

Control Loop Monitoring and Performance Management

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Agenda

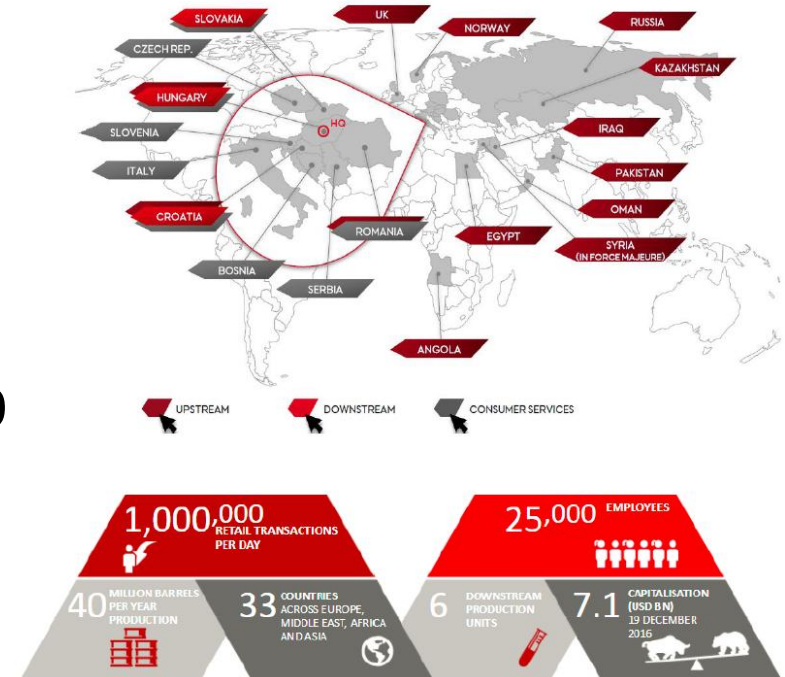
- SLOVNAFT and MOL GROUP
- Control Loop Monitoring - Theory
- Data Mining
- On-site Monitoring
- Applications and use case / How the PI System was applied?
- Implementation in the PI System
- How the challenge has been solved by using other tools
- Results and business impact
- Implementation reports
- Conclusion

Control Loop Monitoring

Performance Management

MOL Group

- MOL Group is an integrated, international oil and gas company, headquartered in Budapest, Hungary
- Active in over 30 countries
- International workforce of over 25,000 people
- Track record of more than 100 years in the industry



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Actual data (2017)

Oil processing: 5,6 mn t/a

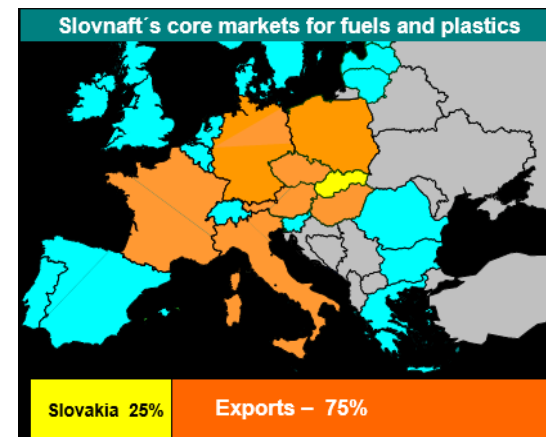
Key products:

Motor fuels 4,4 mn t/a

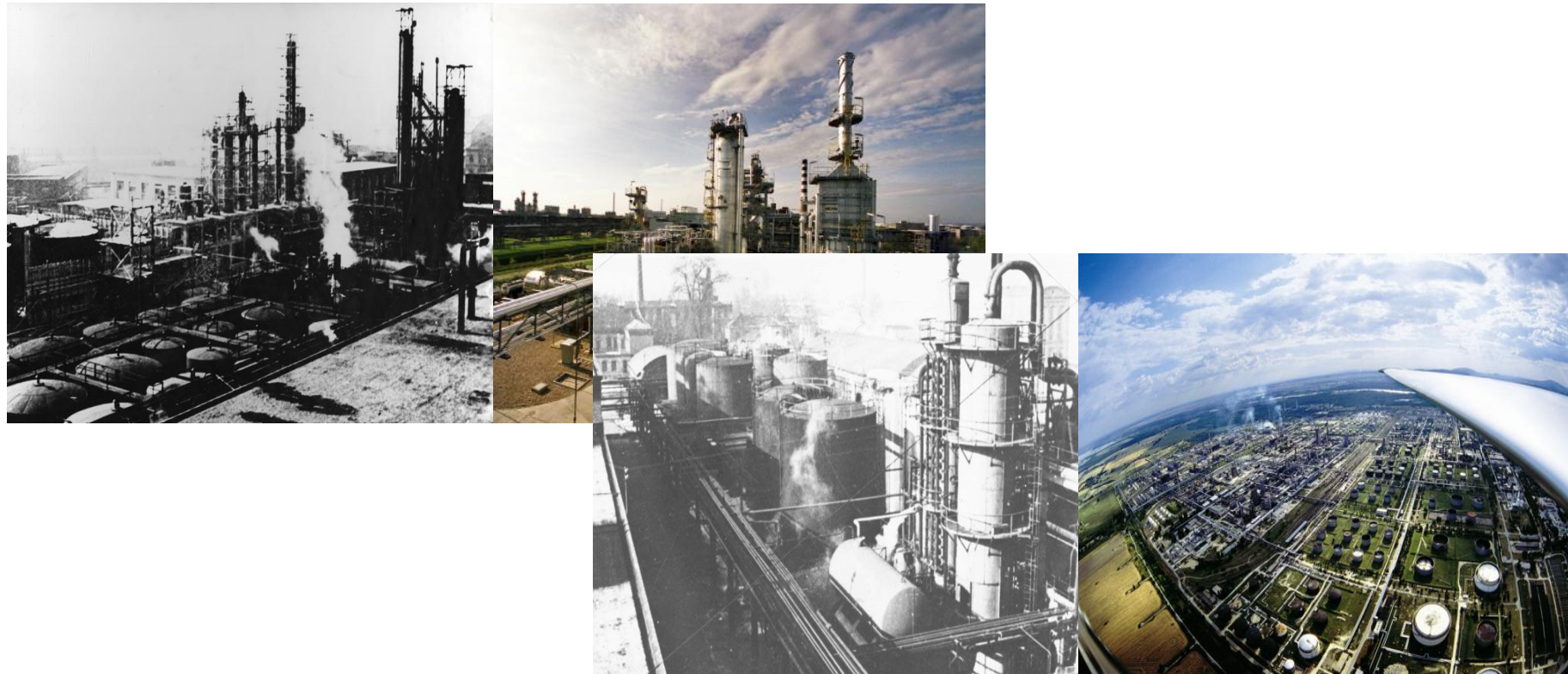
Plastics 406 kt /a

Chemicals 118 kt /a

Employees: 2389 + 1046 (in filling stations)



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Control Loop Monitoring

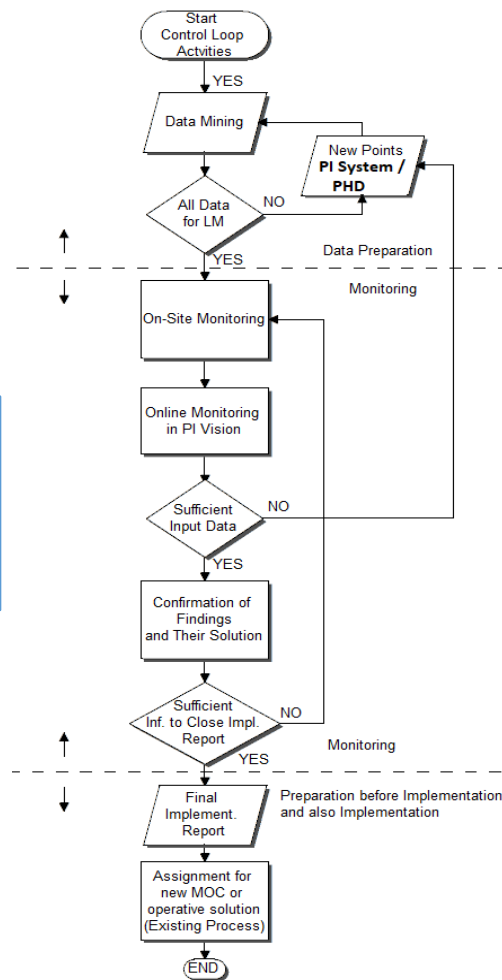
- Idea is to detect degradations of control performance
- Identify and rectify the root-causes of control system problems
- Results of control problems, which can decrease the level of automation:
 - Unsafe, unstable, uneconomical manner, producing off-spec products, consuming more energy, losing profit making opportunities...

Control Loop Monitoring

- This is a continuous activity which should cover discrepancy between desired mode and actual mode (by operators).
- Based on the findings, our team is in charge of implementing changes. As we want to highlight this resolution and to take corrective actions, we need to have an on-line monitoring system.

Flow Chart

LM – Loop Monitoring
PHD – Data Source (Honeywell)
MOC – Management of Change



Data Mining

- Before starting the “Loop Monitoring” we do data mining (getting appreciated data from available sources: Asset management or controller export)

Honeywell

me Explore Search Change Tracking Integrity Issues **Queries** Spares Management Print Management

Create/Edit Queries

Asset: SLO6

Query Access: Private Query Type: Property Data

Delete Delete All Per Page: 14

Query Name

---Create New Query---

☒ EJ2_SL01

☐ HRP7_SL23

Query Definition - EJ2_SL01 - (Private)

Type of query: Property Data

Asset: SLO6

Object type: Tag

Sub types: REGAM, REGCLNM

Property names: _Type, Name, NMDC, CTALGID

Search criteria: (CTALGID = 'PID') OR (CTALGID = 'PIDERFB') OR (CTALGID = 'PIDFF')

Preview

Results: 450 records retrieved in 0 minutes 4 seconds.

Object Type	Object Name	_TYPE	NAME	NMODE	CTALGID	ALNBST	KEYWORD	NODENUM	NTWKNUM	NODETYP	PT DESC	SLOT NUM	UNIT	PVEULO	PVEUHI	EJDESC
Tag	12FC1003	REGCLNM	12FC1003	AUTO	PD	ENABLE	12V101	11	1	HPM	NAFTA+PETROLEJ DO 12V101	26	01	0	70000	kg/h
Tag	12FC1019	REGCLNM	12FC1019	AUTO	PD	ENABLE	12P101AB	11	1	HPM	VY TLAK 12P101A/B	1	01	0	190000	kg/h
Tag	12FC1027A	REGCLNM	12FC1027A	AUTO	PD	ENABLE	12E102C	11	1	HPM	KOMB.NASTREK DO 12E102C	2	02	0	90000	kg/h
Tag	12FC1034A	REGCLNM	12FC1034A	CAS	PD	ENABLE	12K101	11	1	HPM	REDRK.PLYN Z 12K101	33	02	0	14000	kg/h
Tag	12FC1035A	REGCLNM	12FC1035A	CAS	PD	ENABLE	12K101	11	1	HPM	REDRK.PLYN Z 12K101	32	02	0	14000	kg/h
Tag	12FC1040A	REGCLNM	12FC1040A	AUTO	PD	ENABLE	12E102D	11	1	HPM	KOMB.NASTREK DO 12E102D	3	02	0	90000	kg/h
Tag	12FC1061	REGCLNM	12FC1061	CAS	PD	ENABLE	12H101	15	1	HPM	12H101-VYKUROV/ACI PLYN	22	02	0	18000	kg/h
Tag	12FC1065	REGCLNM	12FC1065	CAS	PD	ENABLE	12H101	15	1	HPM	12H101-VSTUP SPALVZDUCH	24	02	0	25000	kg/h
Tag	12FC1069	REGCLNM	12FC1069	CAS	PD	ENABLE	12R102	11	1	HPM	QUENCH FRED 12R102	17	02	0	2700	kg/h
Tag	12FC1101	REGCLNM	12FC1101	CAS	PD	ENABLE	12R102	11	1	HPM	QUENCH ZA 1.LOZKOM	19	02	0	5000	kg/h
Tag	12FC1102	REGCLNM	12FC1102	CAS	PD	ENABLE	12R102	11	1	HPM	QUENCH ZA 2.LOZKOM	21	02	0	5000	kg/h
Tag	12FC1180	REGCLNM	12FC1180	CAS	PD	ENABLE	12P103AB	15	1	HPM	FRACIA VODA Z 12P203A/B	16	04	0	6500	kg/h
Tag	12FC1182	REGCLNM	12FC1182	AUTO	PD	ENABLE	12P103AB	11	1	HPM	CRKJULACIA 12P103A/B	4	04	0	13000	kg/h
Tag	12FC1209	REGCLNM	12FC1209	AUTO	PD	ENABLE	12P102AB	11	1	HPM	FRACI OLEJ ZA 12P102A/B	5	03	0	40000	kg/h
Tag	12FC1218	REGCLNM	12FC1218	AUTO	PD	ENABLE	12P105A	15	1	HPM	CRKJULACIA 12P105A/B	1	07	0	80000	kg/h

Data Mining – Input Report (PI DataLink)

Excel interface showing the PI DataLink Input Report. The report displays data for various process units (SATO) and their associated parameters (Tag, Description, Current MODE, NMODE, Reason 2017, New NMOD, Unity, Change NMOD, Condition, Selector, Maintenance, Technology).

Tag	Description	Current MODE	NMODE	Reason 2017	New NMOD	Unity	Change NMOD	Condition	Selector	Maintenance	Technology
1 SATD_DC249.MODE	MERNA HMOTNOST PO ZVJ										
2 SATD_FC205A.PIDA.MODE	NASTREK PRACEJ VODY										
3 SATD_FC205B.PIDA.MODE	NASTREK PRACEJ VODY										
4 SATD_FC211.PIDA.MODE	UPRAVENA VODA ZO SIETE										
5 SATD_FC212.PIDA.MODE	KONDENZAT ZO SIETE DO										
6 SATD_FC213.MODE	VODA DO D1/1										
7 SATD_FC214.MODE	VODA DO D1/2										
8 SATD_FC216.MODE	ROPA DO C1										
9 SATD_FC218.MODE	REFLUX C1										
10 SATD_FC219A.MODE	ROPA DO F1 1. PRUD										
11 SATD_FC219B.MODE	ROPA DO F1 2. PRUD										
12 SATD_FC219C.MODE	ROPA DO F1 3. PRUD										
13 SATD_FC219D.MODE	ROPA DO F1 4. PRUD										
14 SATD_FC220.MODE	BCR1 ZA P7										
15 SATD_FC221.MODE	BCR3 ZA P9										
16 SATD_FC222.MODE	VOL ZA P12										
17 SATD_FC223.MODE	STRIPOVACIA PARA DO C										
18 SATD_FC224.MODE	REFLUX DO C2 STUDENNY										
19 SATD_FC228.MODE	PO ZA P11										
20 SATD_FC229.MODE	FE ZA P10										
21 SATD_FC230.PIDA.MODE	BENZIN Z T6										
22 SATD_FC231.MODE	ROPA ZA P1										
23 SATD_FC232.MODE	TBI ZA P15										
24 SATD_FC233.MODE	TBI Z C4										
25 SATD_FC235.MODE	REFLUX C4										
26 SATD_FC235.MODE	REFLUX C4										
27 SATD_FC235.MODE	REFLUX C4										
28 SATD_FC235.MODE	REFLUX C4										
29 SATD_FC238.MODE	REFLUX C6										
30 SATD_FC239.MODE	BCR2 DO R1/1,2										
31 SATD_FC274.MODE	BI Z T2 DO T8										
32 SATD_FC279.PIDA.MODE	Prietok pracej vody do CB15										
33 SATD_LDC421.MODE	VYPIERACIA NADRZ T10										
34 SATD_PC340.MODE	VOT Z VJ										
35 SATD_TC132.MODE	VSTUP BCR1 DO C2										
36 SATD_TC147.MODE	BCR2 ZA W08										
37 SATD_TC153.MODE	SBF ZA CE15/01B										
38 SATD_TC821.MODE	VZDUCH DO APEXU										

On-site Monitoring

- After we prepared this input report, we went to the production and discussed the problematic loops (FALSE in previous slide) with operations.
- Based on these discussions, we categorised the findings.

On-site Monitoring - Categories

VODA DO D1/2												
	A	B	C	D	E	F	G	H	I	J	K	L
	Tag	Description	Current MODE	NMODE	Reason 2017	New NMOD	Unity	Change NMOD	Condition	Selector	Maintenance	Technolog
1	SATD_FC211.PIDA.MODE	UPRAVENA VODA ZO SIETE DO T26	CAS	AUTO	Nepouziva sa na CAS, rozhadzuje meranie. Nefunkcna logika. Je to nova slucka a je nevladena P:0.8 I:1 D:0	CAS	FALSE	x				x
5	SATD_FC212.PIDA.MODE	KONDENZAT ZO SIETE DO T26	CAS	AUTO	Nepouziva sa na CAS, rozhadzuje meranie. Nefunkcna logika. Je to nova slucka a je nevladena P:0.8 I:1 D:0	CAS	FALSE	x				x
6	SATD_FC221.MODE	BCR3 ZA P9	MAN	Auto	OK	AUTO	FALSE	x				
16	SATD_FC235.MODE	REFLUX C4	CAS	Auto	Je nutne vyladit slucku. Reaguje pomaly na teplotu hlavy. Standardne by sa mala pouzivat kaskada.	CAS	FALSE	x			x	x
26	SATD_FC238.MODE	REFLUX C6	CAS	Auto	Momentalne je tam problem, ktorý sa riesi. Normalne to vporiadku drzi na kaskade.	CAS	FALSE	x				
29	SATD_FC239.MODE	BCR2 DO R1/1,2	MAN	Auto	OK	AUTO	FALSE	x				
30	SATD_FC274.MODE	BI Z T2 DO T8	CAS	Auto	OK	CAS	FALSE	x				
37	SATD_FC279.PIDA.MODE	Prietok pracej vody do CB15	AUTO	CAS	OK	CAS	FALSE	x				
38	SATD_LDC421.MODE	VYPIERACIA NADRZ T10	MAN	Auto	OK	AUTO	FALSE	x				
39	SATD_PC340.MODE	VOT Z VJ	AUTO	MAN	Batterlimit_T na rozvodoch_AUT iba v nestand. Steve	MAN	FALSE	x				
32	SATD_TC132.MODE	VSTUP BCR1 DO C2	CAS	MAN	Reguluje sa bud prietok alebo teplota. Tento regulator , alebo FC220 musi byt v CAS a druhy v AUTO.	CAS	FALSE	x		x		
03	SATD_TC147.MODE	BCR2 ZA W08	MAN	Auto	OK	AUTO	FALSE	x				
07	SATD_TC153.MODE	SBF ZA CE15/01B	AUTO	MAN	Je to v MAN, ale standardne ked technologia bezi je v AUTO. DCS obrazovka zobrazuje BAD PV. Je tam skrat.	AUTO	FALSE	x				
00												

Resolution of the findings

- After defining the report, we created extended reports and started the second round of this activity.
- In order to support this activity, a good online visualisation tool is necessary. We decided to use the PI System for implementation of this application.

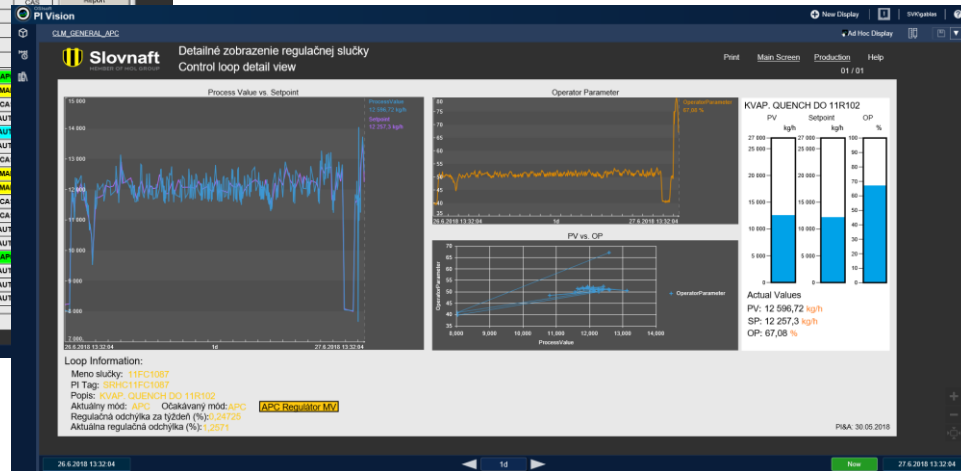
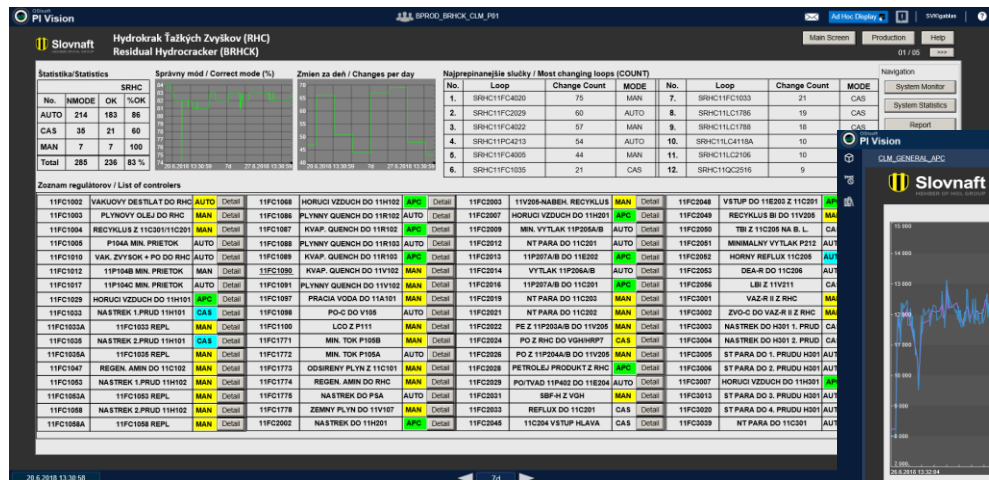
Why the PI System has been selected?

- This system was already working in the refinery
- Good consistency of the data which we need
- We defined one source of truth
- Good development environment



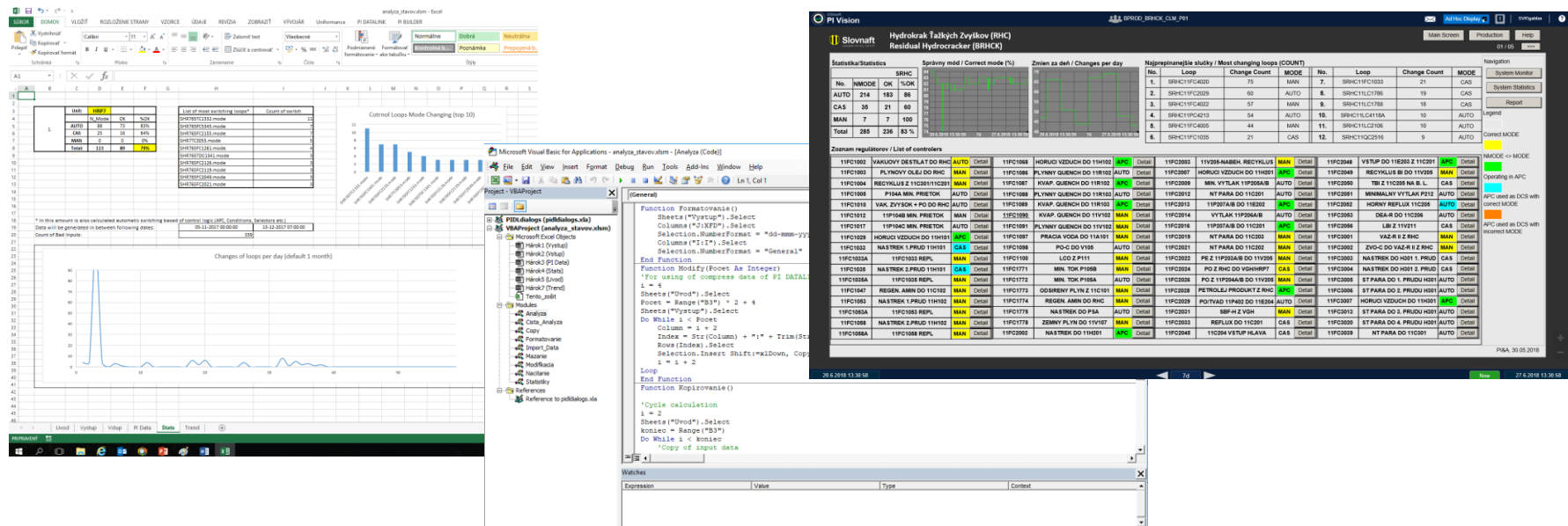
Motivation for on-line monitoring

To create a tool for visibility of control related problems: operational, instrumentation, tuning etc.



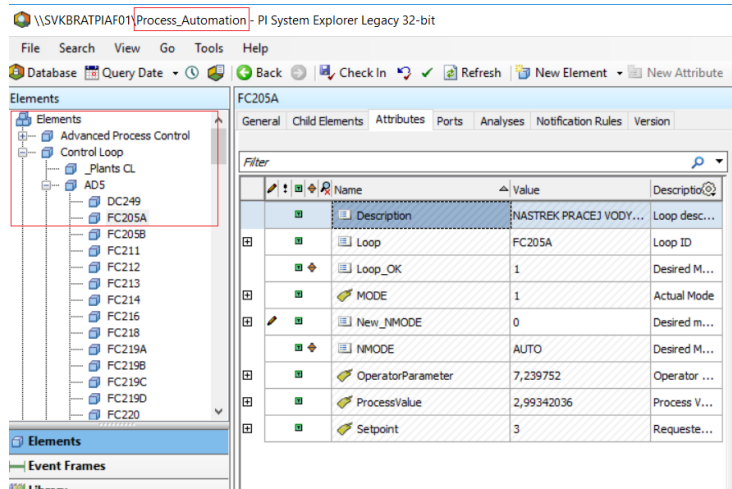
Motivation for on-line monitoring

But... previous slide is the actual implemented solution and there was a very long path to come to this point.



Why we used PI AF?

- To define good structure of data (PI System Explorer)
 - Database\Application\Unit (T)\Loop (T)
- For using of specific calculations (conditions / selectors / APC)

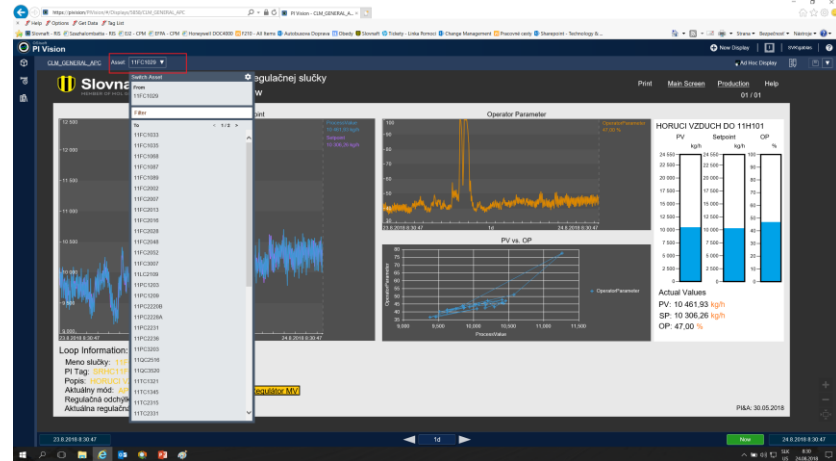
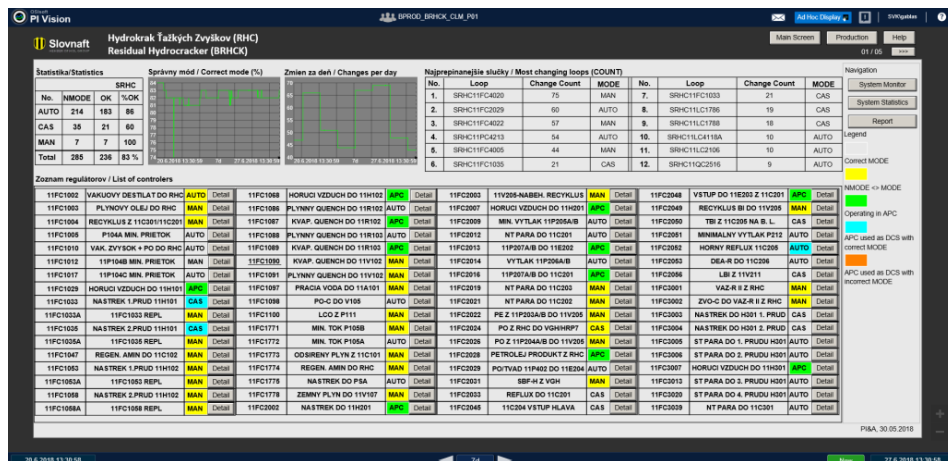


The screenshot shows the 'AD5' table in the PI System Explorer Legacy 32-bit interface. The table has columns: Name, Description, Category, Type, and Template. The table contains the following data:

Name	Description	Category	Type	Template
DC249	MERNA HMOTNOST PO z V3	CLM	None	ControlLoop
FC205A	NASTREK PRACEJ VODY - VETVA A	CLM	None	ControlLoop
FC205B	NASTREK PRACEJ VODY - VETVA B	CLM	None	ControlLoop
FC211	UPRAVENA VODA ZO SIETE DO T26	CLM	None	ControlLoop
FC212	KONDENZAT ZO SIETE DO T26	CLM	None	ControlLoop
FC213	VODA DO D1/1	CLM	None	ControlLoop
FC214	VODA DO D1/2	CLM	None	ControlLoop
FC216	ROPA DO C1	CLM	None	ControlLoop
FC218	REFLUX C1	CLM	None	ControlLoop
FC219A	ROPA DO F1 1. PRUD	CLM	None	ControlLoop
FC219B	ROPA DO F1 2. PRUD	CLM	None	ControlLoop
FC219C	ROPA DO F1 3. PRUD	CLM	None	ControlLoop
FC219D	ROPA DO F1 4. PRUD	CLM	None	ControlLoop
FC220	BCR 1 ZA P7	CLM	None	ControlLoop

Why we used PI AF?

- As all necessary data are based on the templates we can simply generate dashboards.
- Detail displays are “Element / Asset Relative” – only one display for all loops from selected template.



PI as a tool for implementation of CLPM

For the implementation of Control Loop Performance Management (CLPM) – Loop Monitoring application, we used the following tools:

- In the first step MS Excel and VBA – PI DataLink
- PI AF Server (for connection we are using PI System Explorer)
- PI OLEDB (which is executing the logic implemented in SQL)
- PI ProcessBook / PI Vision
- MS PowerShell

Development of the SQL Application

For generation of dashboard data (list of loops etc.) we used SQL Tables connected to PI System via PI OLEDB interface.

The screenshot shows the PI System Explorer Legacy 32-bit interface. The left pane displays the 'Elements' tree with 'HRP7' selected. The main pane shows the 'HRP7' table structure with columns: Name, Value, and ID. The 'Count' column is highlighted. The right pane shows the 'Data Reference' tab with a SQL query: `SELECT count FROM [Controlers_Top12_HRP7] WHERE tag = @Tag ORDER BY ID DESC;stepped=True;RWM=0`. The query is circled in red.

Name	Value	ID
Change_Count	1	0000000004SHR76SLC5312.MODE
Changes	1	
Top01	SHR76SPC5541	
Top02	SHR76SLC5312	
Count	4	
ID	0000000004SHR76SLC5312.MODE	
Tag	SHR76SLC5312.MODE	
Trend	AUTO	
Top03	SHR76SLC5190	
Top04	SHR76SLC1301A	
Top05	SHR76SPC5086L	
Top06	SHR76SPC1483	
Top07		
Top08		
Top09		

The screenshot shows the PI System Explorer Legacy 32-bit interface. The left pane displays the 'Library' tree with 'Actual_State_HRP7' selected. The main pane shows the 'Actual_State_HRP7' table structure with columns: Name, Description, Categories, Connection, Query, Time Zone, and Cache Interval. The 'Query' field contains a SQL query: `Internal - SELECT 'Auto' as Code, count(a.tag)FROM [piarchive]...[piarchive] aWHERE tag like 'shr 7%mode'`. The 'Cache Interval' is set to 1 hour.

Name	Description	Categories	Connection	Query	Time Zone	Cache Interval
Actual_State_HRP7		HRP7	Internal - Provider=PIOLEDB.1;User ID=;Initial Catalog=piarchive;Data Source=SVKBRATP101;Integrated Se	Internal - SELECT 'Auto' as Code, count(a.tag)FROM [piarchive]...[piarchive] aWHERE tag like 'shr 7%mode'	<None>	1 Hours

PI OLEDB Enterprise

PI AF Tables contain SQL scripts which have been generated and debugged in PI SQL Commander.

The screenshot displays two software interfaces. The left window, 'IZOM_Loop_Monitoring - PI SQL Commander', shows a SQL script for monitoring loop events. The right window, '\\SVKBRATPIAF01\\Process_Automation - PI System Explorer Legacy 32-bit', shows a tree view of the 'Process_Automation' database with 'Changes_Significant_HRP7' selected. Below the tree, a table of data is displayed.

SQL Script (Left Window):

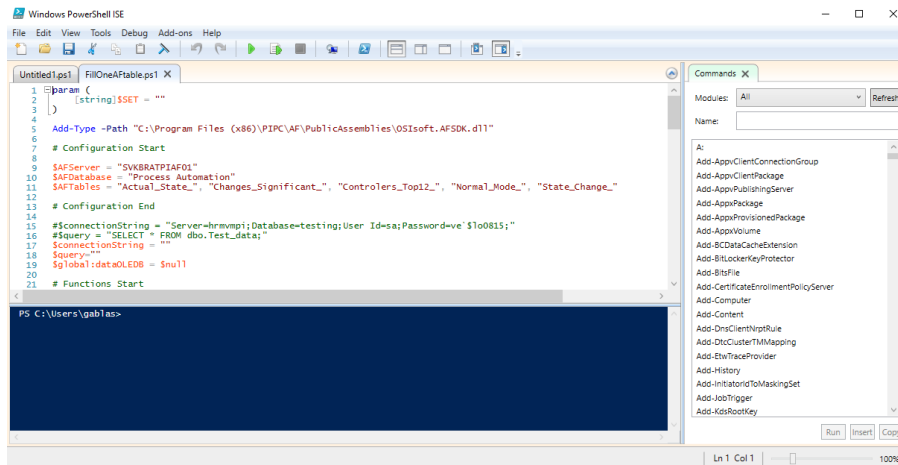
```
-- all tags all significant events with status
SELECT time, t.tag, t.strvalue,
DIGSTRING(CAST((( -65536)*DigStartCode-TypicalValue)as int32)) as NormalMode,
CASE
  WHEN t.strvalue = DIGSTRING(CAST((( -65536)*DigStartCode-TypicalValue)as int32)) THEN 'OK'
  ELSE 'not OK'
END as NMStatus
FROM (
  SELECT c.*,
  DIGSTRING(CAST(value AS int32)) strvalue,
  PREVVAL(c.tag, time) prevvalue
  FROM [piarchive].[picomp2] c
  WHERE c.tag like '*SIZ%mode'
  AND time BETWEEN '**-10d' AND '**'
  AND status = 0
) t
INNER JOIN pioint.p ON p.tag = t.tag
WHERE prevvalue IN (SELECT name FROM [pids].[SI_Modes])
AND strvalue <> prevvalue
ORDER BY time
OPTION (FORCE ORDER)
```

Table Data (Right Window):

time	tag	strvalue	NormalMode	NMStatus
30.03.2018 12:24:40	SHR.765PC1483.MODE	AUTO	AUTO	OK
03.04.2018 14:48:46	SHR.765LC1301A.MODE	AUTO	AUTO	OK
03.04.2018 15:27:45	SHR.765PC5086L.MODE	AUTO	AUTO	OK
04.04.2018 14:45:45	SHR.765LC5312.MODE	MAN	AUTO	not OK
04.04.2018 14:47:45	SHR.765LC5312.MODE	AUTO	AUTO	OK
04.04.2018 15:12:45	SHR.765LC5312.MODE	MAN	AUTO	not OK
04.04.2018 19:29:45	SHR.765LC1301A.MODE	MAN	AUTO	not OK
05.04.2018 13:26:45	SHR.765LC5312.MODE	AUTO	AUTO	OK
06.04.2018 9:38:46	SHR.765PC5541.MODE	AUTO	AUTO	OK
07.04.2018 6:56:46	SHR.765PC5541.MODE	MAN	AUTO	not OK
07.04.2018 8:00:46	SHR.765PC5541.MODE	AUTO	AUTO	OK
07.04.2018 8:04:46	SHR.765PC5541.MODE	MAN	AUTO	not OK
07.04.2018 8:11:46	SHR.765PC5541.MODE	AUTO	AUTO	OK
07.04.2018 8:17:46	SHR.765PC5541.MODE	MAN	AUTO	not OK
07.04.2018 8:41:46	SHR.765PC5541.MODE	AUTO	AUTO	OK
07.04.2018 23:41:48	SHR.765LC5190.MODE	AUTO	AUTO	OK
08.04.2018 15:52:49	SHR.765LC5190.MODE	MAN	AUTO	not OK

Automatic Refresh

We developed application for some production units as a pilot using Import Tables. Import Table cannot be set to reload data in PI System Explorer automatically. For this, we used MS PowerShell script using PI AF SDK at first.



```
Windows PowerShell ISE
File Edit View Tools Debug Add-ons Help
Untitled.ps1 FileOneAFtable.ps1 X
1 param (
2     [string]$SET = ""
3 )
4
5 Add-Type -Path "C:\Program Files (x86)\PIPC\AF\PublicAssemblies\OSIsoft.AFSDK.dll"
6
7 # Configuration Start
8
9 $AFServer = "SVKBRATPIAF01"
10 $AFDatabase = "Process Automation"
11 $AFTables = "Actual_State", "Changes_Significant", "Controllers_Top12", "Normal_Mode", "State_Change"
12
13 # Configuration End
14
15 $ConnectionString = "Server=brmmp1;Database=testing;User Id=sa;Password=ve $100815;"
16 $Query = "SELECT * FROM dbo.Test_data;"
17 $connectionString = ""
18 $Query = ""
19 $label:dataOLEDB = $null
20
21 # Functions Start
22
23 PS C:\Users\gablas>
```


Automatic Refresh

This script is being executed during the night and it takes about 12 minutes (for 8 production units). This is big difference in comparison to the old excel tool (developed in VBA) which took a couple of hours for same amount of loops. This script is executed on the server as a scheduled task.

Pros vs. Cons

- Pros

- Fast response
- Data availability for all users
- Possible modifications of screens (Ad Hoc displays)
- Template based solution
- Possible to generate reports and export them to *.csv or *.xml, from predefined screens

- Cons

- Many different tools have to be used
- Longer time for development and debugging
- No automatic updates of the tables (has to be started from external environment)

Implementation of findings

- Complete the implementation reports in cooperation with other departments
 - analysis of problems for non-desired modes
 - solution proposal of the first step
 - definition of criteria for individual solution
- Initialisation of assignment of a new MOC (Corrective Action) and operative orders based on common rules

Findings (Types of corrective actions)

- NewNMODE (change NMODE)
- Maintenance (trouble with instrumentation or other HW components)
- Conditions (setting and agreeing conditions for correct statistics for LM) – implemented as a calculation in PI System Explorer
- Selection (setting and agreeing selectors for correct statistics for LM) – implemented as a calculation in PI System Explorer
- Technology (the changes in the technology process)
- Cancellation (cancellation of the control loop or some of its elements)

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CONTROL LOOP MONITORING AND PERFORMANCE MANAGEMENT



CHALLENGE

Is to increase the level of automation on the production with a monitoring of desired mode of control loops, based on which we want to define corrective actions.

- For online monitoring we can decrease the time to make data available
- With using other solution we consume a lot of time.

SOLUTION

Integration of PI Tools (PI AF, PI OLEDB, PI Vision) in to one logical part which can provide in a user friendly way fast access to requested data.

- This was a cooperation between local IT and Process Information and Automation departnemnts.
- To be aligned, we had to split the work tasks between Automation and IT.

RESULTS

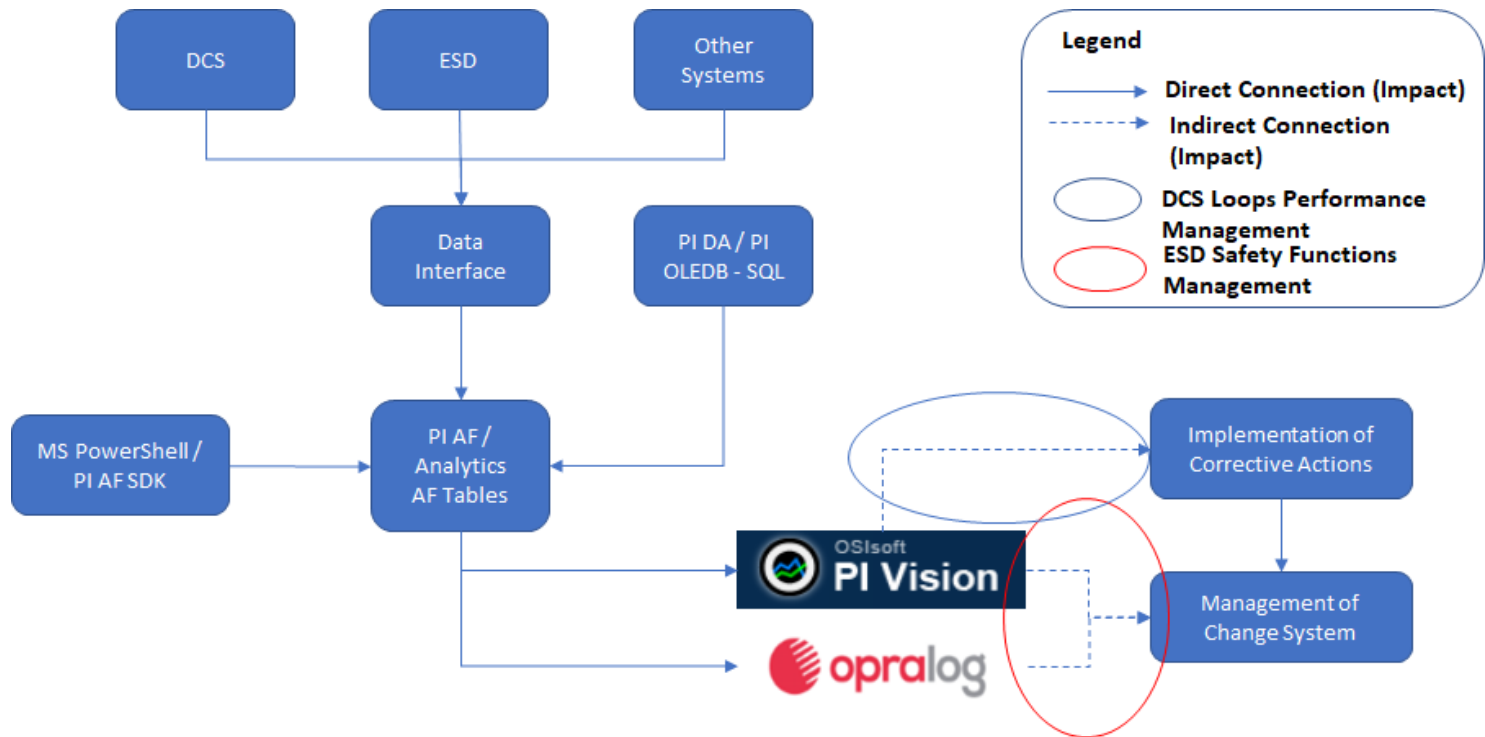
An application which we can use to increase level of automation by identifiing problems in production.

- The tool make data available in few seconds instead of hours.
- The tool should be used by production for checking the production status.

Next steps...

- Integration with whole Refinery Information System,
- Add monitoring and management of ESD functions based on IEC 61511,
- Add calculation of statistics and control quality,
- Development of full Information System of Control System with monitoring of Network, ESD and DCS, Loops, Safety Functions etc.

Next steps... (ISCS)



Speaker



- Peter Gablas
- Senior Control Engineer
- SLOVNAFT, a.s.
- peter.gablas@slovnaft.sk

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the **microphone**

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name & company



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