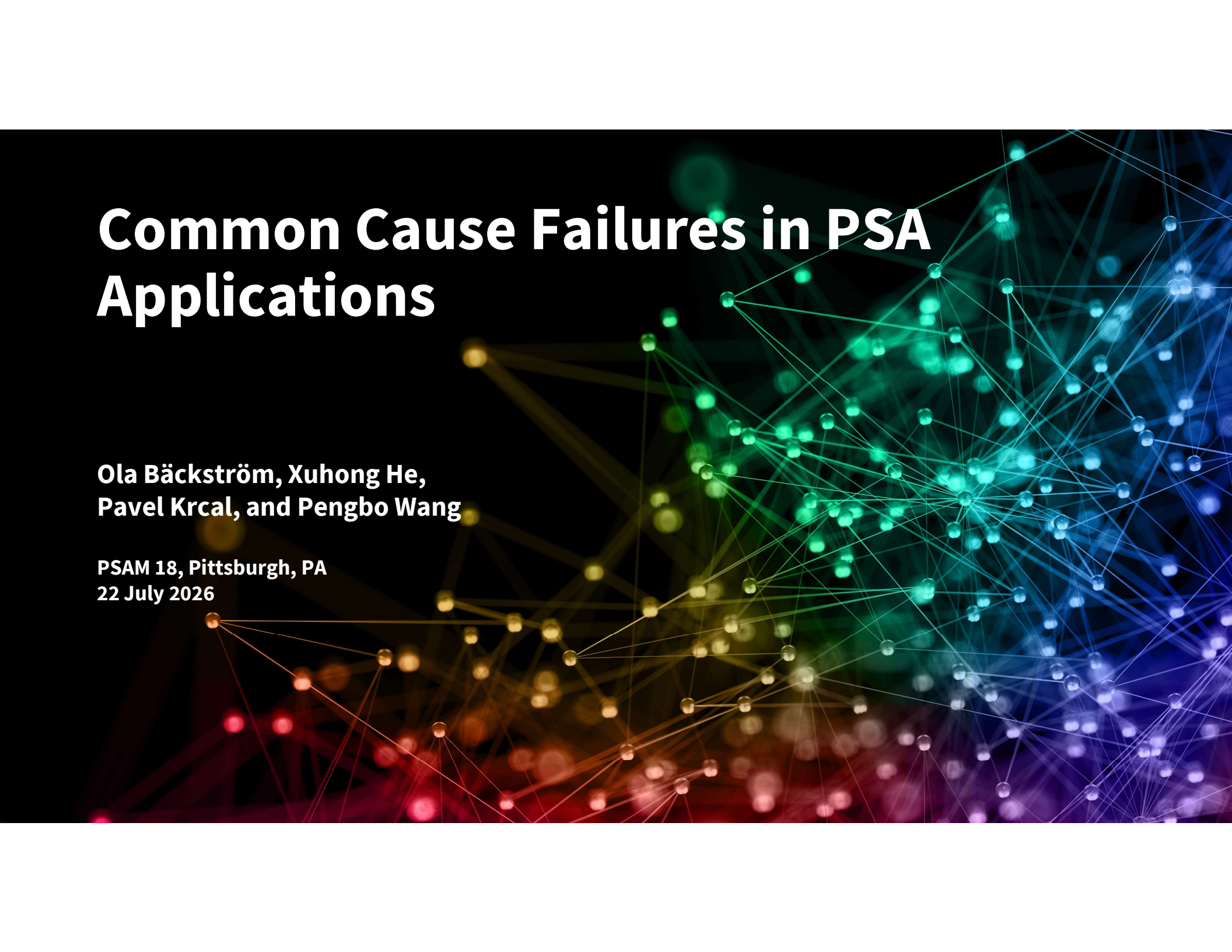


Common Cause Failures in PSA Applications

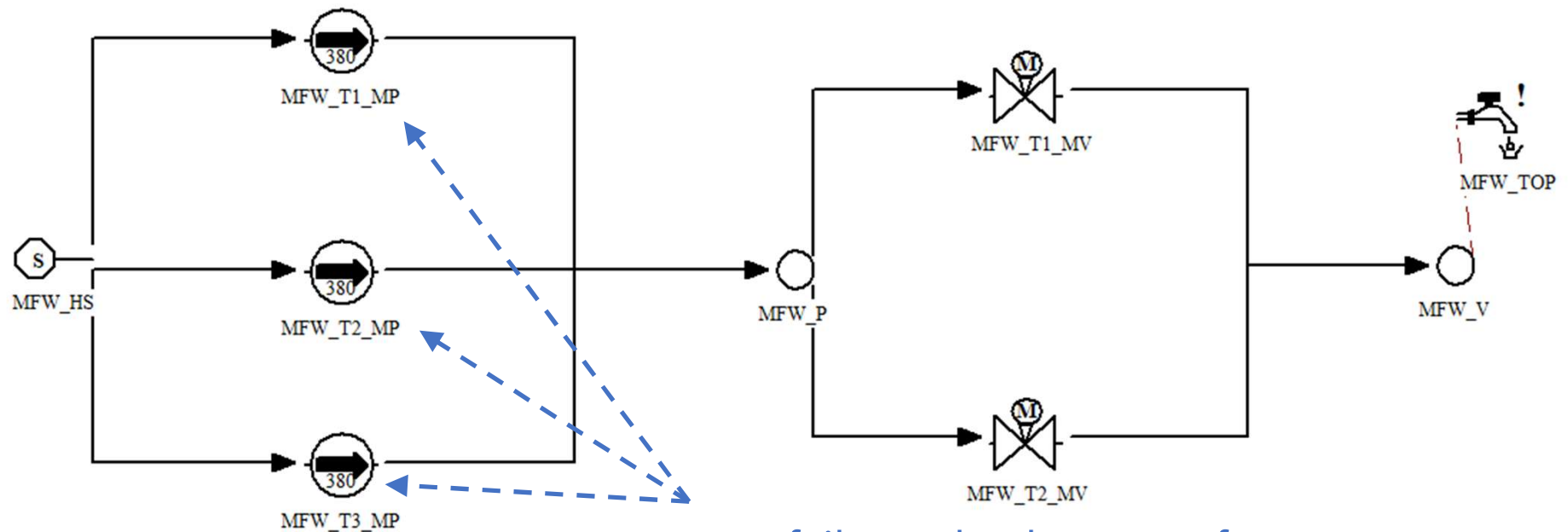


**Ola Bäckström, Xuhong He,
Pavel Krcal, and Pengbo Wang**

**PSAM 18, Pittsburgh, PA
22 July 2026**

Common Cause Failures

A counterweight on redundancy



May fail together because of a common cause

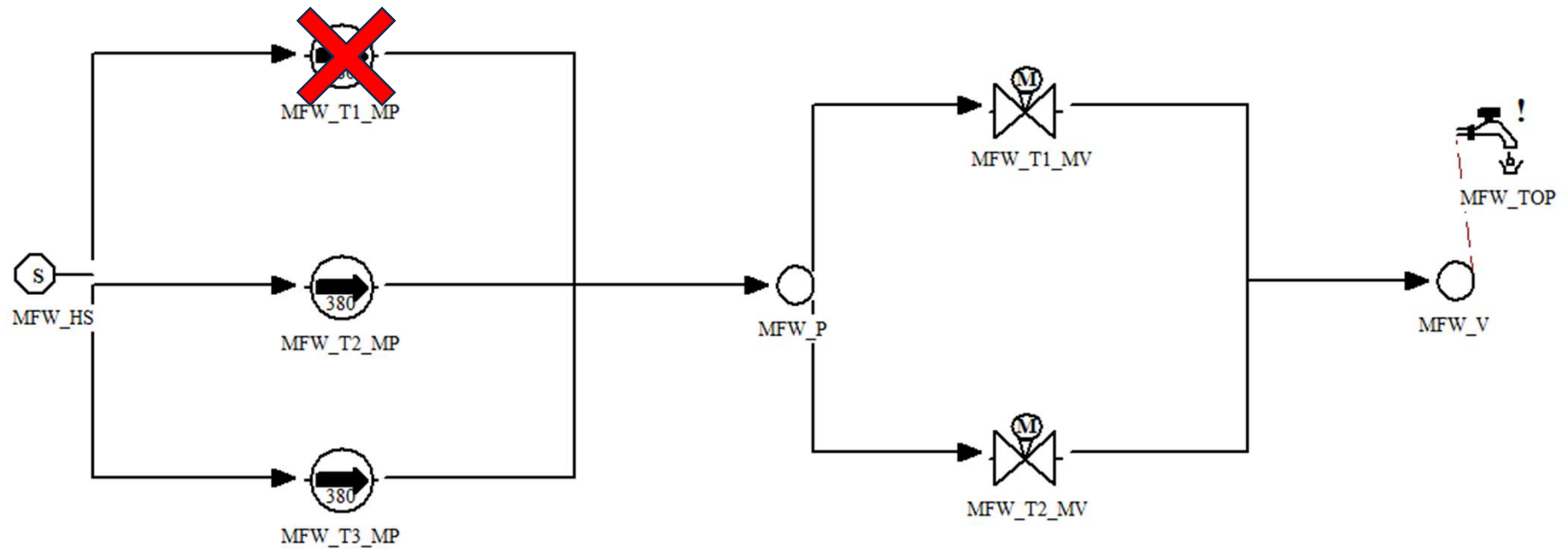
Applications

Use your PSA for more!

- Risk monitoring
- Significance determination process
- Importance analysis

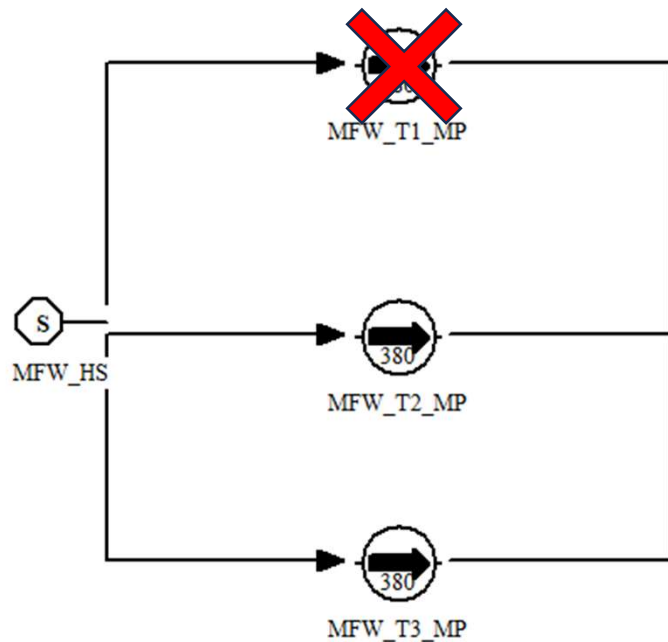
A Take-Out

How does it affect symmetrical components?



A Take-Out

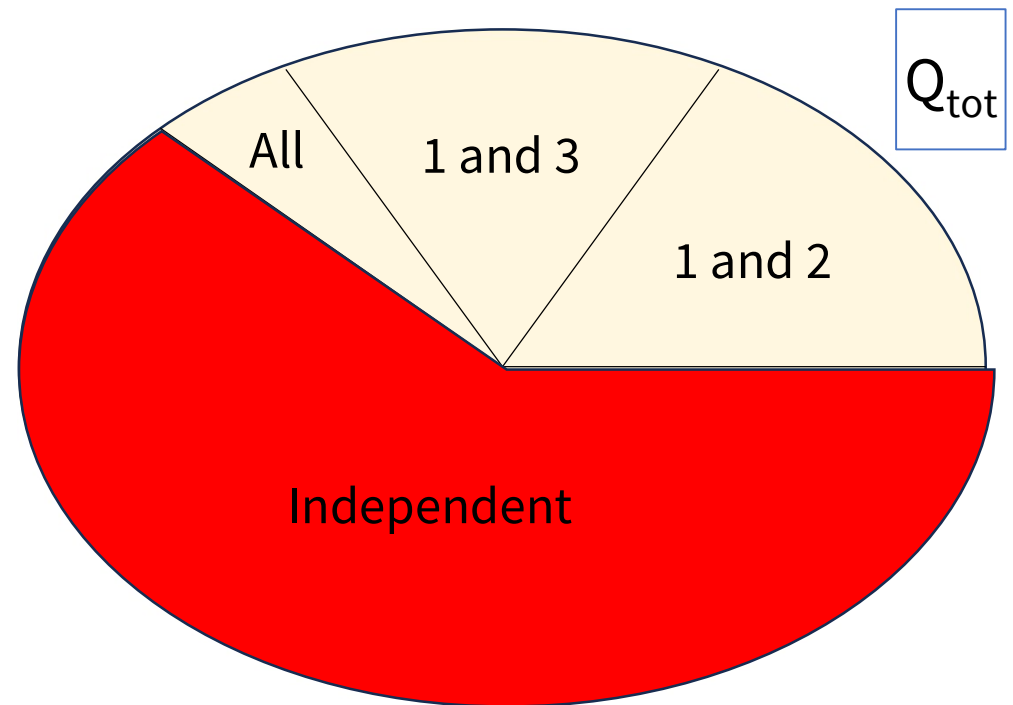
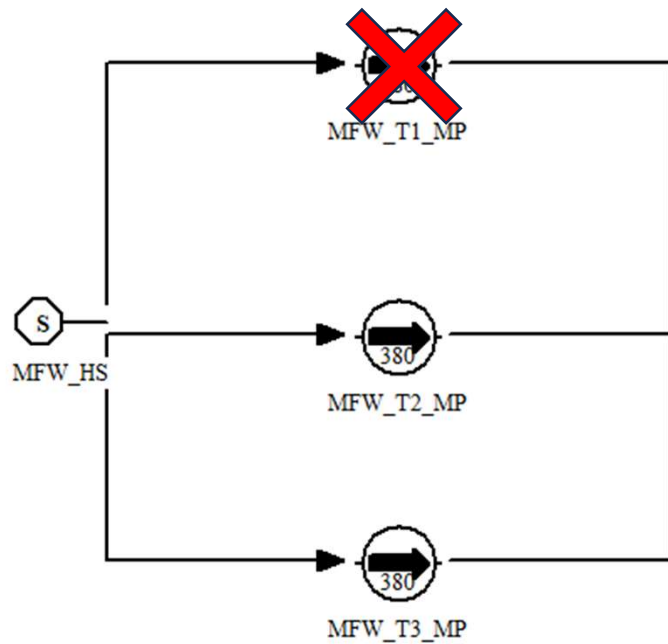
Common cause failures not affected



- Planned maintenance
- Fire analysis
- ...

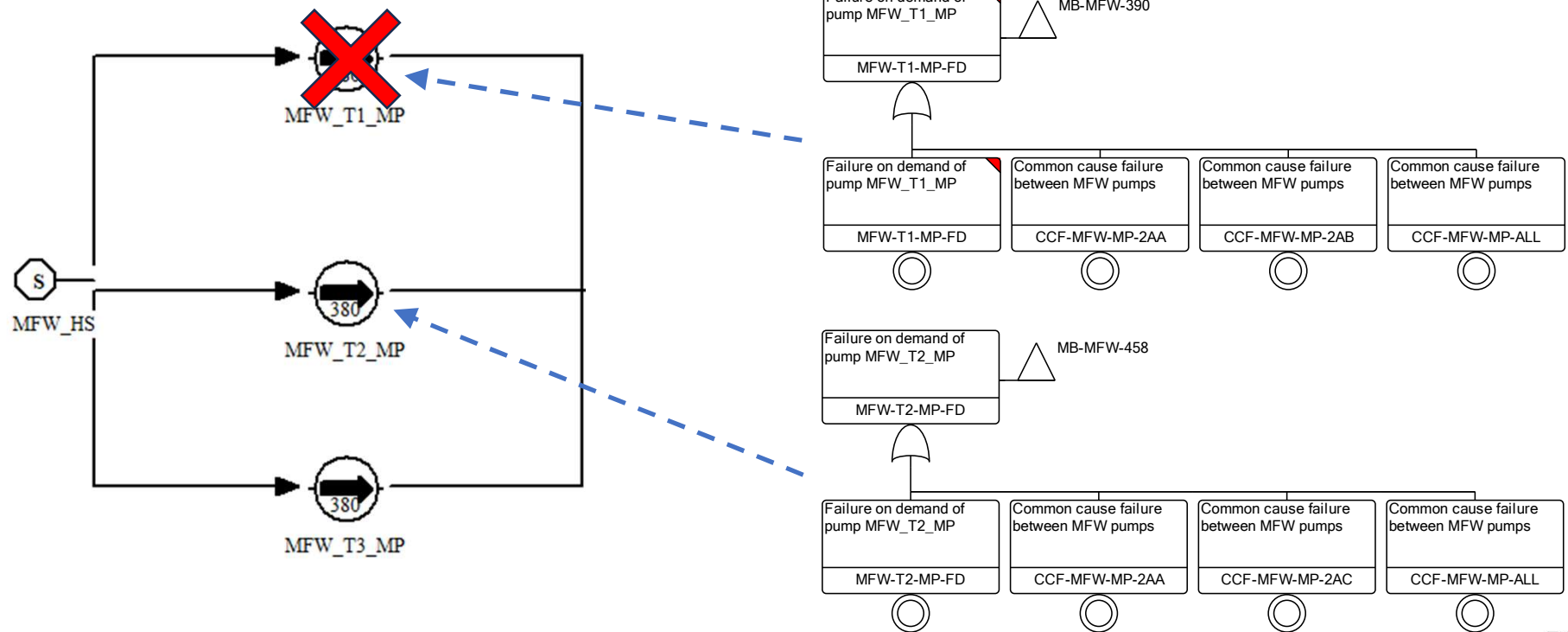
A Take-Out

Common cause failures not affected



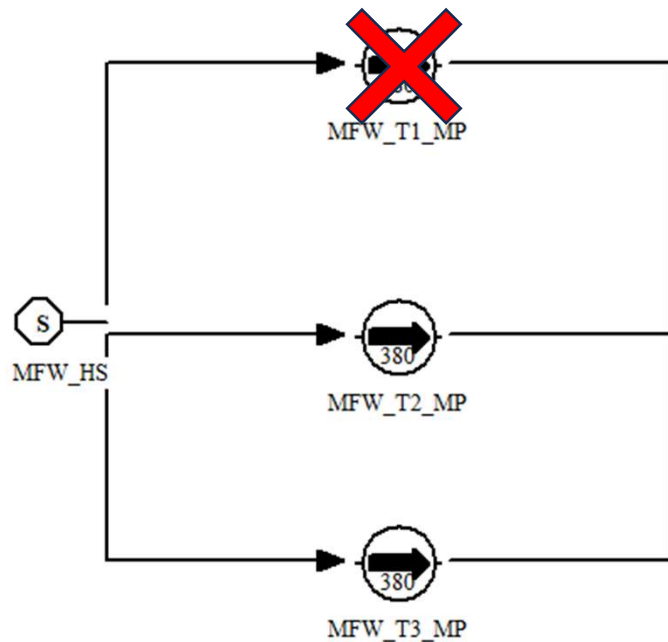
A Take-Out

Common cause failures not affected



A Take-Out

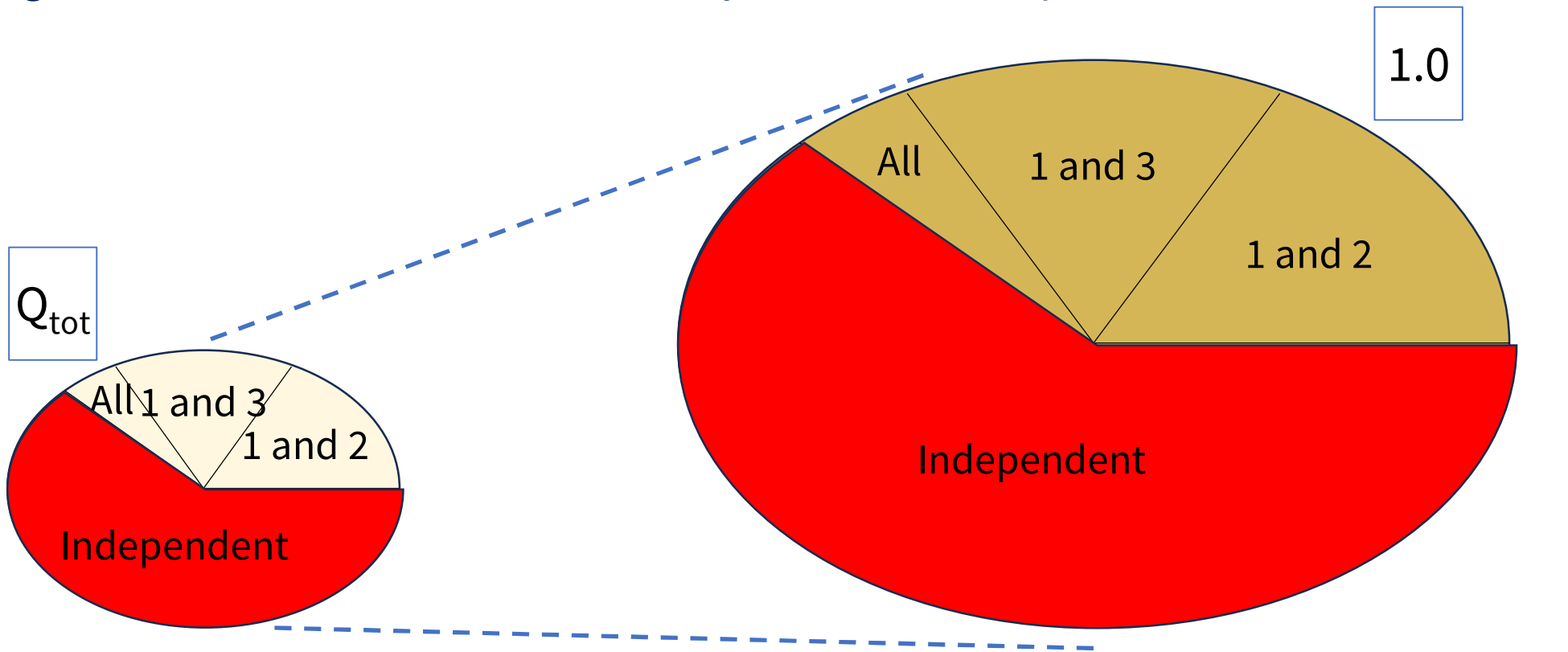
Might be a common cause with other symmetrical components



- A failure in operation
- A failure discovered by a test
- ...

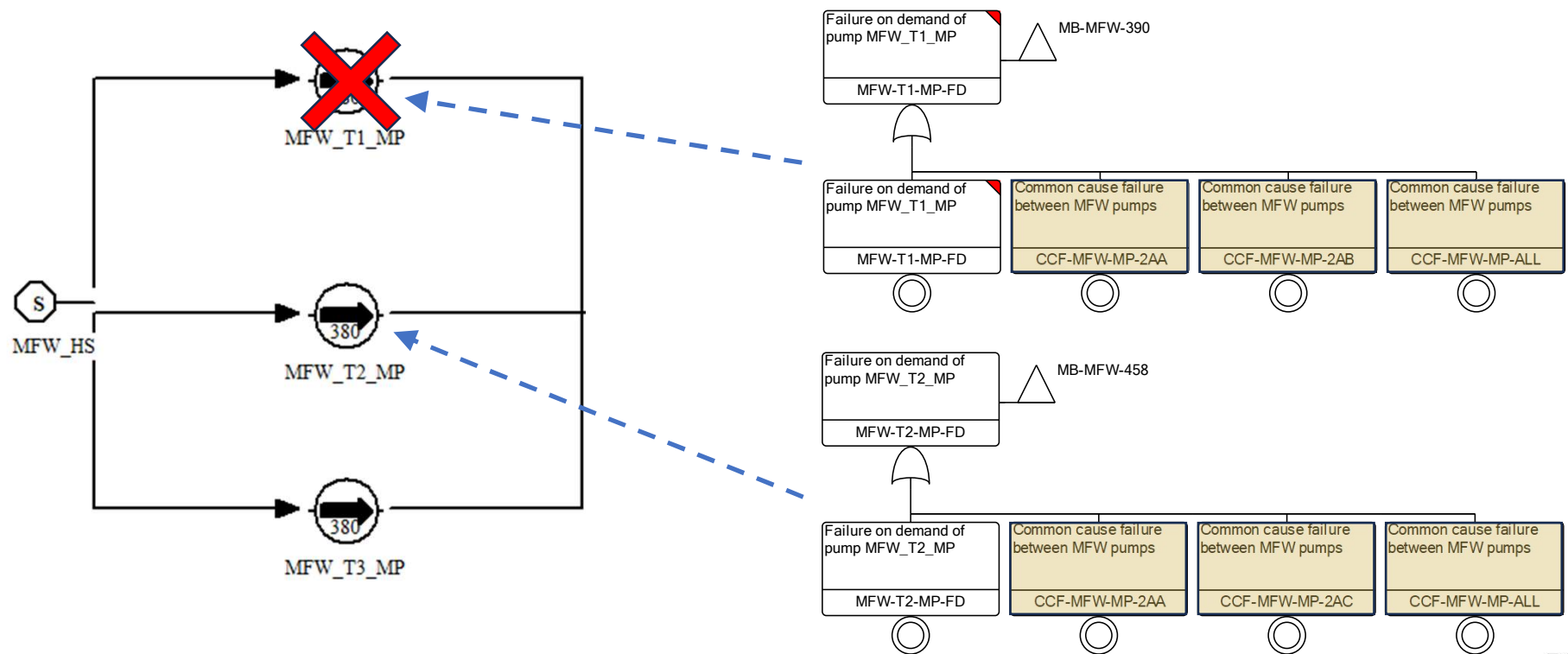
A Take-Out

Might be a common cause with other symmetrical components



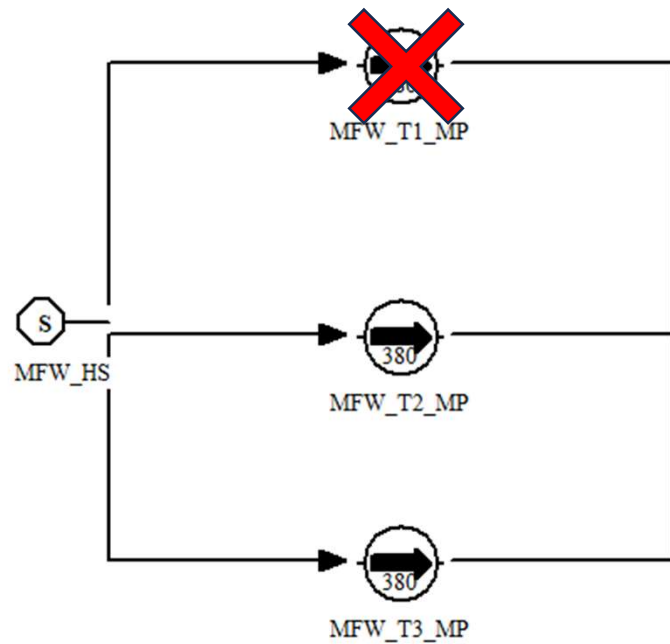
A Take-Out

Might be a common cause with other symmetrical components



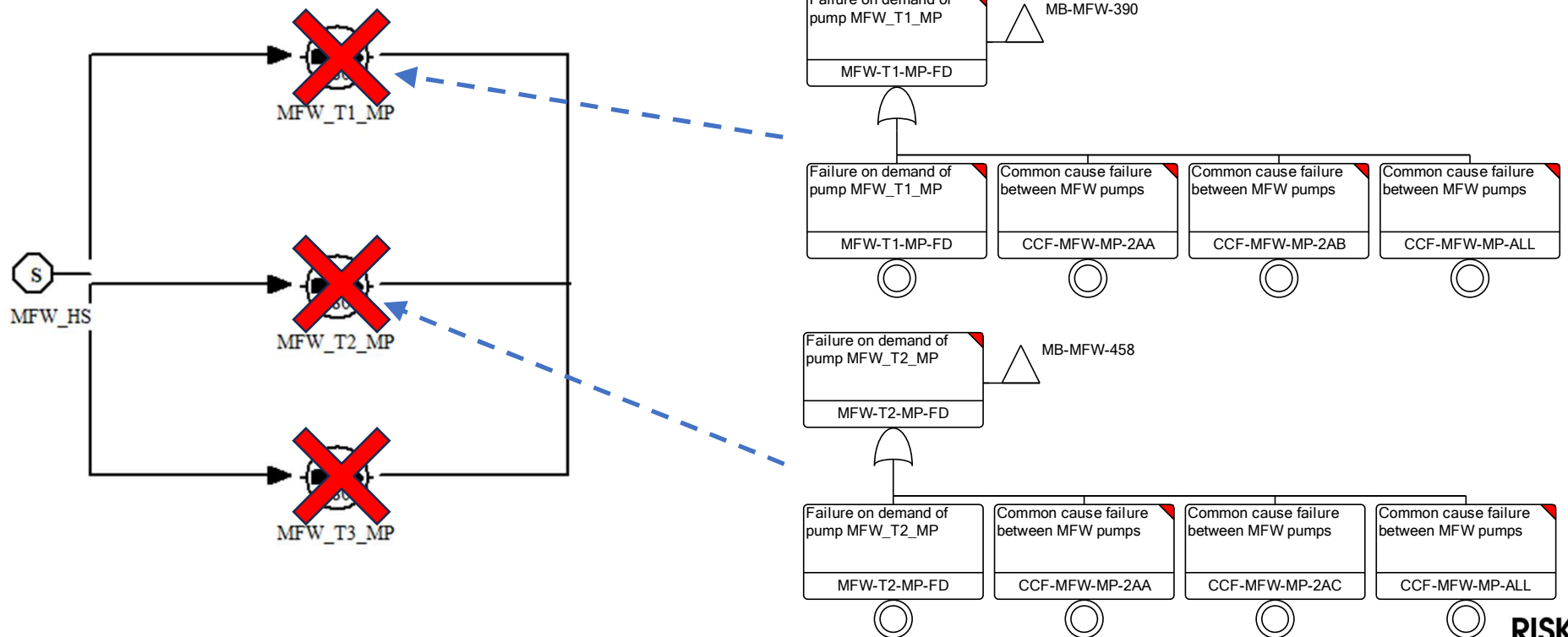
A Take-Out

Fails also common cause events (Full CCF)



A Take-Out

Fails also common cause events (Full CCF)



Practical Treatment of Common Cause Failures



Significance Determination Process

A component is unavailable – retrospective information

Equipments

Equipment Groups

Systems and Sub-systems

System	Description
▶ ACP	AC Power System
▶ CCW	Component Cooling Water System
◉ CPO	Condensation Pool
◉ DPS	Depressurisation System
◉ DWS	Demineralized Water Storage
▼ ECC	Emergency Core Cooling System
◉ ECC-1	Emergency Core Cooling System train 1
◉ ECC-2	Emergency Core Cooling System train 2
▶ EFW	Emergency Feed Water System
◉ MFW	Main Feed Water System
▶ RHR	Residual Heat Removal System
▶ SWS	Service Water System

Equipment

	ID	Description
Filter:		
☒	ECC-PM01	Emergency Core Cooling System pump 1
☐	ECC-VC01	Emergency Core Cooling System check va
☐	ECC-VM02	Emergency Core Cooling System Motor Op

Event Time Point	Event	ID	Description	State	Action	CCF related
2025-02-21 14:17:47	TAKE OUT	ECC-PM01	Emergency Core Cooling System pump 1		Undo	☒

Significance Determination Process

A component is unavailable – retrospective information

Equipments

Equipment Groups

Systems and Sub-systems

System	Description
▶ ACP	AC Power System
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Equipment

ID	Description
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Event Time Point	Event	ID	Description	State	Action	CCF related
2025-02-21 14:17:47	TAKE OUT	ECC-PM01	Emergency Core Cooling System pump 1		Undo	☒

Significance Determination Process

Timing for 'CCF related'

- SDP accumulates risk over time
- Tested components with a staggered scheme
 - Some combinations can be excluded
 - Some combinations might have lower unavailability because of a test of an included component

Risk Monitoring

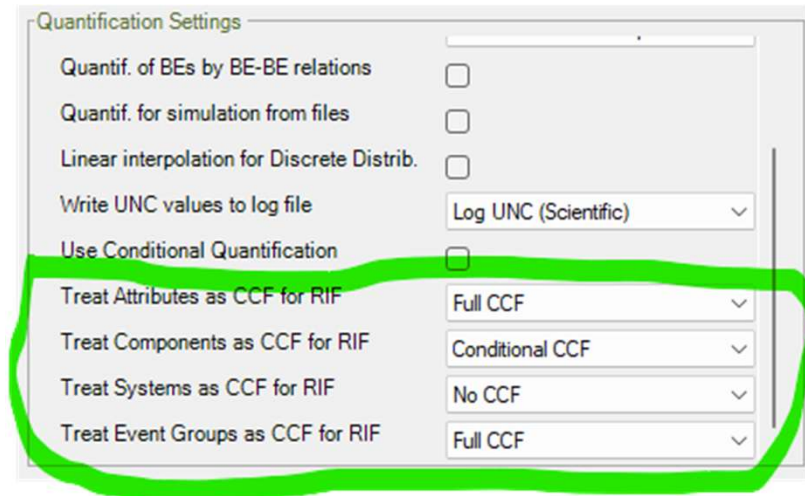
A need to reset the CCF flag

- Unavailability is flagged with 'CCF related'
 - Conditional quantification of CCFs
 - The risk level might rise significantly
- Tests/inspections show that related components are OK.
- CCFs can be quantified normally
 - The risk level drops.
 - A short peak of an elevated risk
- Encouraging 'CCF related' (higher risk can be fixed again)

Risk Increase Factor (Risk Achievement Worth)

Flexibility for different situations

- Components – possibly CCF related (conditional CCF)
- Attributes – rooms, fire analysis (no CCF)
- Systems – unavailability of the whole system (full CCF)
- Event Groups – ??



Quantification Settings	
Quantif. of BEs by BE-BE relations	☐
Quantif. for simulation from files	☐
Linear interpolation for Discrete Distrib.	☐
Write UNC values to log file	Log UNC (Scientific) ▼
Use Conditional Quantification	☐
Treat Attributes as CCF for RIF	Full CCF ▼
Treat Components as CCF for RIF	Conditional CCF ▼
Treat Systems as CCF for RIF	No CCF ▼
Treat Event Groups as CCF for RIF	Full CCF ▼

Symmetry Assumption in Common Cause Failures



A New CCF Model

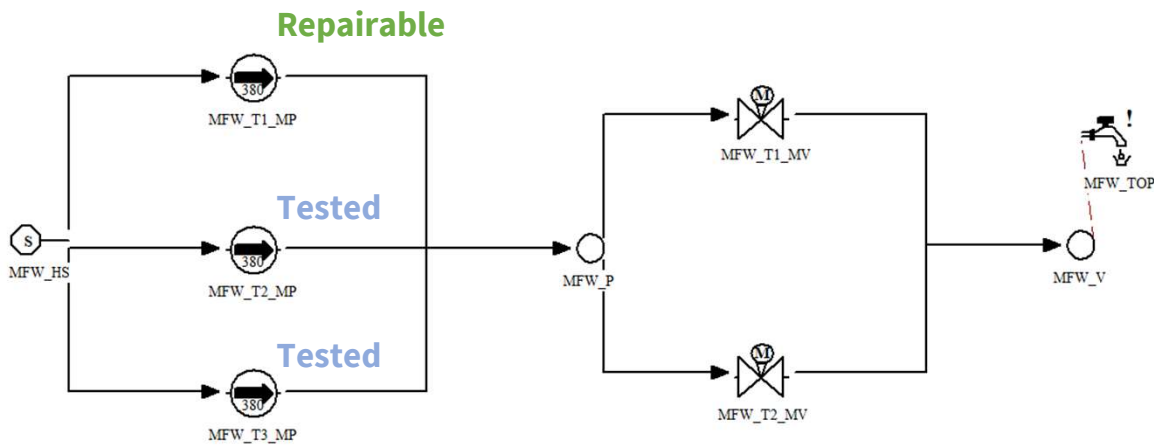
Beta, Alpha, MGL

- Basic event unavailability + CCF parameters → CCF event unavailabilities

A New CCF Model

Basic Parametric Model

- Basic event unavailability + CCF parameters → CCF event unavailabilities



A New CCF Model

Parameters – probabilities of CCF events

CCF Group			
ID	Char #	Description	CCF model
CCF-ACP-DG---A		Diesel generator in standby fails to start	BPM Model
CCF-CCW-PM---A		Component cooling water system pumps fails to start	Beta Factor
CCF-PRV-VC---A		Pressure relief valves fails to open	MGL Model
CCF-ECS-PM---A		Emergency Core Cooling System pumps fails to start	Beta Factor
Parameter type	Record	Char #:	Value
BPM Q2 Probability	Q2 PROB		9.00E-01
BPM Q3 Probability	Q3 PROB		9.00E-02
BPM Q4 Probability	Q4 PROB		7.00E-03
BPM Q5 Probability			
BPM Q6 Probability			
BPM Q7 Probability			
BPM Q8 Probability			

A New CCF Model

Two variants

- Quantification of independent failures
- BPM (*Basic Parametric Model*):
 - The sum of all CCF events including a certain Basic Event gives the original unavailability.
 - The unavailability of the independent event is decreased by CCF events.
- BPM-D (*Basic Parametric Model with Direct Independent Quantification*):
 - The unavailability of the independent event is equal to the original unavailability.
 - Conservative, but offering even more flexibility

Summary



Conclusions

Improvements in calculation

- CCF in applications
 - Different CCF quantification for different purpose of the analysis
 - RiskWatcher
 - SDP
 - Risk Increase Factor
- Symmetry assumption



Thank you

Please contact:
support@riskspectrum.com