

# PLCopen - IEC 61131 - 3

## Overview

Version 2.1, September 2006



PLCopen 2006

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# Advantages of IEC 61131-3

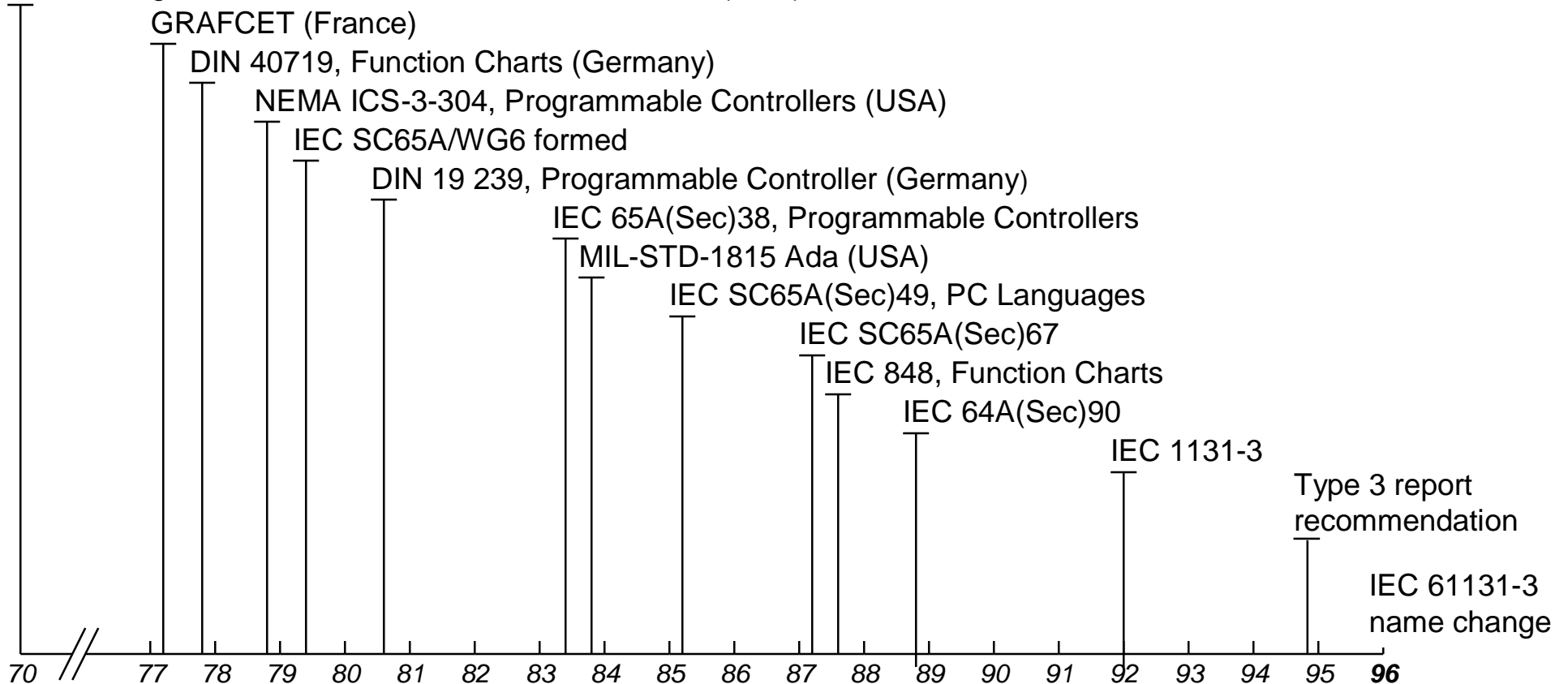
- **International accepted standard**
  - Step by step all suppliers will support it
  - Uniform structures, languages, and the way of handling
- **It saves you time**
  - Unique software model and data/ type concept
  - You only have to learn it once for different controller types
  - Reduced misunderstandings and errors
  - Standard functions and function blocks
  - Reusability of tested software

## Advantages of IEC 61131-3

- **Supports safety and quality programming**
  - Easy and comfortable structuring
  - Data typing prohibits programming errors
- **Provides the best language for each problem**
  - Consistent specifications of 5 languages
  - Two textual and two graphical languages
  - One structuring language, providing an overview
  - Availability of high level language
  - Possibility to mix different languages

# International Language Standardisation

NEMA Programmable Controllers Committee formed (USA)



Source: Dr. J. Christensen

## The 7 Parts of The IEC 61131 Standard

- Part 1      **General overview, definitions**      **IS**
- Part 2      **Hardware**      **IS**
- Part 3      **Programming Languages**      **IS**
- Part 4      **User Guidelines**      **IS**
- Part 5      **Communication**      **IS**
- Part 7      **Fuzzy Logic**      **IS**
- Part 8      **Technical Report**

**IS = International Standard**

# IEC 61131 - Part 1 - General Overview

- Definitions and glossary of terms used in the standard
- List of related / referenced IEC standards
- Principal functional characteristics of programmable controller systems

## **IEC 61131 - Part 2 - Hardware**

- **Electrical, mechanical and functional requirements for Programmable Controllers and associated peripherals**
- **Service, storage and transportation conditions**
- **Information to be supplied by manufacturer**
- **Test methods and procedures for verification of compliance of programmable controllers and associated peripherals**

# IEC 61131 - Part 3 - Programming Languages

- **Software-, communication- and programming-model**
- **Definition of five interlinked programming languages**
- **Syntax and semantics of two textual and two graphical languages: Instruction List (IL), Structured Text (ST), Ladder Diagram (LD) and Function Block Diagram (FBD)**
- **Sequential Function Chart (SFC) for program structuring**

# IEC 61131 - Part 4 User Guidelines

Assists the user in:

- Utilizing the other parts of the programmable controller standard
- Specifying the requirements for applications
- Selecting and implementing systems

# IEC 61131 - Part 5 Communication

- **Based on MMS (Manufacturing Message Specifications) (still in progress)**

*The provider is allowed to add more items!*

# IEC 61131 - Part 7 Fuzzy Logic

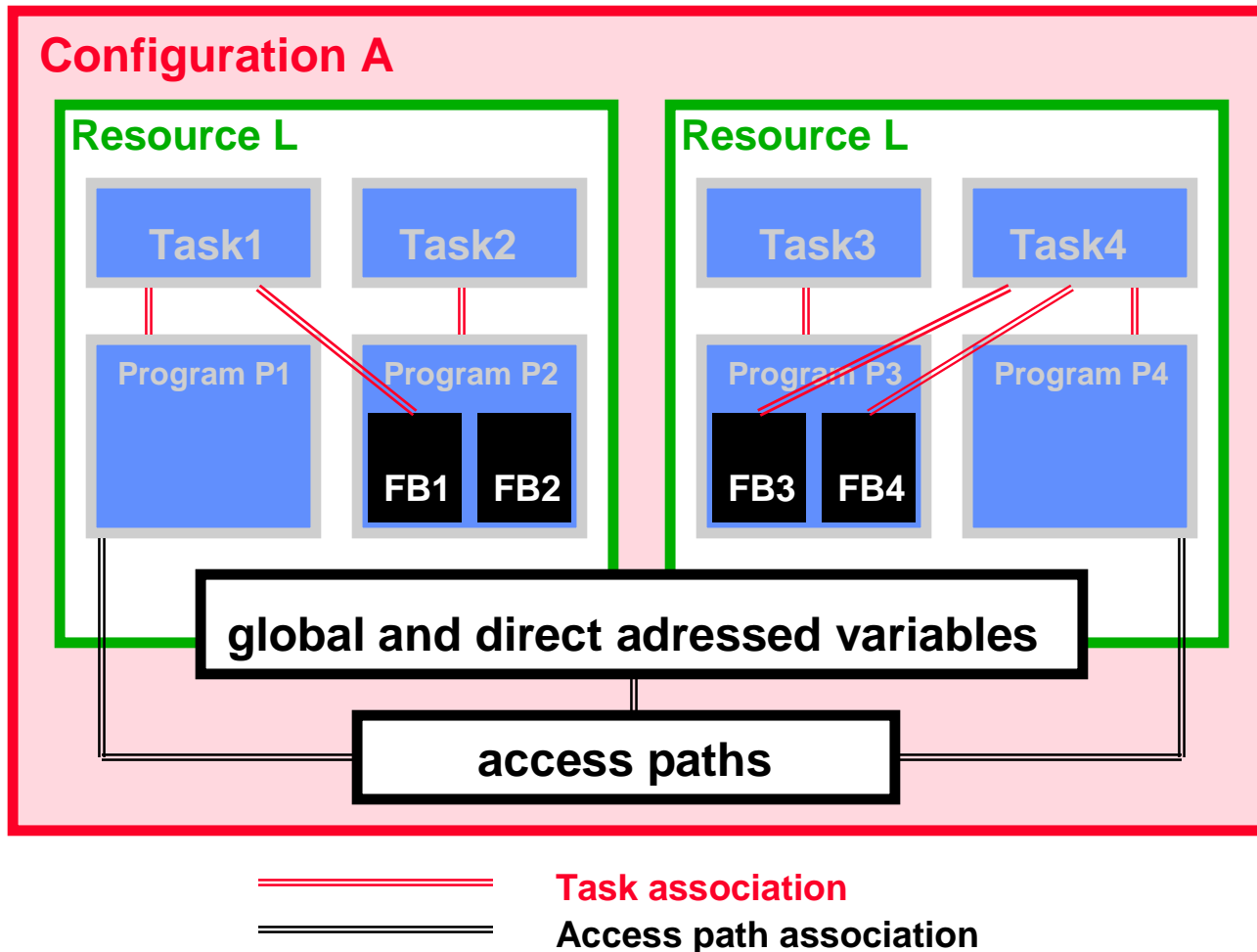
- Provides the definition of fuzzy control sets

*The provider is allowed to add more items!*

# IEC 61131 - Part 8 Technical Report

- Provides guidelines for the application and implementation of programming languages for programmable controller

# IEC 61131-3 Software Model



# Definition of Software Model Terms

- **Configuration**

A language element corresponding to a programmable controller system

- **Resource**

A language element corresponding to a signal processing function and its human-machine interface and sensor actuator functions, like a CPU in your system

- **Task**

An execution control element providing for periodic or triggered execution of a group of associated program organization units

- **Program**

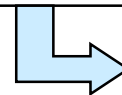
Highest level program organization unit, several in - and outputs possible, can call FBs and Functions

- **FB**

Program organization unit Function Block, several in - and outputs possible, can call other FBs and Functions

# IEC 61131-3: The Common Elements

- **Character set** (English.....)
- **Data types** (BOOL, WORD, INTEGER.....)
- **Variables** (VAR, VAR\_input, VAR\_output.....)
- **POUs, Program Organisation Units** (Function, Function Block...)
- **SFC Elements** (Steps, Transitions.....)
- **Configuration elements:** (Tasks)



• **Basis for software re-use**

# IEC 61131-3 Elementary Data Types

PLCopen to efficiently in automation  
IEC 61131.3 the Industrial Programming Standard

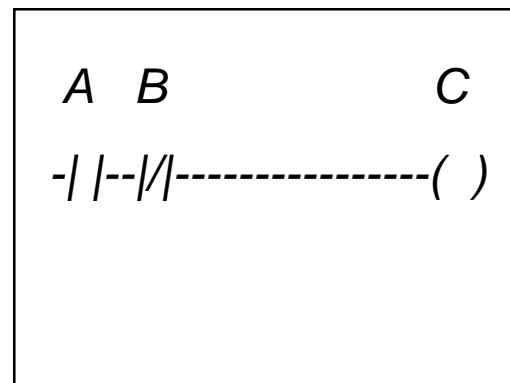
Information at  
[www.PLCopen.org](http://www.PLCopen.org)

No.	Keyword	Data Type	Bits
1	BOOL	Boolean	1
2	SINT	Short integer	8
3	INT	Integer	16
4	DINT	Double integer	32
5	LINT	Long integer	64
6	USINT	Unsigned short integer	8
7	UINT	Unsigned integer	16
8	UDINT	Unsigned double integer	32
9	ULINT	Unsigned long integer	64
10	REAL	Real numbers	32
11	LREAL	Long reals	64
12	TIME	Duration	
13	DATE	Date (only)	
14	TIME_OF_DAY or TOD	Time of day (only)	
15	DATE_AND_TIME or DT	Date and time of day	
16	STRING	Character string	
17	BYTE	Bit string of length 8	8
18	WORD	Bit string of length 16	16
19	DWORD	Bit string of length 32	32
20	LWORD	Bit string of length 64	64



## Ladder Diagram (LD)

- Standardized, rationalized set of relay ladder programming symbols
- Based on well-known US-style of programming, resembling electrical drawing standard



## Instruction List (IL)

- Single Accumulator based execution model
- Based upon the German 'Anweisungsliste', AWL
- Only one operation such as storing a value in the accumulator register, is allowed per line

<i>LD</i>	<i>A</i>
<i>ANDN</i>	<i>B</i>
<i>ST</i>	<i>C</i>

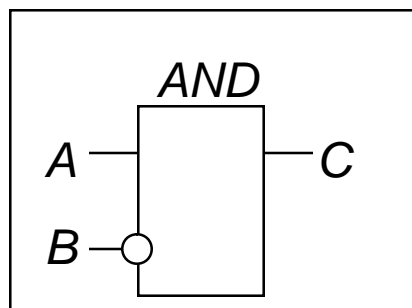
## Structured Text (ST)

- High level language, block structured
- Syntax resembles PASCAL
- Complex statements and nested instructions possible
- Support for
  - Iteration loops (REPEAT-UNTIL; WHILE-DO)
  - Conditional execution (IF-THEN-ELSE; CASE)
  - Functions (SQRT(), SIN())

```
C:= A AND NOT B
```

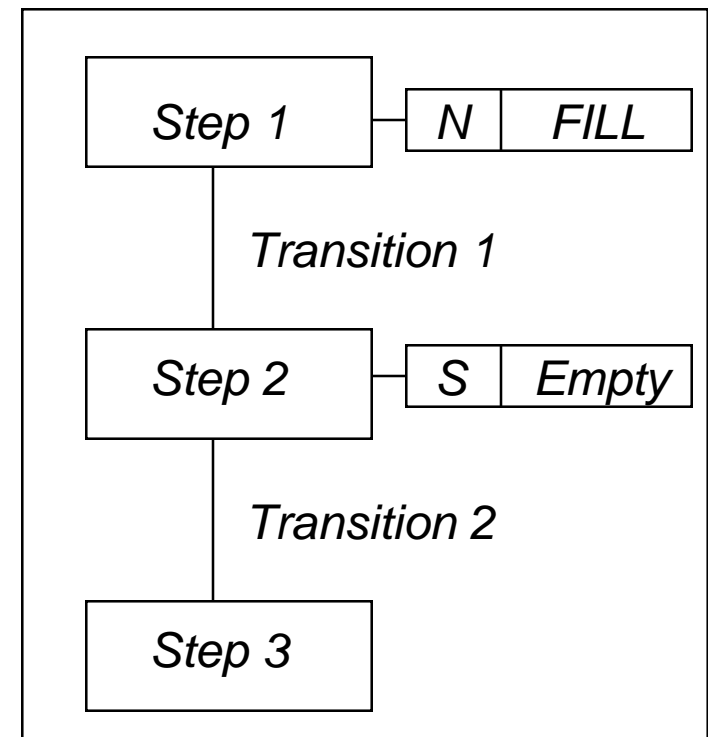
## Function Block Diagram (FBD)

- Graphical language, widely used in Europe
- Allows program elements which appear as blocks to be "wired" together in a form analogous to a circuit diagram
- Used in many applications that involve the flow of information or data between control components



# Sequential Function Chart (SFC)

- Graphical language which provides a diagrammatic representation of program sequences --> flowchart
- Based on the French Grafcet (IEC 848)
- Main structure and suitable for rapid diagnostics
- The basic elements are steps with action blocks and transitions
- Steps consist of a piece of program that is carried out until a condition specified in the transition is met
- Programming of complex tasks by dividing in smaller parts
- Each element can be programmed in any IEC-language



# POU = Program Organization Unit

POU's enable re-use of software from macro level (Programs) to micro level (FB and Functions).

A POU consists of a header (variable declaration) and the body (instructions).

POU Type	Replicated as:	Comments
Program	Program instance	Main program
Function Block	FB instance	Subroutine with own memory, several in - and outputs possible
Function	Function	Subroutine without memory

## IEC 61131-3 Standard Datatypes

- **Bit string types** (BOOL, BYTE, WORD, DWORD, LWORD)
- **Integer types** (SINT, INT, DINT, LINT)
- **Unsigned integer types** (USINT, UINT, UDINT, ULINT)
- **Real types** (REAL, LREAL)
- **Time types** (TIME, DATE, TIME\_OF\_DAY, DATE\_AND\_TIME)
- **Character types** (STRING)

### Vendor and user defined data types are possible

- Direct derived, sub range, enumeration
- Array, structure

## IEC 61131-3 Standard Functions

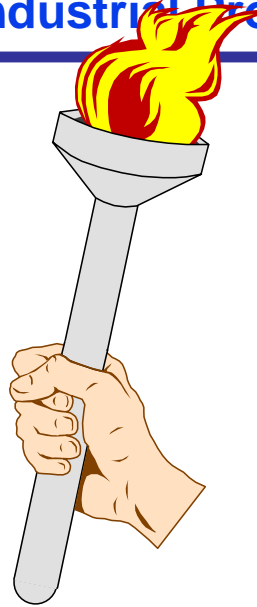
- **Bit string functions** (AND, OR, XOR, NOT, SHL, SHR, ROL, ROR)
- **Numerical functions** (ADD, SUB, MUL, DIV, MOD, EXPT, ABS, SQRT, LN, LOG, EXP, SIN, COS, TAN, ASIN, ACOS, ATAN)
- **Type conversions** (e.g. USINT\_TO\_DINT, BOOL\_TO\_BYTE)
- **Selection functions** (SEL, MIN, MAX, LIMIT, MUX)
- **Comparison functions** (GT, GE, EQ, LT, LE, NE)
- **String functions** (LEN, LEFT, RIGHT, MID, CONCAT, INSERT, DELETE, REPLACE, FIND)

**Vendor and user defined functions are possible**

## IEC 61131-3 Standard Function Blocks

- **Bistables** (SR, RS, SEMA)
- **Edge detection** (R\_TRIG, F\_TRIG)
- **Counters** (CTU, CTD, CTUD)
- **Timers** (TP, TON, TOF, RTC)

**Vendor and user defined function blocks are possible**

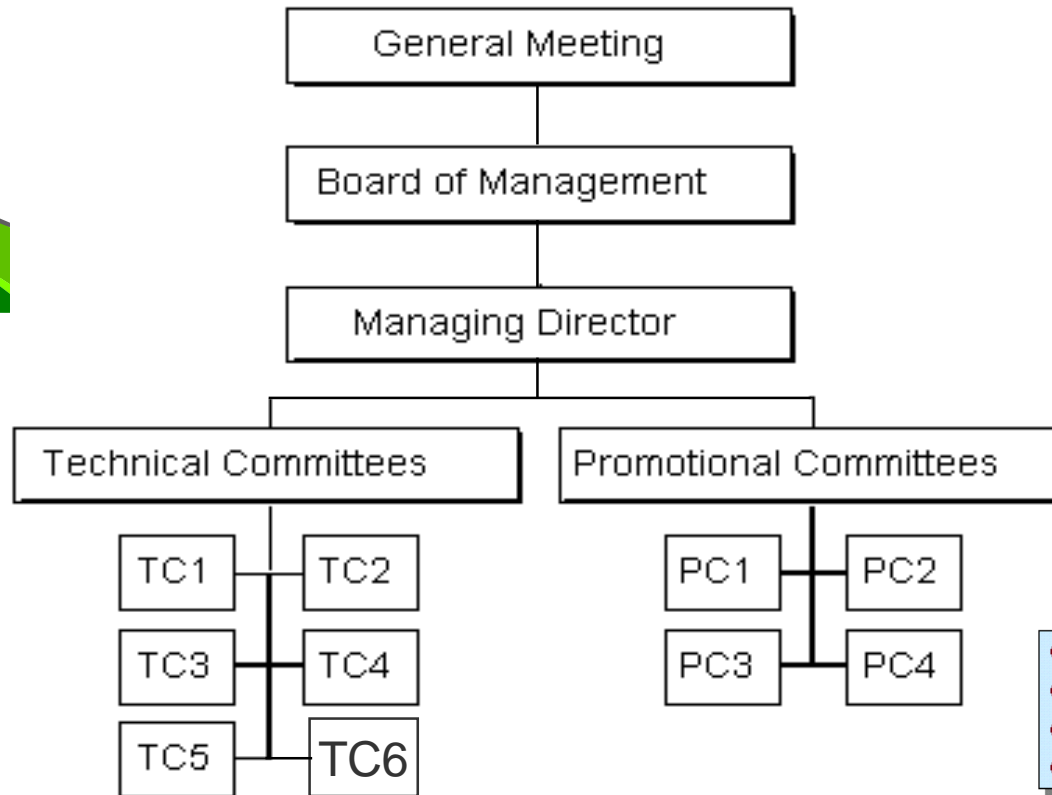
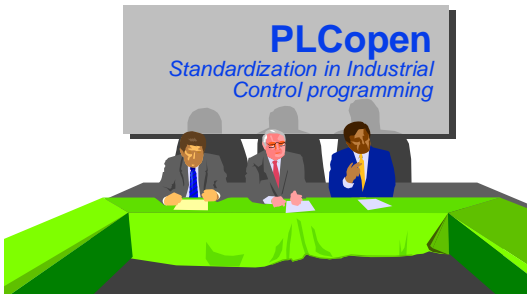


# PLCopen

## *Mission*

**We want to be the leading association  
resolving topics related to  
control programming  
to support the use of  
international standards in this field.**

PLCopen was founded on June 15, 1992 in Giessen, Germany. Target was to promote IEC 61131-3, inform customers and give more weight to the IEC 61131-3 standard.



- PC1 Main promotion committee
- PC2 Common training program
- PC3 North-America
- PC4 Japan

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# The Essence of Compliance

without testing there is no standard

- The IEC 61131 standard gives rules for compliancy
- Certification gives guidance for users towards real IEC 61131-3 programming systems (e.g. PLCopen certified list shows compliant products)

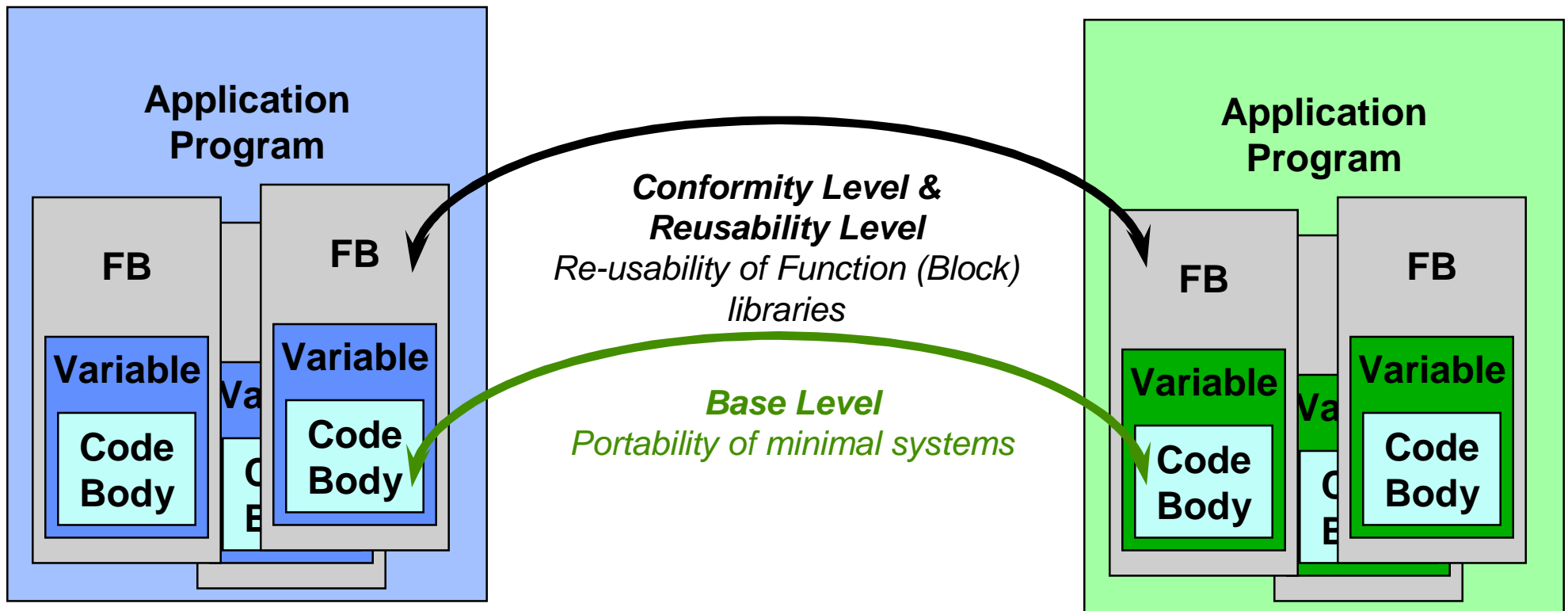
## PLCopen Compliance Level

To take away the confusion, PLCopen....

- .... has defined 2 levels of compliance with a defined set of features
- .... has defined an accreditation procedure
- .... has accredited test institutes
- .... developed test software, shared amongst members
- .... has defined a certification procedure
- .... and has members with certified products

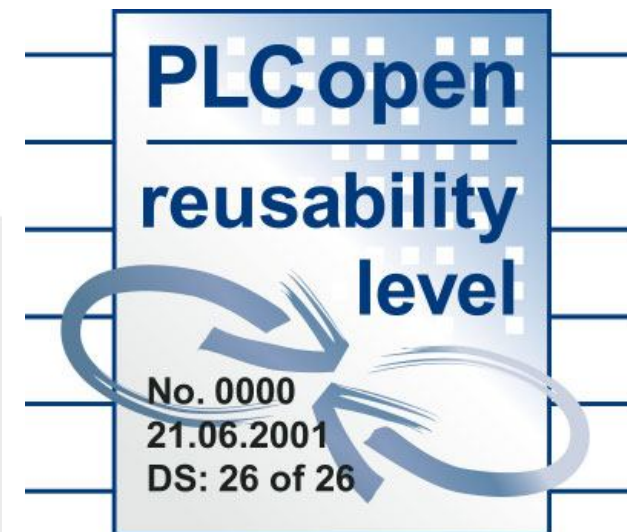
This assures compliance now, and in the future.

# PLCopen Compliance Levels



# Compliance

Certified products  
can use these logo's



## PLCopen Training Logo



# PLCopen

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# Industrial Control Systems

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**Electrical - Control Systems – Automation - Instrumentation**  
**Providing Solutions and Services since 1980**

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**David James (Dave) McInnes**

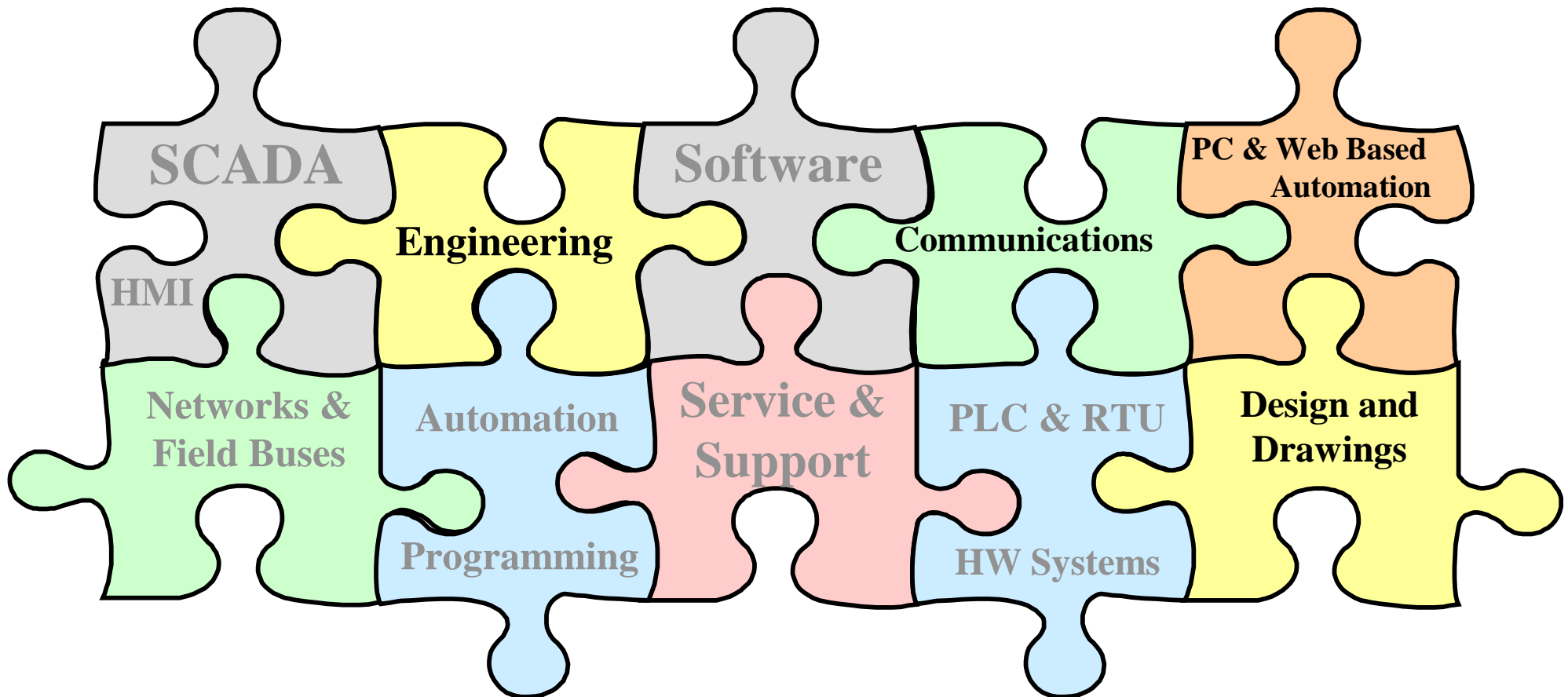
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pieces of the technology puzzle that **ICS** solves



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