МЭК 61850
Тестирование систем автоматизации и управления
IEC 61850
Extend the Testing with Automation and Control

Т. Шоссиг, Э. Карвальейра, OMICRON electronics GmbH Австрия

Th. Schossig, E. Carvalheira, OMICRON electronics GmbH Austria

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Automation and Control Testing

> **P**rotection Testing: lots of improvements in the last 20 years
  > Tools for Automated Testing
 > Standardized Test Plans reduced efforts dramatically

> But what happened in the...

acworld ?

> Testing **A**utomation and **C**ontrol Systems:
  > Manual procedures in a Conventional Hardwired Substation
  > Increase complexity with Communication
  > Use of Logics, Interlockings
  > SCADA, Gateways, RTUs
  > Firmware and Patch Updates due to Cybersecurity requirements

  > Still using the same Manual Testing Methods...

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IEC 61850 Substations

> Data Models

> Client/Server (Reports), GOOSE, Sampled Values
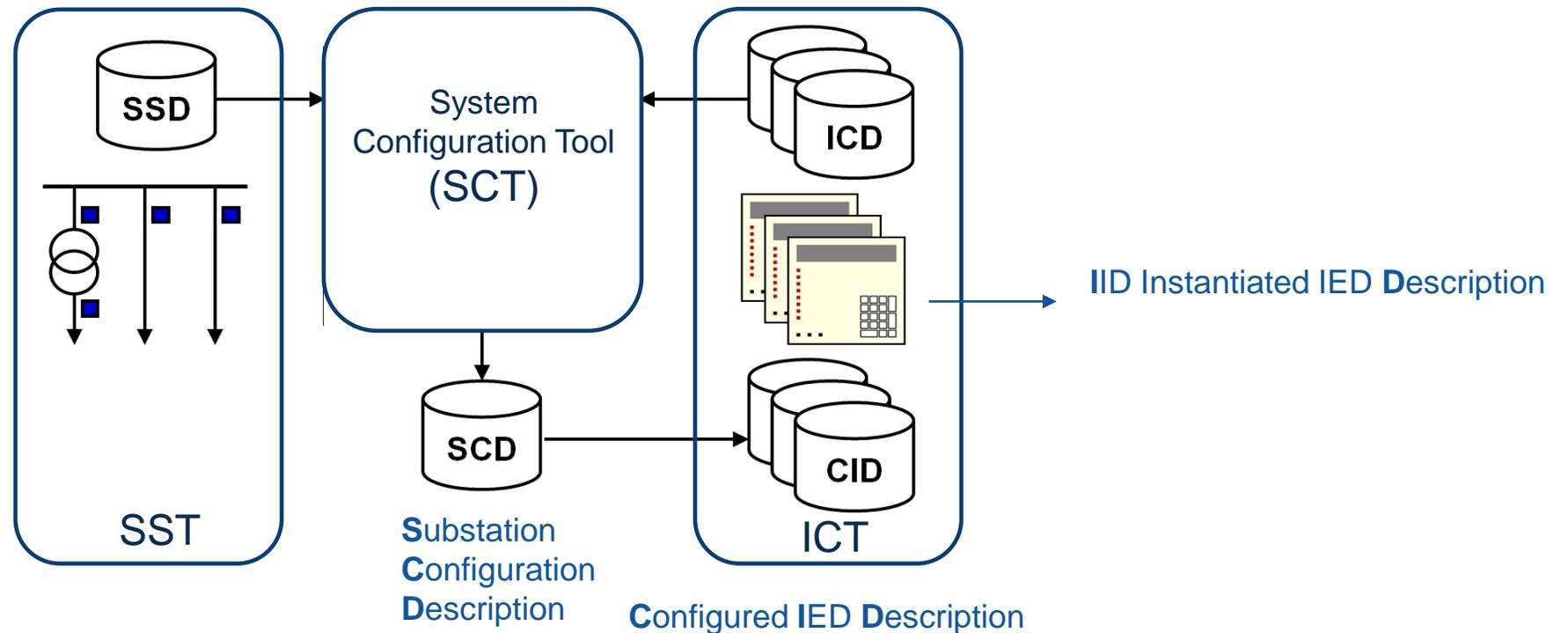
> System Configuration Language (SCL)
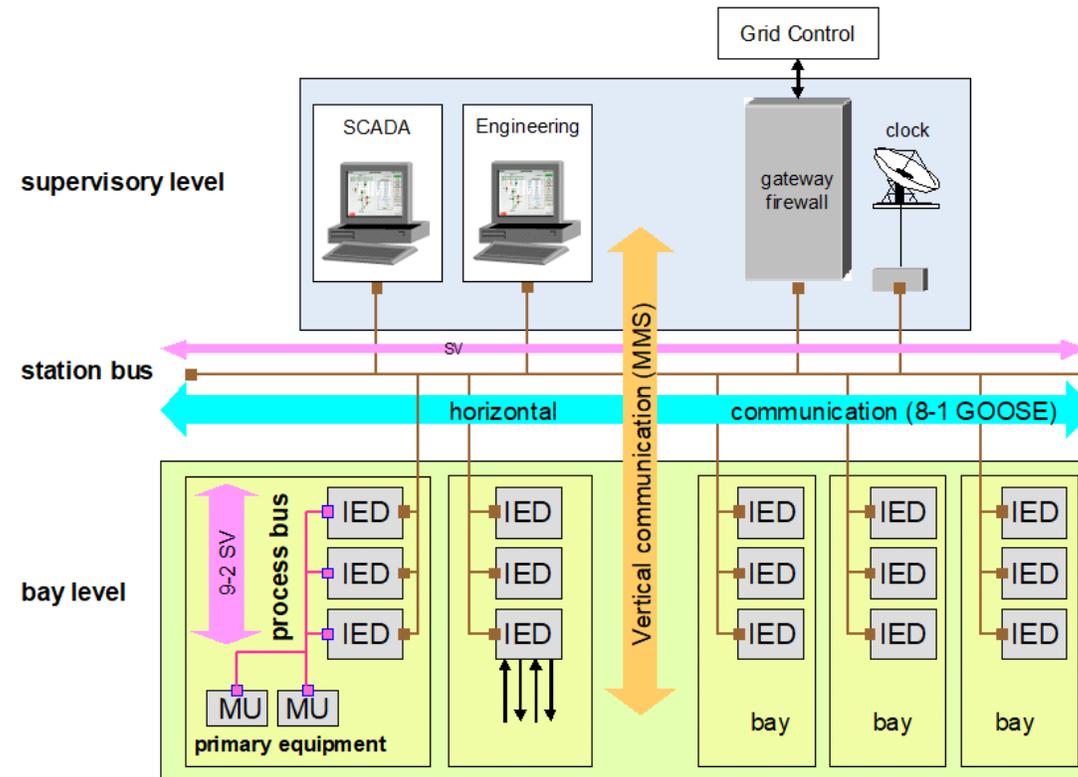
Engineering of IEC 61850 with SCL

> IEC 61850-6

> Configuration of overall communication system
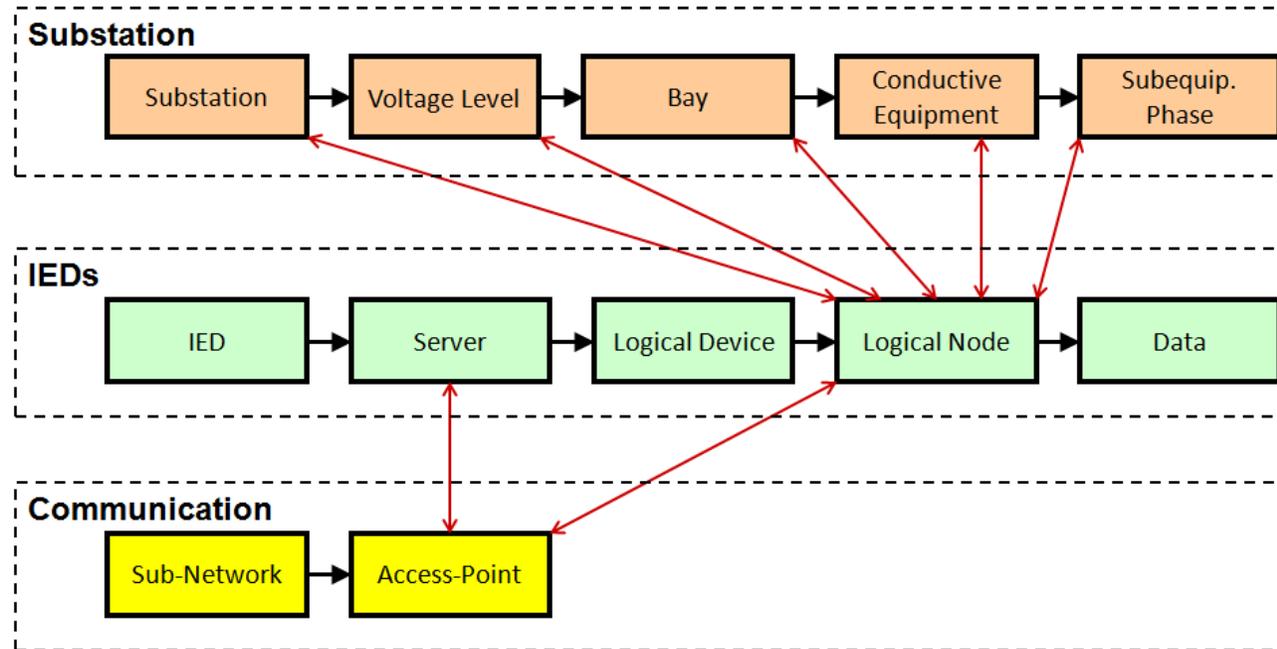
> Interoperability between Engineering Tools

System Specification Description

IED Capability Description

SSD

System Configuration Tool (SCT)

ICD

IID Instantiated IED Description

SCD

CID

SST

Substation Configuration Description

ICT

Configured IED Description

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SCL Scope

> SCL uses XML-based files

> An SCL file contains following information:

> IEDs: Data Models and Configuration of Reports, GOOSE, SV

> Correlation between Switchgear and Functions to IED Logical Nodes
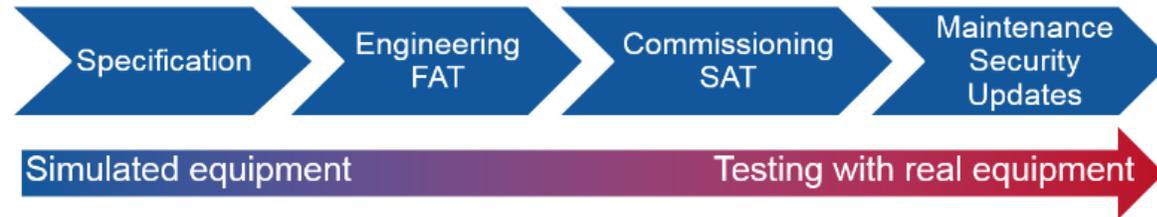
> Communication links between IEDs

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New Test Approach

> Based on SCL Information

> Visualize and Test entire Substation Automation System

> Automated Test Plans

#1 Monitor and Test Communication

#2 Identify errors

#3 Test Logic

#4 Simulation (e.g. FAT)

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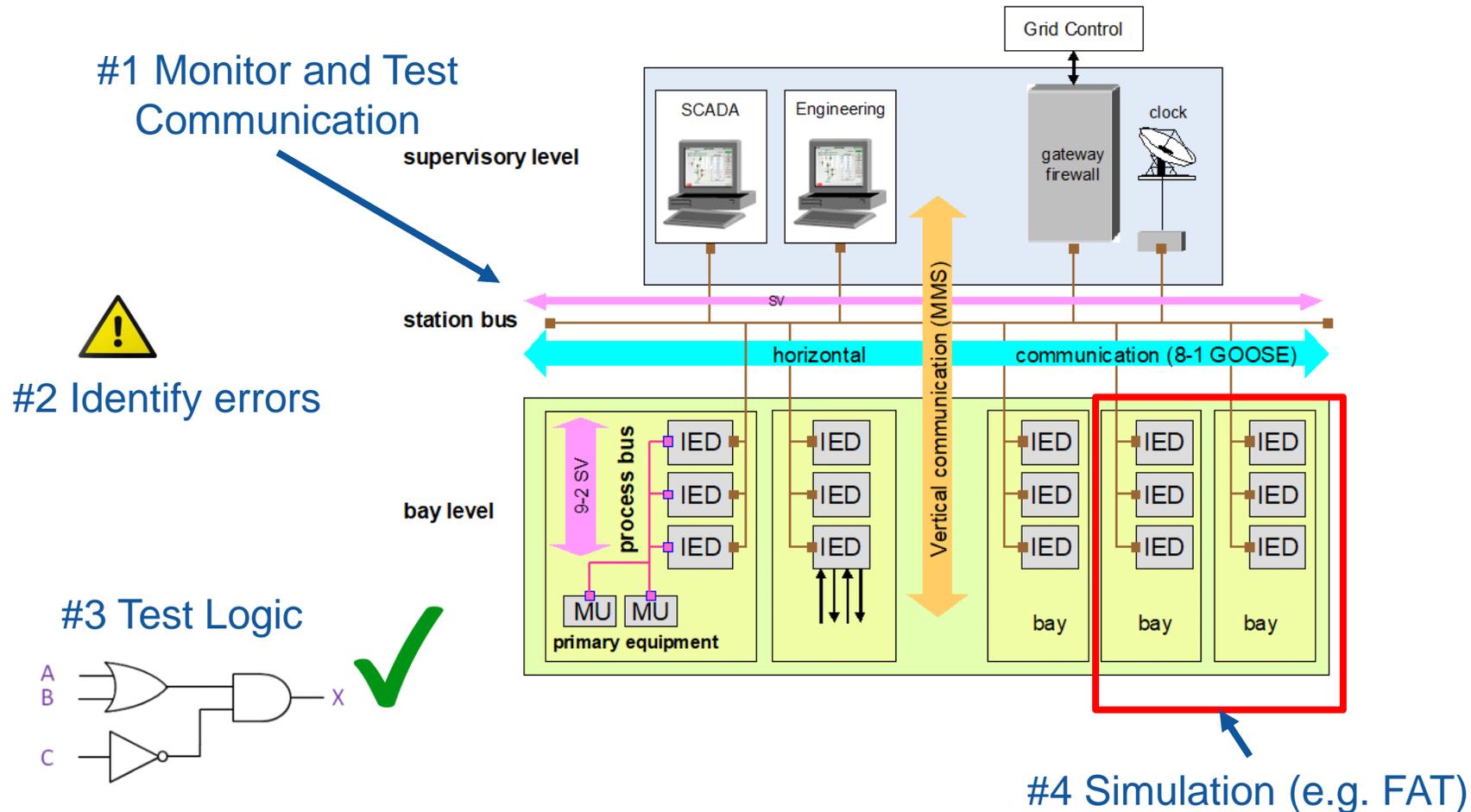
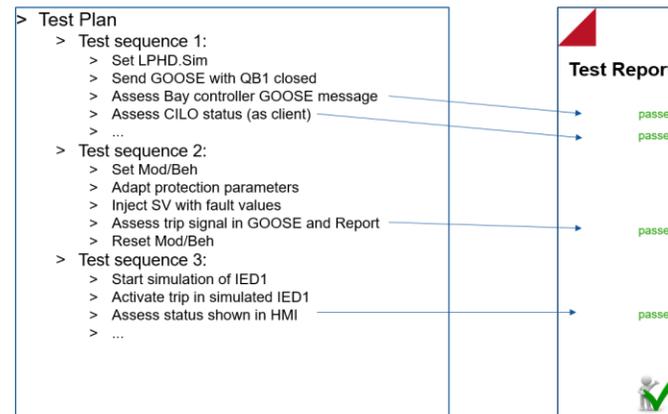# New Test Approach

> Testing the SAS during its entire Lifecycle

> Automated Test Plans

Requirements for Efficient Testing:
- Optional IED Features
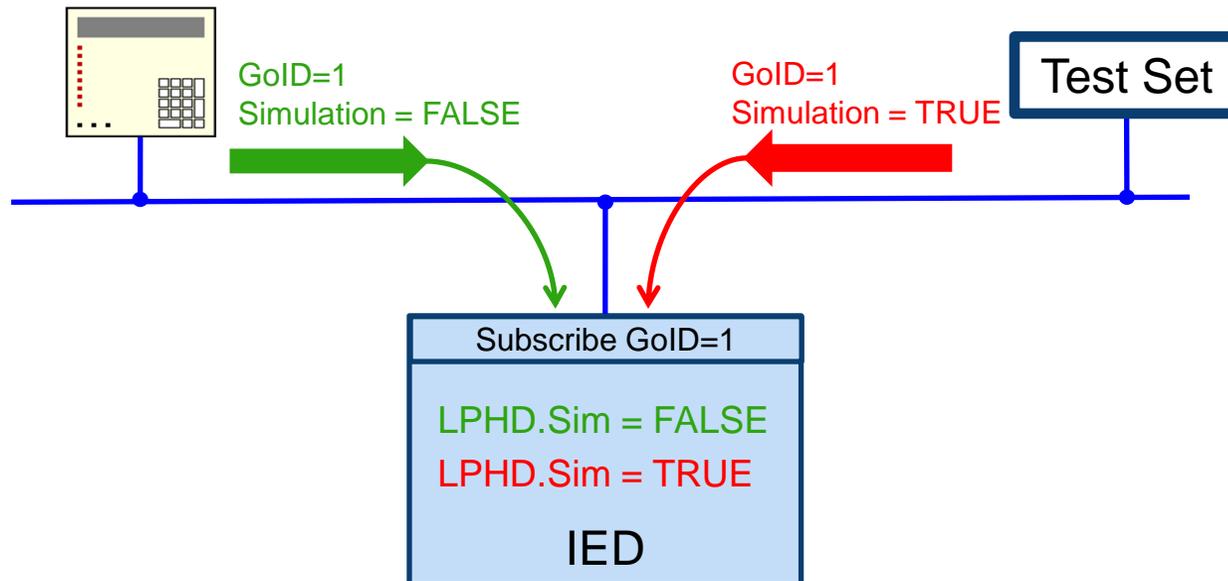- Quality SCD file!

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Test Mode and Simulation Flag

> Test Mode: what are the DUT

GOOSE data → **IED**

q.test = FALSE

Beh = ON

Beh = TEST

Output to process →

processed

not processed

> Simulating Messages with Test Set

GoID=1
Simulation = FALSE

GoID=1
Simulation = TRUE

Test Set

Subscribe GoID=1

LPHD.Sim = FALSE

LPHD.Sim = TRUE

IED

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Req.#2

> Substation Topology in SCD

```
<Substation desc="Munich" name="AA1" sxy:x="1" sxy:y="5">
  <PowerTransformer name="TA1" sxy:y="9" type="PTR">
  <PowerTransformer name="TA2" sxy:x="15" sxy:y="9" type="PTR">
  <VoltageLevel name="D1">
    <Voltage multiplier="k" unit="V">380</Voltage>
    <Bay desc="TF1" name="Q01" sxy:x="1" sxy:y="2">
      <LNode iedName="AA1D1Q01Q1" ldInst="C1Q01F1" lnClass="PDIS" lnInst="1"/>
      <LNode iedName="AA1D1Q01Q1" ldInst="C1Q01F1" lnClass="PTOC" lnInst="1"/>
      <LNode iedName="AA1D1Q01Q2" ldInst="T3S1S1" lnClass="ATCC" lnInst="1"/>
      <LNode iedName="AA1D1Q01Q2" ldInst="T3T1P1" lnClass="YLTC" lnInst="1"/>
      <LNode iedName="AA1D1Q01Q2" ldInst="T3T1P1" lnClass="YPTR" lnInst="1"/>
      <LNode iedName="AA1D1Q01Q1" ldInst="C1Q01F1" lnClass="PTRC
      <LNode iedName="AA1D1Q01Q1" ldInst="C1Q01F1" lnClass="RBRF
      <LNode lnClass="MMXU" lnInst="1"/>
      <ConductingEquipment name="BC1" sxy:y="4" type="CTR">
      <ConductingEquipment name="QA1" sxy:y="5" type="CBR">
        <LNode iedName="AA1D1Q01Q1" ldInst="C1Q02QA1" lnClass="C
        <LNode iedName="AA1D1Q01Q1" ldInst="C1Q02QA1" lnClass="X
        <LNode iedName="AA1D1Q01Q1" ldInst="C1Q02QA1" lnClass="C
        <Terminal bayName="Q01" cNodeName="L11" name="L11" subst
        <Terminal bayName="Q01" cNodeName="L12" name="L12" subst
      </ConductingEquipment>
```

Substation

Voltage Level

Bay
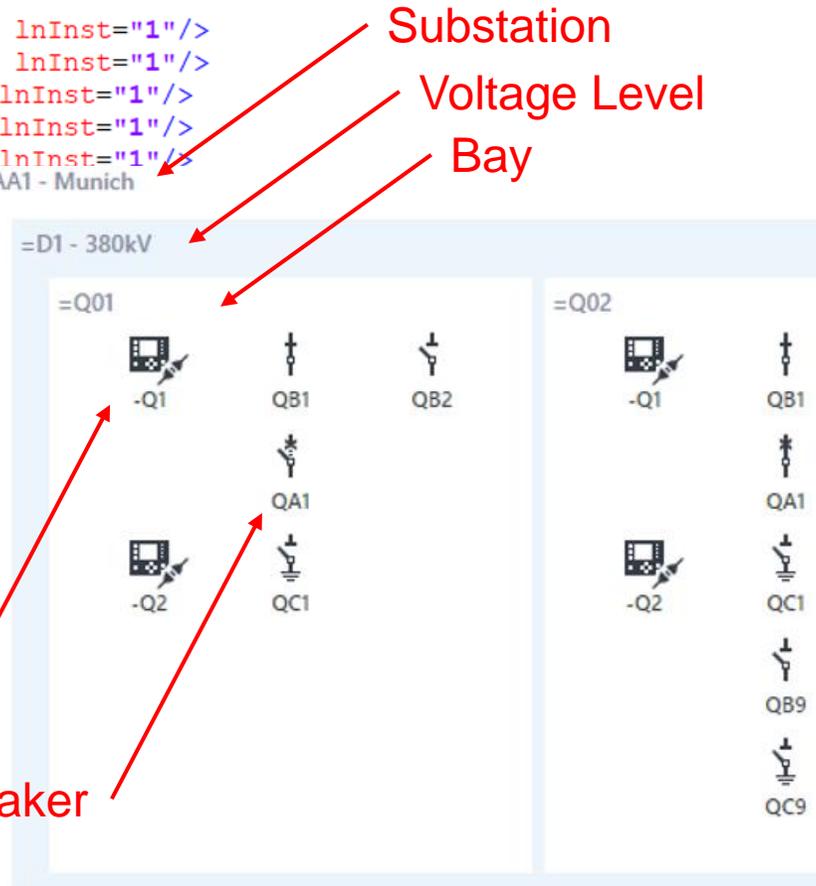
IED

Breaker

Testing Tool

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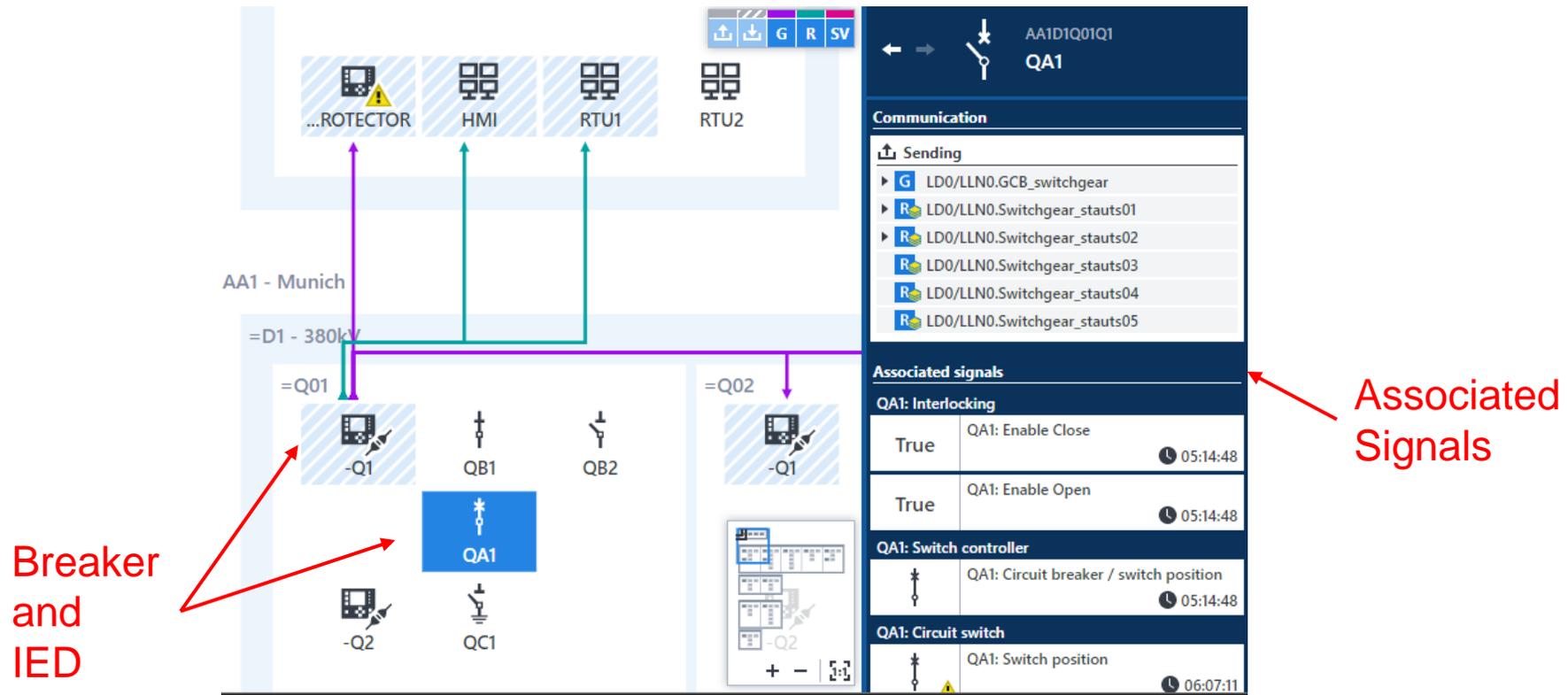# SCD Substation Section

> Association between Switchgear and LNs

```xml
<ConductingEquipment name="QA1" sxy:y="5" type="CBR">
  <LNode iedName="AA1D1Q01Q1" ldInst="C1Q02QA1" lnClass="CILO" lnInst="3"/>
  <LNode iedName="AA1D1Q01Q1" ldInst="C1Q02QA1" lnClass="XCBR" lnInst="1"/>
  <LNode iedName="AA1D1Q01Q1" ldInst="C1Q02QA1" lnClass="CSWI" lnInst="3"/>
  <Terminal bayName="Q01" cNodeName="L11" name="L11" substationName="AA1" vo
  <Terminal bayName="Q01" cNodeName="L12" name="L12" substationName="AA1" vo
</ConductingEquipment>
```


Breaker and IED

Associated Signals

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SCD: Signal Descriptions

> "desc" attribute of Data Objects should be present in SCD file

> IEC 61850 allows to hide 61850

> Instead of Complex Addresses, use signal names from Engineering

> If unavailable, use smart names from Standard

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Describing GOOSE connections

> Subscriptions defined in SCD

```
<GSEControl name="GCB_switchgear" type="GOOSE"
  <IEDName>BB_PROTECTOR</IEDName>
  <IEDName>AA1D1Q02Q1</IEDName>
  <IEDName>AA1D1Q03Q1</IEDName>
  <IEDName>AA1D1Q04Q1</IEDName>
  <IEDName>AA1D1Q05Q1</IEDName>
</GSEControl>
```
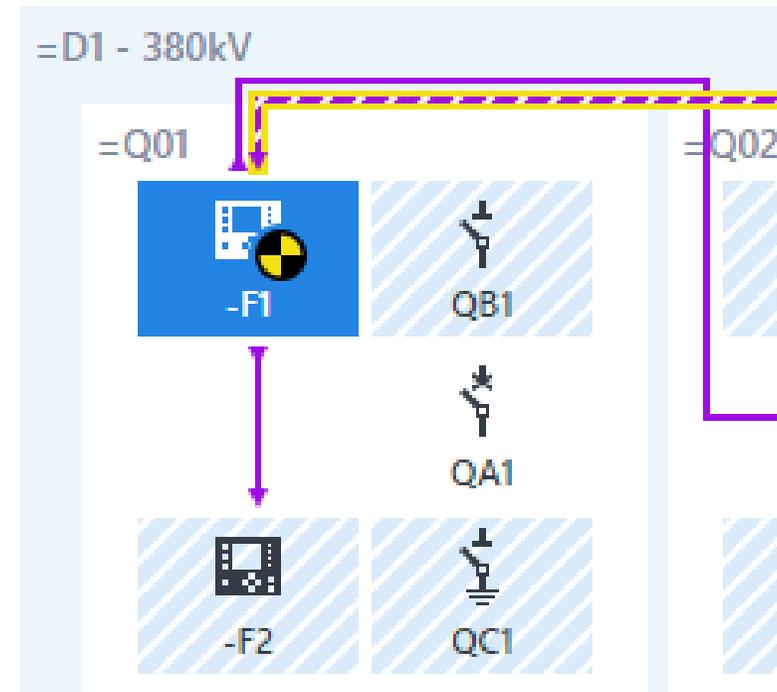
> Use of LGOS
> > Logical Node for GOOSE Subscription
> > One per Subscription
> > Enable Monitoring of Receive Status

AA1 - Niflheim

=D1 - 380kV

=Q01   =Q02

-F1   QB1

QA1

-F2   QC1

> Benefit → Check of GOOSE links:
> > Verify Publisher
> > Verify mismatches by comparing traffic with SCD
> > Verify Reception with Subscribers LGOS

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Report Configuration

> Reports used for SCADA Communication

> One-to-one connections between IED and Clients

> Reports can be reserved
>> "Owner" attribute
>> Described in SCD

```
<ReportControl name="Measurments" buffered="true" bufTime="100"
    <TrgOps dchg="true" qchg="true" dupd="true" period="true"
    <OptFields seqNum="true" timeStamp="true" dataSet="true"
    <RptEnabled max="5">
<ClientLN iedName="HMI" ldInst="none" lnInst="1" lnClass="IHMI"
<ClientLN iedName="RTU1" ldInst="none" lnInst="1" lnClass="ITCI
    </RptEnabled>
    </ReportControl>
```


...ROTECTOR   HMI   RTU1   RTU2

AA1 - Munich

=D1 - 380kV

=Q01   =Q02

-Q1   QB1   QB2
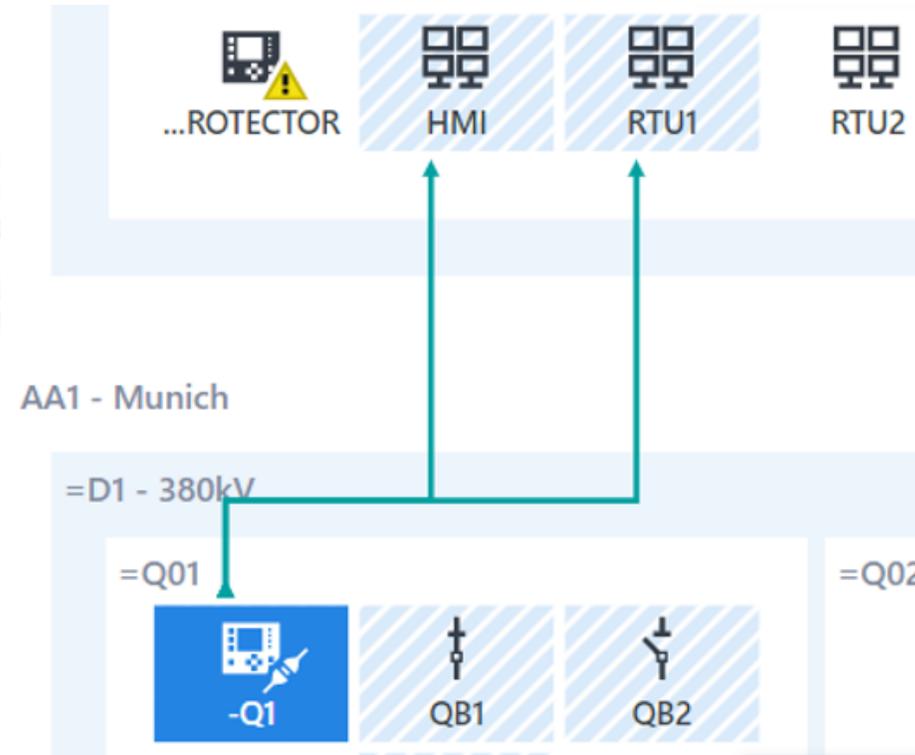
> Benefit → Check Report links:
>> Verify "Owner" is the Client defined in the SCD

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Dynamic Reports

After going online StationScout reads the report communication partner from the RCBs "Owner" field resulting in the additional arrows:

Dynamic DataSets

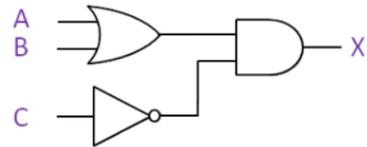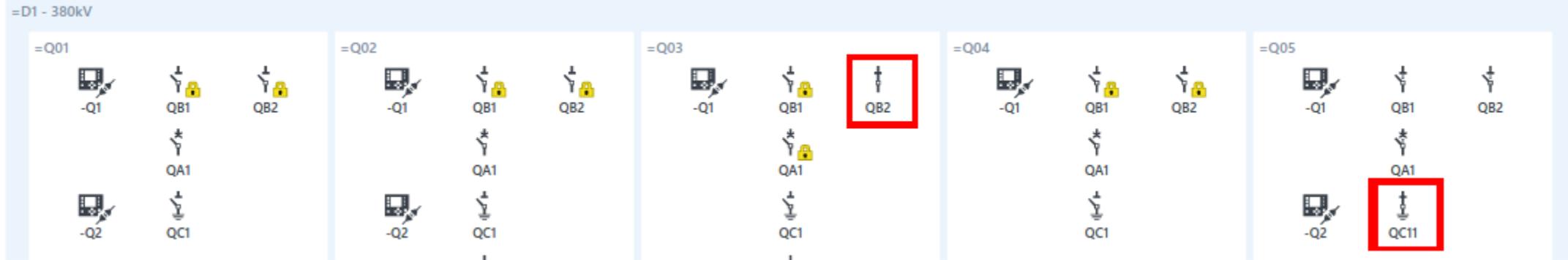# Dynamic DataSets

Network Design Considerations

Req.#6

> Testing Requirements should be considered for Network Design

> Clear Access Points for Testing considering:
>   > Topology: Station Bus and Process Bus
>   > Traffic Control: VLAN and Multicast Filtering
>   > Redundancy: RedBox
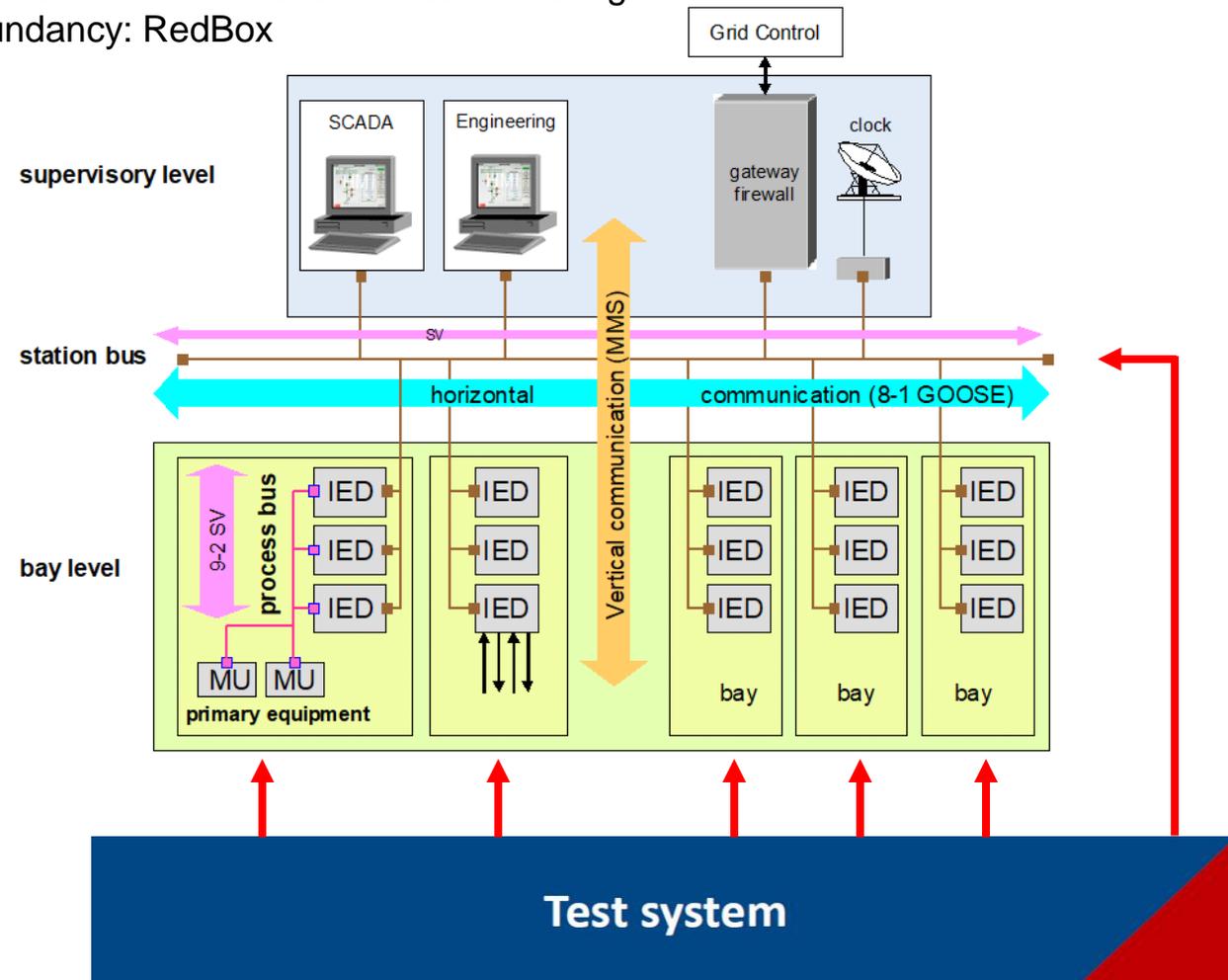
Example: Testing Interlocking Logics

Interlockings

> CILO LN shows interlocking logic result for each switch

Test case Q01-1

Simulation

QB1: ╱─ QB2: ─╮ QA1: ─✳
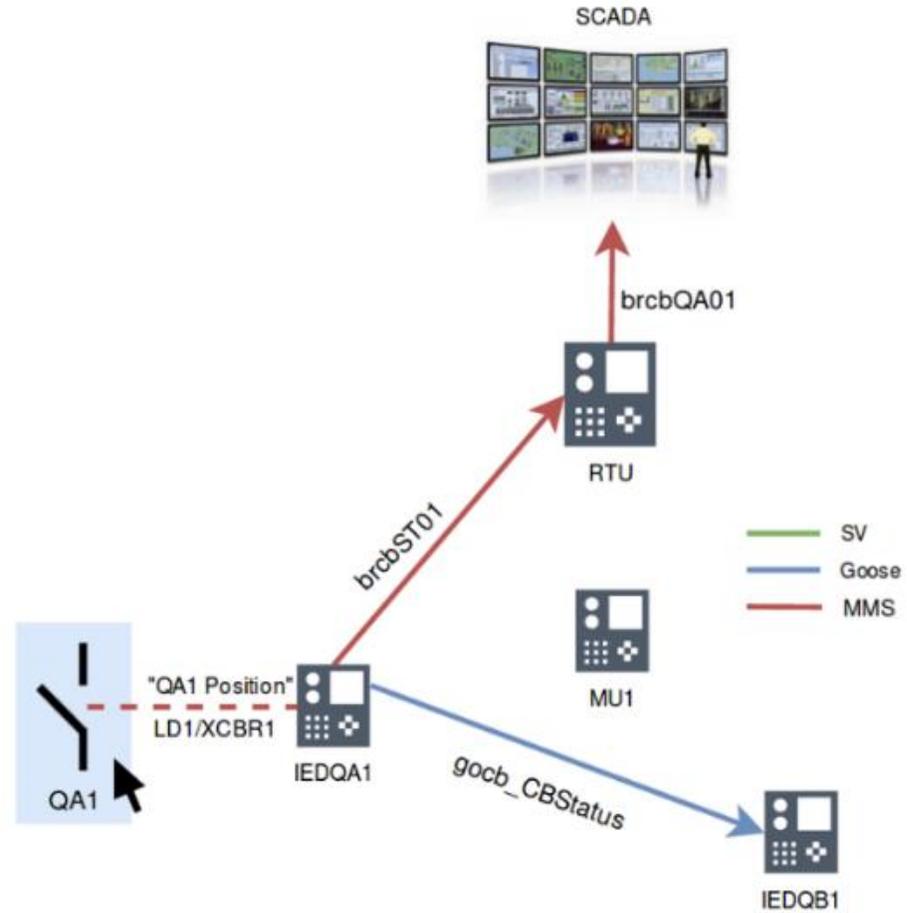
Assessments

QB1-CILO: close-locked
QB2-CILO: open-locked
QA1-CILO: unlocked

Test case Q01-2

Example: Troubleshooting

> Tracing Signals through the SAS

Example: Re-testing after Security Updates

Before firmware update

Firmware update

After firmware update

Conclusion

> SCL is a very powerful aspect of IEC 61850

> Benefits go beyond engineering:
>> Testing / Monitoring
>> Cybersecurity
>> Documentation

> Save Time and Increase Efficiency Using what SCL Offers

> Challenges:
>> Some features are Optional
>> Lack of Tools

> Requirements to be considered during System Design and Engineering

> Enable New Test Methods for entire SAS Lifecycle
>> Automated Test Plans
>> Simulation during Design and FAT Phase
>> Re-test after Security Firmware/Patches Updates

> Enable Functional Security Monitoring of the SAS

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Thank you!

> **thomas.schossig@omicronenergy.com**

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