PLCopen:
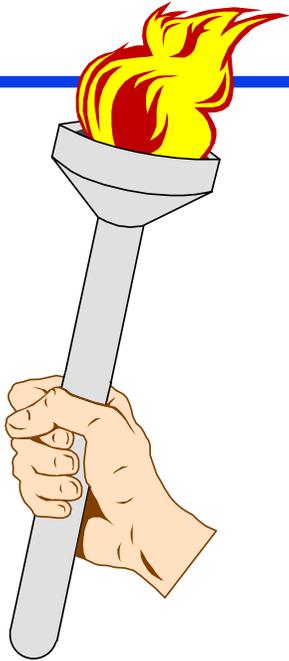
changing the world of industrial automation

-

status, structuring tools, activities and libraries
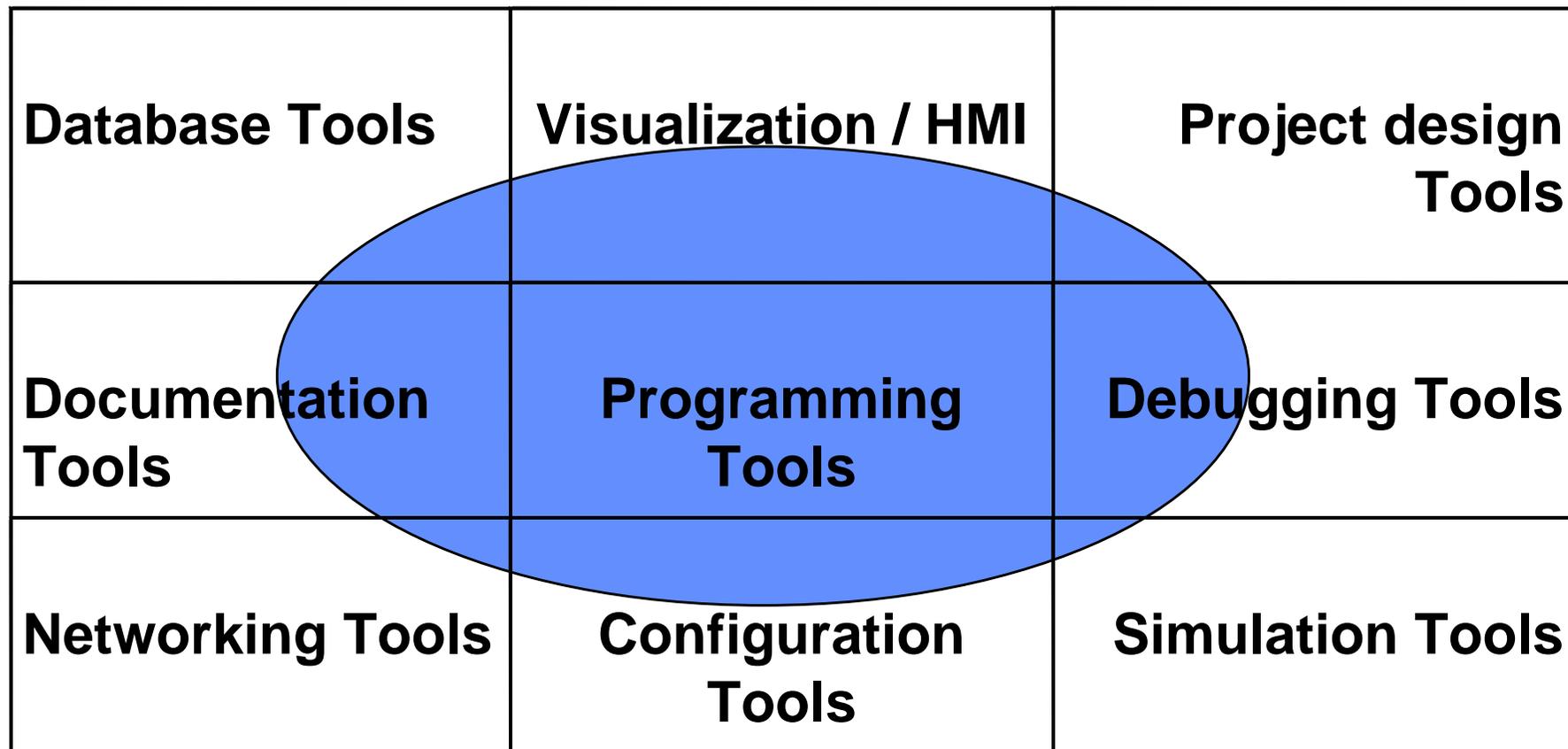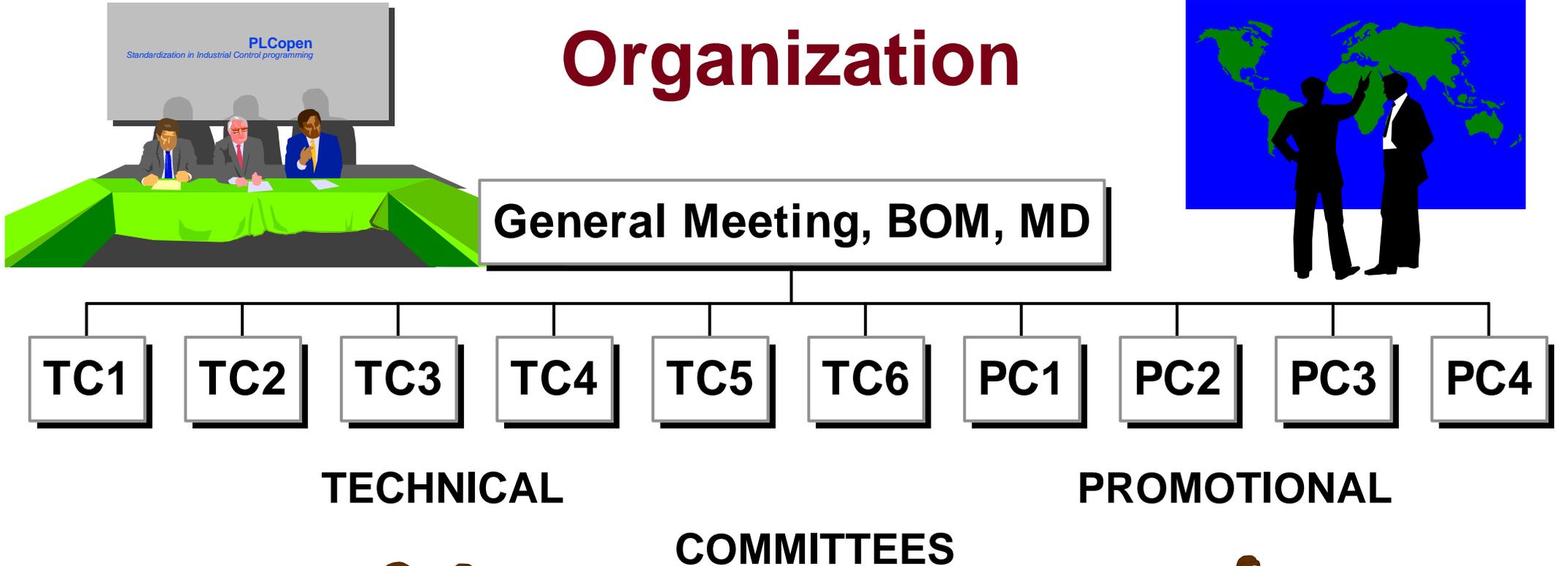
Eelco van der Wal

Managing Director PLCopen

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.

Programming in its environment

Database Tools	**Visualization / HMI**	**Project design Tools**
Documentation Tools	**Programming Tools**	**Debugging Tools**
Networking Tools	**Configuration Tools**	**Simulation Tools**

Organization

General Meeting, BOM, MD

| TC1 | TC2 | TC3 | TC4 | TC5 | TC6 | PC1 | PC2 | PC3 | PC4 |

TECHNICAL

PROMOTIONAL

COMMITTEES

TC1: Standards

- **IEC 61131-3 is enhanced with Corrigendum & Amendments**

- **Development of joint PLCopen position for IEC**

- **Communication of information from IEC to PLCopen**

- **Improvement proposals**

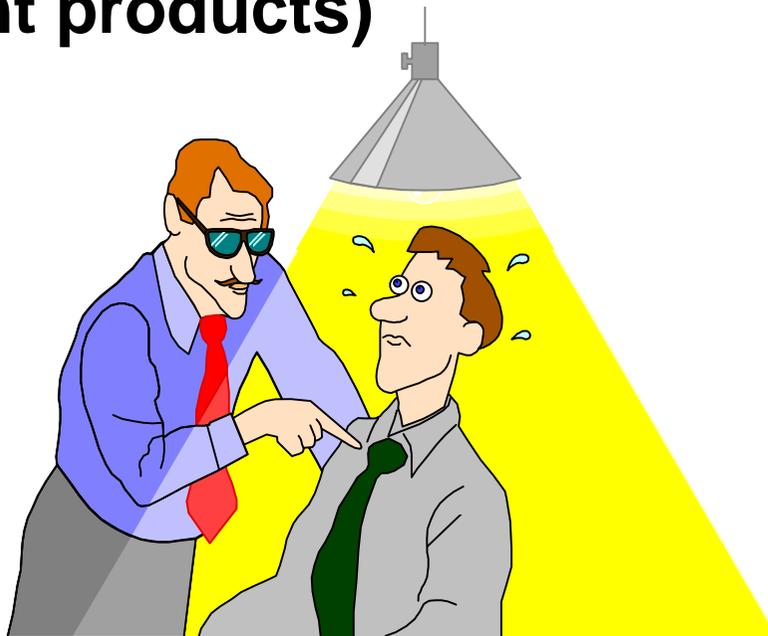- **Focused to upcoming update: end of 2002**

TC2: Functions

- **Definition of Function Block libraries & calling conventions**

- **… for example…**

- **Motion Control Library: the integration of different technologies: logic and motion**

- **Safety Library – providing the basis for safety critical environments**
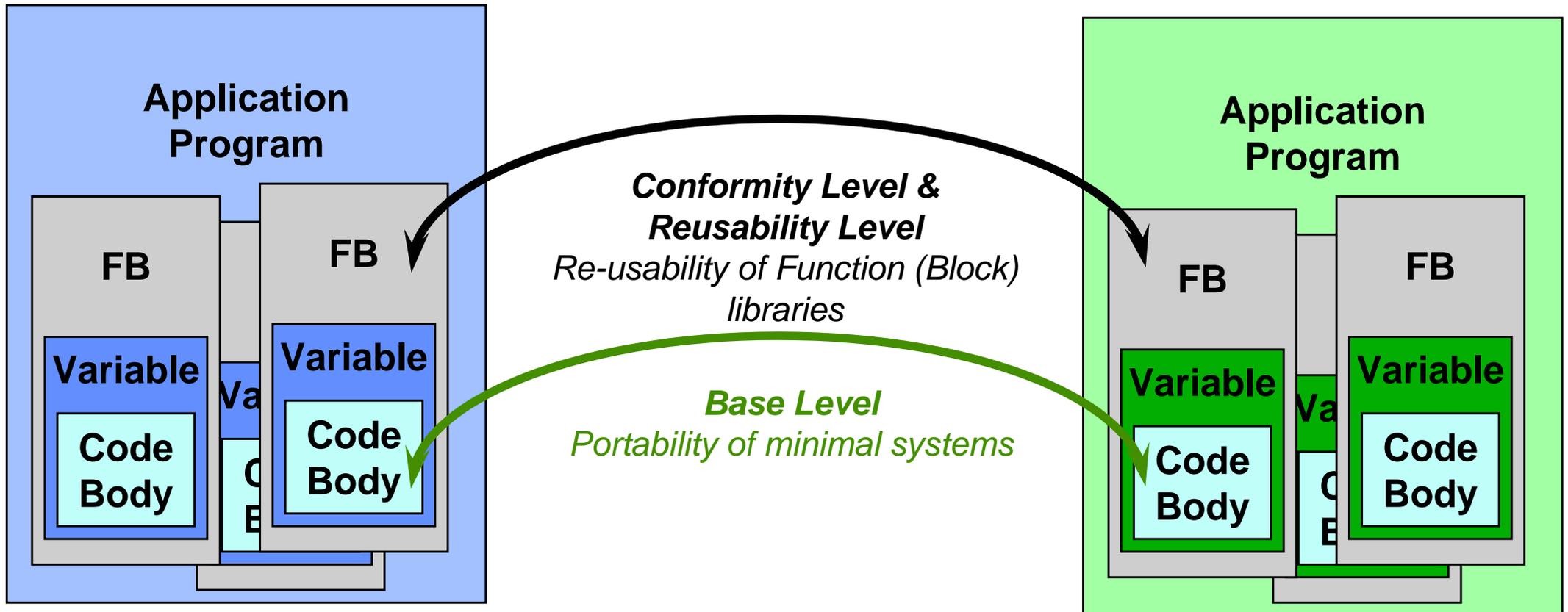
TC3 : Certification

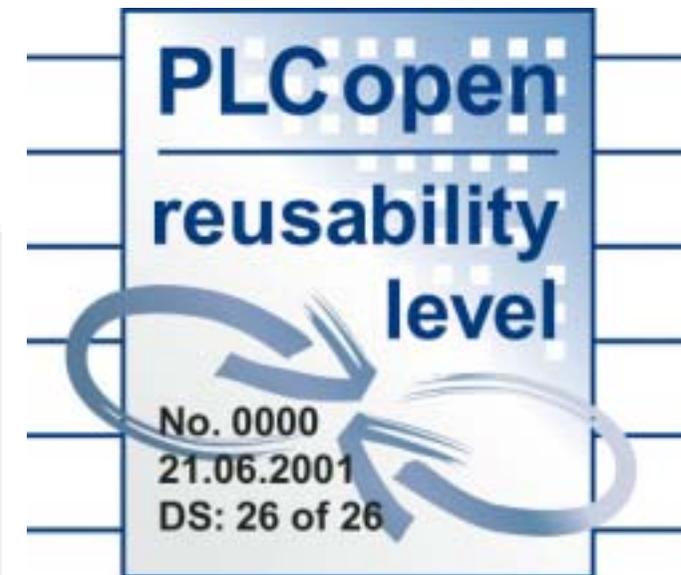## *…*without testing there is no standard*…*

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

TC3: PLCopen Compliance Levels

Application Program

FB

FB

Variable

Va

Variable

Code Body

C E

Code Body

Conformity Level & Reusability Level
Re-usability of Function (Block) libraries

Base Level
Portability of minimal systems

Application Program

FB

FB

Variable

Va

Variable

Code Body

C E

Code Body

Compliance: Results

TC3 - CL and RL for LD

No. 0000
LD
21.06.2001

Datatypes supported: 26 of 26

No. 0000
21.06.2001
DS: 26 of 26
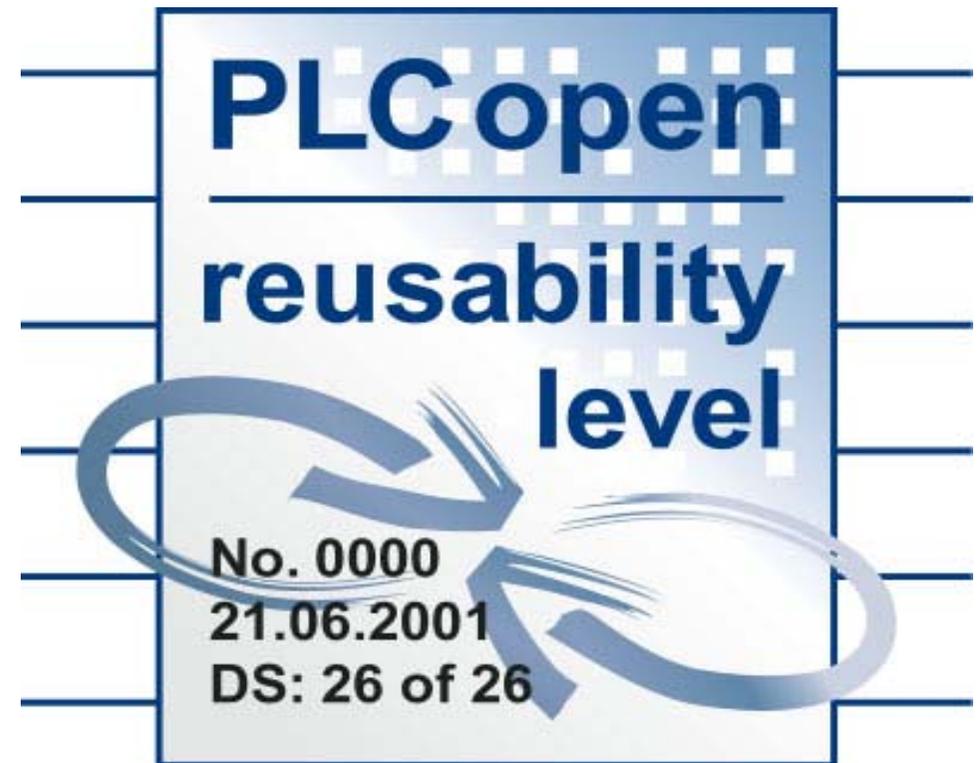
TC3 - CL and RL for LD : status

- **Next logical step: Conformity Level for LD**

- **Draft document as basis ready**

- **The kick off meeting will be held on May 7, 2003 at**

  Matsushita, Holzkirchen, Germany

- **Specification ready. Test software under development**

First Certificates for CL and RL - ST

PLCopen CONFORMITY LEVEL
No. 0000
ST
21.06.2001
Datatypes supported: 26 of 26

PLCopen reusability level
No. 0000
21.06.2001
DS: 26 of 26

First Certificates for CL and RL - ST

- **Matsushita Electric Works (Europe) with Control FPWIN Pro**

- **Schneider Electric with Concept**

Compliance:
Results and Status Base Level (Oct. '03)

- **Accreditation installed: two institutes accredited**

- **Base Level definition ready for IL, ST, FBD, LD and SFC**

- **Test software ready for IL, ST, FBD and SFC. LD in preparation**

- **22 software packages certified (see website for status)**

TC4: Communication

- **Communications interfaces**

- **Interfaces to add-on packages**

- **Application interchange format**

- **Mapping of Profibus has been done**

- **Mapping of CANopen has been done**

TC5: Safe software guidelines

- **Support for safe programming techniques**
- **Focus to IEC 61508 "Functional Safety of Safety Related systems"**
- **Guidelines for the use of the IEC standard**
- **Basis for easier commissioning**
- **In combination with the Function Blocks**
- **First results expected April 2004**

TC6: XML

- **Definition of XML schemes for all the IEC languages**

- **Representation of graphical information**

- **Interface to other tools**

- **Possible basis for distribution of Function Block libraries**

- **Work is under construction (members-only)**

- **Results will be made publicly available**

PLCopen as a World-wide association

Main Office in Europe

Office in North America

Office in Japan
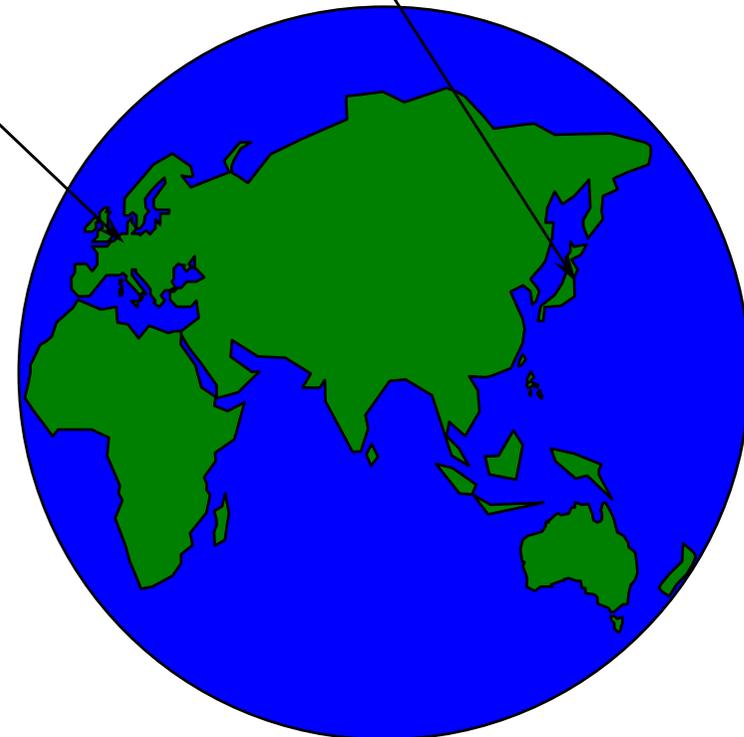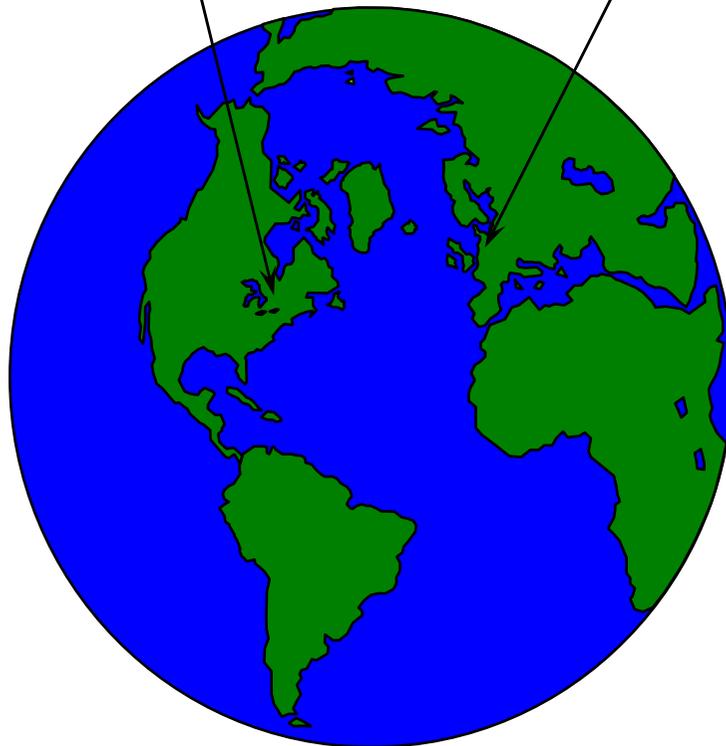
General Promotion

- **PC1: General Promotion**
- **PC3: Promotion North America**
- **PC4: Promotion Japan**

PC4 - Activities in Japan – Dec. 2002

- **Fuji Electric,**

- **Matsushita Electric Works,**

- **Toshiba,**

- **Yokogawa Electric**

(listed in alphabetical order)

have decided to resume the activities of PLCopen in the Japanese market.

As independent organization, Kanagawa Industrial Technology Research Institute joined this group.

PC4 - Activities in Japan

Objectives and planned activities:

- **Introducing and promoting IEC 61131-3 and JISB3503**

- **Providing training for users with common needs**

- **Promoting standardization**

- **Promoting the utilization of user development resources through users groups**
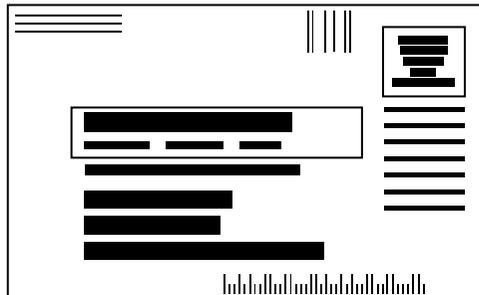
- **Certification in Japan**

PC4 - Activities in Japan

Mr. Kanno / Yokogawa

Mr. Mitsuo / MEW

Mr. Kawashima / Fuji

Dr. Miyazawa

Mr. Kitamura / MEW

Mr.Imai / Toshiba   Mr.Kaneko / Yokogawa
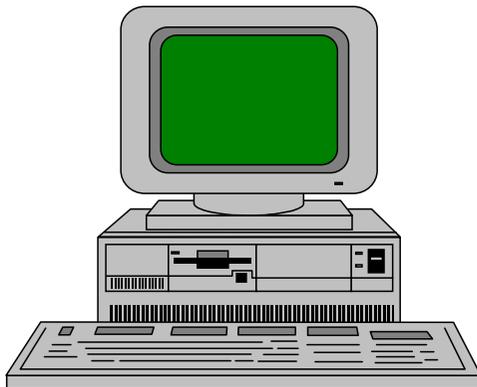
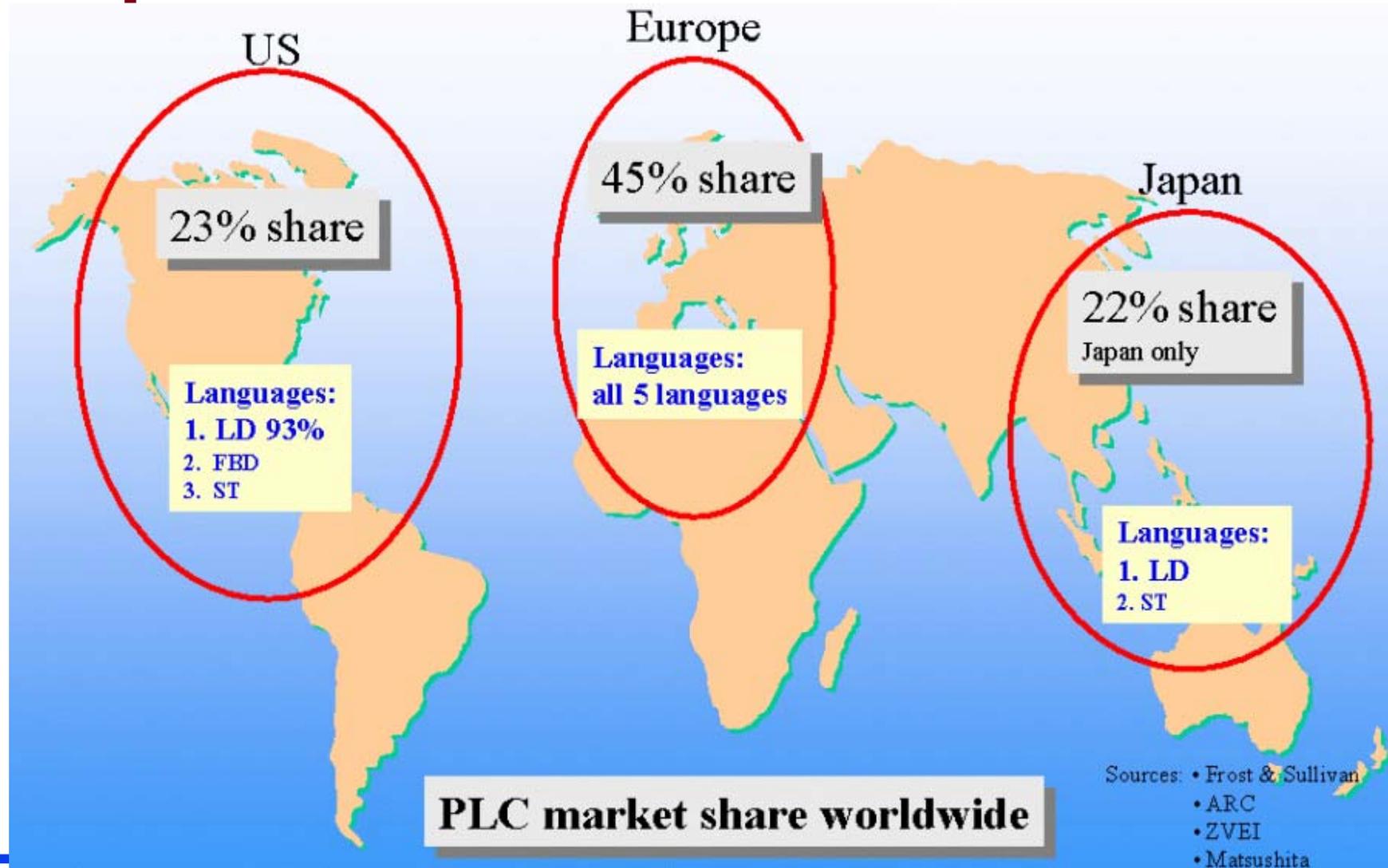Mr.Satoh / Toshiba

Mr.Tomizawa / Fuji

www.plcopen-japan.jp

PLCopen China

Under construction …..

Acceptance and WW PLC market share

PC2: Common training program

- **The effect of training is often underestimated**

- **Standardization can be very useful and provide a better interface between study and reality**

- **PC2 defined common basics for training..**

- **.. for instance: a IEC 61131-3 training guideline is published**

- **Training facilities fulfilling basic requirements can be certified and listed / referenced to (see website for listing)**
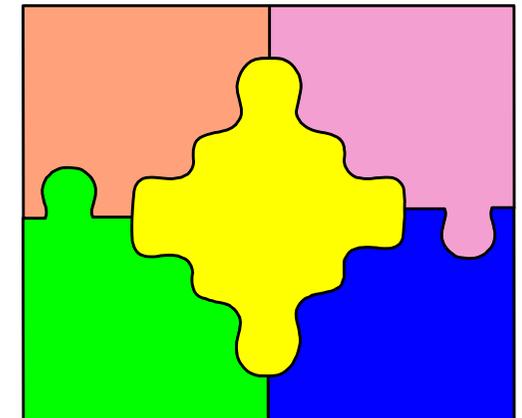
IEC 61131-3

Harmonizing the way people look to control

the future is here

The 7 parts of the IEC 61131 Standard

- 1   **General overview, definitions**   **IS**

- 2   **Hardware**   **IS**

- 3   **Programming Languages**   **IS**

- 4   **User Guidelines**   **IS**

- 5   **Messaging Service Specification**   **IS**

- 7   **Fuzzy Logic**   **IS**
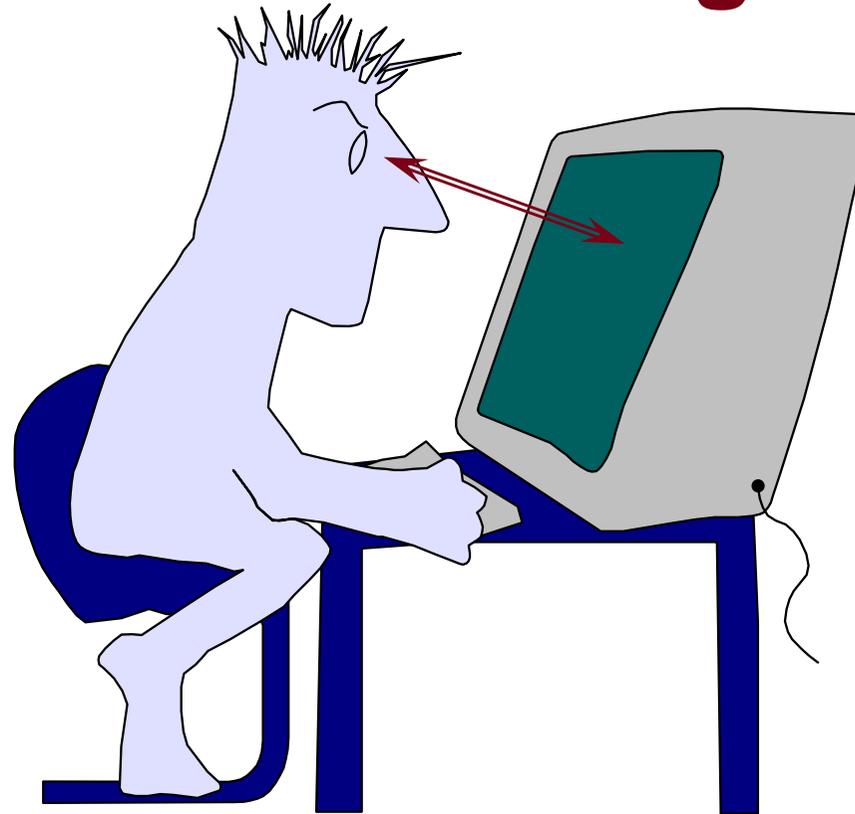
- 8   **Technical Report**

IS = International Standard

IEC 1131 versus IEC 61131

- **The good news is – there is no difference**

- **It is an international harmonization of all the IEC standards and the localized versions**

- **… however, there are second editions for parts of the IEC 61131 standards**

IEC 61131-3 Programming languages / Industrial Control Programming

The interface between the programmer and the control system

IEC 61131-3 Programming languages / Industrial Control Programming

...with support for people with different backgrounds

The IEC 61131-3 Standard

Common Elements

Programming Languages

IEC 61131-3 : Common Elements Variables & Data Types

What is this?

01010101 10101010

Historically

- **Reference to a physical memory location**

- **Reference to a physical Input**

IEC 61131-3 : Common Elements
Variables & Data types
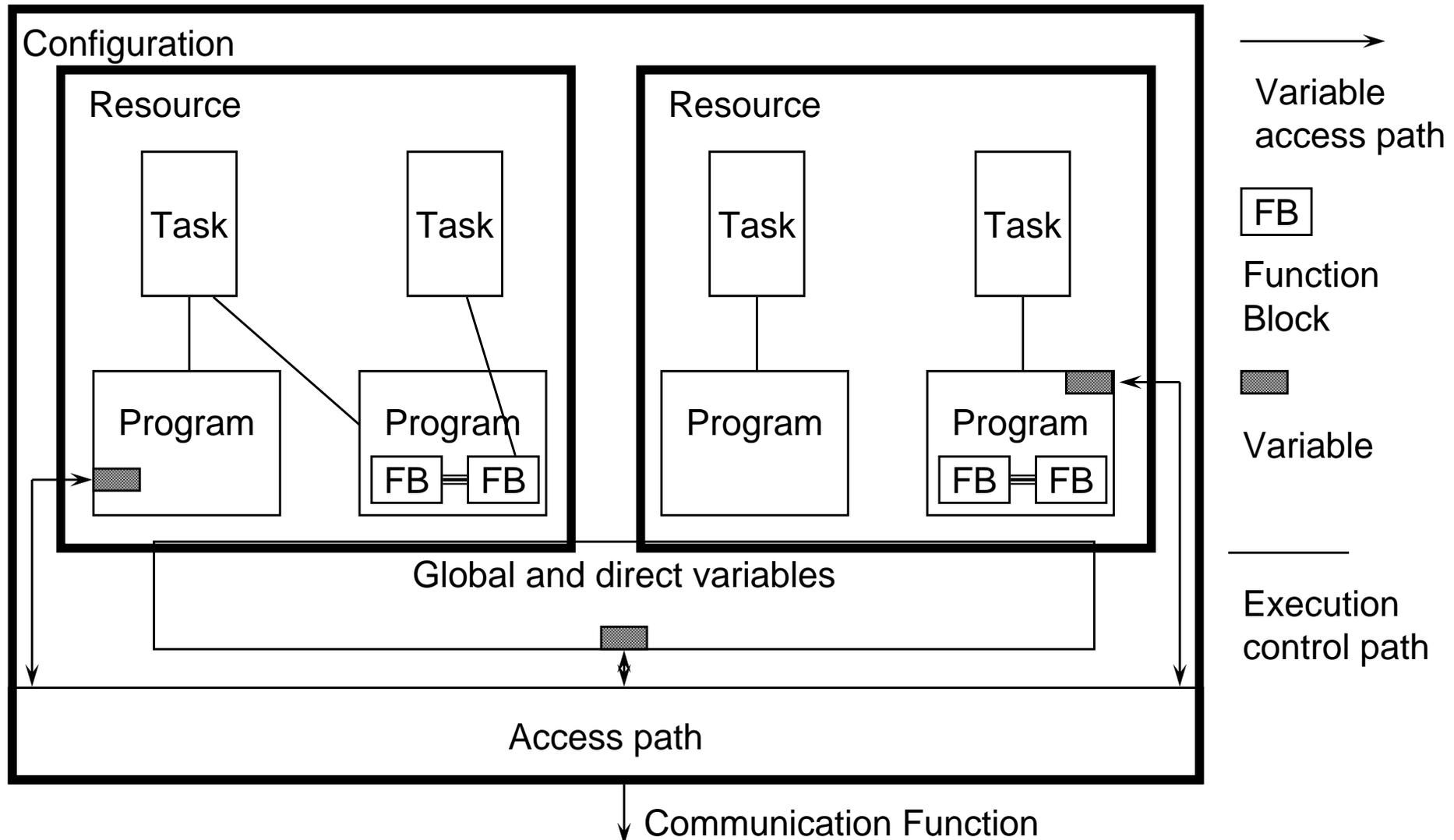
Temperature_Sensor_1 : Integer

- **Symbolic representation via labels**

- **Restricted area for I/O mapping**

- **Hardware independent code**

- **Higher transparency & readability**

- **Less errors**

IEC 61131-3 : Common Elements

Software Model

- Configuration
  - Resources
    - Tasks

IEC 61131-3 Software Model

Configuration

Resource

Task

Task

Program

Program

FB — FB

Resource

Task

Task

Program

Program

FB — FB

Global and direct variables

Access path

Communication Function

Variable access path

FB

Function Block

Variable

Execution control path

IEC 61131-3 vs conventional PLC

Configuration

Resource

Task

Task

Program

Program

FB — FB

Resource

Task

Program

Task

Program

FB — FB

Global and direct variables

Access path

Communication Function

→ Variable access path

FB Function Block

▮ Variable

—— Execution control path
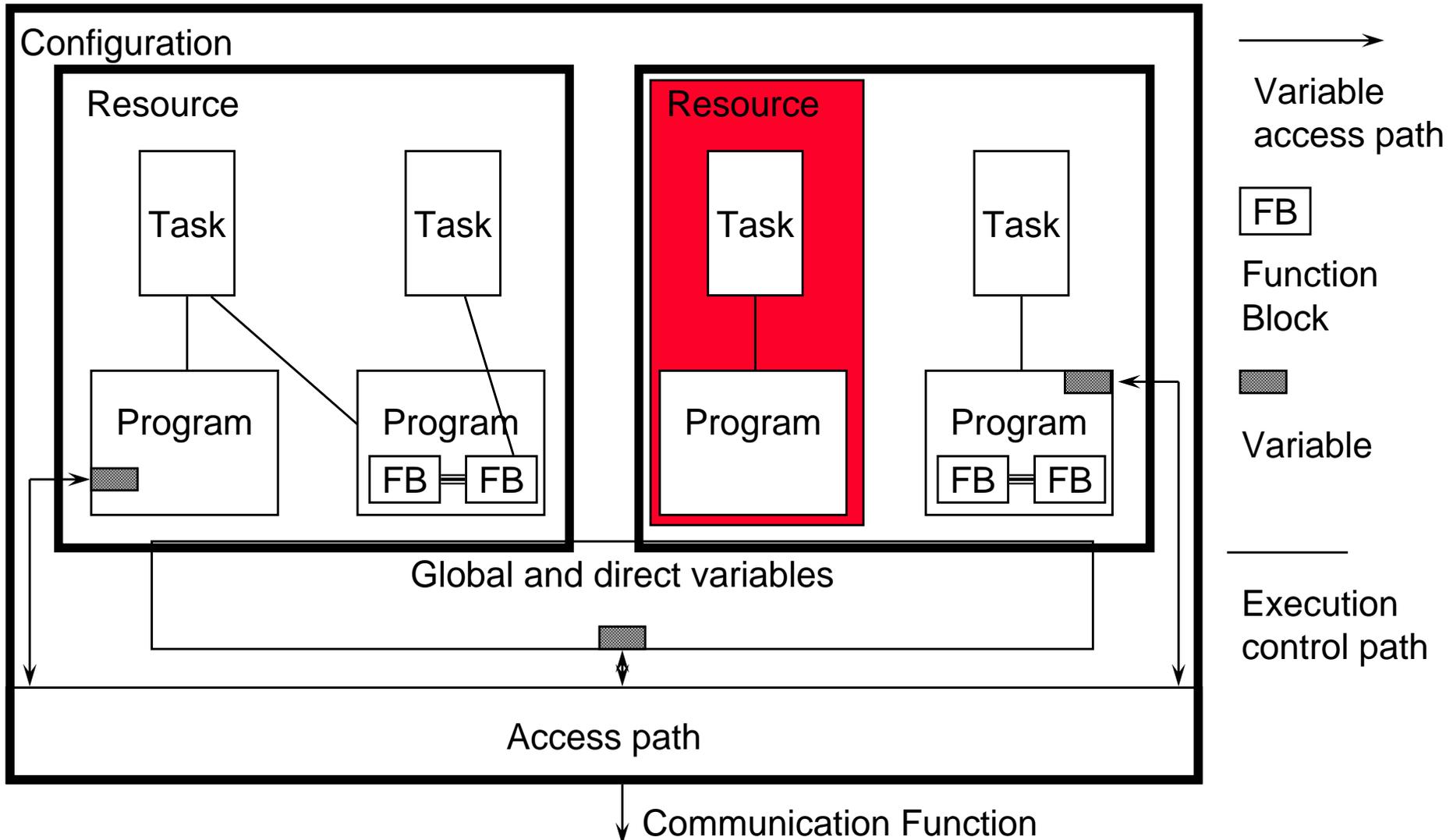
Conventional PLC vs IEC 61131-3

Resource

Task

Program

Endless Loop:

Read inputs

Do Calculations

Set Outputs

Task 1   *Time based*

Task 2   *Events based*

Task 3   *Events based*

Time based   Task 4

Common Elements: Tasks

PLCs

Embedded

DCS

IEC 61131-3

Drives

PC based Control

SoftLogic
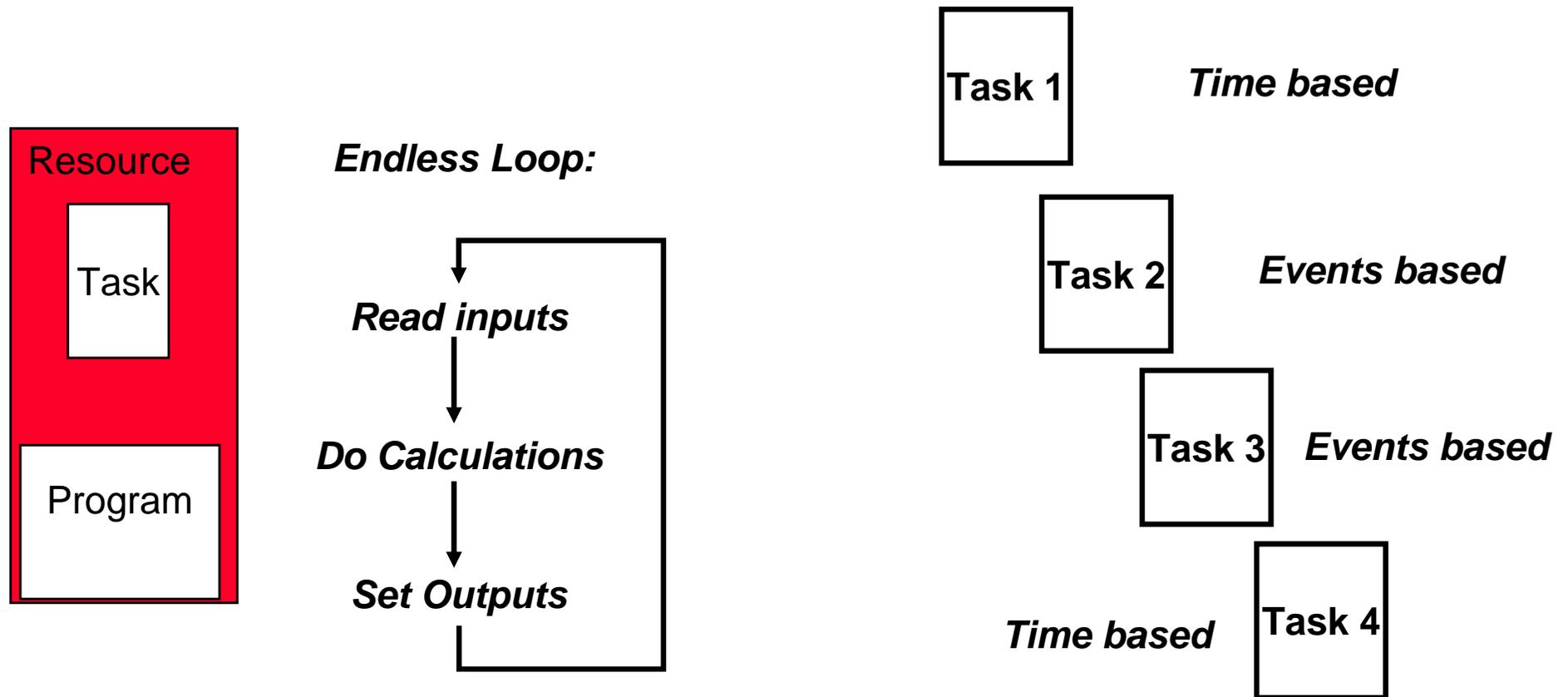
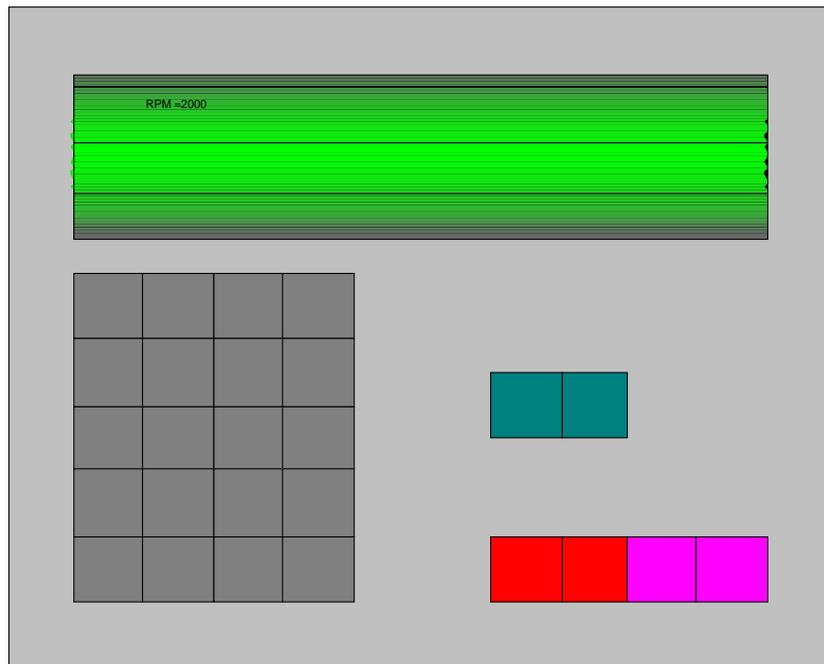LON nodes
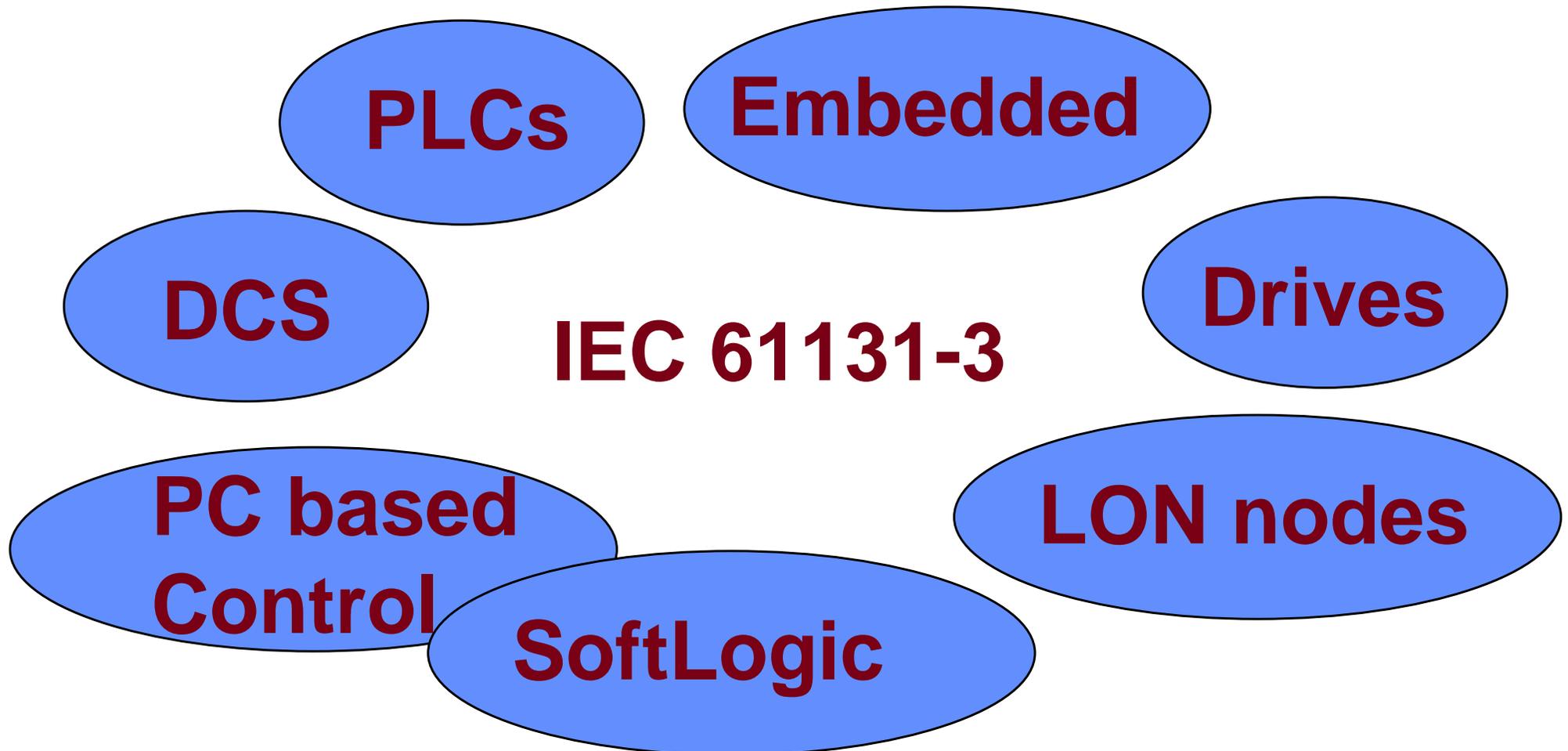
Common Elements : Tasks & Datatypes

Multi –functional Operator Panel

RPM =2000

Windows CE 3.0

IEC 61131-3 tasks

SCADA & HMI tasks

I/O Communication tasks

OPC

I/O Communication bus

IEC 61131-3 : Common Elements

COMMON ELEMENTS

a.o.

Data Types   &   Variables

Configuration, Resources, Tasks

Programming Organization Units

* Functions

* Function Blocks
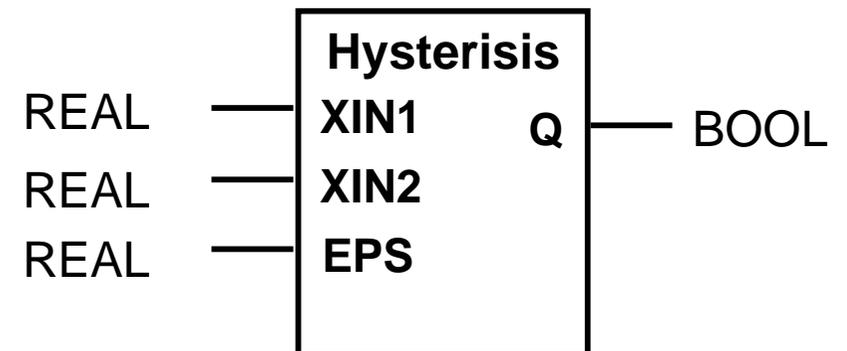
* Programs

Functions …..

* Standard functions

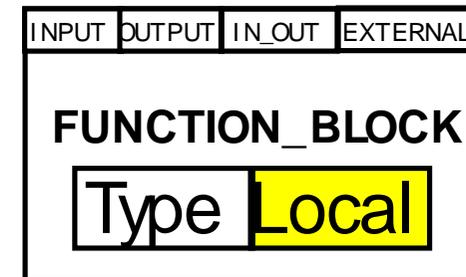   **ADD, SQRT, SIN, COS, GT, MIN, MAX, AND, OR, etc.**

* Your own defined functions:

```
FUNCTION SIMPLE_FUN : REAL
        VAR_INPUT
                A, B     : REAL;
                C                   : REAL := 1.0;
        END_VAR
SIMPLE_FUN := A*B/C;
END FUNCTION
```
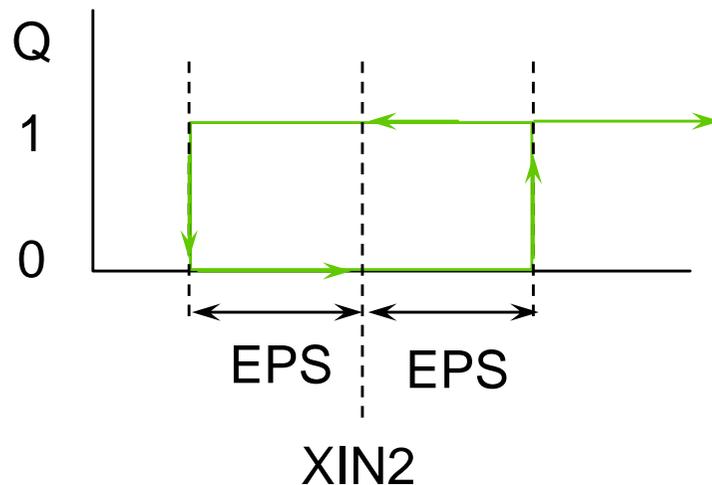
…. & Function Blocks

- **Standard Function Blocks**

- **Additional supplied Function Blocks**

- **Your own defined Function Blocks**

- **All FBs are highly re-usable in same program, different programs or project**

INPUT	OUTPUT	IN_OUT	EXTERNAL

FUNCTION_BLOCK

Type Local

Hysterisis

REAL — XIN1   Q — BOOL

REAL — XIN2

REAL — EPS

Function Block example

```
Hysterisis

REAL ──── XIN1        Q ──── BOOL
REAL ──── XIN2
REAL ──── EPS
```



```
Q
1
0

      EPS   EPS
        XIN2
```
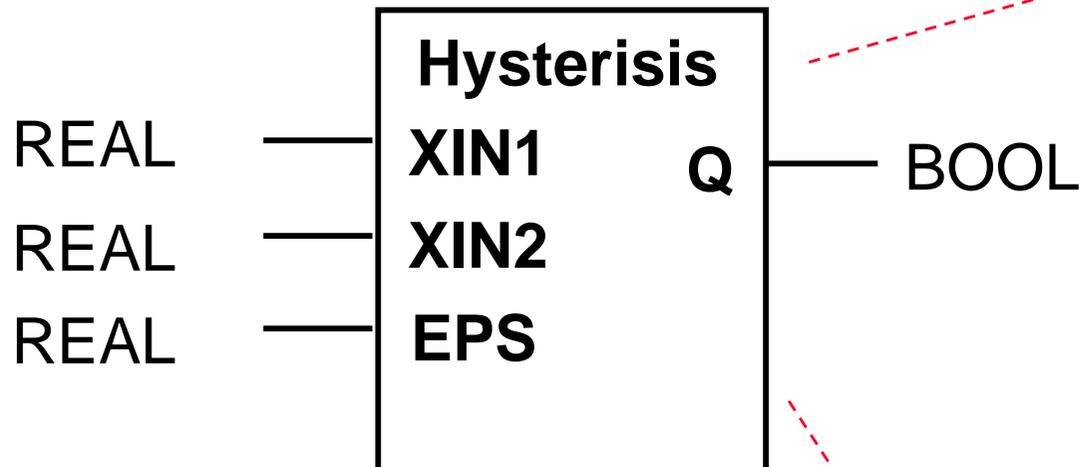
FUNCTION_BLOCK HYSTERISIS
VAR_INPUT
  XIN1, XIN2 : REAL;
  EPS : REAL; (* Hysterisis band *)
END_VAR
VAR_OUTPUT
  Q : BOOL := 0
END_VAR
IF Q THEN
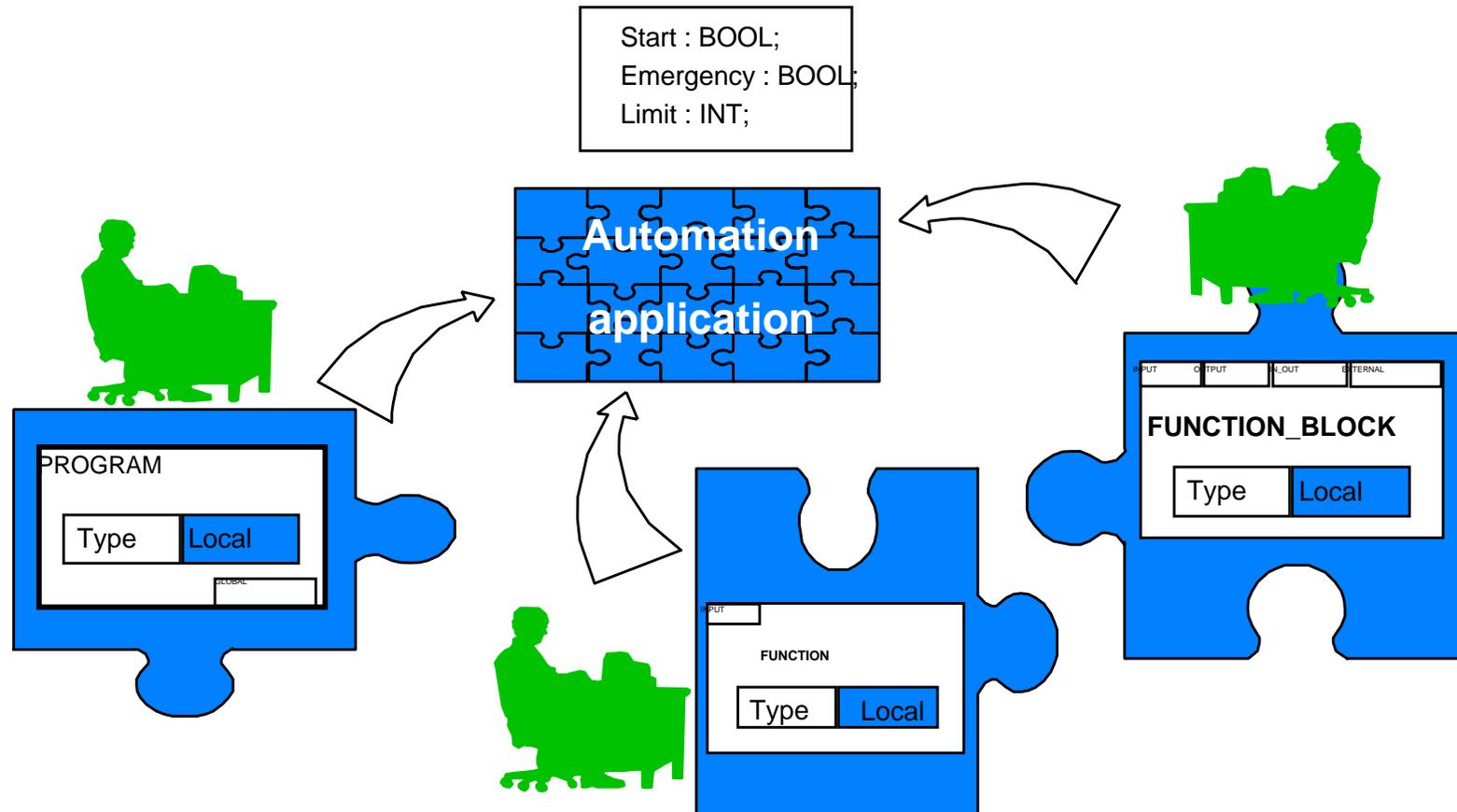 IF XIN1 < (XIN2-EPS) THEN
    Q := 0 (* XIN1 decreasing *)
  END_IF;
ELSIF XIN1 > (XIN2 + EPS) THEN
  Q := 1; (* XIN1 increasing *)
END_IF;
END_FUNCTION_BLOCK

Programs : hierarchical design

```
Start : BOOL;
Emergency : BOOL;
Limit : INT;
```

Automation application

PROGRAM

Type	Local

GLOBAL

FUNCTION

Type	Local

INPUT

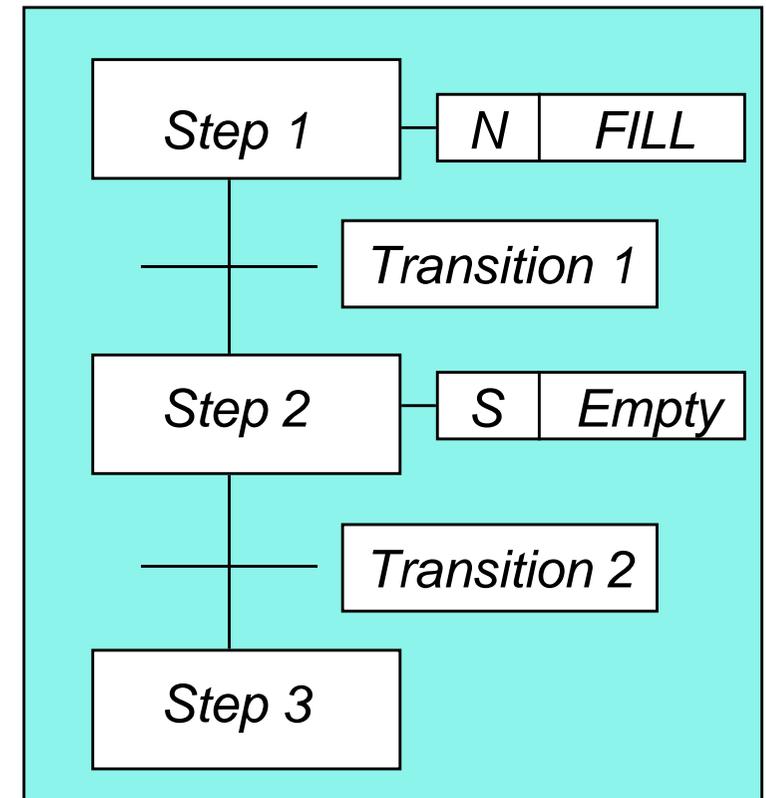| INPUT	OUTPUT	IN_OUT	EXTERNAL

FUNCTION_BLOCK

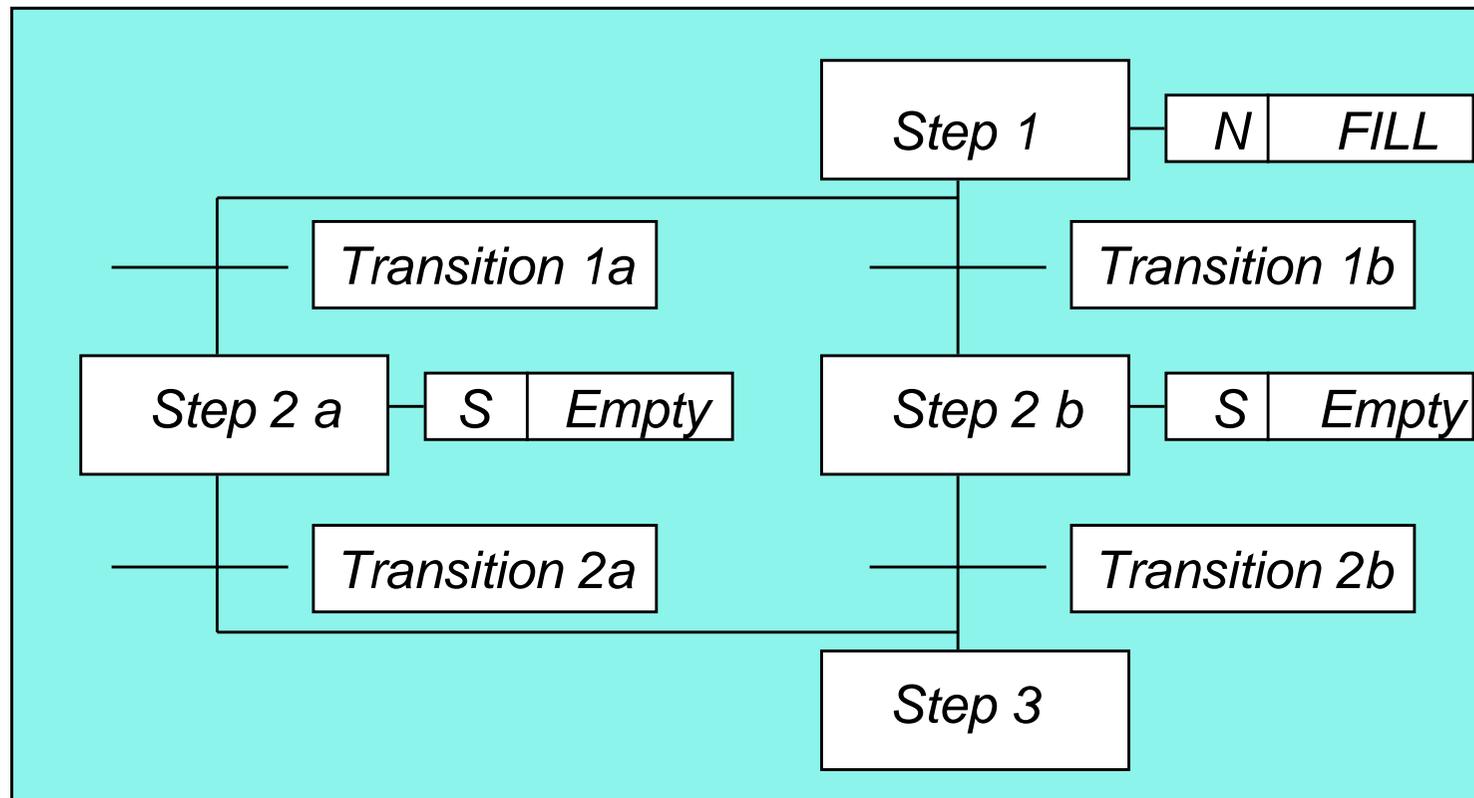| Type	Local

Advantages POU's

- **Create own Function Block Libraries (per application area)**

- **FBs are tested and documented**

- **Make libraries (world wide) accessable**

- **Re-use as much as possible**

- **Change programming to creating networks of FBs**

- **Save 40% on next project**

Sequential Function Chart, SFC

- **Powerful graphical technique for describing the sequential behaviour of a control program**

- **Used to partition a control problem**

- **Shows overview, also suitable for rapid diagnostics**

- **The basic elements are STEPS with ACTION BLOCKS and TRANSITIONS**

- **Support for alternative and parallel sequences**

Step 1	N	FILL

Transition 1

Step 2	S	Empty

Transition 2

Step 3

SFC : alternative sequences

Step 1	N | FILL

Transition 1a	Transition 1b

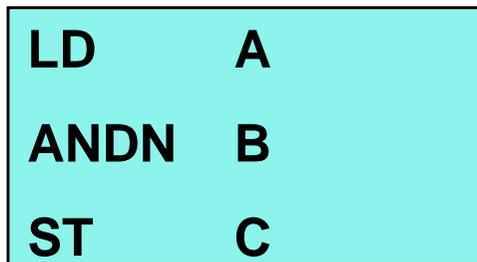|		
Step 2 a	S | Empty	Step 2 b	S | Empty

Transition 2a	Transition 2b

Step 3

The IEC 61131-3 Standard

Common Elements

Programming Languages

The IEC 61131-3 Programming Languages

Instruction List

```
LD        A

ANDN      B

ST        C
```

Structured Text

```
C:= A   AND  NOT B
```
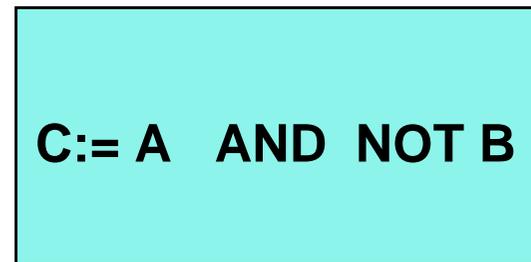
Function Block Diagram

```
        AND
       ┌──────┐
A ─────┤      ├───── C
       │      │
B ────○┤      │
       └──────┘
```

Ladder Diagram

```
 A   B              C
-| |--|/|---------------( )
```
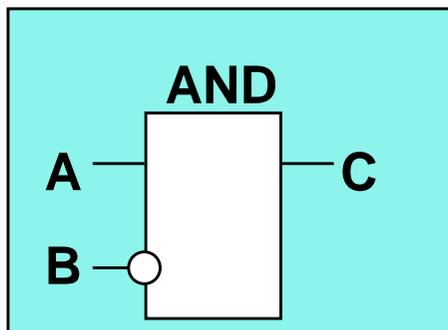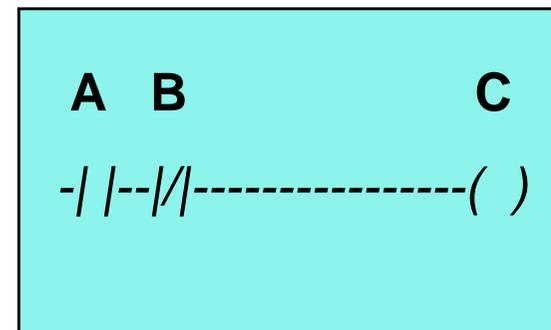
The IEC 61131-3 Standard

Common Elements

Programming Languages

Top Down

Bottom Up

IEC Programming Environments

Many of them offer:

- **graphical programming screens**
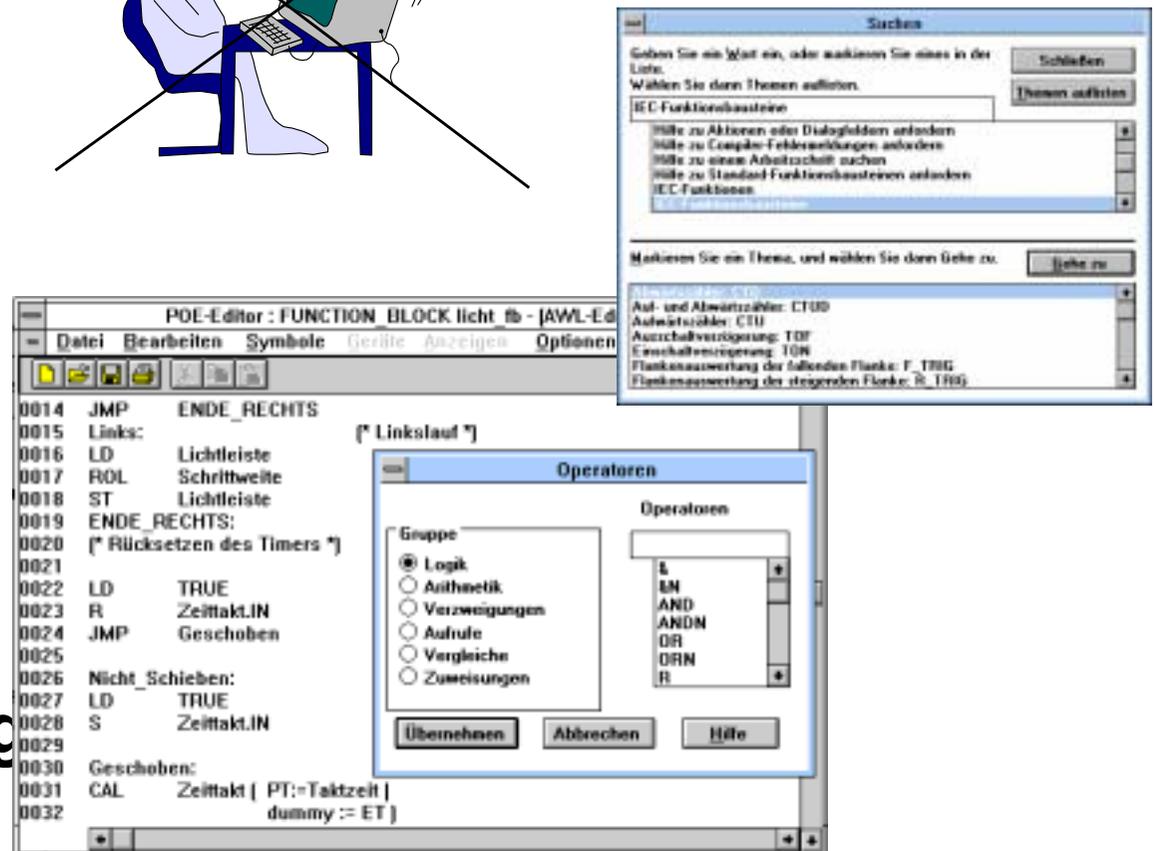
- **support for multiple windows**

- **mouse operation**

- **pull-down menus**

- **built-in hypertext help function**

- **software verification during design**

Recap … TC2: Functions

- **Definition of Function Block libraries & calling conventions**

- **… for example…**

- **Motion Control Library: the integration of different technologies: logic and motion**

- **Safety Library – providing the basis for safety critical environments**

Revolutionizing the industry

The Rationale of a
Motion Control Library

Let us look at

the Packaging Industry

for food and beverage…

Example of a changing landscape: Packaging for the Food & Beverage (F&B) Industry

- **Retail Food and Foodservices = 11% of US economy**

- **Shipment of Packaging Machinery = 10% of retail food**

- **Packaging Machines sales volume in 1999: $ 4.85 bio.**

No Technology push – but market trends

- **Changes in consumer behavior**

- **Changes with suppliers towards F&B consumers**

- **Forced changes with packaging machine suppliers**

- **… enforcing changes with control suppliers**

Changes in consumer behavior…?

■ **How about looking at your own behavior ?**

- So here is looking at you !

*Hi,
I am a
pack of
coffee*

So am I !
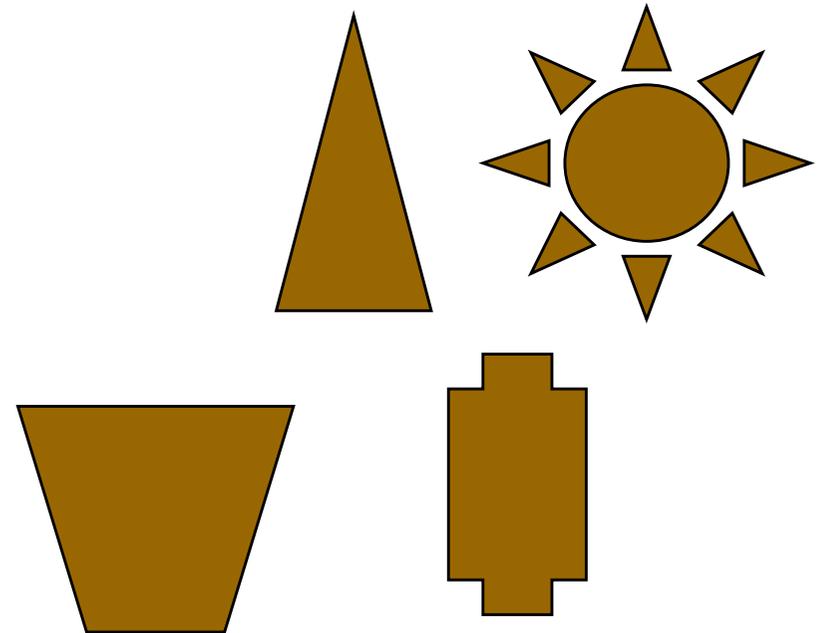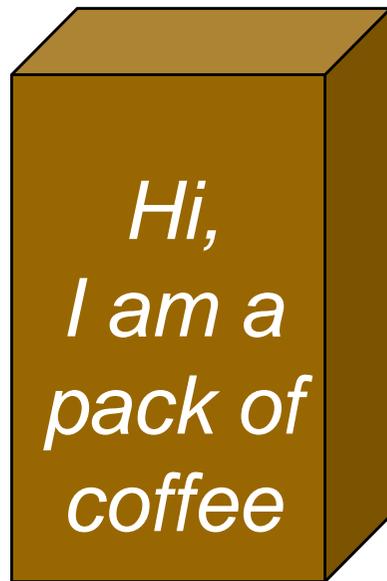
The suppliers compete for market share...

(… still looking at you !)

…. by providing different varieties in different packages

….. requiring more flexible packaging equipment

Changing packaging requirements

….are pushed backwards in the supply chain:

the packaging industry is putting pressure

on the leading packaging machine builders

to better fulfill their needs

Changing needs in..

- **Smaller footprints**

- **Faster startups**

- **Higher speeds**

- **Improved efficiency**

- **Faster changeovers**

- **Better quality package**

- **Reduced waste in production**

- **Improved reliability of equipment**

How to cope with this ?

..machine mechanics do not help anymore…
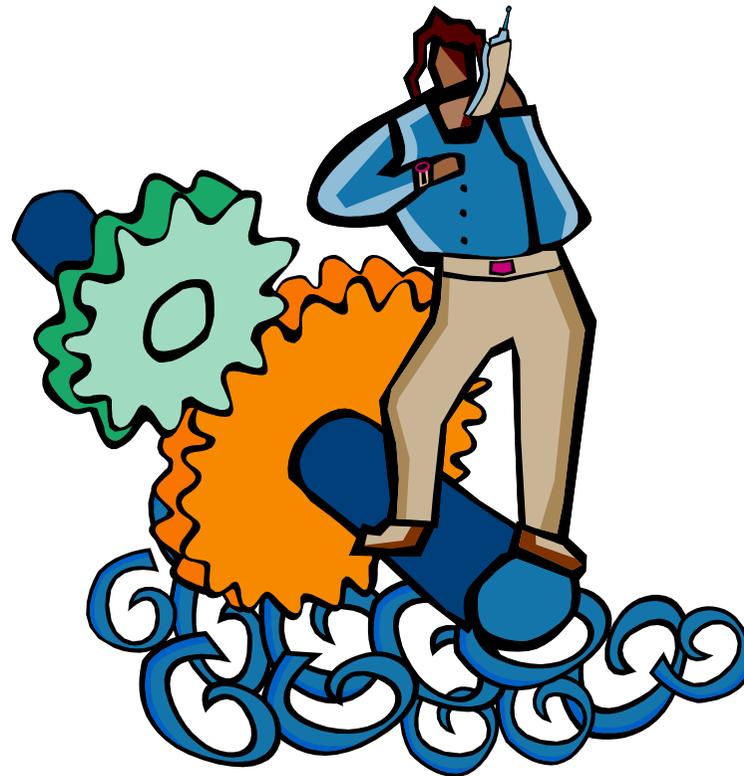
How to cope with this ?

by replacing mechanical and electrical solutions

by electronic solutions

=> Mechatronic Solutions:

Examples:

- **Camming**

- **Gearing**

Camming

Multiple movements mechanically coupled to a master axis

Electronic Camming

Control

Drive — **Motor**   **Master Axis**

Drive — **Motor**   **Slave Axis**

Drive — **Motor**   **Slave Axis**

Electronic Gearing

Control

Drive — Motor

Drive — Motor

Drive — Motor
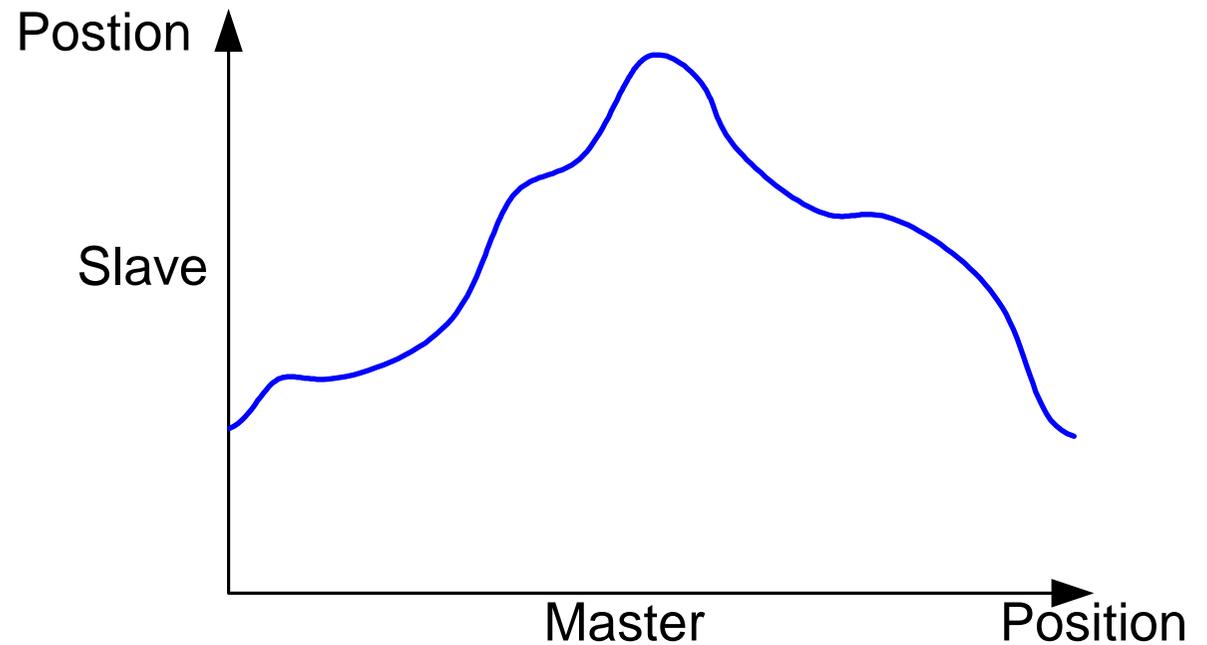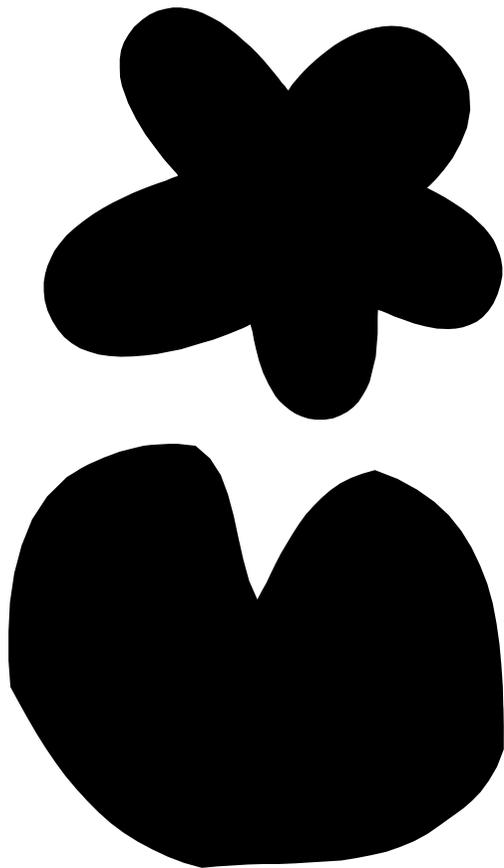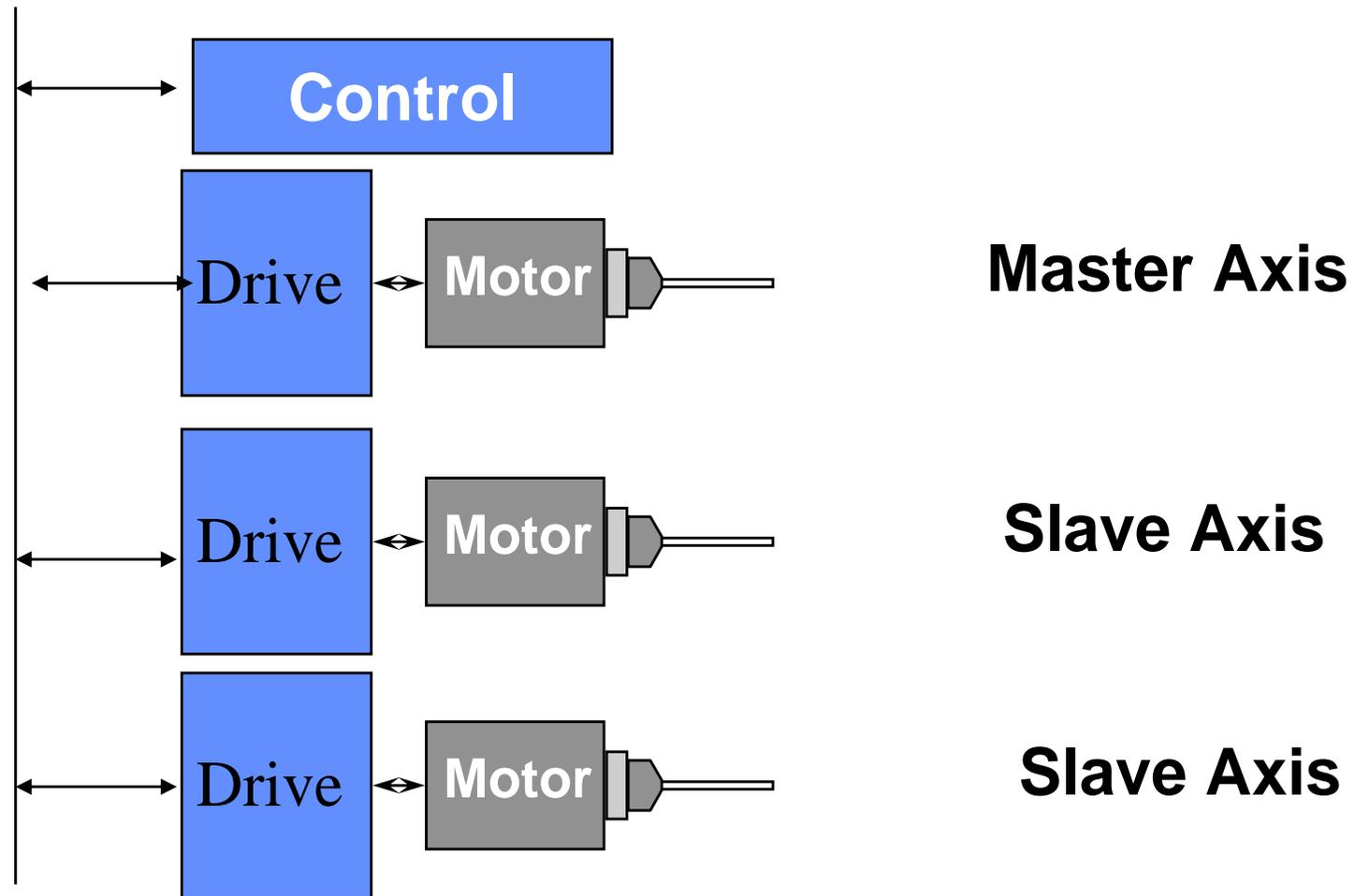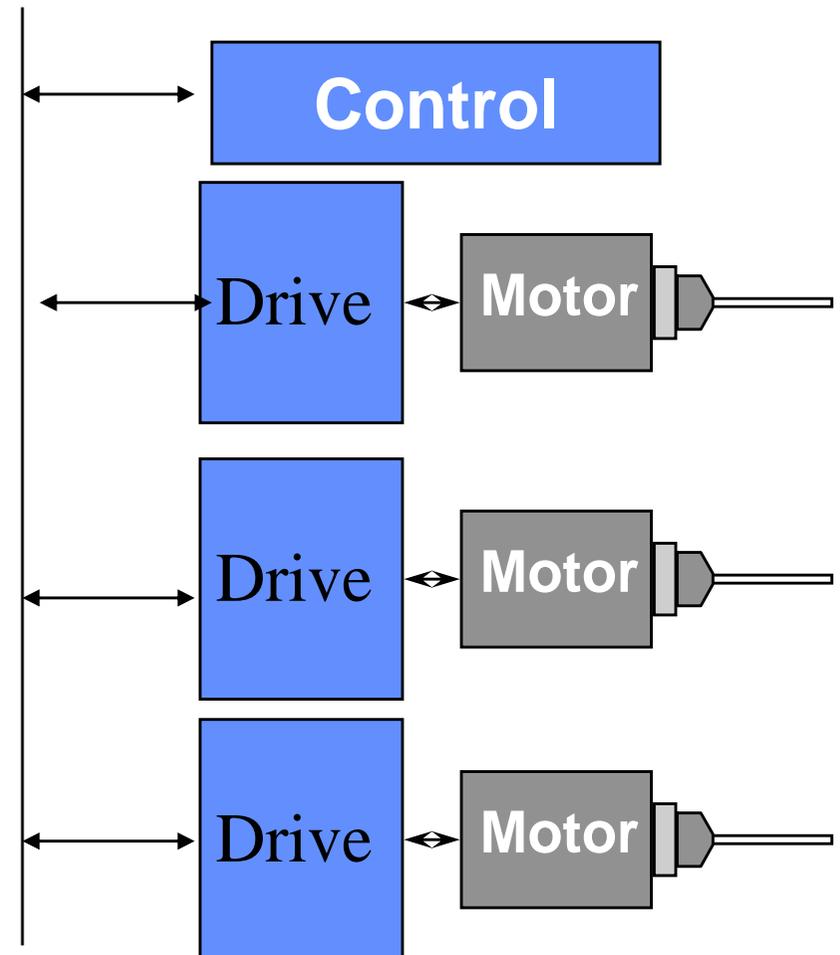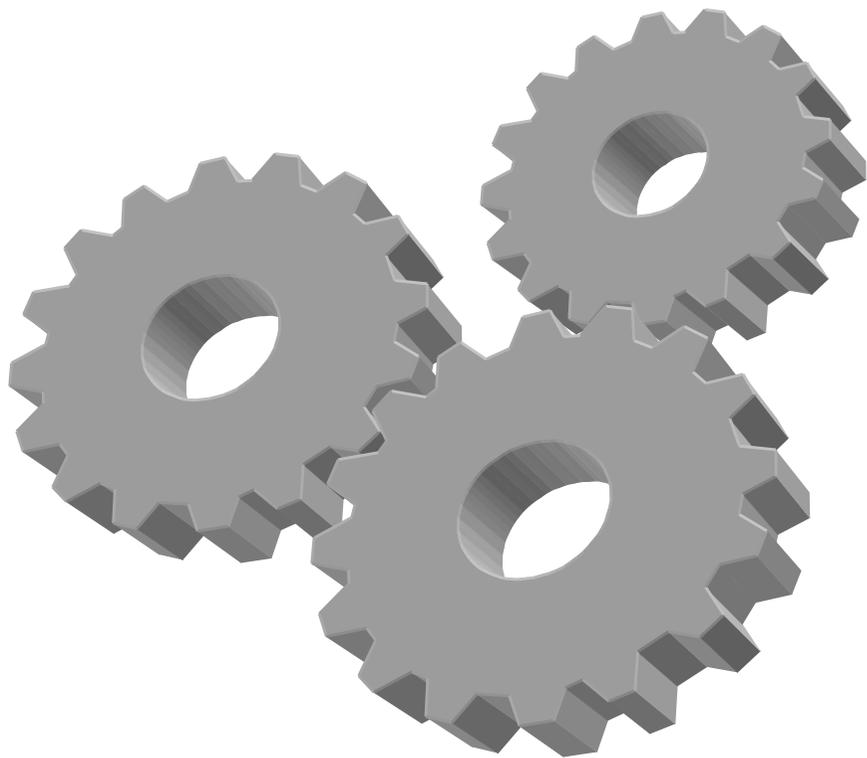
Real – life Advantages

Targets for a new design:

- ‘Zero’ maintenance

- Sanitation design

Solution

◆ **Aim for a 50% mechanical parts reduction**

Traditional Mechanical Design

Over 350 parts
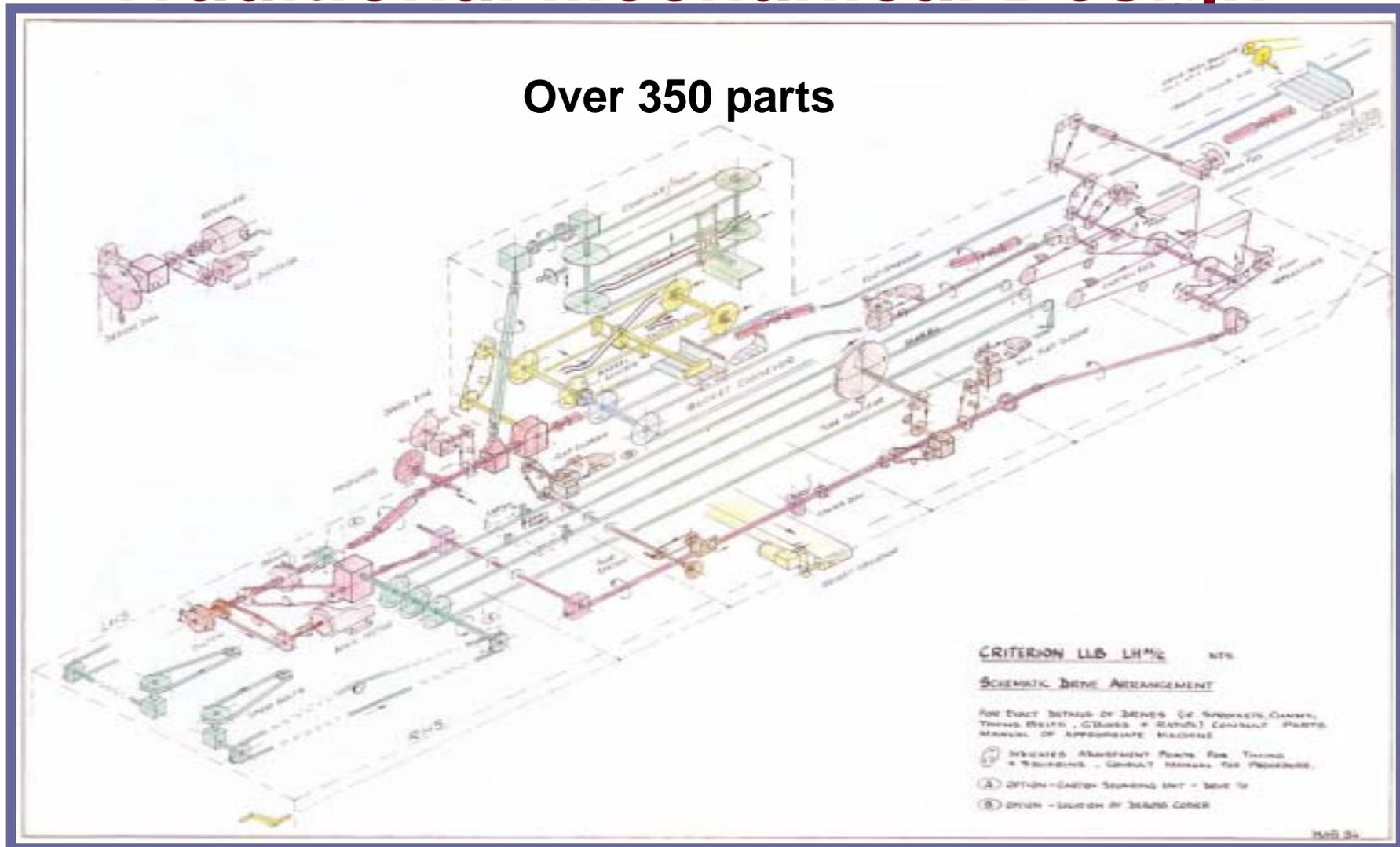
Multi Axis Servo Drive
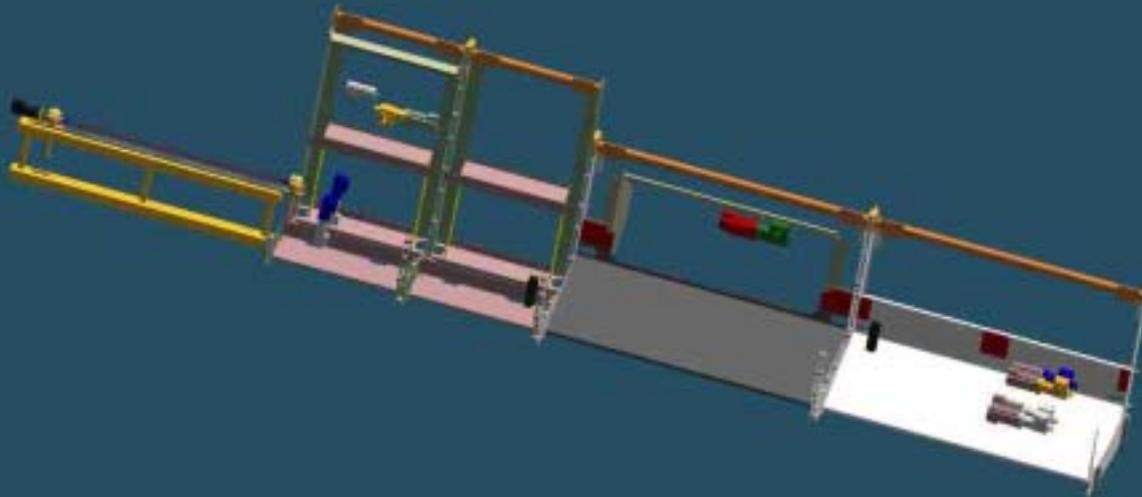
Major part count reduction

- 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)

Push on control suppliers

- **Control get into the heart of the machine**

- **in a strategic role**

- **to match (and beyond) the new requirements**

- **via added mechatronics functionality**

- **Requiring tight control between 'PLC' and Motion functionality**

Control needs software

The world is not just about physical mechanics anymore…

The name of the game is….

Software

Software needs standardization

To increase acceptance and usage

As well as ease of application

……

There are sufficient examples in the marketplace ……

Standardization means:

■ **Hardware independent Software Development**

Example: Machine Industry

Software Development

Total Result

Used for High End Result (showing Capabilities)

Standardization means:

■ **Hardware independent Software Development**

Example: Machine Industry

Software Development

T o t a l   R e s u l t

... for Medium End Result (Mainstream)

Standardization means:

■ **Hardware independent Software Development**

Example: Machine Industry

Software Development

Total Result

...for Low End Result (Low Cost)
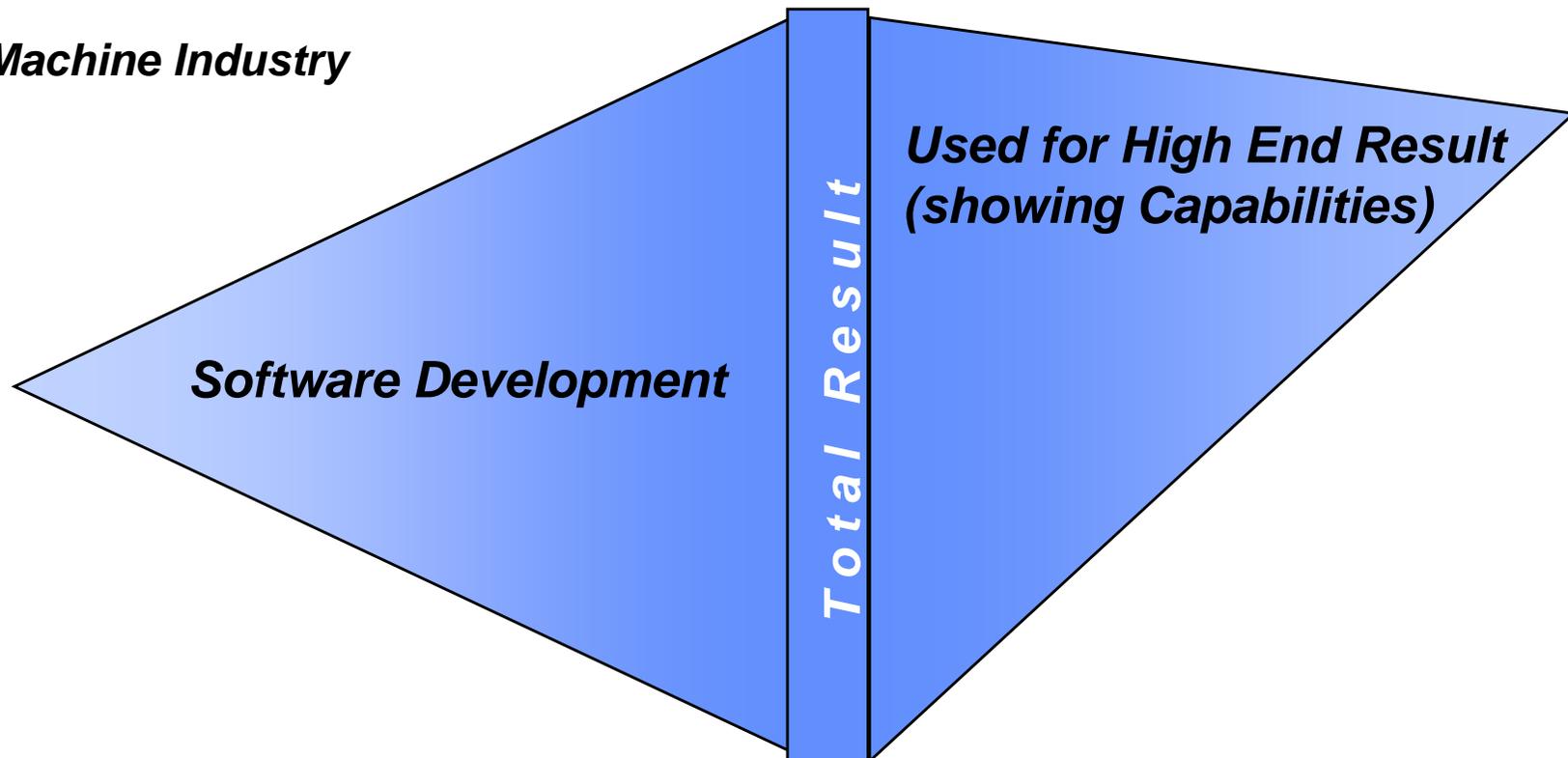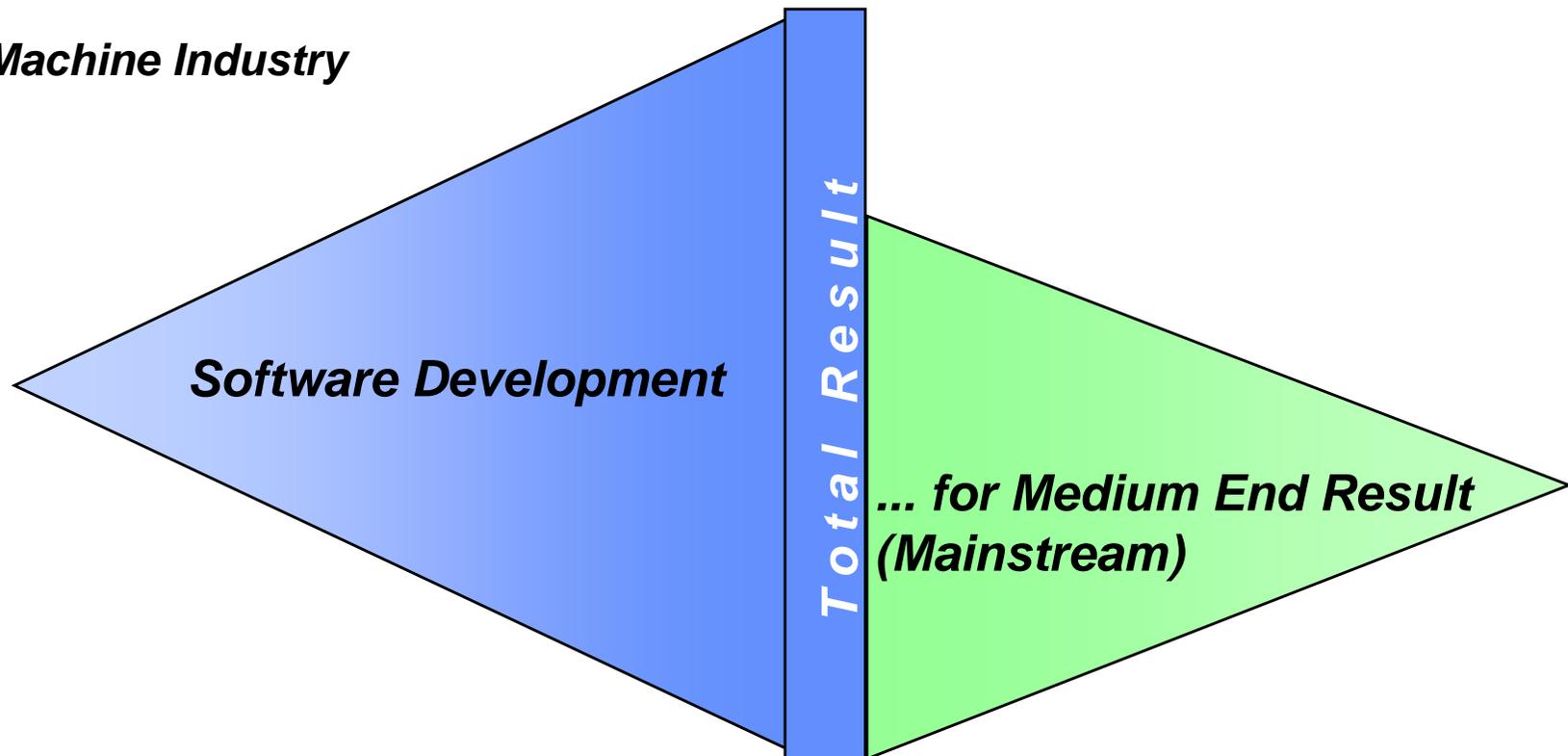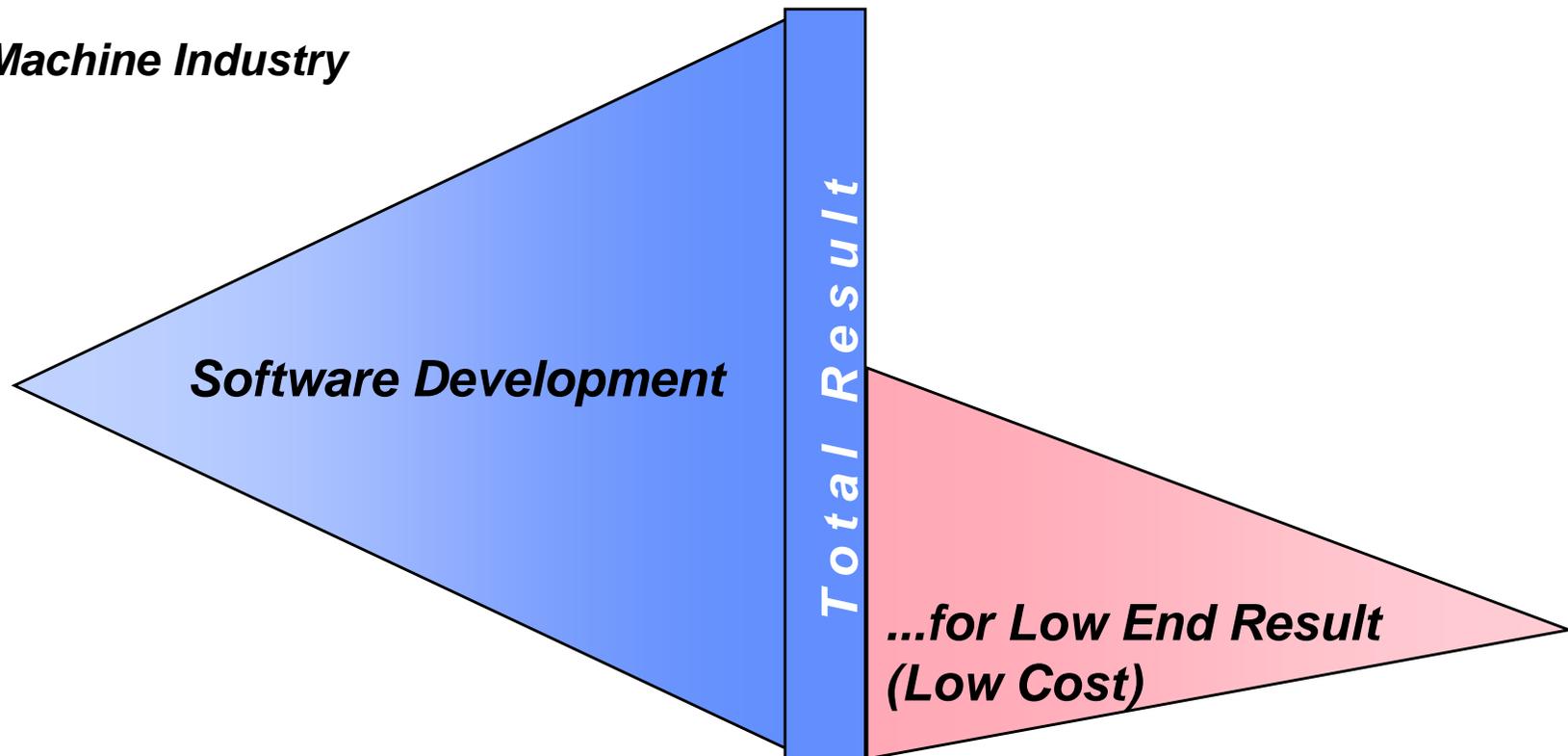
Standardization means:

- **Hardware independent Software Development**

- **Consistent Development Environment**

- **Consistent Installation and Maintenance Interface**

Same

'Look and Feel'

How can we fulfil this ?

- **Standardized Programming Tools**

- **Standardized Programming Languages**

- **Standardized access to drive / motion specifics**

  - centralized or distributed control

IEC 61131-3 provides the only platform for this !

The PLCopen Task Force Motion Control

- **Initiated by Users to fulfil _their_ requirements**

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

Administrative

Motion

Administrative		Motion	
Single Axes	**Multiple Axes**	**Single Axes**	**Multiple Axes**

Non-Interpolated

Single Axes	Multiple Axes	Single Axes	Multiple Axes (Non-Interpolated)
Power	*CamTableSelect*	*MoveAbsolute*	*CamIn*
ClearPendingActions		*MoveRelative*	*CamOut*
ReadStatus		*MoveSuperImposed*	*GearIn*
ReadAxisError		*MoveContinuous*	*GearOut*
ReadParameter		*MoveVelocity*	
WriteParameter		*Home*	
ReadActualPosition		*Stop*	
		PositionProfile	
		VelocityProfile	
		AccelerationProfile	

Example of a Function Block


```
                          MoveAbsolute
AXIS_REF ─── Axis                            Axis ─── AXIS_REF
BOOL ─────── Execute               Done ─────────── BOOL
REAL ─────── Position      CommandAborted ─────────── BOOL
REAL ─────── Velocity             Error ─────────── BOOL
REAL ─────── Acceleration       ErrorID ─────────── WORD
REAL ─────── Deceleration
REAL ─────── Jerk
MC_Direction ─ Direction
```

Axis_Ref as Var_In_Out

	MoveAbsolute	
AXIS_REF —	**Axis**	**Axis** — AXIS_REF
BOOL —	Execute	Done — BOOL
REAL —	Position	CommandAborted — BOOL
REAL —	Velocity	Error — BOOL
REAL —	Acceleration	ErrorID — WORD
REAL —	Deceleration	
REAL —	Jerk	
MC_Direction —	Direction	

Axis_Ref as Var_In_Out

Axis1

FB

Axis_Ref
Structure

Axis_Ref with 1 FB

Axis_Ref with 2 FBs

Axis1

FB1   FB2

Time or event driven

Task Manager

Axis_Ref Structure

Conver-sion

I/F   Drive
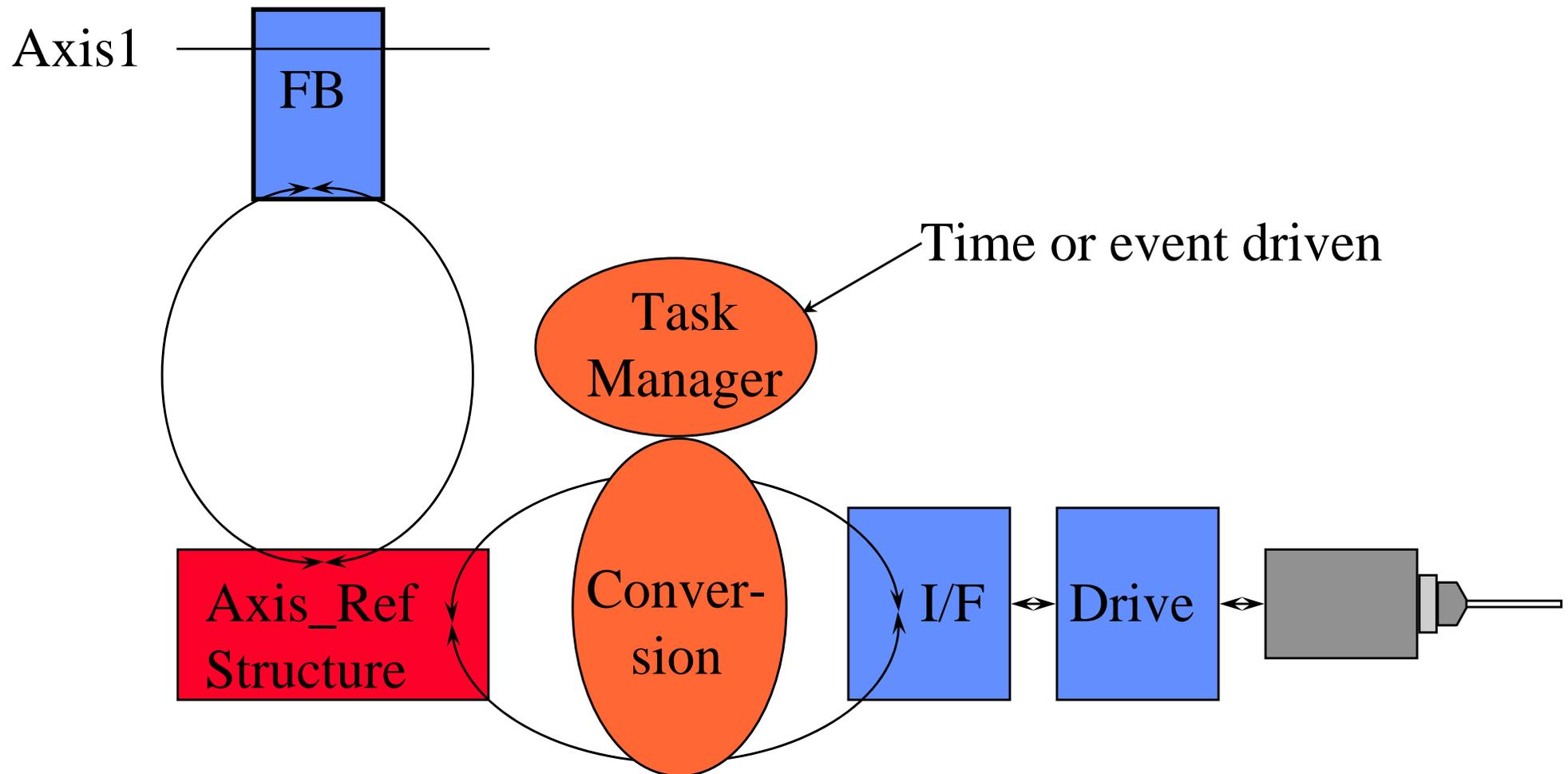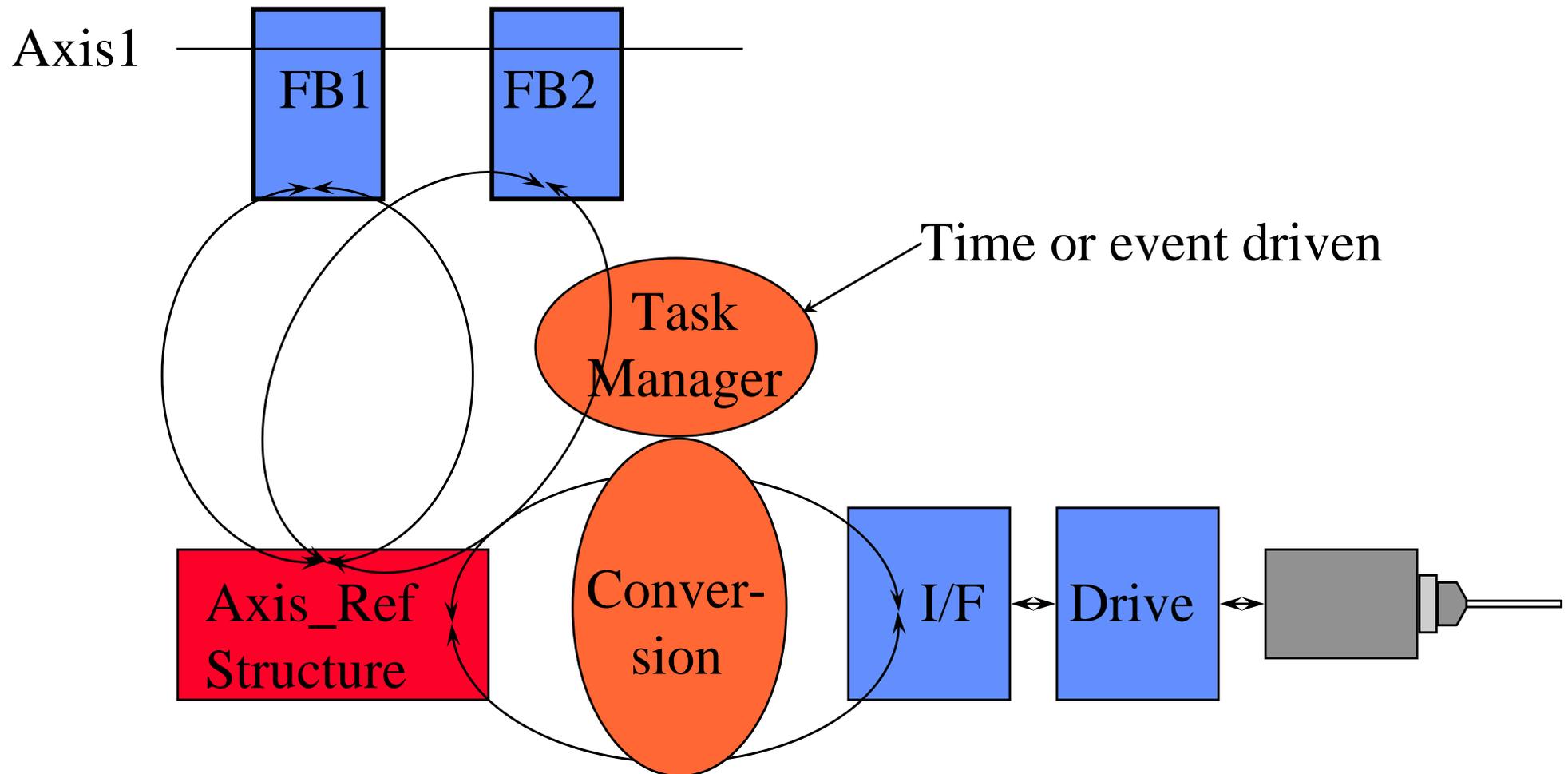
Error Handling
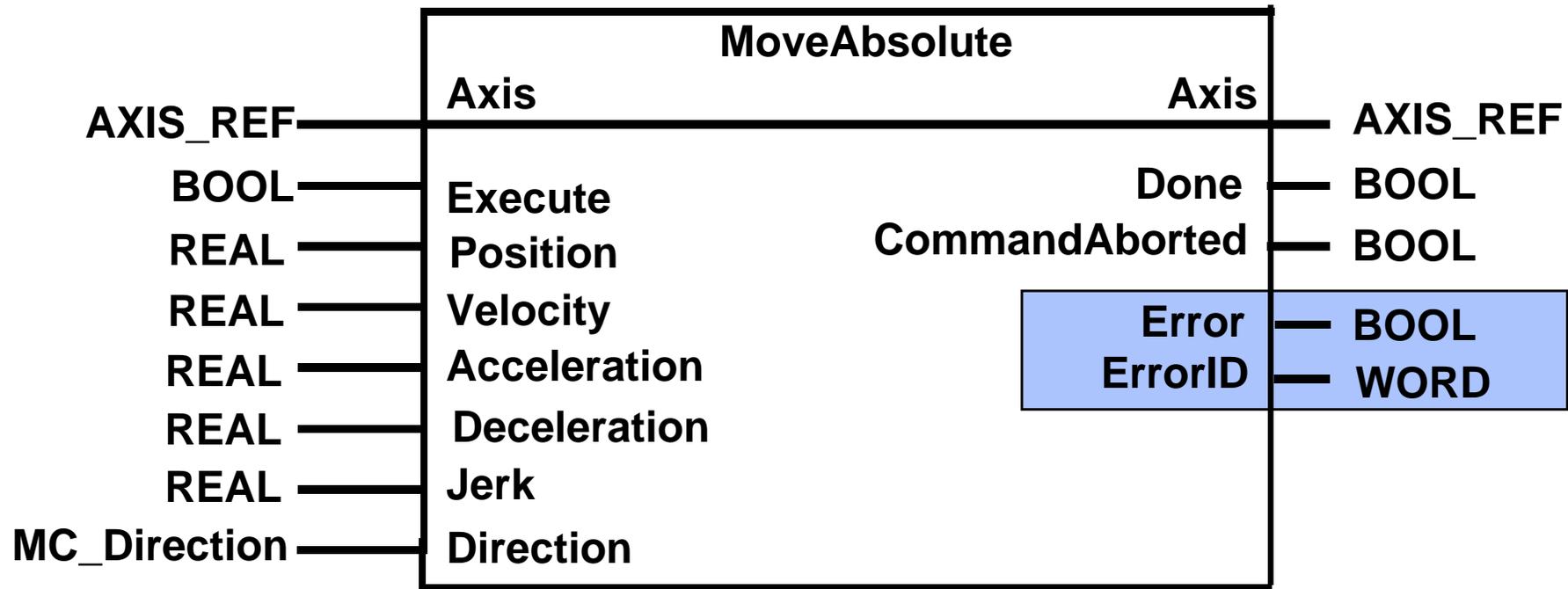
Error - Rising edge – error during execution of the FB

ErrorID - Error identification

Conclusion

- **IEC 61131-3 provides a good framework for Motion Apps**

- **PLCopen Motion Control Library provides and 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**

Status and Future

- **Part 1 of the PLCopen Motion Control Library released Nov. 2001**

- **Is implemented now by several suppliers (see website)**

- **Part 2 deals with extensions – release date Dec. 2003**

- **Part 3 will deal with user guidelines**

- **Part 4 deals with Homing Functionality**

- **Part 5 deals with Stacked Commands**

Revolutionizing the industry

PLCopen TC2
Function Blocks for Safety

- **Definition of a set of Function Blocks for safety related applications**

- **Under TC2 – Function Blocks**

TF - Safety : Goal

Allow the user to achieve the functional safety

at the plant and machine level

TF - Safety : What does this mean ?

- **Reference Standards –IEC 61508 and IEC 61511**

- **Additional standards - IEC 62061, EN 954, ISO 13849**

- **Machine Directive 98/37/EC, clause 1.2.5. - and related US and Asia directives**

TF - Safety : Ideas of FB

- **Operating mode**
  - Manual, Automatic, Semi-automatic, Maintenance
- **Stop functionality**
  - Emergency Stop ('Not-aus')
  - Safe operation stop (MC related)
  - Time-delay Stop
  - Safety door monitoring
- **Safe reduce speed (MC related)**
- **Two-hand Control**
- **Safety door interlocking**
- **Testable Safety sensors**
- **Muting (for light barriers) – controlled by-passing of the safety functionality**
- **Redundant inputs (Q?: is this the right level of functionality)**
- **Safe Communication**

TF - Safety : additional Safety aspects for software development

- **Merge of logic, motion and safety functions**

- **a reduction in the syntax of the languages used is an item**

- **Support in software tools for safety environments**
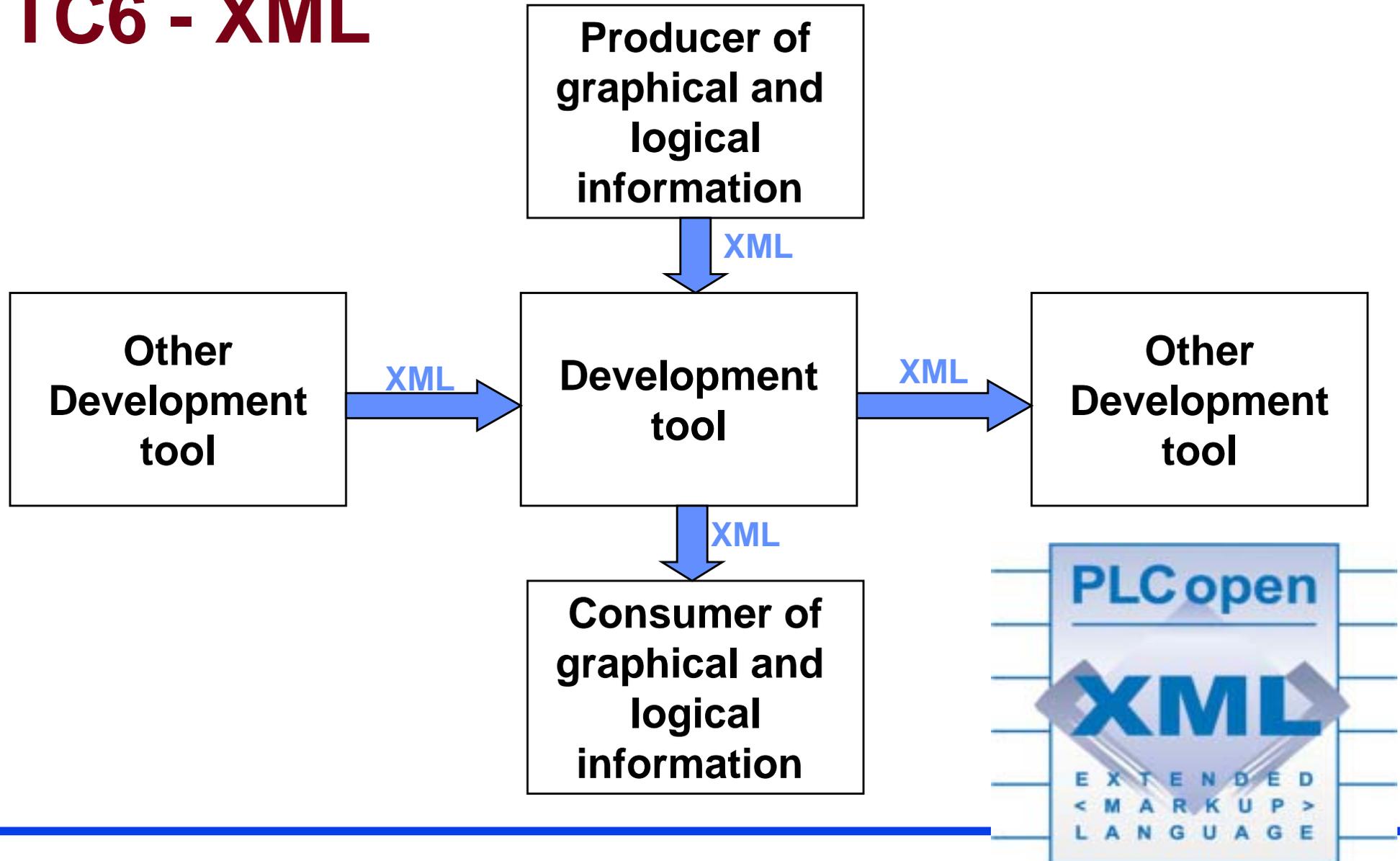
TF - Safety : Time frame

First draft planned for

April 2004

PLCopen TC6 – XML

Opening up the

development environments

by specifying XML formats for

IEC 61131-3

TC6 - XML

```
                    ┌──────────────────┐
                    │   Producer of    │
                    │  graphical and   │
                    │     logical      │
                    │   information    │
                    └────────┬─────────┘
                             │ XML
                             ▼
┌──────────────┐    ┌──────────────────┐    ┌──────────────┐
│    Other     │ XML│   Development    │ XML│    Other     │
│ Development  │───▶│      tool        │───▶│ Development  │
│    tool      │    │                  │    │    tool      │
└──────────────┘    └────────┬─────────┘    └──────────────┘
                             │ XML
                             ▼
                    ┌──────────────────┐
                    │   Consumer of    │
                    │  graphical and   │
                    │     logical      │
                    │   information    │
                    └──────────────────┘
```

What is included

In principle all…..

- **Textual Programming Languages – IL and ST**

- **Graphical Programming Languages – LD, FBD**

- **Structural Language – SFC**

- **…continued….**

What is included

- **Graphical Information, like …**

    - **Place and position**

    - **Routing of connections**

- **Comments**

- **…continued….**

What is included

- **Program Organization Units – (User Derived) Functions and Function Blocks, Programms**

- **(User Derived) Datatypes**

- **Project information (layered structure)**

- **Mapping information**

What is included

- **The exported file contains 'everything'**

- **Including supplier specific information**

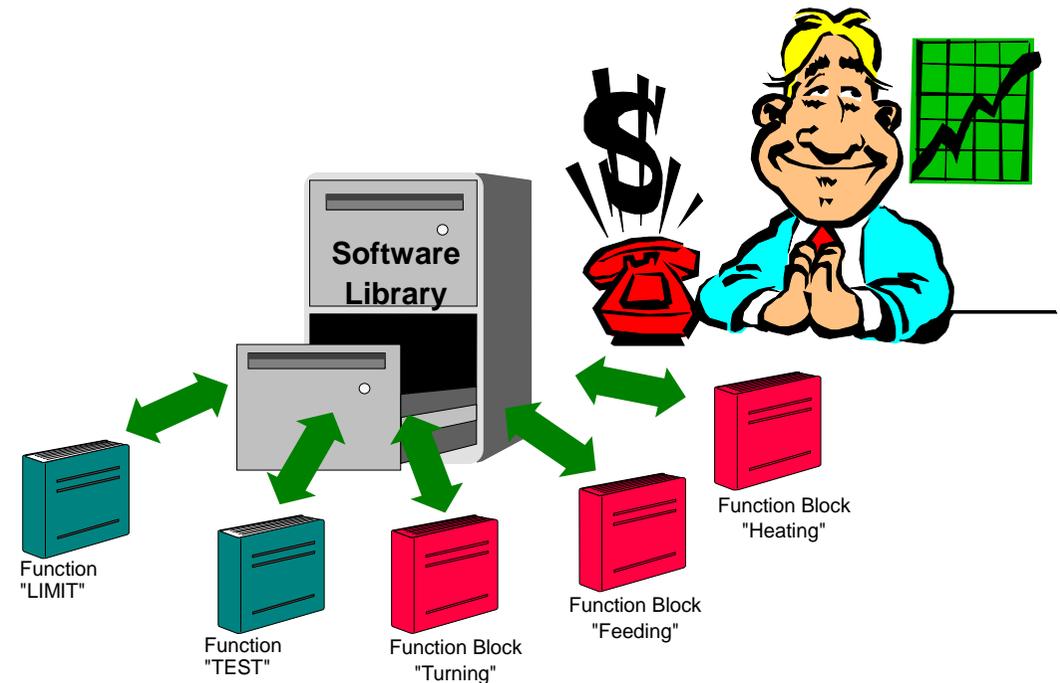- **The intelligence is in the parsing function during input**

TC6 – XML : status

- **First 'release for comments' planned for November 2003**

- **Available on public website www.plcopen.org**

- **Comments will be merged into final version for publication**

- **Will also be available on www.plcopen.org**

What are the benefits ?

Benefits

- **Reduced waste of human resources (in training, debugging, maintenance and consultancy)**

- **Creating a focus to problem solving via software re sability (reduced application investment and supplier dependency)**

- **Reduced misunderstandings and errors**

- **Programming techniques usable in more environments (general industrial control)**

- **Combining harmoniously different components from different locations, companies or countries, or projects**

- **Increased connectivity (investment protection)**

Software Library

Function "LIMIT"

Function "TEST"

Function Block "Turning"

Function Block "Feeding"

Function Block "Heating"

The association PLCopen

Together we can make it happen:

Standardization in Industrial Control Programming

WE NEED YOUR SUPPORT FOR THIS !
Join the organization PLCopen

More Information...

www.plcopen.org

- **Free-of-Charge electronic Newsletter 'PLCopening' (in english)**

email: evdwal@plcopen.org

Thanks !