

A large offshore wind turbine stands in the center of the frame, its three blades extending outwards. To its right, a large service vessel with a complex superstructure is visible. The sea is calm, and the sky is filled with dramatic, grey clouds. The overall scene is industrial and maritime.

KAIROS - Control Room Assistant Alarm Management EPSC WG on digitalisation

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31.08.2021

Agenda

- Background Kairos Technology
- The challenge of alarms
- A different way to address alarms
 - From symptoms to diagnoses
 - Alarm traffic control
- Technology enabler
 - MFM Multilevel Function Modelling
 - Qualitative physics AI



Kairos Technology - Background

- Established 2014

- 22 employees
- 5 PhD's

- Investors

- Eldor Holding
- Skagerak Maturo
- Proventure

- Technology



- Multilevel Flow Modelling theory from DTU
- Developed in JIP with Chrysaor (Harbour), TotalEnergies and Danish Hydrocarbon Research and Technology Centre (with funding from Research Council of Norway)

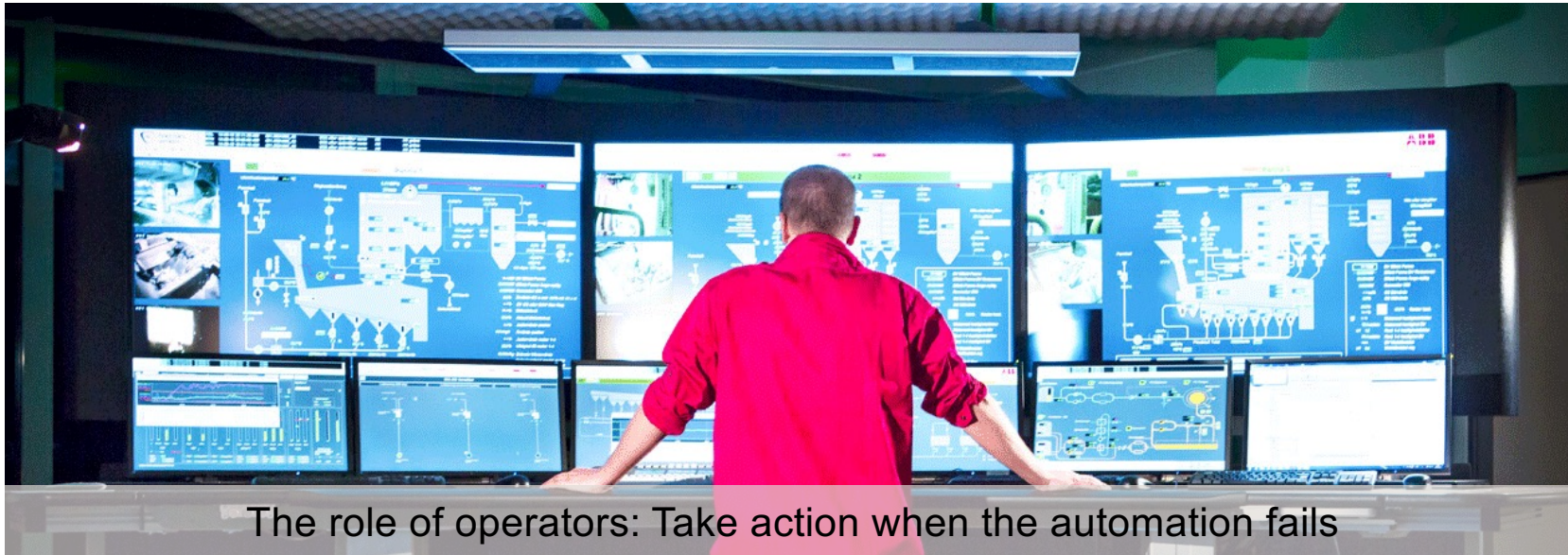
Pilots and clients



TotalEnergies



The complexity in today's control rooms is vast and increasing

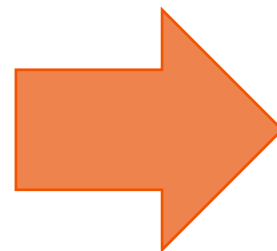


Control rooms today

50 000+ sensor values to monitor

Thousands of alarms per day

Thousands of failure modes that may cause shutdown



Challenges for operators

Hundreds of qualified decisions to be made each day

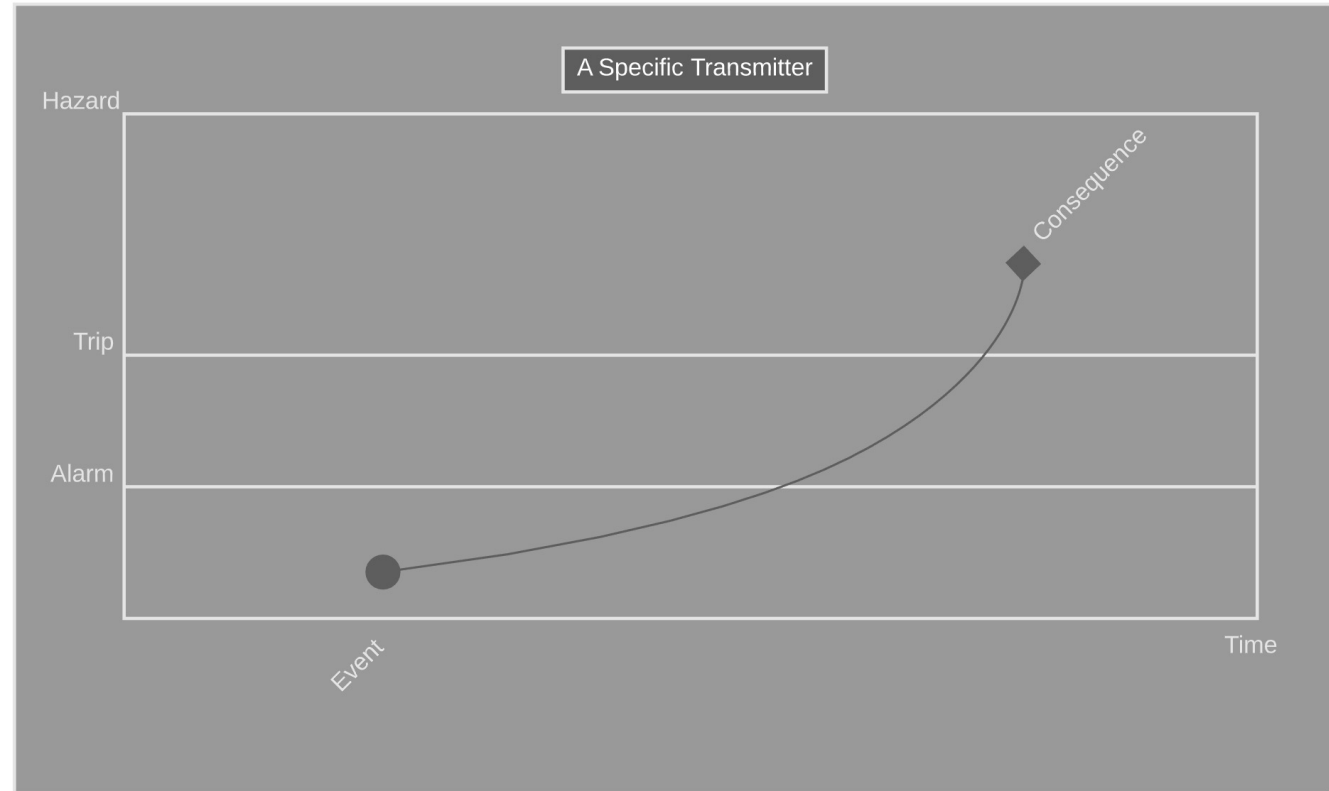
Minutes to identify root cause and make correction to avoid major disturbance in production



Safety & Automation System (SAS)

Engineering Equipment and Materials Users Association (EEMUA 191)

- An alarm will indicate a problem requiring operator action generally initiated by a process measurement passing a defined alarm setting as it approaches an undesirable or potentially unsafe value. It may also indicate equipment status becoming unhealthy.



Perfect Alarm Ranking

Pri	Description	ESD	F&G	PSD / HIPPS / BMS	PCS
1	Safety Critical alarms	Warning, Action alarms & ESD shutdown level alarms Manual Pushbuttons Failure in performing a shutdown action Conflict	Warning, Action alarms Manual Pushbuttons Failure in performing a shutdown action Conflict	Failure in performing a shutdown action Conflict	Health critical alarms e.g., Breathing air, Eye washer
2	Critical alarms	Critical system and components failure	Pre-Warning alarms (smoke) Critical system and components failures Failure of detectors	Critical Warning alarms Trip & PSD shutdown level alarms with risk of escalation Critical system and components failure	Critical Warning alarms from hydrocarbon or essential utility systems that may escalate to a PSD trip Critical system and components failure Conflict
3	Less Critical alarms			Less critical Warning alarms Trip & PSD shutdown level alarms, without risk of escalation	Less critical Warning or Trip alarms from non-escalating events
4	Non Critical alarms	ESV failure with no demand Non-Critical ESD System alarms	Non-Critical F&G System alarms	Failure with no demand Non-Critical PSD System alarms	Non-critical alarms PCS system failures or component failures for all PCS signals

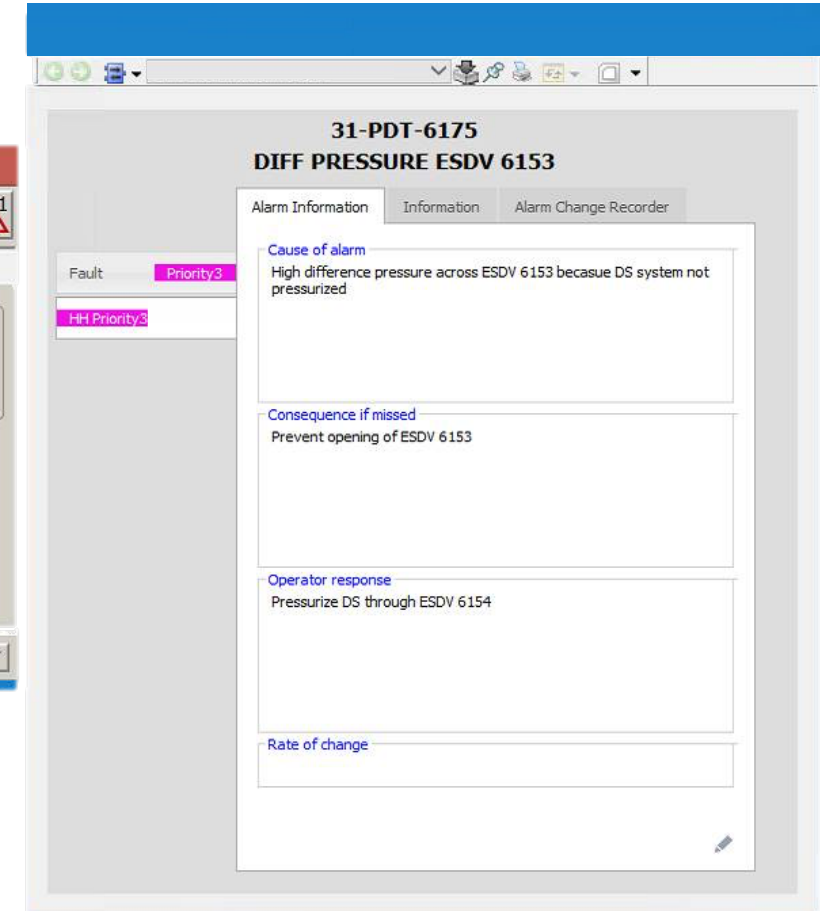
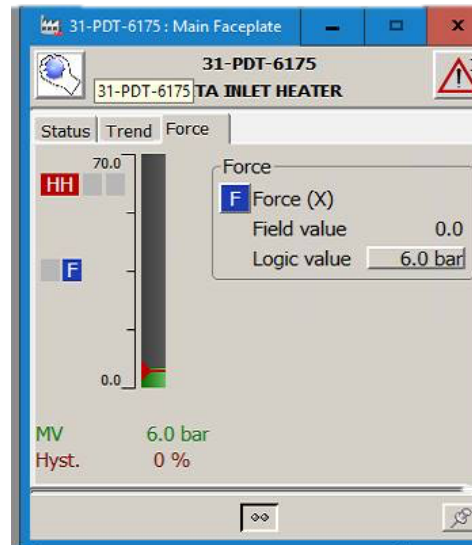


Alarm System Example

HH alarm was enabled, and you can see that the Alarm Helper opens with the HH tab.

To open the helper – the control room operator can right-click on the faceplate and select the alarm helper.

The text in the alarm systems will stay the same until a control room operator requests a change.




Alarm response system

How is the knowledge captured?

- 1-2 experienced operators to fill in **Alarm details** for each critical alarm
- It takes typically 1 hour to handle 5 alarms

How is this tool used?

- When an alarm occurs, the CRO can click on the alarm to see the 4 information fields



Alarm details >

Purpose of alarm

Cause of alarm

Consequence if missed

Operator response





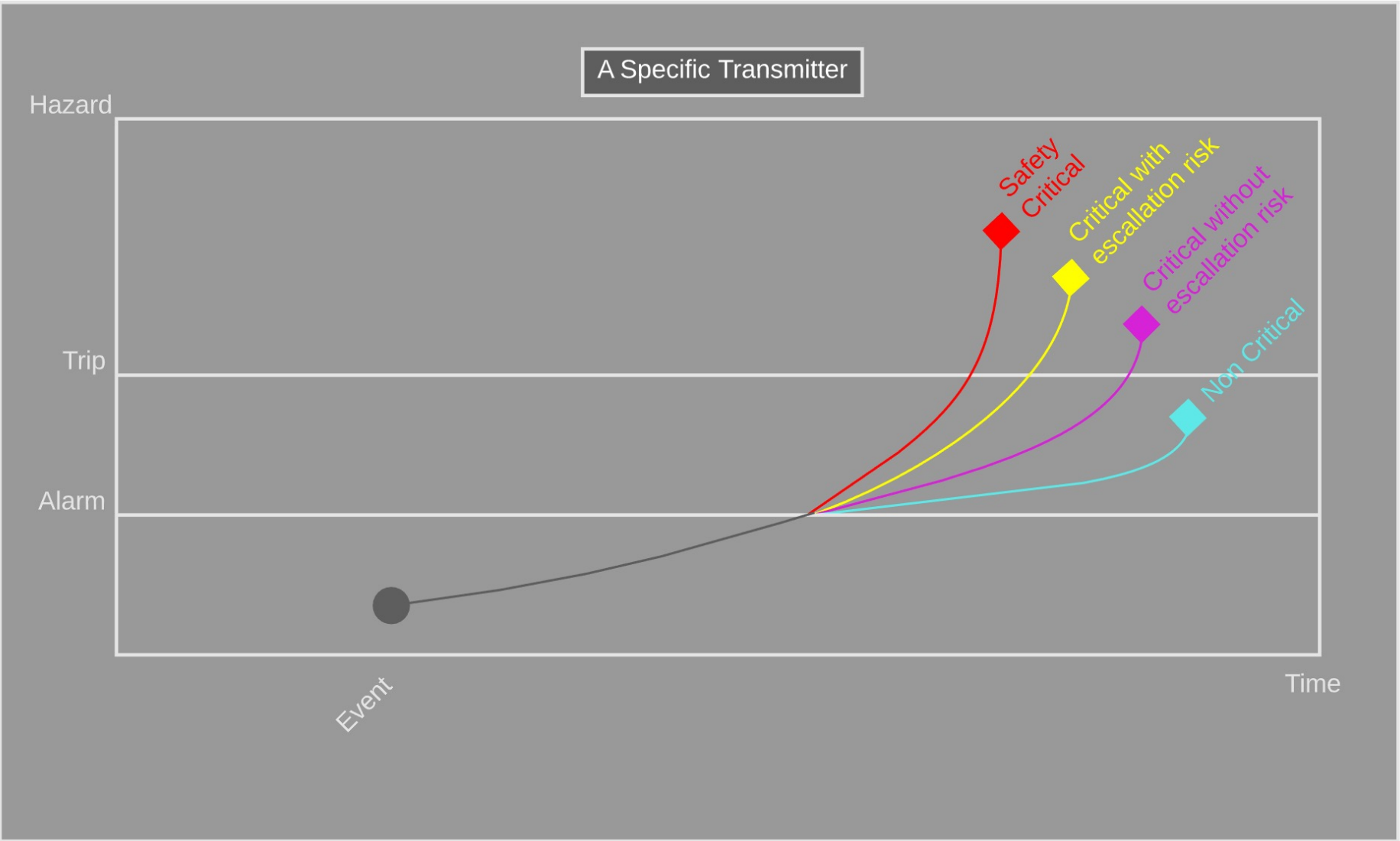
The challenge:

One individual alarm is a symptom of a root cause

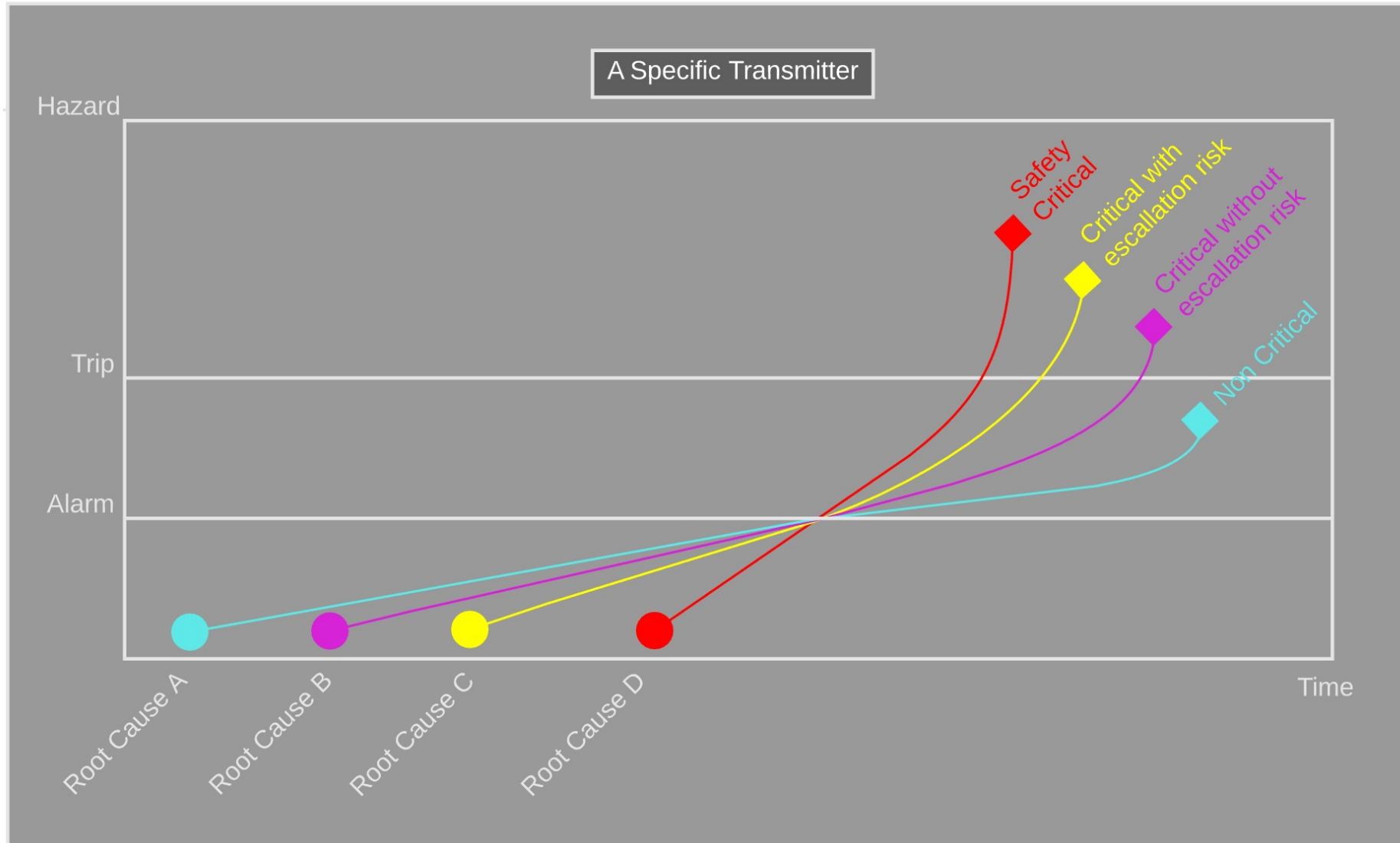
One root cause will have multiple alarms



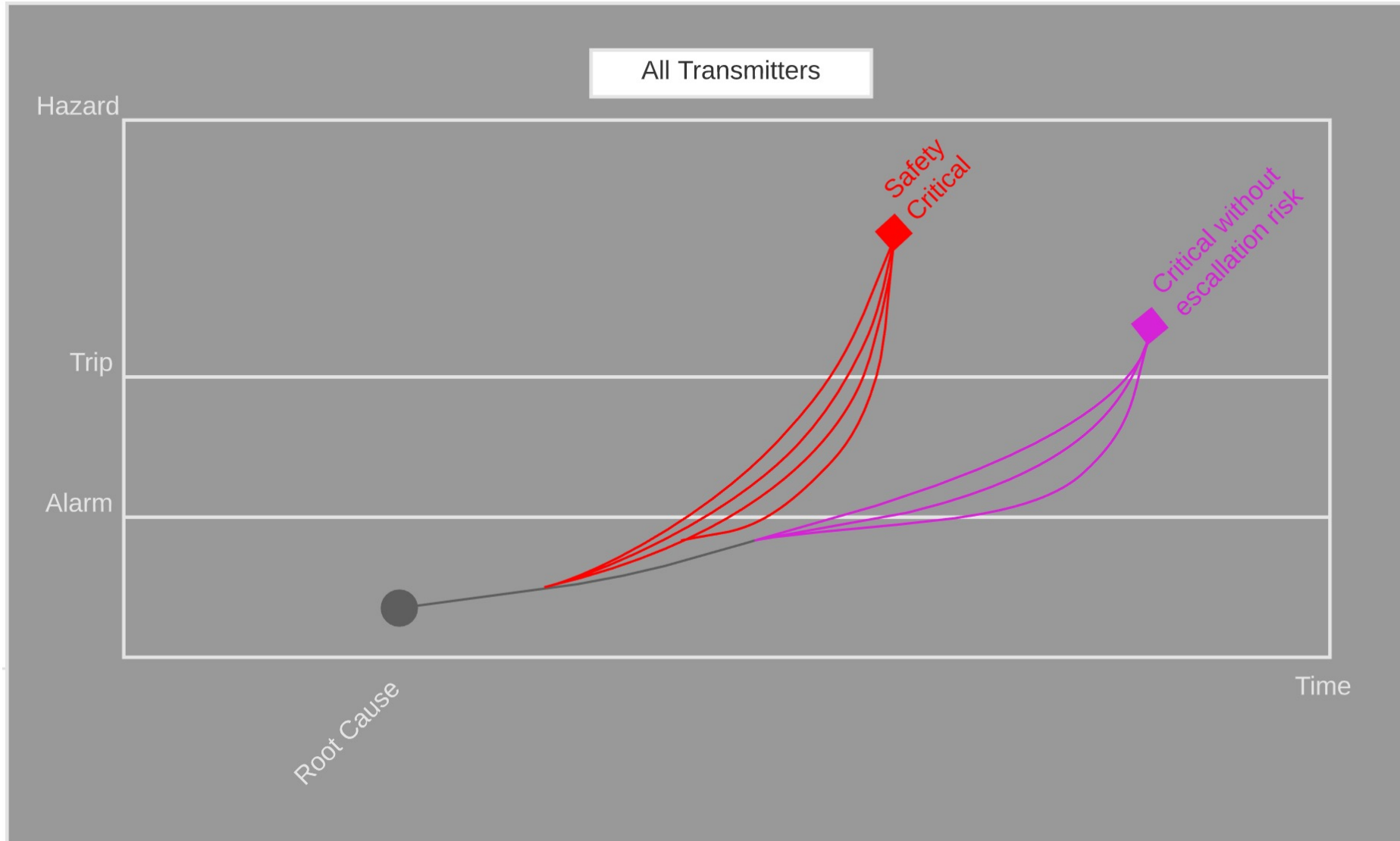
An alarm can develop into different consequences



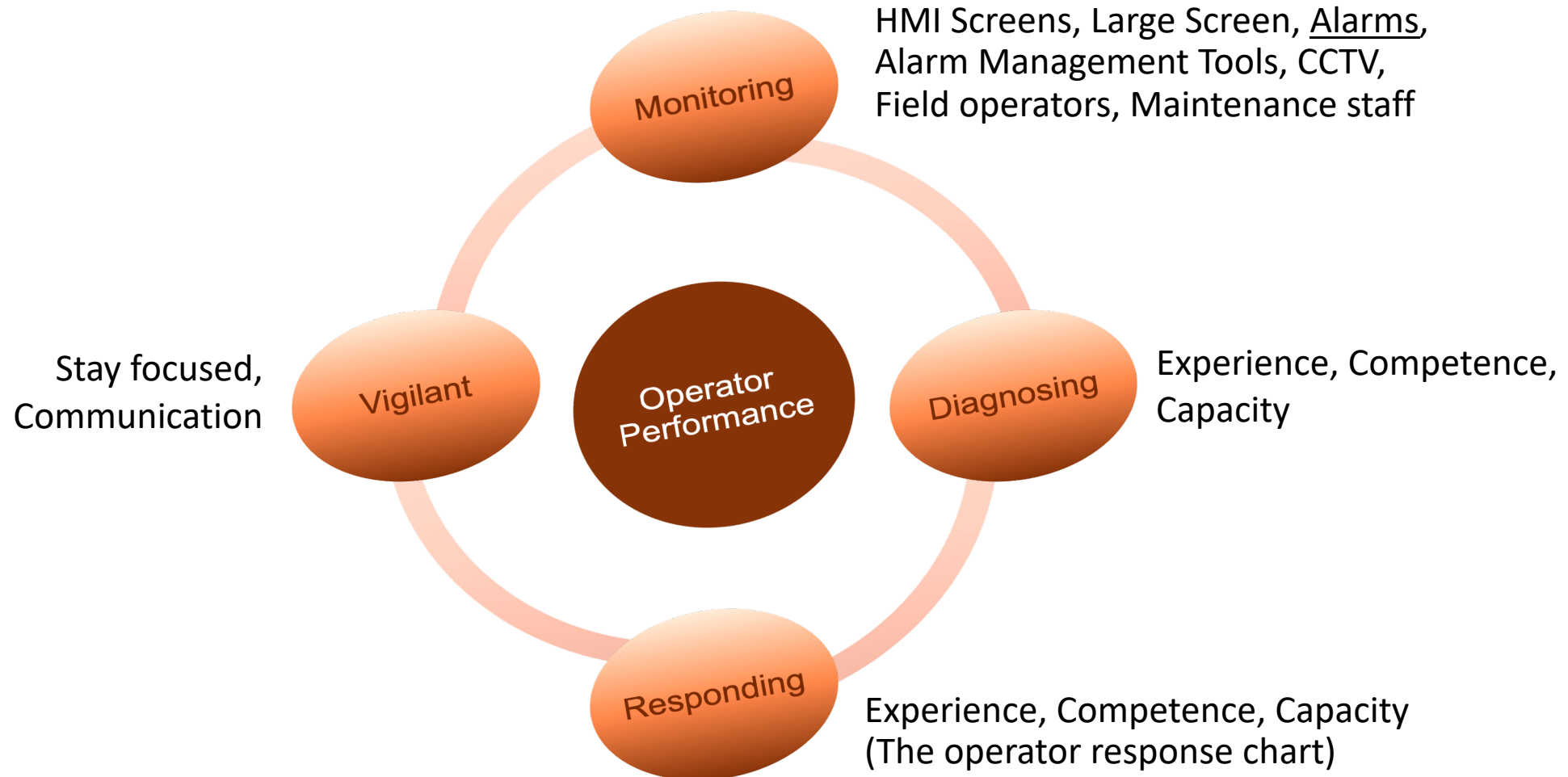
A transmitter can observe multiple causes



Multiple sensors to create "Fingerprint"



Operator Performance



A different approach to alarms

3 Counteraction
Fastest and safest return to normal situation

2 Consequence
Future propagation of the abnormal situation

1 Cause
Immediate detection of the root cause behind the abnormal situation



Ranked Causes

HP Flare In
HP Flare system to Recompression

- CORRECTIVE ACTIONS**
- Tune process control parameters to include this scenario (conditional setpoints)
 - Increase compressor capacity (modification project)

- Gas inlet 20VA003**
Flow of gas to stabilisation separator
 - Gas to Recompression**
Gas flow to 1st stg. suction cooler from Stabilisation ...
 - Flow through 20LV0177**
20VA001 Interface level control valve
 - 20VL0177**
Inlet separator Oil level ctrl valve
 - Well Stream to 20HB001A**
Multiphase flow from Manifold to 20HB001A
 - 20VL0176**
Inlet separator Oil level ctrl valve
 - Surge mode**
23KA001 1st stage Recompressor
 - Discharge Enthalpy**
23KA001 1st stage Recompressor
- VIEW MORE CAUSES

Ranked Consequences

- SAFETY CRITICAL**
- 23PT0082**
Suction Pressure
- PRODUCTION CRITICAL 6**
- 23PT0303 Pressure**
- 23KA001 High Power Trip**
23KA001
- 20VA003 Flaring**
- Discharge pressure**
23KA001 1st stg. Recompressor
- ENVIRONMENTAL 2**

VERIFY CAUSE

- HP flare pressure high?
- Compressor discharge line surge line?
- Low gas injection rate?

Verify

MITIGATION STEPS

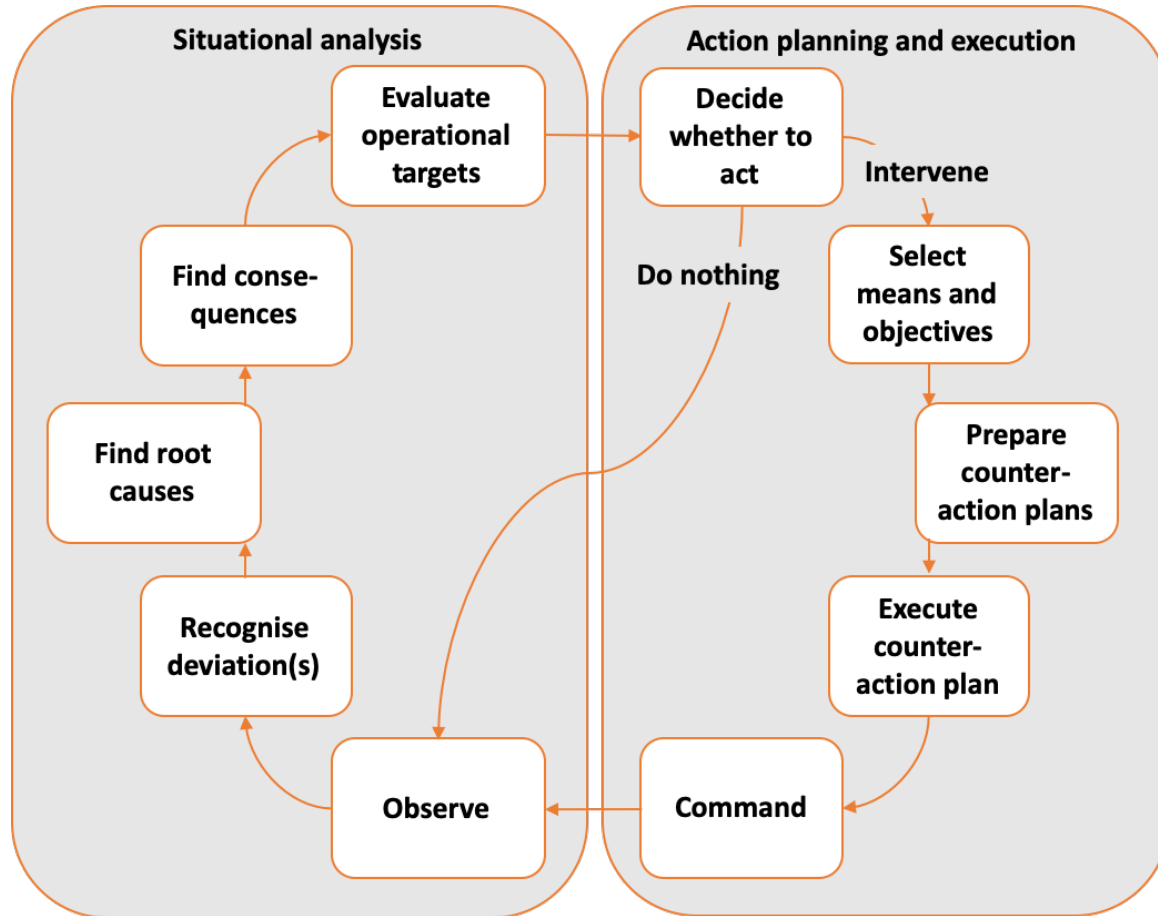
- Open gas injection choke (if possible)
- Flaring (last resort - emissions)

Mitigations

3 CONFIRMED OBSERVATIONS 3 CURRENT 1 RECENT 4 STALE



Situational Management



- A rational process of management of situations in complex systems involves two phases: Analysis and Action.
- Humans tend to violate these principles by making shortcuts based on experience and knowledge.
- Lack of informed decisions can lead to suboptimal production, abnormal situations, shutdowns or disasters
- Decision Support Systems that guide the operator thru the process are recommended

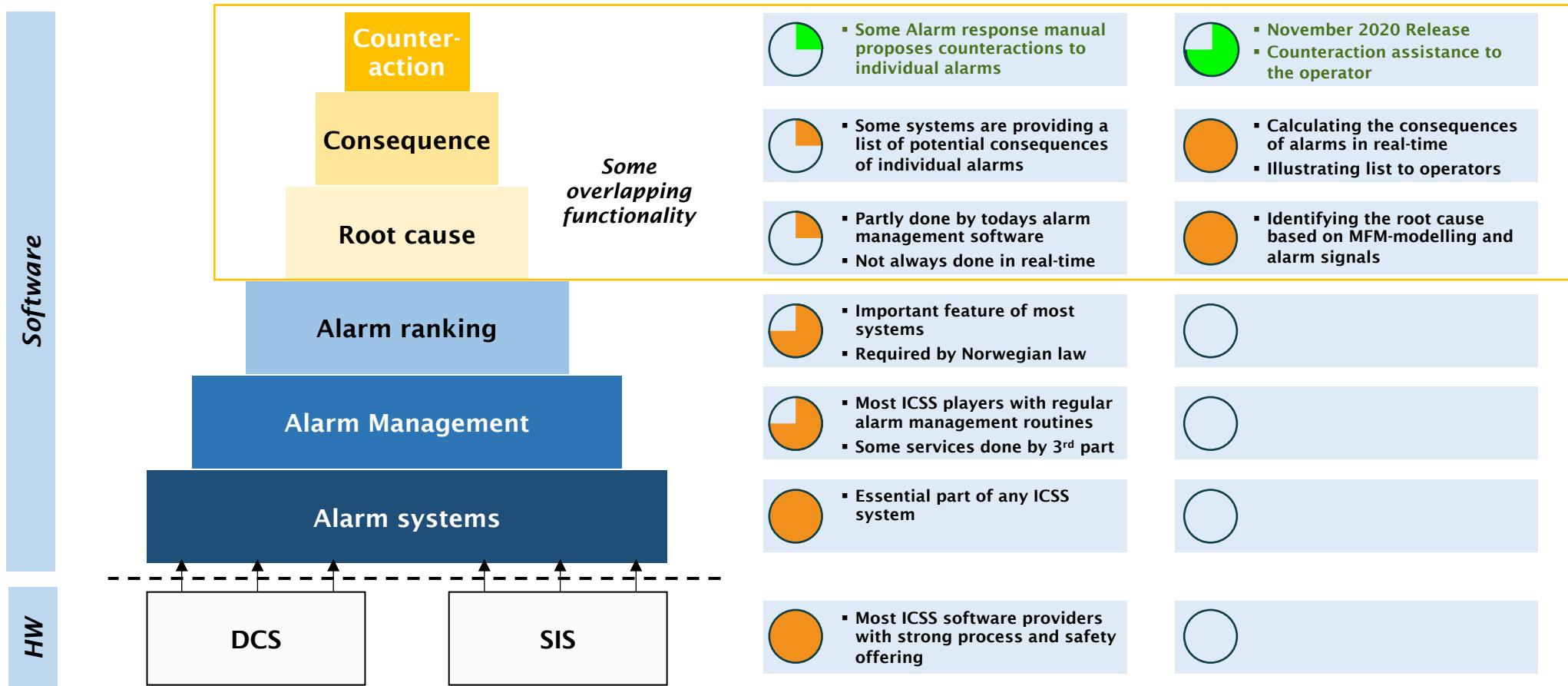


ICSS offerings

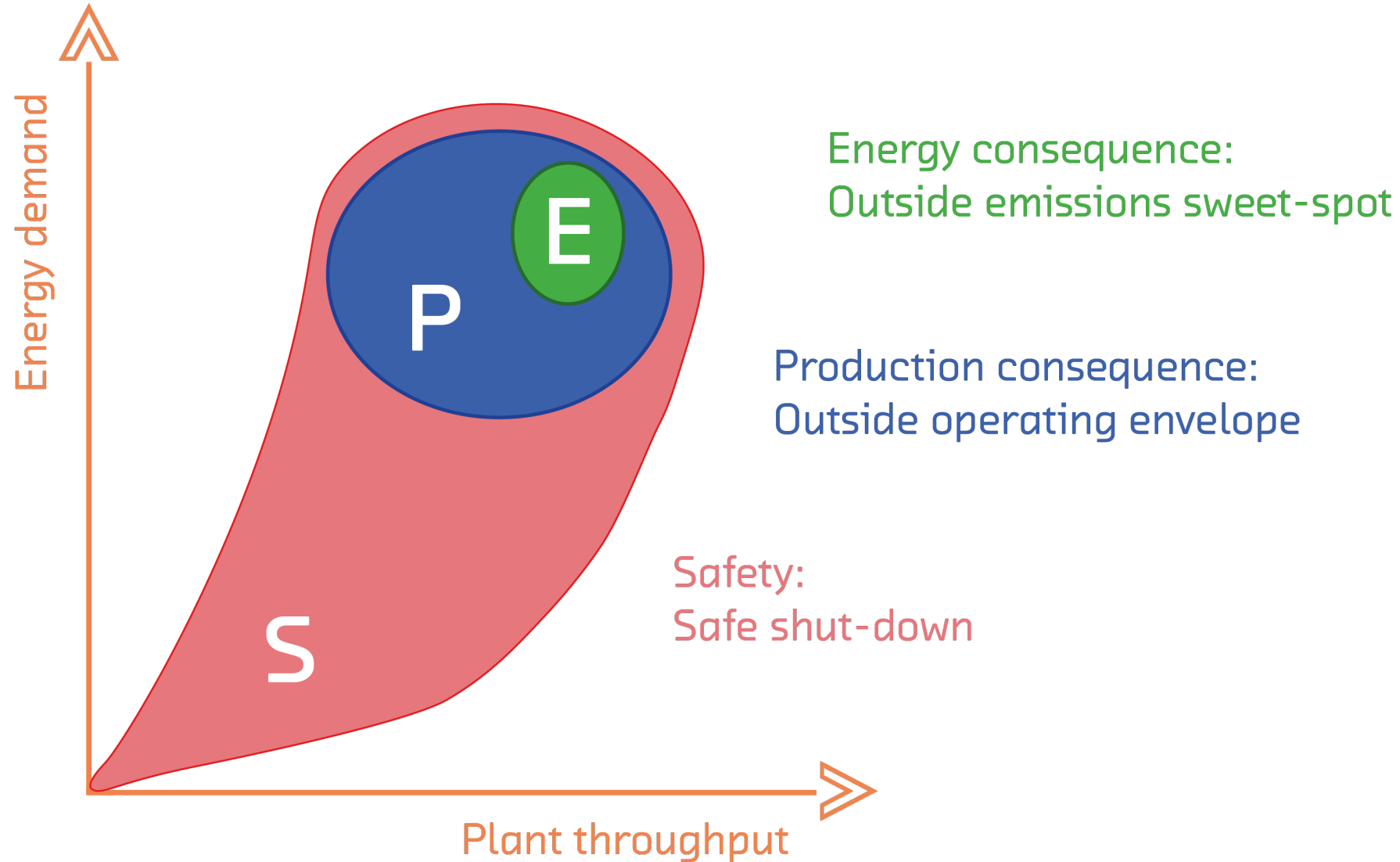
Hardware and software modules

ICSS players

Kairos



Goal Hierarchy



Oil

Gas

Quadrant indicates system at risk

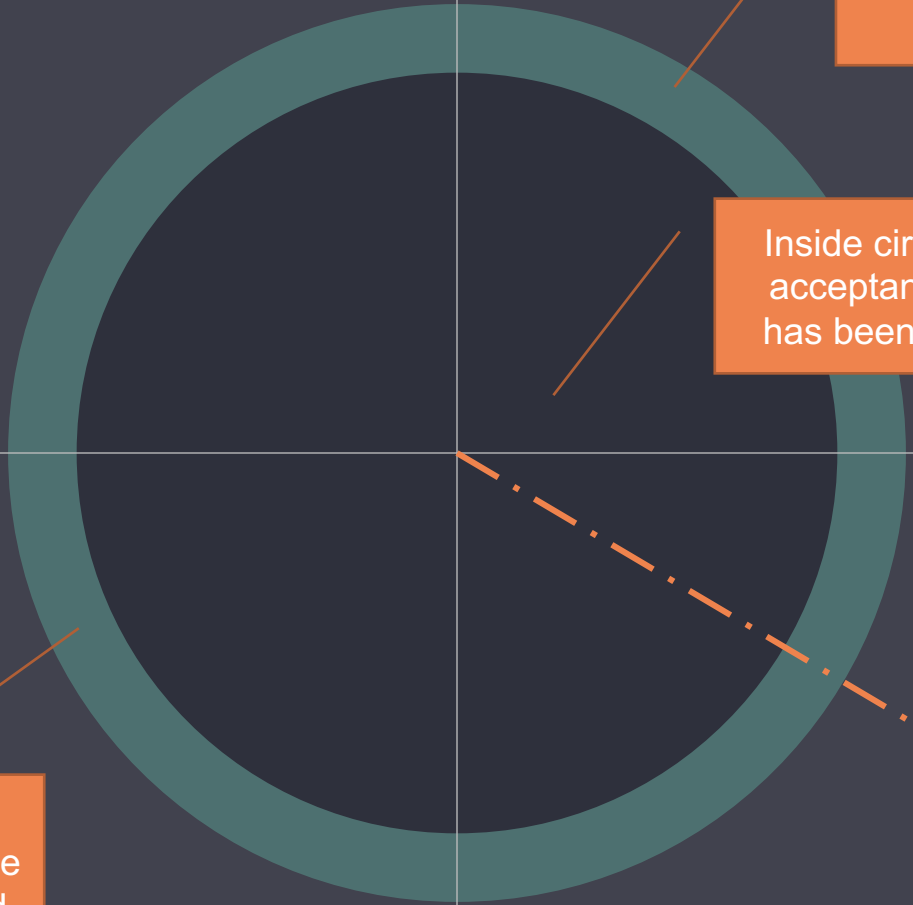
Green when no production targets are at risk

Show safety risk when the circle is yellow

Inside circle implies acceptance criteria has been exceeded

Yellow when production acceptance criteria are exceeded

Distance based on risk (cause ranking x consequence impact)



Water

Utilities

OIL

GAS



Condensate
pump power



Injection compressor
surge margin



Injection compressor
suction flow

YOU CAN IMPROVE EMISSIONS



Injection compressor recycle valve



Electric coalescer power consumption

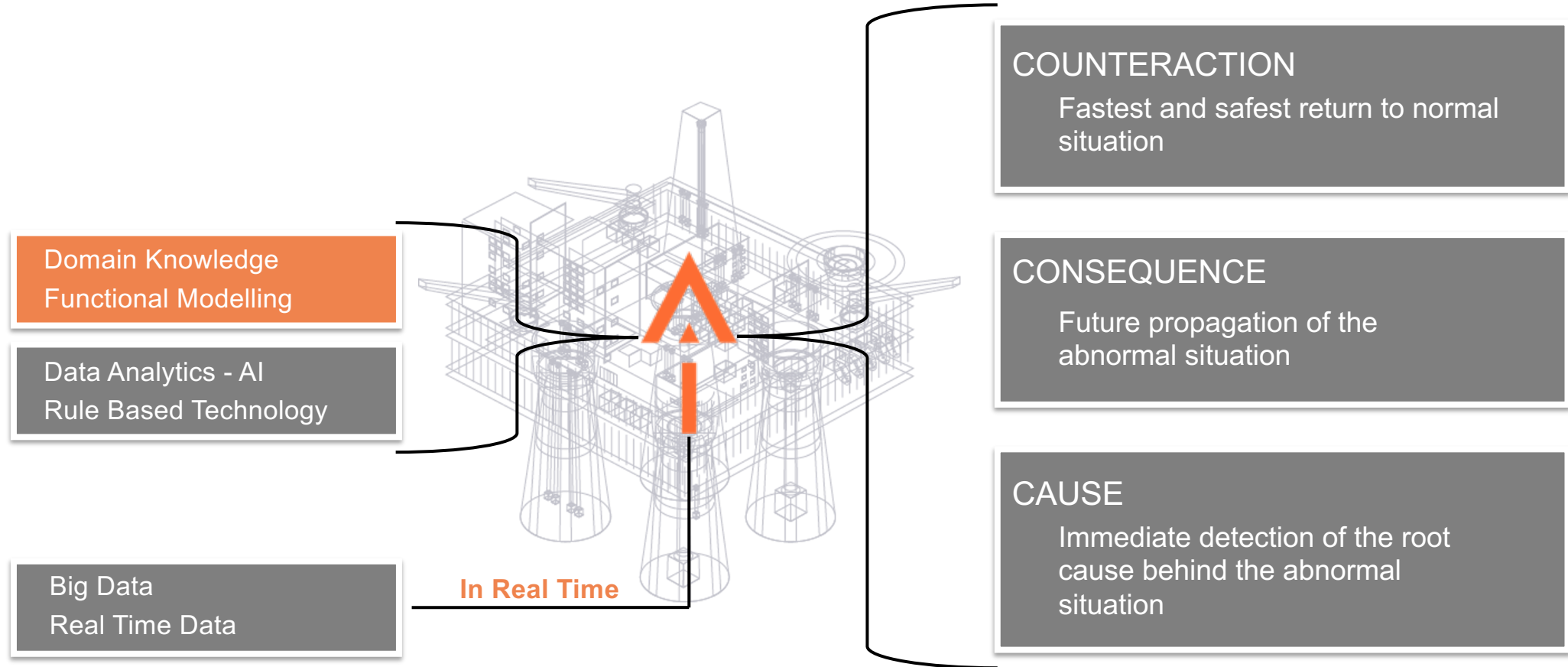
WATER

UTILITIES



Cooling water
filter resistance

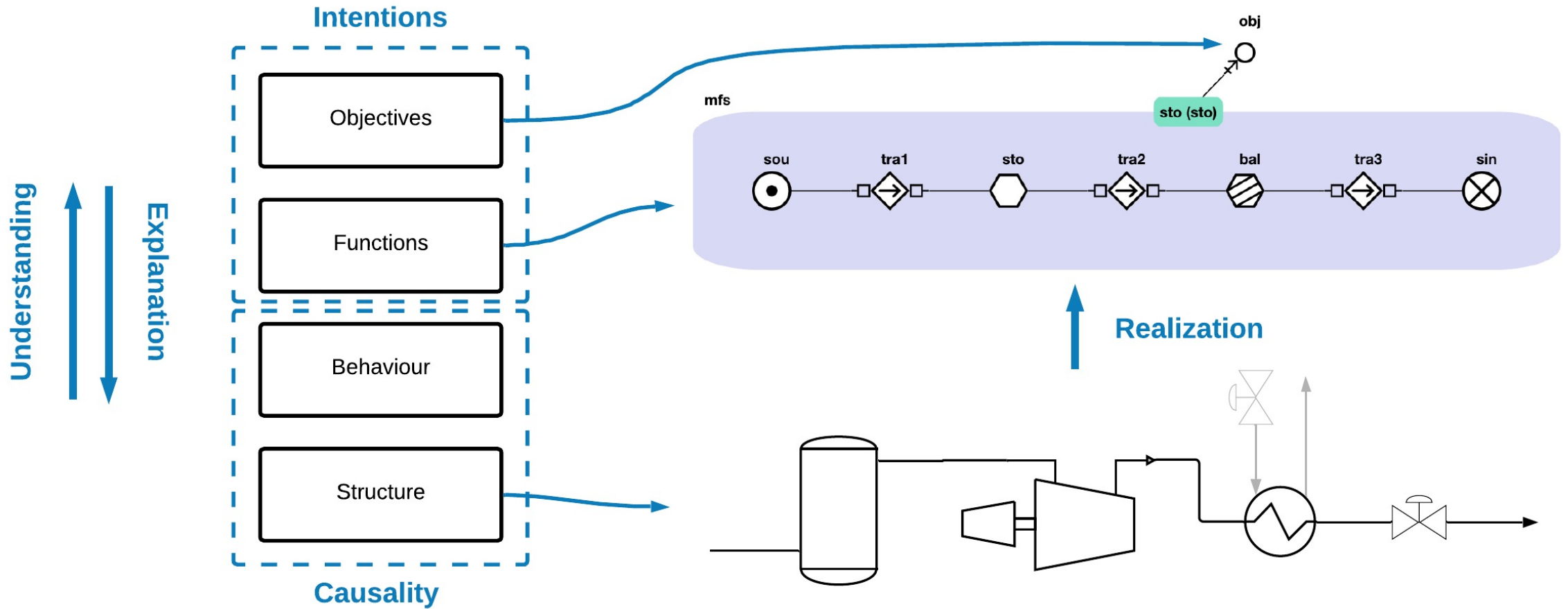
Control Room Assistant



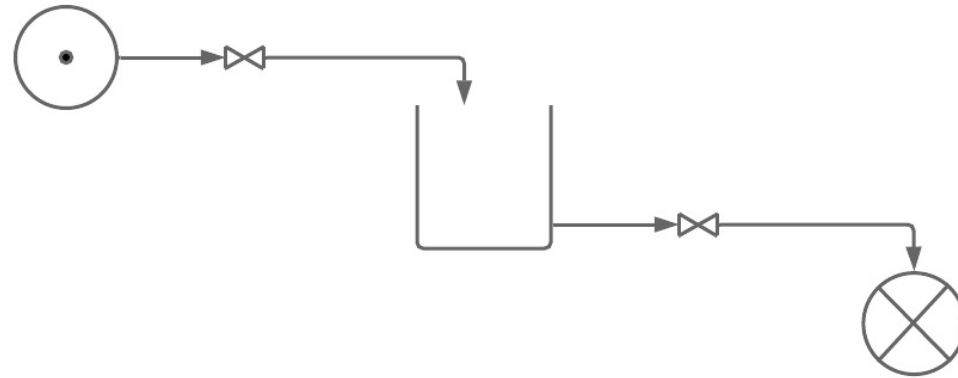
Kairos Suite



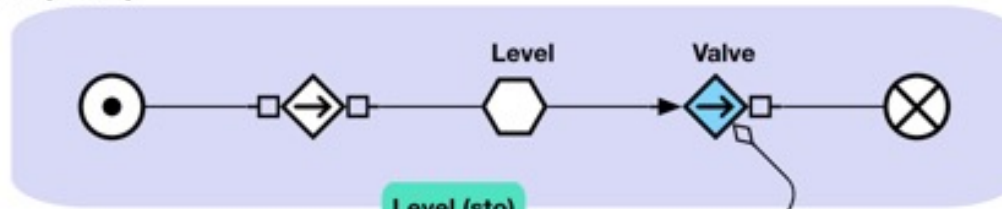
MFM Approach – Process Knowledge Digitalization



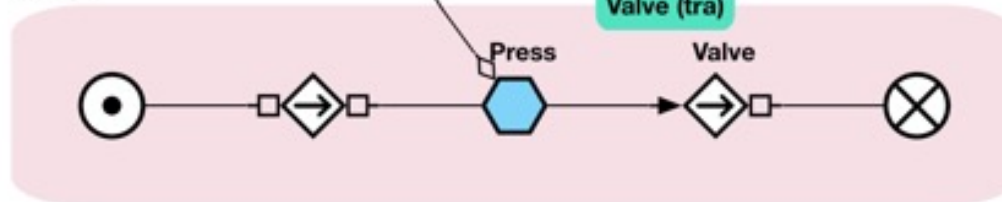
MFM Model – Qualitative Physics AI



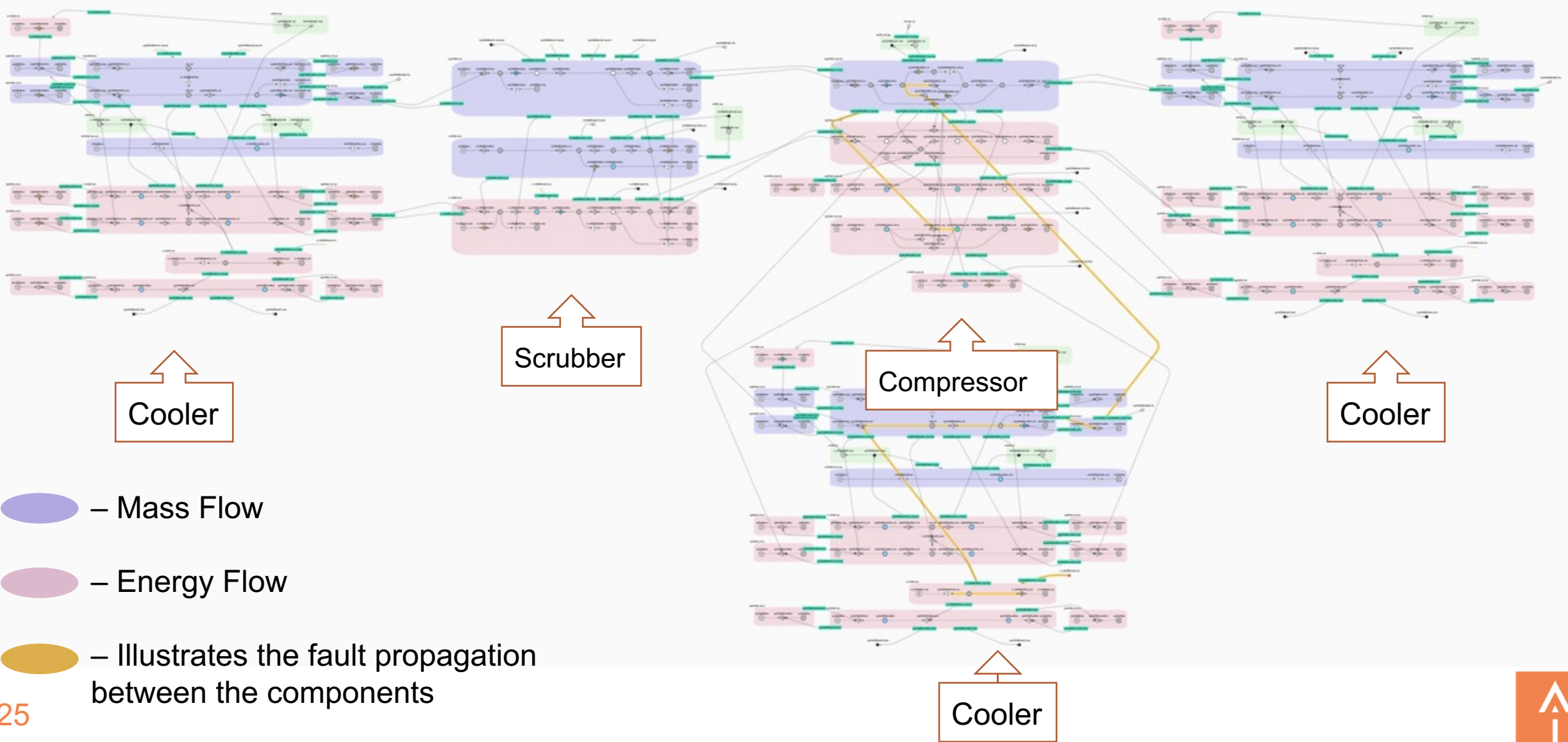
Mass (faucet)



Energy

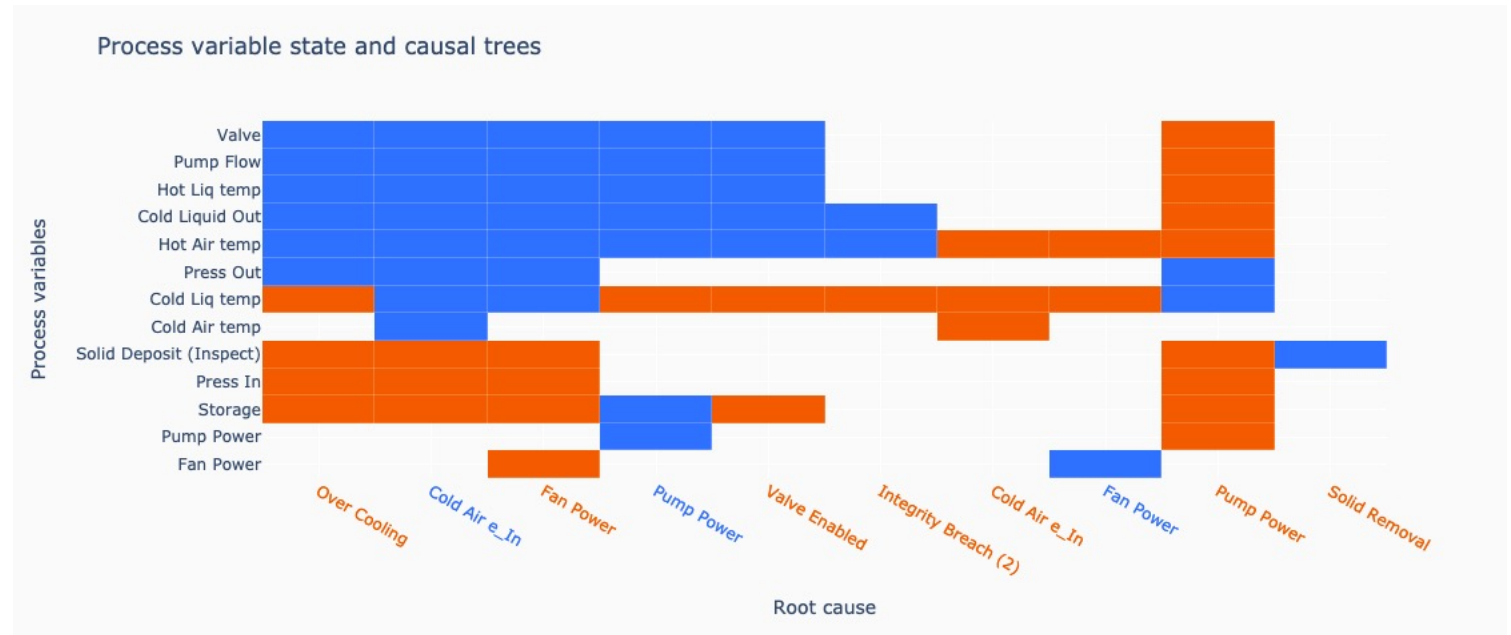
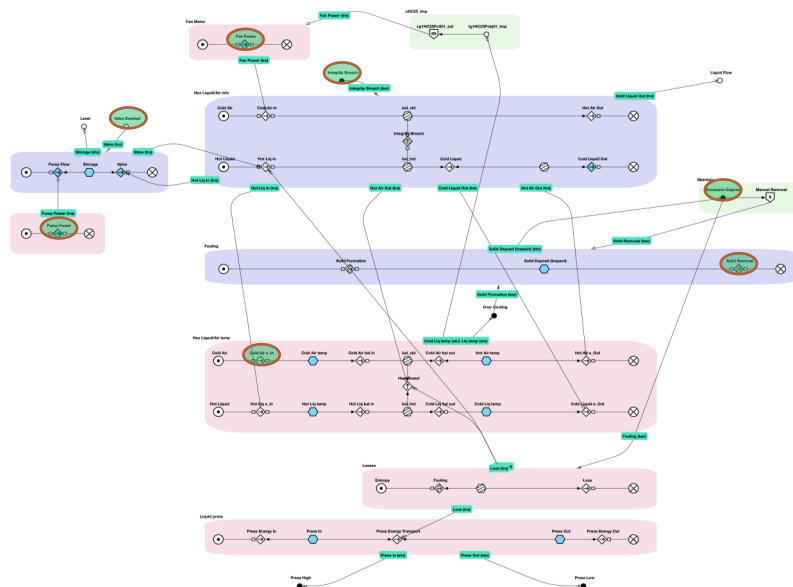


MFM model (3.stage compressor)



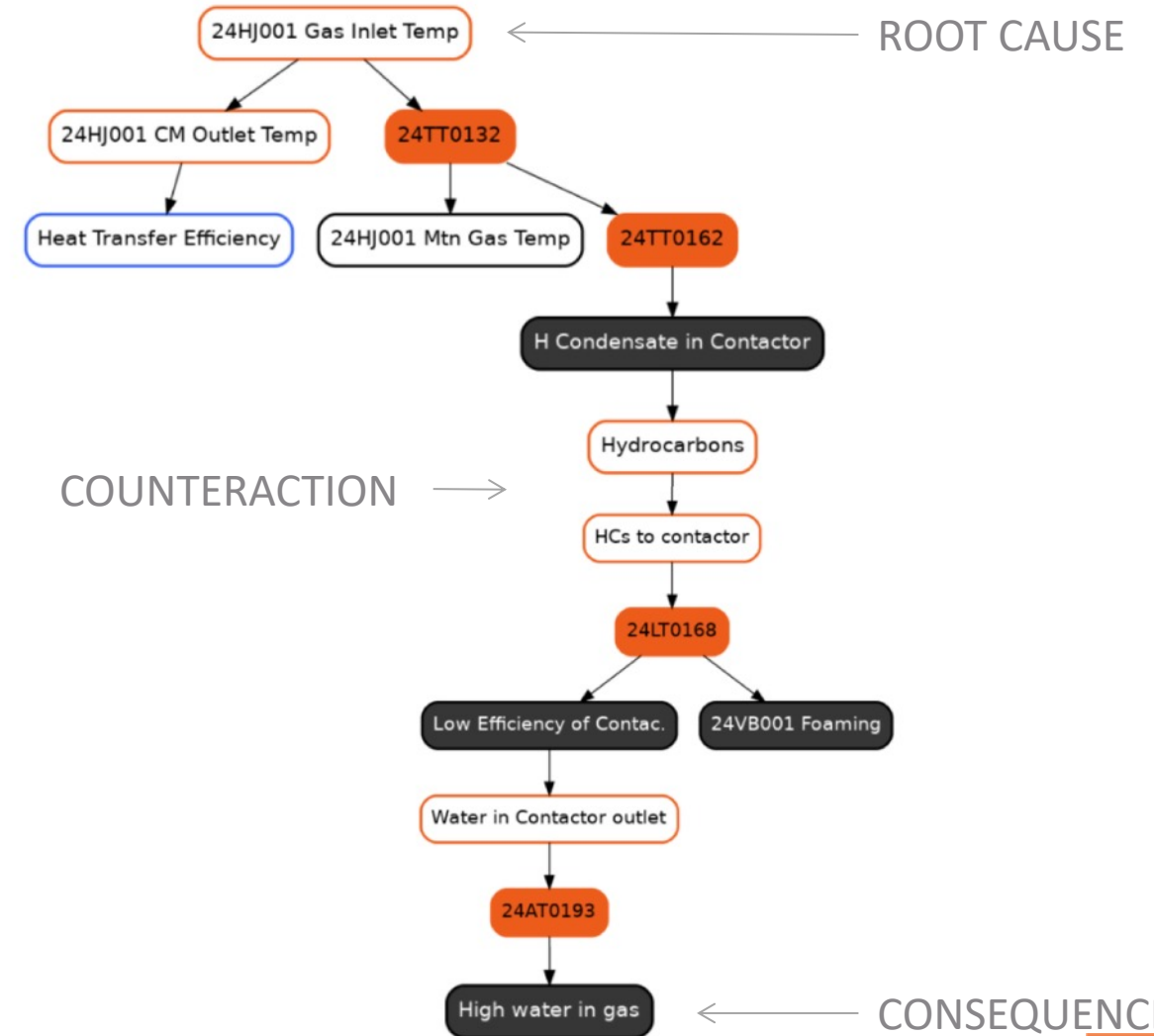
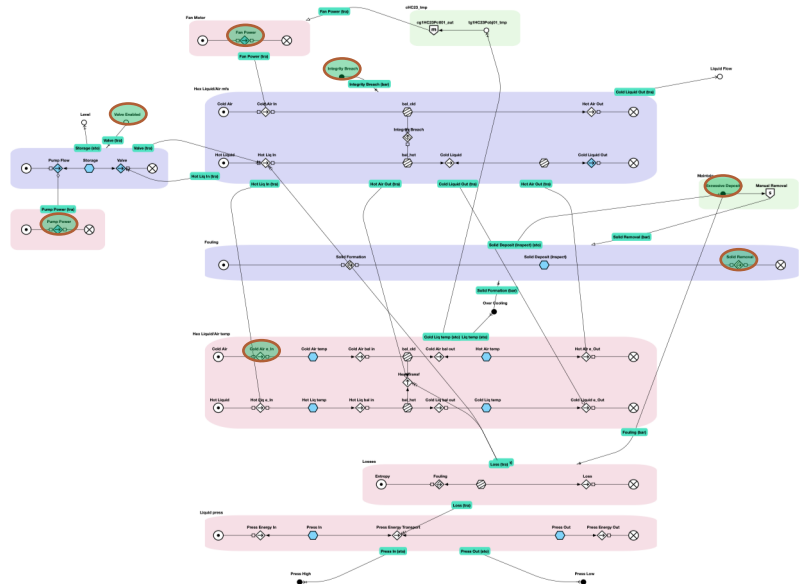
Safeguard Mapping

- Map barriers for every root cause



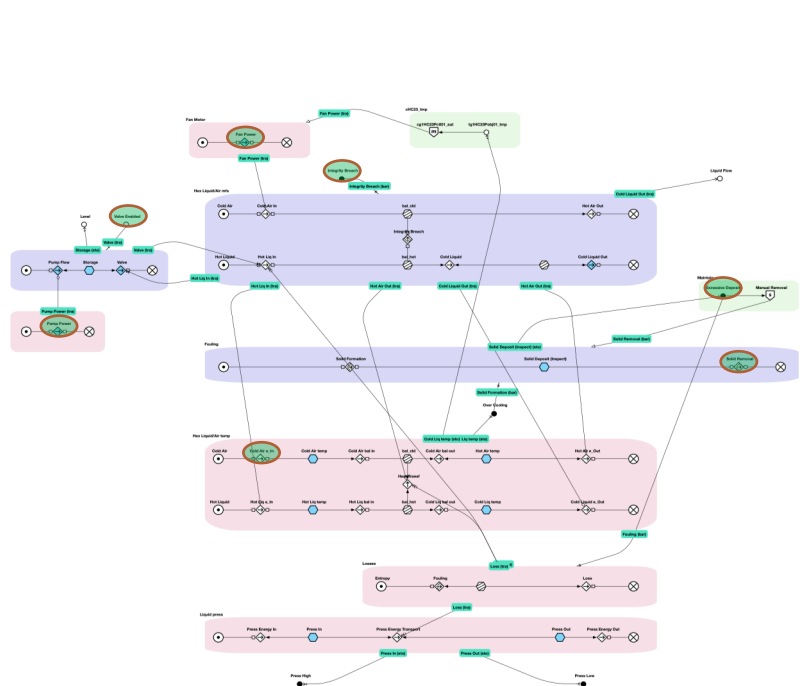
Counteraction – Causal mode graphs

- Understand barriers
 - For every cause
 - Against operating procedure



Counteraction - Cause Mitigation

- Group and combine causal graphs



Kairos – Control Room Assistant

Multilevel Flow Modelling (MFM)

Kairos

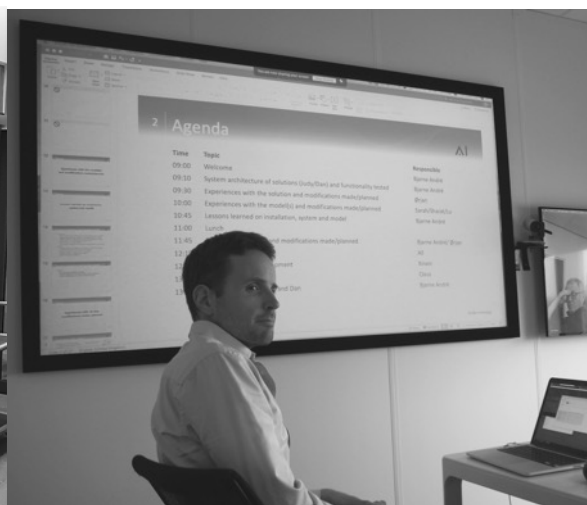
Faster and better decisions

Multilevel Flow Modeling (MFM) is a modeling strategy, designed to model the goals and functions of complex industrial systems.

~~One Sensor = One Alarm~~
All Sensors = Two lists ranking possible causes and consequences in **Real Time**.
Avoid alarm flooding due to early counteractions by operators.

Provides the operators with an improved status overview of the entire flow system

→ Increased safety offshore, and reduced downtime and production loss



Thank you!

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