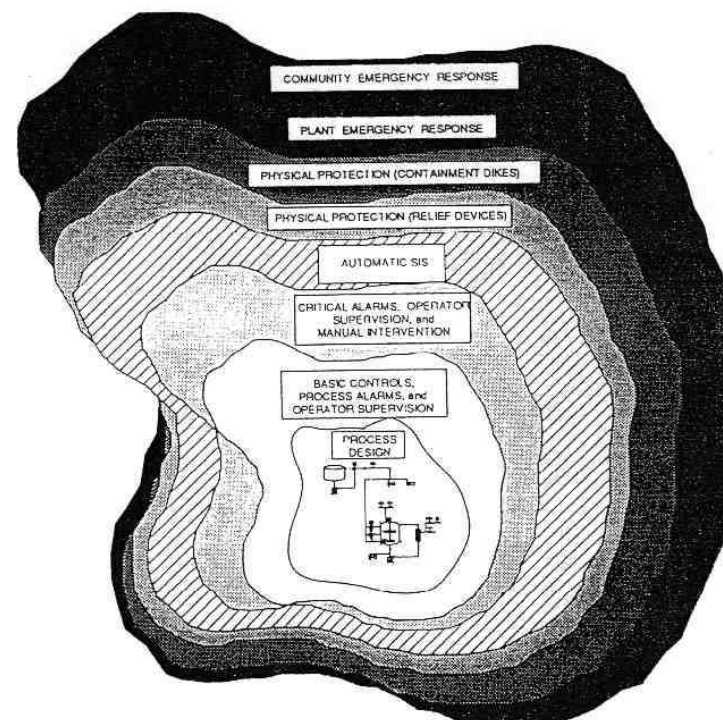




LOPA

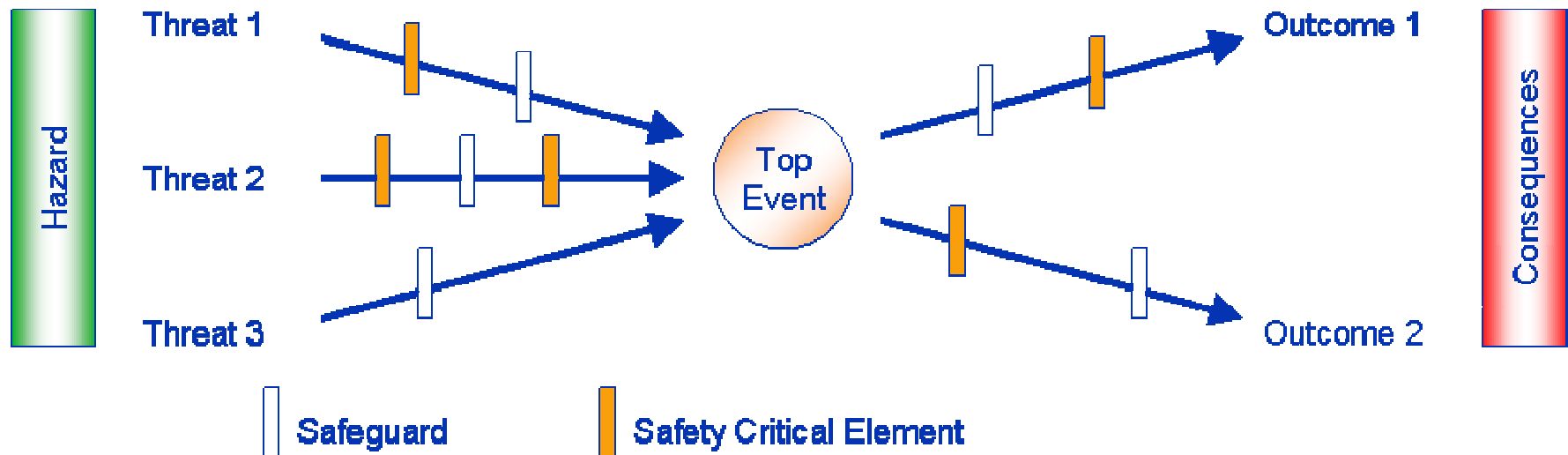
Layers Of Protection Analysis

- Simplified risk assessment method that supports decisions on safeguarding (selection of alternatives)
 - Looks at potential consequences of undesired events and their initial frequency, combined with a failure of all the protection layers (PLs)
- Typically uses order of magnitude categories for likelihood & consequence assessment
- Extension of PHA, but more rational/objective
- In combination with clear risk criteria, IPLs can be assessed for their effectiveness
- LOPA helps to decide how many protection layers should be used
- Qualitative → (semi-) quantitative

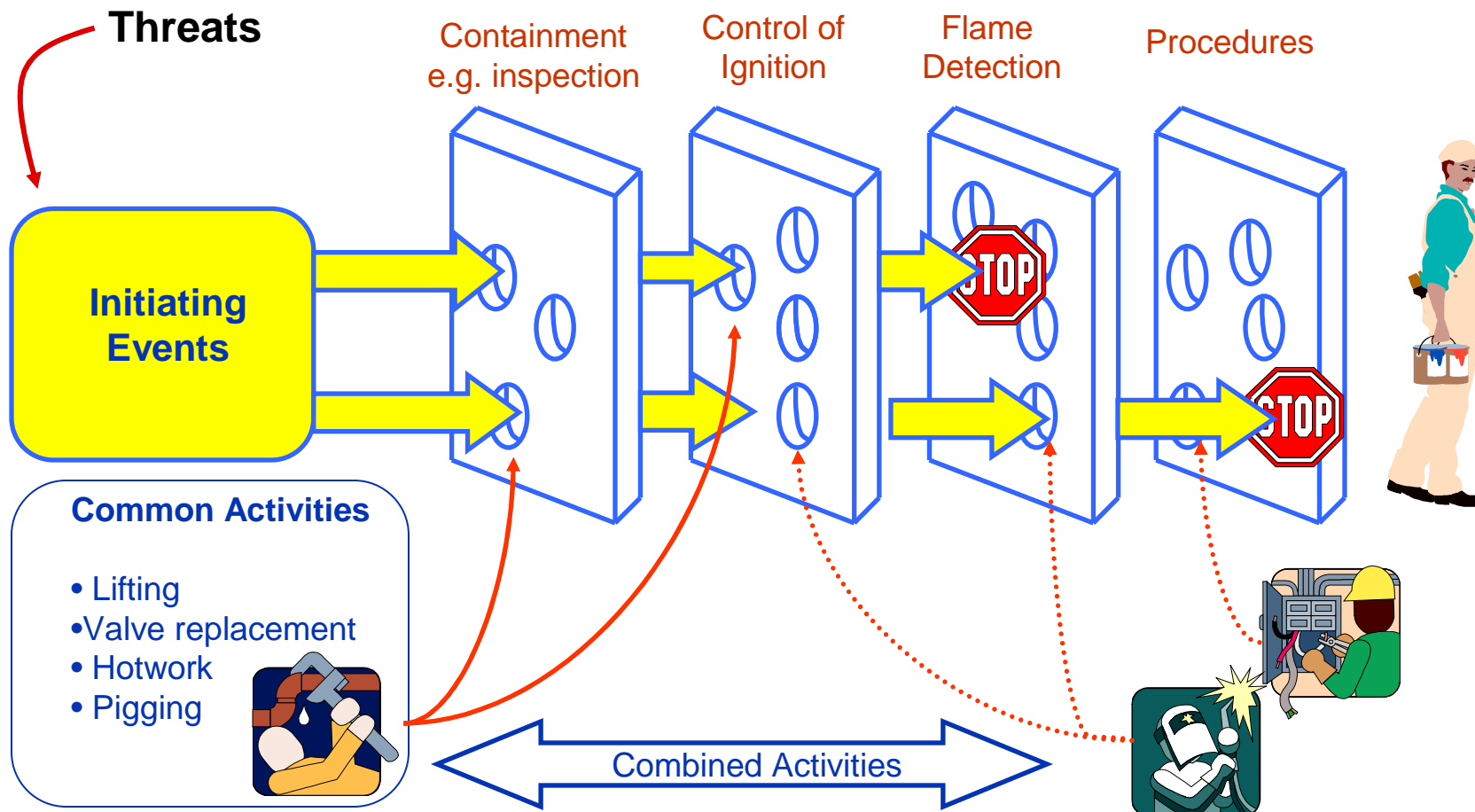


Independent Protection Layers (IPL)

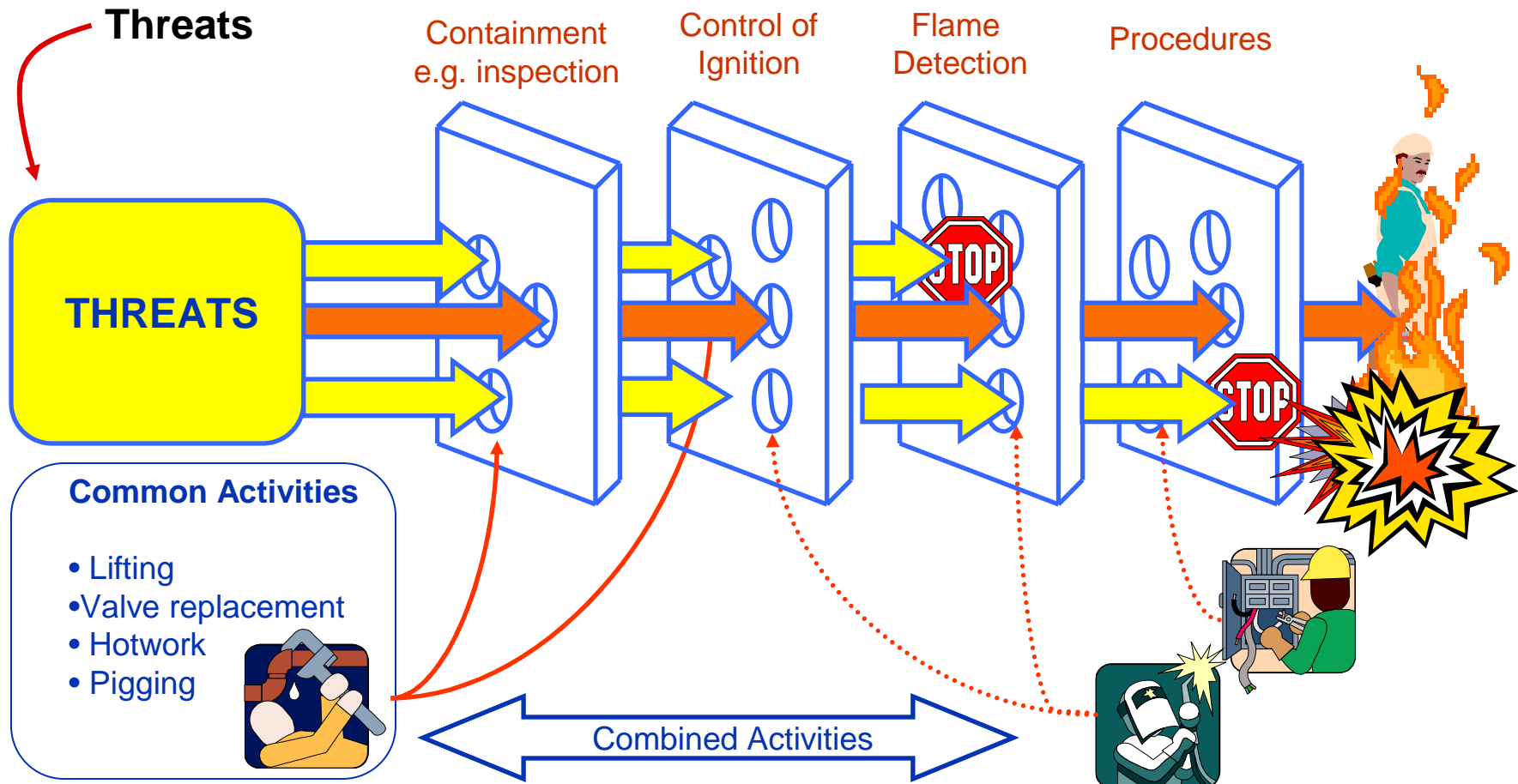
- Definition:
Device, system or action that is capable of preventing a scenario from proceeding to its undesired consequence independent of the initiating event or action of any other layer of protection associated with the scenario.
- The effectiveness and independence of an IPL must be auditable



Swiss Cheese Model of Accident



Swiss Cheese Model of Accident



Example LOPA table

Severity level C = Catastrophic, E = Extensive, S = Serious, M = Minor													
Likelihood values are events per year. Other numerical values are probabilities of failure on demand average.													
	1	2	3	4	5			6	7	8	9	10	11
					Protection layers (PLs)								
	Impact Event Description B.2	Severity Level B.3	Initiating Cause B.4	Initiation Likelihood B.5	General Process Design B.6.1	BPCS B.6.2	Alarms, Etc. B.6.3	Additional Mitigation, Restricted Access B.7	IPL Additional Mitigation, Bunds (Dikes), Pressure Relief B.8	Intermediate Event Likelihood B.9	SIF PFD B.10	Mitigated Event Likelihood B.11	Notes
	Fire from distillation column rupture (individual risk)	S _s	Loss of cooling water	0,5	1	0,1	0,1	0,1	1	5E-4	1E-2	5E-6	High pressure causes column rupture
	(four fatalities case)	E _s	Loss of cooling water	0,5	1	0,1	0,1	0,08	1	4E-4	1E-3	4E-7	
	Fire from distillation column rupture (one fatality)	S _s	Steam control loop failure	1	0,1	1	0,1	0,1	PRV 0,01	1E-5	1E-2	1E-7	High pressure causes column rupture
	(no multiple fatalities)	Not applicable											
	Repeat above cases for environmental and commercial risk analysis												
				Continued as required.									

- A reliable protection system is one that has a very small

Probability of Failure on Demand (PFD)

- Only a very small percentage of initiating events will turn into real accidents

$$F_A = F_{IE} \times PFD$$

- Also referred in the literature as
 - Average Unavailability on Demand (Q_{avg})
 - Fractional Dead Time (FDT)
 - Mean Fractional Dead Time (MFDT)



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