

Trace It, Trust It: Making HAZOP & LOPA Work Together

5th EPSC Safety Congress– Aachen

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HIMA

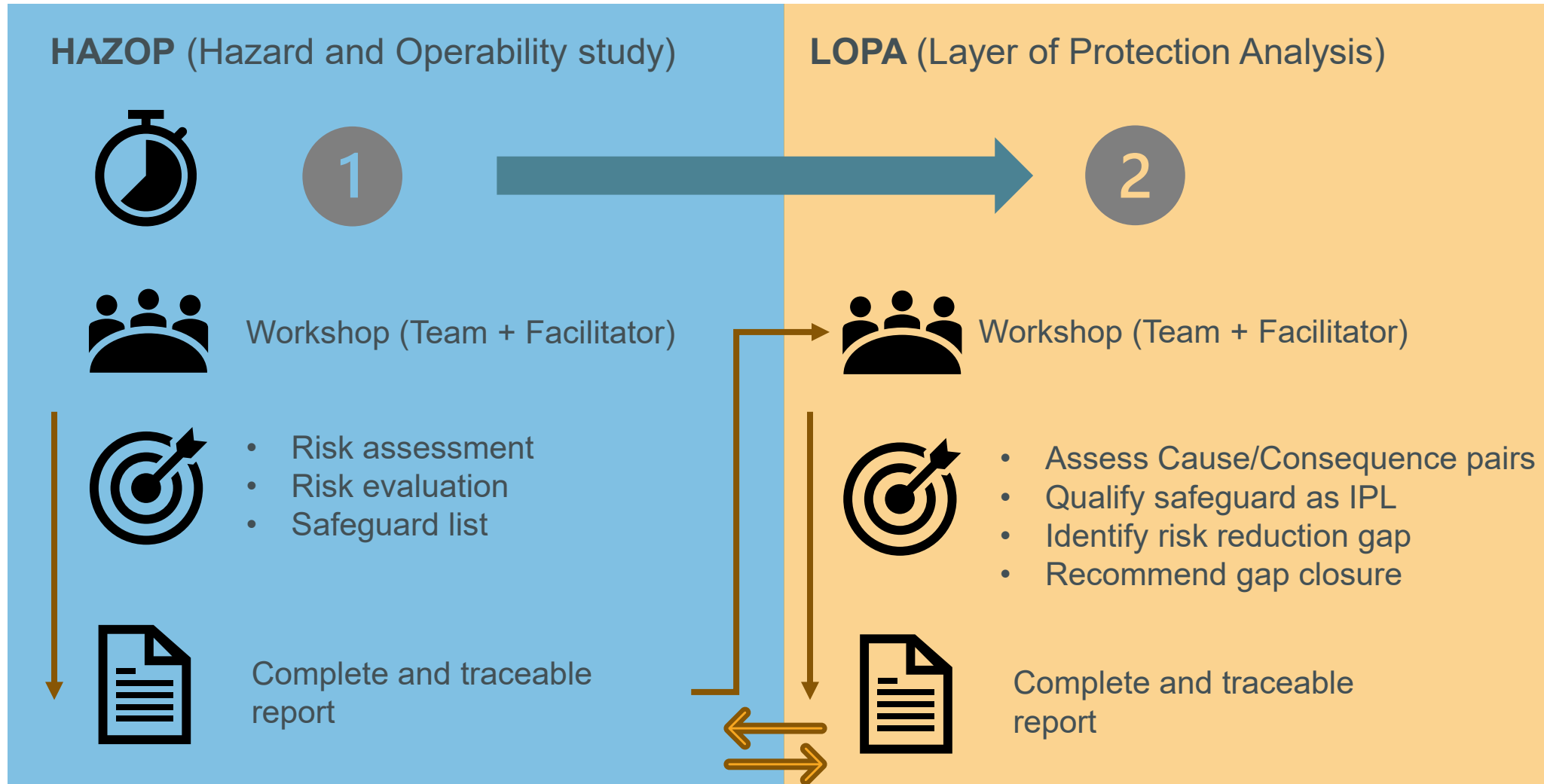


SMART
SAFETY.

#safetygoesdigital

HAZOP and LOPA studies

What we would like



HAZOP and LOPA studies

What is often in reality

HAZOP (Hazard and Operability study)



1



Workshop (Team + Facilitator)



- Risk assessment
- Risk evaluation
- Safeguard list



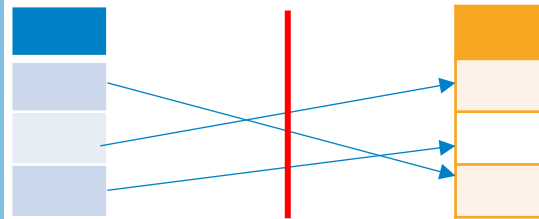
Complete and traceable report



Months



≠



LOPA (Layer of Protection Analysis)

2



Workshop (Team + Facilitator)



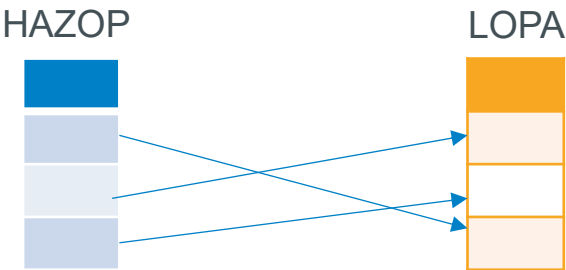
- Assess Cause/Consequence pairs
- Qualify safeguard as IPL
- Identify risk reduction gap
- Recommend gap closure



Complete and traceable report

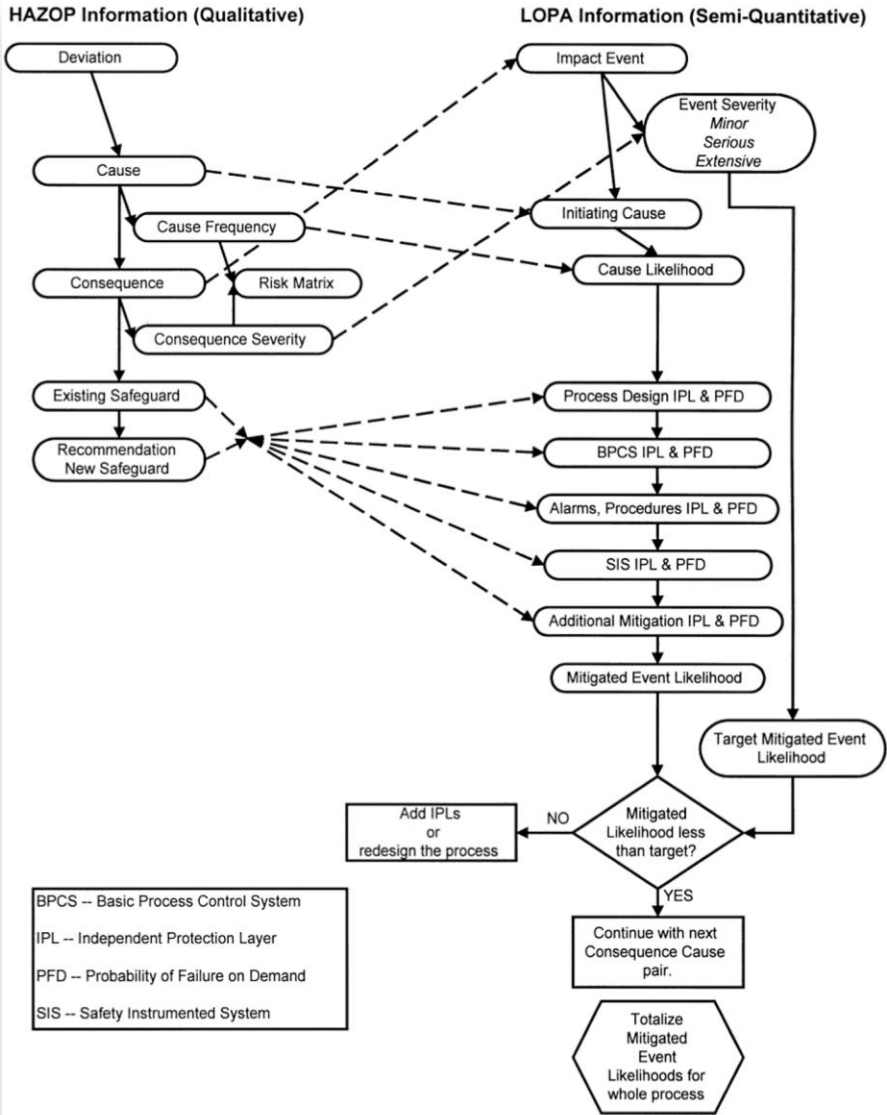
What to connect to keep traceability

Traceability = Proper data mapping



Data mapping is given, it is rule based and known since a while.

How well is it systematically applied?



What to connect to keep traceability

Example of real experience

Let's test the traceability between HAZOP and LOPA in a real example starting from LOPA and going back

What I searched in order

- ✗ HAZOP ref node / deviation
- ✗ initiating cause = cause
- ✗ Impact event = consequence
- ✗ SIF tag
- ✓ Tag included in the initiating cause

Finding one link, I should have taken some **assumptions** to build a real connection between HAZOP and LOPA scenarios.

Is it a traceable and auditable situation?

Likelihood values are events per year; other numerical values are probabilities of failure on demand average.												
Ref Tag ID	Impact Event Description	Severity Level	Initiating Cause	Initiation Likelihood (events per year)	Protection layers (PLs) and					Intermediate Event Likelihood (per year)	SIF Integrity Level & PFD	Target Mitigated Event Likelihood (events per year)
					General Process Design (probability)	BPCS (probability)	Alarms, Etc. (probability)	Additional Mitigation, Restricted Access (probability)	IPL Additional Mitigation Dikes, Pressure Relief (probability)			
ESD No.:			Sensors:	LSHH-0002A/B/C								
P&ID No.:			Final Elements:	UV-0001A/B - C								
	Overpressure and rupture of NHT Feed Surge Drum.	Safety 4	Cause 1	FV-0003				Ignition Probability	PSV-0001A/B		In IL a range	1.00E-04
				0.10				0.10	0.01	1.00E-04		
			Cause 2	FV-0004				Ignition Probability	PSV-0001A/B			
				0.1				0.10	0.01	1.00E-04		
			Cause 3									
			Cause 4									
										2.00E-04	5.00E-01	1.00E-04

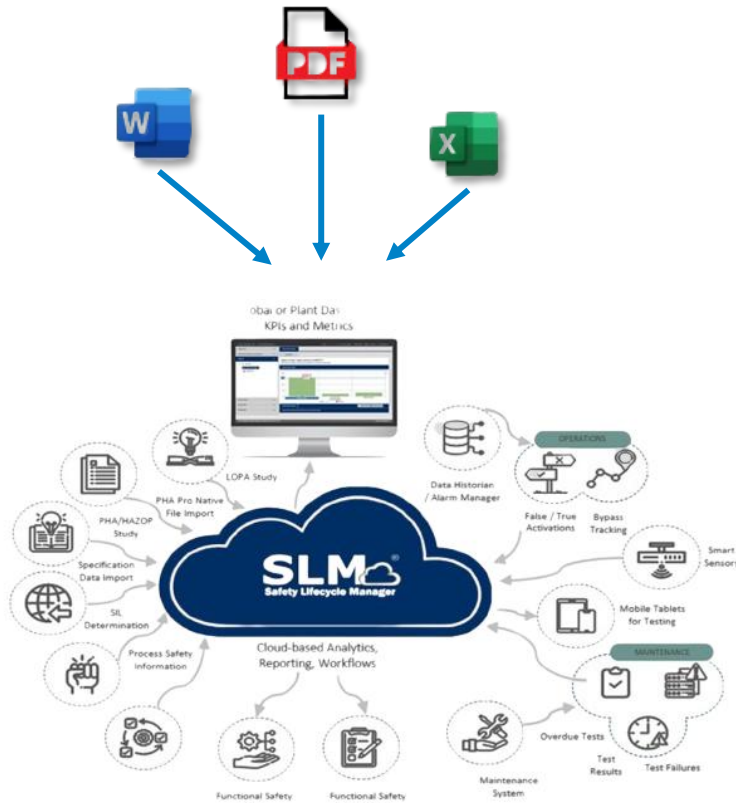
DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R
	9. FV-0004 fails closed, sticks closed, mismanaged closed or blocked in.	9.1. Possible decreased level in NHT feed surge drum. Possible damage to feed pump due to cavitation.	9.1.1. LIC-0003 to open FV-0004 and FV-0003. 9.1.2. Operator intervention. 9.1.3. LALL-0002 interlock to stop pump.	C	4	4

This was the easiest example; in many cases was not possible even to assume

What was the task and how it ended up?

Digitalization project to trigger quality improvement

Customer requested to digitalize the entire Functional Safety Lifecycle.



Low
quality of
inputs



Option 1: digitalize as it is.



**Option 2: quality is raised and
THEN is digitalized.**



What was the task and how it ended up?

Digitalization project to trigger quality improvement

A clear link between HAZOP scenario and LOPA worksheet was build together with the customer.

PARAMETER: Flow

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	S	L	R
More Flow (Naphtha from storage)		spec product.				
	17. FV-0003 sticks open, mismanaged open or bypassed.	17.1. Increased level in NHT feed surge drum. Possible overpressure of NHT feed surge drum. Possible release of naphtha. Potential fire.	17.1.1. LAHH-0002 interlock to close UV-0001.	B	4	4
			17.1.2. PSV-0001A/B sized for this scenario.			

Likelihood values are events per year; other numerical values are probabilities of failure on demand average.														
Ref Tag ID	1	2	3	4	5					6	7	8	9	10
Impact Event Description	Severity Level	Initiating Cause	Initiation Likelihood (events per year)	Protection layers (PLs) and										
General Process Design (probability)	BPCS (probability)	Alarms, Etc. (probability)	Additional Mitigation, Restricted Access (probability)	IPL Additional Mitigation Dikes, Pressure Relief (probability)	Intermediate Event Likelihood (per year)	SIF Integrity Level & PFD	Target Mitigated Event Likelihood (events per year)							
ESD No.:	Sensors:			LSHH-0002A/B/C										
P&ID No.:	Final Elements:			UV-0001A/B - C										
Overpressure and rupture of NHT Feed Surge Drum		HAZOP Cause 1 scenario	FV-0003					Ignition Probability	PSV-0001A/B					
			0.10					0.10	0.01	1.00E-04				

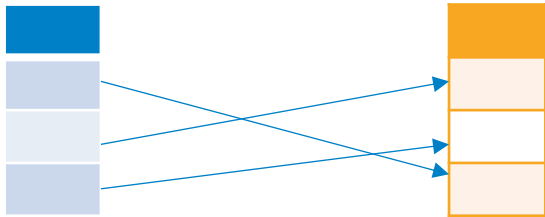
End of the story: It was possible to digitalize HAZOP and LOPA improving their quality and data mapping ensuring clear traceability.

What if?



What if customer had started digitally?

Reduce manual operation and trust digital solution



Modern Functional Safety / Process Safety digital platforms automate the needed mapping

Real example:

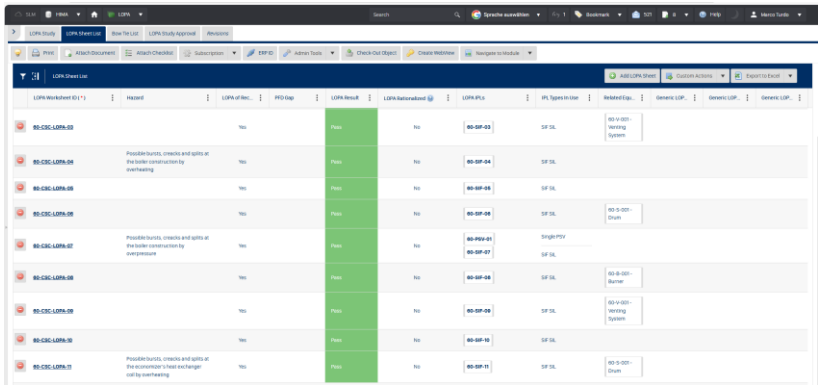
The image displays two screenshots of digital safety platforms, with a large black arrow pointing from the left screenshot to the right one. The left screenshot shows a 'HAZOP Node Facilitation' interface. It features a table with columns for 'Scenario ID', 'Mark', 'Parameter', 'Guideline', 'Deviation', 'Cause', 'Cause Source', 'Cause Type', 'Cause', 'Consequence', 'Hazard Register', 'Barriers', and 'ID'. A yellow box highlights a 'Custom Actions' menu with options like 'Add Scenario' and 'Create LOPA'. Numbered callouts (1-5) point to specific elements: 1 points to a 'HAZOP SCENARIO-001' entry, 2 points to a 'Failure of control system (BPCS) opening main fuel gas control valve' description, 3 points to a 'Flame interruption and an uncontrolled entry of fuel gas to the combustion chamber leading to possible creation of explosion atmosphere' consequence, 4 points to a 'SA' barrier, and 5 points to a 'BPCS instrument loop failure' barrier. The right screenshot shows a 'LOPA Worksheet Approval' interface. It features a table with columns for 'LOPA ID', 'HAZOP Node No.', 'HAZOP Link', 'Severity', 'Description', 'Deviation', 'Consequence', 'THAL (yr)', 'Initiating Causes', 'Short Description', 'Cause Source', 'Cause Type', 'IEF', 'Applicable Enabling Events', 'Applicable PFLs', 'Applicable Conditional Modifiers', 'MEP w/CMs', 'LOPA Gap', and 'LOPA Result'. Numbered callouts (1-5) point to specific elements: 1 points to a 'Show HAZOP Scenario' button, 2 points to a 'Failure of control system (BPCS) opening main fuel gas control valve' description, 3 points to a 'Flame interruption and an uncontrolled entry of fuel gas to the combustion chamber leading to possible creation of explosion atmosphere' consequence, 4 points to a 'Severity' table, and 5 points to a 'BPCS instrument loop failure' description.

Now you can trace and trust data

Keep control over critical changes

Not only trust and trace, get more support from digitalized solutions

Scenario: HAZOP-LOPA revalidation



LOPA Description	LOPA ID	LOPA Type	LOPA Status	LOPA Category	LOPA Sub-category	LOPA Details
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-01	Yes	Yes	BO-CSC-01	SF 1A	BO-CSC-01-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-02	Yes	Yes	BO-CSC-02	SF 1A	BO-CSC-02-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-03	Yes	Yes	BO-CSC-03	SF 1A	BO-CSC-03-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-04	Yes	Yes	BO-CSC-04	SF 1A	BO-CSC-04-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-05	Yes	Yes	BO-CSC-05	SF 1A	BO-CSC-05-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-06	Yes	Yes	BO-CSC-06	SF 1A	BO-CSC-06-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-07	Yes	Yes	BO-CSC-07	SF 1A	BO-CSC-07-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-08	Yes	Yes	BO-CSC-08	SF 1A	BO-CSC-08-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-09	Yes	Yes	BO-CSC-09	SF 1A	BO-CSC-09-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-10	Yes	Yes	BO-CSC-10	SF 1A	BO-CSC-10-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-11	Yes	Yes	BO-CSC-11	SF 1A	BO-CSC-11-Boiler System

No Gap is present before revalidation in the LOPA report (after IPL implementation)

Hazop



Workshop (Team + Facilitator)

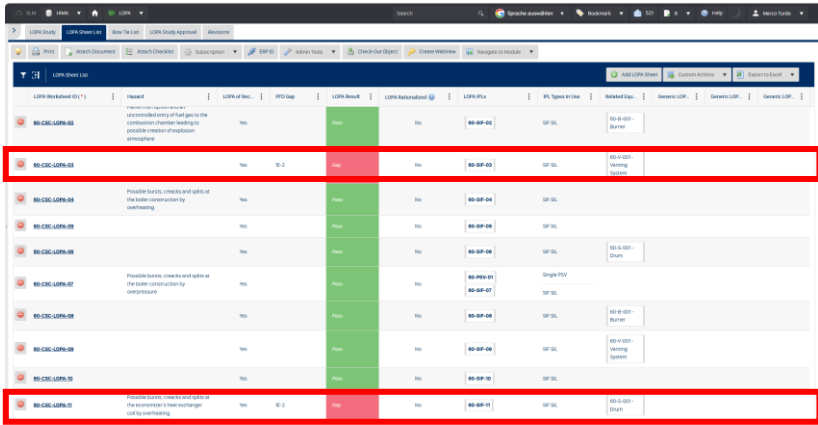


- Risk assessment
- Risk evaluation
- Safeguard list



Complete and traceable report

Changes

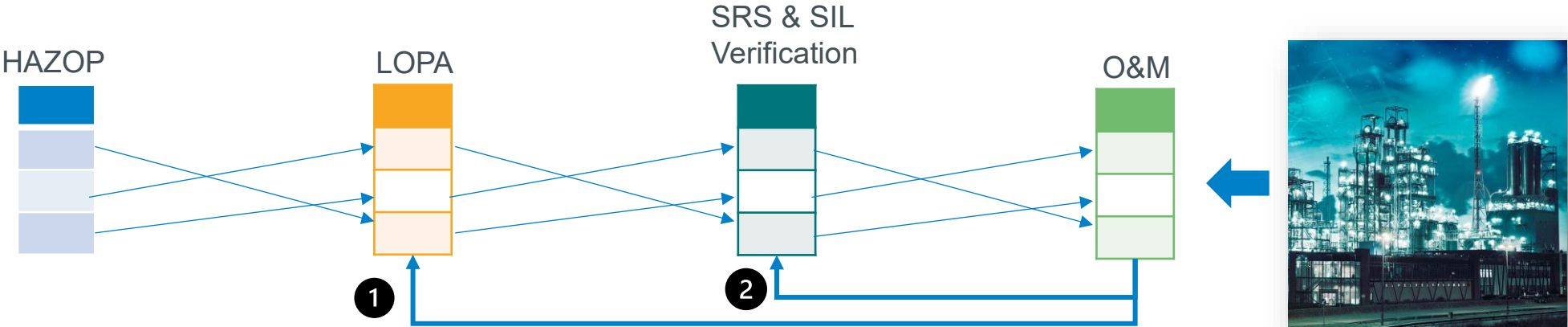


LOPA Description	LOPA ID	LOPA Type	LOPA Status	LOPA Category	LOPA Sub-category	LOPA Details
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-01	Yes	Yes	BO-CSC-01	SF 1A	BO-CSC-01-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-02	Yes	Yes	BO-CSC-02	SF 1A	BO-CSC-02-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-03	Yes	Yes	BO-CSC-03	SF 1A	BO-CSC-03-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-04	Yes	Yes	BO-CSC-04	SF 1A	BO-CSC-04-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-05	Yes	Yes	BO-CSC-05	SF 1A	BO-CSC-05-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-06	Yes	Yes	BO-CSC-06	SF 1A	BO-CSC-06-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-07	Yes	Yes	BO-CSC-07	SF 1A	BO-CSC-07-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-08	Yes	Yes	BO-CSC-08	SF 1A	BO-CSC-08-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-09	Yes	Yes	BO-CSC-09	SF 1A	BO-CSC-09-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-10	Yes	Yes	BO-CSC-10	SF 1A	BO-CSC-10-Boiler System
Process units, vessels and pipes at the boiler construction by overhauling	BO-CSC-LOPA-11	Yes	Yes	BO-CSC-11	SF 1A	BO-CSC-11-Boiler System

New Gaps are highlighted

Following the data journey

Think beyond LOPA



1 Example 1: IPL performance compliance is indicated during the LOPA

The screenshot shows a table of Independent Protection Layers (Barriers). The table has columns for Barrier ID, Barrier Category, Type, Long Description IPL, Assumed PFD, and Related Instrument. One barrier is listed: 60-SIF-09, Instrumented, SIF SIL, with a description: "In case of HH pressure in the combustion chamber, the SIF shutdowns the valve gas (also pilot) and the trip the FD fan to avoid damages". The Assumed PFD is 0.01. A related instrument 60-CSC-SIF-09 is also shown.

Barrier ID	Barrier Ca...	Type	Long Description IPL	Assumed PFD	Related Instrument
60-SIF-09	Instrumented	SIF SIL	In case of HH pressure in the combustion chamber, the SIF shutdowns the valve gas (also pilot) and the trip the FD fan to avoid damages	0.01	60-CSC-SIF-09

2 Example 2: Statistical failure rates are used for actual PFD calculation

The screenshot shows a table for Total RRF Calculation within 60-CSC-SIF-12. The table has columns for Failure Rate Source, Input Group PFD, Logic Solver PFD, UPS PFD, Output Group PFD, Total PFD, Total RRF, and MTTFs. The data is as follows:

Failure Rate Source	Input Group PFD	Logic Solver PFD	UPS PFD	Output Group PFD	Total PFD	Total RRF	MTTFs
Prior Use	5.11E-3	5E-5	N/A	7.05E-3	1.22E-2	82	65.67 yr
Custom Failure Rate	0E+0	5E-5	N/A	0E+0	N/A	N/A	0.00 yr
Design Basis Failure Rate	3.27E-8	5E-5	N/A	8.12E-6	5.82E-5	17195	0.00 yr
External Result	0E+0	5E-5	5E-5	0E+0	1E-4	10000	N/A

Some digital lifecycle management platforms allows quality, consistency and traceability during the entire functional safety lifecycle.

Conclusions



It does not matter if digitalized or not, we should be able to trust safety relevant data



Digitalized processes and platforms supports with built in data mapping and traceability



Behind tools and processes, key competences shall be available



Extended Safety Lifecycle Digitalization multiplies benefits within organizations

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