Actual PLC Programming Standard and Worldwide Acceptance

IEC 61131-3 and PLCopen Activity

Ralf Wohlschlaeger

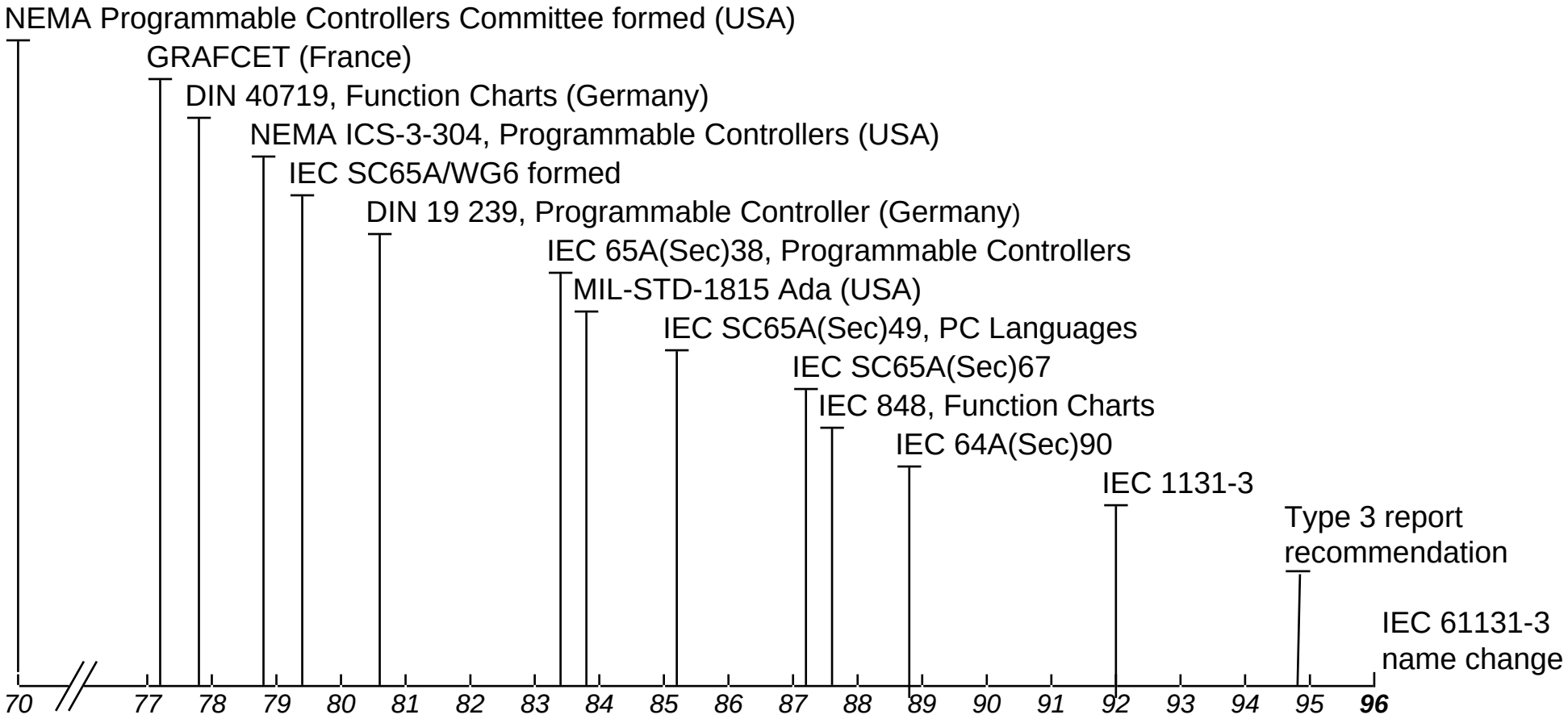
General Manager Factory Automation
Matsushita Electric Works (Europe) AG

Chairman of PLCopen PC1 committee (promotion)

Contents :

- What is IEC 61131-3 ?
  - History
  - Advantages
  - Explanation
  - Applications
- World-wide popularity ?
  - Europe/USA/Asia
- What is PLCopen ?
  - Organisation
  - Current topics
    - Conformity Level, Reusability Level, Motion Control FBs, XML etc.
  - Future prospect

The Way to IEC61131-3 Programming



Source: Dr. J. Christensen

Style of Software

Conventional styled software

Direct hardware address :

- **X0, X1...Y0,Y1....DT0,DT1.....**

1 Program from start to end

No structure

IEC 61131-3 styled software

IEC address:

- **%IX0.....%QX0.....%MW5.0**
- **each Variable have a name**
- **each Variable have a data type**
- **global and local Variables**

POU concept:

- **1 program or more programs**
  → **tasks**
- **Function Blocks and Functions**

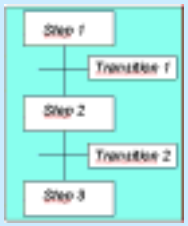
Well structured

IEC 61131-3
An internationally accepted standard

- **Unified rules in systems worldwide,**
  reduces misunderstandings and shortens training

- **Reuse of ready-made Functions and Function Blocks,**
  saves time for programming and debugging

- **Better overview through structure and modularity**



- **Fewer errors through defined data types and encapsulation**

- **Safe investment due to standardisation**

Examples of IEC 61131-3 advantages

Variables :

- better documentation --> programming by names / symbols
- I/O connection list already stored in the project
- Base for the re-use of software

POUs :

- structured programming
- well defined interface --> other variables can be used in other projects
- re-use of Function Blocks saves time and debugging

SFC :

- flowchart on the monitor
- divide big programs into small and easy parts
- top down development / bottom up --> well structured
- different languages in the program
- easy debugging and error locating - only the current step is active

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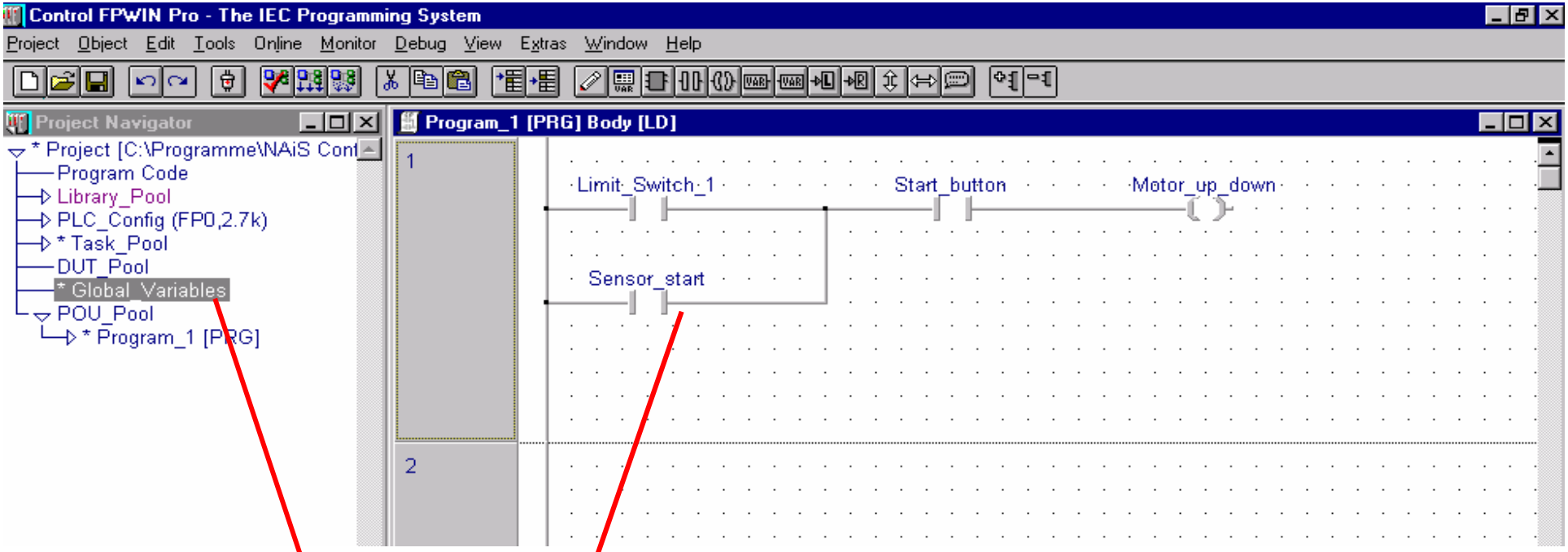
General :

- save training time for programmers
- enables parallel software development by more programmers
- certification ensures users to protect their investments for the future

Use Variable Names instead of Addresses



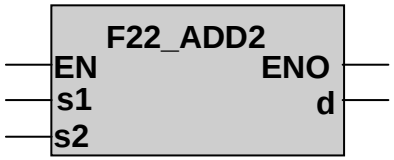
Global_Variables

	Class	Identifier	Matsushita	IEC_Addre:	Type	Initial	Au	Com
0	VAR_GLOBAL	Sensor_start	X0	%IX0.0	BOOL	FALSE		
1	VAR_GLOBAL	Limit_Switch_1	X1	%IX0.1	BOOL	FALSE		
2	VAR_GLOBAL	Start_button	X2	%IX0.2	BOOL	FALSE		
3	VAR_GLOBAL	Motor_up_down	Y0	%QX0.0	BOOL	FALSE		

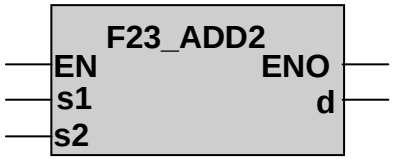
IEC 61131-3 Functions

Conventional programming requires different functions for e.g.:

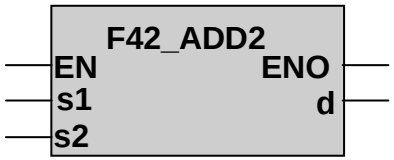
16-bit



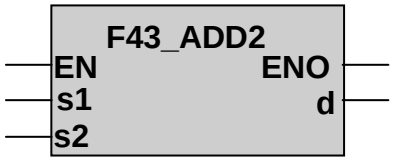
32-bit



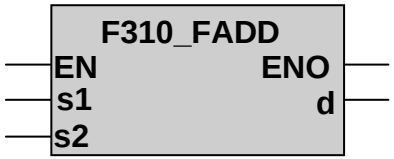
4-digit BCD data



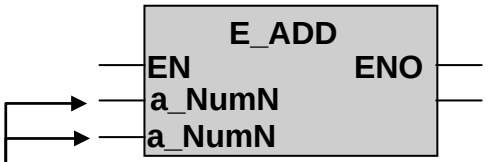
8-digit BCD data



Floating point data



Flexible IEC instructions: 1 function instead of several

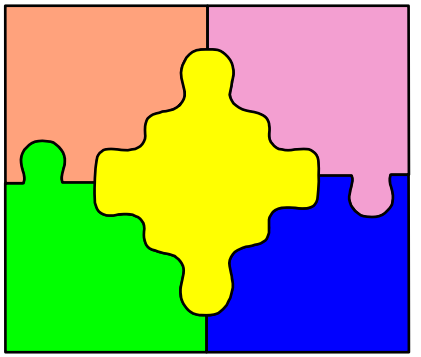


Input data must be of the same data type!

The IEC 61131 Standard - The PLC Standard

PLCopen
Creating the foundation for your efficiency

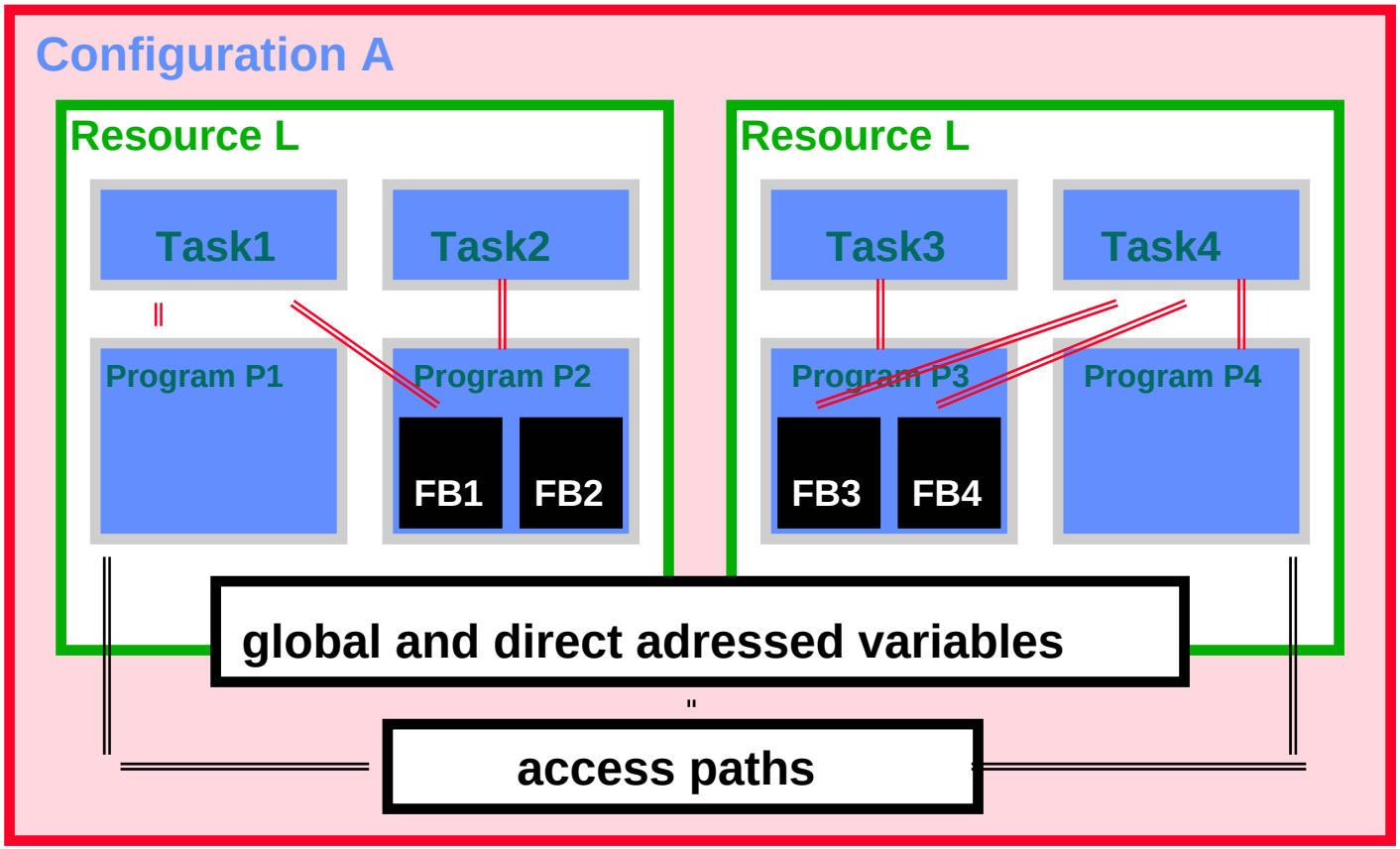
- **Part 1** General overview, definitions
- **Part 2** Hardware
  - I/O signals, safety requirements, environment
- **Part 3** Programming Languages
- **Part 4** User Guidelines
- **Part 5** Communication



- **Part 6** Reserved
- **Part 7** Fuzzy control
- **Part 8** Guidelines for the application and implementation

International Standard

IEC 61131-3 Software Model



Task association

Access path association

IEC 61131-3: The 5 Programming Languages and 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

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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

The 5 Languages of IEC 61131-3

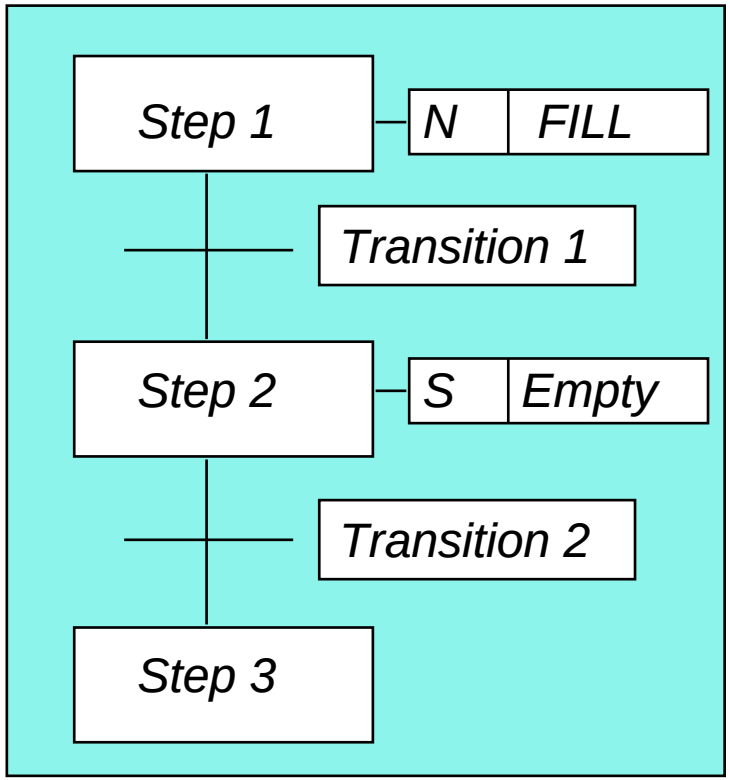
Instruction List

```
LD      A
ANDN    B
ST      C
```

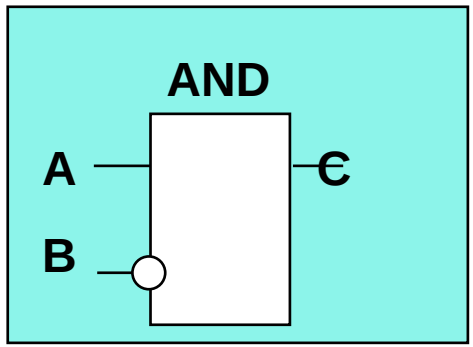
Structured Text

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

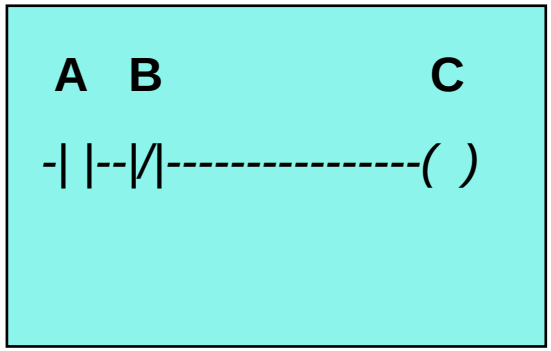
Sequential Function Chart



Function Block Diagram

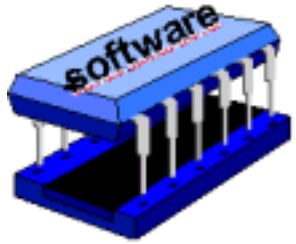


Ladder Diagram



POU = Program Organization Unit

- **A POU consists of a header (variable declaration) and the body (instructions)**
- **POUs enable the re-use of software from macro level (Programs) to micro level (FB and Functions)**



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 own memory

Function Blocks can be easily reused

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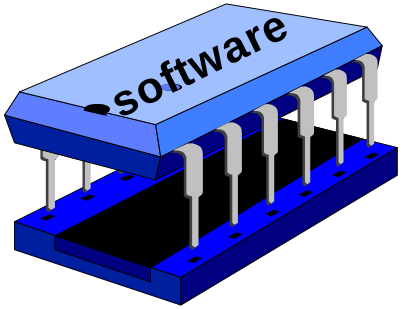


1. Function Block

FU_Block

OUT_1

IN_1

IN_2

IN_3

2. Variable Interface

FU-Block Header

	Class	Identifier	Type
0	VAR_INPUT	IN_1	BOOL
1	VAR_INPUT	IN_2	BOOL
2	VAR_INPUT	IN_3	BOOL
3	VAR_OUPUT	OUT_1	BOOL

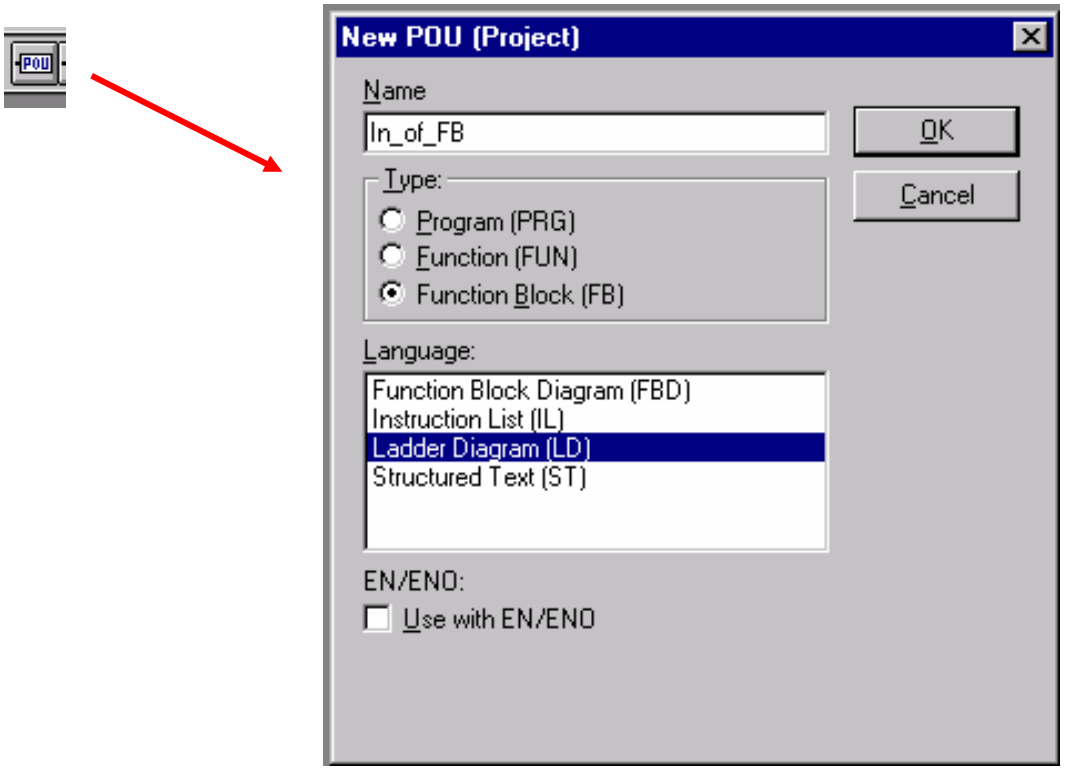
Program once

reuse always

3. Program body

```
LD      IN_1
AND     IN_2
OR      OUT_1
AND     IN_3
  :       :
  :       :
  :       :
  :       :
ST      OUT_1
```

Easy Programming of FBs and FUN



Easy Programming of FBs and FUN

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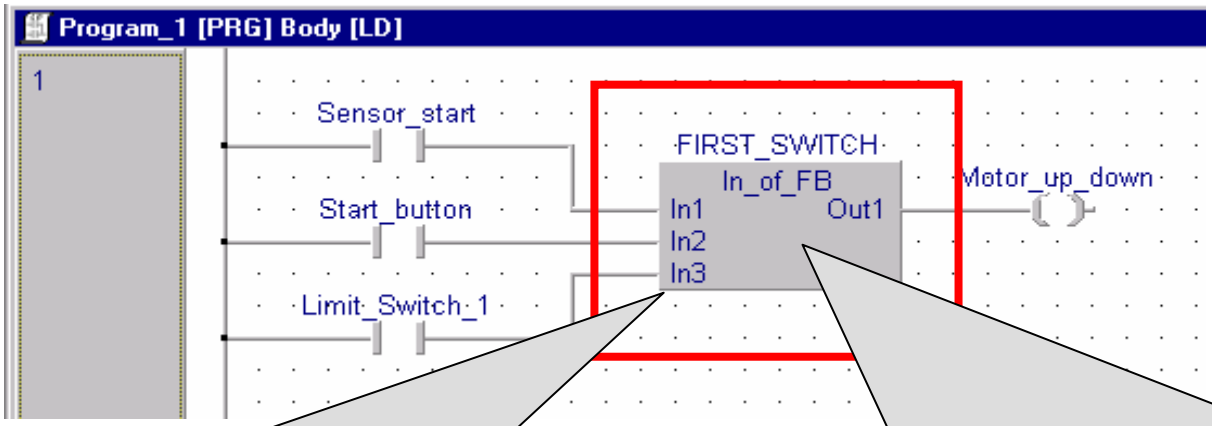
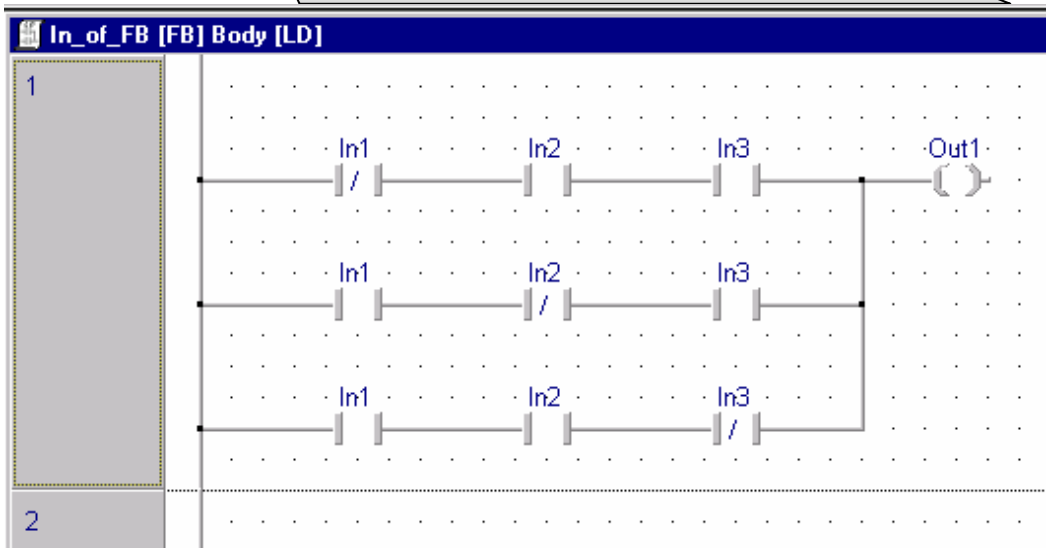


Define inputs and outputs

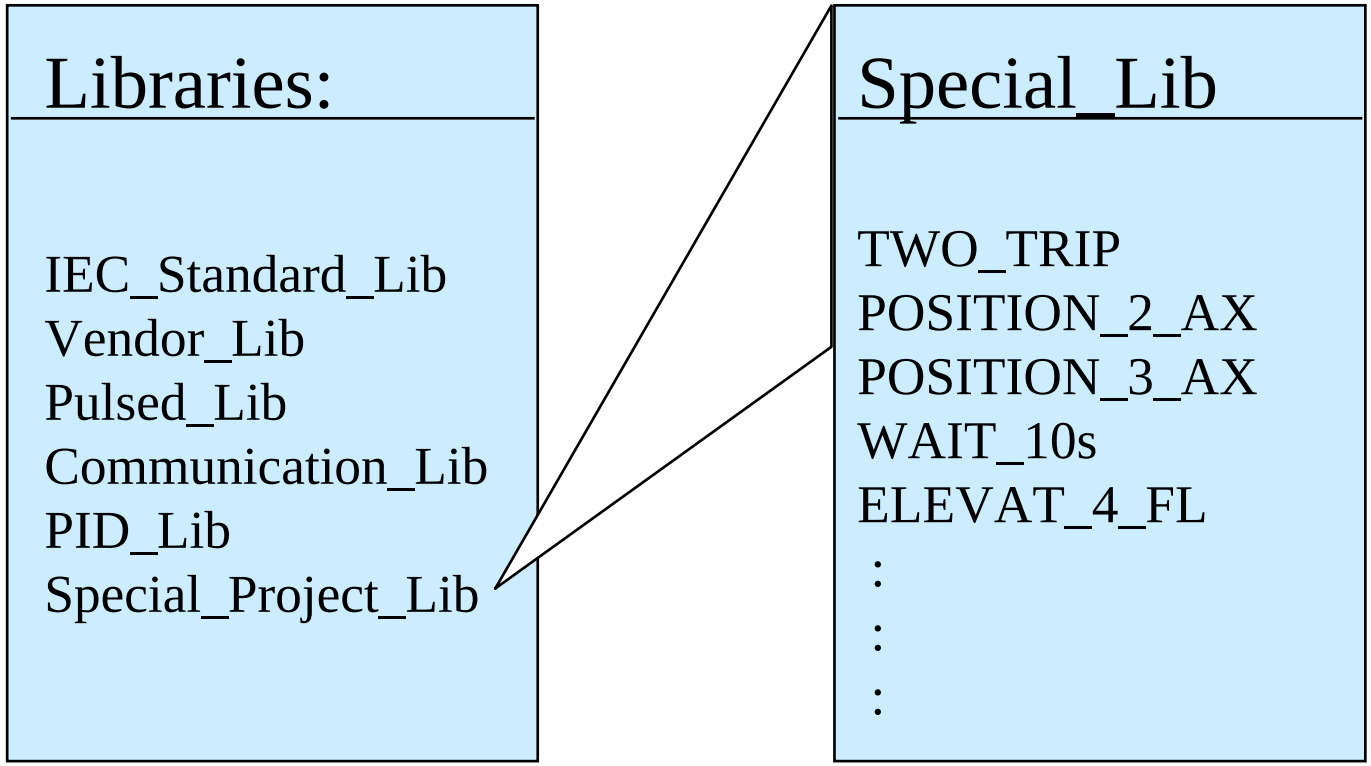
Program FB contents

In_of_FB [FB] Header

	Class	Identifier	Type	Initial	C
0	VAR_INPUT	In1	BOOL	FALSE	
1	VAR_INPUT	In2	BOOL	FALSE	
2	VAR_INPUT	In3	BOOL	FALSE	
3	VAR_OUTPUT	Out1	BOOL	FALSE	



Library Concept



- **Self-created FBs can be stored in libraries**
- **Comfortable structuring and sorting in the libraries**
- **Know-how protection of FBs and libraries**
- **Easy reuse of tested software --> saves time**

Applications

Building Automation

Elevators

Building Automation
Light, alarm, window, heating

Linishing-grinding and polishing machines

Bakery

Temperature control
Telecommunication

Applications

water cleaning plant

Agricultural industry
flower bulbs

Wrapping Machines

Medical Equipment

Applications

Baggage handling in airports

Food production and packing

Garage control and traffic remote communication

Calibration of taximeters

Lift cars

International Acceptance of IEC 61131-3

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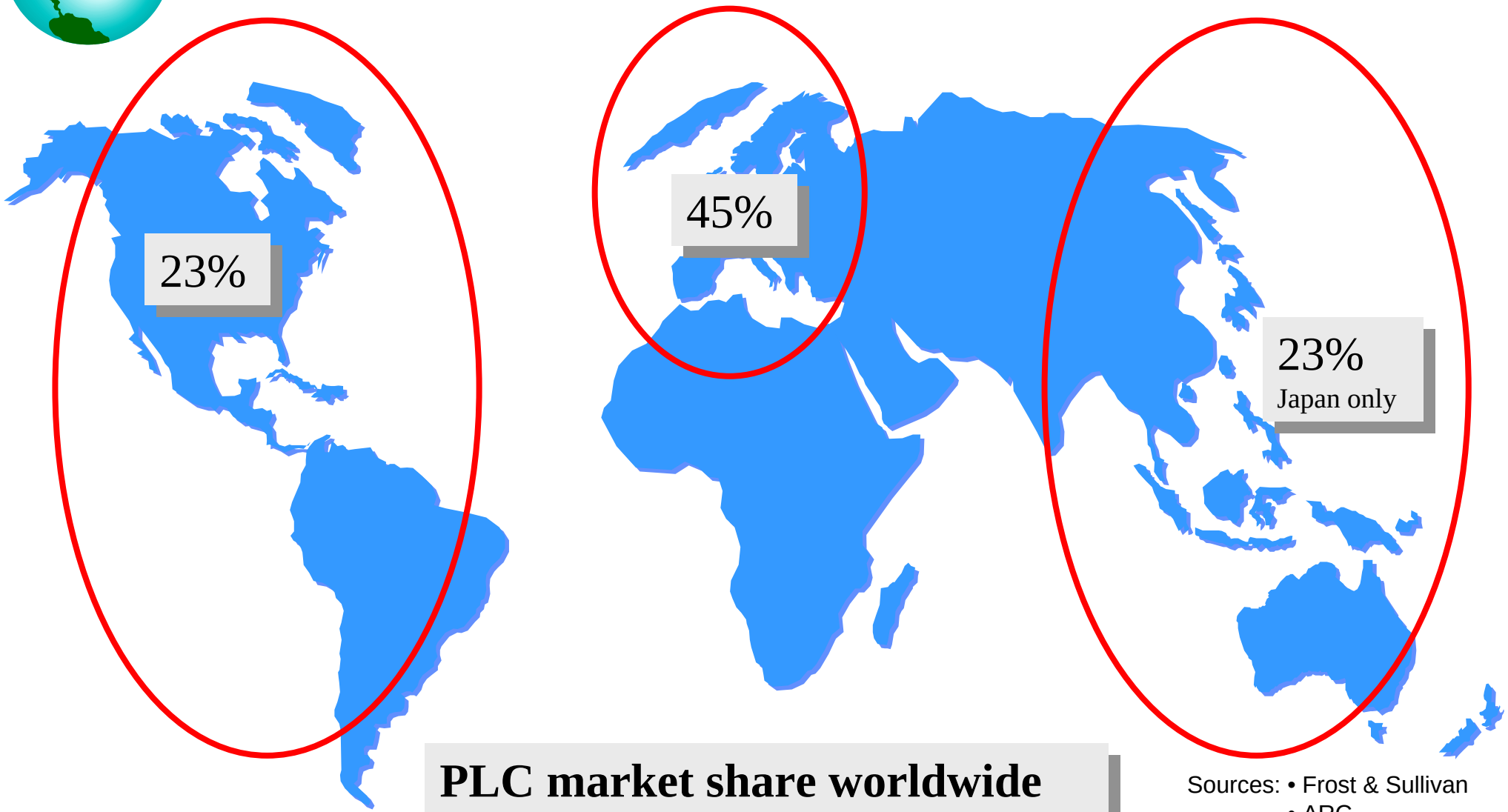

PLC market share worldwide

Sources: • Frost & Sullivan
• ARC
• ZVEI

Popular Languages Worldwide

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Outside Europe LD is the most popular PLC programming language

International Acceptance of IEC 61131-3

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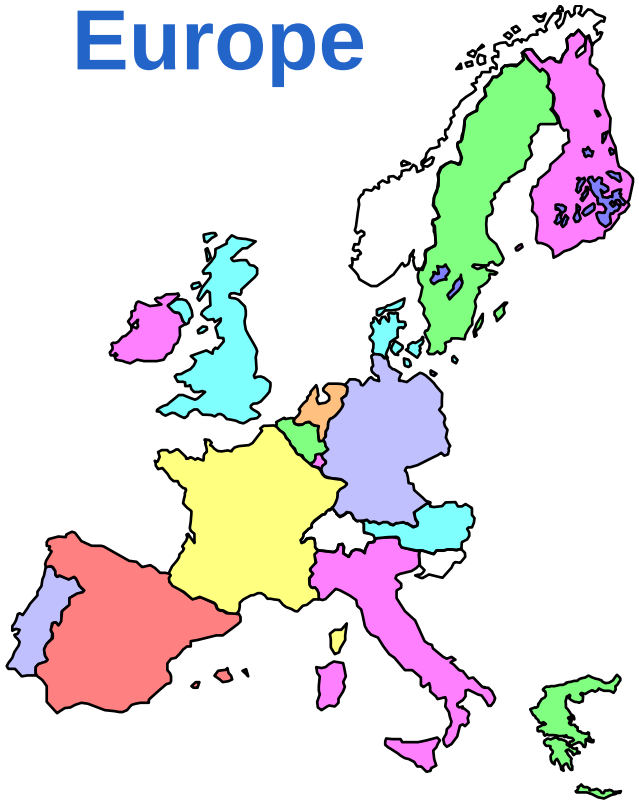
Europe



- **Most PLC suppliers promote IEC 61131-3 in Europe and offer software and training**

- **Germany, Netherlands, Switzerland, Austria : IEC 61131-3 is well-known and accepted, required by at least 80% of users**

- **France, Scandinavia: IEC 61131-3 is known by many users, still some require traditionally styled sytems**

- **UK, Italy, Spain: only few small users know IEC 61131-3, most of them require traditionally styled sytems**

International Acceptance of IEC 61131-3

America

- More and more PLC suppliers start to promote IEC 61131-3. Still in the starting phase.

- Many users do not use IEC 61131-3 style because it is too difficult for field engineers.

- Small increase in IEC 61131-3 step by step

- Customers opinions about IEC 61131-3:
  - 7% : it is a must
  - 41% : somewhat important
  - 39% : not important at all
  - 13% : no answers

- OMAC paper is supporting IEC 61131-3 acceptance in USA

International Acceptance of IEC 61131-3

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Asia

Asia can be divided into 3 parts:

Japan:

Very few users are using IEC 61131-3, still difficult to use and to understand.
Most Japanese PLC suppliers have examined IEC 61131-3. Some first systems are available, but still no real start/success.

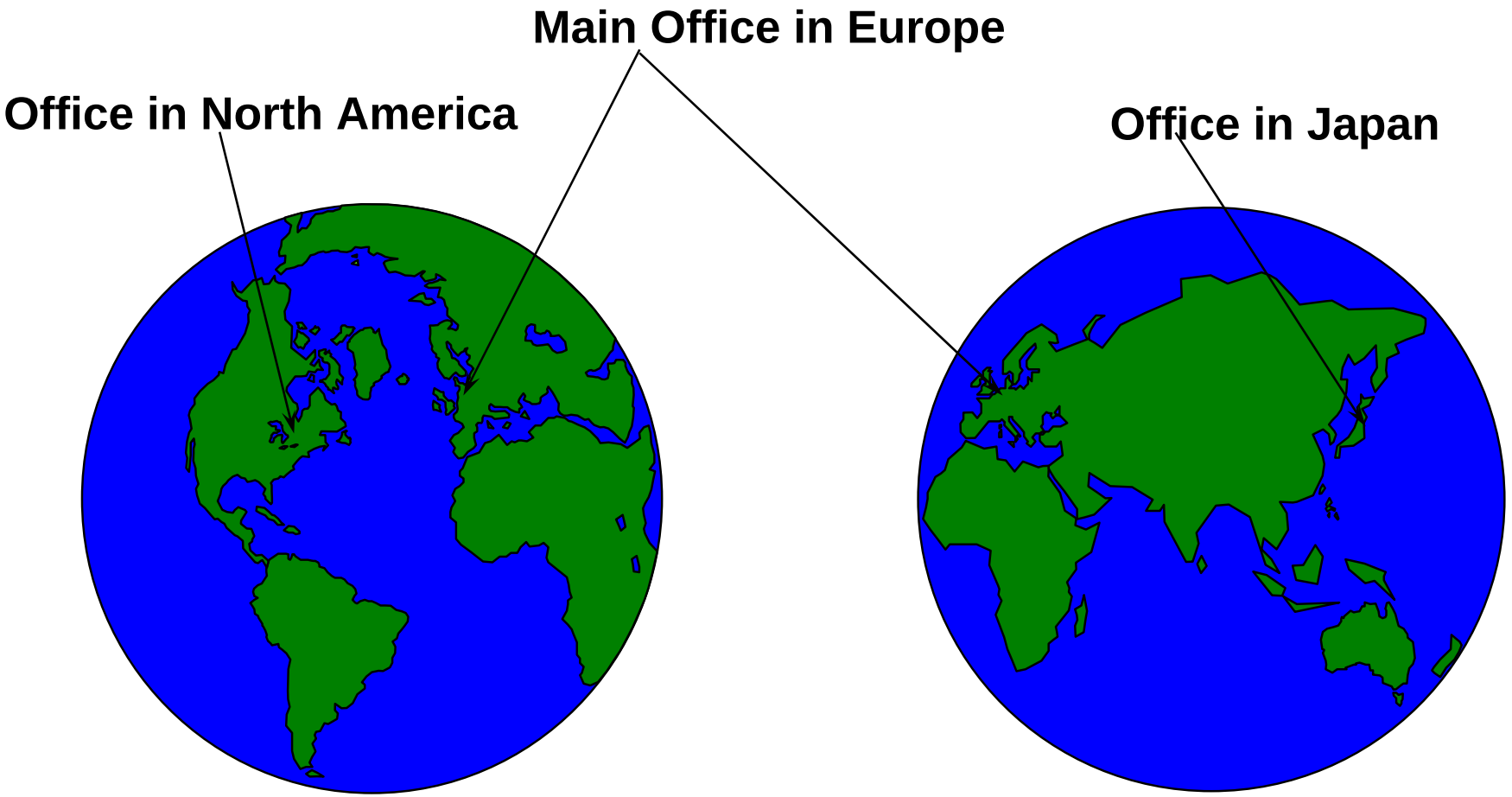
- **Australia:**

  IEC 61131-3 is well-known. Larger companies are using it already and it is accepted. Small companies still prefer traditional software style.

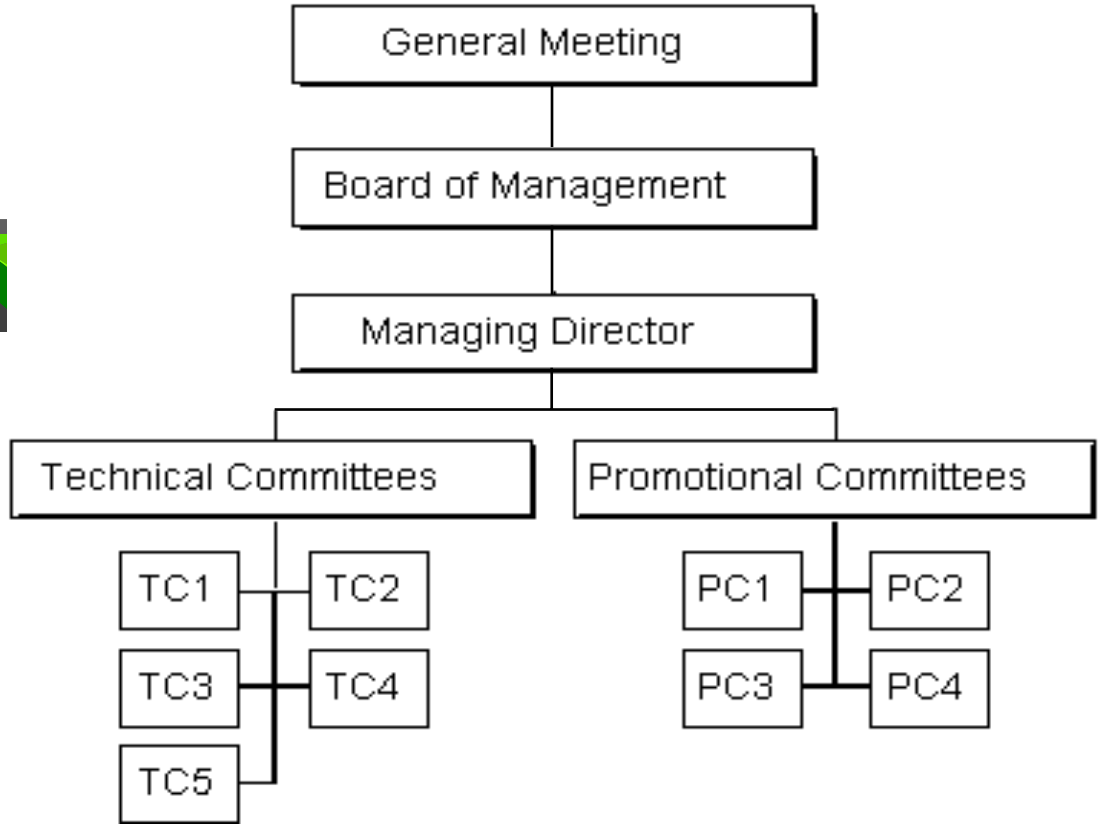
- **Rest of Asia:**

  IEC 61131-3 is still not popular. Users prefer easy Ladder Diagram programs.
  Japan, US and Europe influence the market.
  China is starting now to promote IEC 61131-3

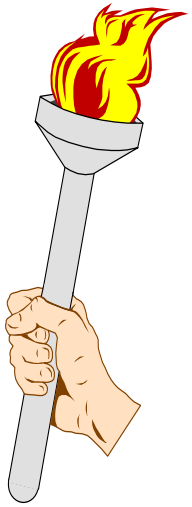
PLCopen is a World-wide association



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

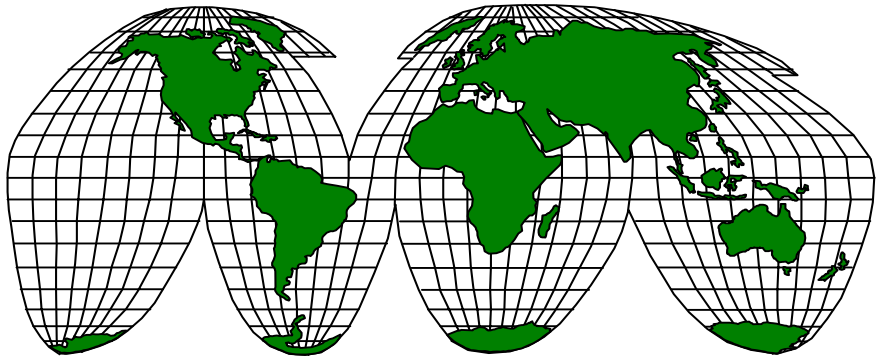


PLCopen *Mission*

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

PLCopen is a World-wide association

- > 100 members (Nov 2002)
- from 21 countries all over the world
- Suppliers, institutes and users
- See newsletter / website for up-to-date list

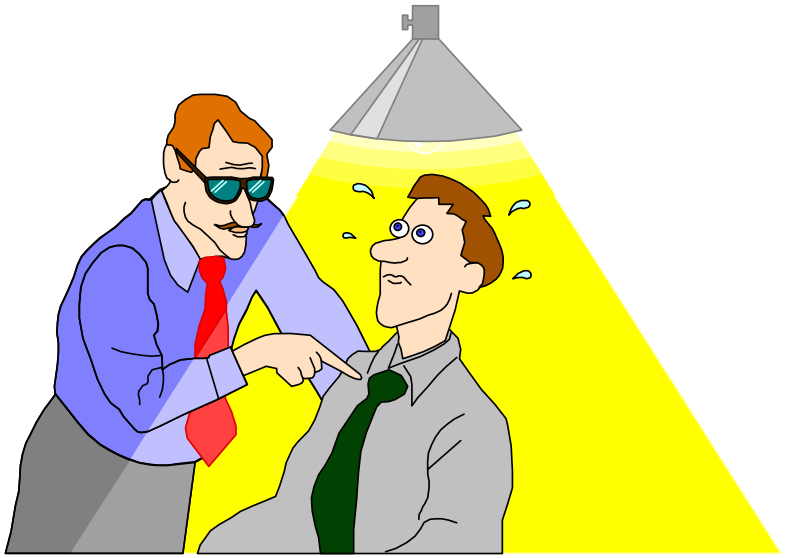


The Essence of Compliancy

- The IEC 61131 standard gives rules for compliancy

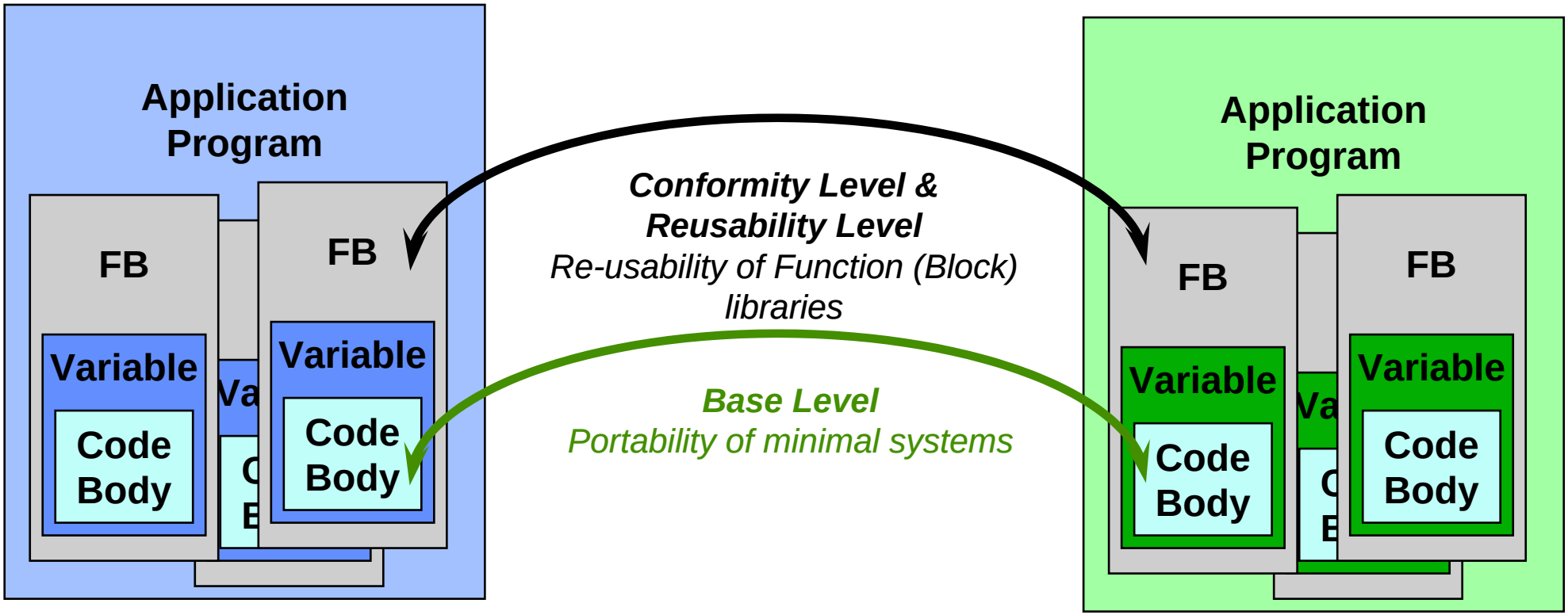
- Certification guides users towards real IEC 61131-3 programming systems (e.g. PLCopen certified products)

Without testing there is no standard



Meanwhile only truly compliant IEC 61131-3 systems are promoted as IEC 61131-3 products

TC3: PLCopen Compliance Levels



Certification

Certified products can use these logos

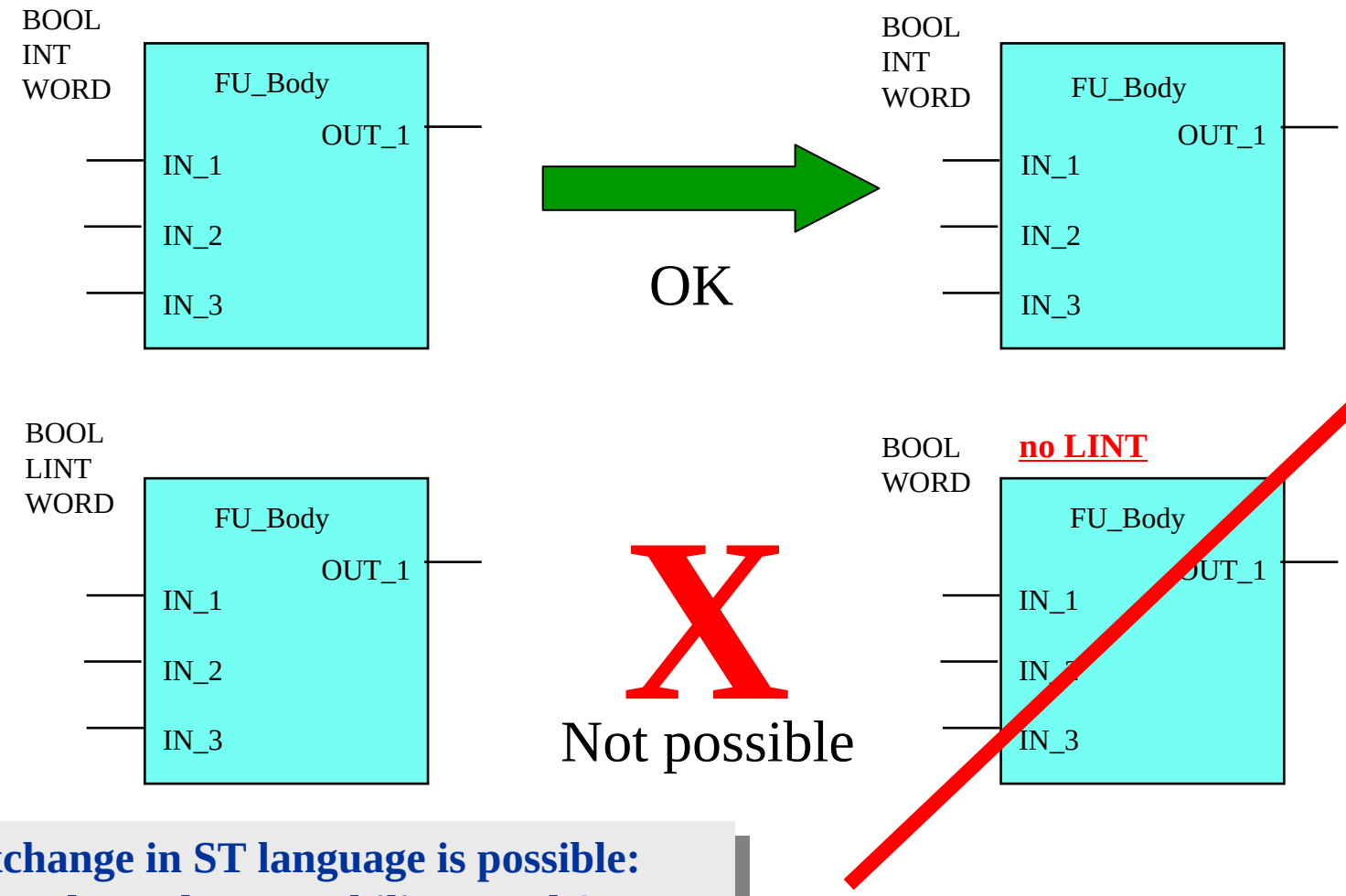
Base Level: first step into IEC 61131-3 software

Conformity Level: conforms to IEC 61131-3 based on supported data types

Reusability Level: reuse of IEC 61131-3 Function Blocks based on supported data types

Motion Control: certified Function Blocks according the Motion Control specification

Reusability Level ST



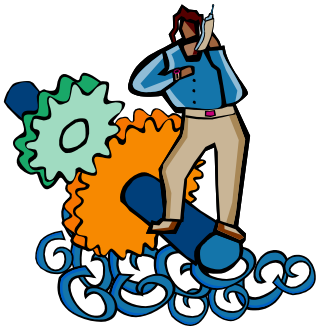
Function Block exchange in ST language is possible:

- **if both systems have the Reusability Level ST**
- **the used instructions are IEC 61131-3 instructions**
- **the same data types are available**

Why Motion Control FBs ?

Revolutionizing the industry with a global standard

Mechanics do not help anymore,
a standard with software is possible



Reduce maintainance and sanitation

Less hardware parts, more software

The solution is……..

……..Software

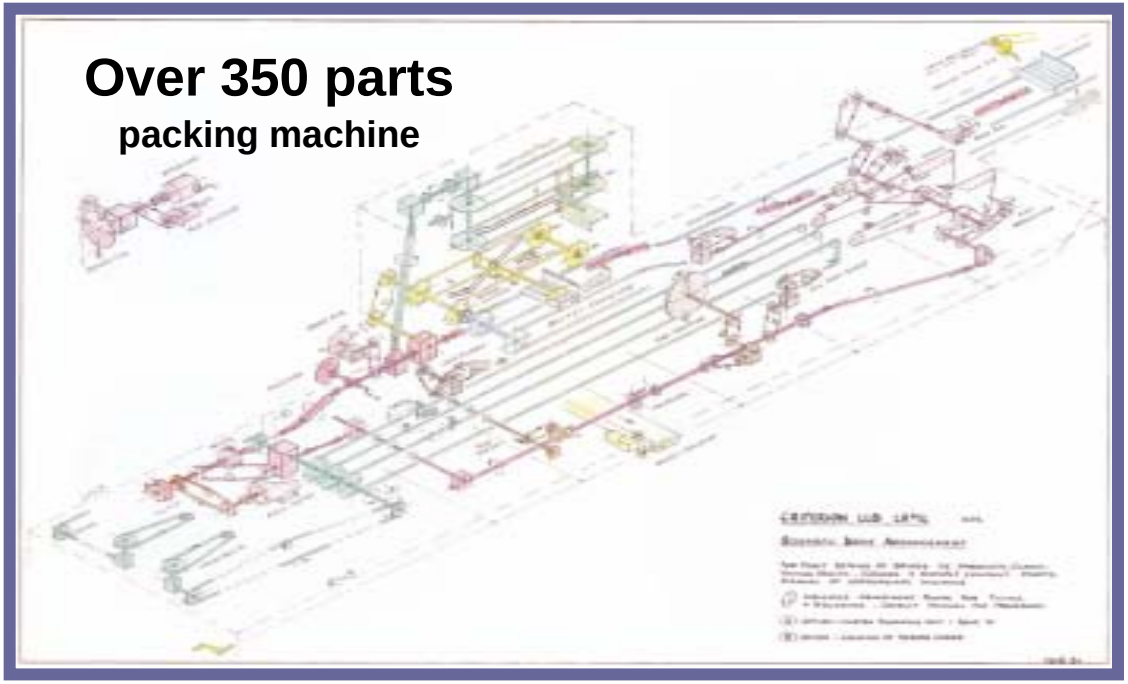
Advantages of servo driven systems

→ OMAC / PackAdvantages

- Research done by company RA Jones / Rick Liddington
- In cooperation with Packaging World (magazine)

Open Modular Architecture Controls OMAC USERS GROUP
www.omac.org

Traditional Mechanical Design



Targets for a new design:

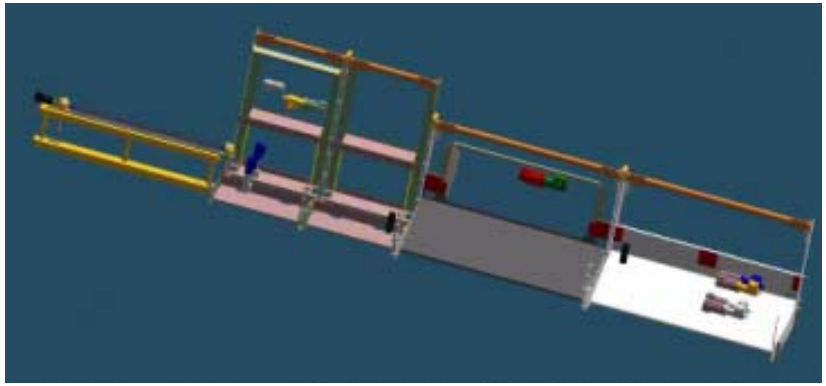
'Zero' maintenance

Sanitation design

Solution

- **Aim for a 50% reduction in mechanical parts**

Multi Axis Servo Drive



Major part count reduction

- Pulleys - 45 to 0
- Belts - 15 to 0
- Drive sprockets - 15 to 0
- Spline shafts - 2 to 0
- Gearboxes - 16 to 10
- Motors - 1 to 10
- Bearings - 18 to 3
- Line shafts - 6 to 0

Total - 118 to 23

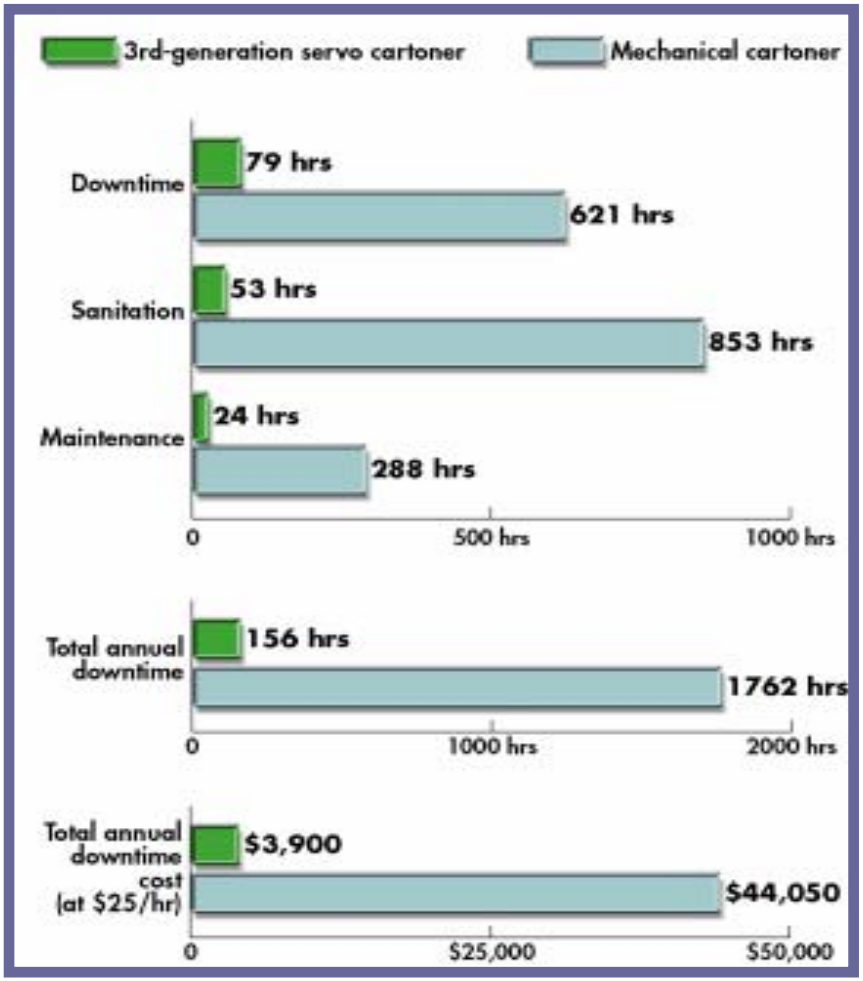
(81% reduction)

Traditional Mechanical Design

Faster – Better – Cheaper!
Software instead of Hardware

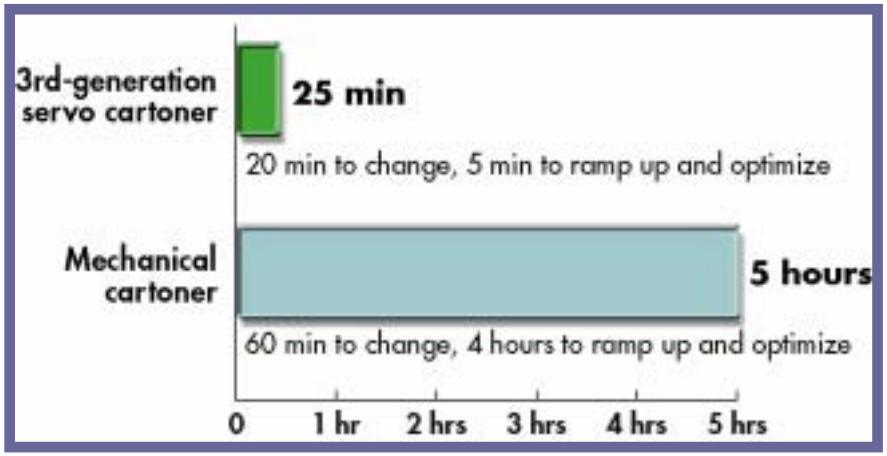
Servo Drive Design

Results :

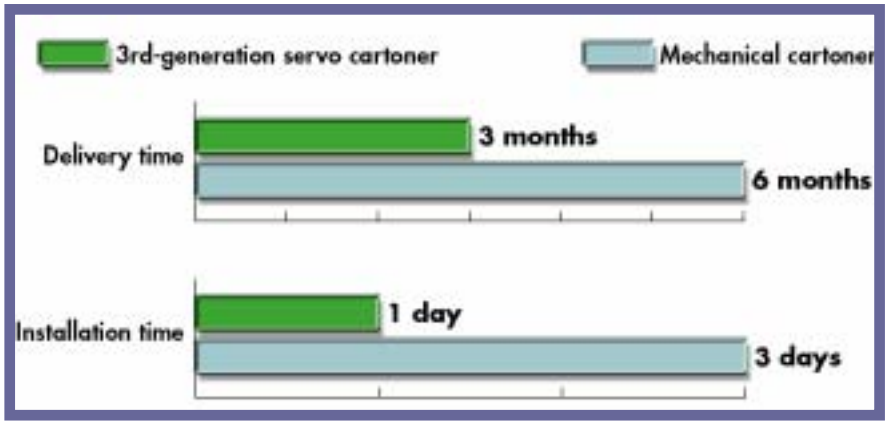


Side effects :

Reduction in Size Changeover Time



Reduce delivery time



Motion Control Standardization means:

- **Hardware independent Software Development**
- **Consistent Development Environment**
- **Consistent Installation and Maintenance Interface**

Same

'Look and Feel'

IEC 61131-3 is a good base

The PLCopen Task Force Motion Control

- **Initiated by Users**
- **..to fulfil their requirements**

Users:
- Bosch Packaging
- Kuka
- Kloeckner Tevopharm
- Focke EKB
- Hershey Foods
- Tetra Pak

Suppliers:
- Siemens
- Elau
- Beckhoff Industrial Electronics
- SEW Eurodrive
- Mitsubishi Electric Europe
- Cross Hueller
- Lenze
- Parker Hannifin
- ISG Stuttgart
- Control Techniques
- Phoenix Contact
- Keba
- KW Software
- Rockwell Automation
- Nyquist
- Baumueller
- infoteam Software
- Rexroth Indramat

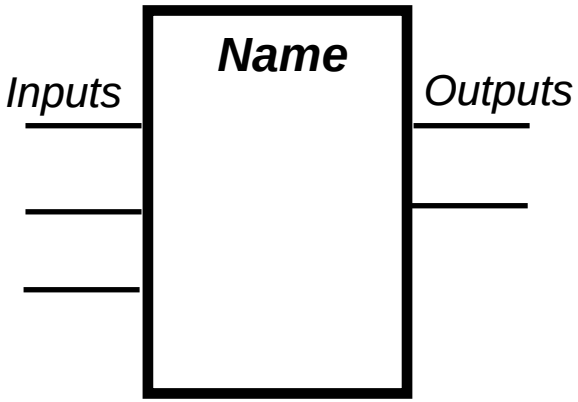
Goal :

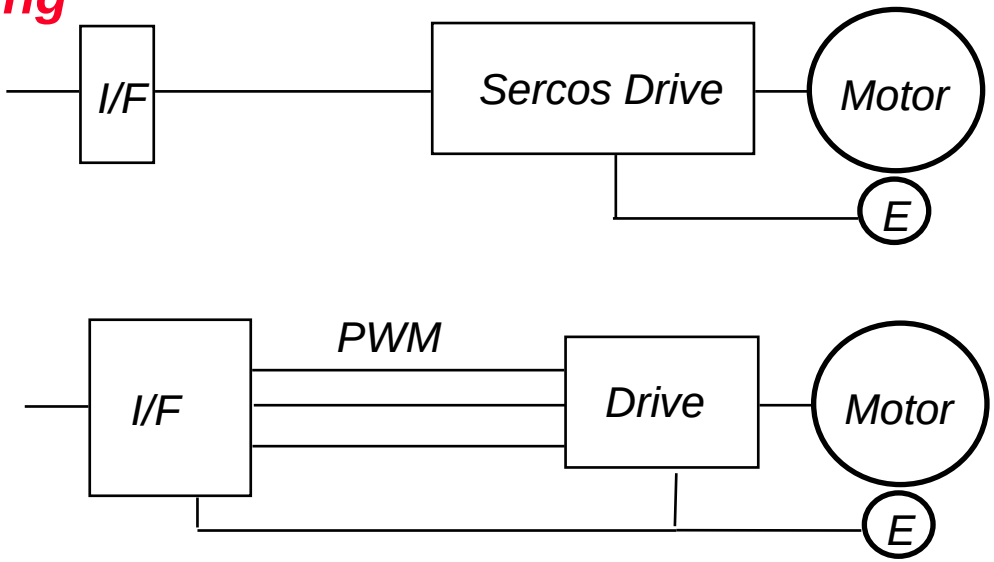
To harmonize the access for Motion Control across different platforms during development, installation and maintenance based on the IEC 61131-3 environment

HW Independence via Function Blocks

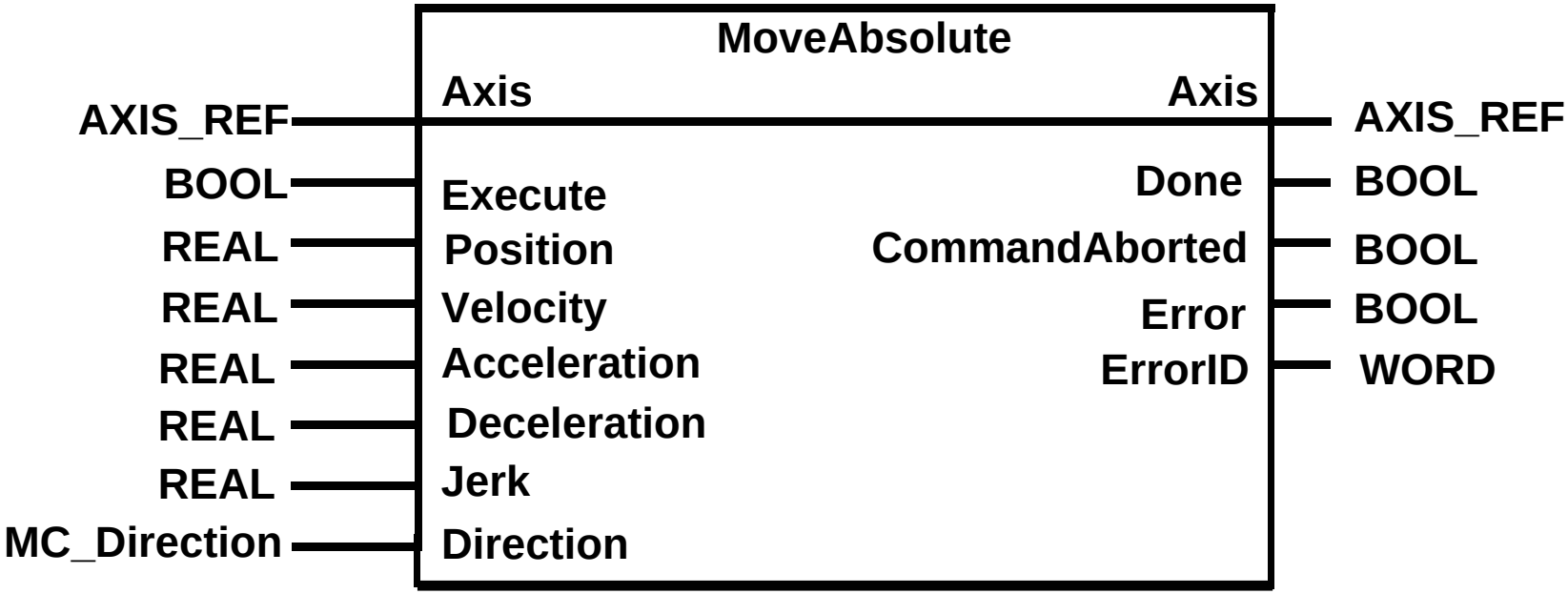
Software View ***Hardware View***

Encapsulation / Information Hiding



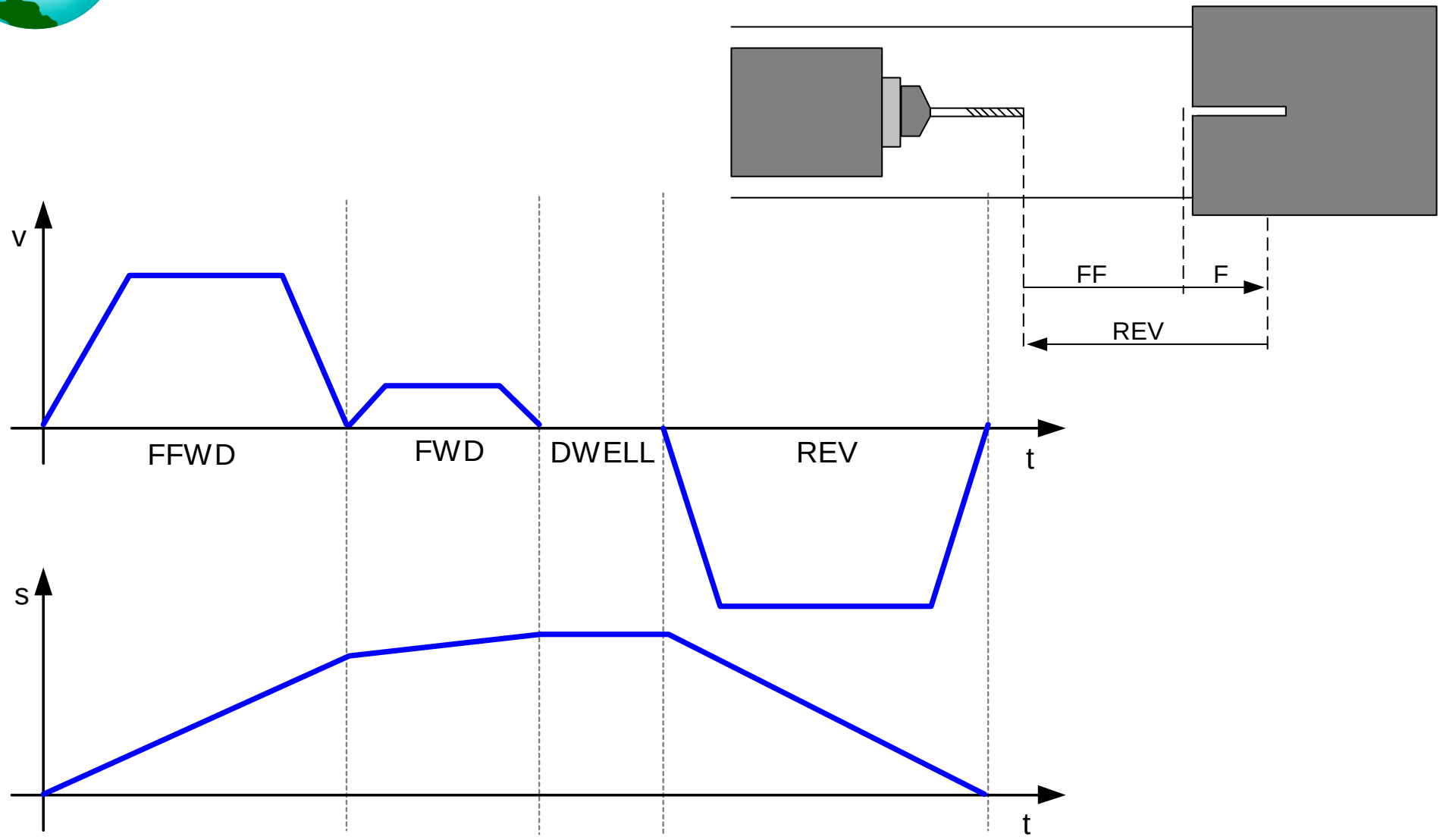


Example of a Function Block

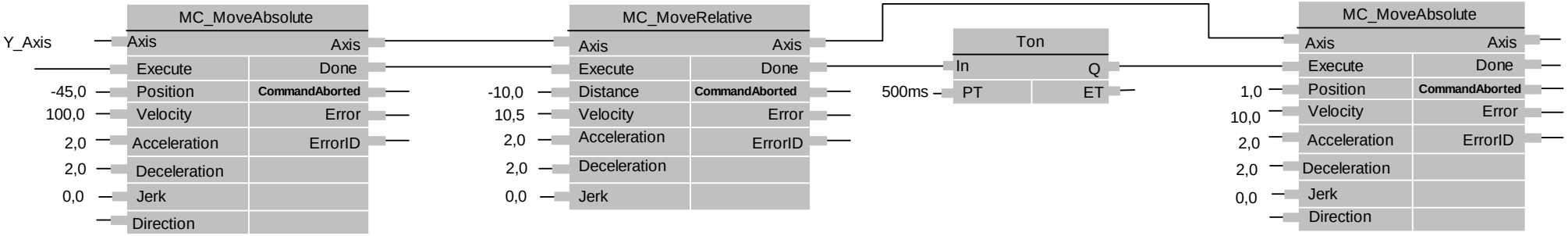


FB-Name	MC_MoveAbsolute
This function block commands a controlled motion at a specified absolute position.	

A Motion Control Example…
Drilling of a hole



Solution with Function Block Diagram

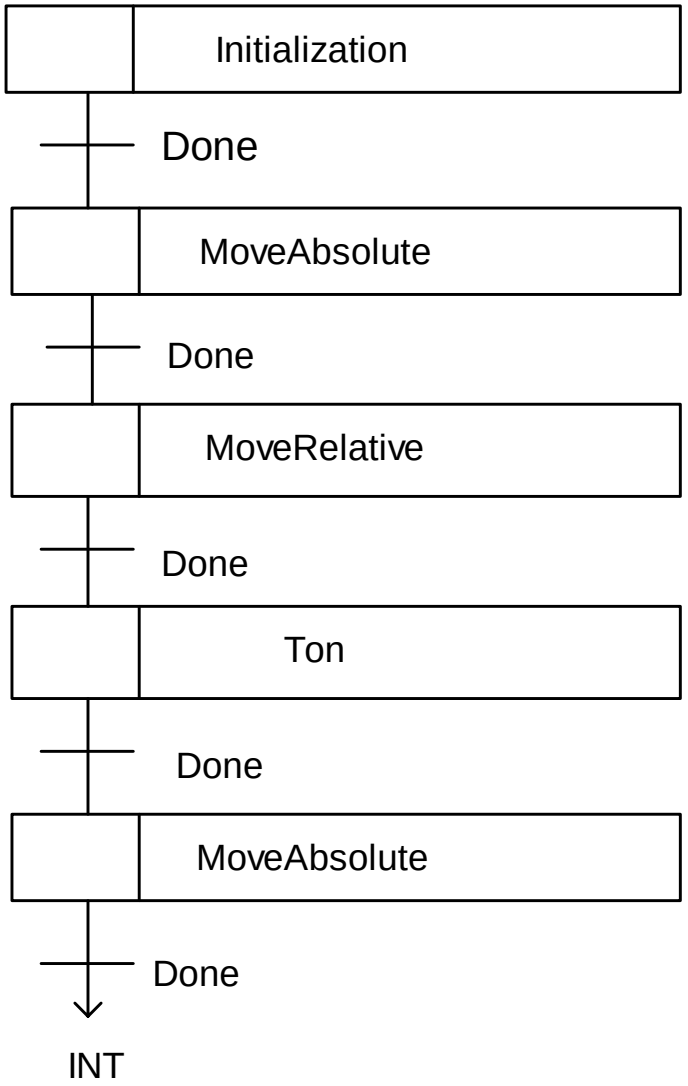


Required functionality

- Move Absolute
- Move Relative
- Timer
- Move Absolute

Solution with SFC

- ***Step 1:*** **Initialization (power up)**
- ***Step 2:*** **Move forward to drilling position and start the drill turning. Check if both actions are completed.**
- ***Step 3:*** **Drill the hole.**
- ***Step 4:*** **After drilling wait for the step-chain sequence to finish dwelling to free the hole of any debris which might have been stuck in the hole.**
- ***Step 5:*** **Move drill back to starting position and shut the spindle off. Combining the completion of moving backwards and stopping the spindle we signal the step-chain to start over.**



Conclusion

- PLCopen Motion Control Library provides an independent user interface
- Support for single axis and multiple axes / motion control
- IEC 6113-1-3 with PLCopen MC provides mechatronic solutions
- User derived FBs and data structures, and multi-tasking are crucial

Future

- Part 1 of the PLCopen Motion Control Library released
- Is implemented now by several suppliers
- Part 2 deals with extensions
- Part 3 will deal with user guidelines

TC6 - XML :

- specification of XML schemes for all IEC 61131-3 languages
- and full projects
- this will provide the basis for exchange (incl. graphical languages)
- and coupling to other software tools
- Start is for FBD languages, as it is the most complicated one

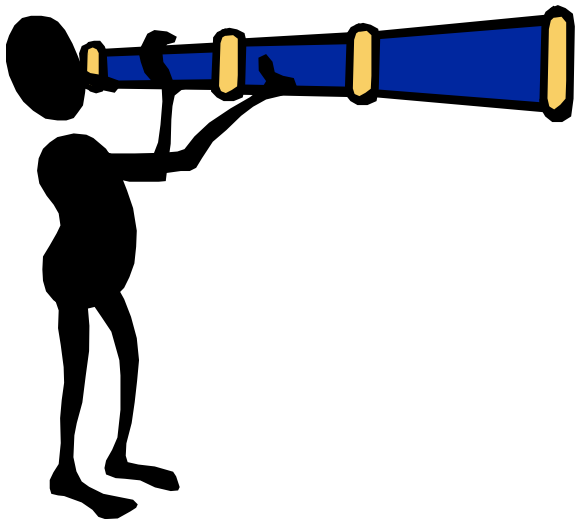
TC6 - XML

- The basis was provided as a proposal from Schneider Automation and handed over to PLCopen.

- Additional proposals were presented by Rockwell Automation, ABB, and Beckhoff.

- First results (specification) are expected end of 2003

Future direction of PLCopen ?



PLCopen - Future Direction

PLCopen and IEC 61499?

Harmonization of new technologies e.g. Ethernet?

Define new FB libraries after Motion Control, which?

Focus on special markets?

Communication proposals? (IEC 61131-5)

Create new advantages for members to increase active support in committees?

Variables / types definition for interfaces to other automation products as SCADA, HMI etc. ?

Other issues???

Depend on members activities !!

Thank you very much for your attention !