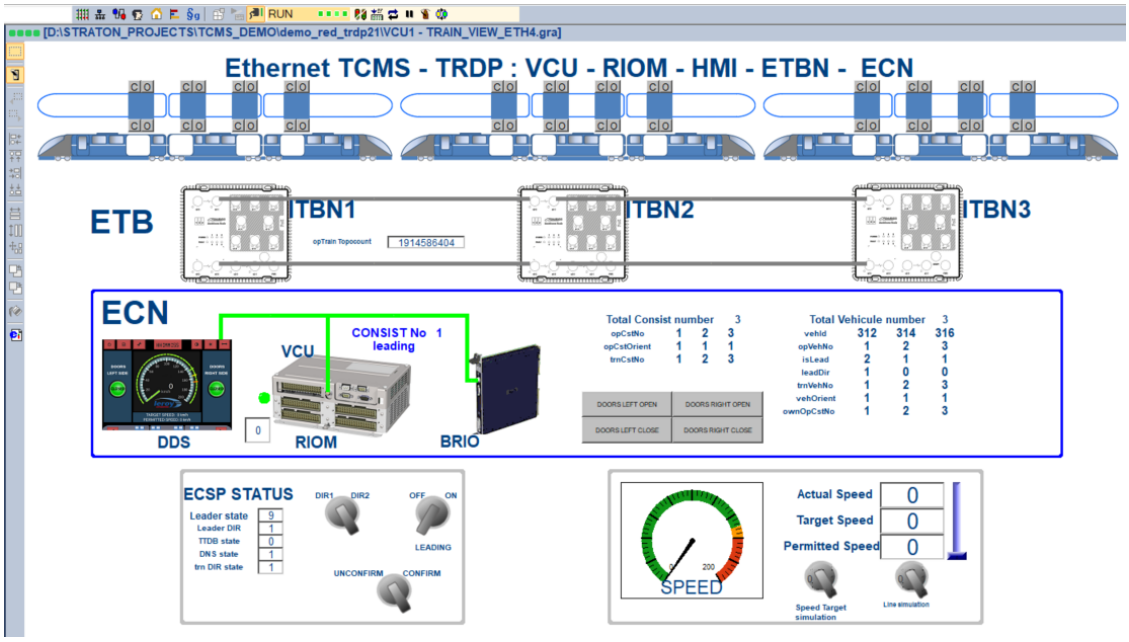


Figure 19: STRATON Graphic View

Straton programs are animated with variable real values; for structured text programs, real values are inserted dynamically next to each variable name:

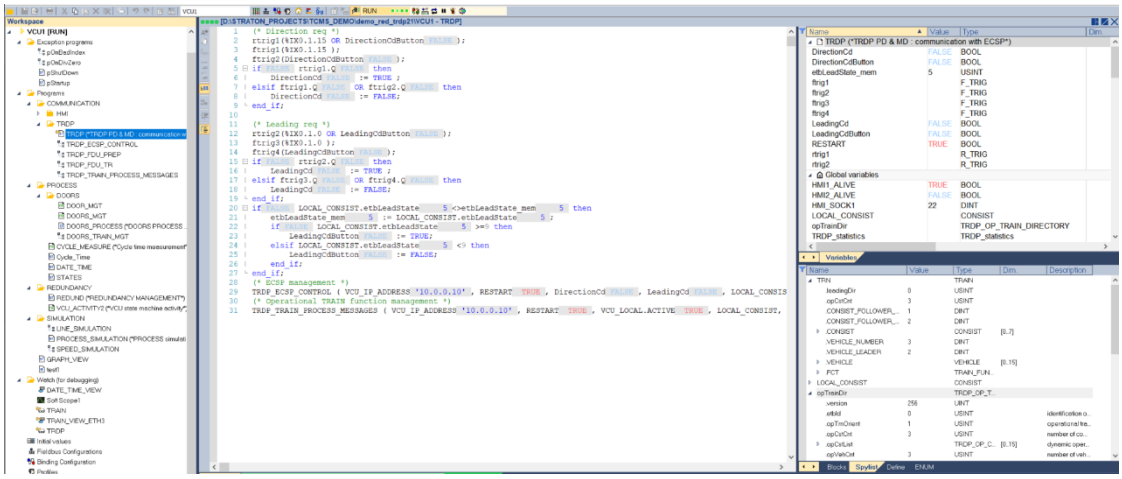
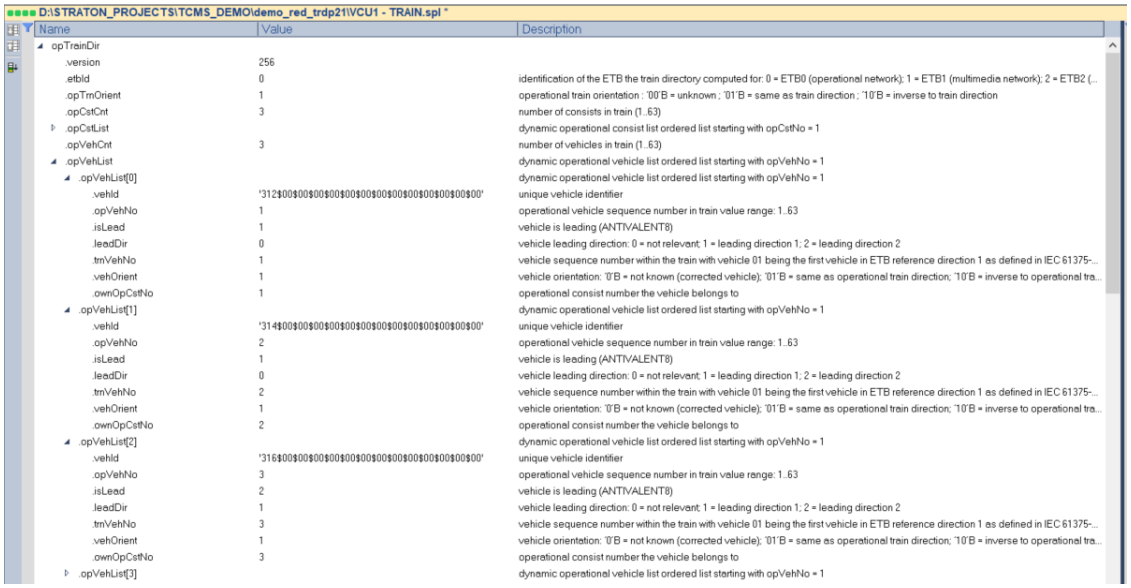


Figure 20 : Straton program online view

Straton spy lists allow spying the real value of any Straton variable:



Name	Value	Description
opTrainDir		
.version	256	
.etbId	0	identification of the ETB the train directory computed for: 0 = ETB0 (operational network); 1 = ETB1 (multimedia network); 2 = ETB2 (...
.opTrnOrient	1	operational train orientation : '00'B = unknown ; '01'B = same as train direction ; '10'B = inverse to train direction
.opCstCnt	3	number of consists in train (1..63)
.opCstList		dynamic operational consist list ordered list starting with opCstNo = 1
.opVehCnt	3	number of vehicles in train (1..63)
.opVehList		dynamic operational vehicle list ordered list starting with opVehNo = 1
.opVehList[0]		dynamic operational vehicle list ordered list starting with opVehNo = 1
.vehId	'312$00$00$00$00$00$00$00$00$00$00$00$00$00'	unique vehicle identifier
.opVehNo	1	operational vehicle sequence number in train value range: 1..63
.isLead	1	vehicle is leading (ANTIVALENT8)
.leadDir	0	vehicle leading direction: 0 = not relevant; 1 = leading direction 1; 2 = leading direction 2
.trnVehNo	1	vehicle sequence number within the train with vehicle 01 being the first vehicle in ETB reference direction 1 as defined in IEC 61375-...
.vehOrient	1	vehicle orientation: '0'B = not known (corrected vehicle); '01'B = same as operational train direction; '10'B = inverse to operational tra...
.ownOpCstNo	1	operational consist number the vehicle belongs to
.opVehList[1]		dynamic operational vehicle list ordered list starting with opVehNo = 1
.vehId	'314$00$00$00$00$00$00$00$00$00$00$00$00$00'	unique vehicle identifier
.opVehNo	2	operational vehicle sequence number in train value range: 1..63
.isLead	1	vehicle is leading (ANTIVALENT8)
.leadDir	0	vehicle leading direction: 0 = not relevant; 1 = leading direction 1; 2 = leading direction 2
.trnVehNo	2	vehicle sequence number within the train with vehicle 01 being the first vehicle in ETB reference direction 1 as defined in IEC 61375-...
.vehOrient	1	vehicle orientation: '0'B = not known (corrected vehicle); '01'B = same as operational train direction; '10'B = inverse to operational tra...
.ownOpCstNo	2	operational consist number the vehicle belongs to
.opVehList[2]		dynamic operational vehicle list ordered list starting with opVehNo = 1
.vehId	'316$00$00$00$00$00$00$00$00$00$00$00$00$00'	unique vehicle identifier
.opVehNo	3	operational vehicle sequence number in train value range: 1..63
.isLead	2	vehicle is leading (ANTIVALENT8)
.leadDir	1	vehicle leading direction: 0 = not relevant; 1 = leading direction 1; 2 = leading direction 2
.trnVehNo	3	vehicle sequence number within the train with vehicle 01 being the first vehicle in ETB reference direction 1 as defined in IEC 61375-...
.vehOrient	1	vehicle orientation: '0'B = not known (corrected vehicle); '01'B = same as operational train direction; '10'B = inverse to operational tra...
.ownOpCstNo	3	operational consist number the vehicle belongs to
.opVehList[3]		dynamic operational vehicle list ordered list starting with opVehNo = 1

Figure 21: Straton Spy list view

3. Conclusion

This application note shows that it is possible to control a complete train from any VCU with the TRDP communication protocol.

This application note shows also the use of several redundancy systems at different levels: Ethernet line redundancy (ETB and ECN level), Ethernet train node redundancy, VCU redundancy, Remote IO redundancy, in order to provide a high level of system availability.

Appendix: Table of Figures