PLCs in automated material handling systems

SAGS presentation 12-2-2008

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AGENDA

- PLC appliances in VI systems
- FSC
- Reasons for applying PLCs
- Siemens S7
- S7 SSS
- Architecture
- Code Generator
- Project ‘Next’
- Discussion issues

DISTRIBUTION SYSTEMS

- Distribution centers for various sectors: care, food and fashion to automotive, parts and components, and retail.
- With solutions for: automated storage and retrieval, order picking, consolidation and sorting.
- Conveyor equipment is PLC controlled.
  High capacity sorters are FSC controlled.
  Integrated systems have their own local controllers.

BAGGAGE HANDLING SYSTEMS

- Baggage Handling systems, from regional to major hub airports.
- With solutions for, from check-in to make up and unload to reclaim. Including baggage screening, storage and sortation.
- Loose baggage conveyor transport, Tubtrax and Bagtrax.
- Conveyor equipment PLC controlled.
  Bagtrax has local controllers besides PLC control.

EXPRESS PARCEL SYSTEMS

- From local depot to large hubs.
- Throughputs from a few thousand parcels a day to 150.000 parcels per hour.
- Used equipment: Line sorters and loop sorters.
- FSC controlled.

FSC

- **Flow System Controller**
  Used for controlling high capacity line and loop sorter systems.
- **Characteristics;**
  - Industrial PC hardware
  - Real-time operating system: QNX Neutrino
  - C/C++
  - CPU response time 2 msec.
  - Systems are implemented by configuration.
  - System layouts and functionality are restricted to building rules.
- **Since 15 years**

Reasons for applying PLCs

Pros

- High reliability (MTBF)
- Easy and fast recovery from HW failures (MTTR)
- Robustness
- ‘Easy’ programming languages
- On-line monitoring and modifying
- Proven technology, widely accepted
- Programmable (FSC is not)

Cons

- Not-open systems
  - Limited communication possibilities
  - Not extendible with other applications
  - Programming languages are not standardized
- Limited memory and performance
- High hardware costs

Siemens S7

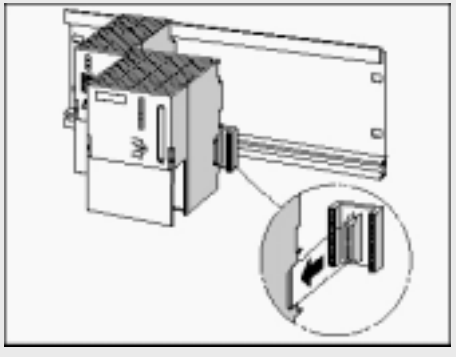
- **VI engineering department is standardized on Siemens S7.**
- **Other PLC brands are subcontracted**
  e.g. Allen-Bradley, Modicon, Mitsubishi, Omron

- **S7-300 and S7-400.**
  Both programmable with Step7 and largely software compatible.
- **Programming language STL (IL according IEC 61131-3).**

Siemens S7-300

- **Modular mini PLC**
- **Often applied CPUs**

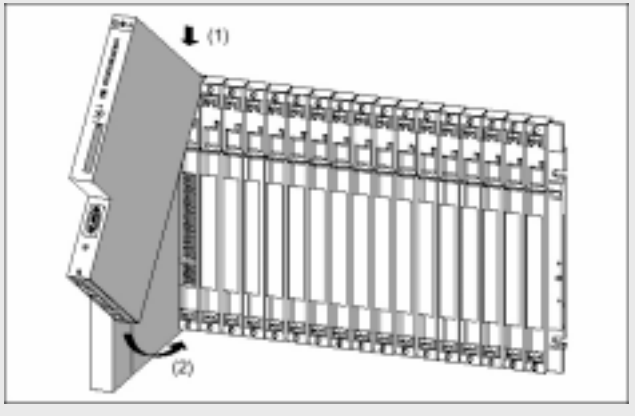
	workmemory	bit	Word	Int instruction
- CPU315-2 DP	128 kb	100	200	2000 ns
- CPU317-2 DP	512 kb	50	200	200 ns
- CPU319-3 PN/DP	1,4 Mb	10	20	20 ns



Siemens S7-400

- **“Power PLC”**
- **Often applied CPUs**

	workmemory	bit	Word	Int instruction
-				
- CPU414-2 DP	1 Mb	45	45	45 ns
- CPU414-3 DP (or PN/DP)	2,8 Mb	45	45	45 ns
- CPU416-2 DP (or PN/DP)	5,6 Mb	30	30	30 ns



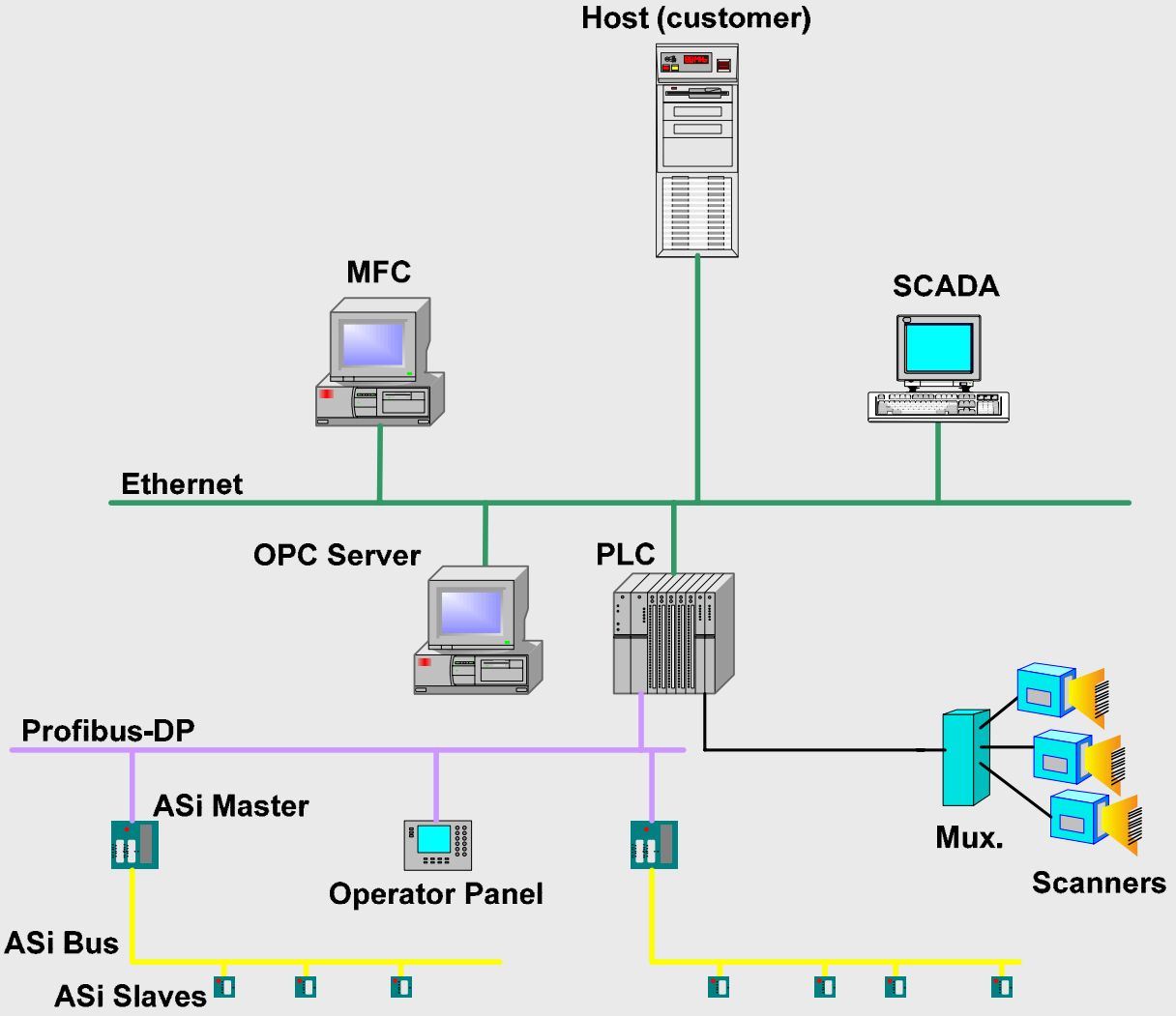
PLC deployment

- **PLC is applied as central controller within a sub/system.**
- **CPU type is chosen on required CPU resources.**
- **Systems are divided in subsystems, considering:**
  - CPU capability
  - Logical subsystems
  - Redundancy and system availability
  - Cost price

- **Distribution systems**
  - Focuses on minimum number of PLCs.

- **Baggage Handling systems**
  - Redundancy in system layout by repetition of autonomous subsystems for achieving higher availability.
    This leads to: use of more PLCs and smaller PLCs.
  - High availability PLC solutions are seldom used.

Controls Architecture



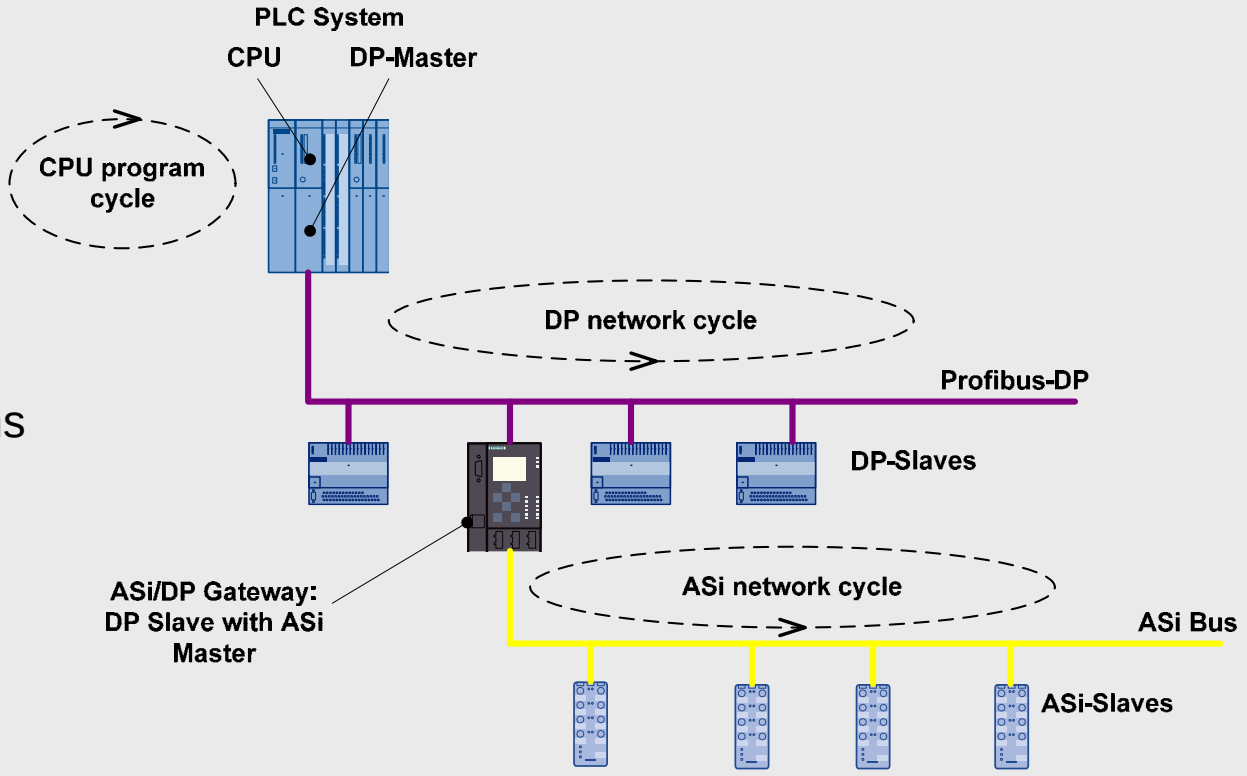
PLC system response time

- **system response time**
  Time duration from input change to output change.
  typically between 50-90 ms

ASi cycle: 5 ms

DP cycle: 10-20 ms

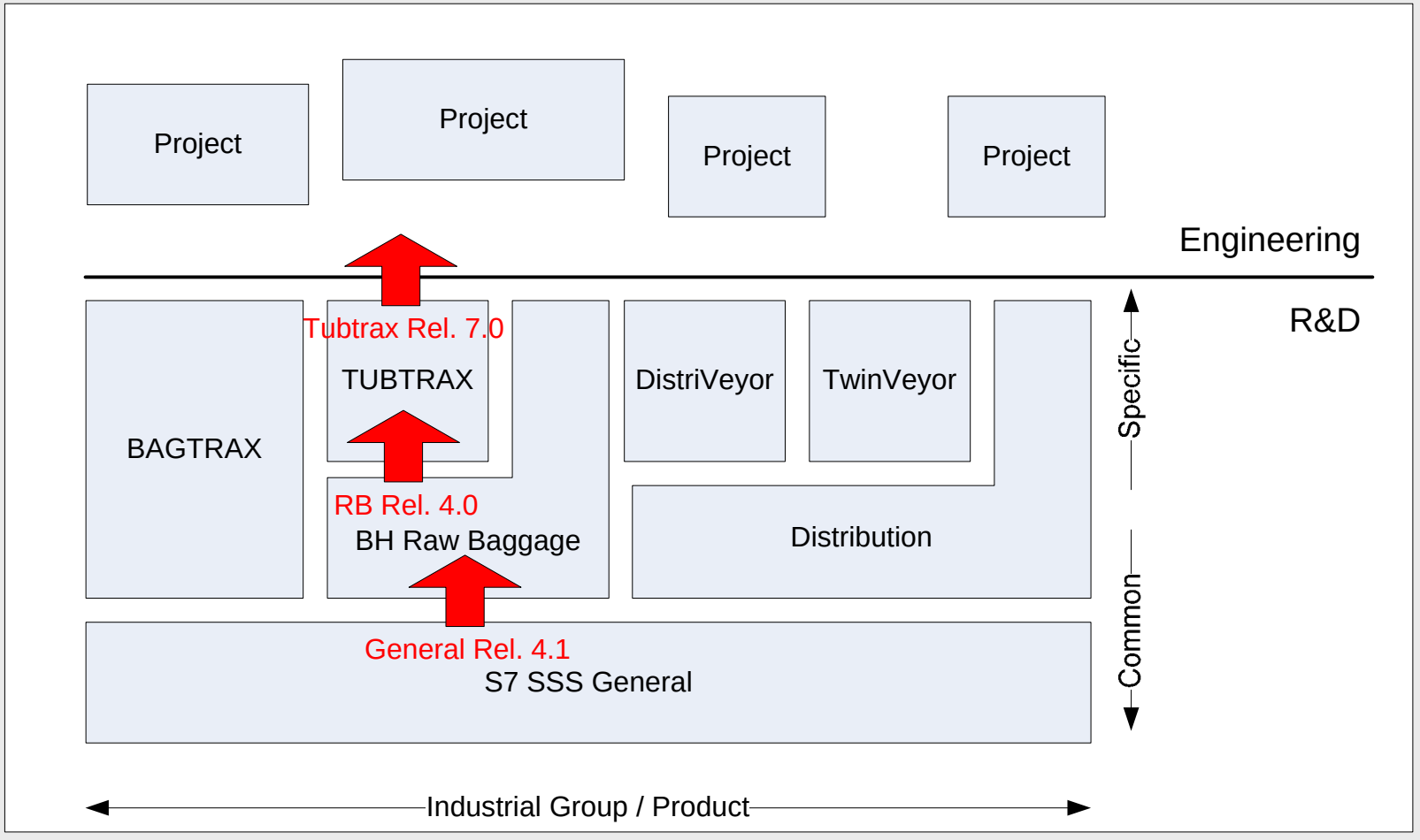
CPU cycle: 10-20 ms



S7 SSS

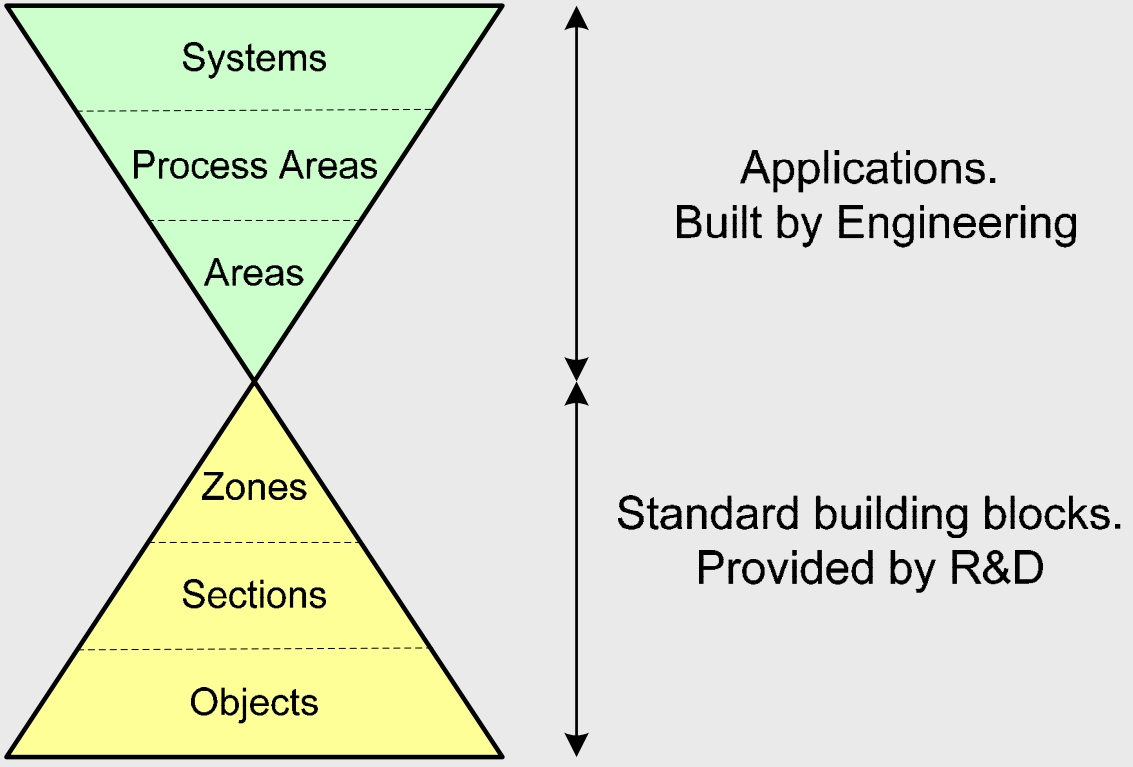
- **S7 Standard Software Structures**
  Product name for the VI standard S7 software.
- **Initially the S7 SSS is developed by the Engineering groups on projects by standardizing the software.**
  Based upon best practices.
- **Today the S7 SSS is managed and maintained by R&D.**

S7 Libraries

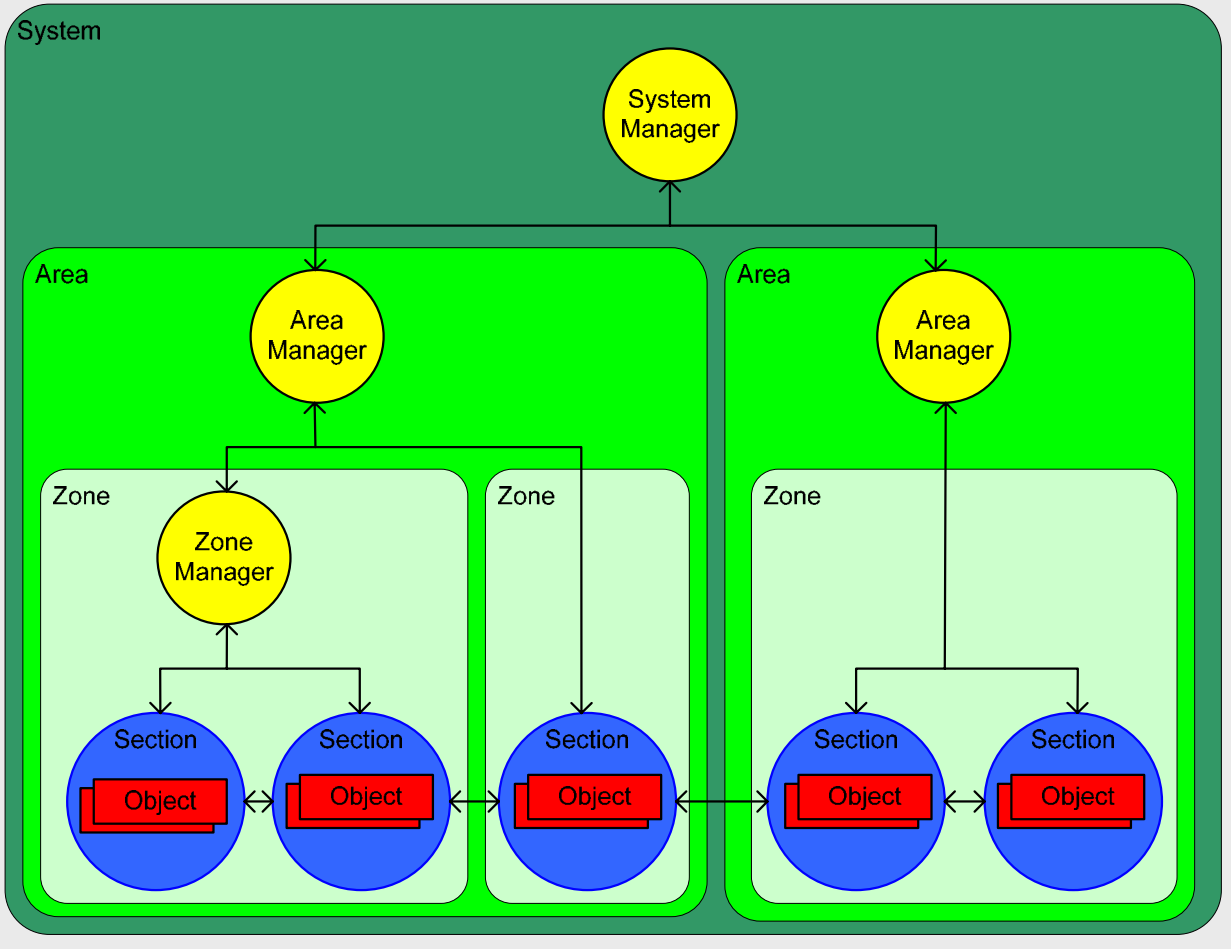


Architecture

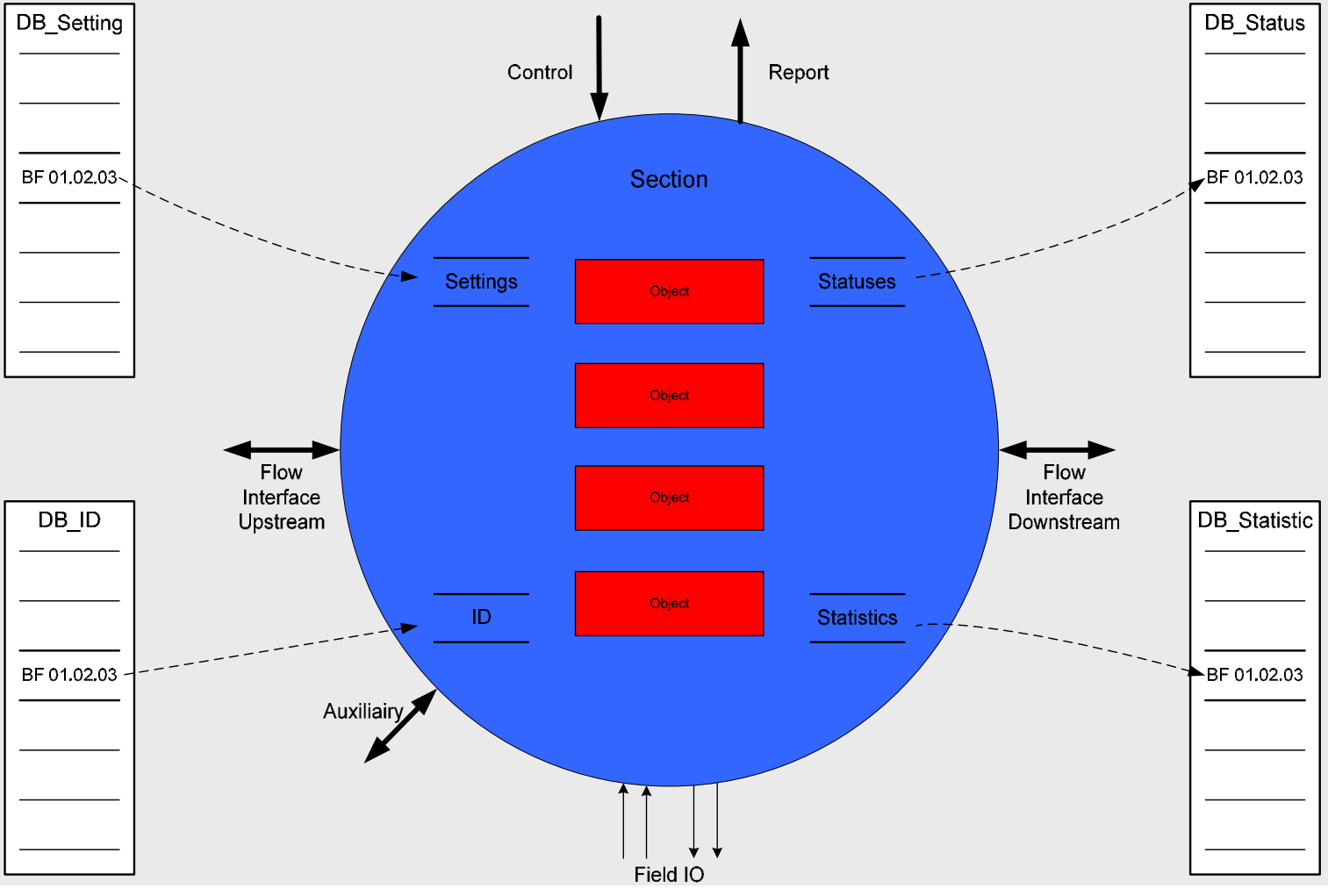
- **Component Based according Sandglass model**



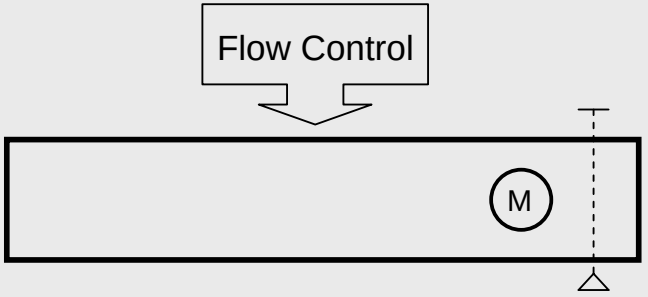
Software Architecture



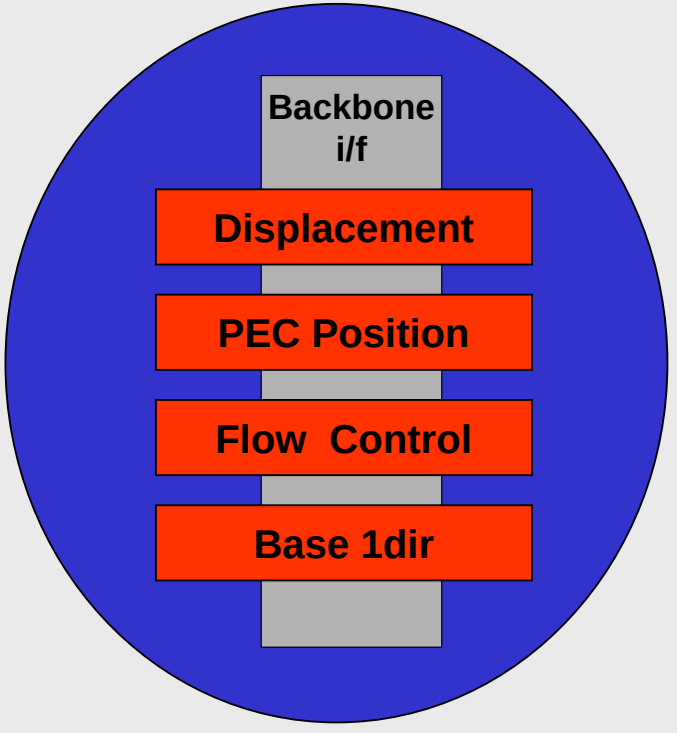
Software building block



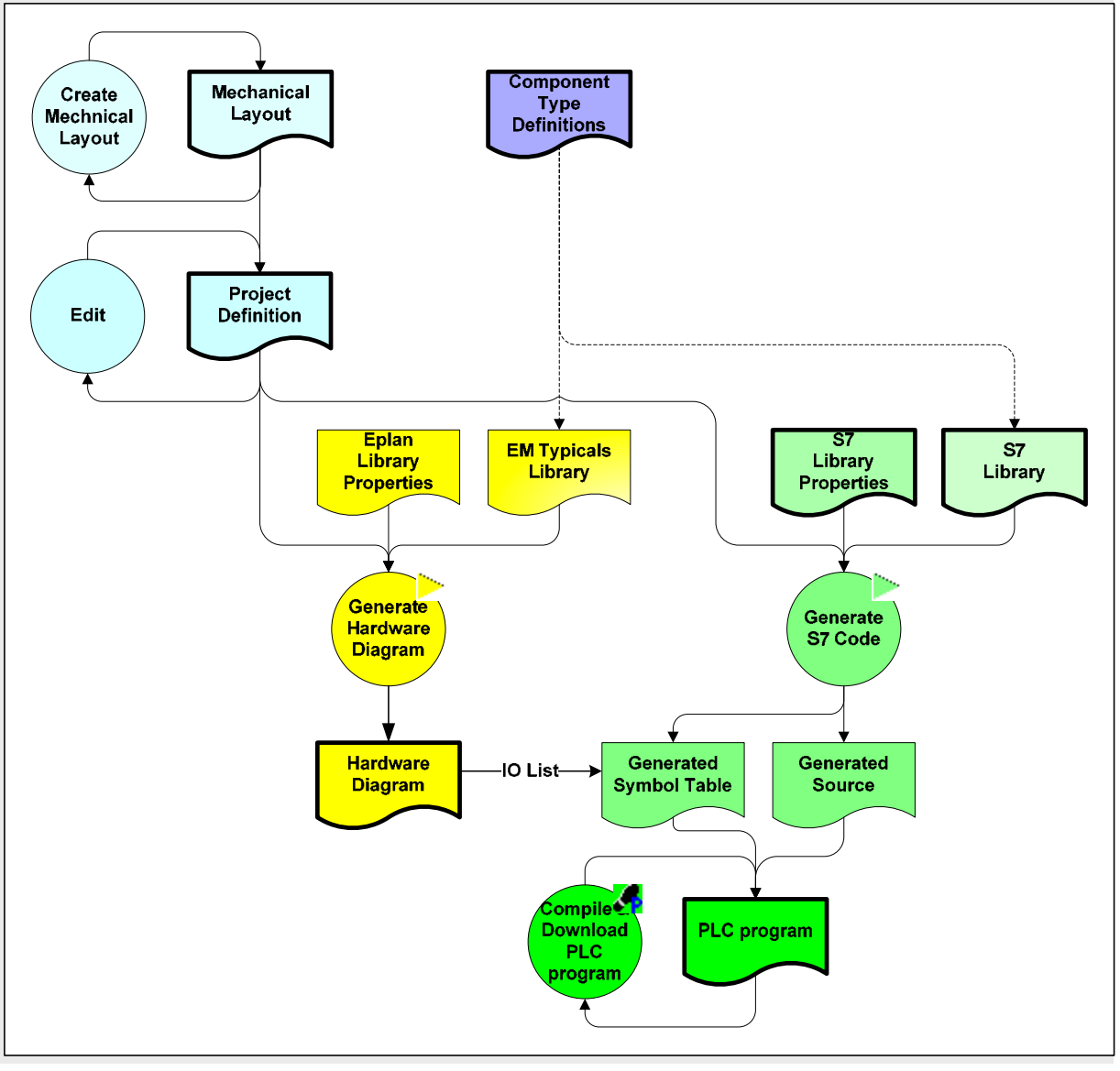
Variants of conveyor building blocks



Conveyor with PEC
and flow control functionality.



Code Generator Suite

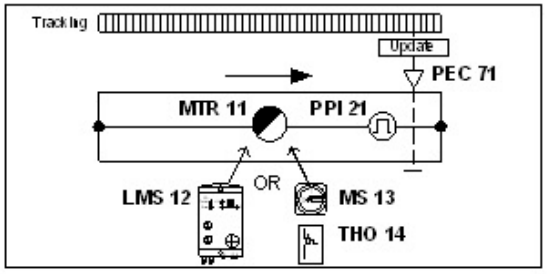


Component Type Definitions

BF11

Owner: General 4.0

Picture:



Definition: Tracking conveyor with PPI.

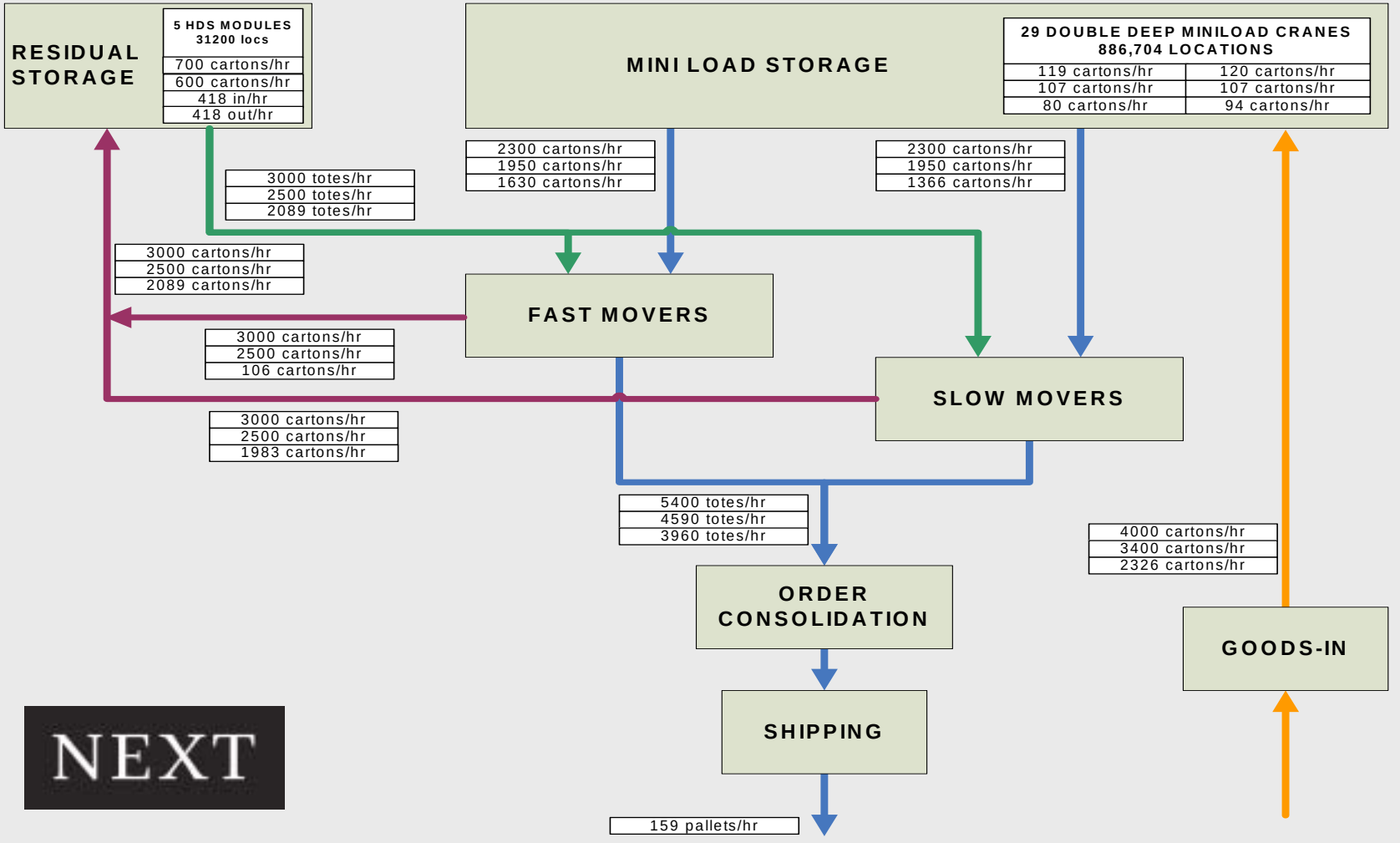
I/O Definition:

Type:	ID:	Comment:
I_BOOL	="I_" & parent.id & "_LMS_Auto"	Mode Switch of LMS in position AUTOMATIC
I_BOOL	="I_" & parent.id & "_LMS_OK"	Healthy signal from LMS
I_BOOL	="I_" & parent.id & "_MS_On"	Maintenance Switch in position 'ON'
I_BOOL	="I_" & parent.id & "_PEC" & parent_func_a	="Photo Electric Cell" & parent_func_descr
I_BOOL	="I_" & parent.id & "_PPI" & parent_func_a	="Pulse Position Indicator" & parent_func_descr
I_BOOL	="I_" & parent.id & "_THO_OK"	No Thermal Overload
Q_BOOL	="Q_" & parent.id & "_MTR"	="Run signal to motor" & parent_func_descr

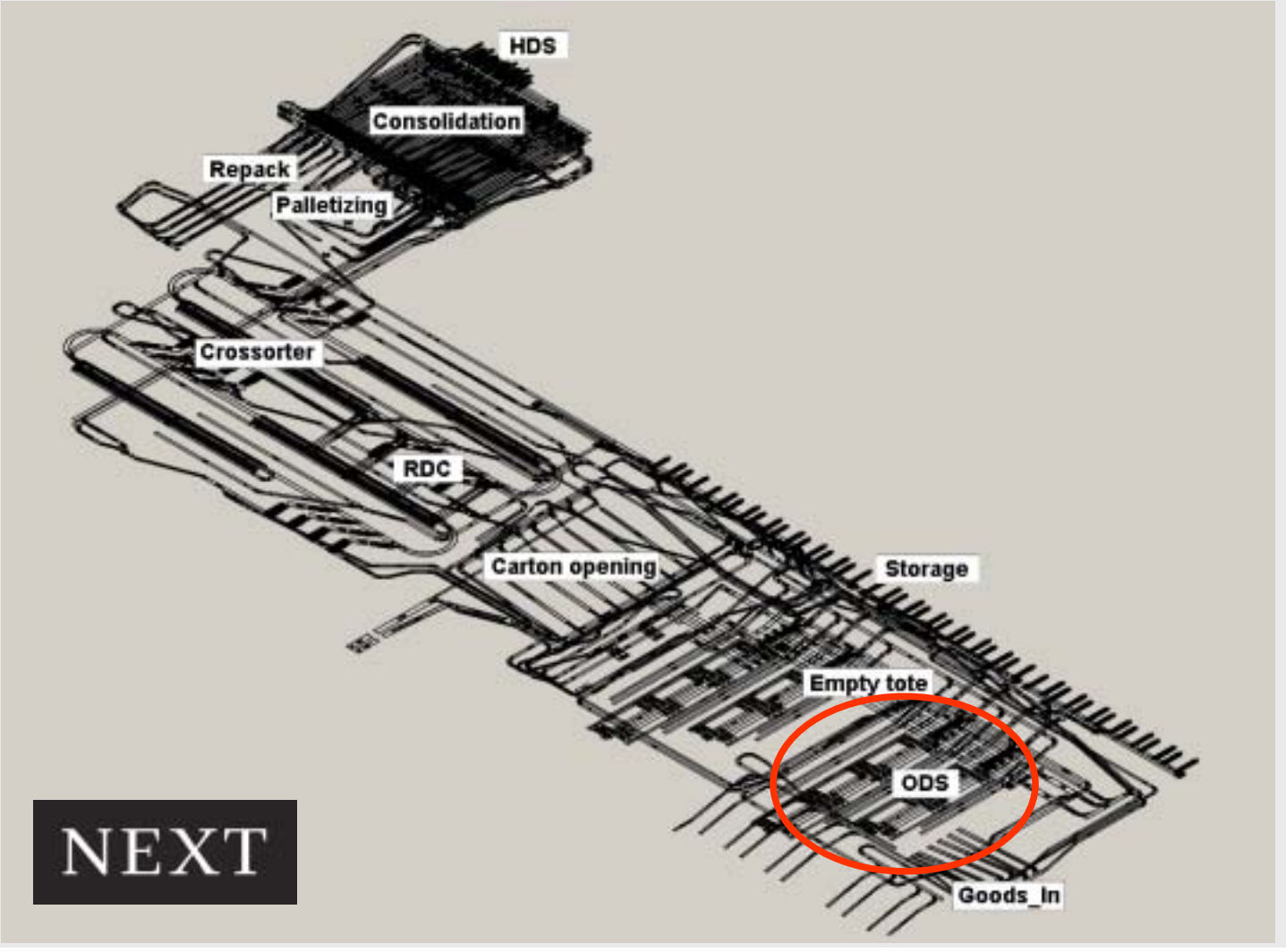
Tags:

SymbolicName	TagTypeId	Address
LMS_12_ASI_Error	DS	0.1
LMS_12_ASI_Not_Prsnt	DS	0.0
LMS_12_Not_Automatic	DS	0.2
LMS_12_Not_Healthy	DS	0.3
MS_13_Not_Automatic	DS	0.4
PEC_71_Blockage	DS	1.1
PEC_71_Missings	DS	1.2
PPI_21_Error	DS	0.6
THO_14_Th_Overload	DS	0.5

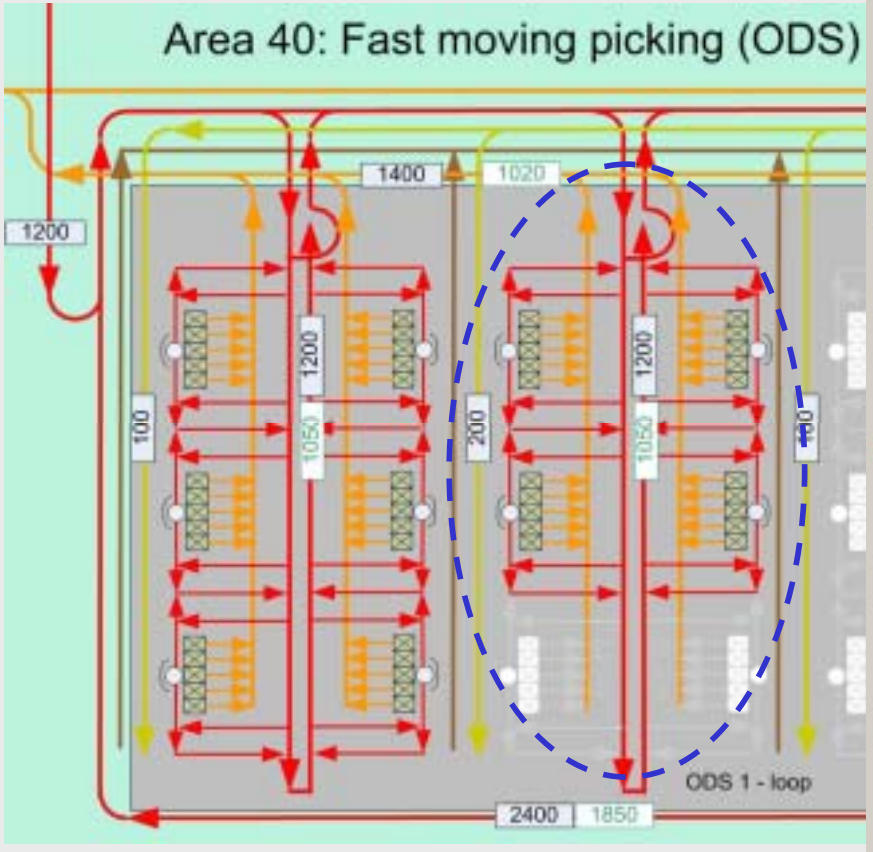
Distribution system 'Next': peakflow overview

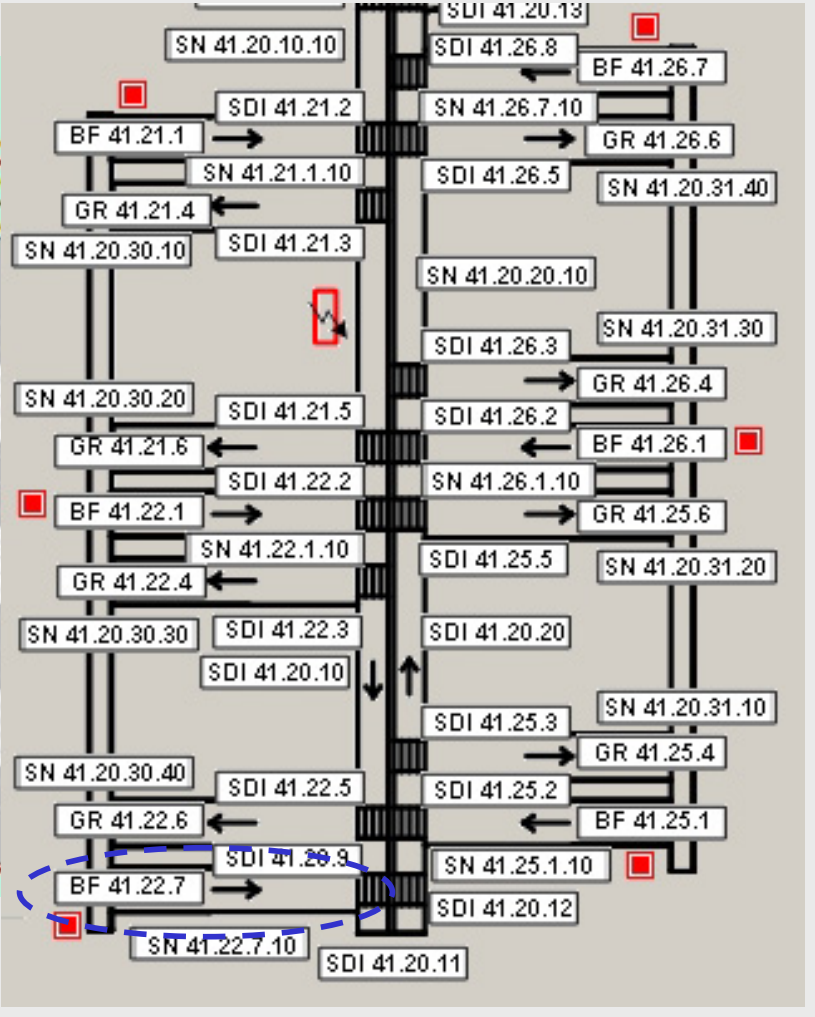


Distribution system ‘Next’: system layout



Distribution system ‘Next’: flow diagram ODS 1 -loop





Project Definition File

- **BF 41.22.7 -> BF33**

	Item	Value
	id	41.22.7.
	mark_code	BF
	cd1_id	BF33
+	length	2.5
+	vila_document	094672-999-14301-EN.DWG
+	guid	9D8A87E1BED04D9D8D84D27A55CD612D
+	activity_number	41600
+	eplan_dd	41+LCC12-916A0
·	eplan_dd1	
·	eplan_dd2	
·	eplan_dd3	
·	eplan_dd4	
·	eplan_dd5	
·	station_id	
	function	33
+	plc_id	41
+	lcc_id	12
+	start_address	64
+	pib_address	12
+	asi_channel	2
+	asi_address	16
·	function_description	
·	function_abbreviation	
+	integration_level	section
+	nominal_current	
+	motor_power	
+	es_area	19
+	thermal_overload_group	400V_GRP02
·	brake	
·	aux_brake	
·	fc_ss	
·	motor_isolator	

S7 Library Property File

- **BF33 -> FB_BC_Track2PECNoUpd**

STL block call

- **BF 41.22.7**

```
Network 6: BF33 41.22.7.
id:BF33, comment:Tracking conveyor with extra PEC without update

      CALL  "FB_BC_Track2PECNoUpd" , "DI_BF_41.22.7._BF33"
       i_Control             :=#s_Control
       i_IO_Available        :="DB_IO_Available".BF_41_22_7
       i_LMS_ASI_Not_Present:="DB_Diagnose_ASI_PF".Gateway_12_Channel_2.Slave_Not_Present[16]
       i_LMS_ASI_Error       :="DB_Diagnose_ASI_PF".Gateway_12_Channel_2.Slave_Error[16]
       i_MTR_Automatic_Mode :="I_41.22.7.1_MTR_AUTO"
       i_MTR_Healthy         :="I_41.22.7.1_MTR_OK"
       i_NOT_PEC_Pos         :="I_41.22.7.3_PEC"
       i_NOT_PEC_Trigg       :="I_41.22.7.2_PEC"
       i_Manual_Mode         :=FALSE
       i_Manual_Run          :=FALSE
       i_DB_Track            :="DB_Track_41.22.7."
       o_MTR                 :="Q_41.22.7.1_MTR"
       o_PEC_Trig_Latch      :=
       io_Auxiliary          :="DB_Aux".BF_41_22_7
       io_FIF_Upstream       :=
       io_FIF_Downstream     :="DB_FIF".BF_41_22_7
       io_Report             :=#s_Report
```

Issues for discussion

- **It seems not possible to apply one PLC brand worldwide.
  The ultimate solution is having platform independent software
  that can be applied with Hard and SoftPLCs of (all) different suppliers.**

- **A promising development is the use of Object Oriented Programming for PLCs.**

- **An interesting trend is the use of embedded PCs for SoftPLC solutions (Programmable Automation Controllers).**

Questions