61850 SCL Runner

The tool capable of simulating a network of IEC 61850 server devices using SCL files. Overview.

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From the recognized supplier of IEC 61850 software libraries and testing tools

- **IEC 61850 Software Library (source code)**
  - **Client part**
  - **Server part**
  - **GOOSE part**
  - **SV part**
- **61850 CCC and 61850 SCC – client and server communication DLLs for MS Windows**
- **61850 Avenue - testing toolset**
  - **IEC 61850 client tool**
  - **61850 Relay Simulator**
  - **GOOSE toolset**
  - **Sampled Values toolset**
  - **61850 ICD Editor**
- **61850 GOOSE System Viewer - testing & monitoring tool**

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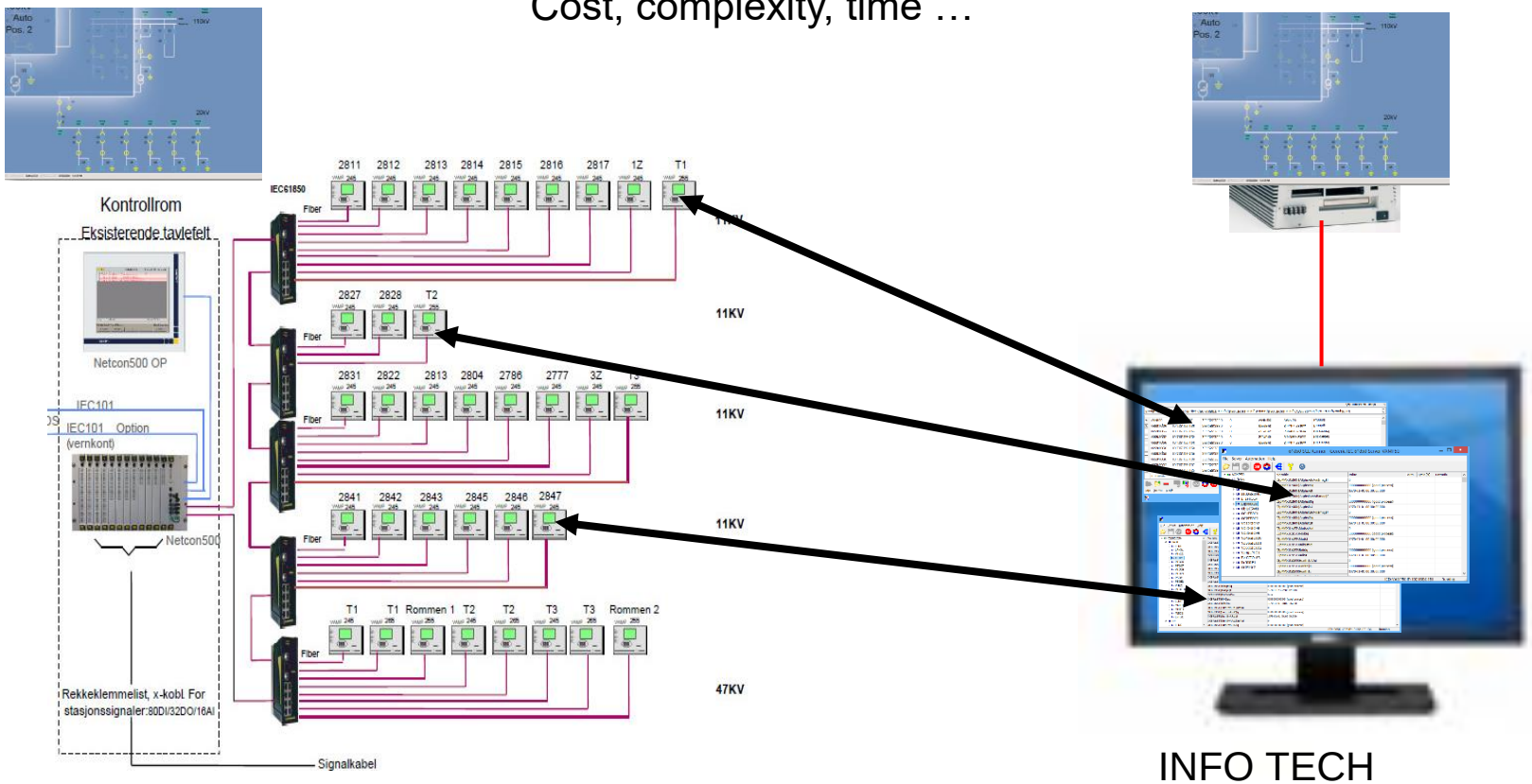
Problem to solve: How to prepare and verify the configuration of the control system?

- One possible approach for the test lab:
  - Acquire all devices to be installed in the target place.
  - Find and implement the way how process data changes and parameter data changes can be stimulated and how controls can be traced.
  - Build a test network together with the control system to be configured.
  - Configure/reconfigure the devices and the control system and test all configured communication exchanges (can be thousands of signals and data points).
  - Iterate the previous step until all obtained test results are correct.

- Is there any more economic and less laborious approach?

Which way of testing is easier? Real system vs simulated system

Cost, complexity, time …



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61850 SCL Runner – for whom

- Configuration of IEC 61850 based control systems is complex due to thousands of data points in tens of intelligent electronic devices (IEDs).
- Configuration engineers begin with offline configuration of the control system based on collected SCL files (communication capabilities of IEDs are described in standard based **S**ubstation **C**onfiguration description **L**anguage, called SCL).
- It would be ideal to verify the control system configuration still before being able to build the target installation with real communication network and tens of devices.
- Here comes the support …

61850 SCL Runner – how

- Collected ICD/CID/SCD files can be used to setup an IEC 61850 server device simulator running on MS Windows PC.
- One or more server devices (IEDs) can be simulated using different IP addresses.
- Data models exactly as in real IEDs.
- Data changes can be defined by the user using formulas: either as fixed values or variable and time dependent.
- The simulator supports data sets and the reporting function with BRCBs and URCBs: data and quality changes, integrity period and GI trigger reports.
- All subscribed data flows can be tested by one click.
- The simulator supports control functions with proper behavior dependent on the control model.
- The simulator supports GOOSE publishing (GoCB) and GOOSE subscription (Inputs).
- IED start, stop and communication break-down situations can be easily tested by one click.

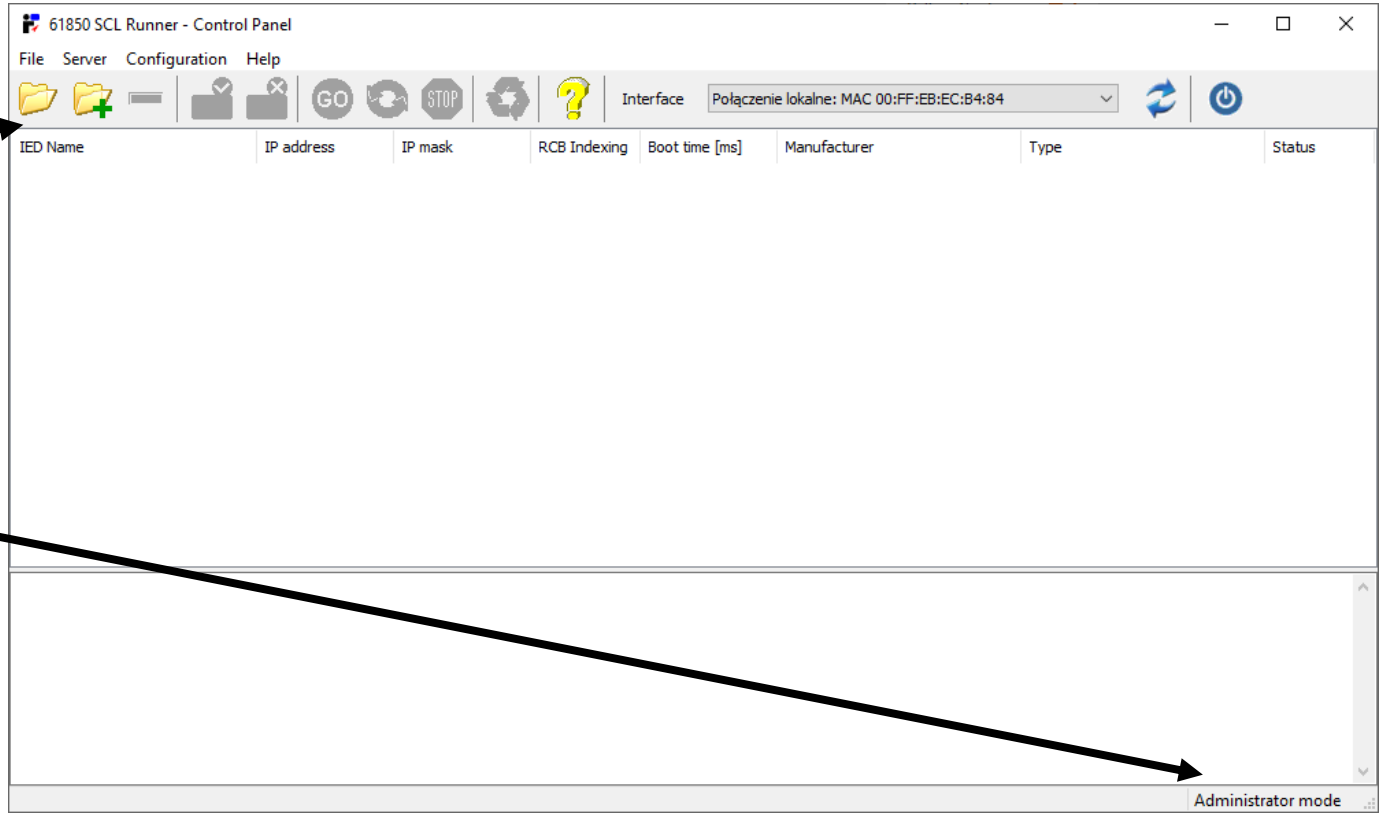
61850 SCL Runner – why

- Test the control system under configuration (IEC 61850 client end) for proper data access from simulated target devices – using real SCL files.
- Save money by reducing purchases of various devices from different vendors to your test lab.
- Save time by avoiding creation of the target system replica in your lab.
- Focus on most critical parts of the project before going to the installation site instead of being distracted with lots of device vendor specific details.

Initial view after the start-up

Simple, intuitive GUI to begin with opening an SCL file.

Remember to run the program in administrator mode – if target IP addresses shall be used.



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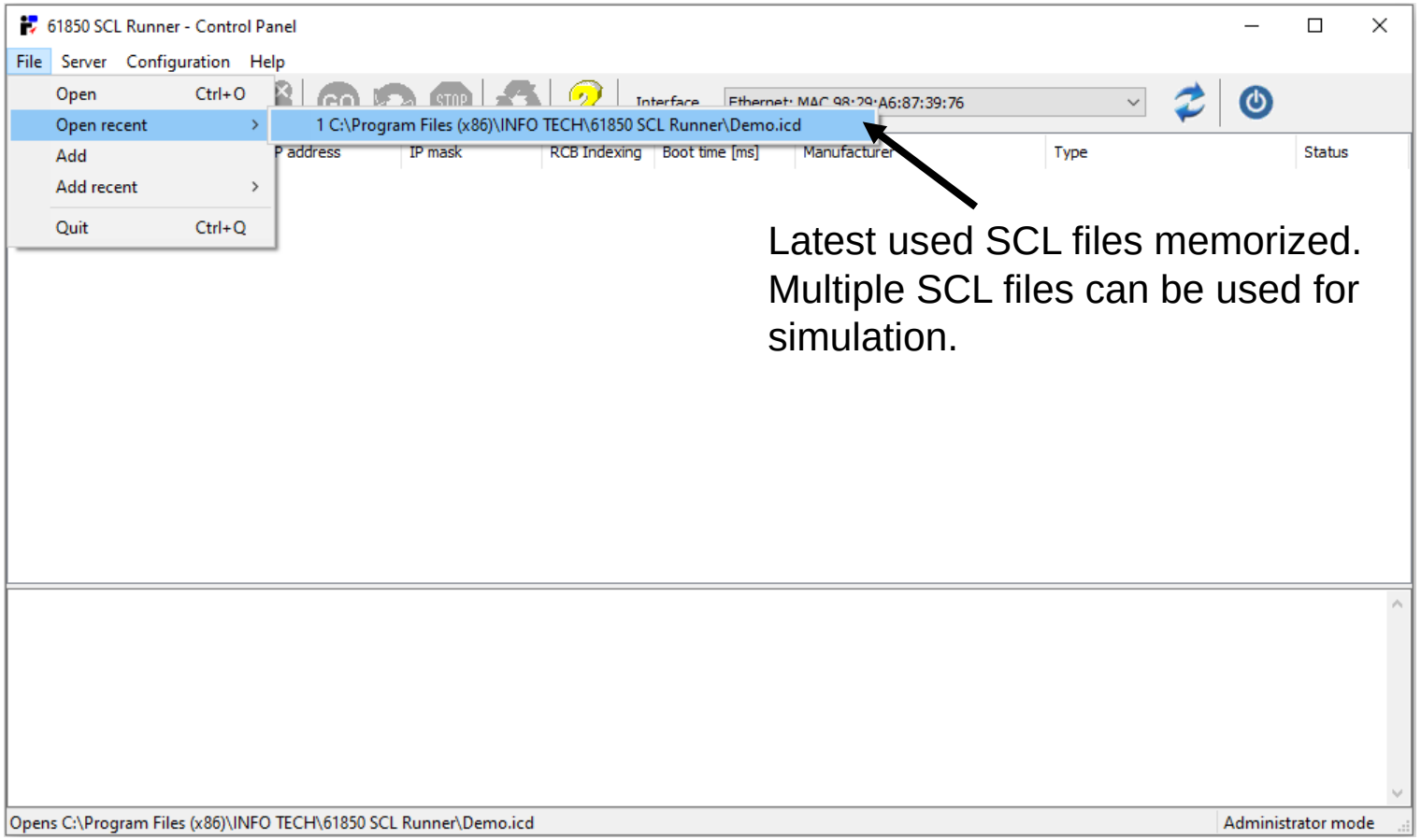
Selection of ICD, CID or SCD file



Latest used SCL files memorized. Multiple SCL files can be used for simulation.

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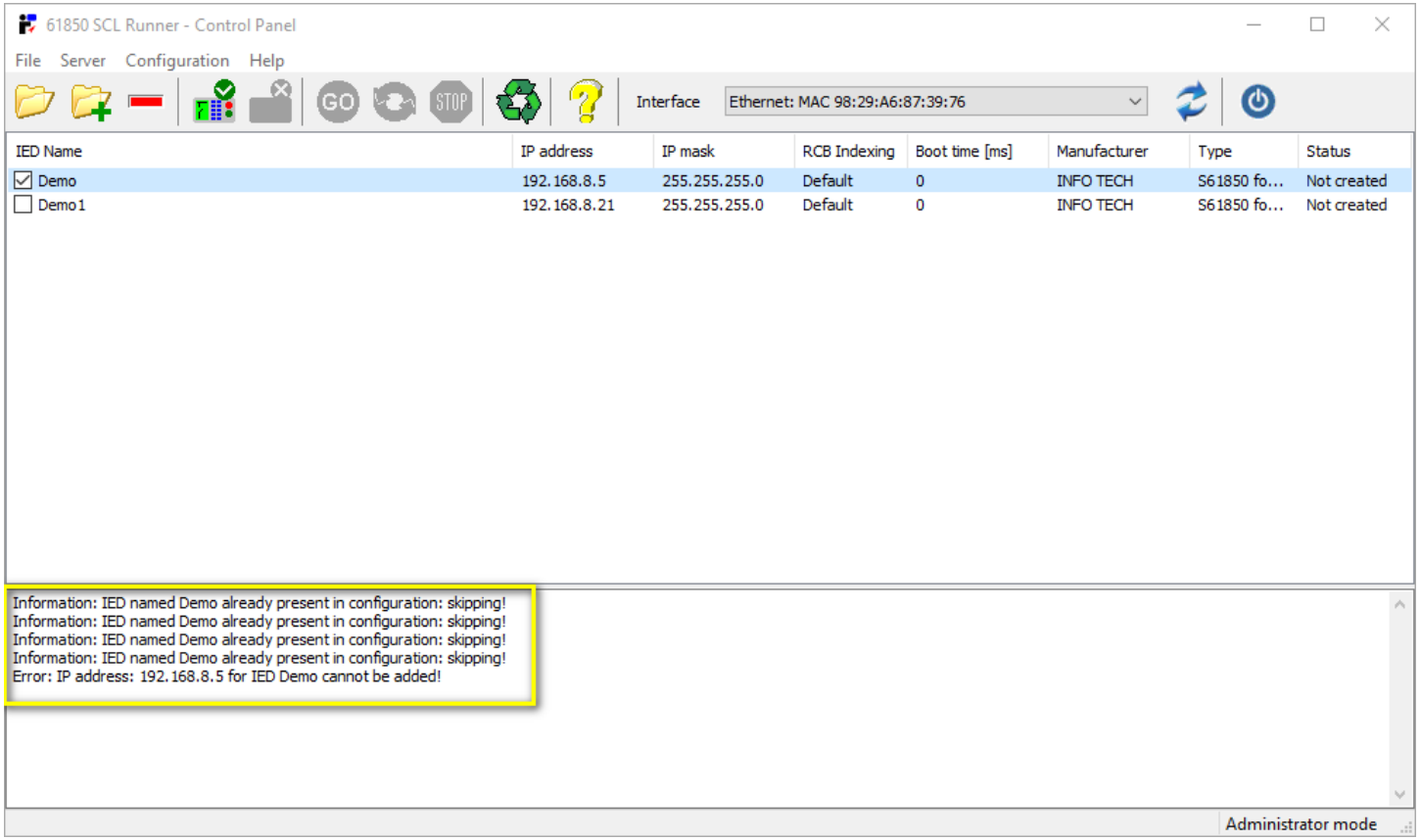
SCL file parsed



Extracted from SCL file: IED name, IP address, IP mask, IED vendor, IED type description.

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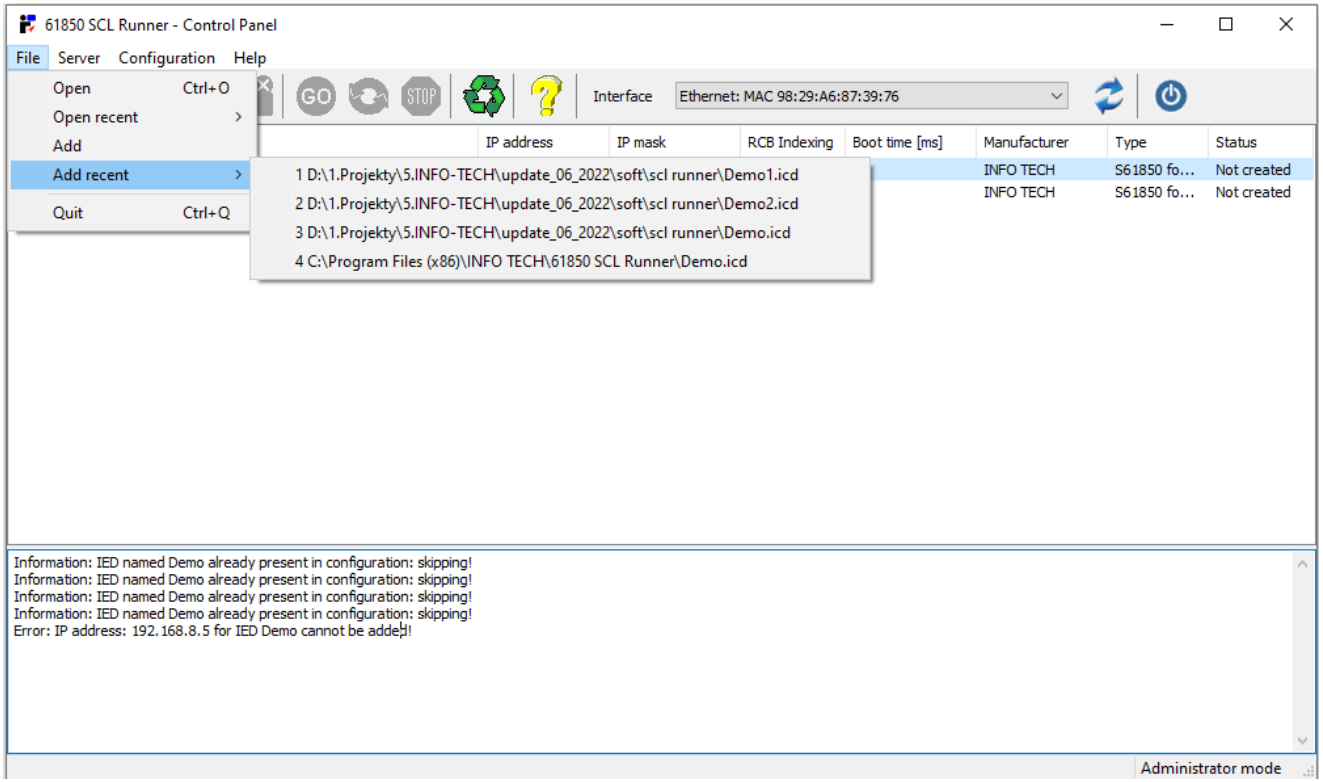
Multiple SCL files can be used



As it is possible that the control system configuration and the simulation will be based on multiple SCL files (ICD/CID) instead of using one SCD file.

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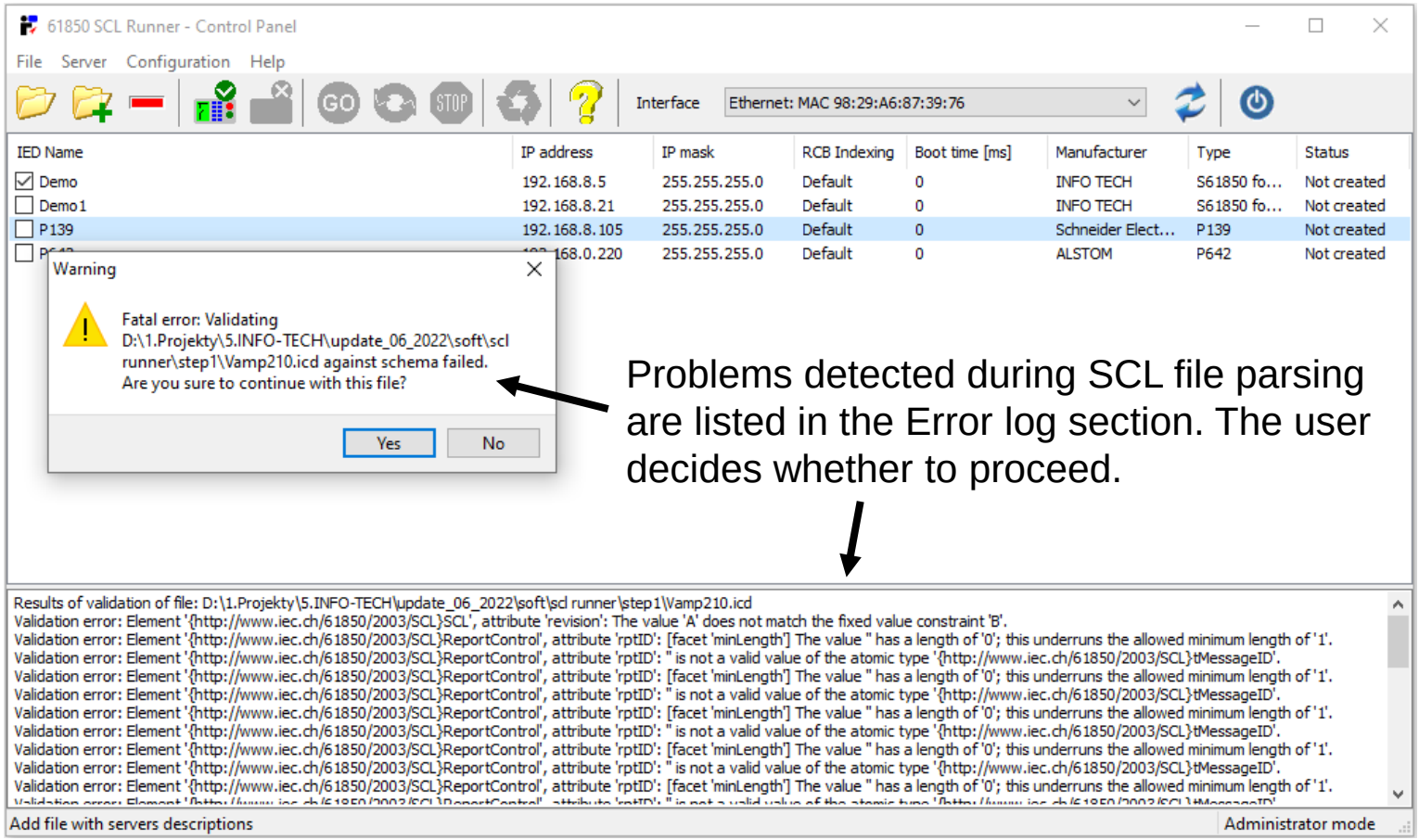
SCL file is validated



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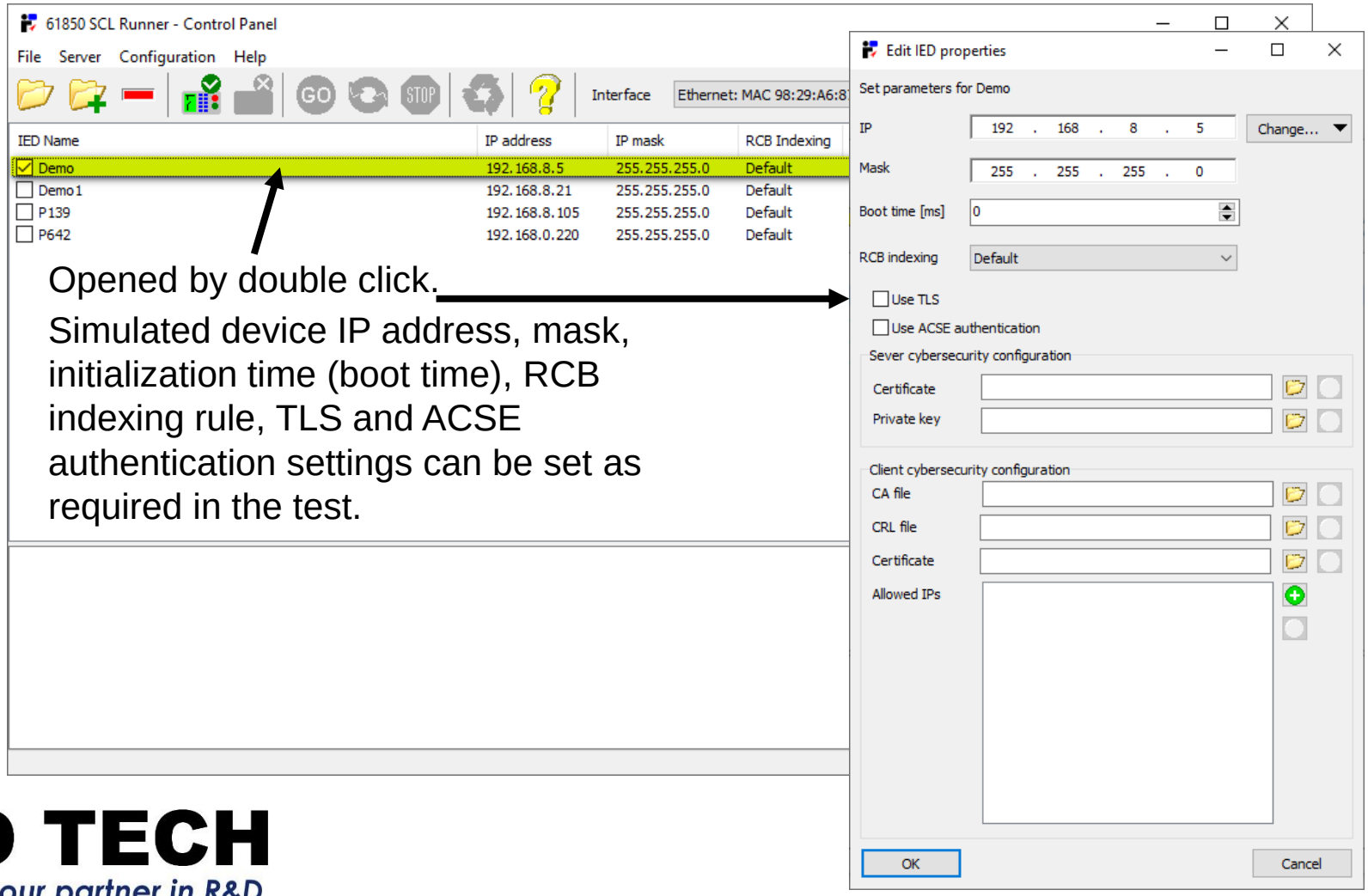
IED properties can be modified



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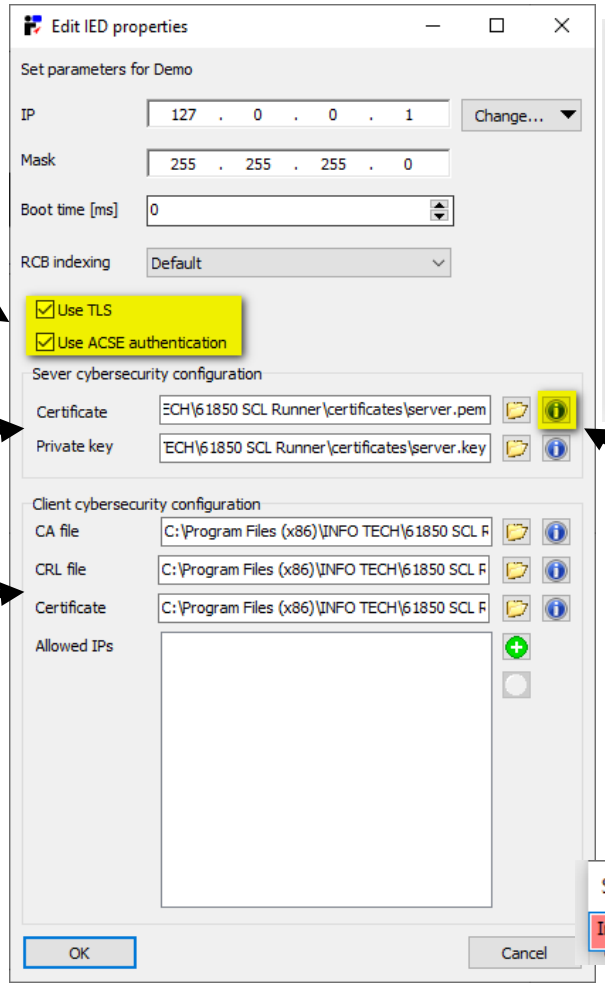
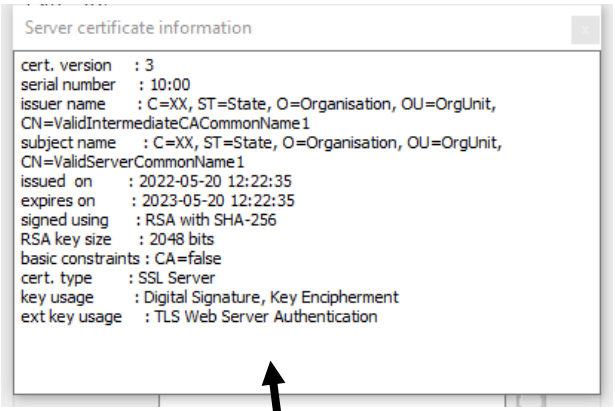
Using secure communication: TLS encryption and ACSE authentication

Enabling / Disabling encryption and authentication.

Server cybersecurity configuration section.

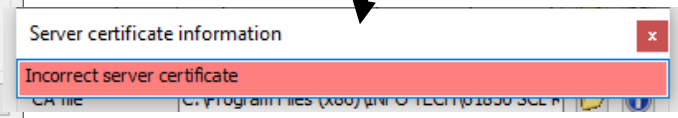
Client cybersecurity configuration section





Selected file validation is listed in pop-up window.

Problems detected during validation are listed in window.



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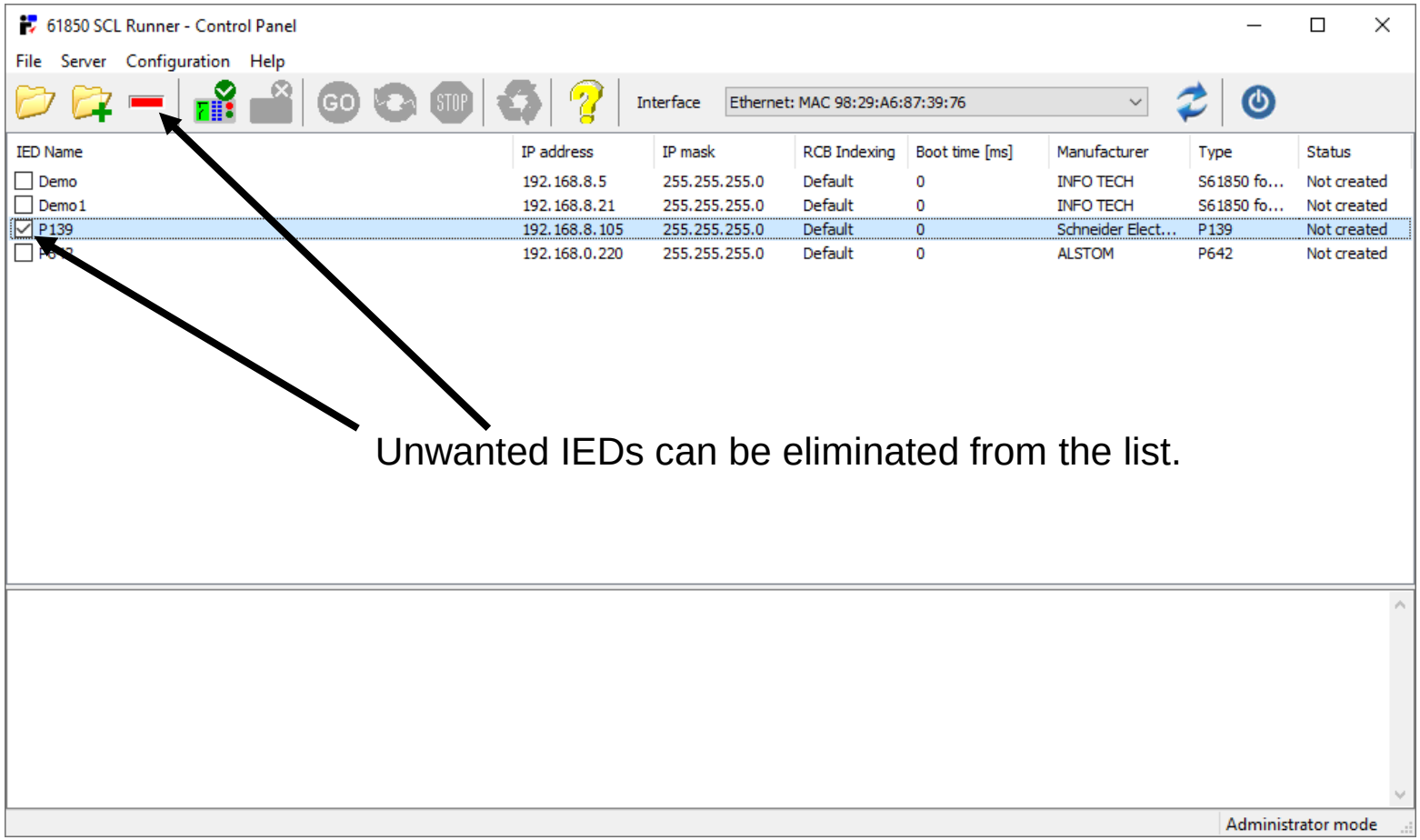
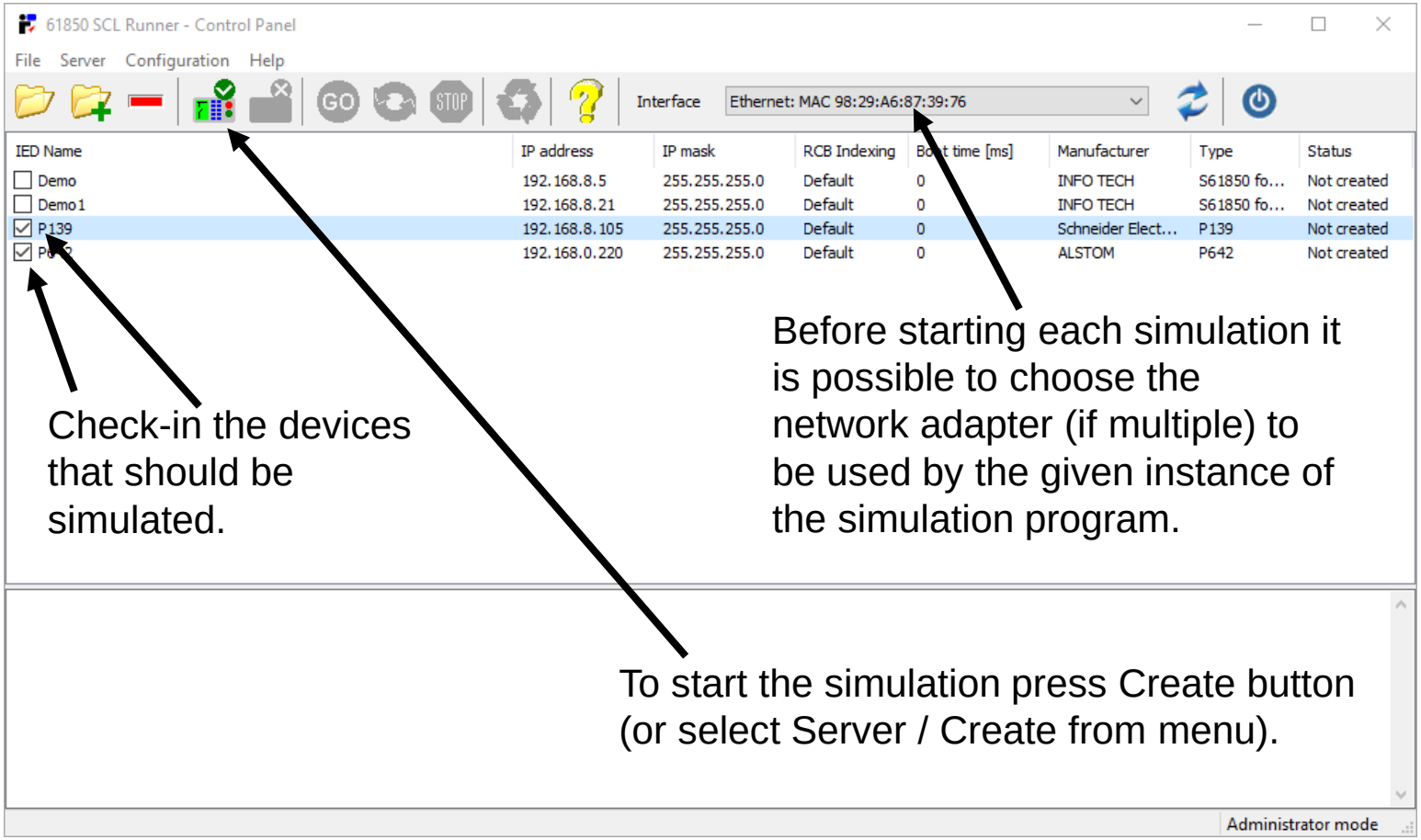
Selected IEDs can be deleted from the simulation set



To start the simulation



Check-in the devices that should be simulated.

Before starting each simulation it is possible to choose the network adapter (if multiple) to be used by the given instance of the simulation program.

To start the simulation press Create button (or select Server / Create from menu).

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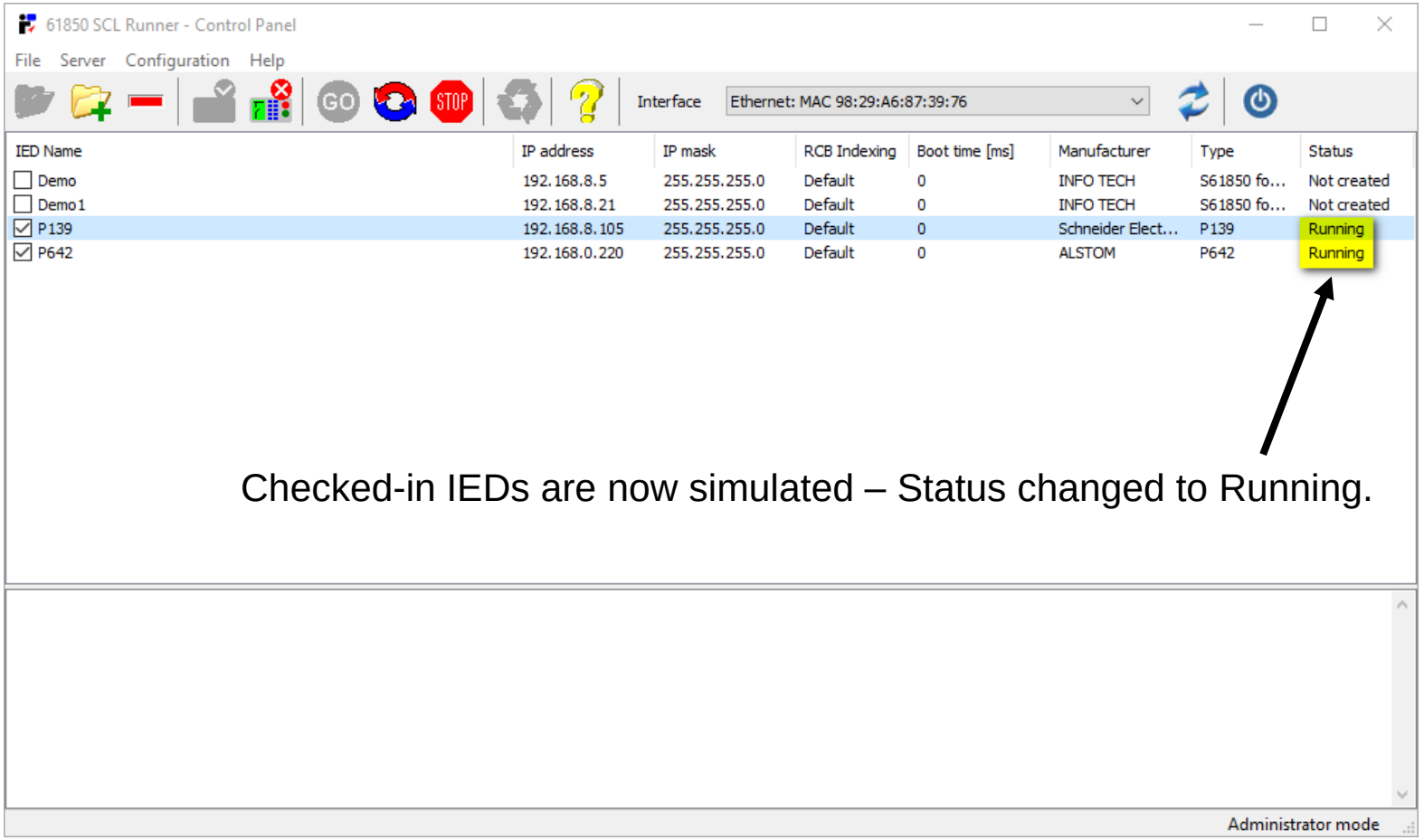
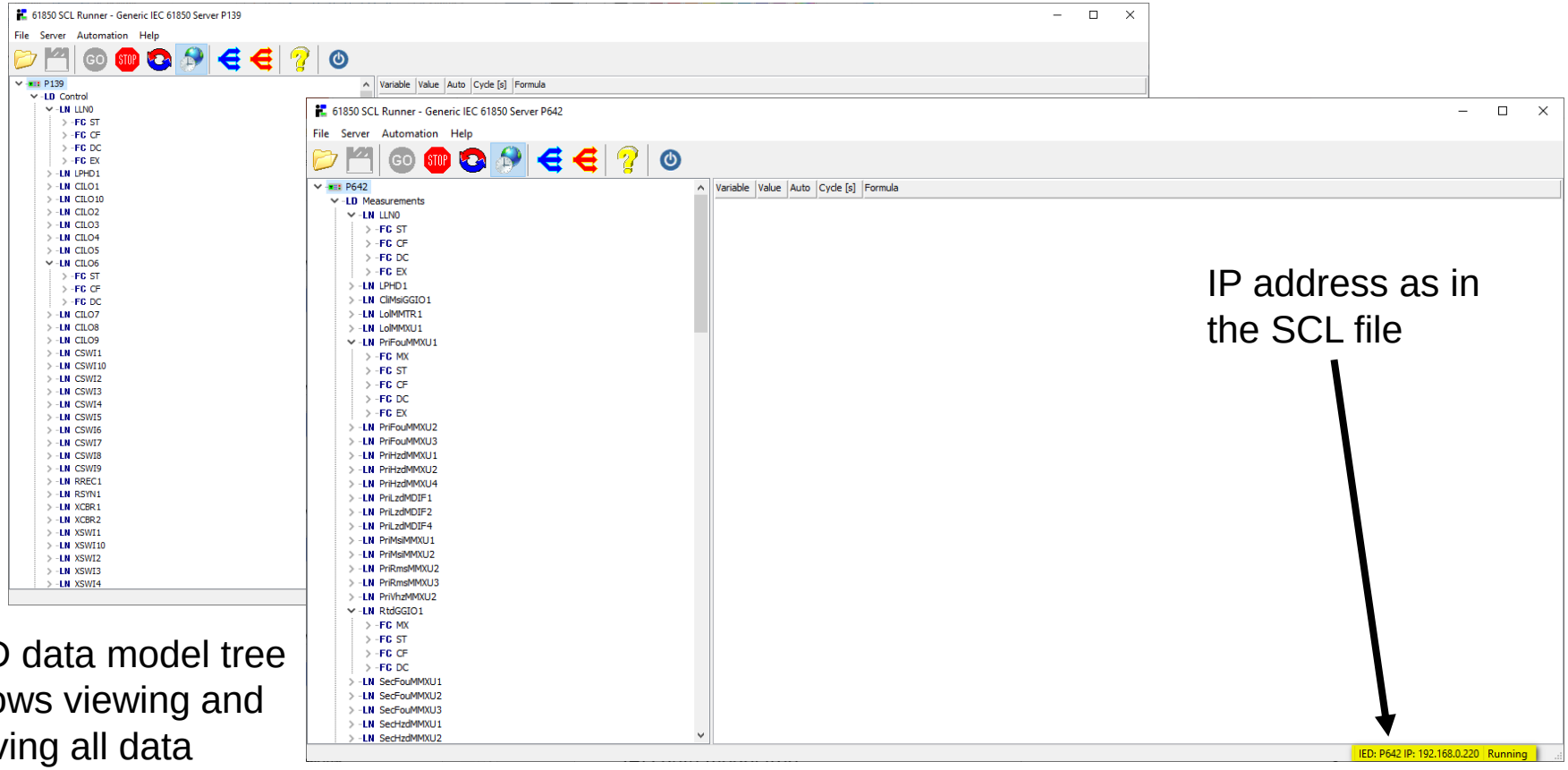
Simulation started



Checked-in IEDs are now simulated – Status changed to Running.

Each simulated IED in a separate window



IP address as in the SCL file

IED data model tree allows viewing and driving all data

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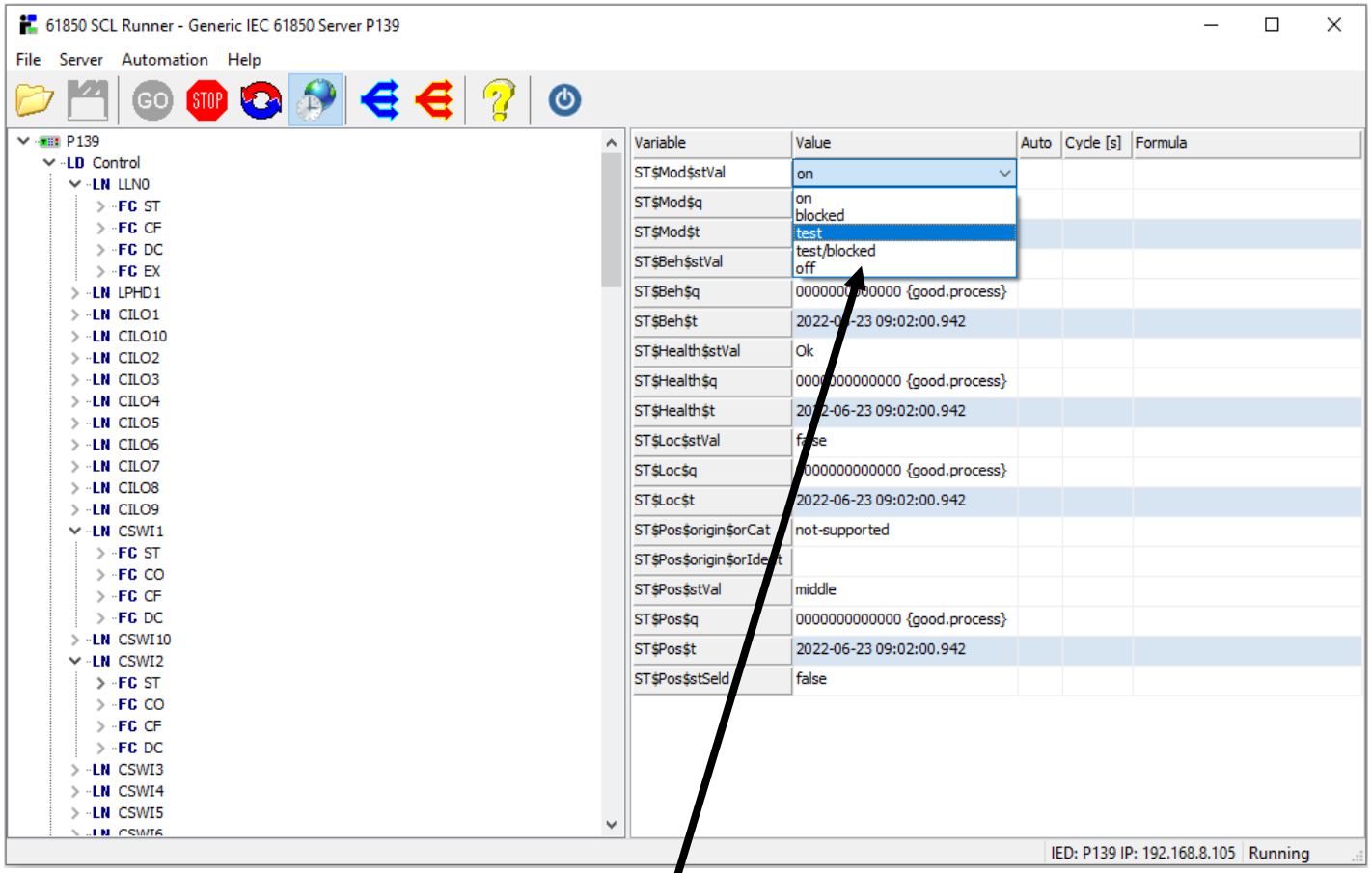
IED data values can be driven by the user



E.g. CB position can be manually set or chosen from drop down list.

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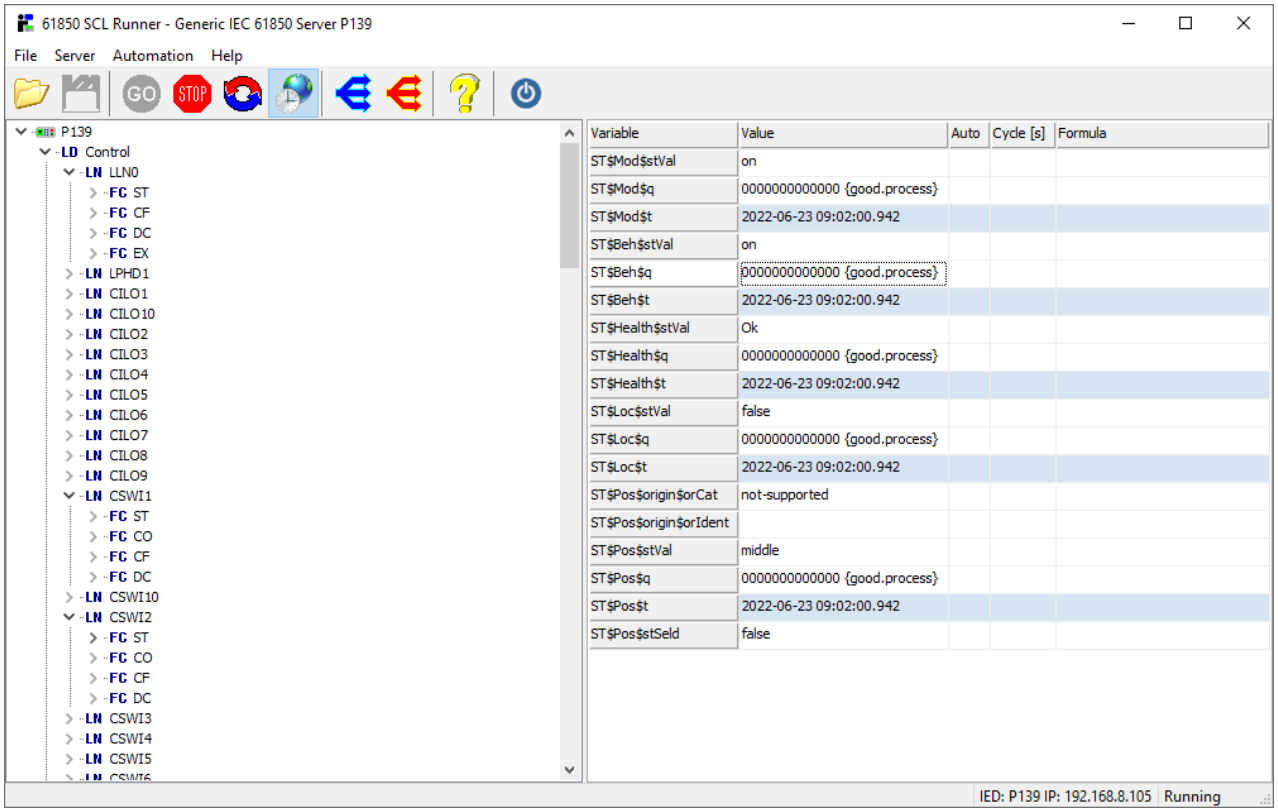
IED data values can be driven by user defined formulas



E.g. time dependent formulas. The formula can be enabled or disabled for automatic execution, the formula execution cycle in seconds can be defined (0 – as fast as possible).

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Examples of simulation formulas

Data attribute	Formula
GGIO1STInd1$stVal	T mod 2
Digital input value changing every second between on and off (true and false)	
MMXU1MXphsA$cVal$mag$f	2000+100*sin(T)
Phase A current amplitude value oscillates around 2000 with ±100	
CSWISTPos$stVal	if(T>300,1,2)
CB position closed and changes to open after 300 seconds	

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Operators and functions in formulas

User defined variables and time can be used with variety of operators and functions to create simulation formulas, e.g. analog signal waveforms, trip conditions with start level, CB position dependent on trip status etc.

Symbol	Explanation
!	Factorial i.e. !5 gives 1*2*3*4*5 = 120
%	Percentage i.e. 10% gives 0.1
-	Negate i.e. -10 gives -10 and --10 gives 10
+	Positive value i.e. +10 gives 10
^	Power i.e. 3^2 gives 9
*	Multiplification i.e. 2*2 gives 4
/	Division i.e. 4/2 gives 2
div	Integer division (result and operands are treated as integers)
mod	Remainder i.e. 3 mod 2 gives 1 (result and operands are treated as integers)
+	Sum i.e. 2+2 gives 4
-	Substract i.e. 4-2 gives 2
-	Substract i.e. 4-2 gives 2
-	Substract i.e. 4-2 gives 2
<	Less than i.e. 3 < 2 gives 0 (false)
<=	Less than or equal to i.e. 1 <= 2 gives 1 (true)
>=	Greater than or equal to i.e. 4 >= 2 gives 1 (true)
>	Greater than i.e. 4-2 gives 2
=	Equal to i.e. 4 = 2 gives 0 (false)
<>	Not equal to i.e. 4 <> 2 gives 1 (true)
not	Logical negation i.e not 0 gives 1 and not 1 gives 0
or	Bitwise or i.e 1 or 4 gives 5
and	Bitwise and i.e. 3 and 6 gives 2
xor	Bitwise xor i.e. 7 xor 5 gives 2

if	Conditional result: if argument 1 evaluates to true (is not 0) result is equal to argument 2 otherwise result si equal to argument 3
intpower	IntPower raises argument 1 to the power specified by argument 2 (both arguments are treated as integers)
ln	Natural logarithm (Ln(e) = 1) of the argument
log10	Logarithm of baase 10 of the argument
logN	Logarithm base N of X
max	Maximum of 2 arguments
min	Minimum of 2 arguments
pi	The ratio of a circle's circumference to its diameter. Pi is approximated as 3.1415926535897932385
pow	Power raises argument 1 (base) to power given by argument 2 (exponent). For fractional exponents or exponents greater than 2147483647, base must be greater than 0
radtodeg	Converts angles measured in radians to degrees
randG	Produces random numbers with Gaussian distribution parametrized by argument 2 (standard deviation) about the argument 1 (mean).
random	Produces random number within the range 0 <= X < 1
round	Rounds a real-type value to an integer-type value
sin	Sine of the argument
sinh	Hyperbolic sine of the argument
sqr	Square of the argument
sqrt	Square root of the argument
tan	Tangent of X
tanh	Hyperbolic tangent of X
trunc	Truncates a real-type value to an integer-type value (value of X rounded toward zero)

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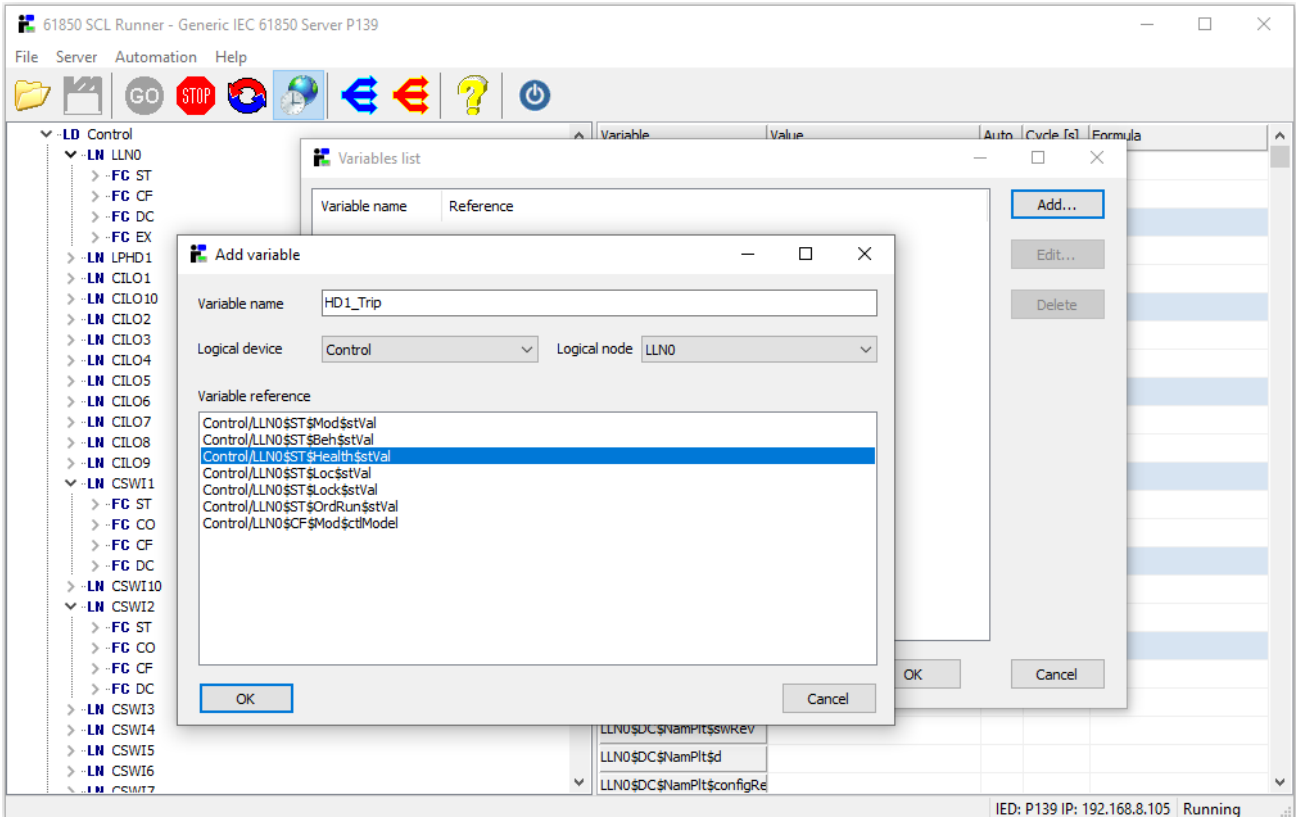
User defined variables in formulas



Formulas can be based on user defined variables, referencing selected IED data attributes.
If required, the formulas can be simultaneously enabled and disabled.

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Examples of simulation formulas with user-defined variables

Data attribute		Formula		User variable
MMXU1MXphsA$cVal$mag$f	=	if(CB_pos = 2,2+1*sin(2*T),0)	→	**IphsA**
Phase A current amplitude value defined by time dependent formula if CB position closed, and value 0 if CB position not closed				
PTOC1STOp$general	=	if(IphsA>2.85,1,0)	→	**OC1_trip**
Overcurrent protection trip if IphsA (value of phase A current) exceeds the given limit				
PTRC1STTr$general	=	OC1_trip or OC2_trip or EF1_trip	→	**Trip**
Common trip signal active if any of the trip signals from 3 protection functions is active				
CSWISTPos$stVal	=	if(Trip,1,2)	→	**CB_pos**
CB position open if Trip active, and CB position closed if Trip not active				

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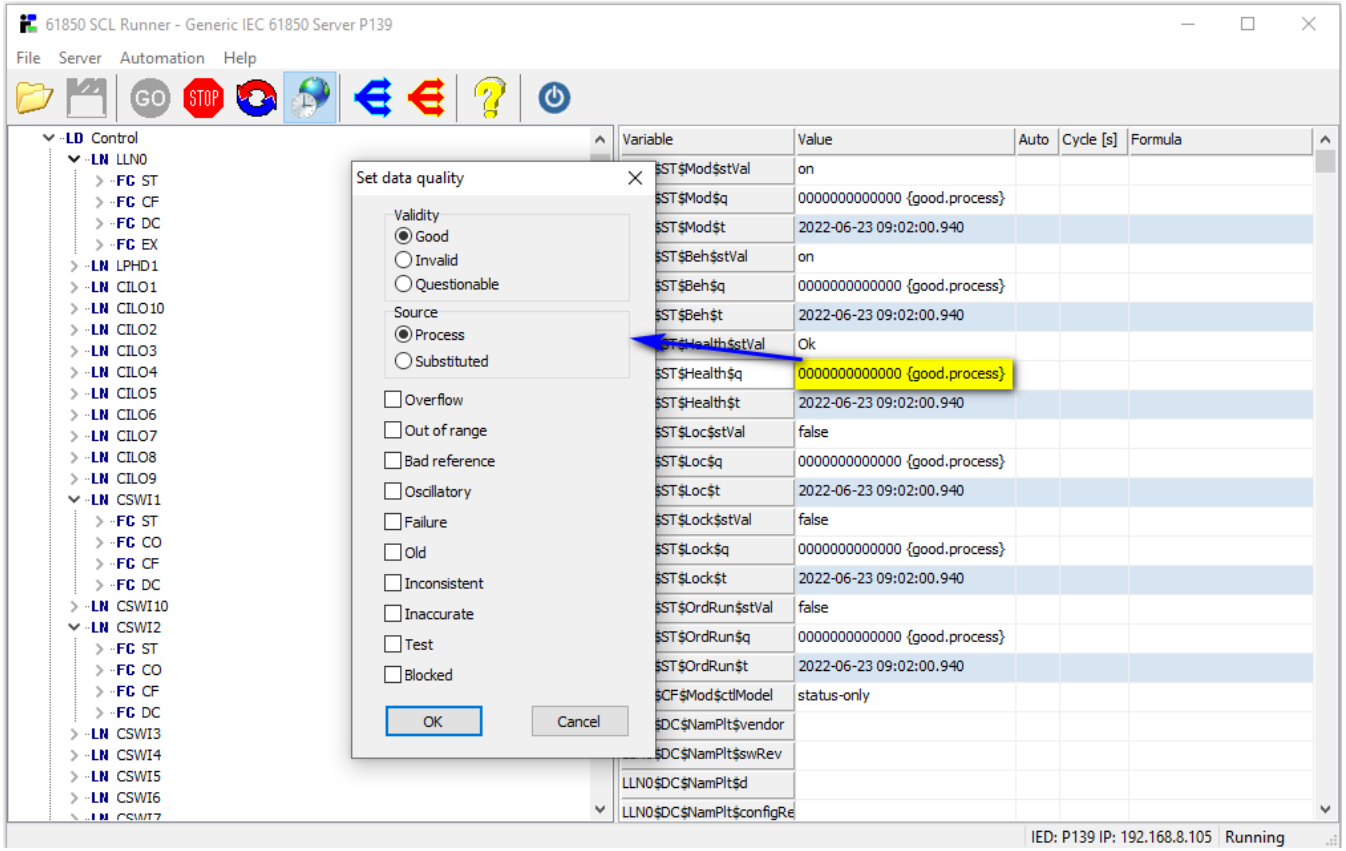
Quality attribute values can be driven by the user

Quality attribute values can be enforced by the user directly, by a formula or set in the dialog window.



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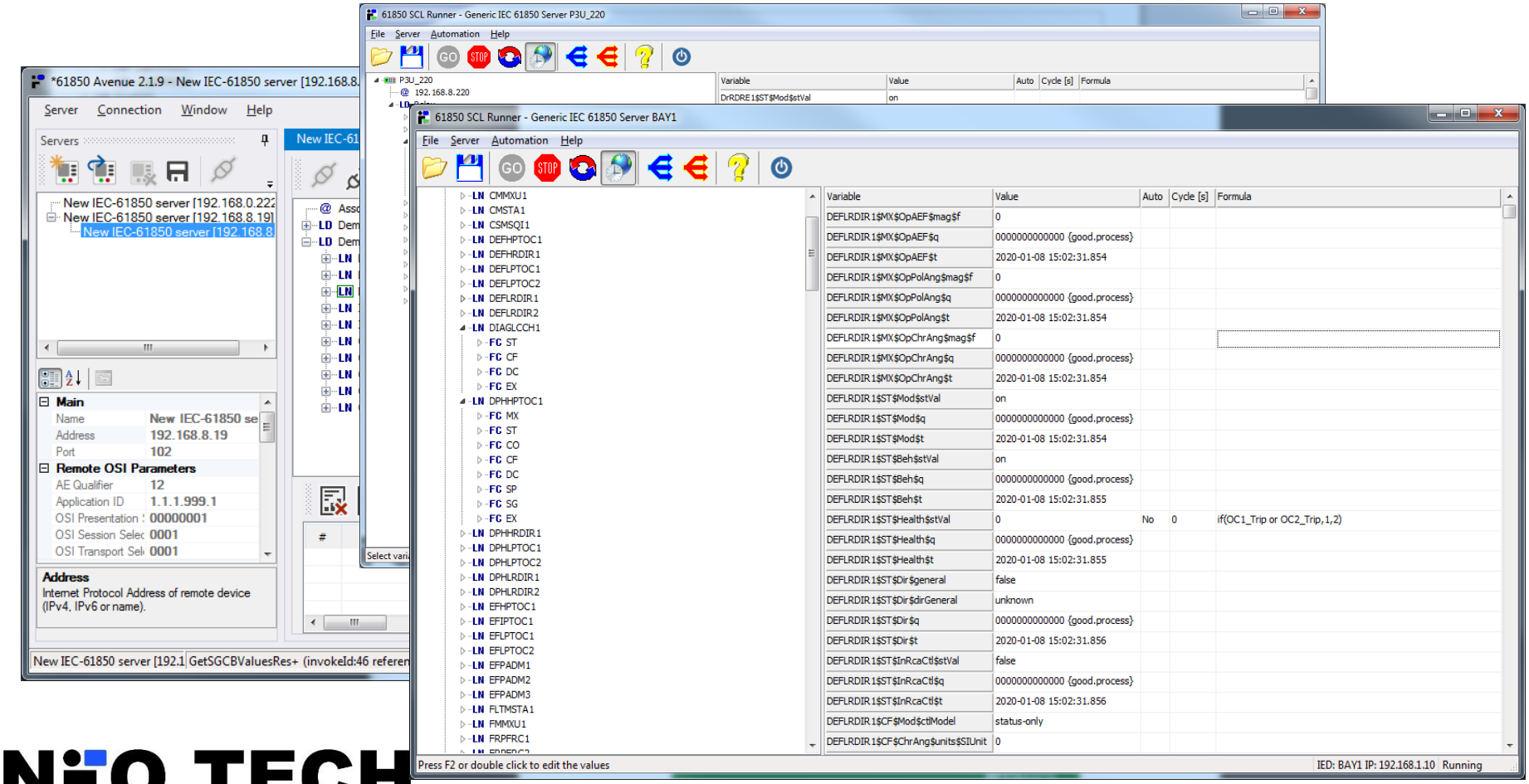
Control system / client can connect to simulated IEDs and act



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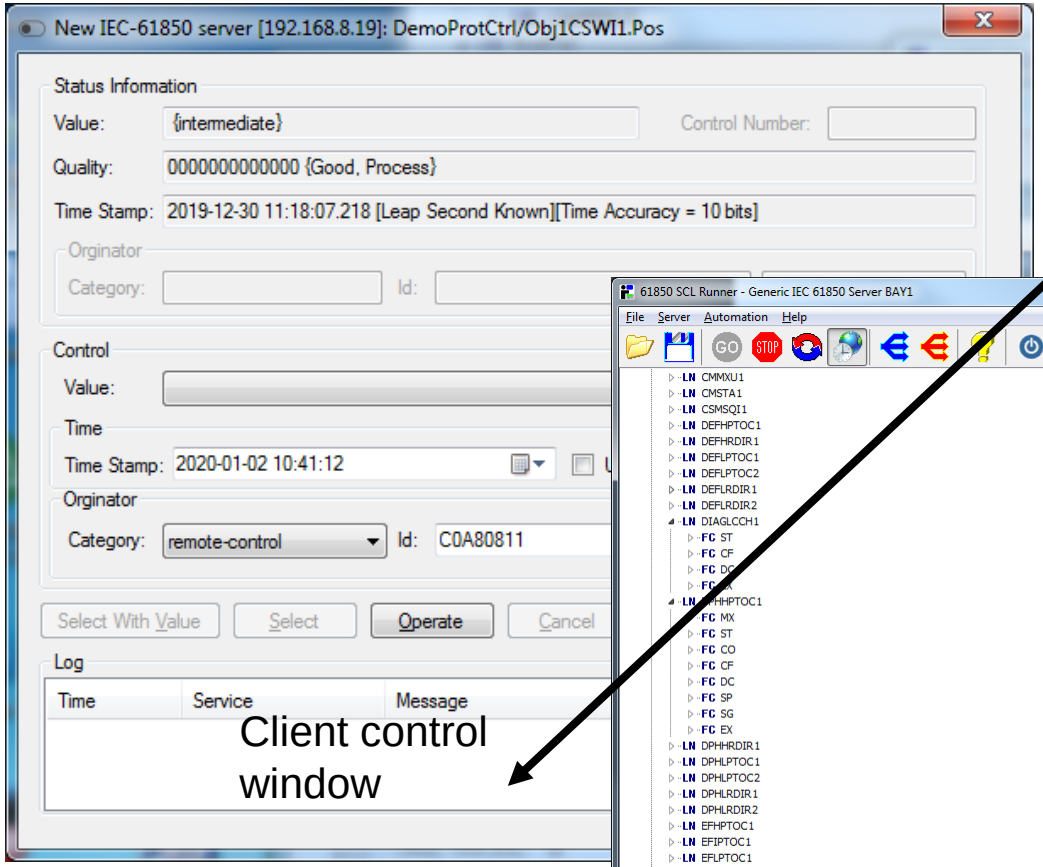
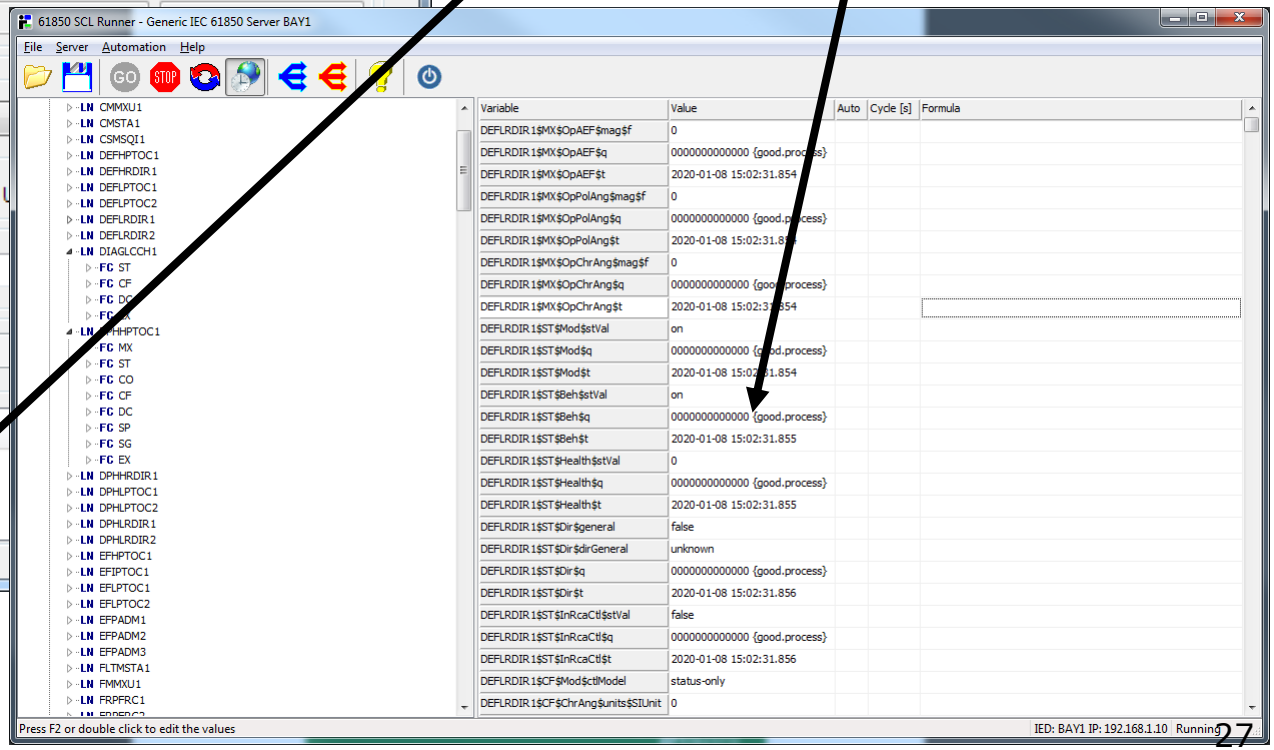
Control command testing



Client control window

Control accepted and executed with generated Command Termination.

IED data view



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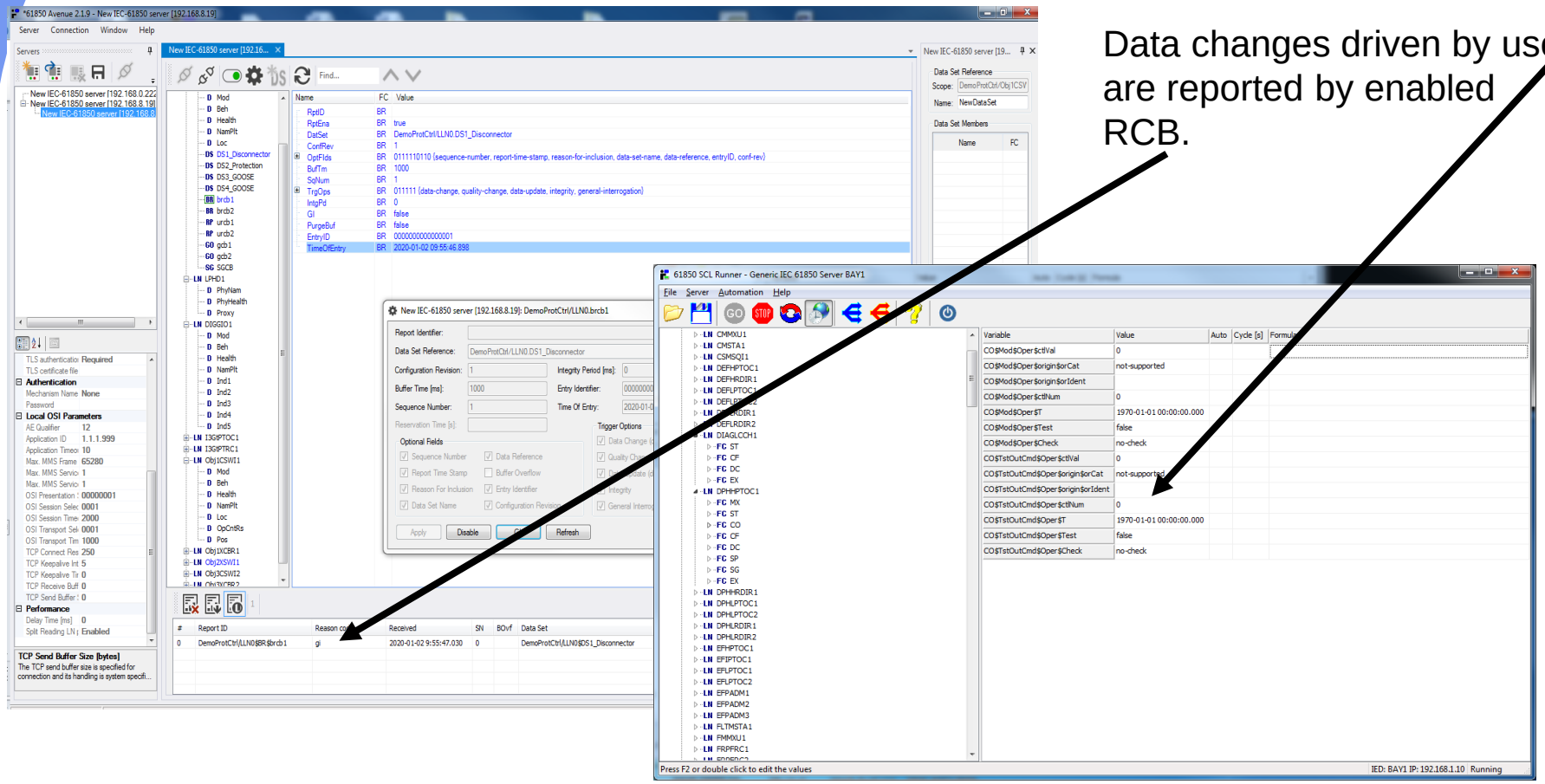
Reporting function testing



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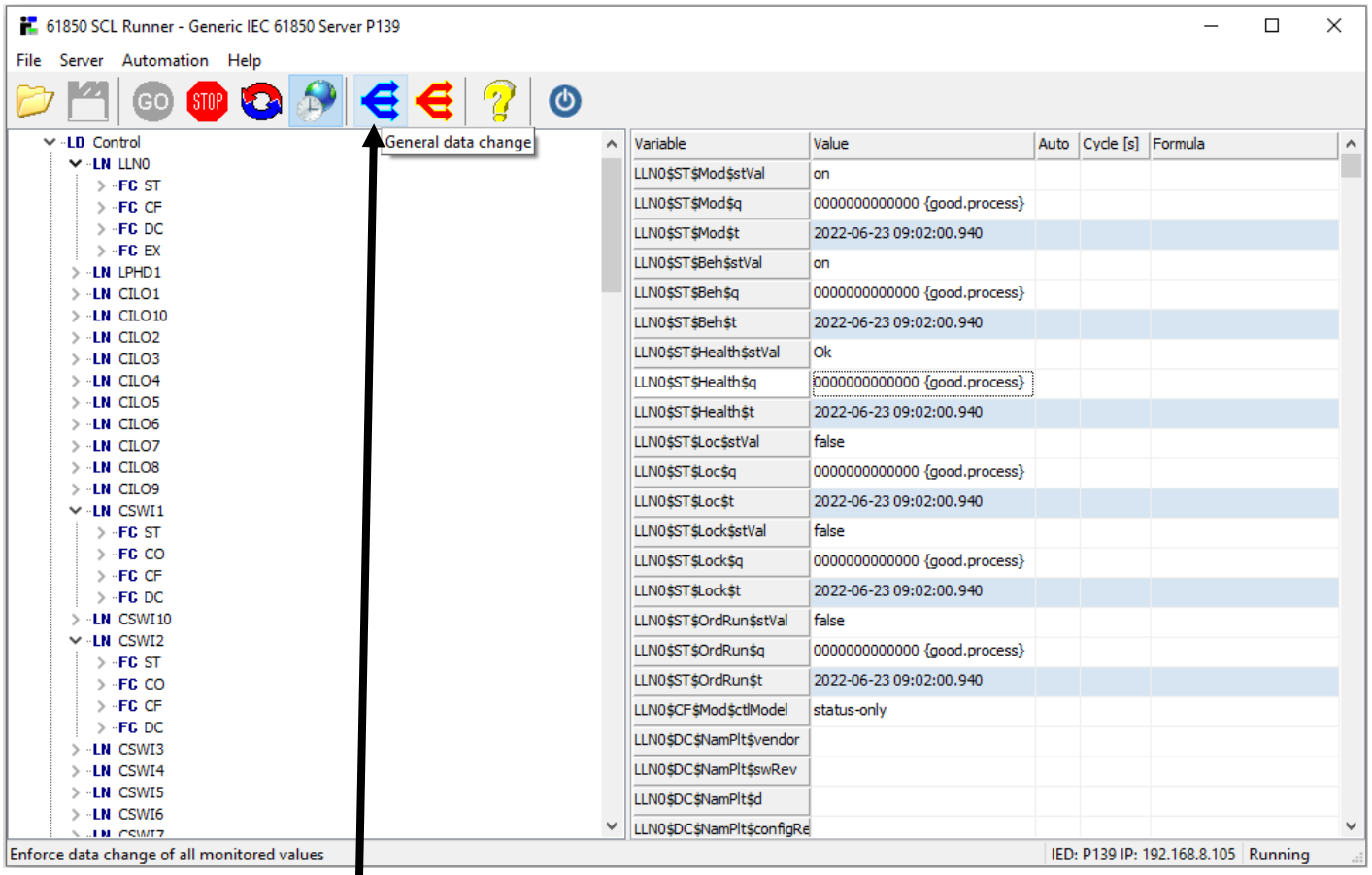
General data change button



Allows to enforce automatic value change for **ALL** data subscribed by clients (from all enabled RCBs) – test of all subscribed data flows to the clients!

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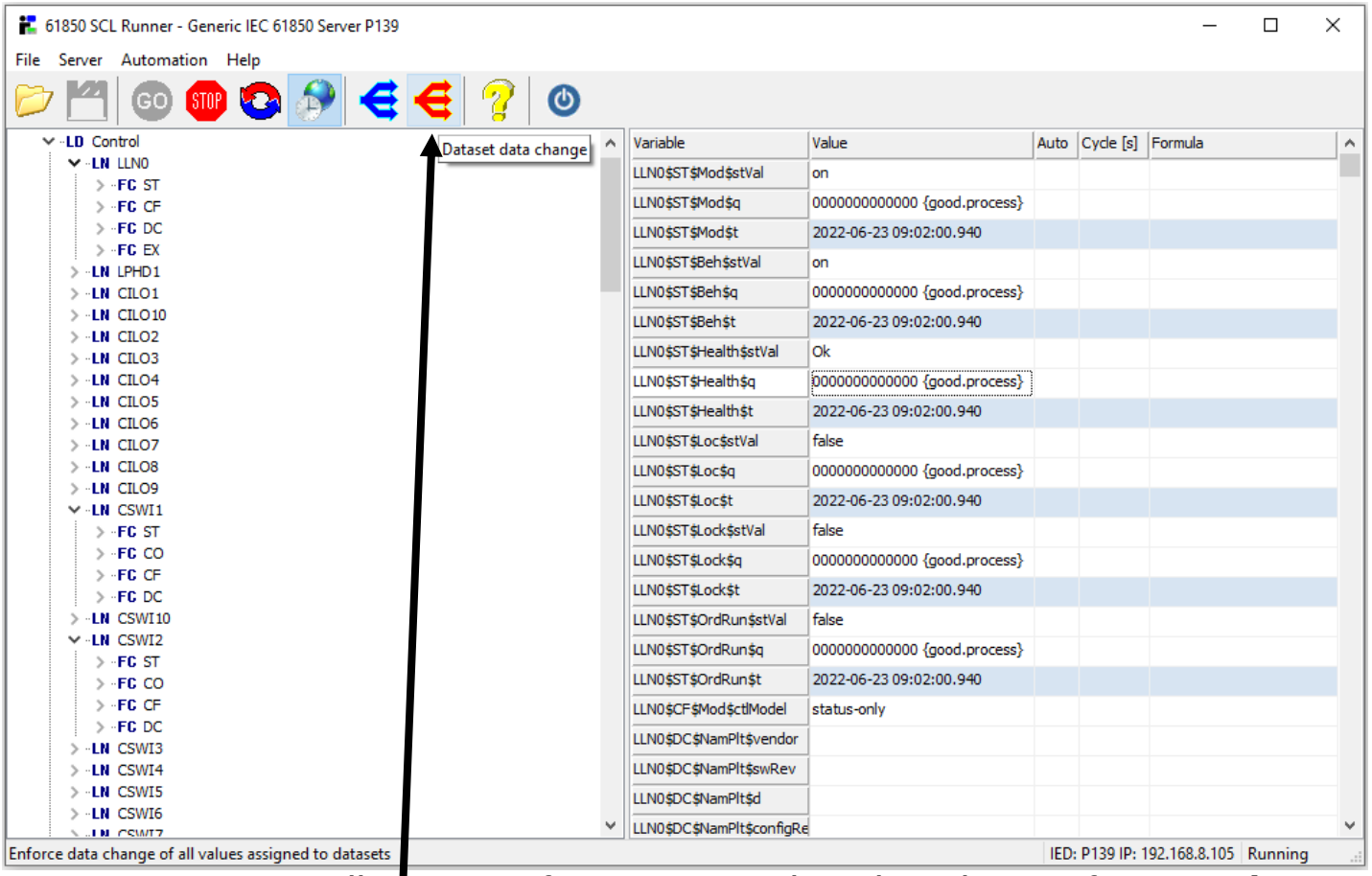
Dataset data change button



Allows to enforce automatic value change for **ALL data assigned to data sets** – for testing data flows to the clients!

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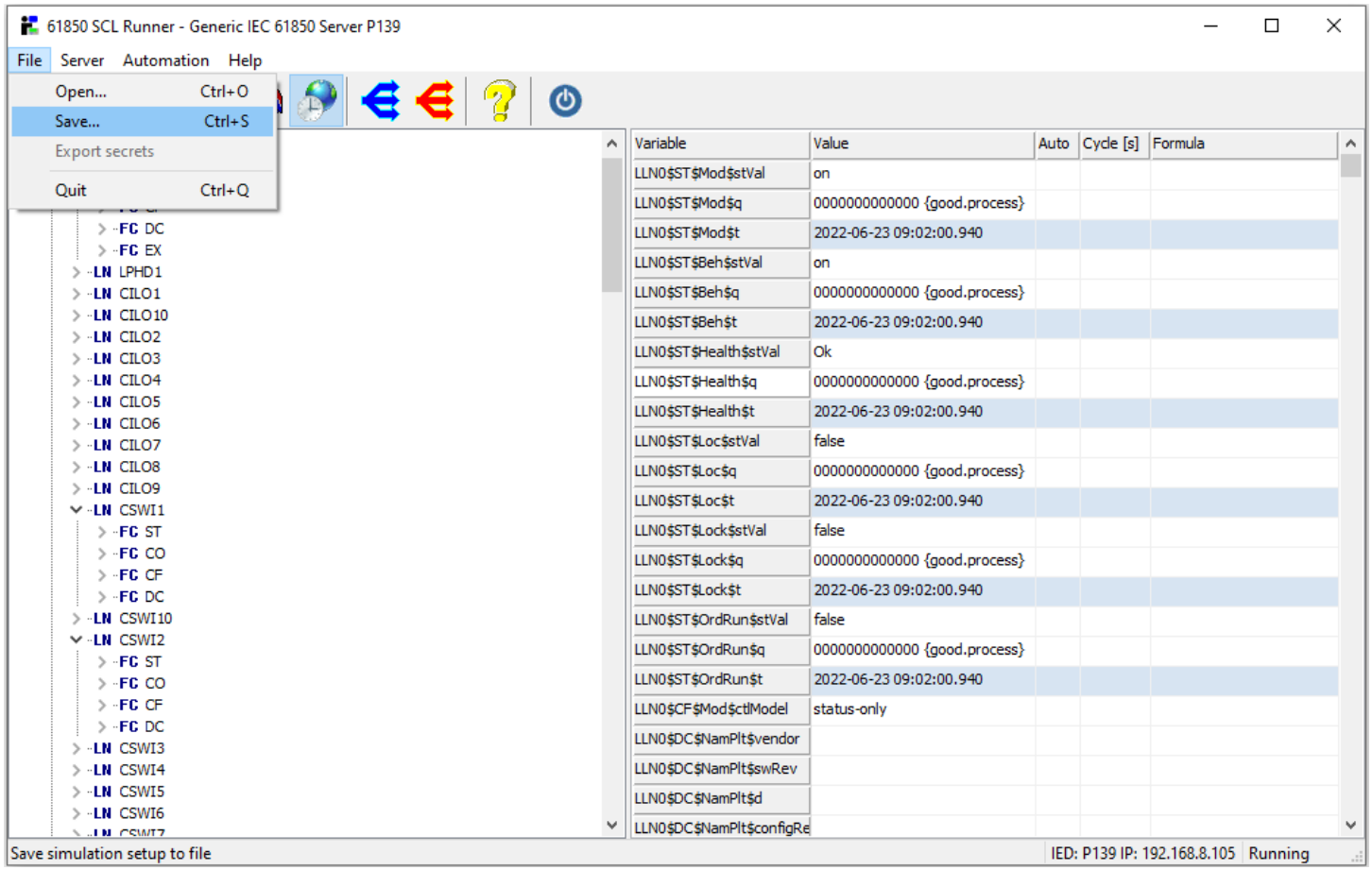
Remember to save created data change formulas for the next test



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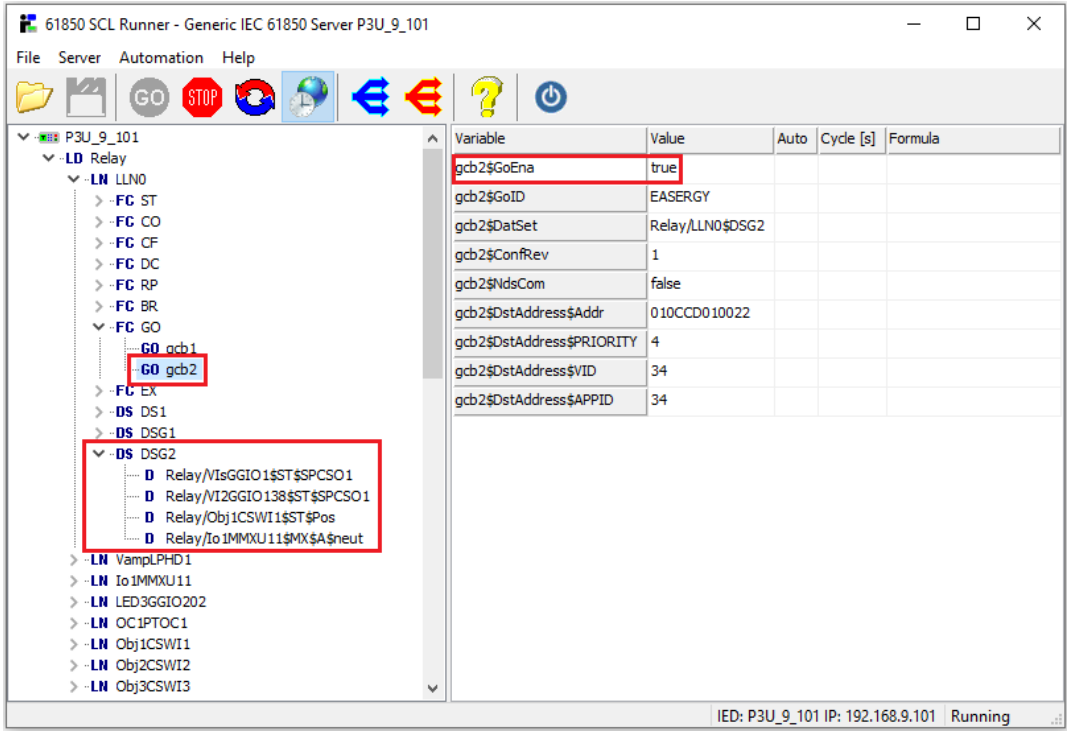
SCL Runner as GOOSE Publisher

Using SCL Runner it is possible to simulate GOOSE Publisher function by the definition of GoCB object included in the imported SCL file. Transmission parameters and the dataset will be configured as specified in the chosen control block of the selected device.

In this way SCL Runner can simulate GOOSE transmission performed by another device. It allows to test how GOOSE messages will be received and processed by devices with GOOSE Subscriber function.



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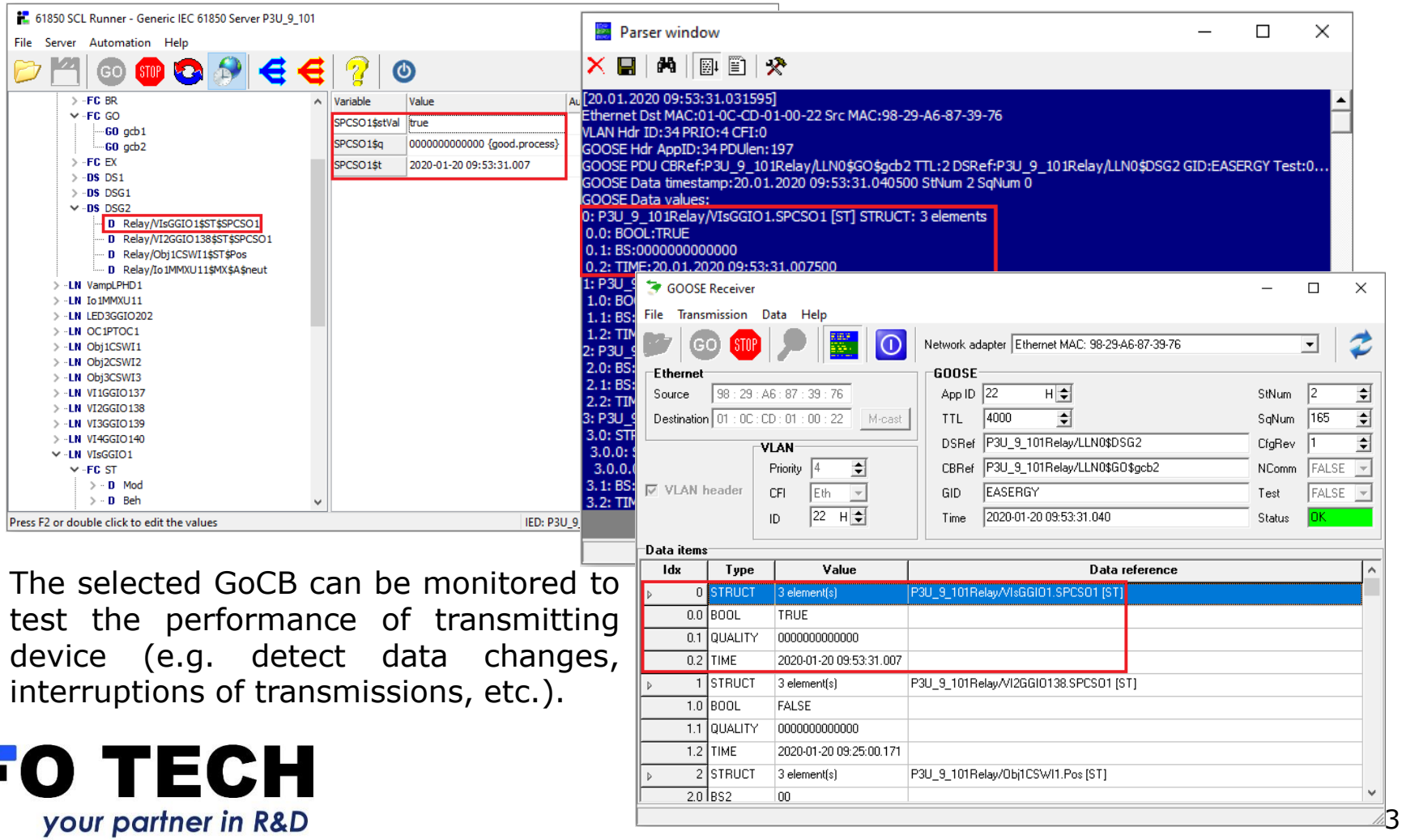
SCL Runner as GOOSE Publisher



The selected GoCB can be monitored to test the performance of transmitting device (e.g. detect data changes, interruptions of transmissions, etc.).

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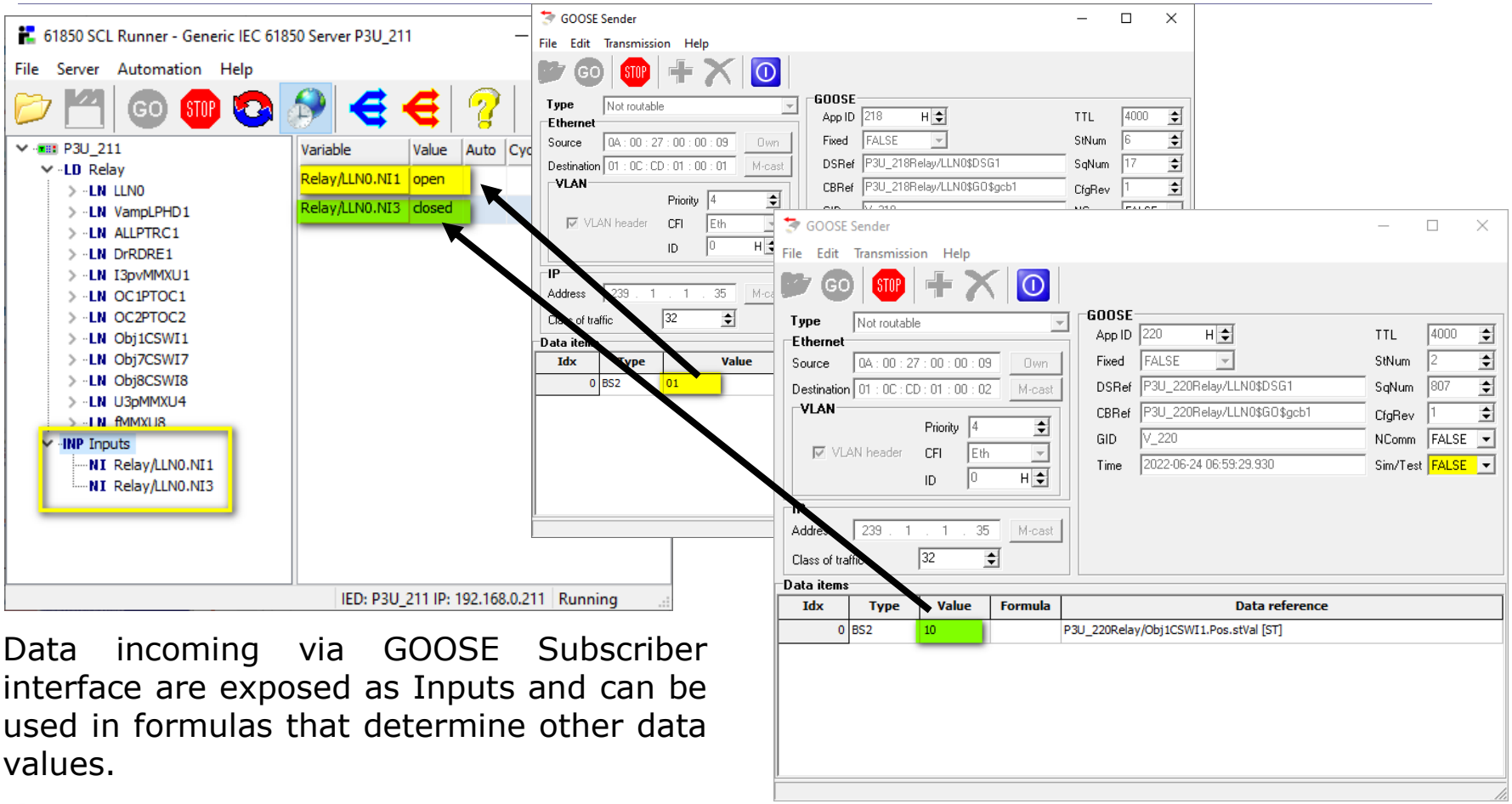
SCL Runner as GOOSE Subscriber



Data incoming via GOOSE Subscriber interface are exposed as Inputs and can be used in formulas that determine other data values.

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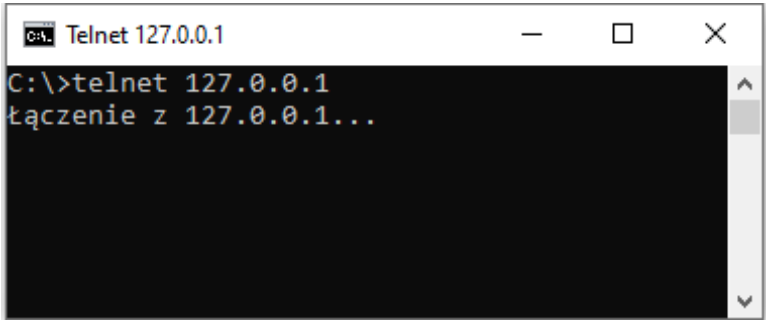
Access to data of simulated devices (IEDs) via telnet

61850 SCL Runner allows for simulation control and read/write access to data attribute values of the simulated server devices (IEDs) via telnet protocol. This enables external programs to define scenarios of data changes in the simulated devices. The toolset package includes an example of such a program in Python.

To connect to simulated server device the user needs to open connection via telnet with IP address of the simulated server device.



Username and password needed for telnet connection are not checked.

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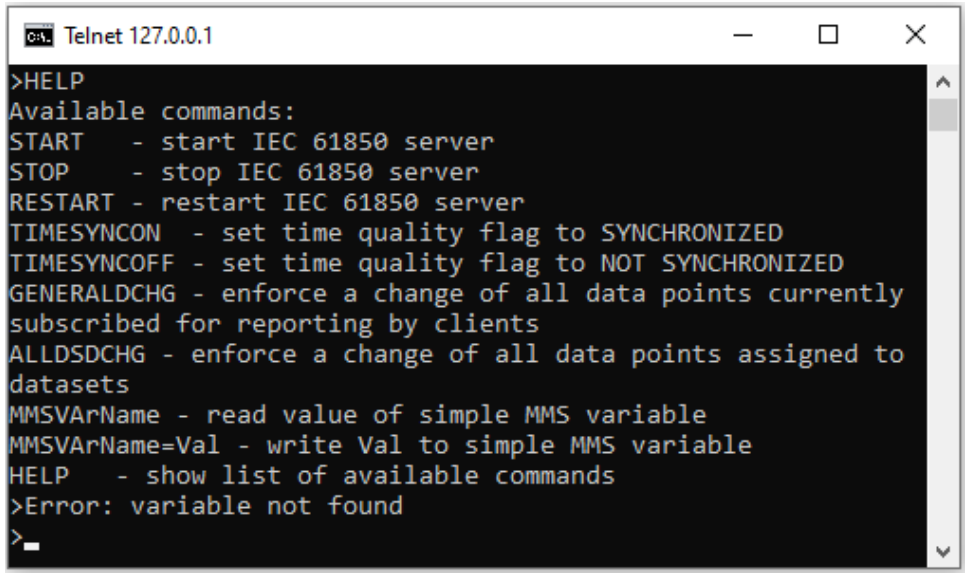
Access to data of simulated devices (IEDs) via telnet – list of commands

Telnet connection allows to perform the following commands on the simulated server device.



Seven of these commands correspond to the buttons on the application GUI:

START

STOP

RESTART

GENERALDCHG

ALLDSDCHG

TIMESYNCON
TIMESYNCOFF

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Example of automation via telnet

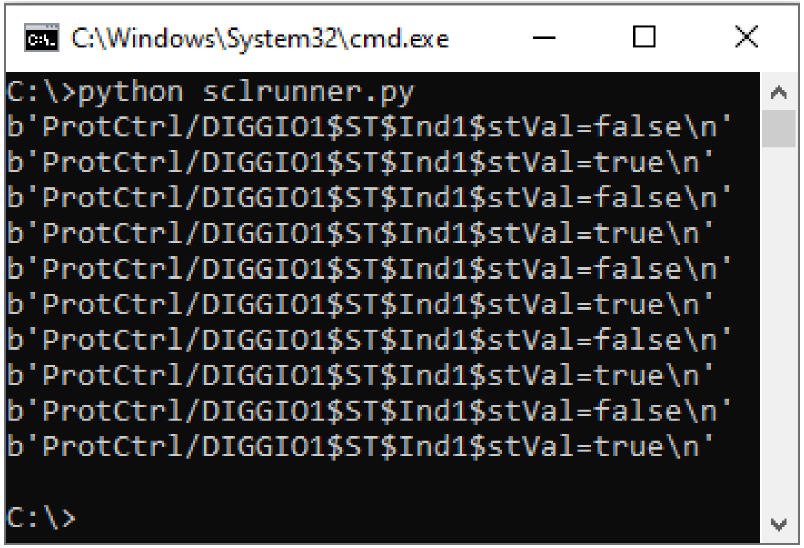
An example of Python program code (*sclrunner.py* - part of the installation package): connects to the simulated server device *(Demo.icd* - part of the installation package) and then performs 10 control commands on the selected object (ProtCtrl/DIGGIO1STInd1$stVal):

```
#IP address of the simulated server device
HOST = "127.0.0.1"

#Establish telnet connection using default port (23)
tn = telnetlib.Telnet(HOST,23)

#Username and password is not checked
tn.read_until(b"Username: ",2)
tn.write(b"\n")
tn.read_until(b"Password: ",2)
tn.write(b"\n")

#Cycle of ten control commands on selected object
tn.read_until(b">")
for i in range(0,10):
  if( i%2 != 0 ):
    line=b"ProtCtrl/DIGGIO1$ST$Ind1$stVal=true\n"
    print(line)
    tn.write(line)
    tn.read_until(b">")
  else:
    line=b"ProtCtrl/DIGGIO1$ST$Ind1$stVal=false\n"
    print(line)
    tn.write(line)
    tn.read_until(b">")
  time.sleep( 1 )
```



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61850 ICD Editor

Supplementary tool to create and modify ICD/IID/CID files used for simulation.

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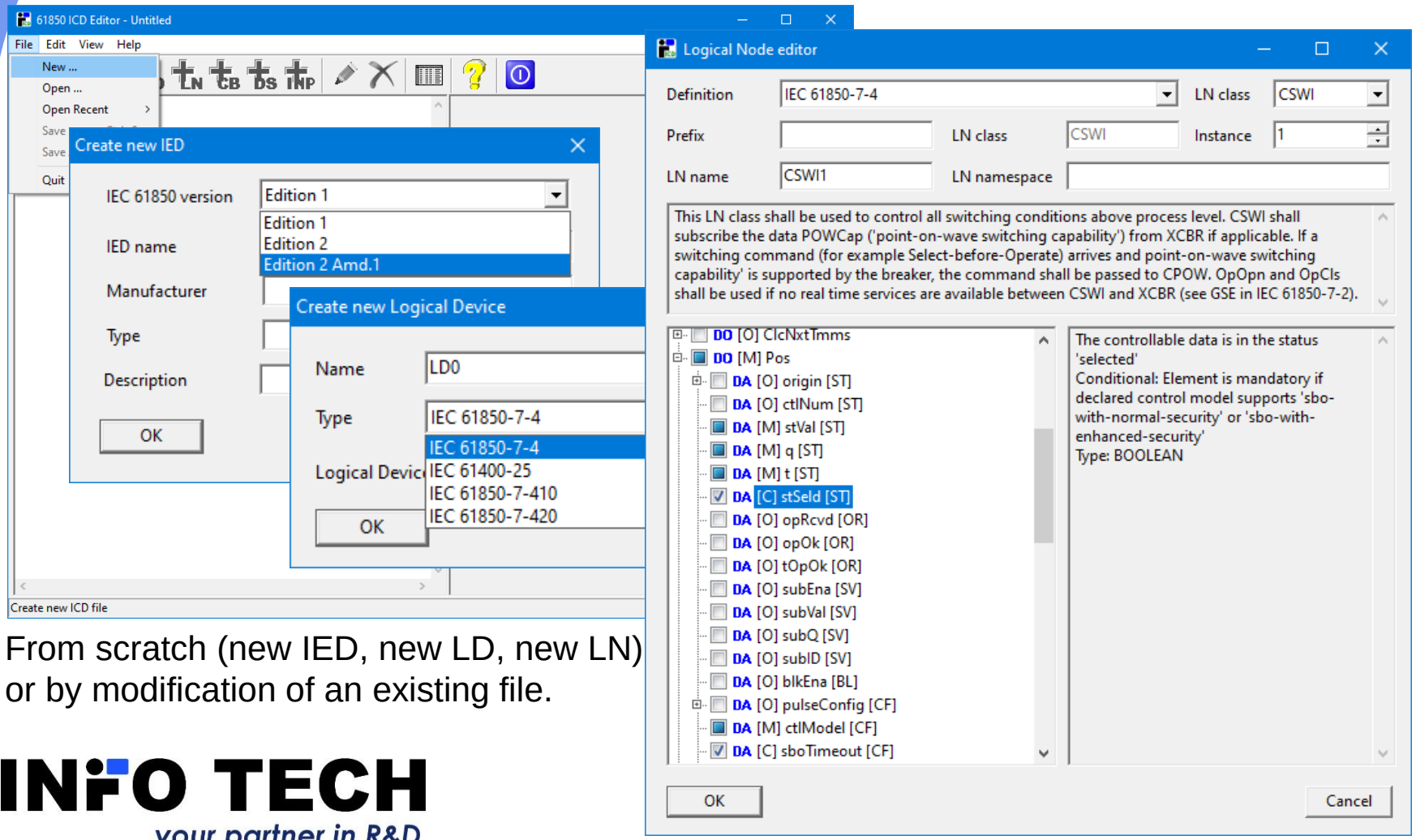
61850 ICD Editor allows to build an ICD file of the server device



From scratch (new IED, new LD, new LN) or by modification of an existing file.

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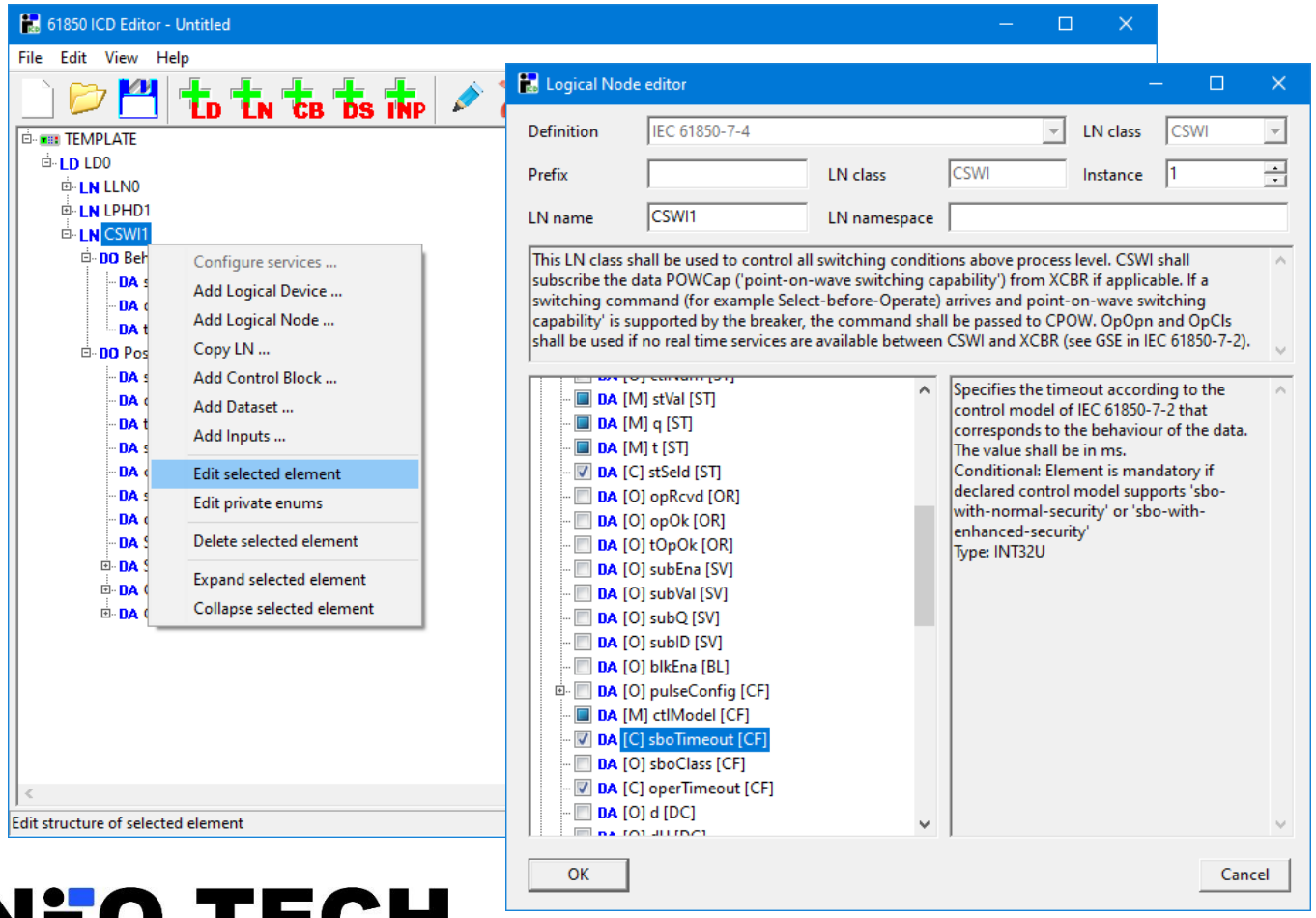
Editing data model



Any added LN can be later modified by adding/deleting optional DOs and DAs.

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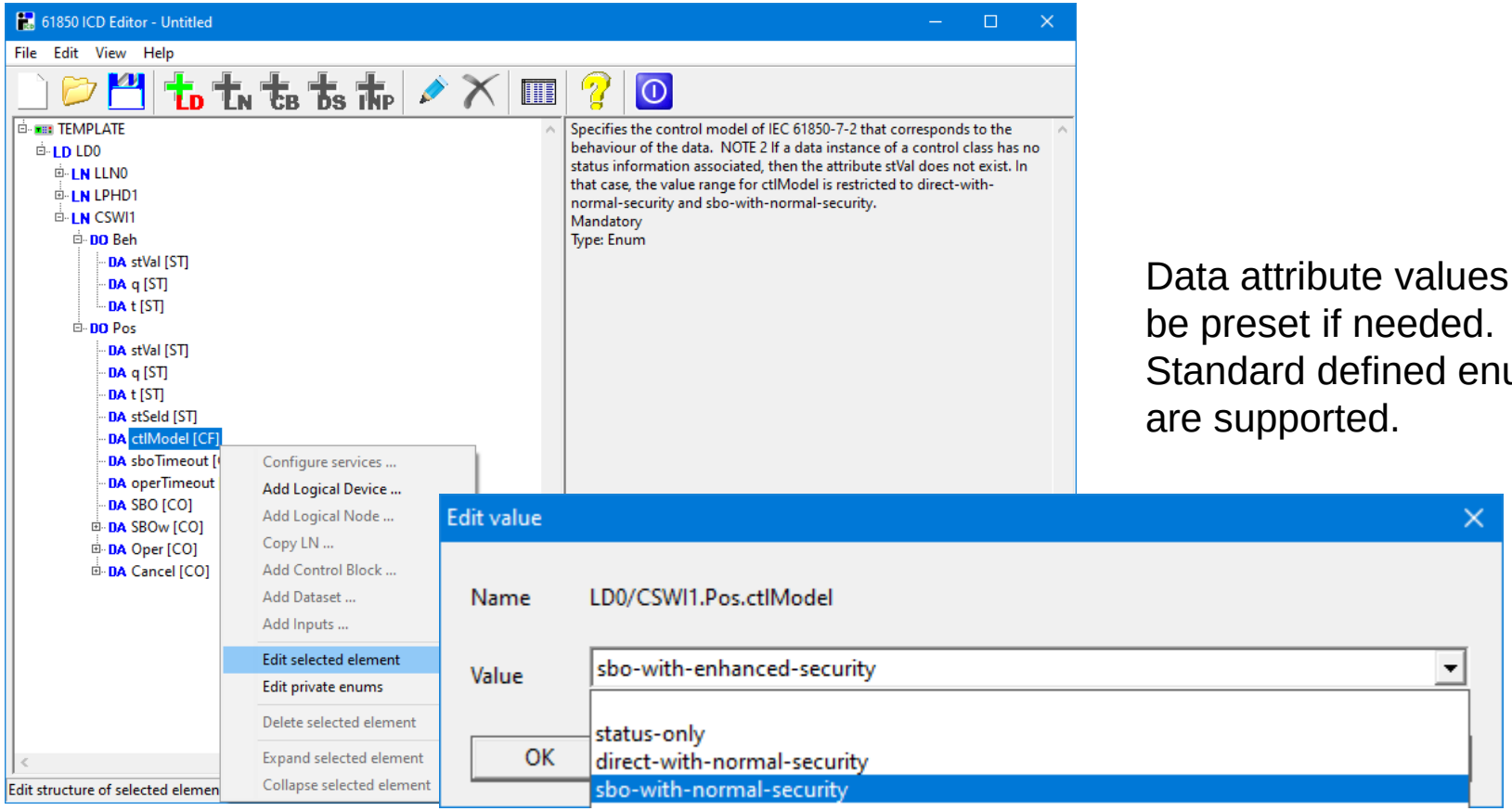
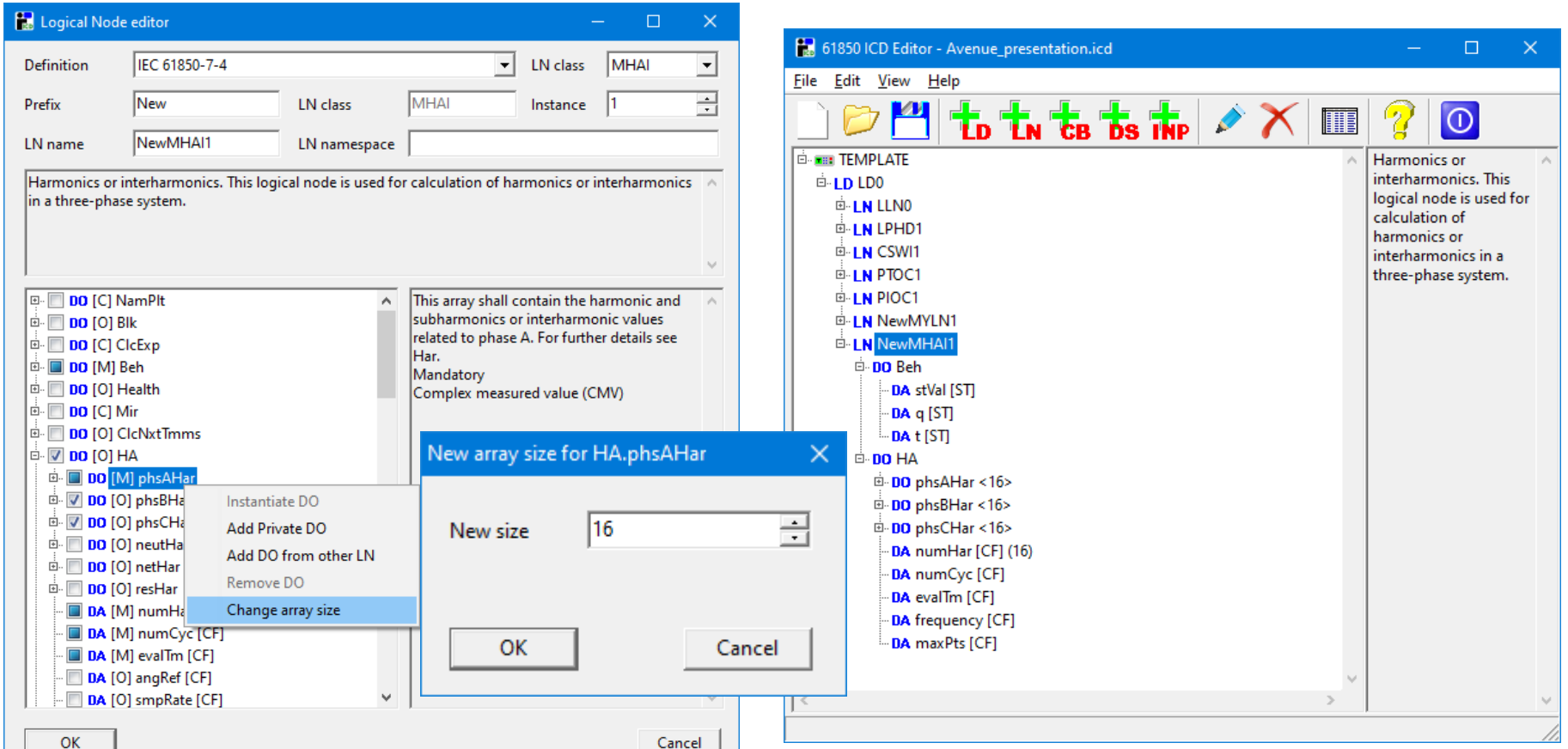
Presetting DA values



Data attribute values can be preset if needed. Standard defined enums are supported.

LNs with DOs containing array types



Array size can be set (default is 32).

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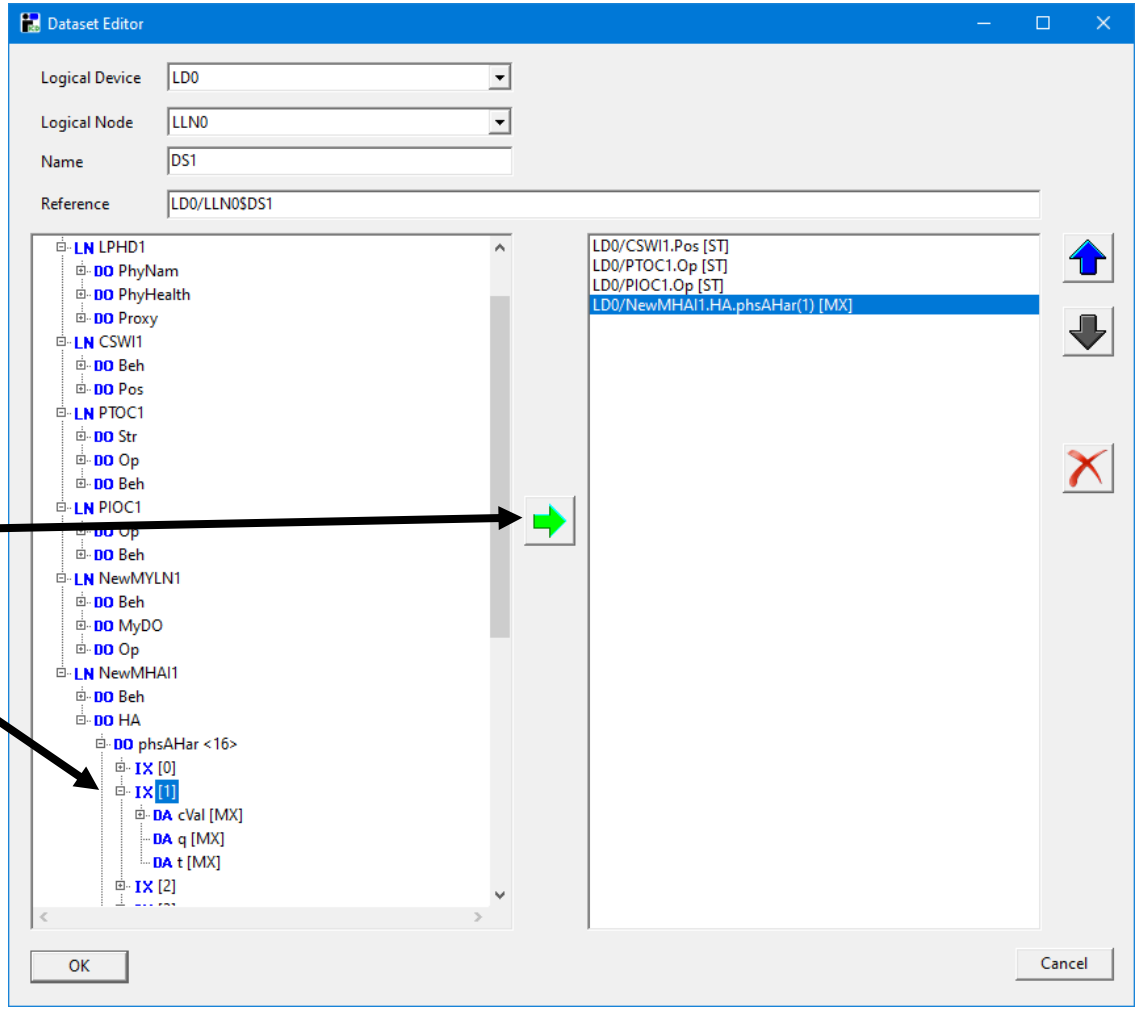
Dataset creation by selection of elements from the data model

Any defined dataset can be later re-edited if needed.

Button for adding a selected element of data model to dataset.

Note that in Ed.2.1 also indexed data can be elements of datasets.



Buttons for changing order of elements in dataset.

Button for removing element of dataset.

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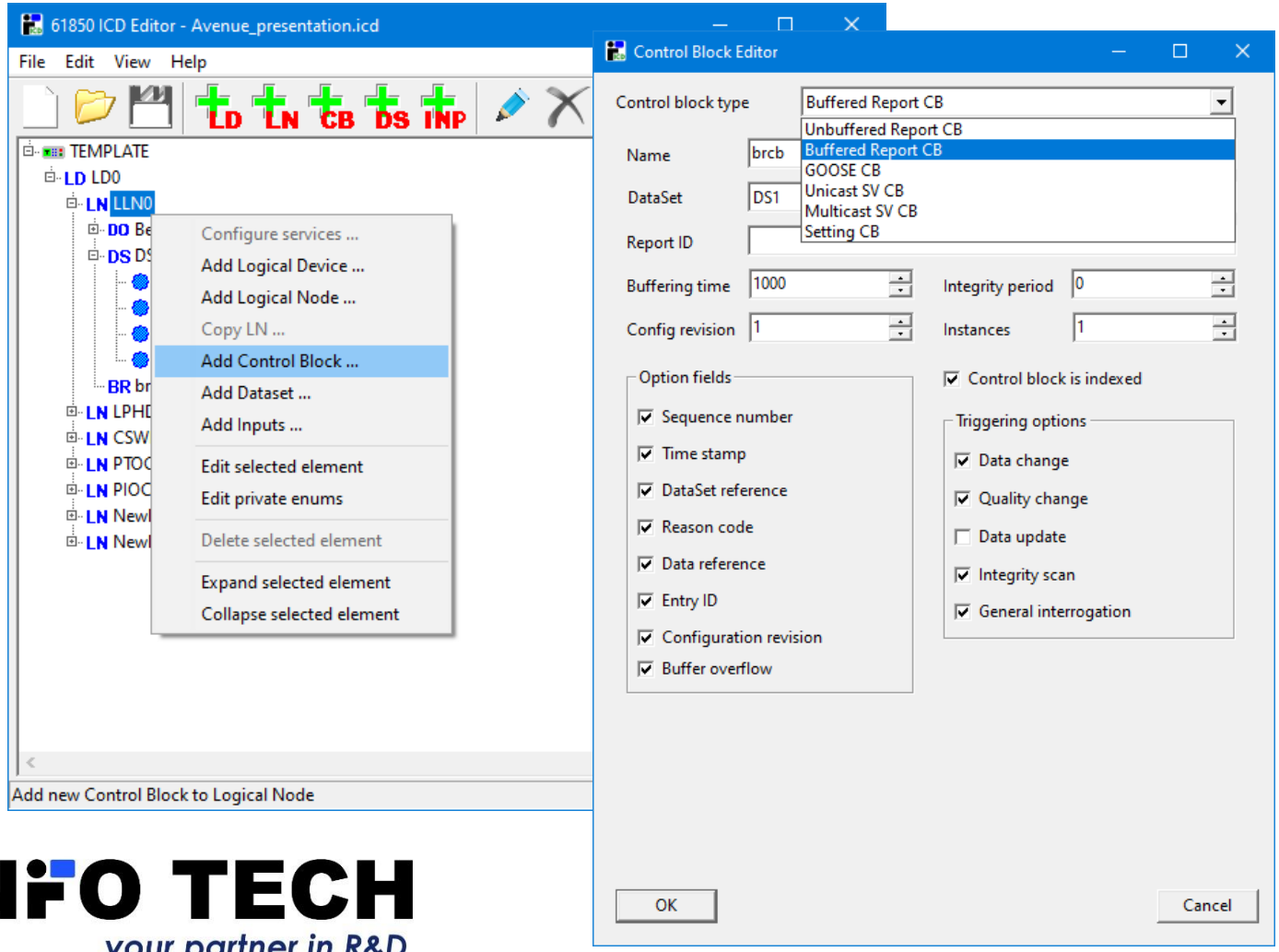
Control blocks



URCB, BRCB, GoCB, USVCB, MSVCB and SGCB can be added to the data model and initially preset.

Any defined control block can be later re-edited if needed.

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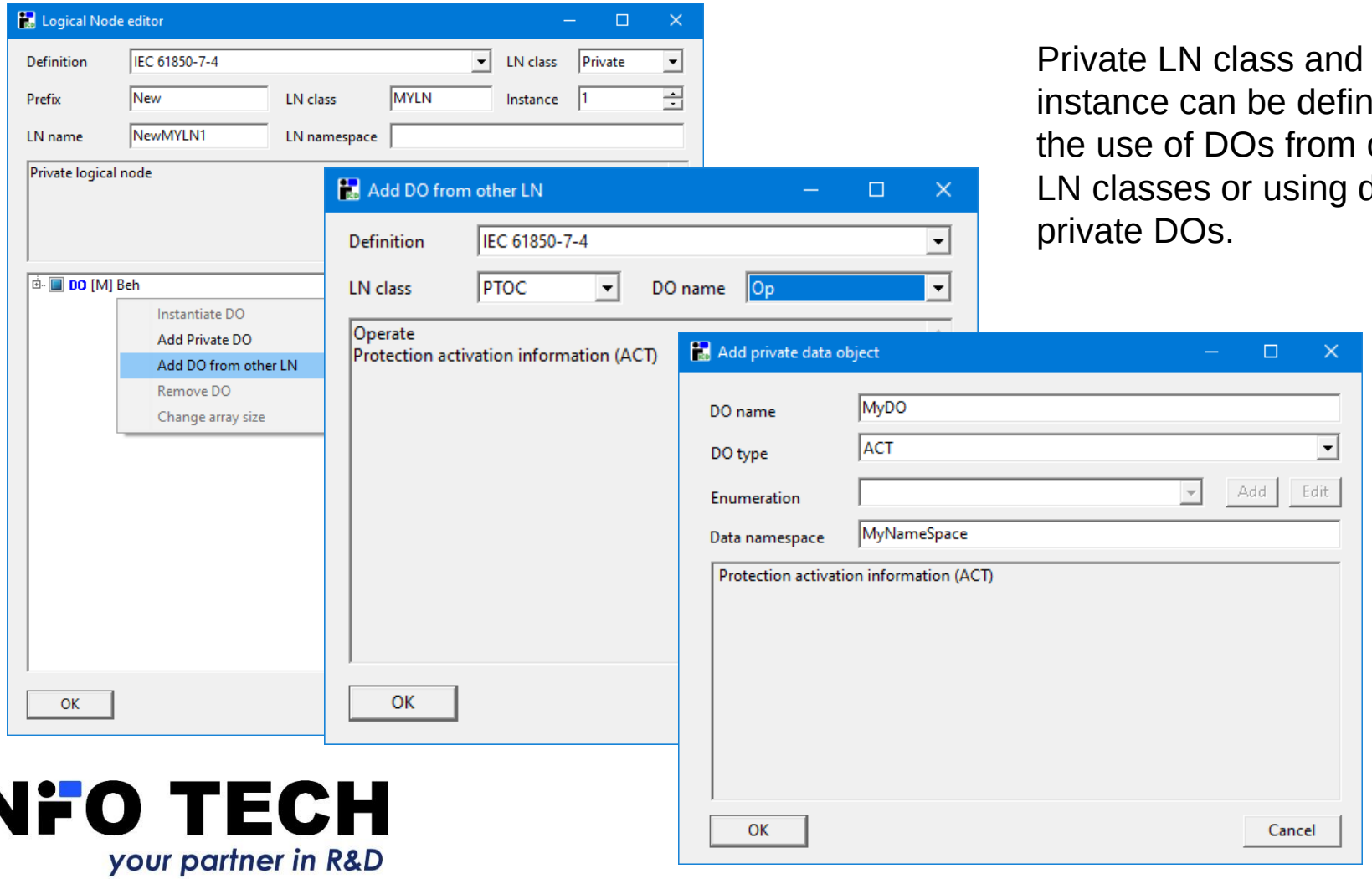
Private Logical Nodes



Private LN class and instance can be defined with the use of DOs from other LN classes or using defined private DOs.

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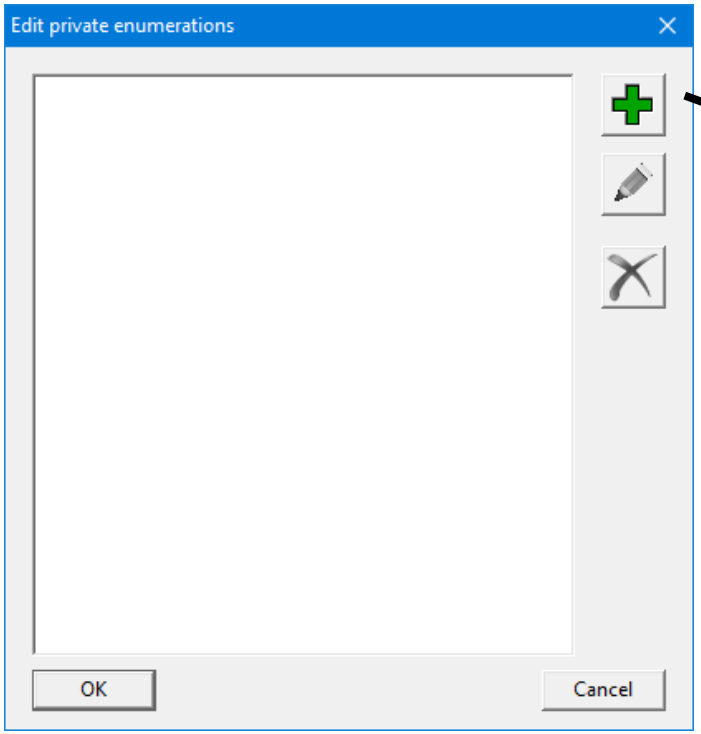
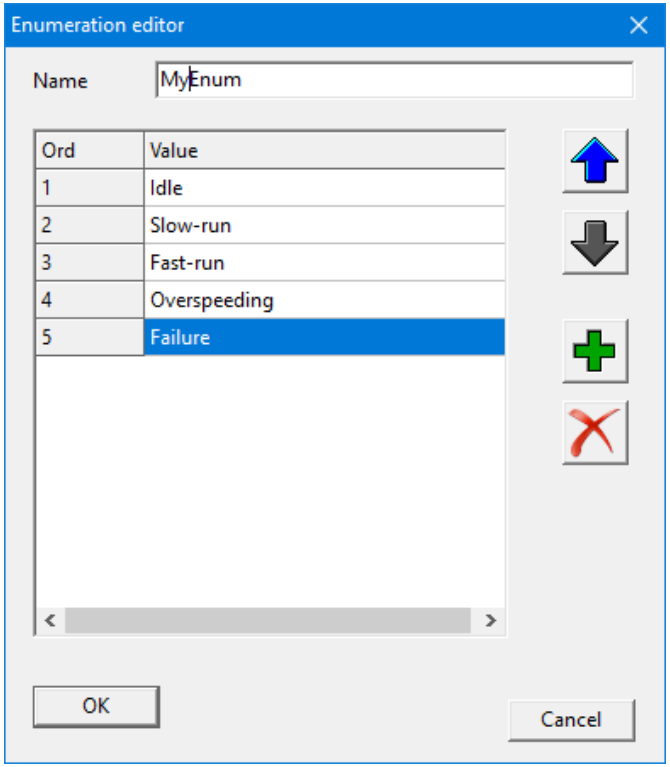
Private enums



Continuous range of integer values with assigned user-defined names.



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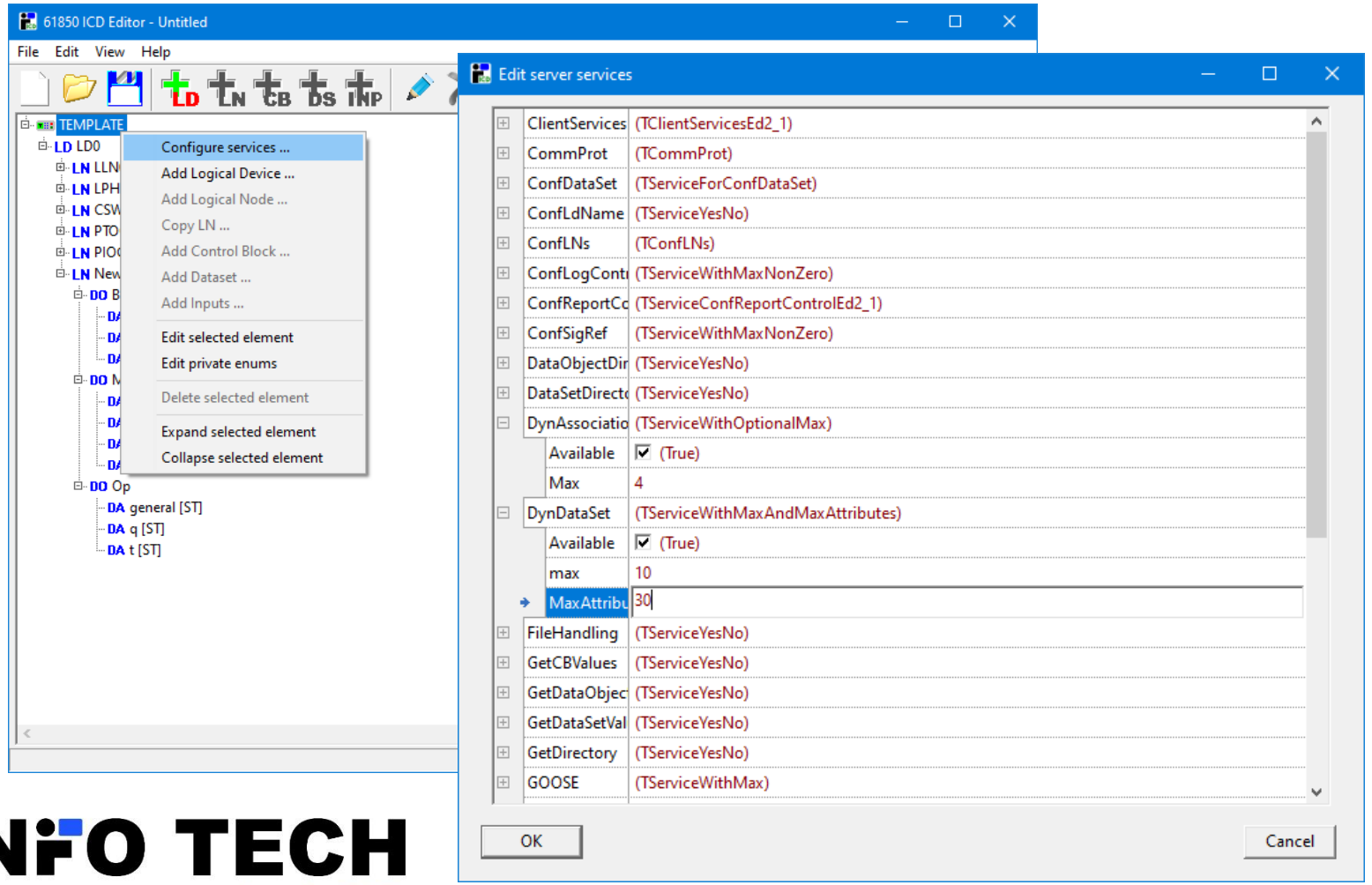
Data model parameters setup



Necessary !!

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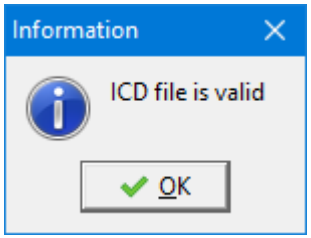
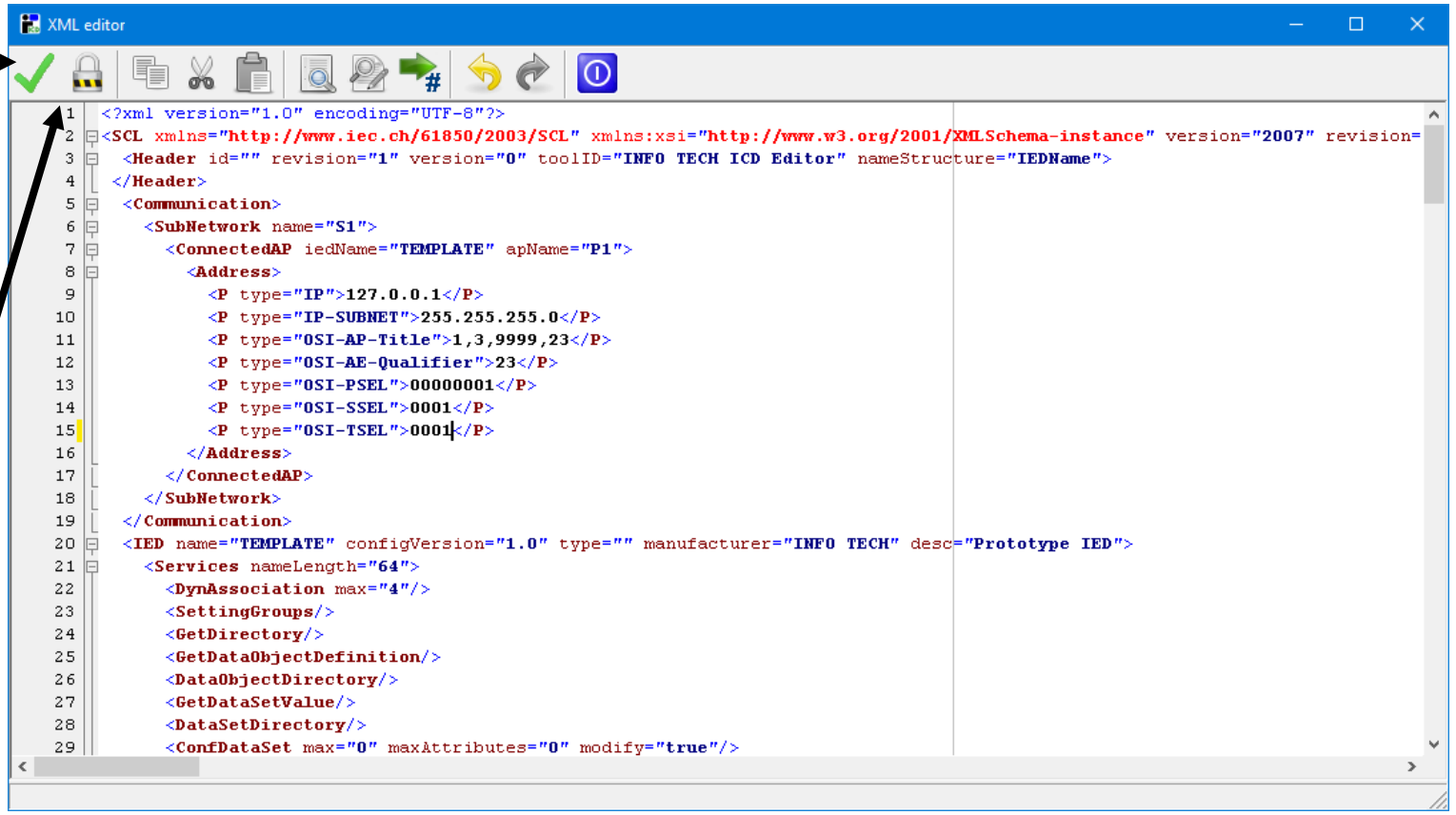
XML Editor and ICD file validation

Validation check button





Unlock/lock button for manual editing.

Possible applications of 61850 ICD Editor program

- Creation and modification of ICD/IID/CID file for the device under configuration.
- Processing of an ICD file into a IID/CID file (addresses, datasets, parameters of control blocks).
- Creation and modification of ICD/IID/CID file to be used for server device simulation (e.g. with the use of INFO TECH 61850 SCL Runner tool).
- Modification of ICD/IID/CID file for the IEC 61850 client program (e.g. 61850 Avenue client), for example to enable execution of negative test cases on the server device.

61850 SCL Runner – and what?

Comments of our customers (system integrators):

„Wow … This simulation seems so easy! We have to try it!”

„Overall, I would just like to say that the SCL Runner is fantastic!”

Order 61850 SCL Runner with 61850 Avenue

- Good luck on your safe and easy road to learn and use the IEC 61850 standard

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