How IEC 61850 started until the release of edition 1

Karlheinz Schwarz, NettedAutomation GmbH

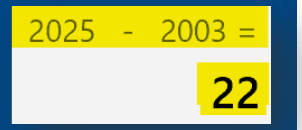
About me

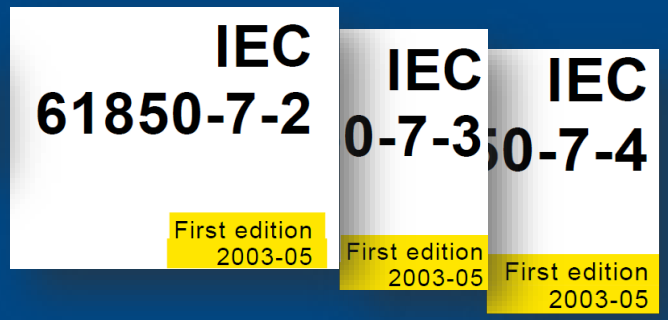
- Electrical Engineer (Siemens 1982 to 1997)
- Consultant since 1992
- One of the grandfathers of IEC 61850
- Started NettedAutomation GmbH in 2000
- Bridge-builder between old & young, engineers & IT, management & workers, …, R&D & Industry, … power systems & industrial automation
- Trainer for 40 years (4,400+ attendees, … 250+ courses all over)

Before we start … a few remarks on the 30 years …

- 30 (?) Years IEC 61850 … from the start in the year 1995 to the year 2025

- First First Editions





2003-05

- First Editions still published in 2018

2018-12

- Presentation covers the first 10 years

Table of contents

- **Foundation (1980-1995)**
  - Ethernet, MMS, MAP, EPRI RP 3599 (UCA 1), TASE.2/ICCP, TC 57 AHWG, SISCO (Herb Falk), Tamarack (George Schimmel), …
- **Decision making process (1995-1999)**
  - WG 10, 11, 12 -> WG 10
  - MMS/FMS, Profibus, Token Bus, Ethernet
  - IEEE SC 36, UCA Substation Initiative, OCIS, …
- **Working on internat. Standard (1999-2005)**
  - WG 10, Editors (!!)
  - Some 10 meetings per year
  - Successful finalization of parts 1, 7-2, 7-3, 7-4, 5, 7-1, 2, 8-1, 6, 10

Traveling back and forth for IEC 61850

Karlheinz Schwarz: Personal travel, activities, and results related to IEC 61850

1981-1985	IEEE 802.3 (Ethernet CSMA/CD) versus 802.4 (Tokenbus); IEC TC 65 PROWAY A and B		
1984 - 2000ff	ISO/IEC 9506 MMS		1992: ISO/IEC 9506-1/-2 Ed 1 published
1982 - 2003ff	MAP (Manufacturing Automation Protocol) - Tokenbus and MMS		1987: MAP 3.0 published (+ Ethernet)
early 1990s	EPRI RP-3599 (Substation Integrated Protection, Control, and Data Acquisition), UCA 1.0 ...		
1992	UCA and IEC TC 57 decided to specify TASE.2/ICCP		
17.09.1994	Loveland (USA)	IEC 57 WG 07	
17.02.1995	Denver/USA	ICCP-Testing Fort Collins	
19.03.1995	Denver (USA)	ICCP-Testing Fort Collins	
14.05.1995	Minneapolis (USA)	IEC TC 57 Meeting	
29.01.1996	San Francisco	IEC TC 57 WG 11	Karlheinz Schwarz met WG 11 first time
25.03.1996	Las Vegas	AEP LAN FMS/MMS/Ethernet Analyse	
15.07.1996	Monterey, CA	IEC TC 57 WG 11	
21.09.1996	Los Angeles	AEP LAN Initiative	
07.10.1996	Ann Arbor (MI)	AEP LAN FMS/MMS/Ethernet Analyse	
26.10.1996	Tampa (FL)	AEP LAN FMS/MMS/Ethernet Analyse	
18.11.1996	Ann Arbor (MI)	AEP LAN FMS/MMS/Ethernet Analyse	
15.12.1996	Ann Arbor (MI)	AEP LAN FMS/MMS/Ethernet Analyse	
11.01.1997	Palm Beach, FL	AEP Initiative	
23.03.1997	Ann Arbor, USA	EPRI UCA AEP Initiative	
07.04.1997	Washington, USA	IEC Expertenmeeting WG 10-12	
28.04.1997	Phoenix, AZ	MMS Forum	
02.09.1997	Detroit, USA	IEC TC 57 WG 10-12 Profiles	
10.11.1997	Phoenix, USA	UCA Forum	IEC 60870-6 TASE.2/ICCP Ed1 published
03.01.1998	Atlanta	UCA/IEC Harmonization Feasibility	
04.02.1998	Tampa (FL, USA)	IEEE/IEC TC 57 Coord. Meeting	
10.03.1998	New Orleans (USA)	UCA Subst. Initiative Meeting	
28.06.1998	Chicago (USA)	UCA Subst. Init. Meeting	
09.09.1998	Atlanta (USA)	Editors Meeting IEC TC 57 WG 10-12	
19.11.1998	Washington DC (USA)	IEEE SC 36 Meeting	
14.12.1998	Ann Arbor (USA)	IEC TC 57 WG 11 Editors Meeting	
19.01.1999	Orlando (USA)	Hertz/ IEC TC 57 Spag Meeting	
15.04.1999	New Orleans (USA)	IEEE SCC 36 Meeting	
10.05.1999	Detroit (USA)	UCA Vorber.	
21.07.1999	Columbus (OH, USA)	AEP Meeting	
16.09.1999	Louisville (KY, USA)	UCA Subst. Initiative	
02.11.1999	Pittsburg (USA)	IEEE SCC 36 Meeting	SCC 36 decided to publish (UCA) Version 2.0 - ICCP
28.11.1999	Atlanta (USA)	IEC TC 57 Editoren Meeting	IEEE-SA TR 1550-1999 published
11.01.2000	San Diego (USA)	UCA Subst. Init	
25.04.2000	Chicago (USA)	WG 10-12 Editoren Meeting	
09.08.2000	Ann Arbor (USA)	IEC 57 WG10-12 Editoren Meeting	
15.10.2000	Ann Arbor (USA)	IEC 57 WG 10-12 Editor Meeting	
14.01.2001	Cocoa Beach, FL	61850 Editoren Meeting	UCA Usersgroup started

Ongoing work ... no meetings listed for 2001-2005

2001-2002	Report: UCA™ update (expected in 2002): The core content of the UCA™ 2.0 specification can be replaced by references to various IEC 61850 documents ... **"UCA™ compatible – IEC 61850 inside".** - harmonization of IEC 61850 with UCA™ 2.0 almost completed	
2003-04		IEC TR 61850-1 Ed1
2003-05		IEC 61850-7-2 Ed1 (editor K. Schwarz)
		IEC 61850-7-3 Ed1
		IEC 61850-7-4 Ed1
2003-07		IEC 61850-5 Ed1
		IEC 61850-7-1 Ed1 (editor K. Schwarz)
2003-08		IEC TS 61850-2 Ed1
2004-05		IEC 61850-8-1 MMS Ed1
		IEC 61850-8-2 Profibus closed in 1998
2005-01		IEC 61850-6 Ed1
2005-05		IEC 61850-10 Ed1 (editor K. Schwarz)

Foundation

Decision making process

Working on an International Standard series

04.08.2025 / 30 Years of IEC 61850 Anniversary, 24. Sept 2025
How IEC 61850 started until the release of edition 1

<<30Years-Anniversary-Travel_single-page.pdf>>

Welcome note of Christoph Brunner to the 10-year celebration in Klaus / Austria on September 1st, 2005: Christoph listed more than 50 IEC meetings related to IEC 61850 including 16 Editor Meetings; (1994-2005)

See Christoph's Meeting List 2005-09-01: <<history.pdf>>

Publications

2001-2002	Report: UCA™ update (expected in 2002): The core content of the UCA™ 2.0 specification can be replaced by references to various IEC 61850 documents … **"UCA™ compatible – IEC 61850 inside".** - harmonization of IEC 61850 with UCA™ 2.0 almost completed
2003-04	IEC TR 61850-1 Ed1
2003-05	IEC 61850-7-2 Ed1 (editor K. Schwarz) IEC 61850-7-3 Ed1 IEC 61850-7-4 Ed1
2003-07	IEC 61850-5 Ed1 IEC 61850-7-1 Ed1 (editor K. Schwarz)
2003-08	IEC TS 61850-2 Ed1
2004-05	IEC 61850-8-1 MMS Ed1 IEC 61850-8-2 Profibus closed in 1998
2005-01	IEC 61850-6 Ed1
2005-05	IEC 61850-10 Ed1 (editor K. Schwarz)

04.08.2025 / 30 Years of IEC 61850 Anniversary, 24. Sept 2025
How IEC 61850 started until the release of edition 1

Foundation (1980-1995): ISO OSI RM (Tower of Hanoi)

"Jakarta 14 Layer Cake" … inter-operation (interoperability) … reference model like ISO/IEC 7498 still missing

IEC 61850 (2013) ACSI, models, SCL, engineering, functions, …

7 ISO/OSI Layer (1985)

Photos by Karlheinz Schwarz

Foundation (1980-1995): IEEE 802.4 versus IEEE 802.3

- My task in the year 1981 (working for Siemens): analyzing Tokenbus vs Ethernet

- Worked in the department of “Tokenbus” believers
- Ethernet was criticized in the automation domain
- Patent: making CSMA/CD deterministic (1984)

Source of picture unknown

Foundation (1980-1995): Proway A&B and Proway C

- Realtime communication was in the focus of automation
- IEC Proway (Process Highway) was the vision

IEC Technical Report 60954 Withdrawn

IEC TR 60954:1991

Process data highway, Types A and B (PROWAY A and B), for distributed process systems.

954 © IEC - 17 -

Provision is made for two frame structures:

- PROWAY A is based on ISO Standard 3309, HDLC frame;
- PROWAY B is based on a frame given in IEC Publication 870-5-1.

IEC 60870-5-1

IEC 60955 Replaced by IEC 61784-1:2007, ...

IEC 60955:1989

Process data highway, Type C (PROWAY C), for distributed process control systems

Specifies those elements which are required for compatible interconnection of statio of a Local Area Network (LAN) using the Token Bus access method in an industrial environment. These elements include: the electrical and physical characteristics of th

"Token Bus local area network IEEE 802.4 is part of the MAP (Manufacturing Automation Protocol) profile and has been adopted for IEC's Process Data Highway (PROWAY) ..."

TOKEN BUS PERFORMANCE IN MAP AND PROWAY;
D. Janetzky (Siemens) and K. S. Watson (Fraunhofer IITB), 1986

Foundation (1980-1995): MAP, TOP, MMS, … Tokenbus

- First trip to the USA
- MAP Meeting at GM TechCenter in Warren Michigan

32 years young

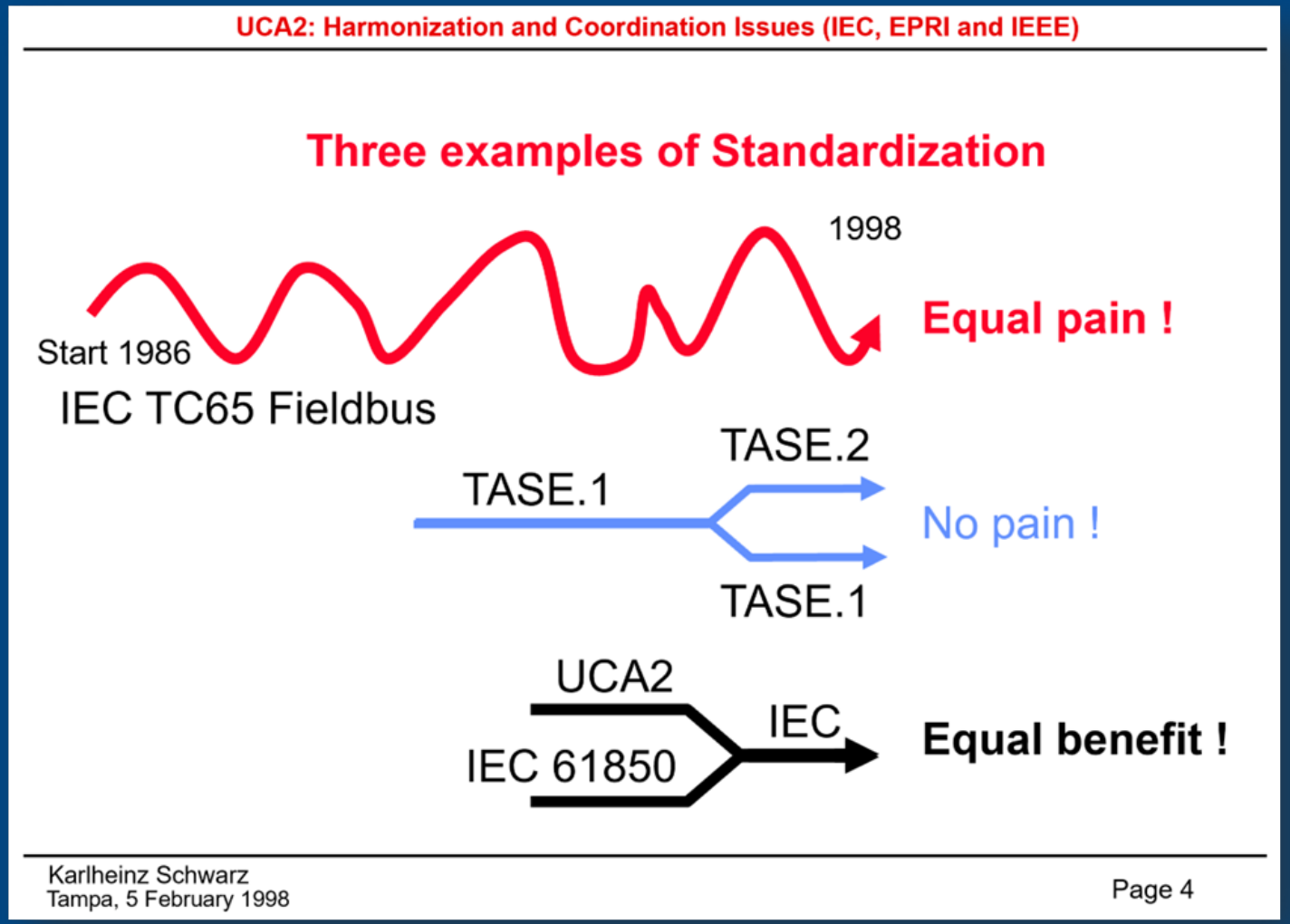
“cool”

Photos by Karlheinz Schwarz

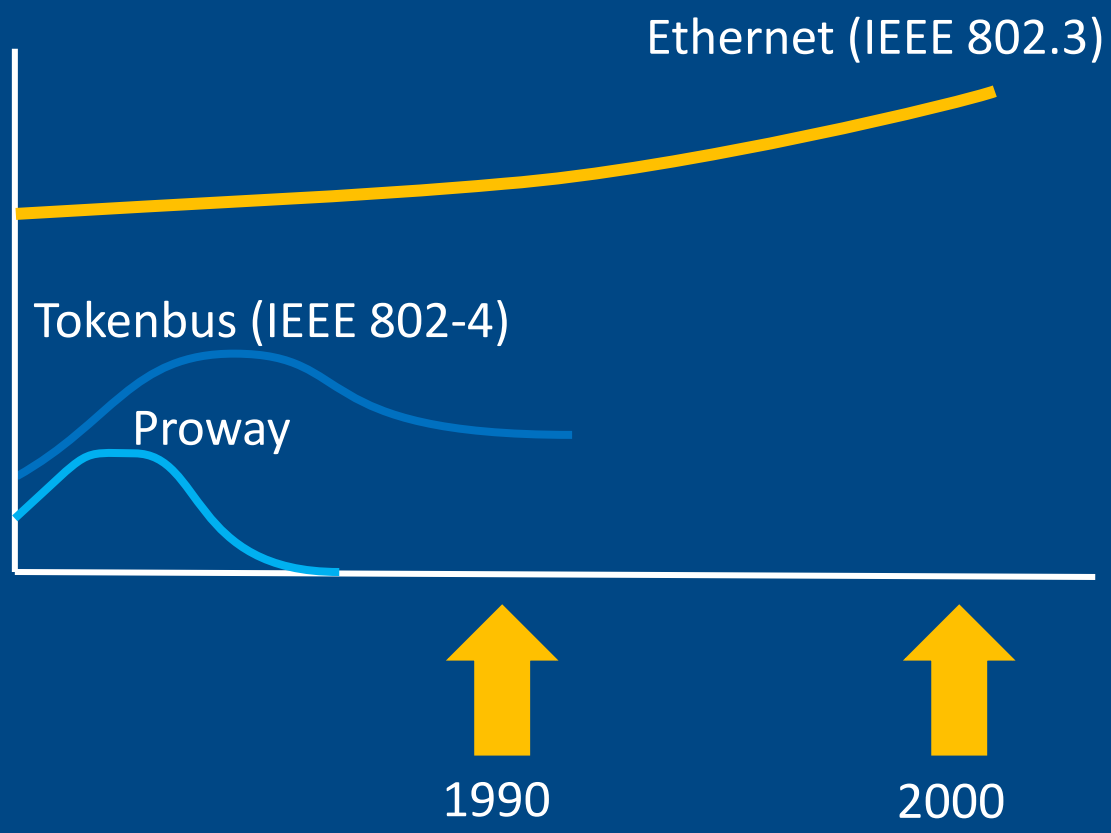
Foundation (1980-1995): MMS, MAP, Fieldbusses

- Herb Falk (SISCO), George Schimmel (Tamarack), and Karlheinz Schwarz (Siemens) had been deeply involved in the development of MMS (ISO 9506), MAP (Manufacturing Automation Protocol), TASE.2 (ICCP) since the 1980s.
- Convinced that the approach of MMS (Manufacturing Message Specification, ISO 9506) and Ethernet (IEEE 802.3) are good foundations for almost all automation systems.
- Ethernet was understood as non-deterministic. Therefore, Tokenbus and Ethernet became both part of MAP 3.0
- MMS was understood as too complex.
- Many believed that Profibus FMS (Fieldbus Message Specification) would help.
- MAP 3.0, Tokenbus, and Profibus FMS struggled.
- IEC 61158 Fieldbus!?

Foundation (1980-1995): The early years



Foundation (1980-1995): MMS, MAP, Fieldbusses



IEC Fieldbus
66 CD ROM (parts)

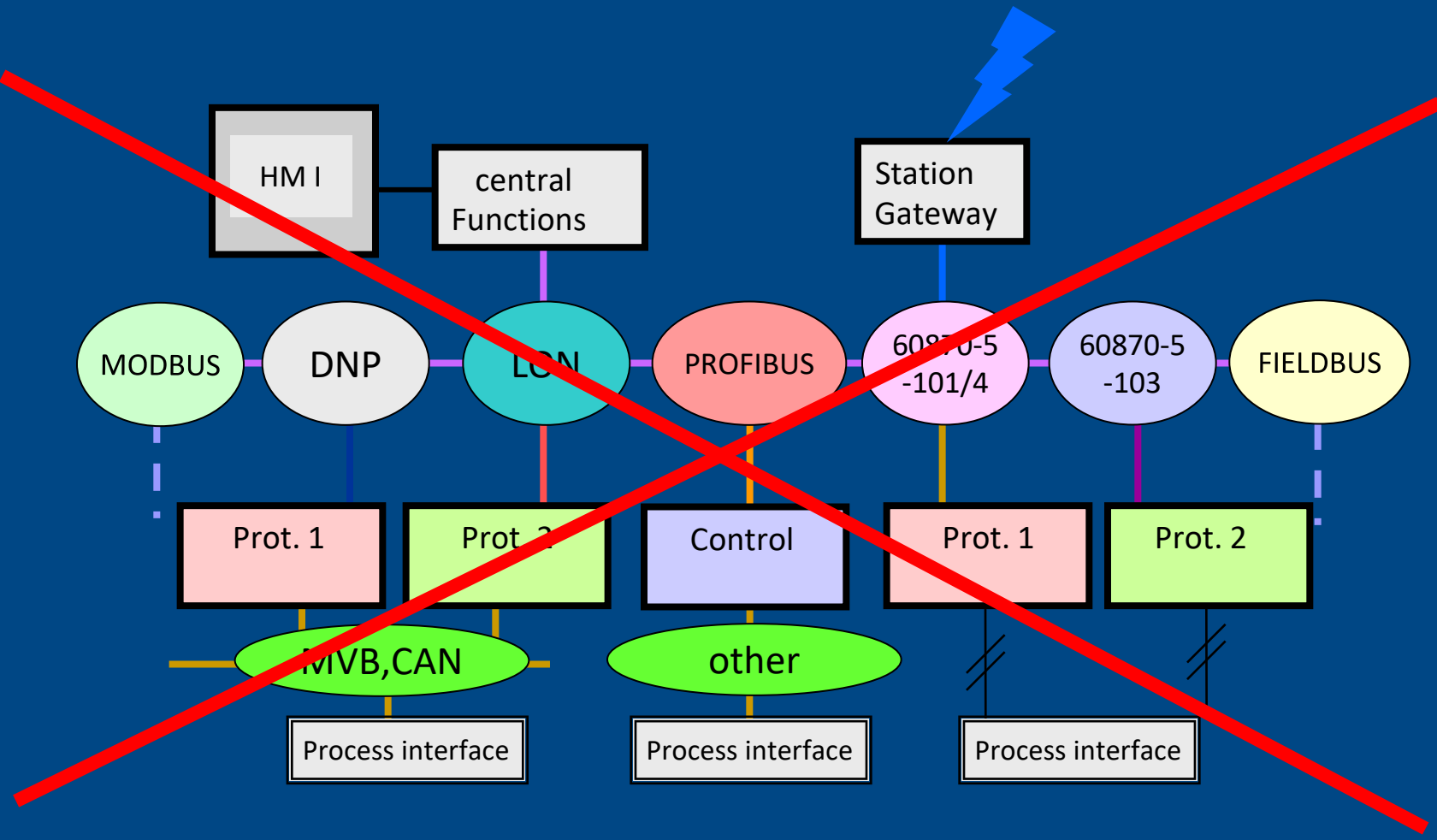
2006

Photo by Karlheinz Schwarz

Foundation (1980-1995): MMS, MAP, Fieldbusses

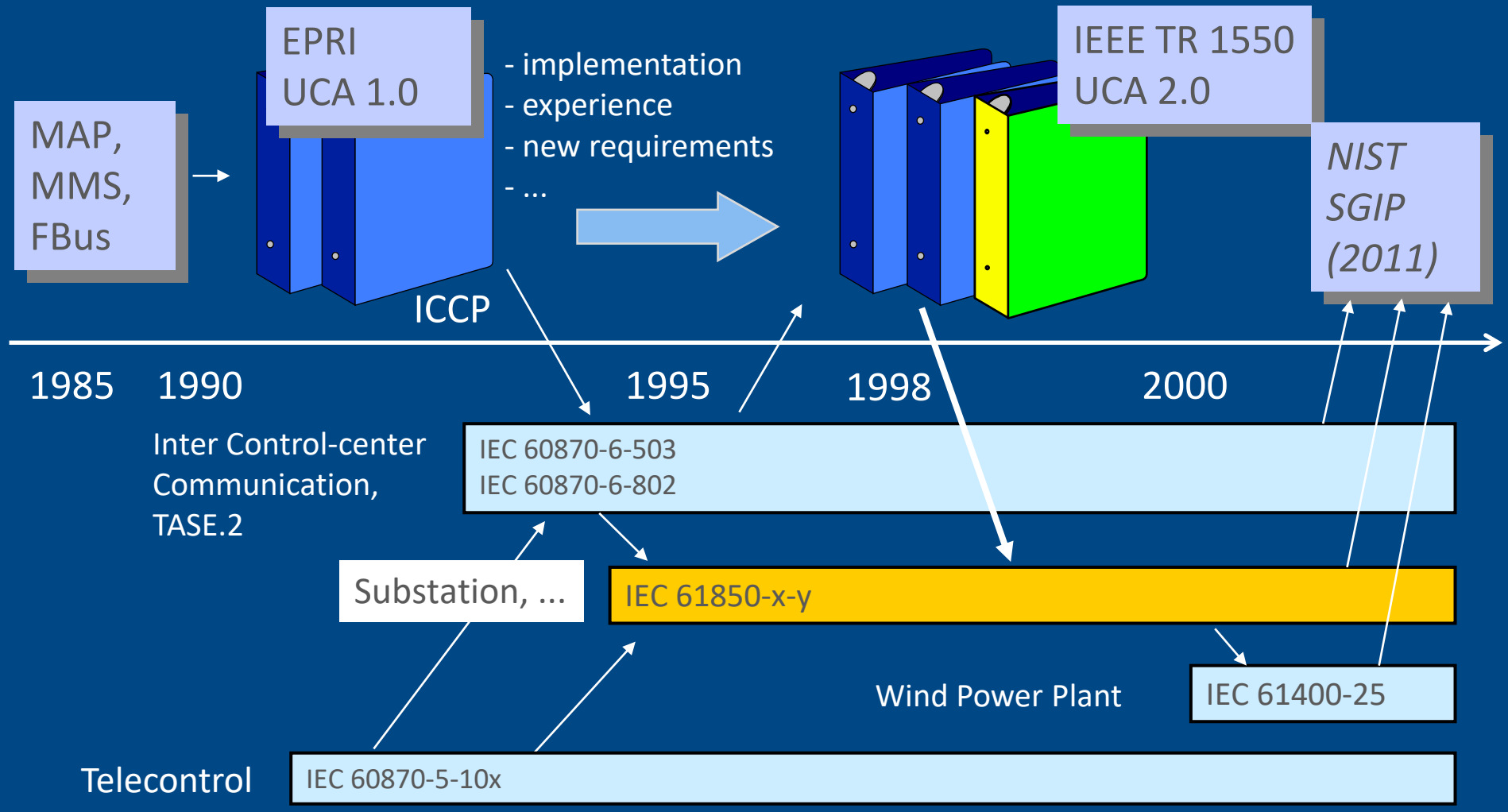
- MMS/MAP/CNMA: mid 1980 to mid 1990s: only MMS survived
- September 1987: IEC TC 57 / WG 07 started to work on "Telecontrol protocols compatible to ISO and ITU-T standards started: ELCOM, WSCC, IDEC, MMS.
- ELCOM -> TASE.1
- I was engaged by German utilities and vendors to bring my expertise of MMS into the standardization of TASE.2 in IEC TC 57 WG 7.
- MMS -> ICCP/TASE.2 – MMS survived (2 Demos March 1995).
- MMS was selected as the main protocol for UCA CASM, GOMSFE, … IEEE 1525 (1999).
- Fieldbusses (TC 65) did not care about the work of TC 57.

Foundation (1980-1995): Proliferation in Substations

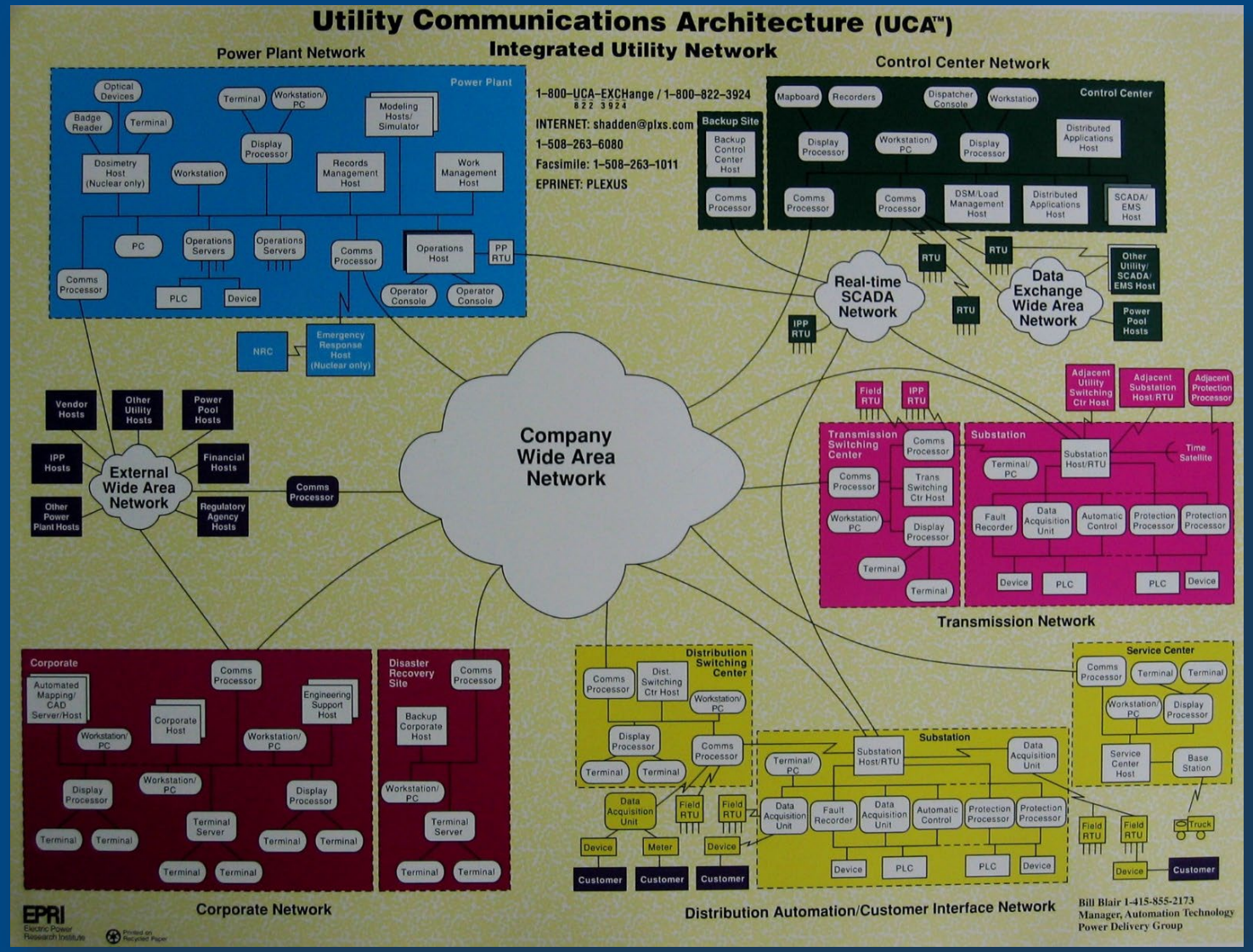


Source: RWE, ABB, Alstom, Siemens

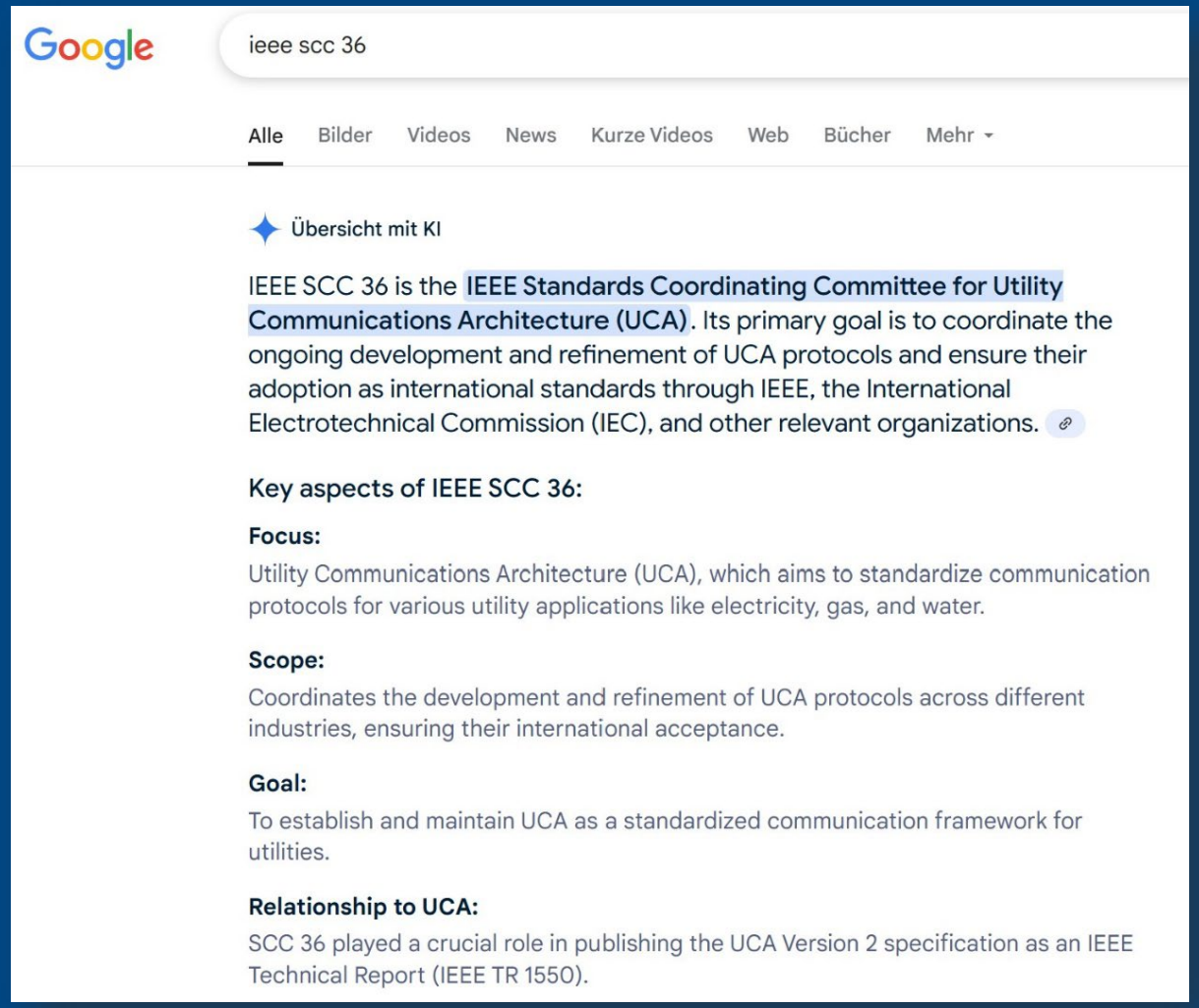
Decision making process (1995-1999): Results



Decision making process (1995-1999): EPRI UCA (Vision)



Decision making process (1995-1999): IEEE SCC 36



Decision making process (1995-1999): IEEE SCC 36

SCC36 inaugural meeting
Joe Koepfinger presiding
09:00 11/20/98

8) Formation of Subcommittees and development of scopes

Discussions of liaison process – chart presented by Joe. Need for liaison with other IEEE societies, IEC, and other interested industry groups such as ANSI, OMG, etc.

Need for user groups – some potentially more active than others – to act as advocates for the UCA interests.

Motion: Dan Nordell to chair, Frances Cleveland, Karlheinz, Jack Robinson, Stan Klein to come up with plan for education. Also to begin to develop materials. Passed unanimously.

Decision making process (1995-1999): IEC TC 57, IEEE, EPRI

IEC TC 57, EPRI, IEEE SCC 36 Coordination

Memorandum of Understanding

Tampa, 5.2.98

1. UCA2 (GOMSFE, CASM and PROFILE) will be published as IEEE Technical Report as soon as possible, publication to be expected in 6 months.
2. Improvement from UCA2 field tests will be fed to IEC.
3. IEC will be the living standard.
4. SPAG will examine EPRI proposal for overall UCA2 coordination, results get back to Bill Blair (EPRI).
5. IEC TC 57 WG 10, 11, and 12 will proceed as outlined by Falk/Schwarz (Atlanta Agreement)
6. Further harmonization will be through IEC WGs (not by updating IEEE Technical Report)

Decision making process (1995-1999): Would Ethernet work?

Excerpt from my invoice regarding Ethernet LAN Simulation

Hotel costs

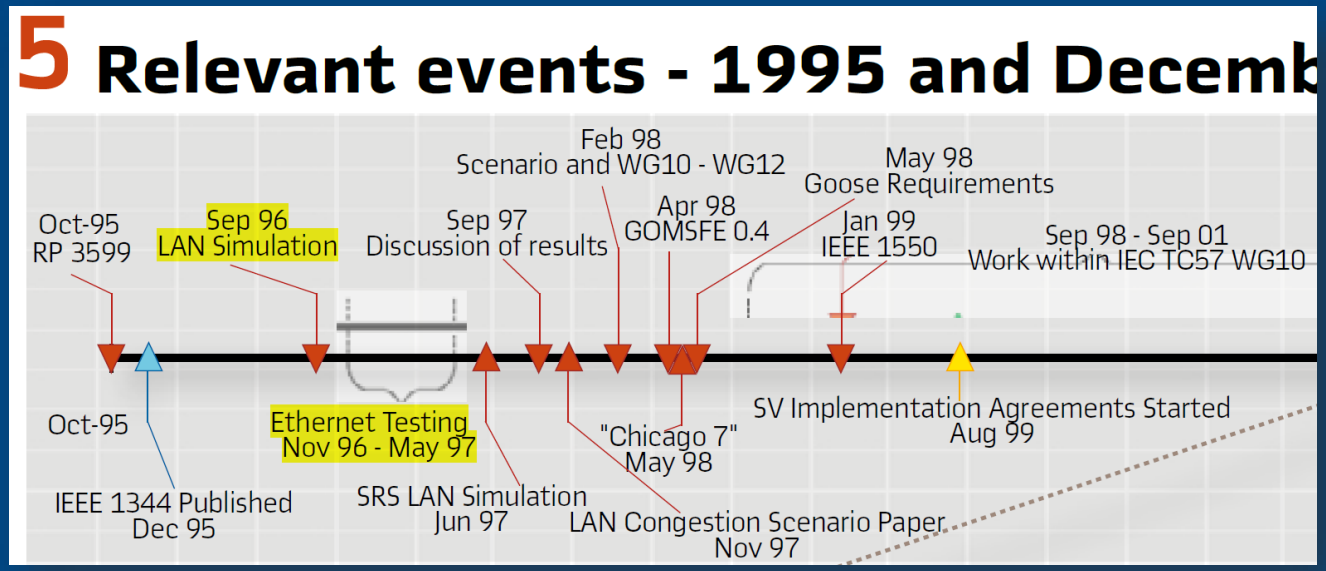
Hotel Biltmore Los Angeles

For the time until October 11, 1996 I invoice you for the following activities:

1) Preparation and presentation for AEP Substation meeting in Los Angeles (22. Sept. 96)

2) Technical support and drafting of the FMS/MMS Analysis

Diverse Costs	
Copying at Kinko's	47,59 $
	47,59 $



Source: Herb Falk, PAC World, Dec 2012

Decision making process (1995-1999): Proof of Concept

OTSecurityProTechTalk | R-GOOSE Essentials for OT Professionals

Herb Falk reported: Cyber-Resilient Messaging for Power Grids & Utilities (2025-07-09)

Industry did not believe it (IEEE, IEC, others…)

OT SECURITY PROFESSIONALS

- *Needed to prove it (EPRI funded):*
  - Collision Testing at SISCO (20 nodes and Ethernet Hubs)
  - Network Simulations for 100 nodes at Fraunhofer Institute (Germany)

  Special thanks to: 3com (Bob Metcalf) ,CISCO, Karlheinz Schwarz, Fraunhofer Institute, and ***Bill Blair*** of the Electric Power Research Institute (EPRI) – without whom, don't know where we would be!
- Test results confirmed the simulation results

5

Industry had to believe, and industrial field bus suppliers re-ran the tests against their technologies and confirmed Ethernet to be able to deliver more information and in a more probabilistic deterministic manner. Formed the foundation for Industrial Ethernet adoption!

OT Security Professionals

Courtesy of and with permission of Herb Falk

Decision making process (1995-1999): Bill Blair's greetings

Bill Blair (wrote me in July 2025):

Dear Karlheinz, Please use the following text as you see fit:

I have been proud to have been part of the concept and development of IEC 61850. Also, I want to thank the many other engineers that have contributed to its application and success.

Courtesy of and with permission of Bill Blair

Working on international Standard (1999-2005): WG 10

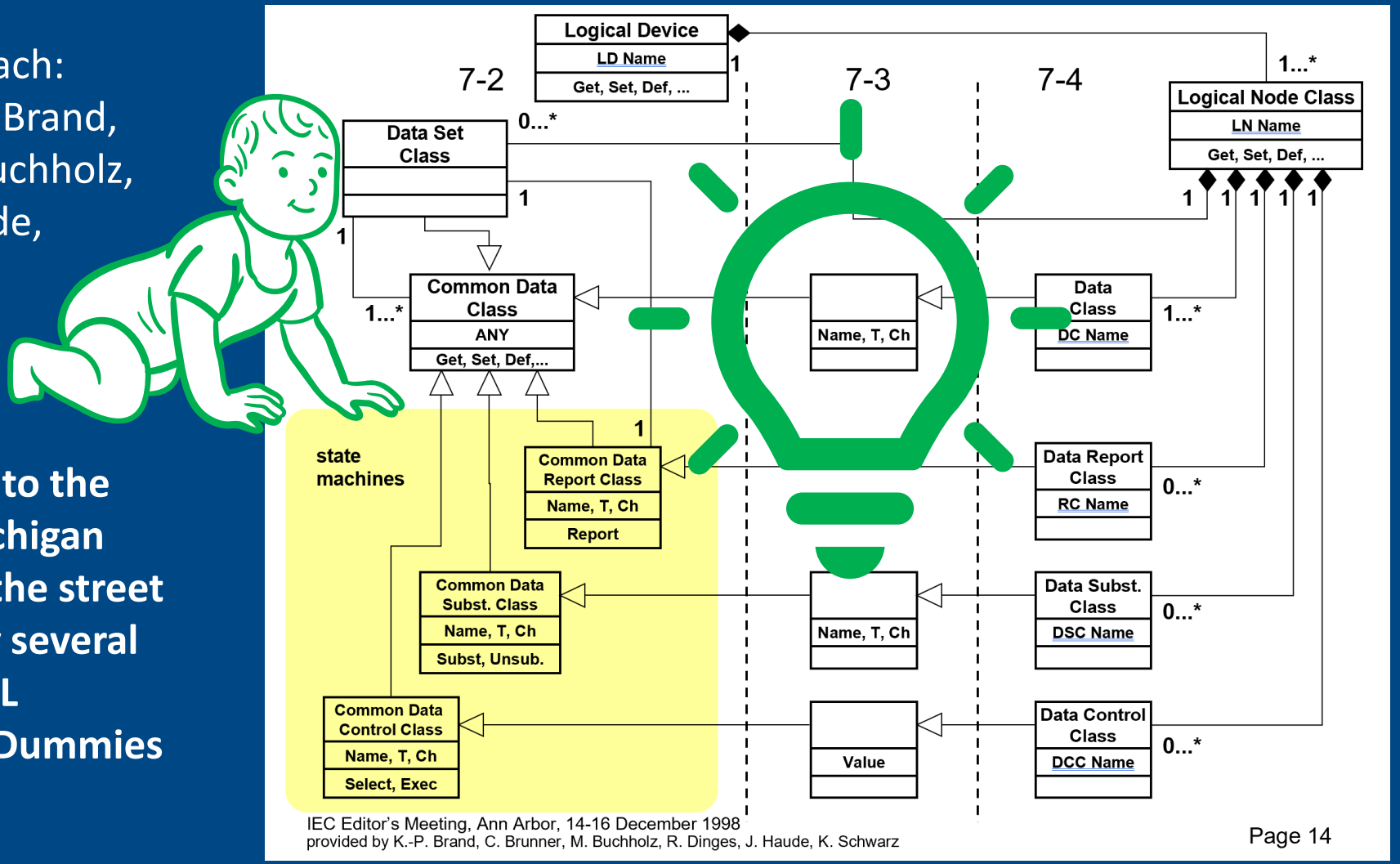
Excerpt from the welcome note of Christoph Brunner to the 10-year celebration in Klaus / Austria on September 1st, 2005: <<history.pdf>>

- "We have learned, how to have fruitful discussions in order to find compromises [see next slide] – and we have learned a lot from a technical viewpoint. When we started, many of us did not know MMS and TCP/IP and did not understand object-oriented modelling. Now, we are all experts in these domains …
- We can be proud, of what we have achieved. Yesterday, we could visit the first two substations [see next slides] built with products using IEC 61850. IEC 61850 is not only requested and being installed in already quite many projects. IEC 61850 is also on the way, to be used in other domains than the substation automation."
- 20 years later (after 2005) we know even better what is needed … more to come …

IEC Editor's Meeting, Ann Arbor, 14-16 December 1998

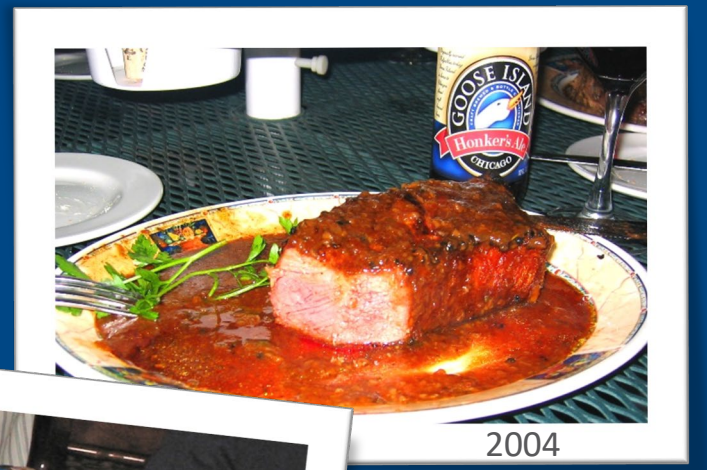
Modelling approach:
provided by K.-P. Brand,
C. Brunner, M. Buchholz,
R. Dinges, J. Haude,
K. Schwarz
on Friday, 16th of
December 1998

… after we went to the University of Michigan bookshop cross the street to buy and study several books about UML modelling for … Dummies … Engineers …



Working on international Standard (1999-2005): WG 10 in action


2002



2004


2002

Famous Beer discussion:
"fruitful discussions in order to find compromises"

… after discussions
… hungry …

Photos by Karlheinz Schwarz

Working on international Standard (1999-2005): 2004

IEC 61850
Seminar and
Implementation Workshop

NettedAutomation GmbH
Information & Communication Sy

Invitation started 9. April 2004

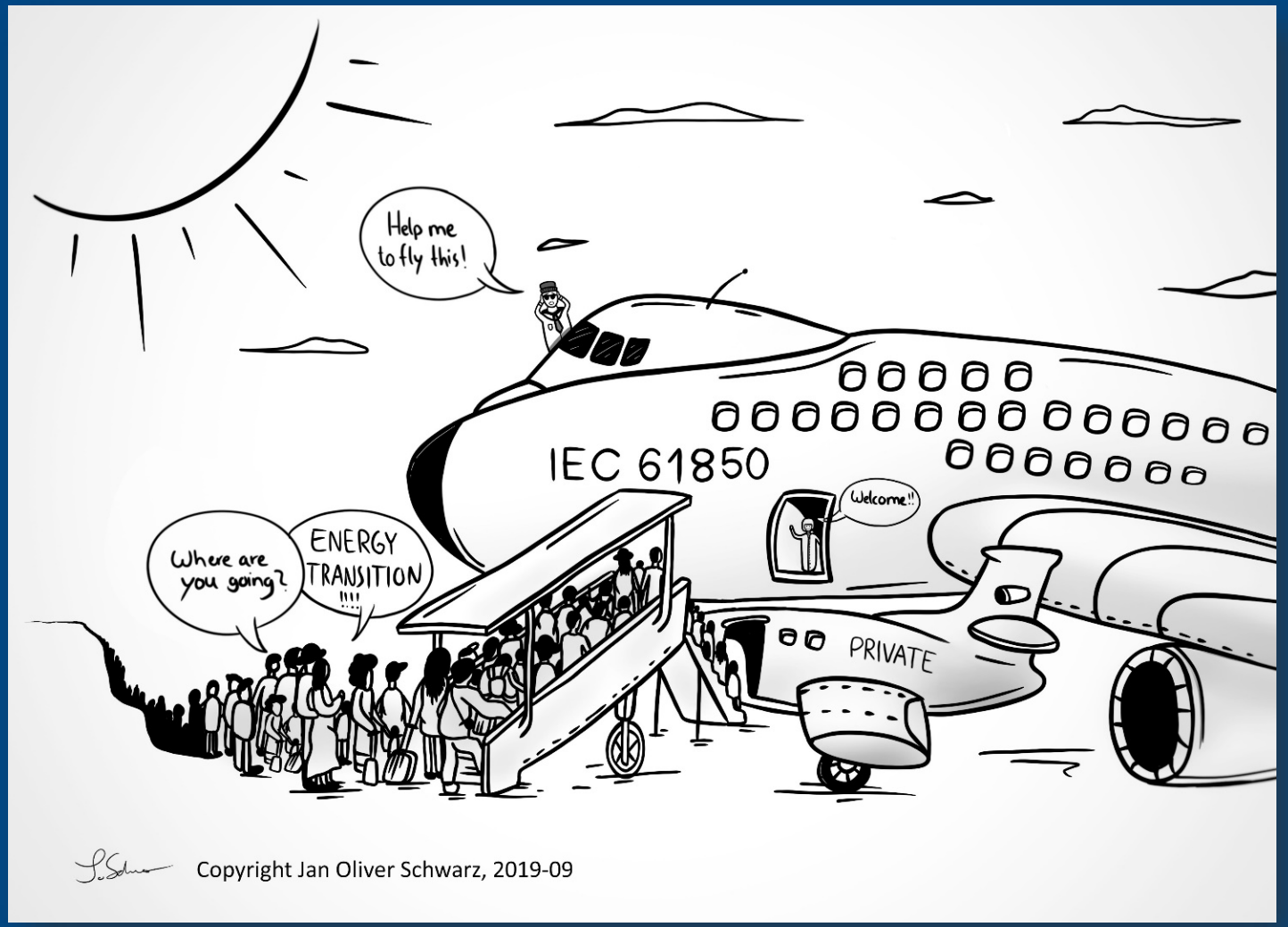
3.-5. May 2004
huge interest right
from the start!

Photo by Karlheinz Schwarz

Thank you to Fred and Christoph for supporting this event!

1)	Austria	4
2)	Belgium	1
3)	Denmark	2
4)	France	4
5)	Germany	7
6)	Hungary	2
7)	Netherlands	3
8)	Poland	2
9)	South Korea	4
10)	Spain	2
11)	Sweden	4
12)	Switzerland	2
13)	United Kingdom	2
14)	USA	1
	Total	**40**

Decision making process (1995-1999): Will IEC 61850 ever “fly”?

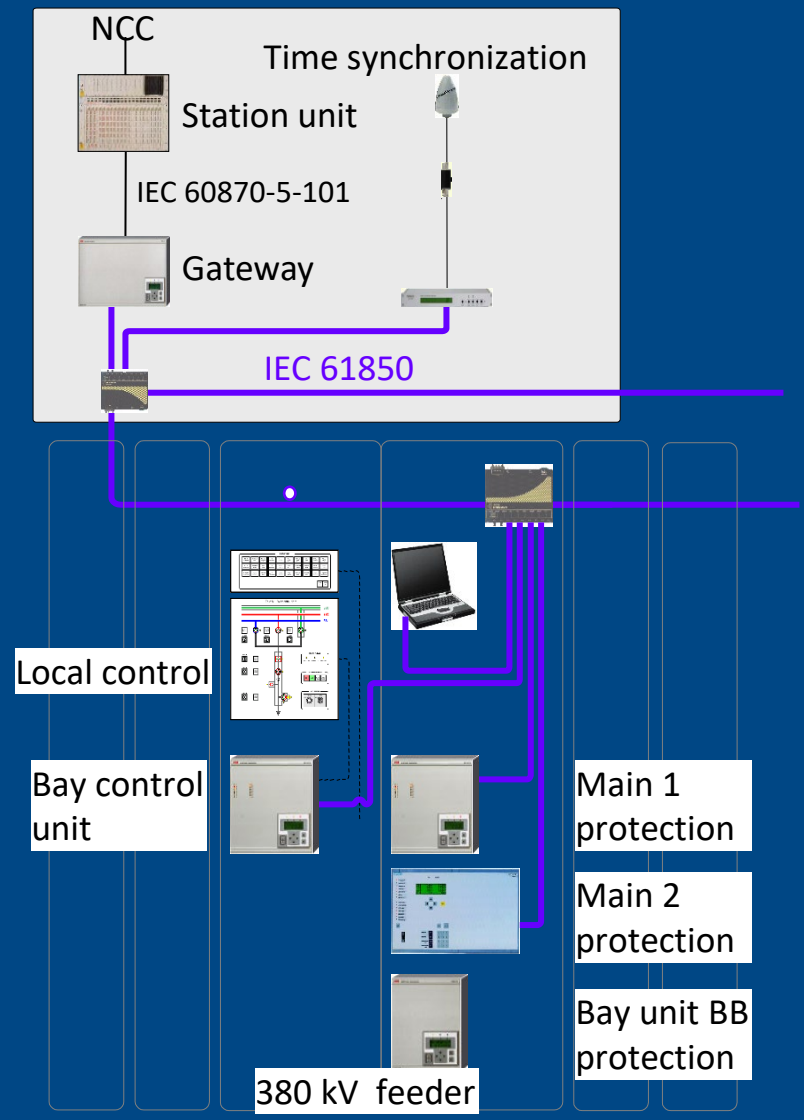


YES it will!

Working on international Standard (1999-2005): Laufenburg (CH)

Here we are!

- First bay in operation since 12/2004
- 380 kV transmission substation
- Main 2 protection from different supplier
- Retrofit
  - Stepwise retrofit of 7 bays
  - Integration of the existing station control system



Source: ABB

Working on international Standard (1999-2005): Laufenburg (CH)

Source: ABB

You can‘t see IEC 61850?
Sure: It is virtual!

Working on international Standard (1999-2005): Winznauschachen (CH)

- In operation since 11/2004
- 16 kV Distribution
- Comprising Substation Controller, Relays, Engineering according to part 6

You can‘t see IEC 61850?
Sure: It is virtual!

Source: Siemens

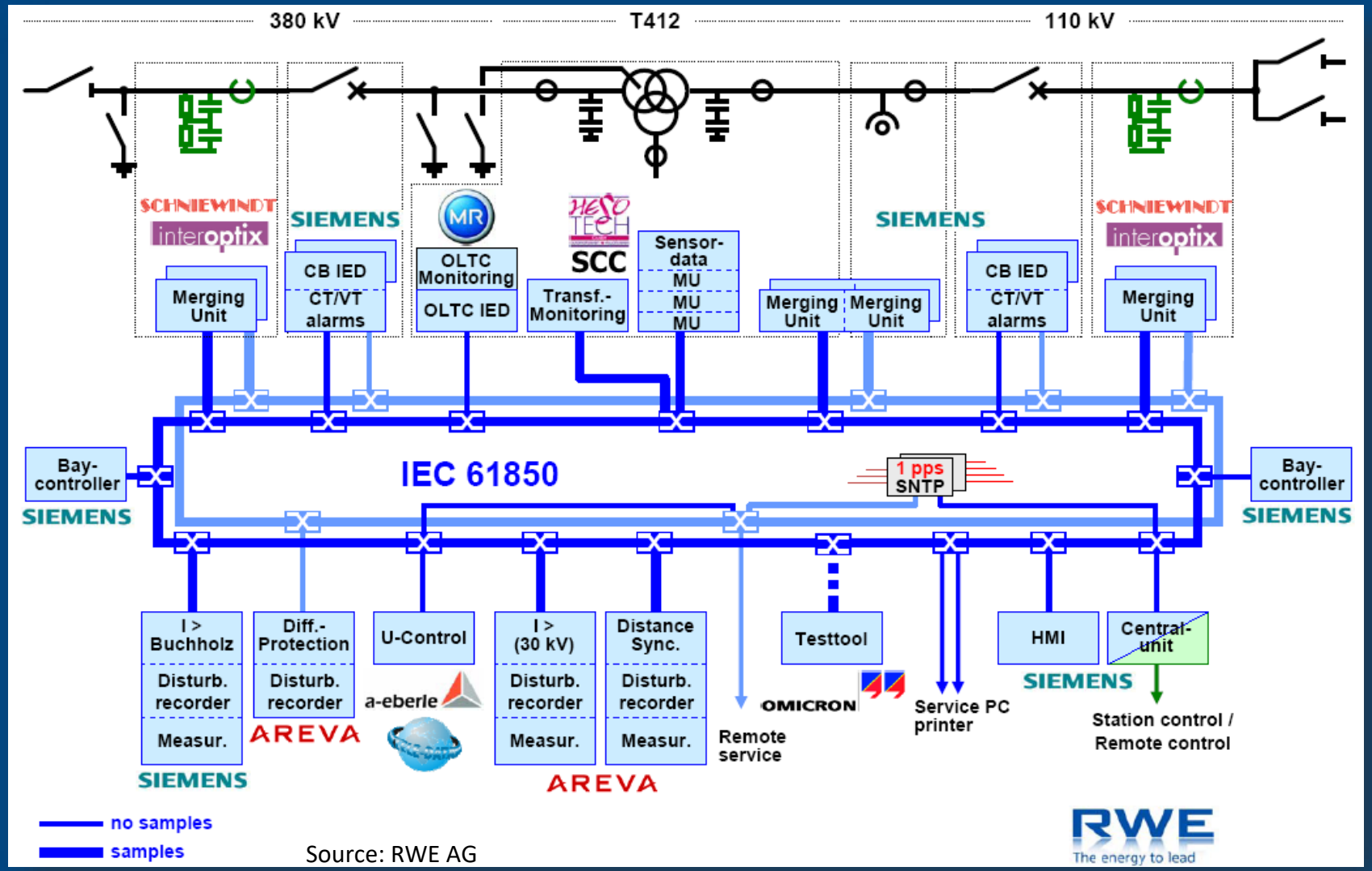
Working on international Standard (1999-2005): 2008

2006

IEC 61850 is in operation!
1,000 plants
50,000 IEDs

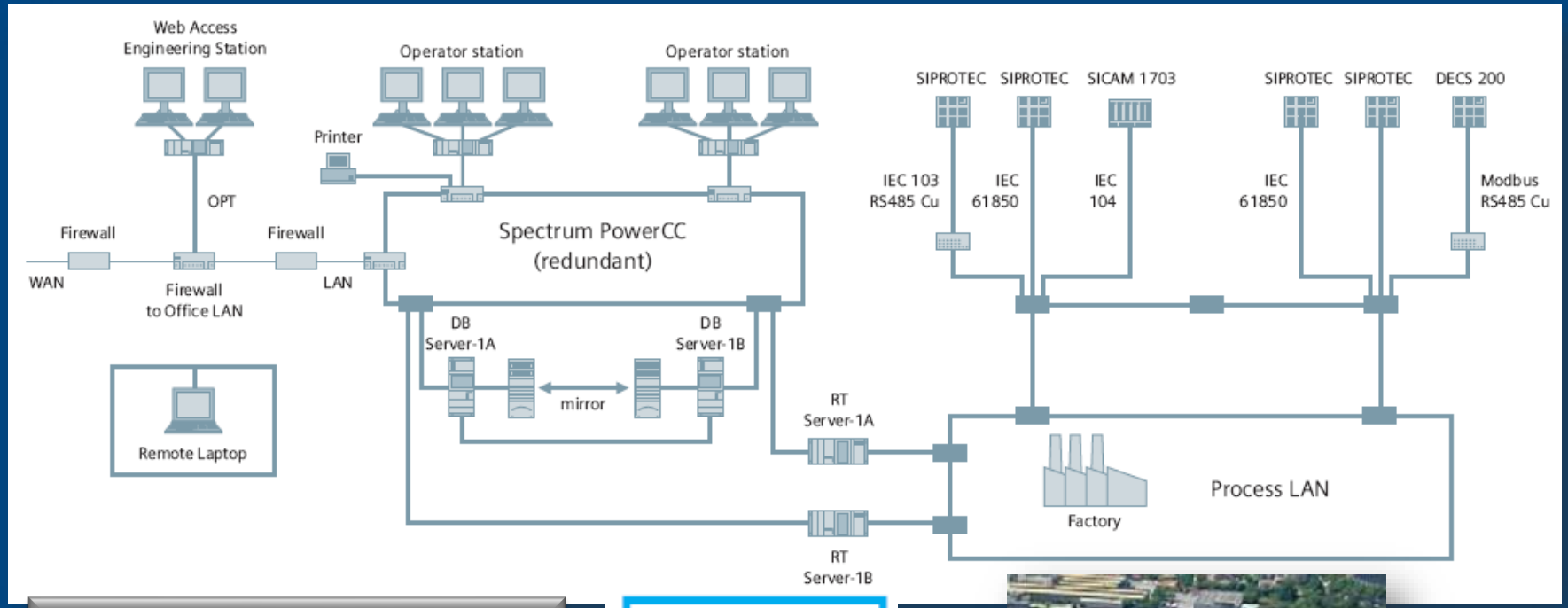
CIGRE: 2008

Working on international Standard (1999-2005): 2008



Source: RWE AG

Working on international Standard (1999-2005): 2012



10 Control Center (Power)
9 use IEC 61850 to communicate with IEDs in the substations

Source: Solvay 2012

SOLVAY

Source: Siemens AG

Working on international Standard (1999-2005): Where are we?

Fieldbus:
MANY international
Standards for “one” domain

IEC 61850:
ONE international Standard
for many domains

Source of pictures unknown

Working on international Standard (1999-2005): Where are we?

- The true international standard series IEC 61850 was possible and successful because:
  - Experts with a wide range of expertise were involved: protection, SCADA, automation, networking, protocols (MMS, ISO 9506), major vendors, institutes, consultants, …
  - Experts were willing to learn and compromise!
  - IEC TC 57 community wanted to prevent proliferations of solutions.
  - UCA international users group supported conformance testing and IOPs.
- The success of IEC 61850 was already visible some 10 years after the start in 1995.
- Maintenance supported with the Tissue Database since 2004.
- The solid foundation for growth of the next decades was laid.

IEC 61850 Tissue 1995 – 30 years after the start

IEC 61850 Tissue Database https://iec61850.tissue-db.com

Home | Technical Issues | Search | Sign In

1995 Figure 3 – SGCB reference to DATA-SET

Created: 01 Sep 2025

Status: Accepted

Part: Part 7-2 (2020; Edition 2.1)

Links:

Page: 23

Clause: 5.3.3

Paragraph: Figure 3

Issue

The Figure 3 present a link between the SGCB and DATA-SET.
According to my understanding of clause 16 dealing with SGCB there is no link with DATA-SET :

Extract from page 90 :
Setting groups span a logical device, and therefore the SGCB, if it exists at all, shall be located in LLN0. A logical node zero may have one setting-group-control-block.
[...]
A SettingGroup contains values for data objects that are contained in several logical nodes. The SettingGroups in the example provide values for data objects in two logical nodes (PDIF and PVOC).

Proposal

Delete the link between the SGCB and DATA-SET on the Figure 3.

Discussion	Created	Status
Agree and propose to treat the tissue as editorial since there is no modification in the SGCB Class.	03 Sep 25	Accepted

MMS survived 40 years

- MMS and the MMS companion standards were (understood as) one of the show-stoppers in projects like MAP, miniMAP, CNMA, Profibus (FMS), international Fieldbus (IEC 61158), Sinec (Siemens PLC communication), ...
- The lack of support for MMS led, e.g., to the project OPC and later OPC UA.
- IEC 61400-25-4 defines several mappings … including MMS (IEC 61850-8-1) … the wind power market is mainly using the MMS mapping.
- OPC Foundation is now mapping the Semantic (Models) of IEC 61850 and IEC 61400-25 onto OPC UA … not the services (except control). IEEE 2030 and … use just the models …
- MMS will continue to be a stable foundation for the information exchange in IEC 61850.
- I hope MMS will not be a show-stopper for IEC 61850 in the long-term and history will not repeat.

Looking forward to the next beer discussion: tonight (2025-09-24)

"The evening event [tonight] will be a joint dinner *and likely some beer and wine discussions* with WG10 at the "Otten Gravour" where we will celebrate the anniversary and raise our glasses together – *looking backward and forward.*

Source: https://www.otten-real.com/otten-gravour/events/gala/

Questions