

PLCopen
Standardization in Industrial Control Programming

IEC 61131-3 Software:

changing the world
of industrial automation

-
the status, the structuring tools, the
activities and the libraries

Eelco van der Wal
Managing Director PLCopen

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"Agenda"

| | |
|-------------------------|----------------------------|
| ◆ the status | - introduction IEC 61131-3 |
| ◆ the structuring tools | - 7 steps to success |
| ◆ the activities | - introduction PLCopen |
| ◆ the libraries | - example Motion Control |

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IEC 61131-3
Harmonizing the way people look to control

the future is here
Fiction?

Imagine

- you are in industrial control
- working with 4 different brands of controls
- using different dialects in their programming languages
- struggling to match the level of your software engineers with the electrical engineers / maintenance on the factory floor
- & seeing that your competitor does better

Why? What's wrong ?

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Out of the jungle

The current variety of problems can be vastly reduced via standardization

... and such a standard is available

IEC 61131-3

"The best thing that happened to industrial control"

Sugar Lantic on Automation Mailist

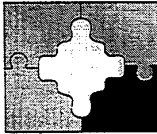
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The 5 parts of the IEC 61131 Standard

| | |
|-------------------------------------|----|
| - 1 General overview, definitions | IS |
| - 2 Hardware | IS |
| - 3 Programming Languages | IS |
| - 4 User Guidelines | |
| - 5 Messaging Service Specification | |

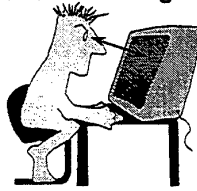
IS = International Standard



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**IEC 61131-3 Programming languages /
Industrial Control Programming**




The interface between the programmer and the control system

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IEC 61131-3 Programming languages / Industrial Control Programming

...with support for people
with different backgrounds



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The IEC 61131-3 Standard

Common Elements

Programming Languages

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IEC 61131-3 : Common Elements Variables & Data Types

What is this?

0101010110101010

Historically

- Reference to a physical memory location
- Reference to a physical Input

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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

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IEC 61131-3 : Common Elements

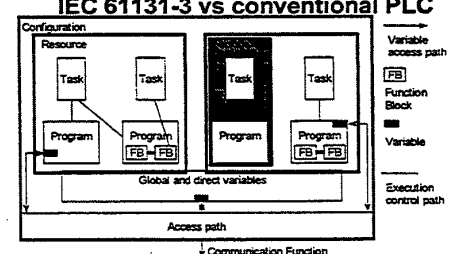
Software Model

- Configuration
- Resources
 - Tasks

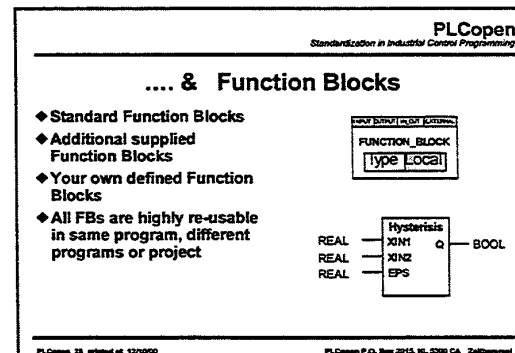
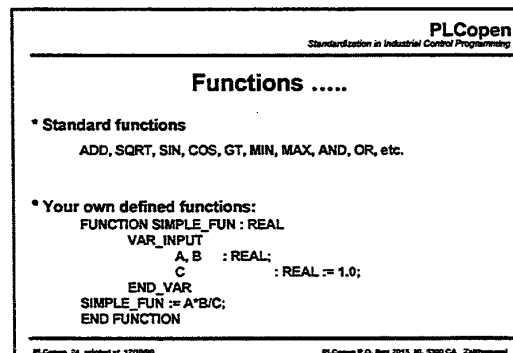
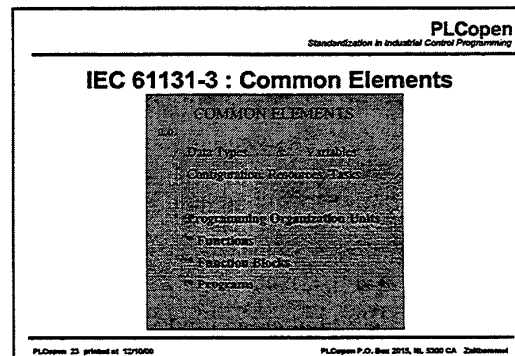
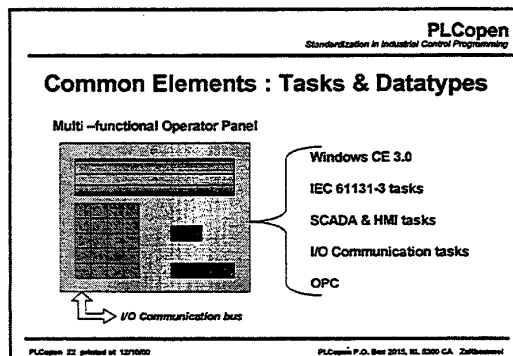
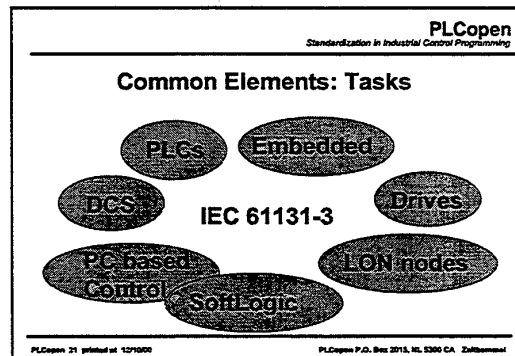
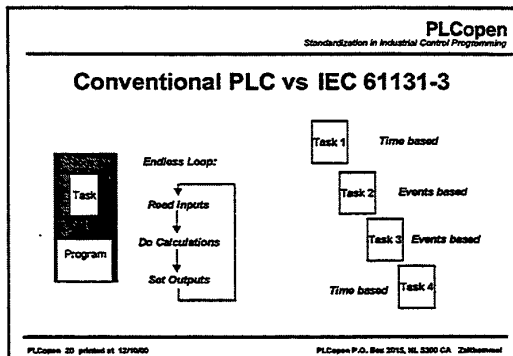
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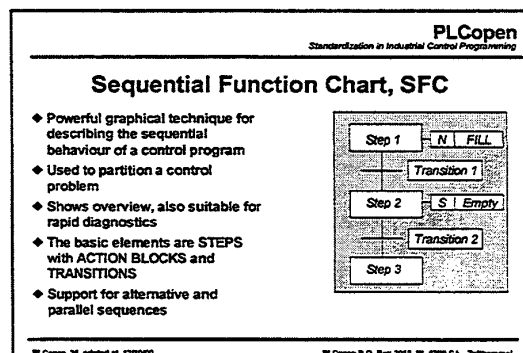
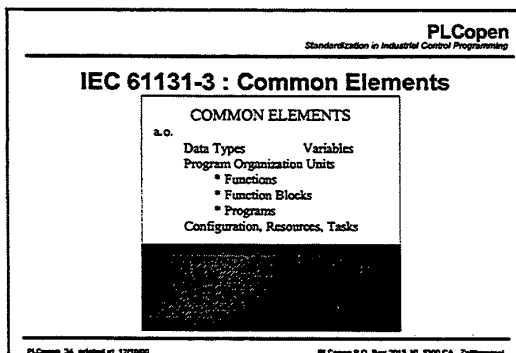
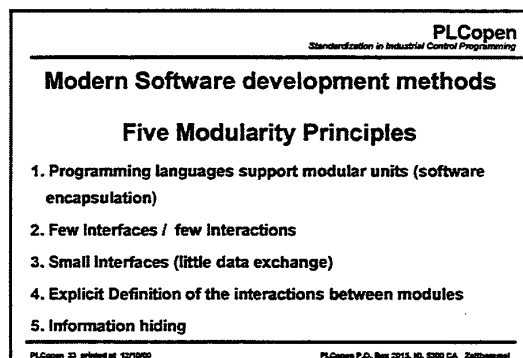
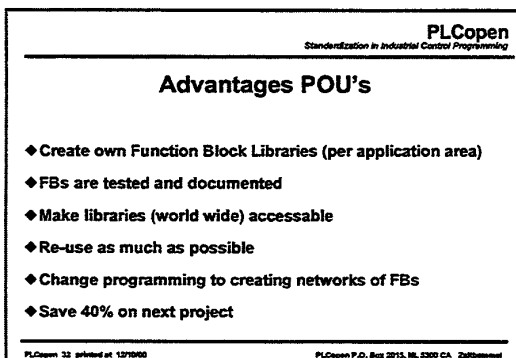
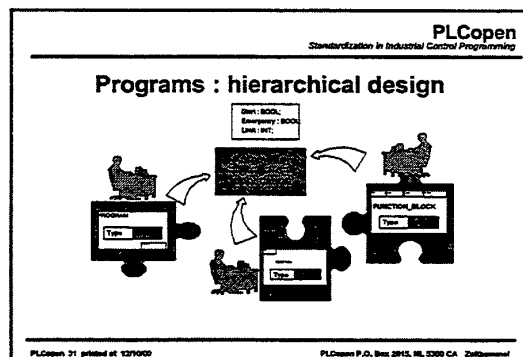
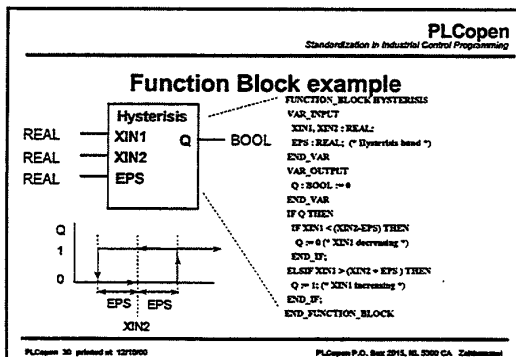
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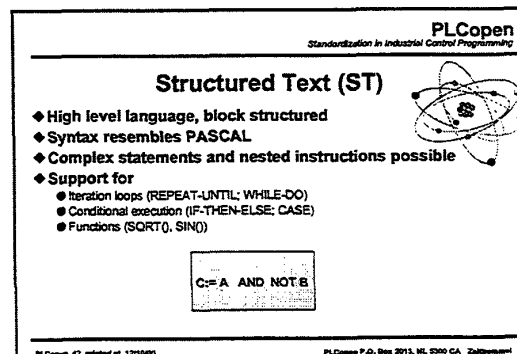
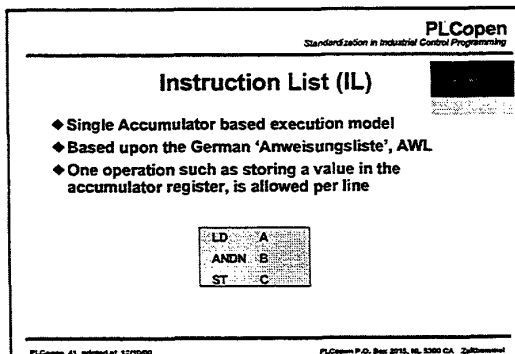
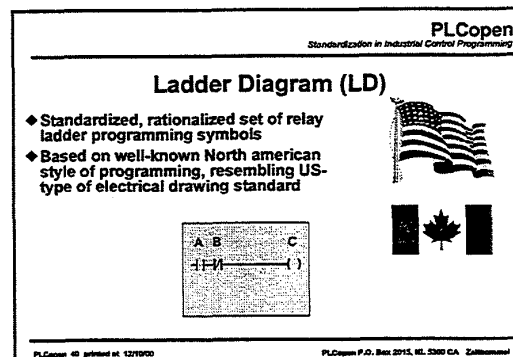
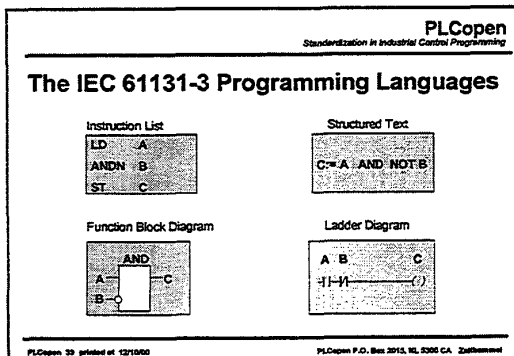
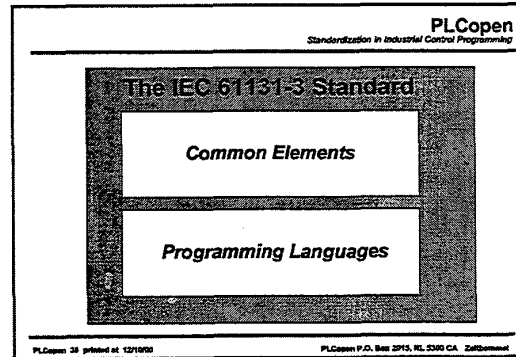
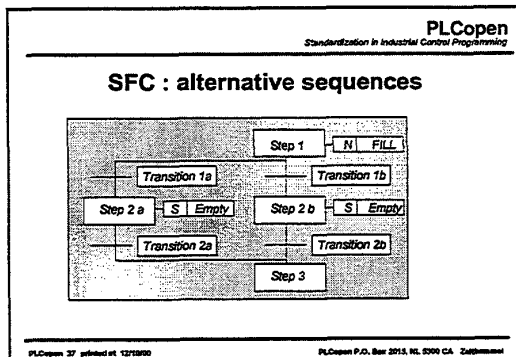
IEC 61131-3 vs conventional PLC



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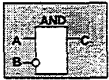





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Function Block Diagram (FBD)

- ◆ 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






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The IEC 61131-3 Standard

Common Elements

Top Down

 Bottom Up


Programming Languages



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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

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How to use IEC 61131-3

an example:

Structuring Software Development with IEC 61131-3

7 steps to success

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Software Development Cycle

Design/
Development /

Installation /

Maintenance..

Phases

enhancements.....

..... new requirements ...

..... new functionality

..... new wishes ...

"... the never ending story of software "

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... software quality factors..

- ◆ Failure Rates: difference between hardware and software
- ◆ External Quality ("Perceived value") versus Internal Quality
- ◆ Correctness, reliability, robustness, integrity, persistence, safety
- ◆ ease-of-use

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What's the topic here?

Structuring Software Development with IEC 61131-3

meaning: internal Software Quality

In the sense of:

Understandable, Reusable, Verifiable, Maintainable, Isolation

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Why Structuring ?

- ◆ The ever increasing role of Software on system quality: errors cost money
- ◆ Requirements increased dramatically: 100 lines of codes now 10,000 lines
- ◆ SW development: not a one-man job anymore, but a team with different know how and background
- ◆ Commissioning, Installation, Maintenance, and Improvements essential parts

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Advantages of Structuring

- Better Overview
- Better Basis for (internal) Communication
- Better Focus to problem solving
- Basis for reusable software
- "Self-documenting"

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How does that look in IEC 61131-3 ?

7 Steps to Success

with a

Fermentation Control System

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Fermentation Process

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How to create a control program for this in a structured way?

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Step 1 :
Identification of external interfaces to the System

- ◆ Feedback from the temperature sensor
- ◆ Feedback from the pH sensor
- ◆ Feedback from the valve positions
- ◆ Feedback from the motor (speed)
- ◆ Output to the valves
- ◆ Output to the motor
- ◆ Output to the heater band

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Step 2:
Definition of the main signals between System and Plant

◆ In this example there is no coupling to the plant, but it could have been, like:

- ◆ ... coupling to main vessels with liquids
- ◆ ... coupling to transportation system / filling station after harvesting

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Step 3:
Definition of all Operator interactions, overrides and supervisory data

◆ For the operator we define:

- ◆ ...a 'Start' button
- ◆ ...a 'Stop' button
- ◆ ...a 'Duration' input

Now we have defined all the interfaces

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Step 4:
Break down from top in logical partitions

- ◆ MainSequence - filling, heating, agitating, fermenting, harvesting, cleaning.
- ◆ ValveControl - operating valves used to fill and empty the vessels
- ◆ TemperatureControl - for controlling the temperature
- ◆ AgitatorControl - agitator motor control
- ◆ pHControl - PH-control

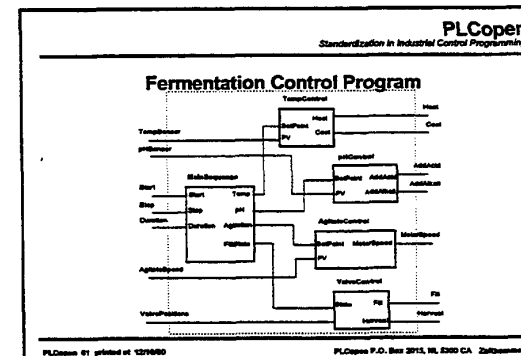
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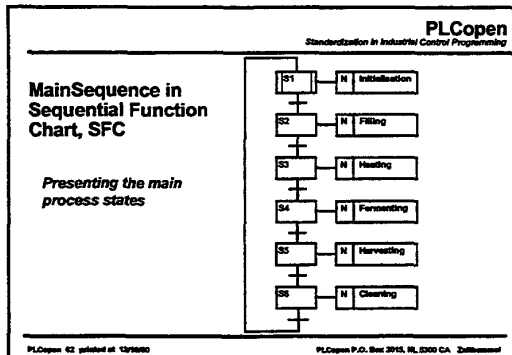
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Step 5:
Definition of the required POU's (Programs and Function Blocks)

- ◆ Using the definitions above and
- ◆ representing it in the graphical way ...

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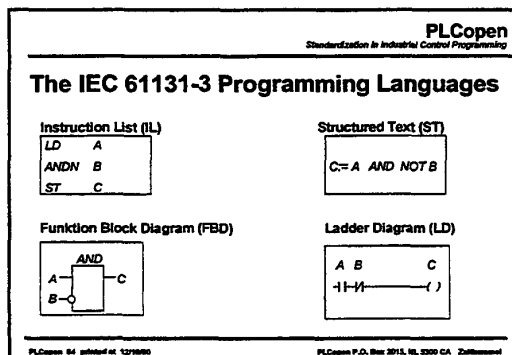




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The Actions Blocks and Transitions can be programmed in any of the four IEC Programming Languages

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Step 6: Definition of scan cycle time requirements for the different parts of the application

- In this example we have only one cycle in continuous mode
- ◆ The remaining time can be used for other cycles like:
 - the filling / transportation system
 - ... checking boundaries and error conditions (in a parallel sequence)

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And last but not least: Step 7: Configuration of the System: Definition of Resources, Tasks and linking of programs with physical I/O

- ◆ Depending on the system involved
- Includes physical mapping of symbols to I/O
- Mapping of the resource (read: CPU's in the system)
- Definition of the scan cycles and events (as defined in Step 6)

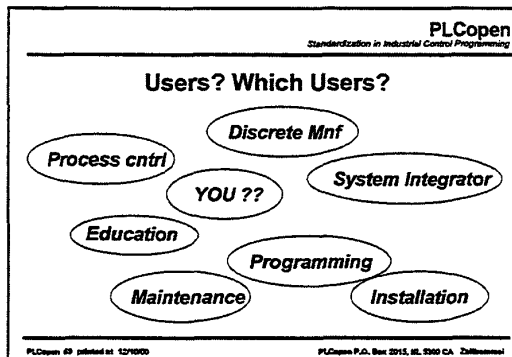
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Conclusion

- ◆ The Software development process has changed:
 - more requirements..
 - more functionalities..
 - more code..
 - more people involved..
 - ... more requirements / wishes
- ◆ Structuring and Decomposition are essential parts of modern software development
- ◆ IEC 61131-3 has the right basis to fulfill your requirements

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Users? Which Users?

- Automobile production lines
- Water treatment plant
- Food processing and packaging machinery
- Cable manufacturing
- Semi-conductor clean room automation
- Theme-park roller coasters
- Nuclear waste treatment plant

This wide range encompass different skills

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What is the Benefit of such a Standard

- ◆ Reduced waste of human resources (in training, debugging, maintenance and consistency)
- ◆ Creating a focus to problem solving via software re-usability (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)

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Advantages for Educational level

IEC 61131-3 programming courses are:

- ◆ Supplier independent
- ◆ Product independent
- ◆ Better matching theory with praxis
- ◆ Based on up-to-date programming techniques and structural thinking

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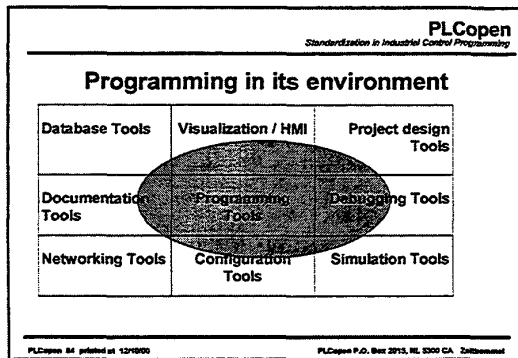
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.. the Chicken and Egg problem

Users vs. Suppliers

| | |
|---|---|
| <ul style="list-style-type: none"> ◆ see the benefits of the standard ◆ but need products ◆ to fulfill their needs | <ul style="list-style-type: none"> ◆ uncertainty about its effect ◆ strategic choice ◆ high investment (SW + HW) ◆ uncertain on ROI |
|---|---|

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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: beginning 2001

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TC2: Functions

- ◆ Definition of Function Block libraries
- ◆ Function block calling conventions
- ◆ ... for example: Motion Control Profile: the integration of different technologies

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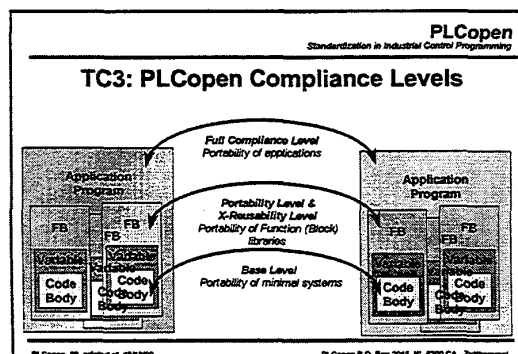
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TC3 : The Essence of Compliance

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)

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Compliance: Results and Status (Oct. '00)

- ◆ Accreditation installed: two institutes accredited
- ◆ Base Level definition ready for IL, ST and SFC. LD and FBD in progress
- ◆ Test software ready for IL, ST and SFC. FBD and LD in preparation
- ◆ 22 software packages certified (see website for status)

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Compliance: Results

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TC4: Communication

- ◆ Communications interfaces
- ◆ Interfaces to add-on packages
- ◆ Application interchange format
- ◆ Mapping of Profibus has been done
- ◆ Mapping of CANopen under construction

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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
- ◆ Function Blocks can be certified
- ◆ Basis for easier commissioning

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General Promotion

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

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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)

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PLCopen as a World-wide association

- ◆ > 100 members (Oct. 2000)
- ◆ from 21 countries all over the world
- ◆ Suppliers, institutes and users
- ◆ See newsletter / website for up-to-date list




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PLCopen as a World-wide association


Office in North America



Main Office in Europe

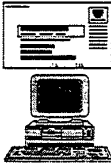


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