Various Experiences with Specifications of Different Customers and the Variety of

Metering Control System Configurations

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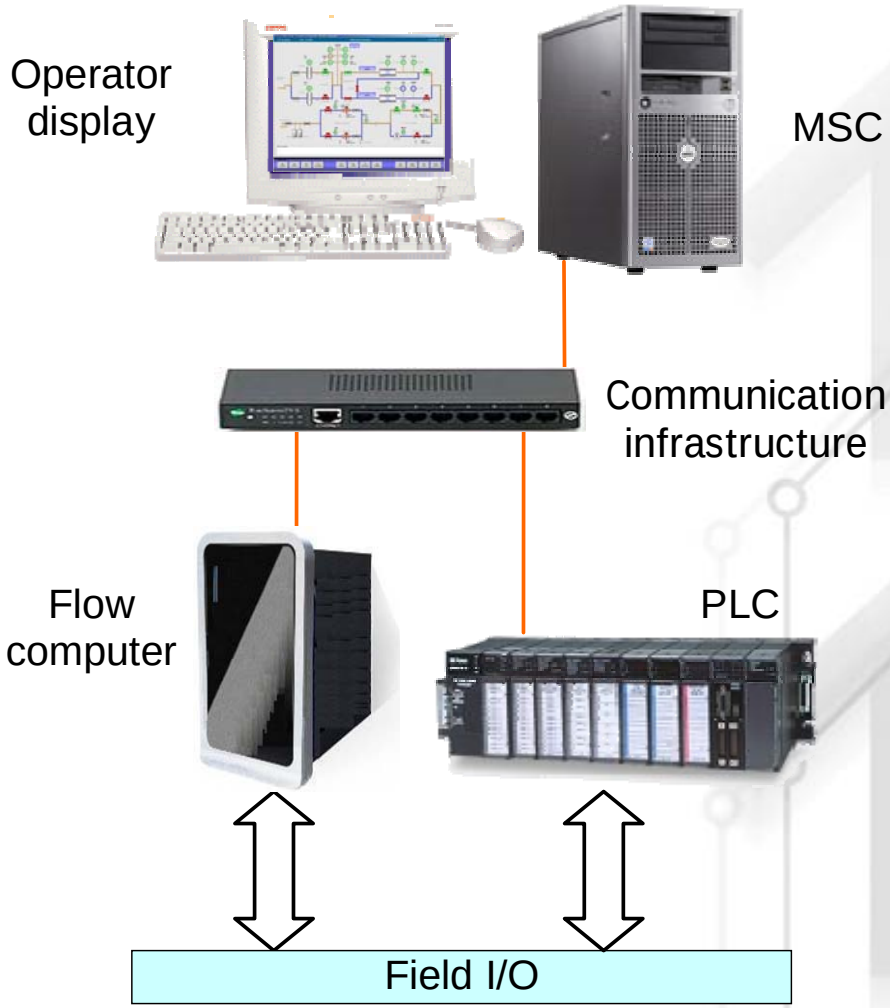
Metering Control System

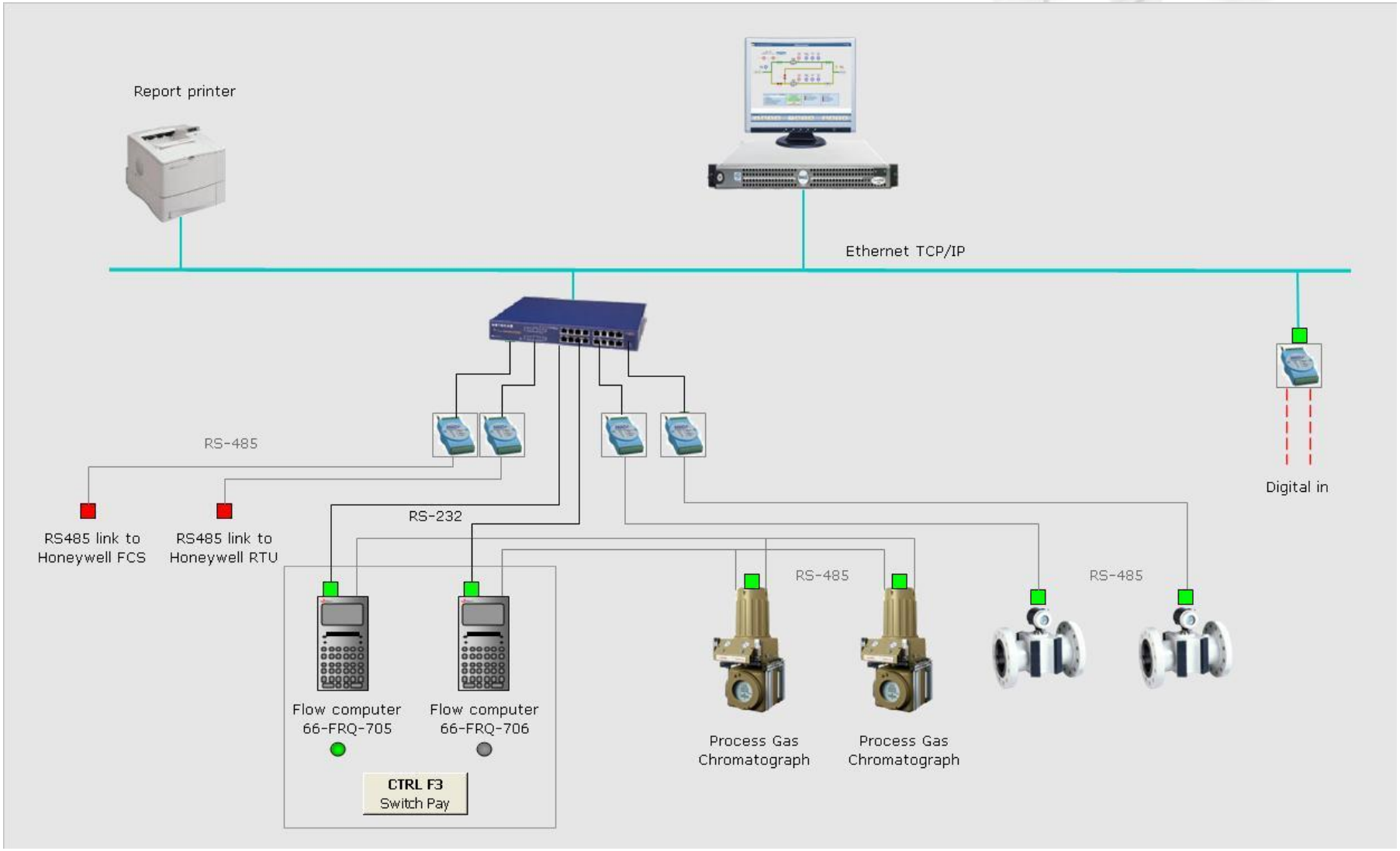


Configuration?

- Standards and regulations?
- Single stream or multi-stream flow computer ‘concept’ ?
- Integrated or separate proving flow computer ?
- MSC ?
- PLC ?
- Number and location of operator screens ?
- Communication capabilities (serial <-> Ethernet) ?
- **Redundancy concept ?**

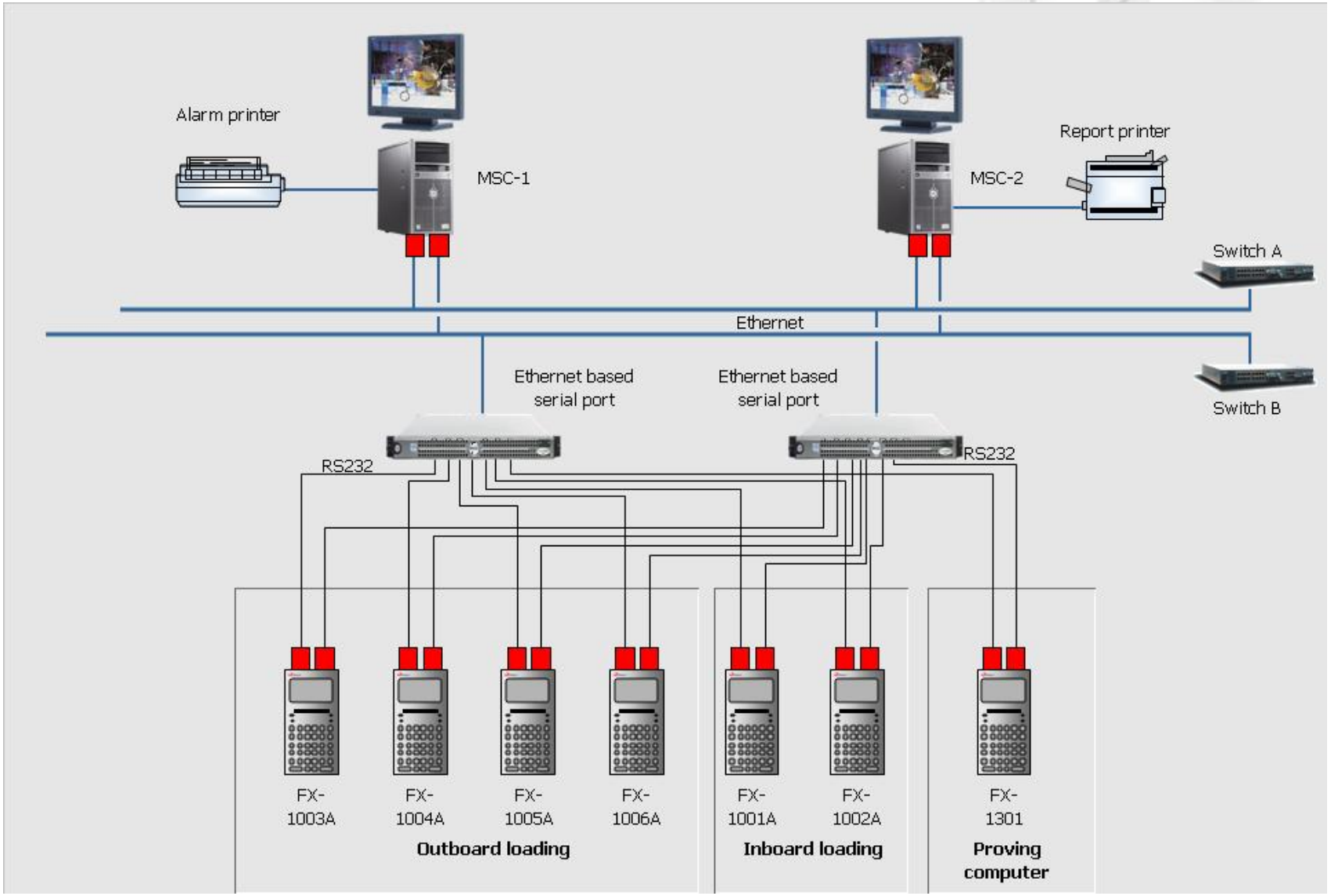
‘Small’ System

- **Gas supply** with 2 single stream FC’s, single MSC and no PLC



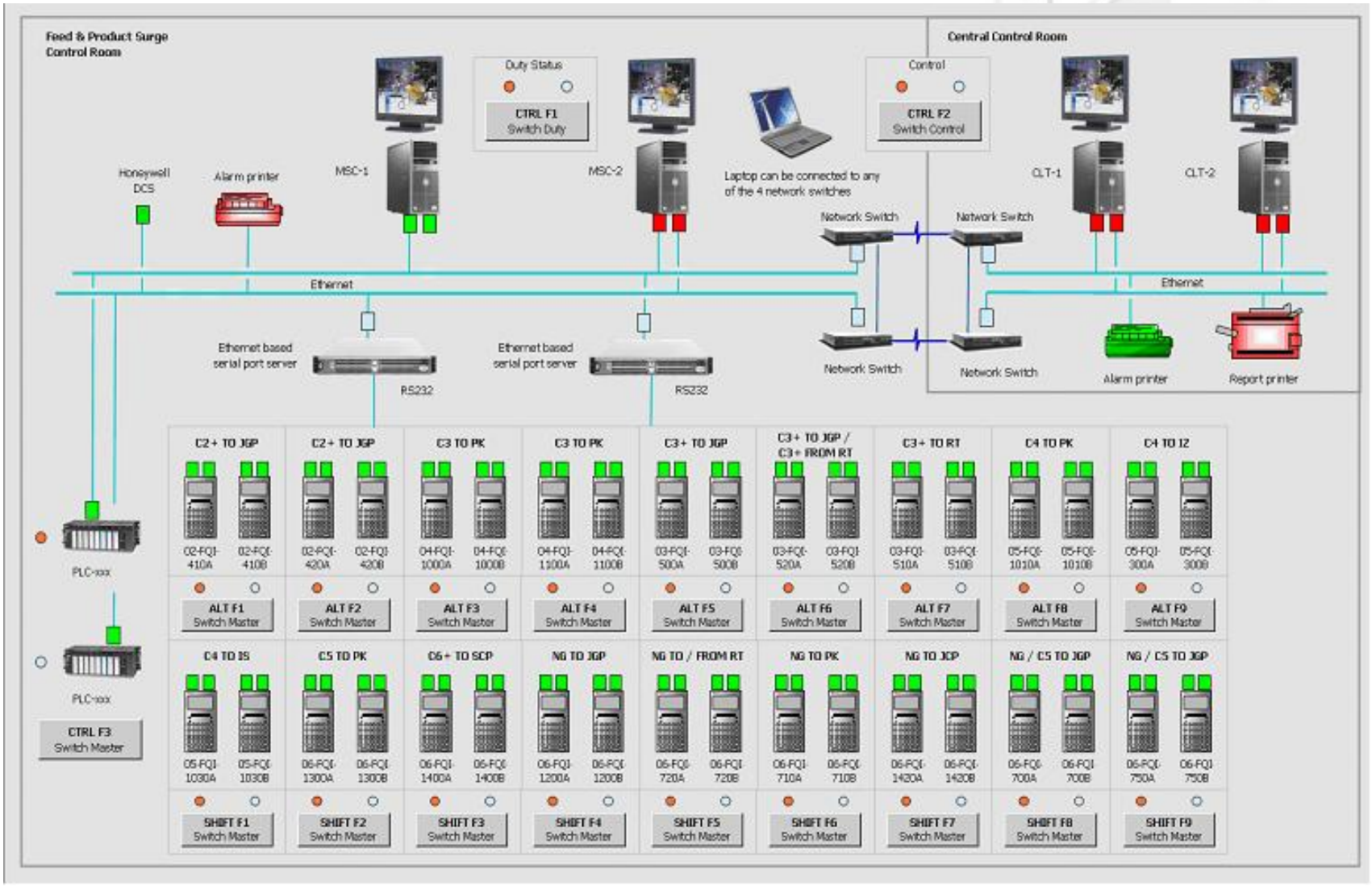
‘N+1 Redundancy’ System

- **Oil export** with single stream FC’s, separate proving FC and no PLC



‘Large’ System

- **Feed & Surge to and from Gas Plant** with multi-stream FC’s and full redundancy with remote control



‘Large’ System

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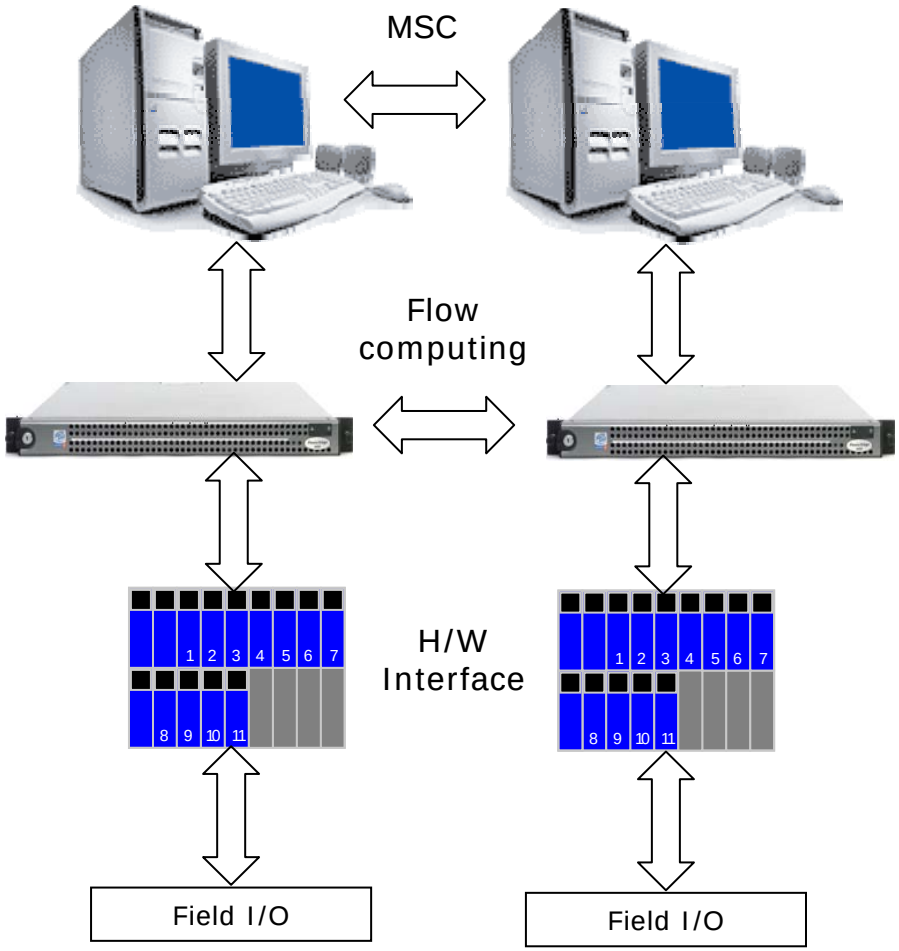
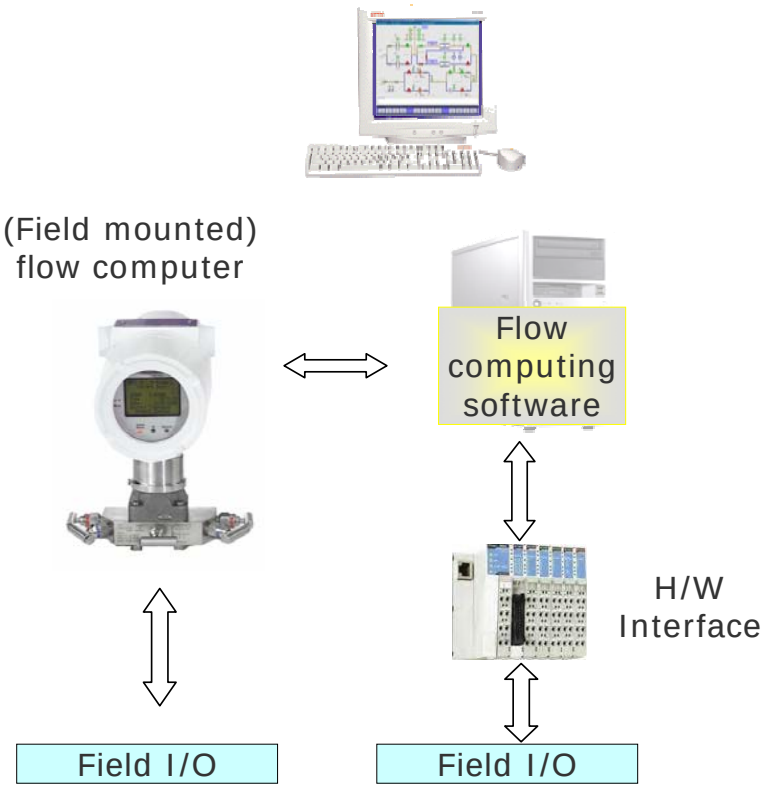
Virtual flow computing systems



- Follows trend in industry (H/W->S/W)
- Standard hardware
- Common practice in UK and Norway
- Proven technology (> 5 years)

Hybrid metering control systems



- **Cost-effective redundancy**
- **On-line verification**
- **SPC prewarns for mismeasurements**
- **Condition-based maintenance**

Redundancy <-> Availability

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- Availability = Uptime / (Downtime + Uptime) * 100%
- Availability = MTBF / (MTTR + MTBF) * 100%

  MTBF Mean Time Between Failures

  MTTR Mean Time To Repair

- Component <-> System
- Typical 5 Nines = 99.999% (5 minutes per year)
- To achieve high availability:
  - 1st: High-quality components
  - 2nd: Redundant components
- Software uptime ?

99%
99.9%
99.99%
99.999%
99.9999%

Redundancy concepts

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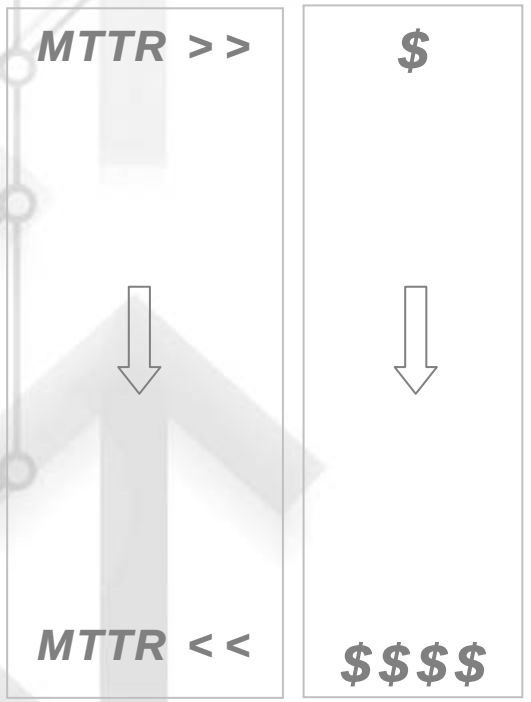
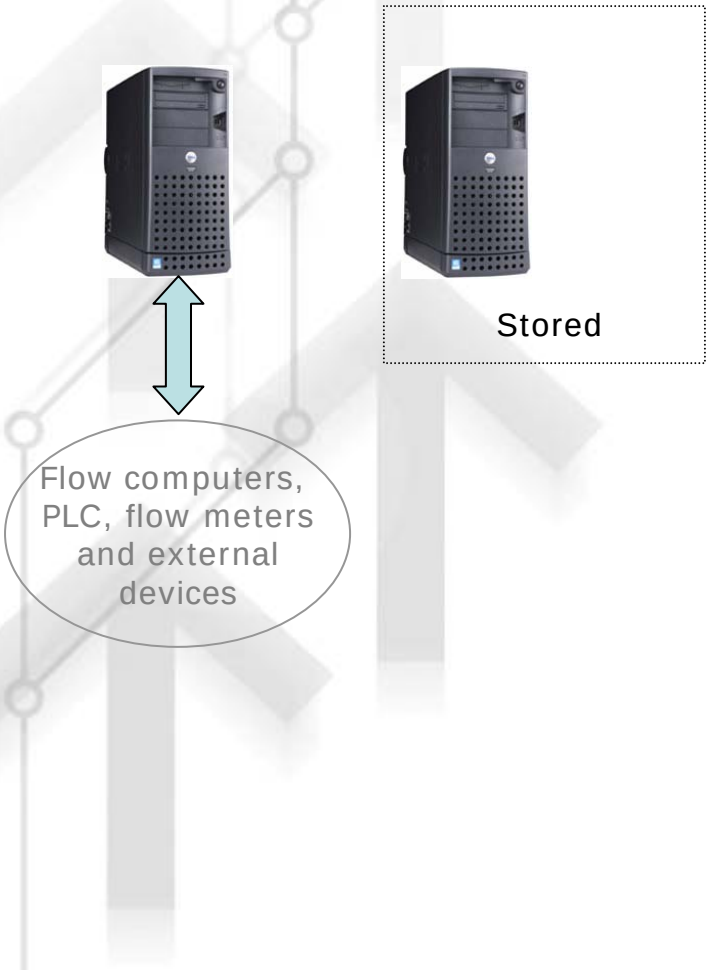
- No spare
- In-house spare
- Cold-standby redundancy
- Warm-standby redundancy
- Hardware-only redundancy
- Autonomous hot-standby redundancy (also called dual redundant)
- Synchronized hot-standby redundancy (also called duty / standby)



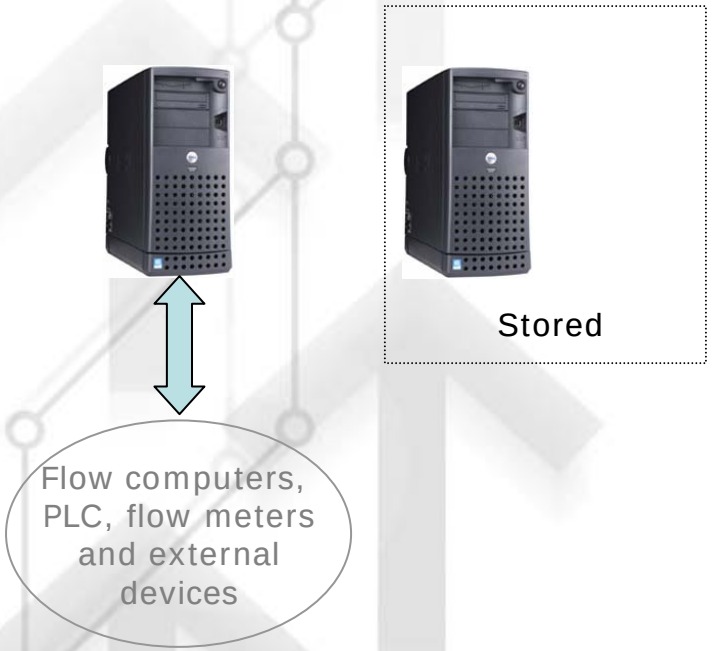
In-house spare

- Just a partial spare (H/W only)
- Software not installed
- Not tested
- MTTR >>



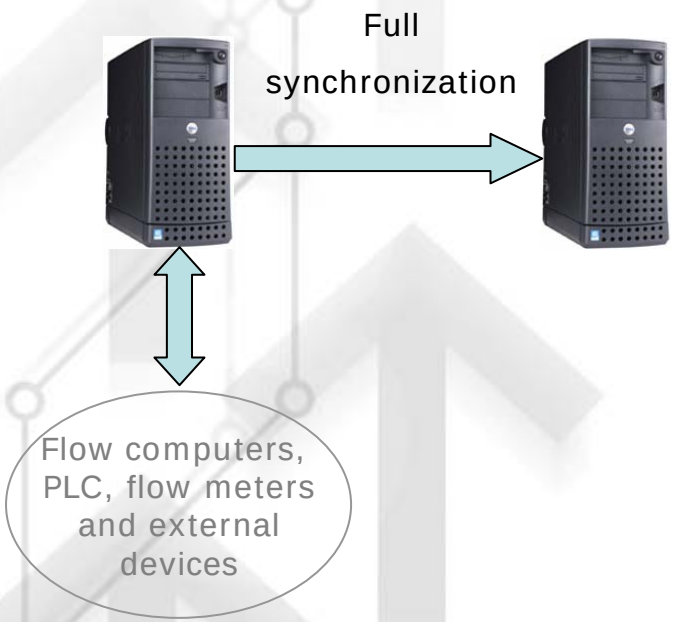
Cold-standby redundancy

- Pre-installed AND Pre-tested
- Cost-effective
- Standby component does not wear out
- System will be out of operation during replacement
- History data is not retained after replacement
- MTTR >
- Not often used !



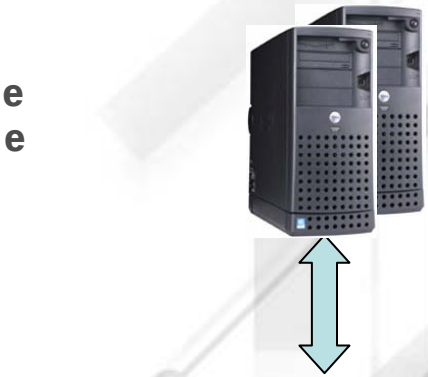
Warm-standby redundancy

- No additional cabinet space required
- No complex redundancy software required
- Standby component wears out as well
- Also serves as a data backup
- Full data history is retained
- MTTR <
- Hardly ever used



Hardware-only redundancy

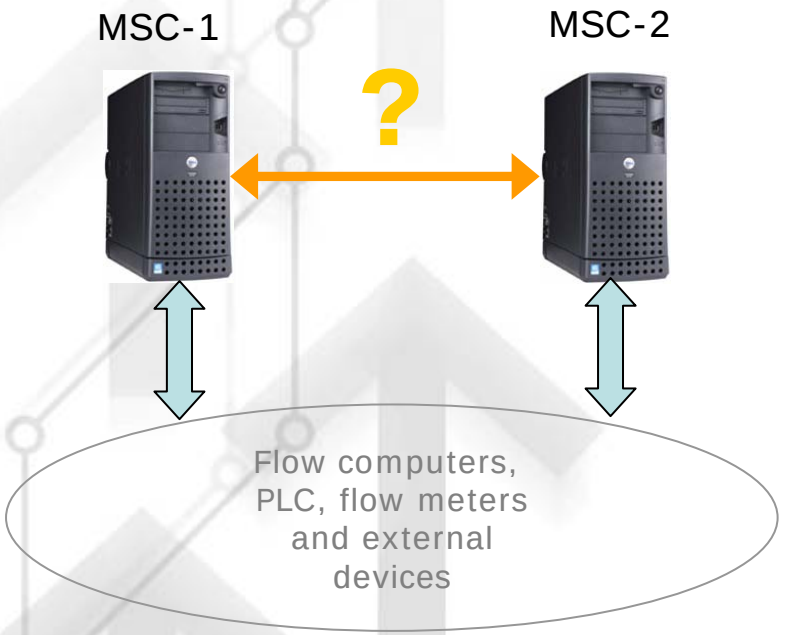
- Software is still a single point-of-failure
- Preferred by system integrators that use software products with no or inadequate redundancy functionality
- MTTR ???



Flow computers, PLC, flow meters and external devices

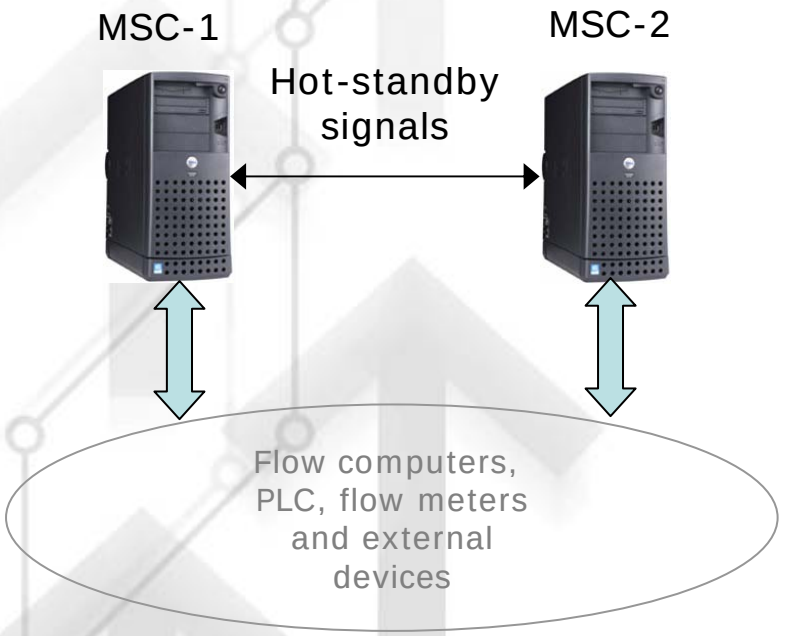
Hot-standby redundancy

- No system down time
- No interruption in operations
- No manual intervention required
- Requires additional cabinet space
- Standby component wears out at equal rate
- MTTR <<



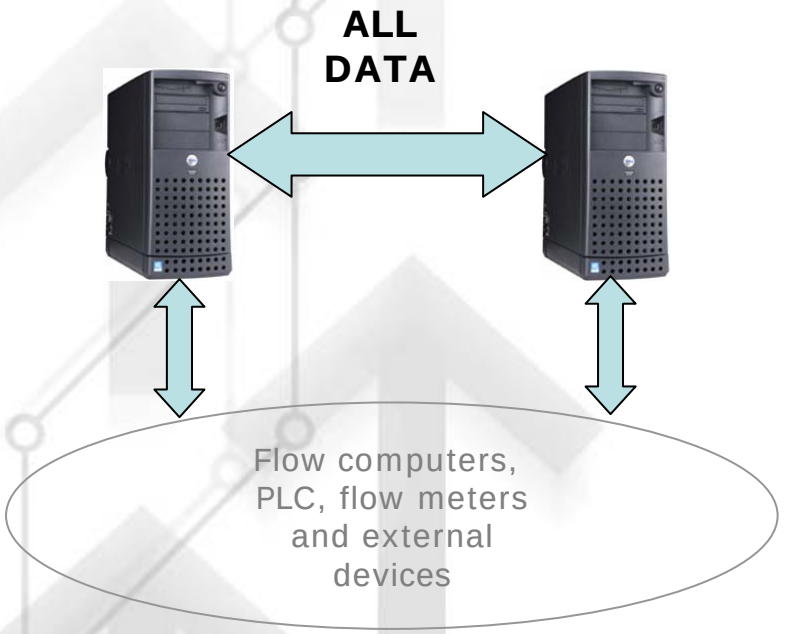
Autonomous hot-standby

- **Independent components**
  Virtually no chance that failing component infects healthy component
- **No complex data synchronization software required**
- **Only very limited exchange of data**
- **Autonomous = Not synchronized**
  - Two different operator interfaces
  - Two different sets of historical data
  - Incomplete report and data history



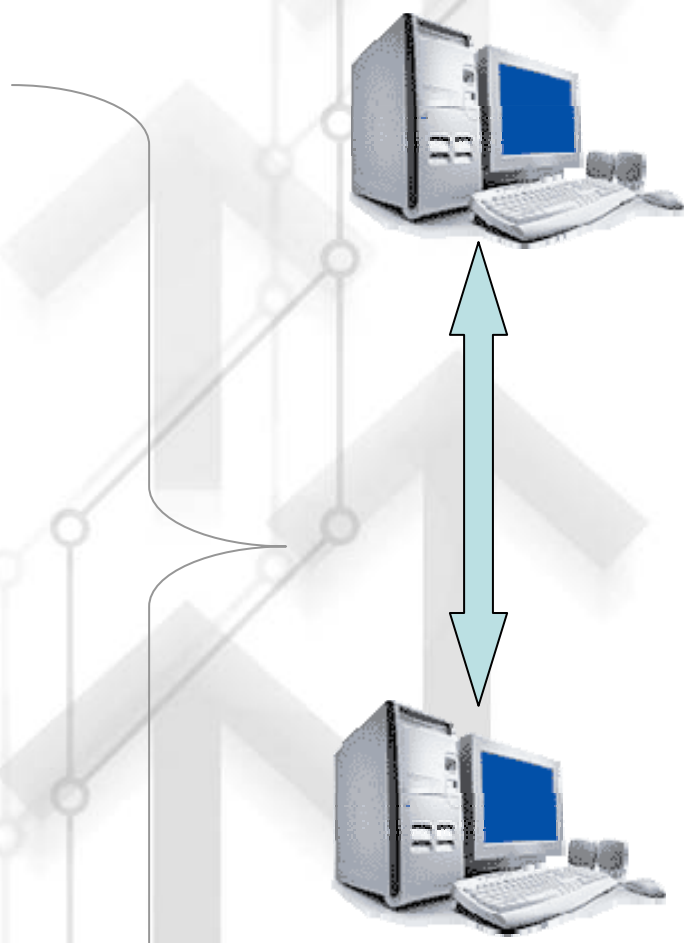
Synchronized hot-standby

- **Single transparent operator interface**
- **Uniform and complete set of reports**
- **Uniform and complete historical data**
- **Several scenarios:**
  - Only at startup
  - On manual command
  - Continuous
- **Requires sophisticated bi-directional data synchronization software**
- **In case of poor software the failing component might infect healthy component**



MSC Data Synchronization

- I/O from & to hardware devices
- Parameters and settings
- Relational database
- Alarm summary and history
- Reports
- Trended data
- Operator commands
- Supervisory control logic



Only very few SCADA packages support it fully

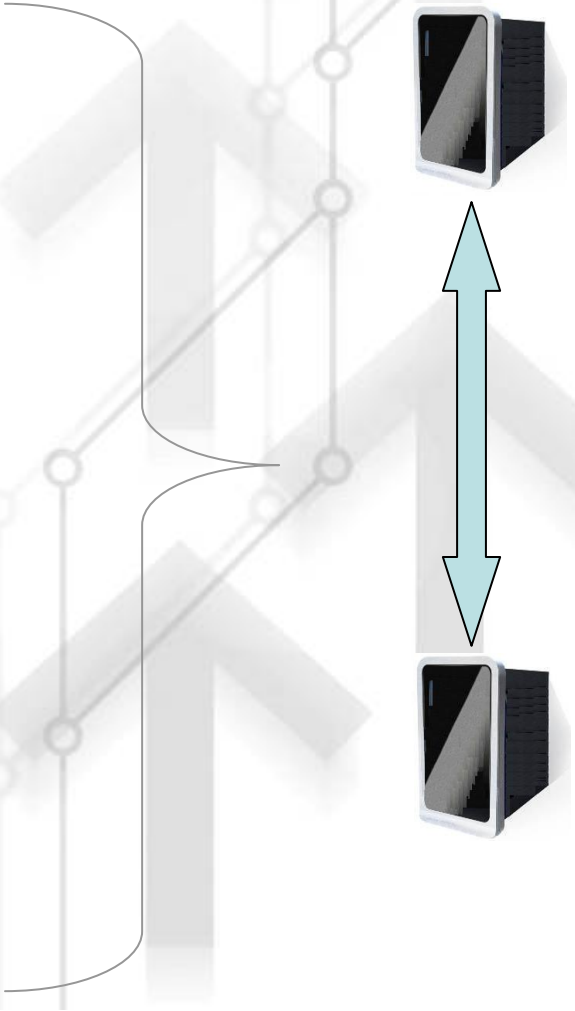
FC Data Synchronization

- Control data (flow control, MOV's, sampling, proving)
- Parameters and settings
- Alarms
- Operator commands

and even …

- Totals and averages
- Meter tickets and prove reports
- Event log and audit trail

Very limited support by current FC's



Non-synchronized data - MSC

- **Operator acknowledges alarm on MSC-1 only**

MSC-1

Timestamp	Name	Location	Type	Description	Limit	Units
24/10/07 14:50:42	FT-205-4B Connection Lost	FlowComputer	Status Alarm	Connection lost with FT-205	1	
24/10/07 14:50:42	MOV-1 Fault	Stream 1	Status Alarm	MOV-1 reports Fault	1	
24/10/07 14:54:55	FT-205-3A Pressure	FT_205_4A	High Alarm	Pressure value of Stream 1	14.9	bar
24/10/07 14:54:55	FT-205-3A Pressure	FT_205_4A	HiHi Alarm	Pressure value of Stream 1	14.99	bar
24/10/07 14:54:55	FT-205-2A Temperature	FT_205_4A	High Alarm	Temperature value of Stream 1	24.9	°C
24/10/07 14:54:55	FT-205-2A Temperature	FT_205_4A	HiHi Alarm	Temperature value of Stream 1	24.99	°C
24/10/07 14:54:55	FT-205-2B Temperature	FT_205_4B	Low Alarm	Temperature value of Stream 2	17.1	°C
24/10/07 14:50:42	FT-205-3A Pressure	FT_205_4A	LoLo Alarm	Pressure value of Stream 1	10.02	bar
24/10/07 14:50:42	FT-205-3A Pressure	FT_205_4A	Low Alarm	Pressure value of Stream 1	10.1	bar

?

MSC-2

Timestamp	Name	Location	Type	Description	Limit	Units
24/10/07 14:52:32	FT-205-3A Pressure	FT_205_4A	High Alarm	Pressure value of Stream 1	14.9	bar
24/10/07 14:52:32	FT-205-3A Pressure	FT_205_4A	HiHi Alarm	Pressure value of Stream 1	14.99	bar
24/10/07 14:52:30	FT-205-2A Temperature	FT_205_4A	High Alarm	Temperature value of Stream 1	24.9	°C
24/10/07 14:52:30	FT-205-2A Temperature	FT_205_4A	HiHi Alarm	Temperature value of Stream 1	24.99	°C
24/10/07 14:50:42	FT-205-4B Connection Lost	FlowComputer	Status Alarm	Connection lost with FT-205	1	
24/10/07 14:50:42	MOV-1 Fault	Stream 1	Status Alarm	MOV-1 reports Fault	1	
24/10/07 14:51:15	FT-205-2B Temperature	FT_205_4B	Low Alarm	Temperature value of Stream 2	17.1	°C
24/10/07 14:50:42	FT-205-3A Pressure	FT_205_4A	LoLo Alarm	Pressure value of Stream 1	10.02	bar
24/10/07 14:50:42	FT-205-3A Pressure	FT_205_4A	Low Alarm	Pressure value of Stream 1	10.1	bar

Non-synchronized data - MSC

- **Different reports**

1. Original report from MSC-1

Final Loading Report		Nomination: 008643	
14-Dec-06 12:15 14-Dec-06 18:43	**FM-073**	**Sm3**	**12223**
14-Dec-06 12:32 15-Dec-06 00:56	FM-074	Sm3	87564
14-Dec-06 20:21 15-Dec-06 00:58	FM-073	Sm3	45682
Total		Sm3	145469

2. Reprinted report from MSC-2 (MSC-2 was down for a short time at 14-Dec)

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Final Loading Report		Nomination: 008643	
14-Dec-06 12:32 14-Dec-06 00:56	FM-074	Sm3	87564
14-Dec-06 20:21 15-Dec-06 00:58	FM-073	Sm3	45682
Total		Sm3	133246

Non-synchronized data - MSC

- Gap in audit trail

```
26/08/2007 06:04:51.342 -  Operator FGH has changed Butane SG from 0.520 to 0.524
26/08/2007 06:04:51.342 -  Operator FGH has issued the Start Loading command for Berth 51
26/08/2007 06:06:54.816 -  FM073_FLOWRATE_LOALM - FM073 -Flow Rate - Low Alarm - changed from Alarm to Normal
26/08/2007 06:06:57.831 -  FM073_FLOWRATE_LOALM - FM073 -Flow Rate - Low Alarm - changed from Normal to Alarm
26/08/2007 06:08:22.817 -  FM074_PLC_ALARM_4 - PLC FM-074 Valves not in auto mode - changed from Normal to Alarm
26/08/2007 06:09:24.286 -  S1_XI_029D - MOV-029 Travel time-out, C3 To L-607 - changed from Alarm to Normal
26/08/2007 06:11:26.848 -  S1_XI_029G - MOV-029 Valve interlock, C3 To L-607 - changed from Alarm to Normal
26/08/2007 06:13:46.800 -  S1_XS_608 - Interlock Violation AT L-608 - changed from Alarm to Normal
26/08/2007 06:20:18.598 -  LOAD52_WARNING1_C4 - Berth 52 loading of butane 90 perc completed - changed from Alarm to Normal
26/08/2007 06:24:14.020 -  S1_XS_608 - Interlock Violation AT L-608 - changed from Normal to Alarm
26/08/2007 06:24:50.816 -  FM073_FLOWRATE_LOALM - FM073 -Flow Rate - Low Alarm - changed from Alarm to Normal
26/08/2007 06:25:52.863 -  FM062_PRESPROC_DEV - FM062 - FC deviation pressure Alarm - changed from Normal to Alarm
26/08/2007 06:26:02.847 -  S1_XI_101D - MOV-101 Travel time-out, FM074 To Berth 52 - changed from Alarm to Normal
26/08/2007 06:26:05.848 -  FM074_PLC_ALARM_4 - PLC FM-074 Valves not in auto mode - changed from Alarm to Normal
26/08/2007 06:26:12.832 -  FM073_FLOWRATE_LOALM - FM073 -Flow Rate - Low Alarm - changed from Alarm to Normal
26/08/2007 06:57:30.864 -  FM073_TEMPPROC_DEV - FM073 - FC deviation temperature Alarm - changed from Normal to Alarm
26/08/2007 07:00:22.113 -  Operator FGH has issued the Open Valve command for MOV-022 L-608 To Vapour

*** FROM THE AUDIT TRAIL IT IS UNKNOWN WHAT HAPPENED BETWEEN 07:00:22 and 08:27:12 ***

26/08/2007 08:27:12.848 -  FM053_PLC_ALARM_4 - PLC FM-053 Valves not in auto mode - changed from Normal to Alarm
26/08/2007 08:28:10.894 -  FM053_PLC_ALARM_4 - PLC FM-053 Valves not in auto mode - changed from Alarm to Normal
26/08/2007 08:29:37.848 -  S1_XI_105C - MOV-105 Local operation, FM052 To 16 inch Prover - changed from Normal to Alarm
26/08/2007 08:30:35.847 -  S1_XI_060D - MOV-060 Travel time-out, C4 To FM053 - changed from Normal to Alarm
26/08/2007 08:33:23.848 -  S1_XI_105C - MOV-105 Local operation, FM052 To 16 inch Prover - changed from Alarm to Normal
```

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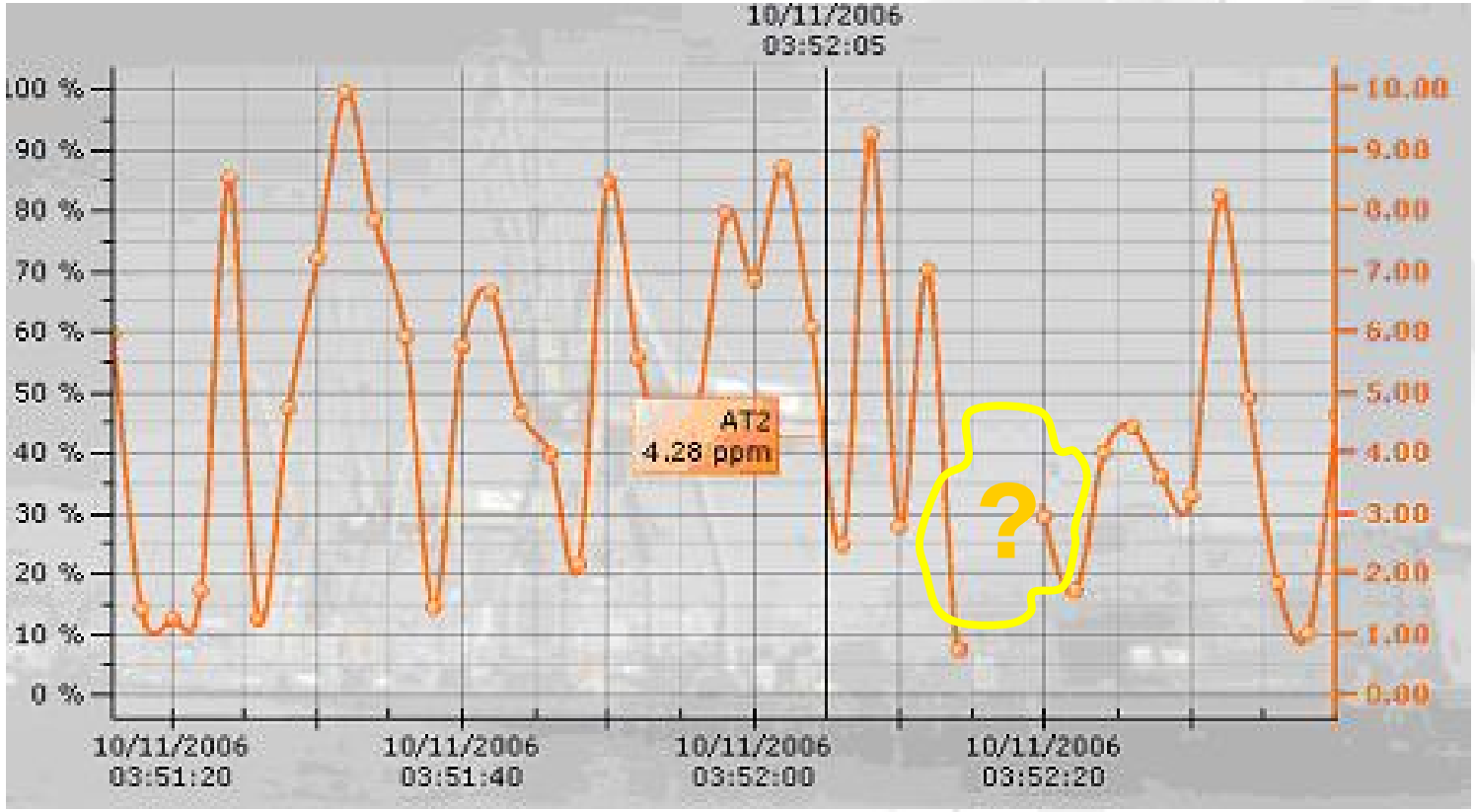
Non-synchronized data - MSC

- Missing trending data



Non-synchronized data - FC

- **Flow computer master / slave switch-over**

1. Primary flow computer is used for reporting

Flow meter		FM-098
Meter ticket		000459
Batch Opening Total	m3	007573332
Batch Closing Total	m3	007585435
Batch Volume	m3	000012103

?

2. Primary flow computer fails, secondary flow computer takes over control

Flow meter		FM-098
Meter ticket		000320
Batch Opening Total	m3	000048563
Batch Closing Total	m3	000051787
Batch Volume	m3	000003224

Non-synchronized data - FC

- **Parameter values need to be entered twice**

Primary flow computer	Meter K-factor	:	1143.591
Secondary flow computer	Meter K-factor	:	1143.519

Conclusions

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- **Use high-quality components (with industrial specs)**
- **Data transparency is crucial to plant operations**
- **Avoid custom-made software for ‘standard’ functionality**
- **Make data synchronization part of the FAT**
- **Make software installation part of the FAT**
- **Use ‘cold-standby’ spares**
- **Be aware of common mode failures** (e.g Ethernet switch)

QUESTIONS ?