PPCL

Process Plant Computing Limited

Scientifically Connecting Alarm Limits and Operating Envelopes

EPSC Webinar 1 September 2021

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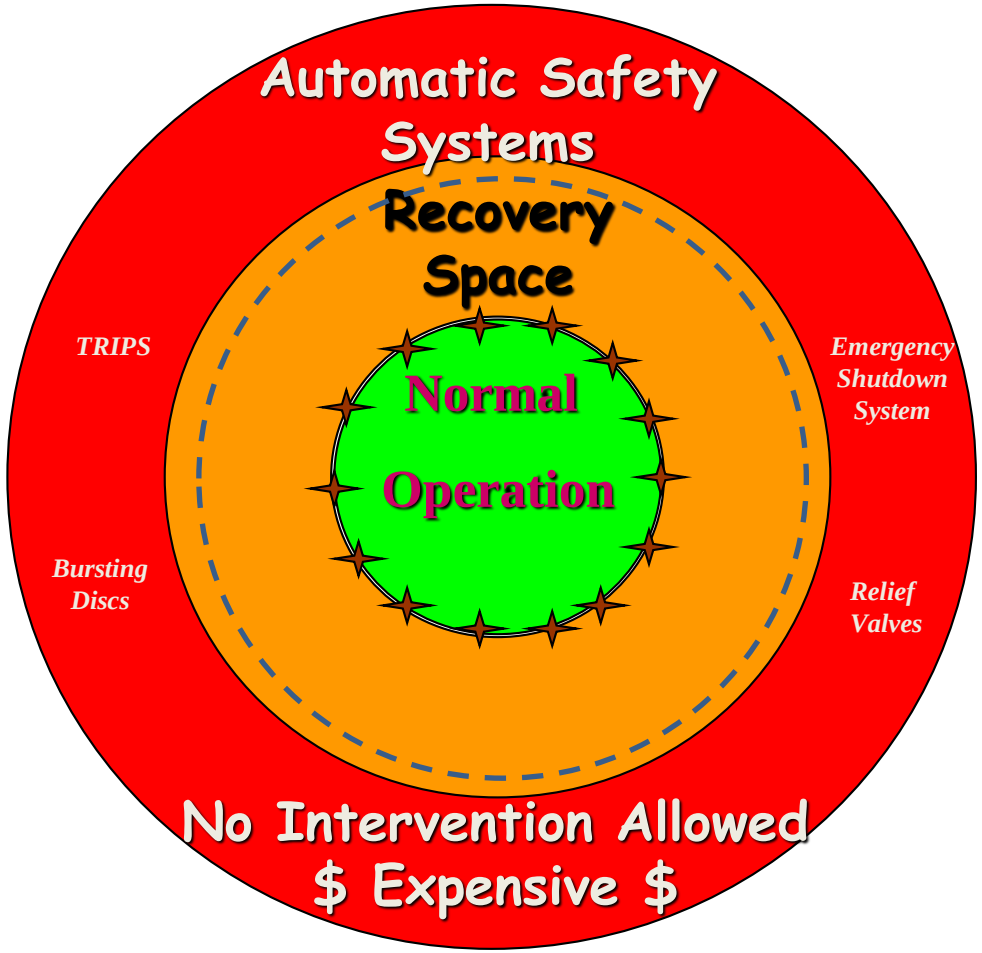
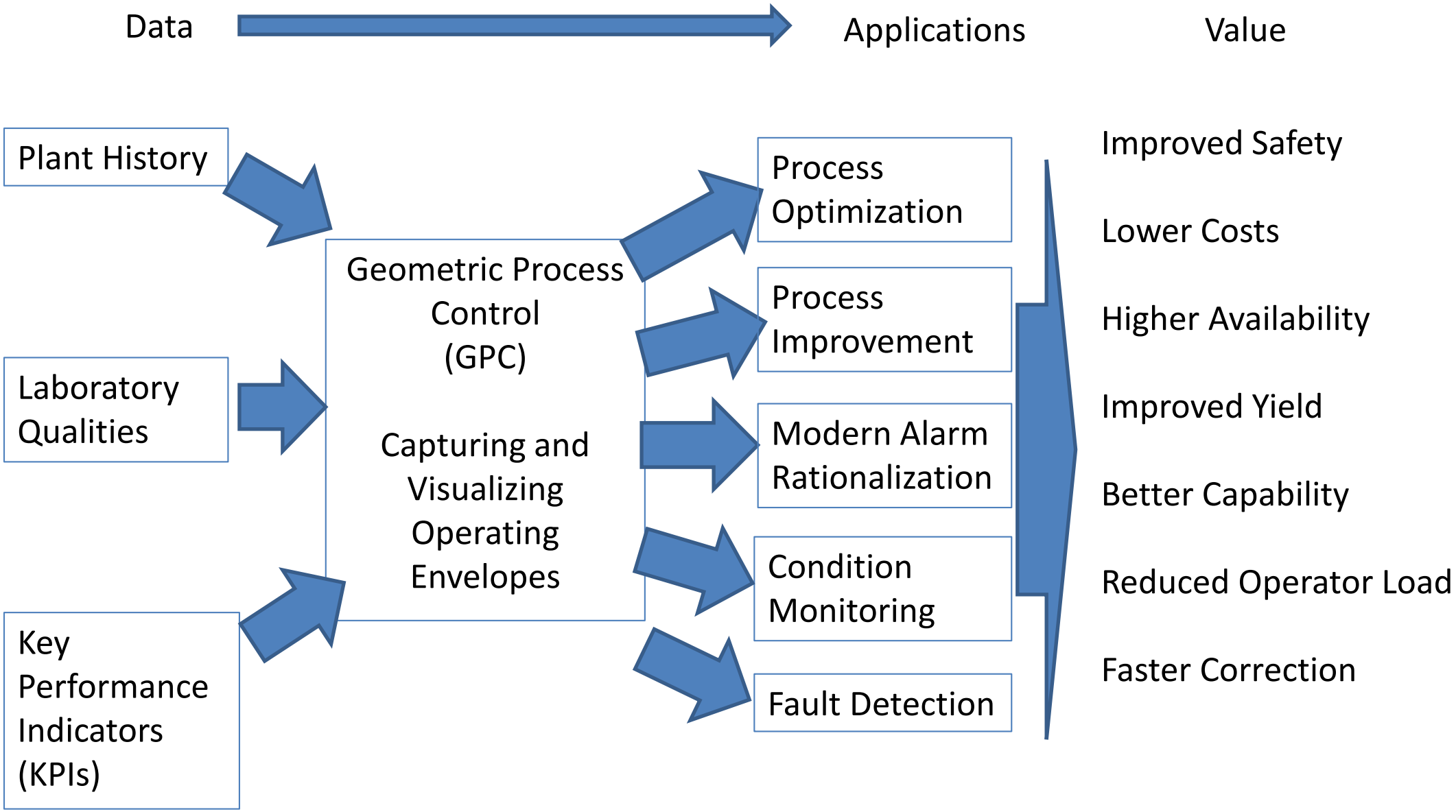
EPSC

Science-Based Alarm Rationalization

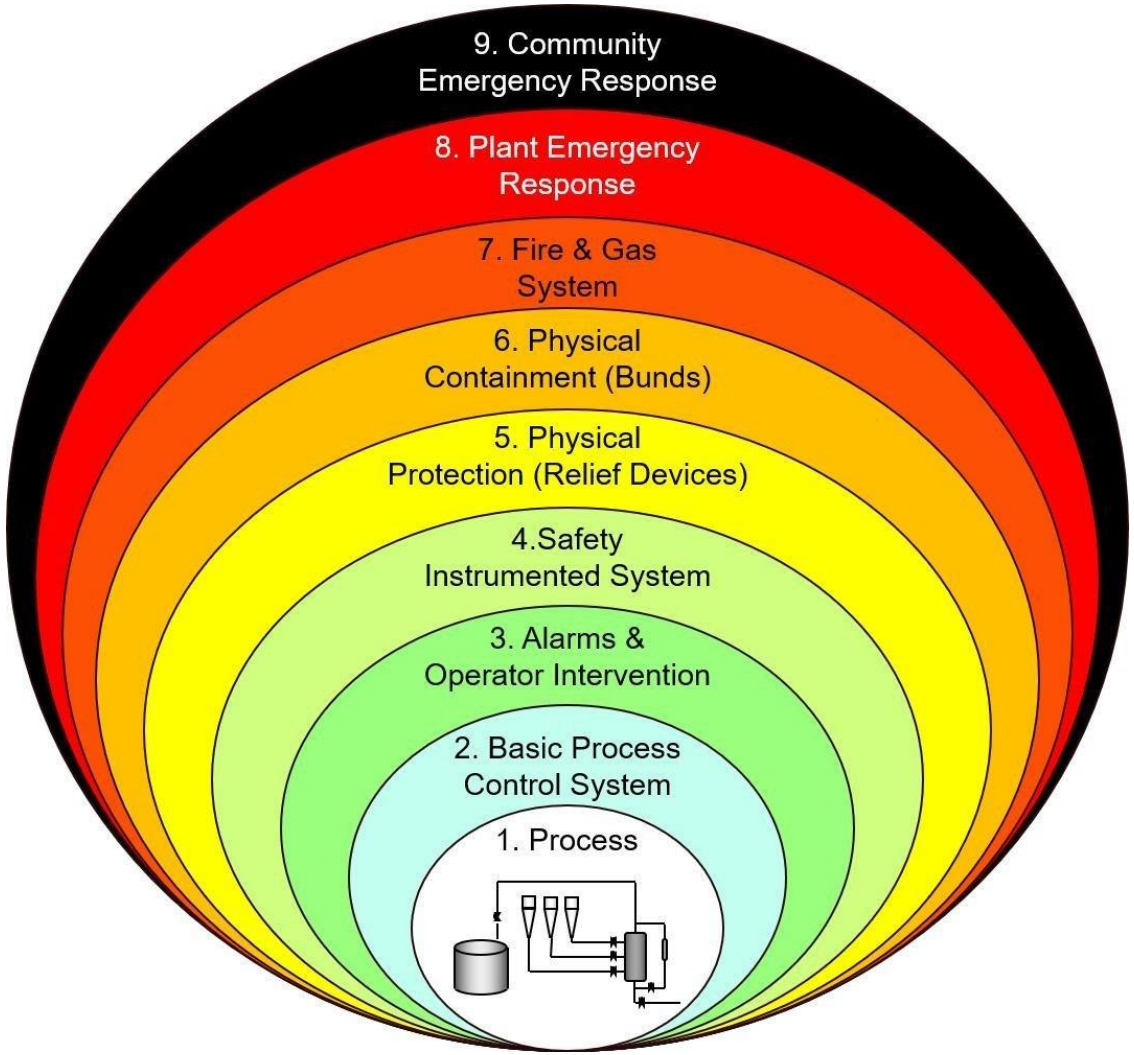
- Introduction
- Why do we have Alarms?
- Relating Alarms and Operating Envelope
- Modern Alarm Rationalization Process
- Case Studies
- Summary
- Q & A



What We Do at PPCL



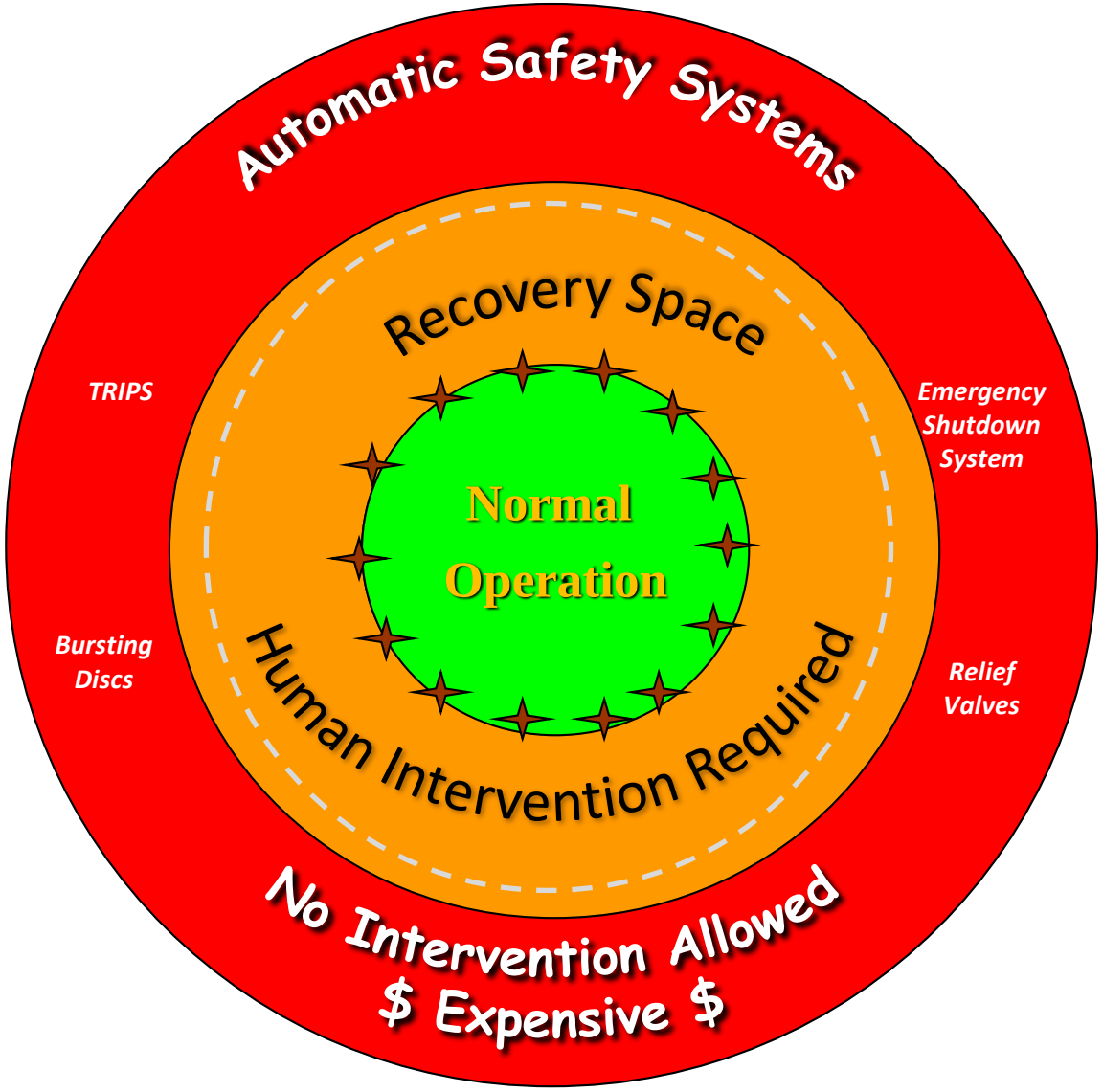
Why have Operator Alarms – a LOPA view



- Alarms are requests from level 2 for the operator to intervene
- Levels 2 and 3 attempt to correct a problem that began in Level 1
- Levels 4 and above attempt to mitigate the consequences of not correcting the problem
- Cost penalty for failure rises very steeply with each level
- Level 3 is the highest level with human intelligence available - and has the highest PFOD

Why have Alarms?

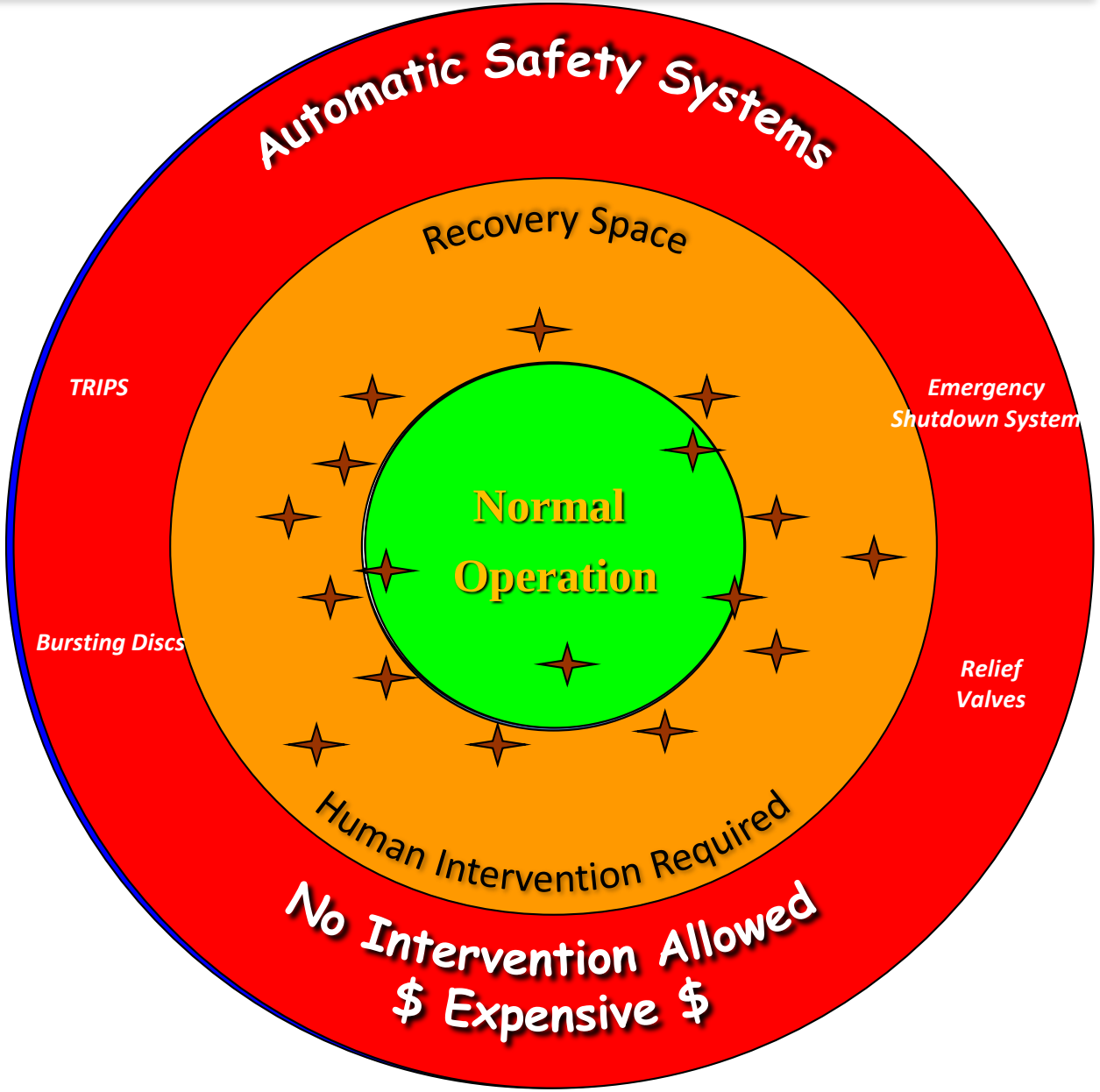
- Alarm Limit values are the single biggest factor determining alarm system performance
- Put your alarm limits at the boundary of where you normally operate



Properly positioned Operator Alarms increase safety, efficiency and throughput while reducing operating costs

Current Alarm Reality

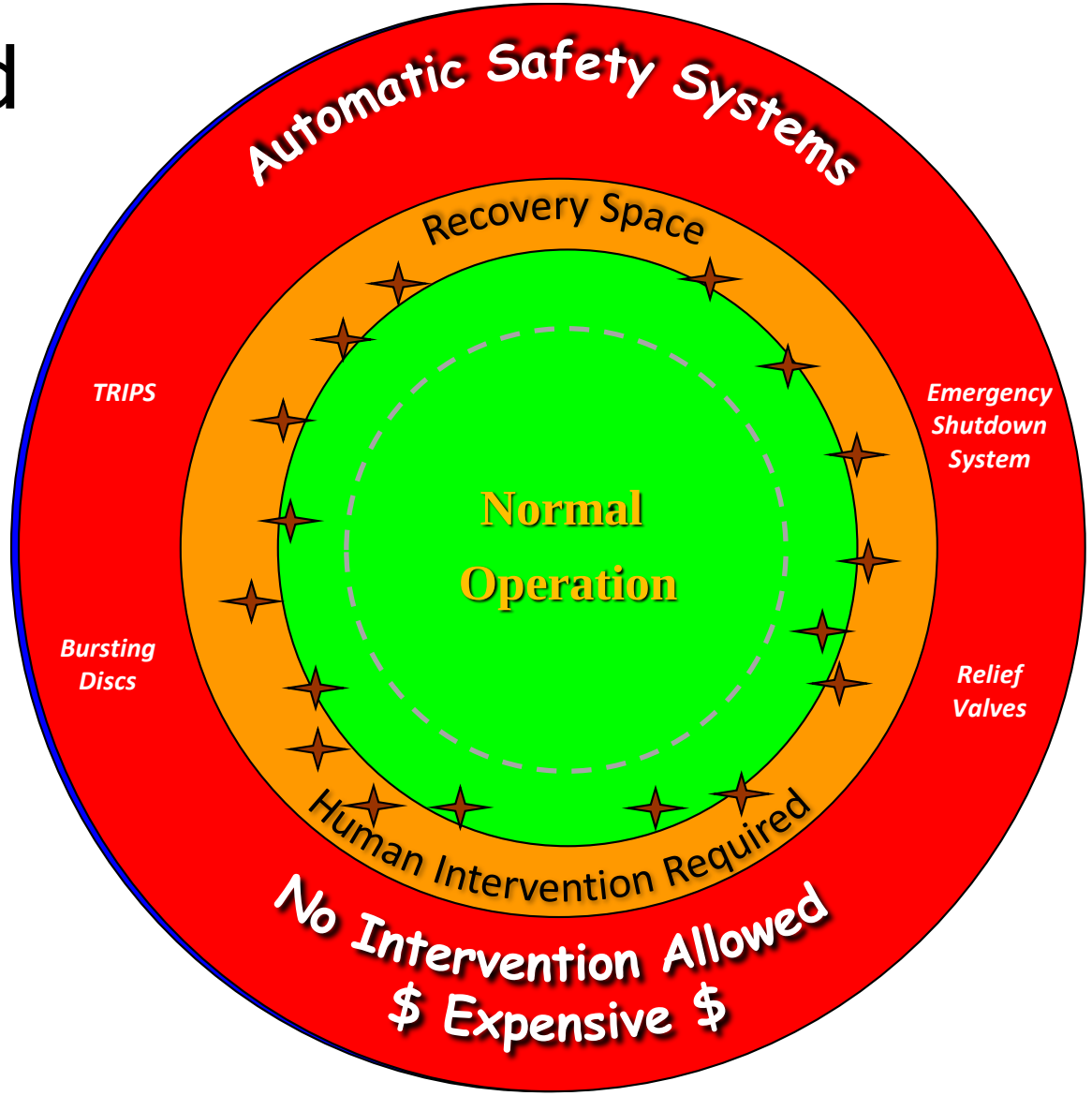
- Alarms in the orange zone cause delay and require bigger corrections
- Alarm limits in the green space are false alarms requesting operator action when none is needed.
- Are “always-silent” alarms monitored?



Effect of Bad-Actor Reviews

- Traditional rationalization and bad-actor reviews drive limits outwards
- Resulting alarm performance not known until weeks later

Rationalization projects are repeated every 5 -7 years



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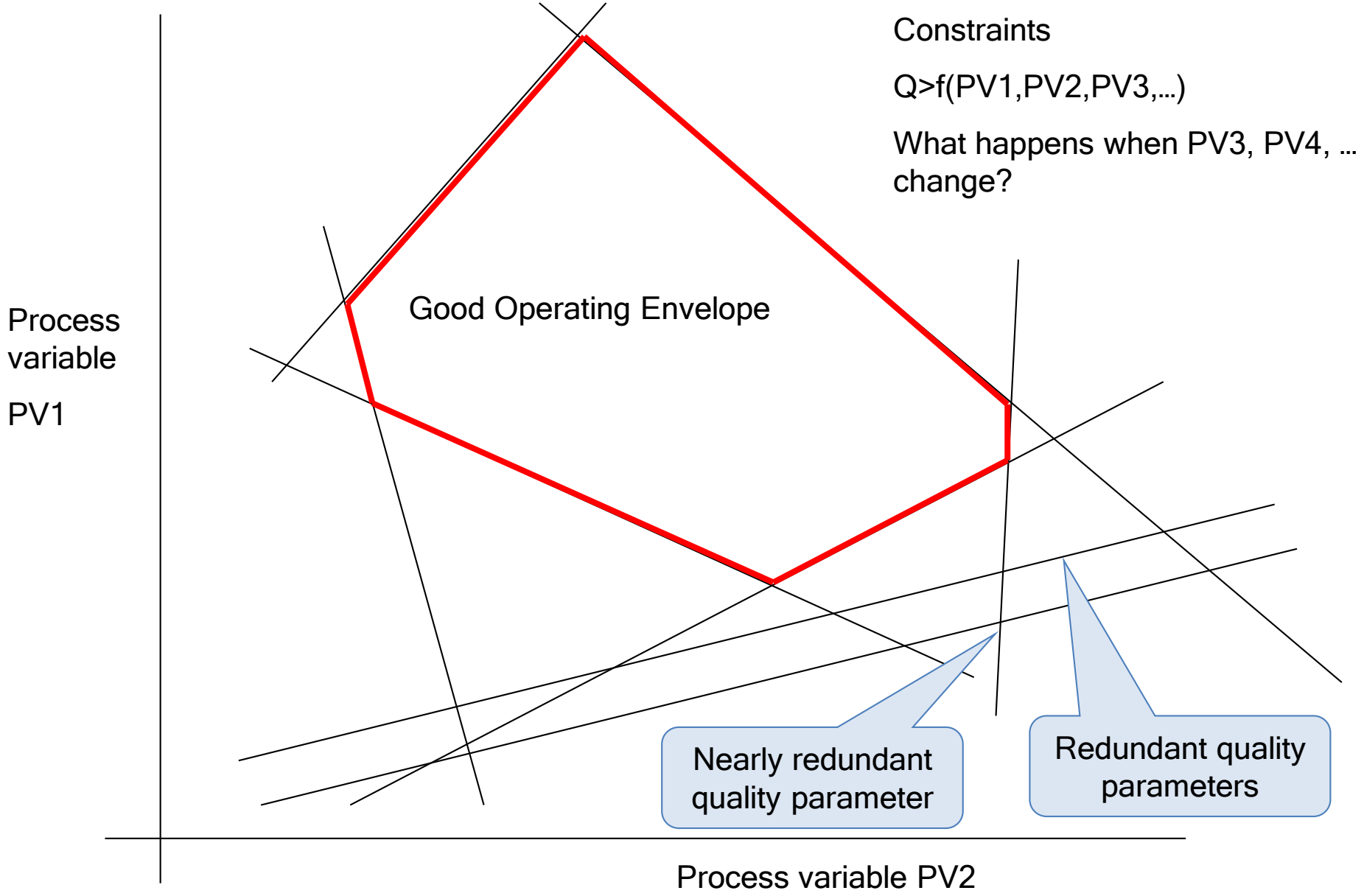
Geometric Process Control:

Identifying the Boundary of Normal Operation

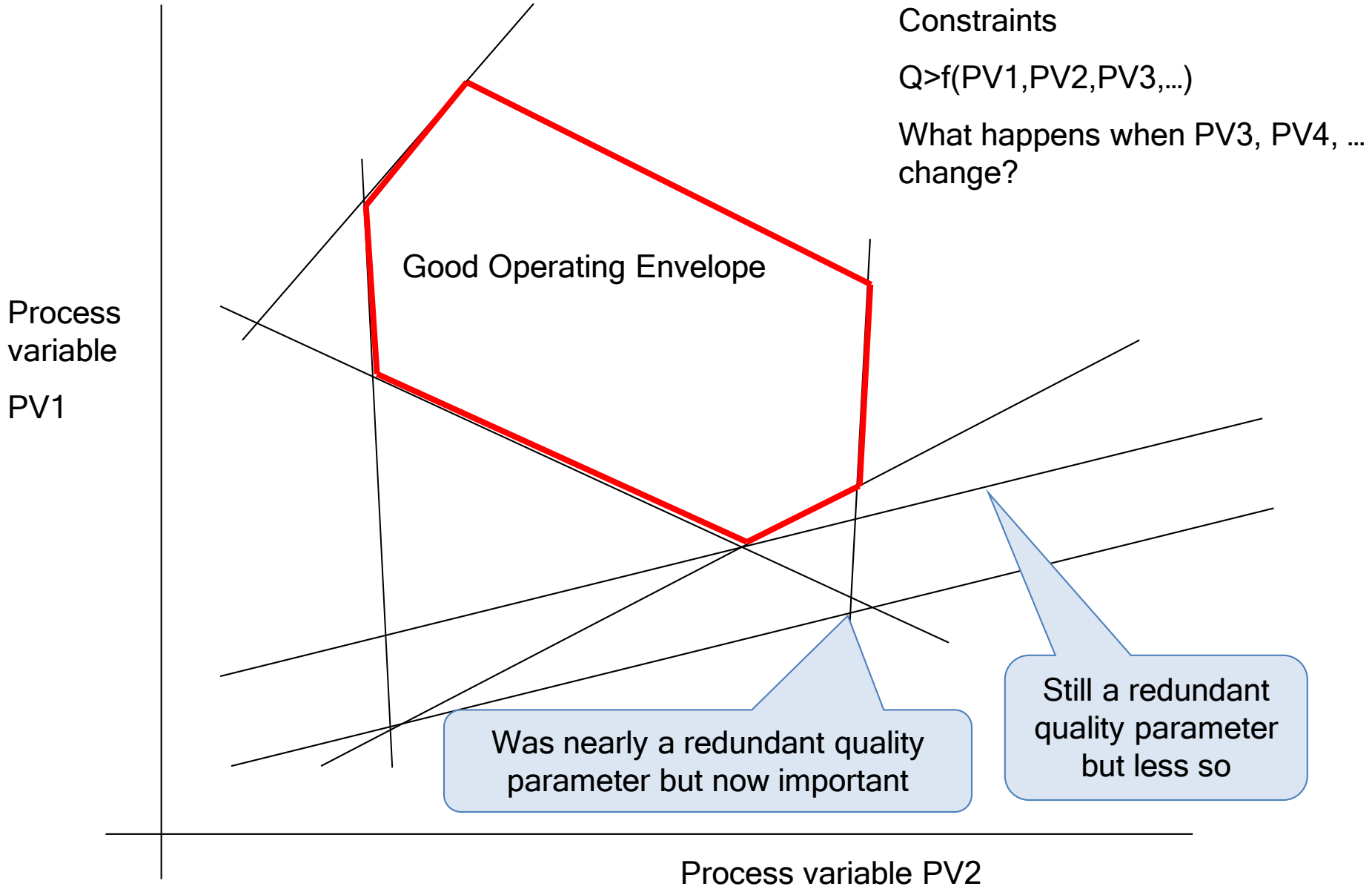
Positioning Alarm Limits on the Boundary

Predicting Alarm Performance

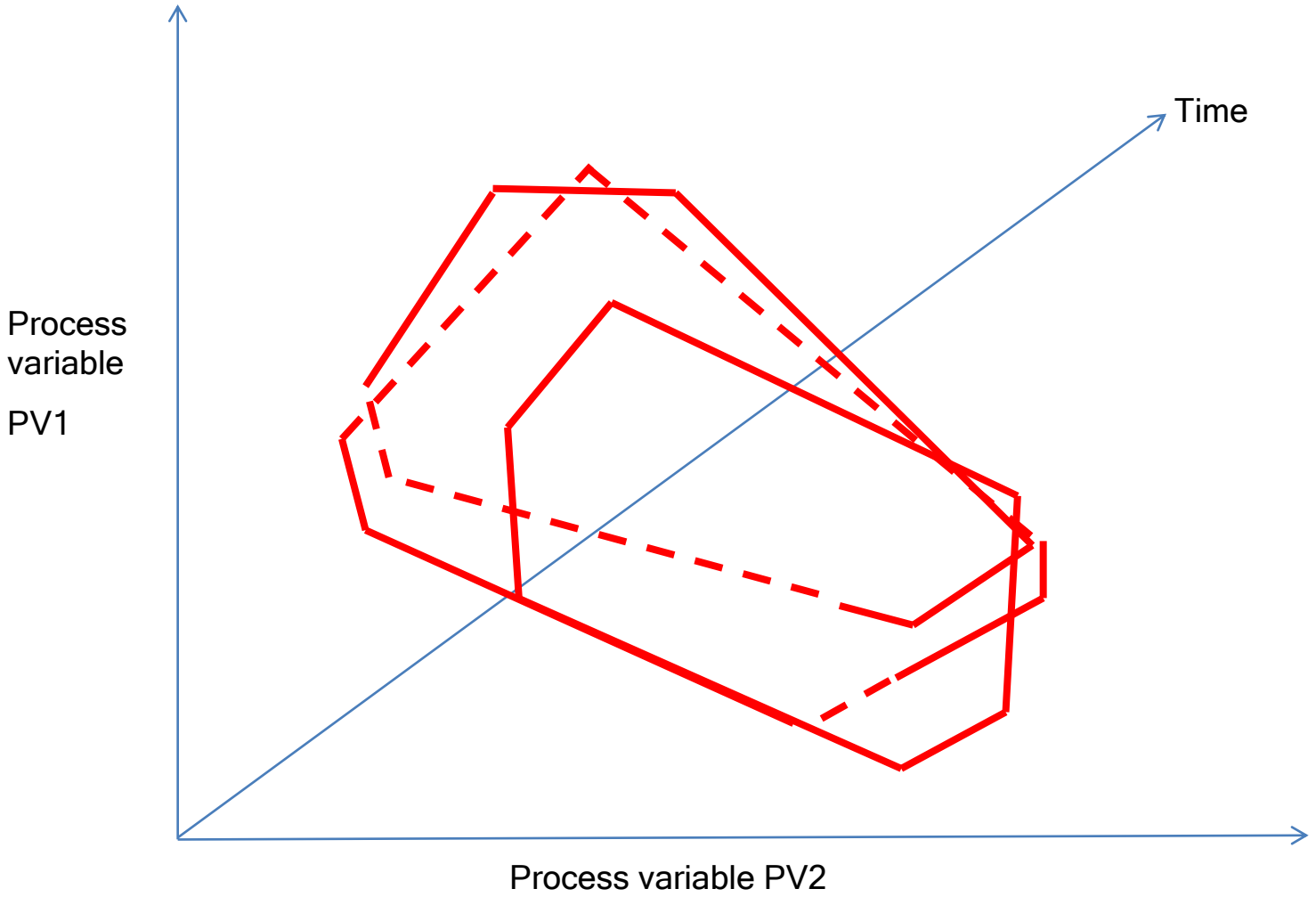
2-D Schematic of Operating Envelope



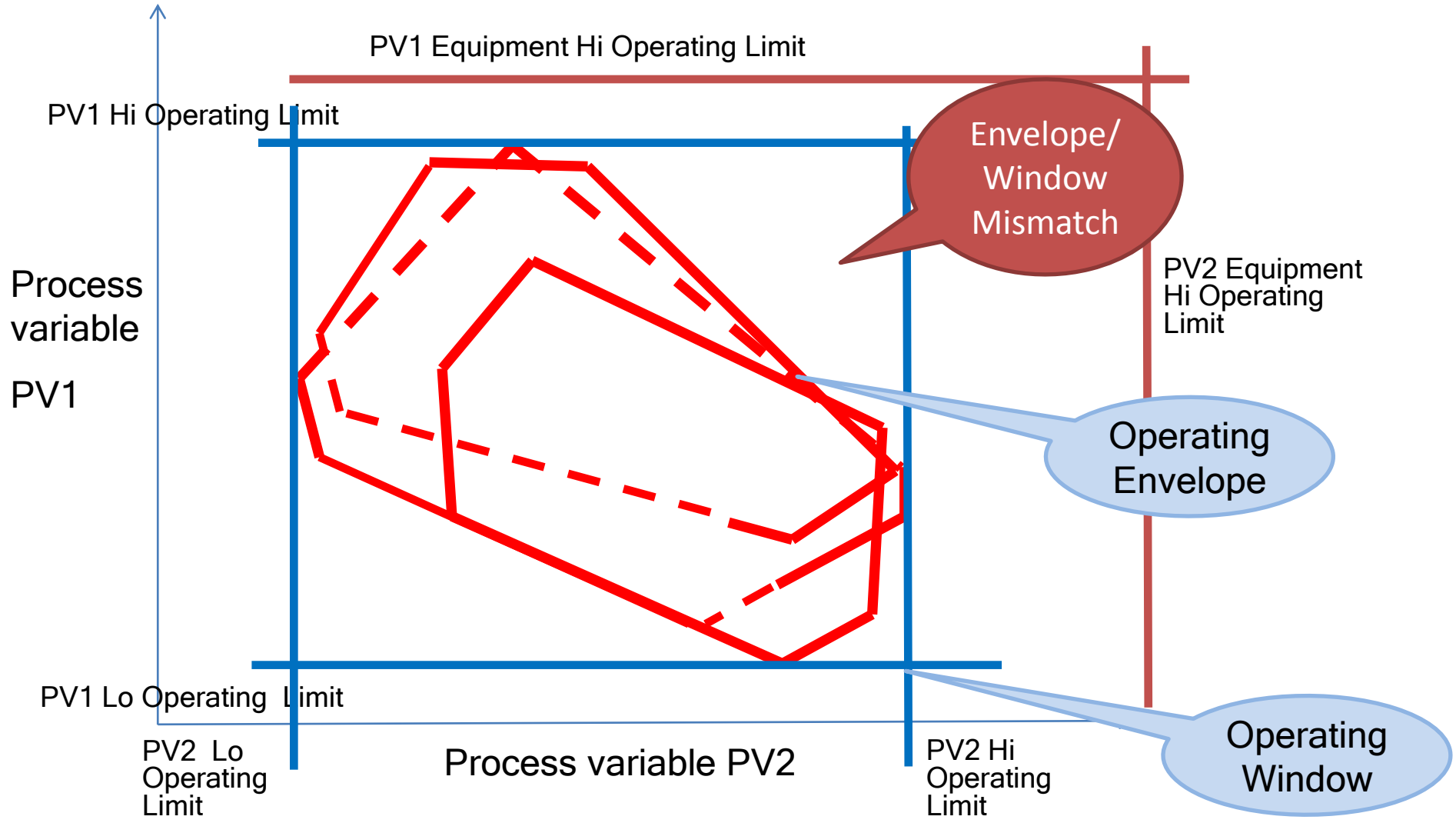
2-D Schematic of Operating Envelope



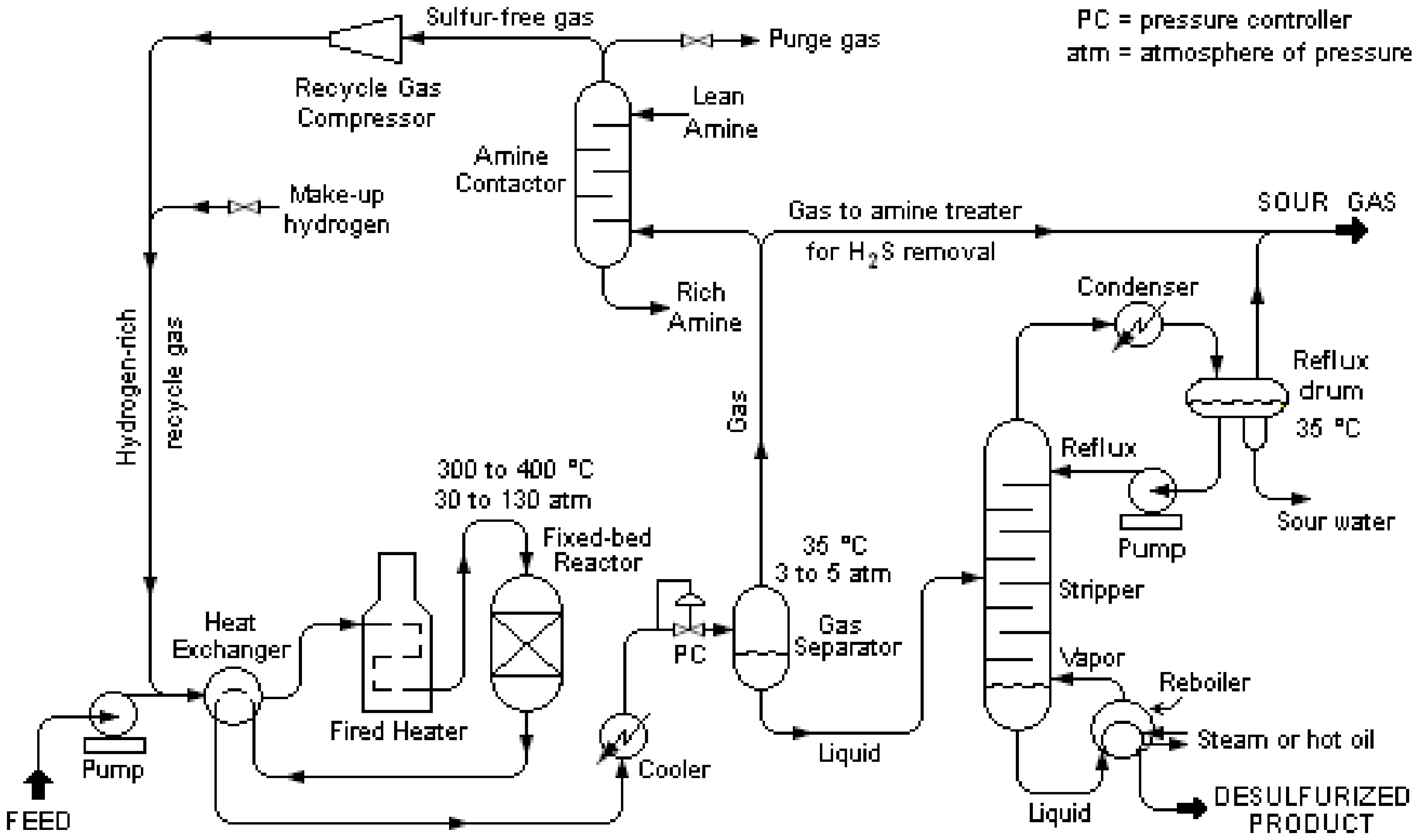
Problem – you cannot see more than three process variables



Operating Limits – Operating Windows – Operating Envelopes



HDS Schematic



Where does it start?

Process History Data import (csv, Excel, PI, PHD) …..

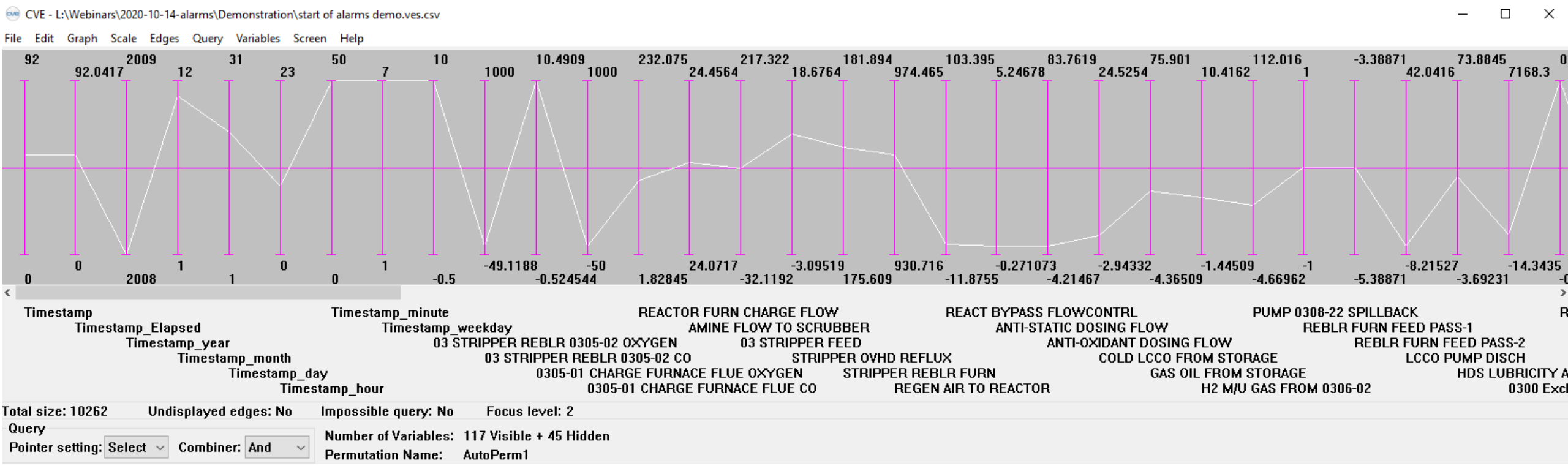
TAMU.ves.csv

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1	M3/HR	KNM3/HR	M3/HR	M3/HR	M3/HR	M3/HR	L/HR	NM3/HR	M3/HR	KNM3/HR	TONNE/HI	M3/HR	KNM3/HR	KNM3/HR	KNM3/HR	M3/HR	DEGC	KNM3/I
2	GAS OIL FI	H2 M/U GA	PUMP 030	REBLR FUF	REBLR FUF	LCCO PUM	HDS LUBRI	0300 Exch	Raw HCN	SCRUBBER	LP SEPRTR	STRIPPER	FUEL GAS	FUEL GAS	FUEL GAS	LCCO PUM	REACTR 2	RECYCL
3	N03FC379	N03FC380	N03FC506	N03FC516	N03FC517	N03FC540	N03FC552	N03FC565	N03FC582	N03FI095	N03FI098	N03FI122	N03FI153	N03FI162	N03FI164	N03FI540	N03FI95_F	N03FR0
4	1.94365	3.39589	6.2016	0	-4.38871	37.7543	0.068464	2841.42	0.00807	-6.81E-06	0.246832	172.348	3.59E-06	1.12695	0.890049	37.8094	506.497	28.57
5	2.05572	3.56238	6.05197	0	-4.38871	37.5725	0.068464	2844.85	0.00134	-6.81E-06	0.249863	179.596	3.59E-06	1.12304	0.890181	37.4313	506.002	28.68
6	2.5549	3.64624	6.15486	0	-4.38871	36.4718	0.068464	2842.36	0.00807	-6.81E-06	0.249955	175.057	3.59E-06	1.11545	0.878297	36.5844	505.892	28.68
7	2.05572	3.67029	6.21854	0	-4.38871	36.5357	0.068464	2844.22	0.00807	-6.81E-06	0.251828	179.174	3.59E-06	1.11669	0.868948	36.7217	506.356	28.76
8	2.44284	3.7123	6.06865	0	-4.38871	36.4884	0.068464	2840.14	0.00807	-6.81E-06	0.25245	177.366	3.59E-06	1.1079	0.867556	36.634	506.171	28.57
9	2.66696	3.67363	6.00893	0	-4.3887													
10	3.4412	3.61907	6.02294	0	-4.3887													
11	2.44284	3.6598	5.96589	0	-4.3887													
12	2.94202	3.65797	6.07973	0	-4.3887													
13	3.4412	3.64802	6.08674	0	-4.3887													
14	2.44284	3.64035	6.12914	0	-4.3887													
15	3.05408	3.58685	6.18657	0	-4.3887													
16	2.44284	3.52842	6.13525	0	-4.3887													
17	2.44284	3.40353	6.09514	0	-4.3887													
18	2.5549	3.1653	6.08954	0	-4.3887													
19	2.44284	2.91333	6.11997	0	-4.3887													
20	2.44284	2.71963	6.05197	0	-4.3887													
21	2.66696	2.77103	6.16785	0	-4.3887													
22	2.44284	2.83438	6.10552	0	-4.3887													
23	4.05244	2.96717	6.12914	0	-4.3887													
24	2.94202	3.12387	6.17206	0	-4.3887													

	A	B	C	D	E	F	G
1	DateTime	Bulk Density (kg/L)	Coating Agent (%w/w)	Friability (%w/w)	Moisture (%w/w)	Oil Absorption (%w/w)	Product Less 1mm (%w/w)
2	01/07/2005 00:00	0.773	0.08	1.05	0.119999997	7.2	0.119999997
3	01/07/2005 06:00	0.79	0.08	1.84	0.140000001	6	0.439999998
4	01/07/2005 21:00	0.765	0.08	2.01	0.209999993	7.3	0.189999998
5	02/07/2005 03:00	0.738	0.08	1.2	0.119999997	7.4	0.209999993
6	02/07/2005 06:00	0.76	0.08	1.3	0.119999997	7.9	0.170000002
7	02/07/2005 09:00	0.728	0.08	1.2	0.119999997	8.7	0.159999996
8	02/07/2005 12:00	0.765	0.19	1.35	0.119999997	8	0.05
9	02/07/2005 18:00	0.762	0.08	1.57	0.109999999	7.6	0.05
10	02/07/2005 21:00	0.774	0.08	1.09	0.100000001	6.5	0.07
11	03/07/2005 00:00	0.774	0.09	1.15	0.109999999	7.5	0.05
12	03/07/2005 03:00	0.773	0.09	1.42	0.109999999	7.6	0.09
13	03/07/2005 09:00	0.754	0.07	1.82	0.159999996	8	0.170000002
14	03/07/2005 12:00	0.767	0.08	0.94	0.109999999	8	0.100000001
15	03/07/2005 15:00	0.763	0.08	1.02	0.119999997	8	0.109999999
16	03/07/2005 18:00	0.77	0.08	1.52	0.119999997	8	0.07
17	03/07/2005 21:00	0.771	0.08	1.17	0.119999997	8	0.05
18	04/07/2005 00:00	0.768	0.07	1	0.119999997	8.1	0.03
19	04/07/2005 03:00	0.77	0.08	1.05	0.119999997	8.1	0.04
20	04/07/2005 06:00	0.771	0.07	1.17	0.119999997	8.1	0.07
21	04/07/2005 12:00	0.765	0.08	1.44	0.129999995		0.08
22	04/07/2005 15:00	0.764	0.09	1.24	0.129999995	8.7	0.09

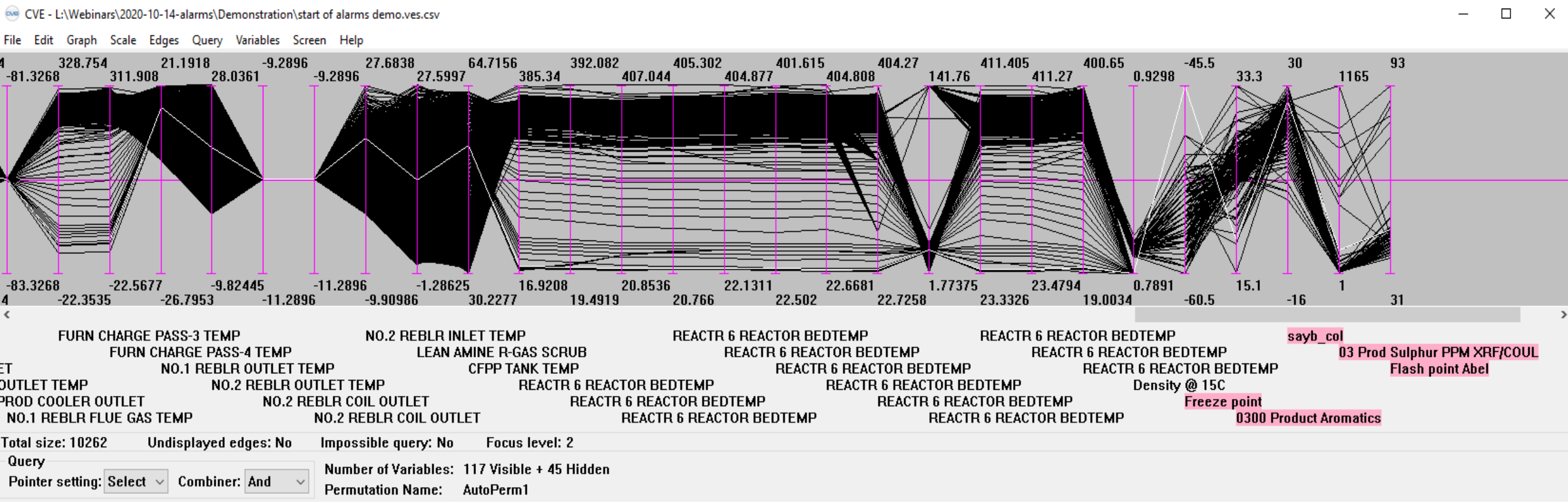
Laboratory Quality Results, Lagging and Leading KPI History

Finding the Normal Operating Envelope from Process History data



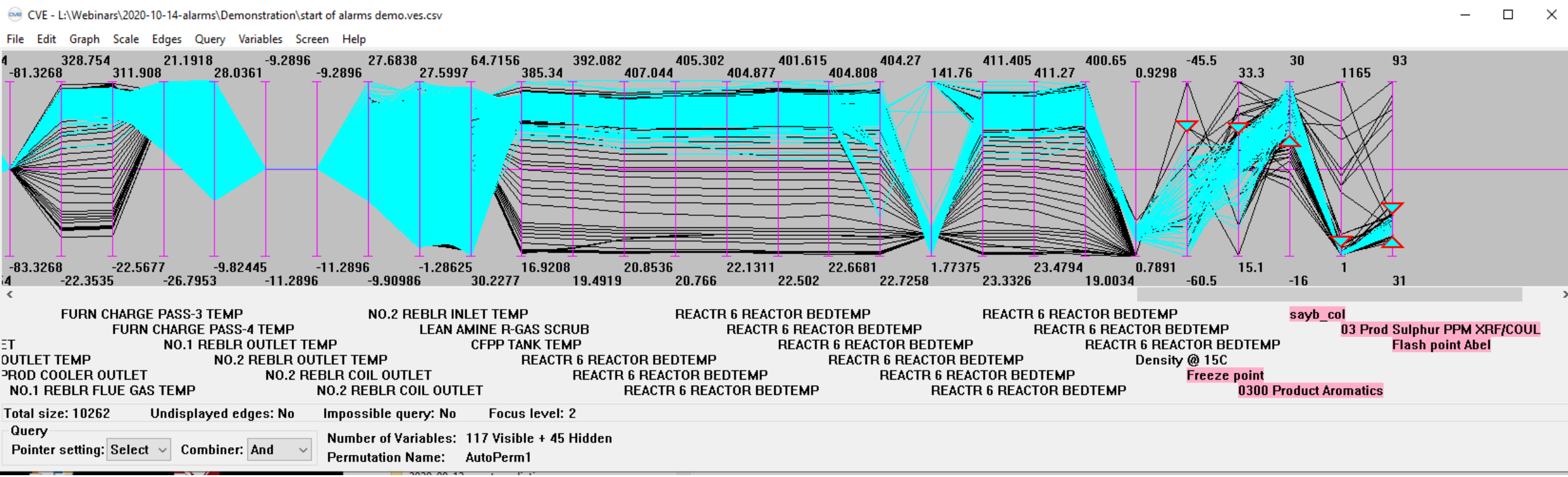
- Graph axes are the vertical pink lines – one variable per axis
- Poly-line represents one row of an excel sheet or one moment in time or one process operating point
- Coordinate transformation between n-space and 2-space (n=117 in this example)

Find the Normal Operating Envelope from Process History data



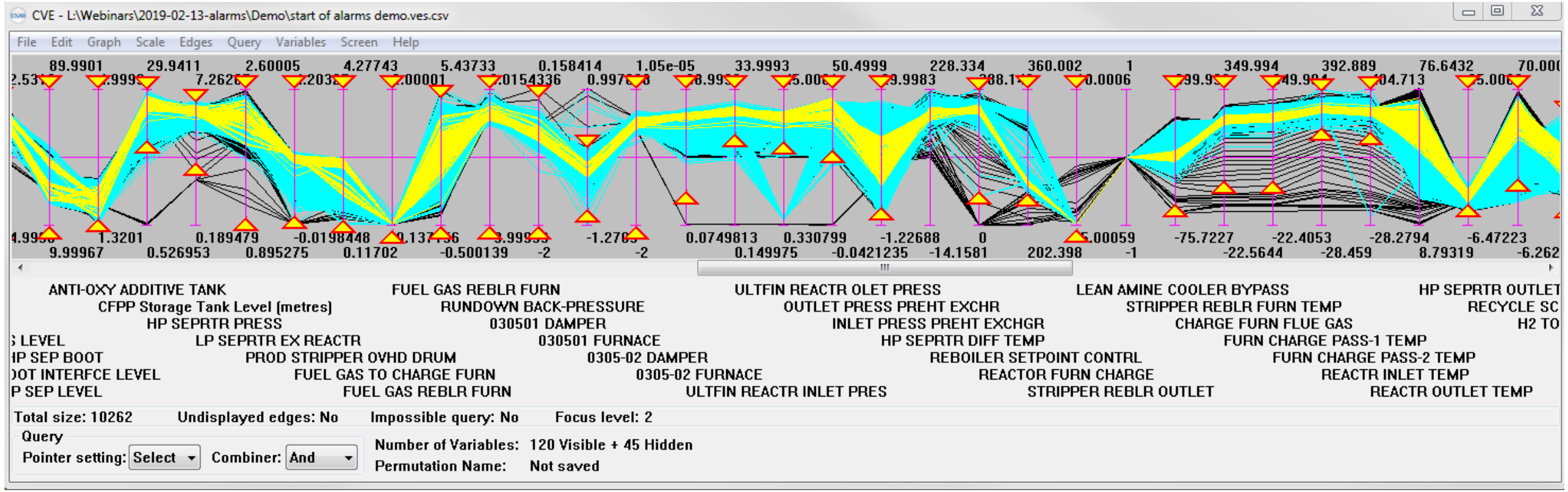
- Each polyline line still represents one point in time but here there are 10,262 polylines
- Links data from left (process causes and leading KPI's) to right (performance results and lagging KPI's in pink)
- Patterns and density capture process behaviour and variable relationships

Lagging KPI Operating Envelope



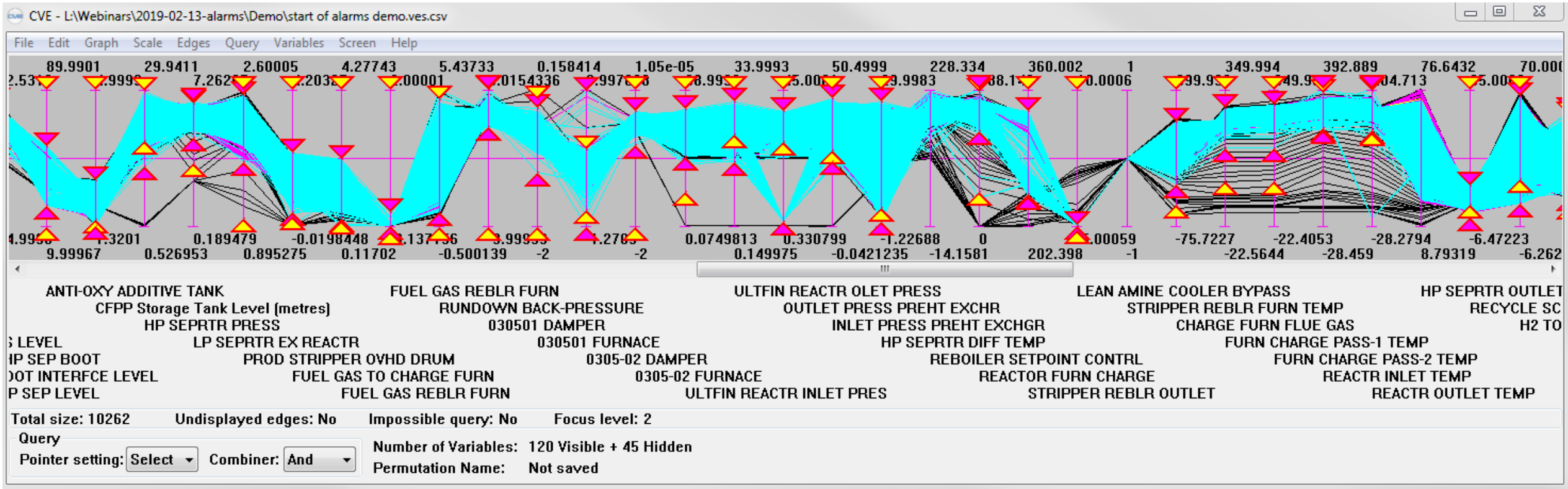
- HDS Unit showing part of an envelope for achievement of the lagging KPI of in-specification kerosene in blue and out of spec in black. 82% was in specification

Alarms and Operating Modes



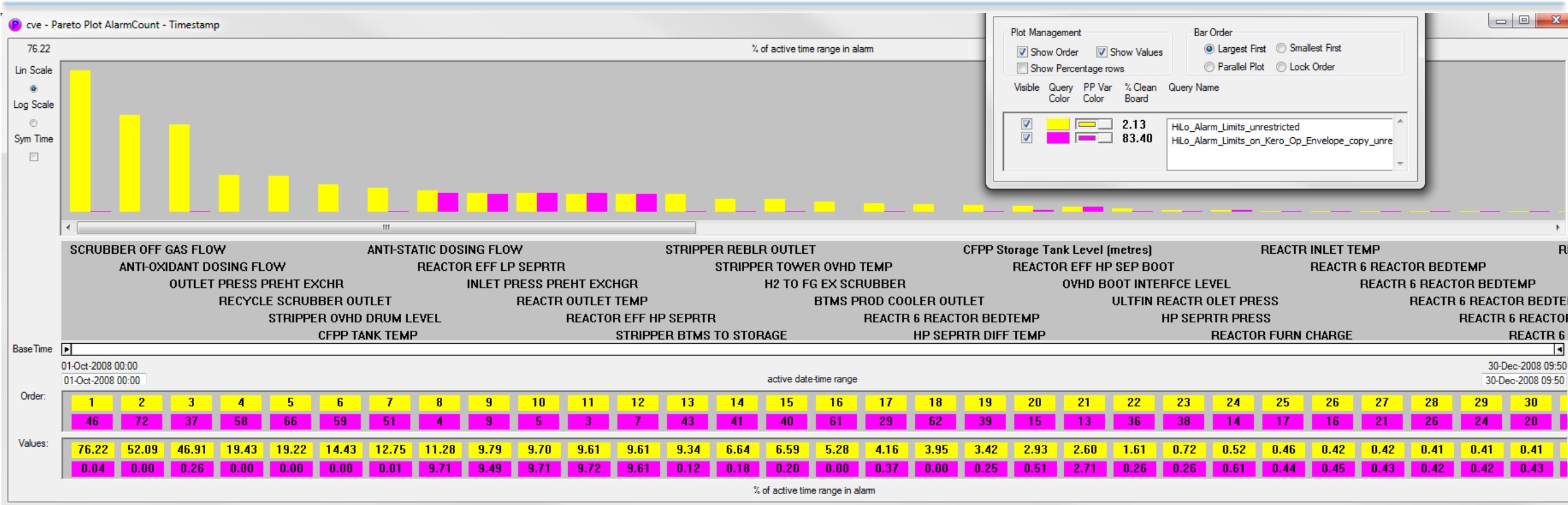
- Current Alarm limits added as yellow triangles. Those inside the blue area will give False Alarms. Those outside may never annunciate and don't help the operator
- Yellow shows 3% of operation was inside all alarm limits. That's the Clean Board Rate.

Hi Lo Alarm Limits consistent with the Lagging KPI Operating Envelope



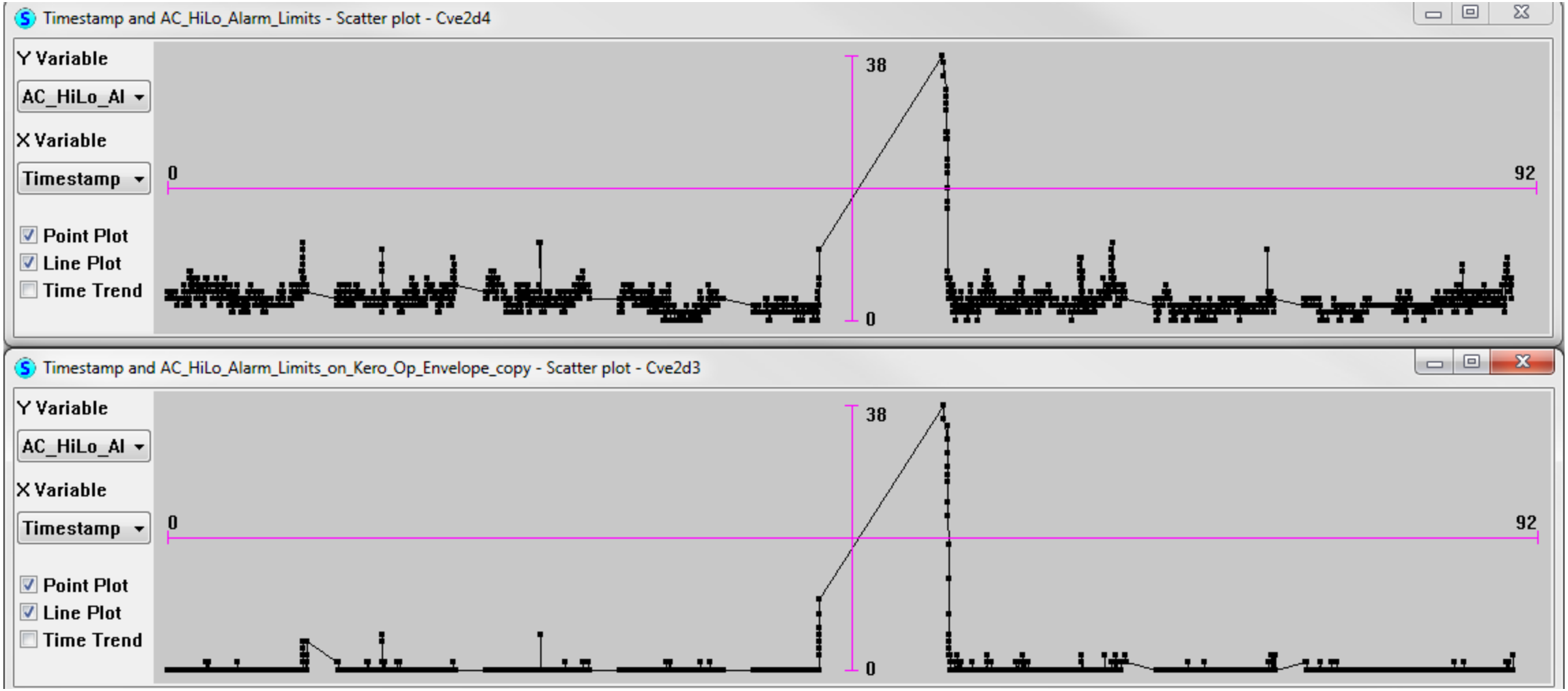
- Magenta are the alarm limits repositioned to the extreme boundary of the Lagging KPI operating envelope. Notice those that were outside have moved in and those that were inside have moved out.
- The pink envelope is underneath the blue. Where pink can be seen would be out-of-specification kerosene. Operating in the pink envelope raises the yield of in-spec kerosene from 82% to 86%

Alarm Performance Prediction



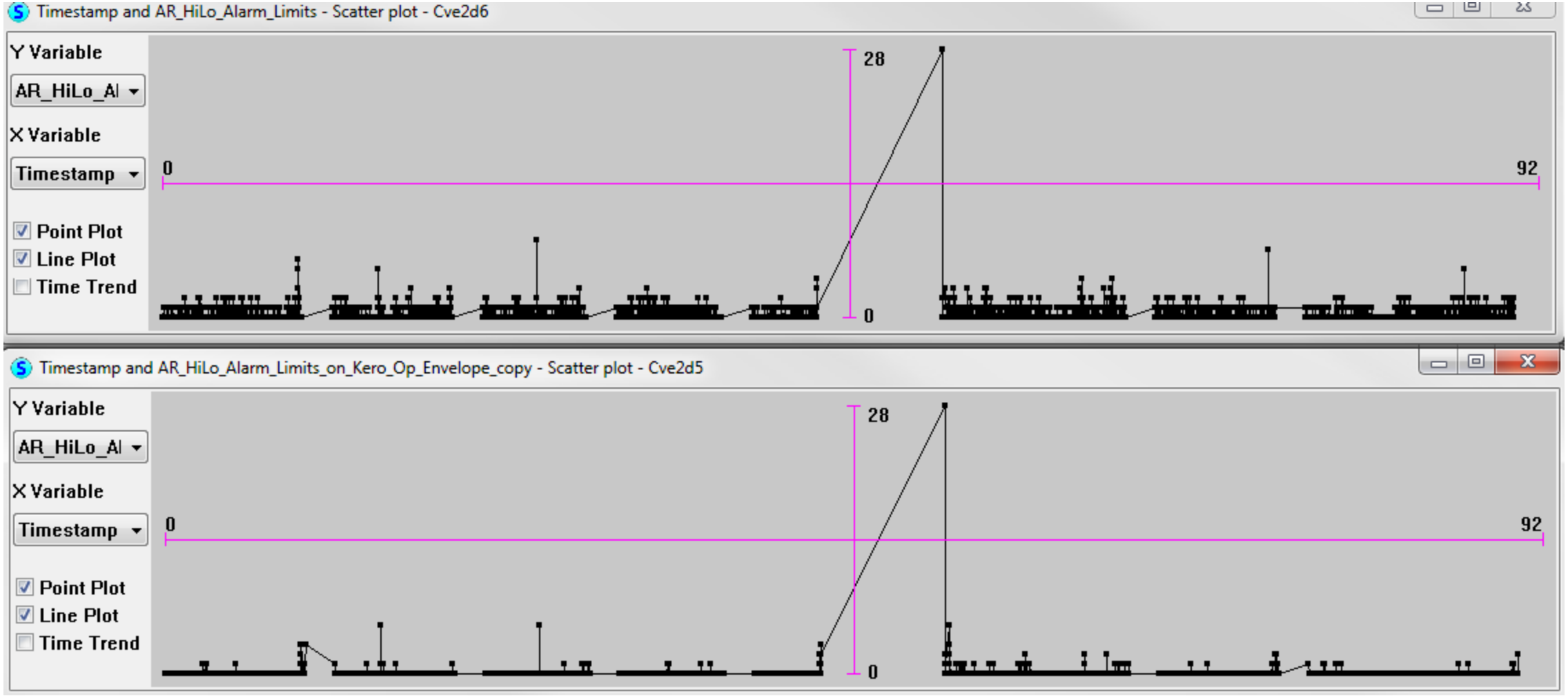
- Alarm performance improves dramatically. Original alarms in yellow, proposed new alarms in magenta.
- “Clean Board” percent (ie. no alarms present in alarm list) rises from **3% to 83% of time.** The span of the data is 3 months.
- Scroll right to see the “always silent” alarms

Alarms Before and After – Alarm Count in the Alarm List Display



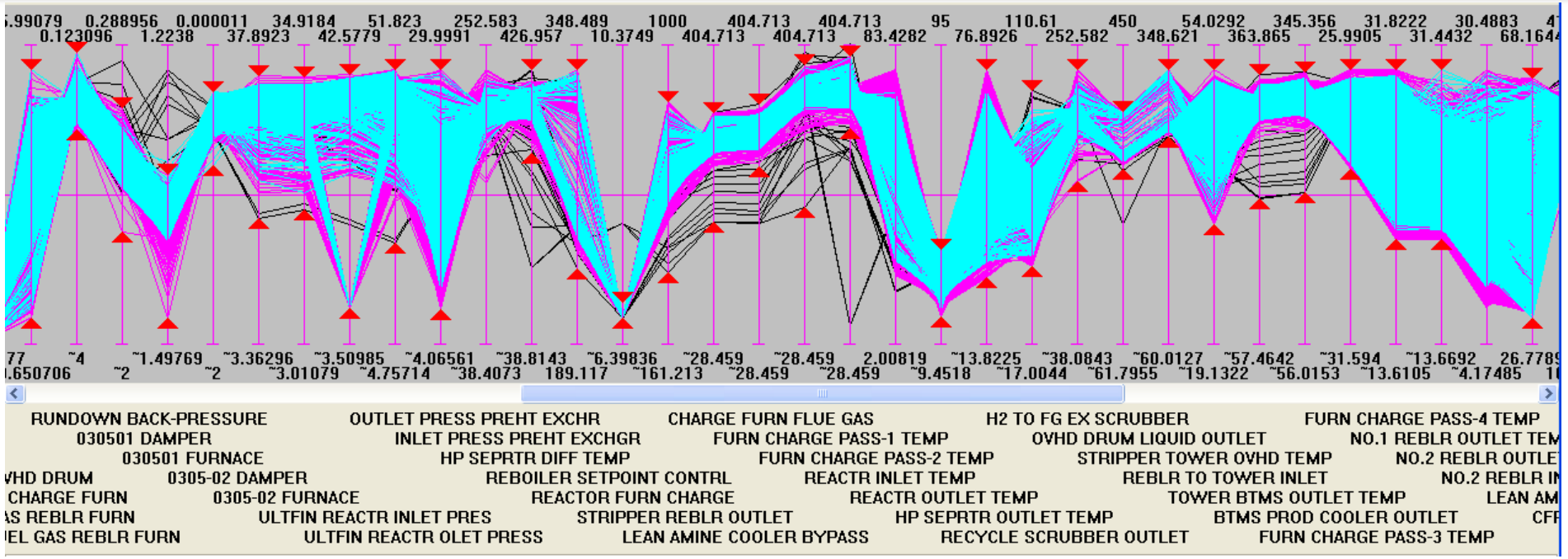
- Number of alarms in the alarm list display before (top) and after (bottom). The data spans 92 days so there are long periods with no alarms present. Fewer alarms will get more attention and earlier action.

Alarms Before and After – Annunciations per hour



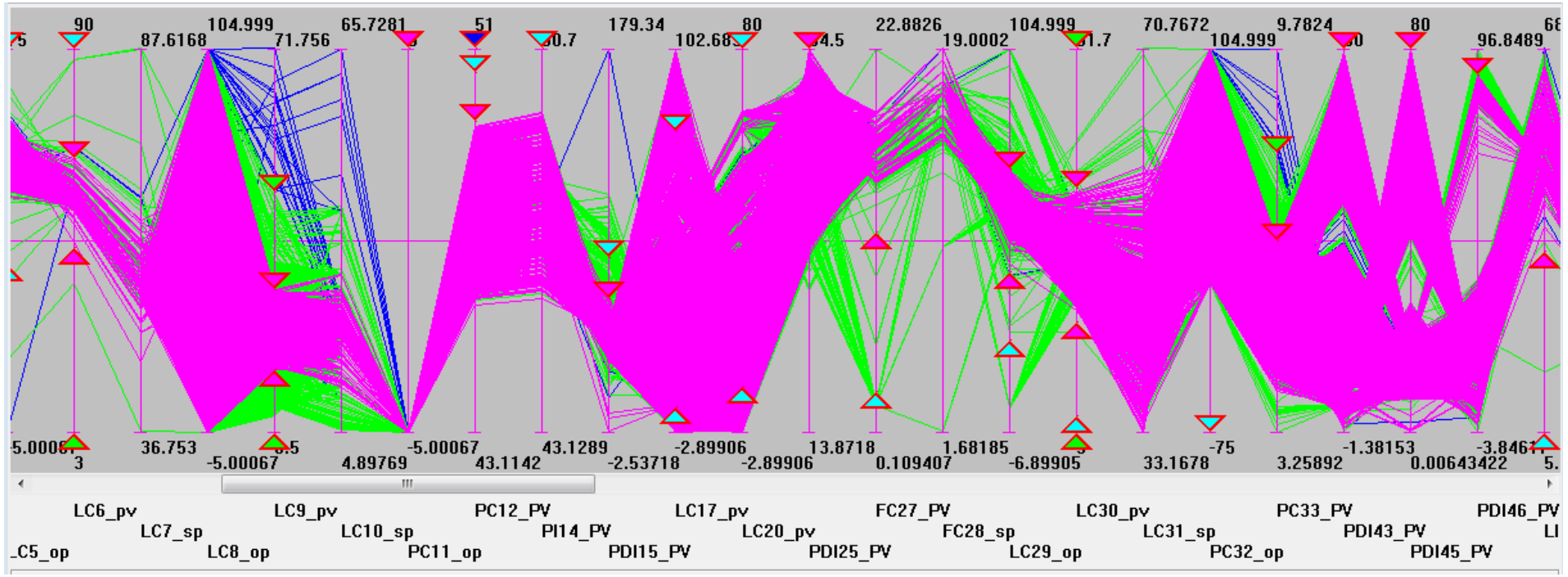
- Alarm Annunciations/hour before (top) and after (bottom). The data spans 92 days so there are long periods with no alarms present. Fewer alarms will get more attention and earlier action.

Alarms in Relation to KPIs

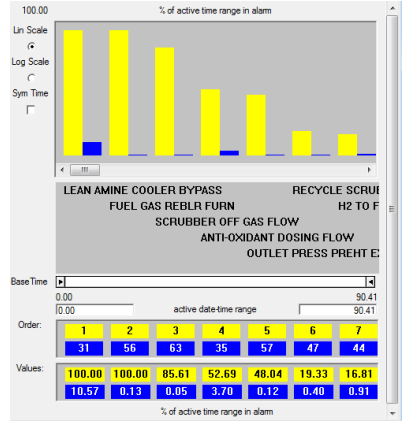


- Turquoise – the Operating Envelope for in-specification Kerosene
- Pink – the No-Alarms Operating Envelope for the new alarm limits
- Should Pink be larger than Turquoise?
- Why don't we operate inside the in-spec Envelope now?
- Is it because we couldn't see it until now?

Many Sets of Limits

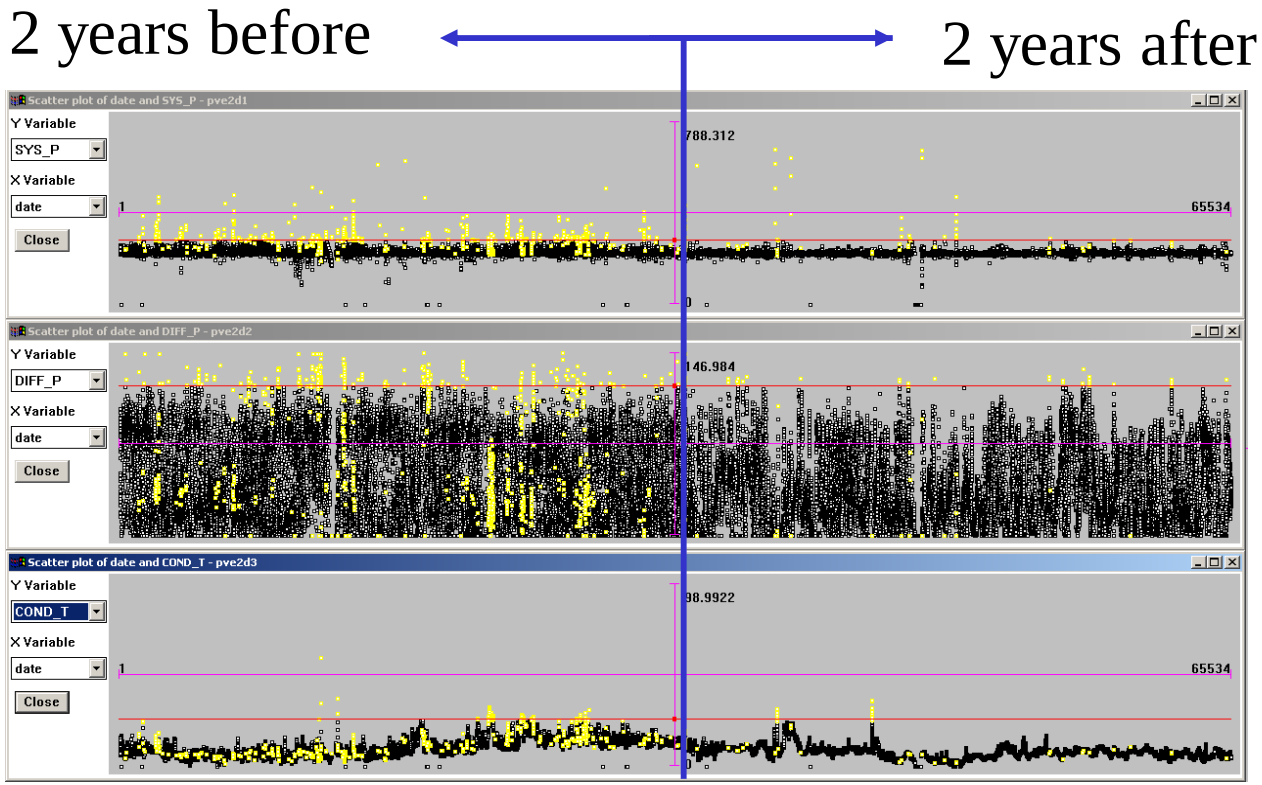


- Trip levels: Blue
- HH/LL: Green
- HI/LO: Maroon
- Previous HI/LO: cyan



Improved Alarm Performance

- Alarms repositioned to boundaries of no-trips envelope
- Operators presented with tighter limits in some cases, but relevant alarms
- Process went from 98% uptime to 99.9% uptime after rationalization



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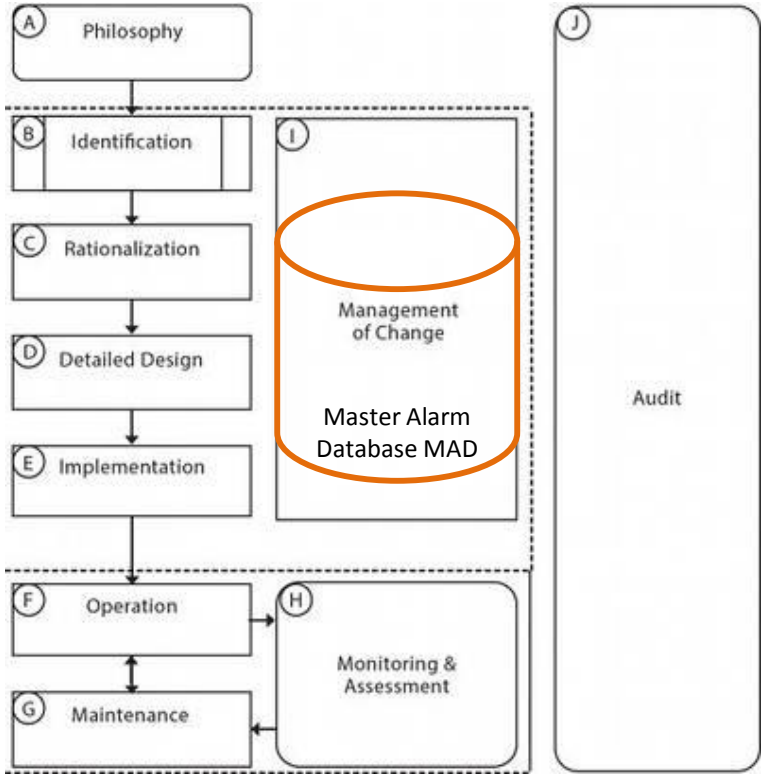
Restructuring the Rationalization Project to Improve Efficiency

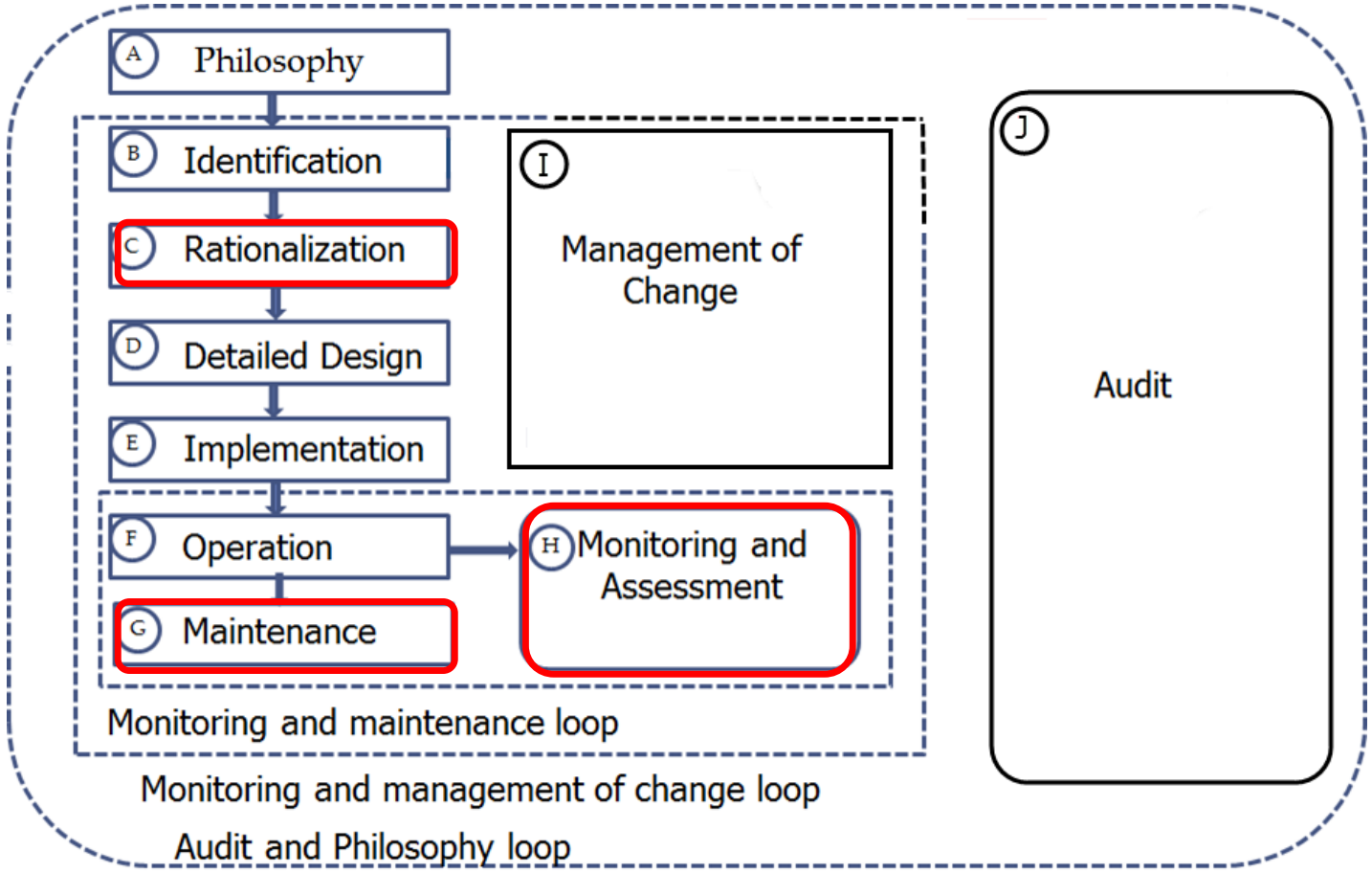
Traditional Rationalization



Stage	Title	Activities
A	Philosophy	Define processes for alarm management and alarm system requirements specification
B	Identification	Determine potential alarms.
C	Rationalization	Rationalization, classification, prioritization, and documentation.
D	Detailed Design	Basic alarm design, HMI design, and advanced alarming design
E	Implementation	Install alarms, initial testing, and initial training.
F	Operation	Operator responds to alarms refresher training.
G	Maintenance	Maintenance repair and replacement, and periodic testing.
H	Monitoring & Assessment	Monitoring alarm data and report performance.
I	Management of Change	Process to authorize additions, modifications, and deletions of alarms.
J	Audit	Periodic audit of alarm management processes.

- Review each alarmed variable top-to-bottom one at a time
- All experts in one room – 7-15 people for several weeks @15mw/week
- Mind-numbingly boring because each expert is under-utilised much of the time so decision quality is inconsistent and it is difficult to capture the rationale of decisions for the MAD
- Participants (esp. process engineers) often too busy to attend, leading to stalled projects

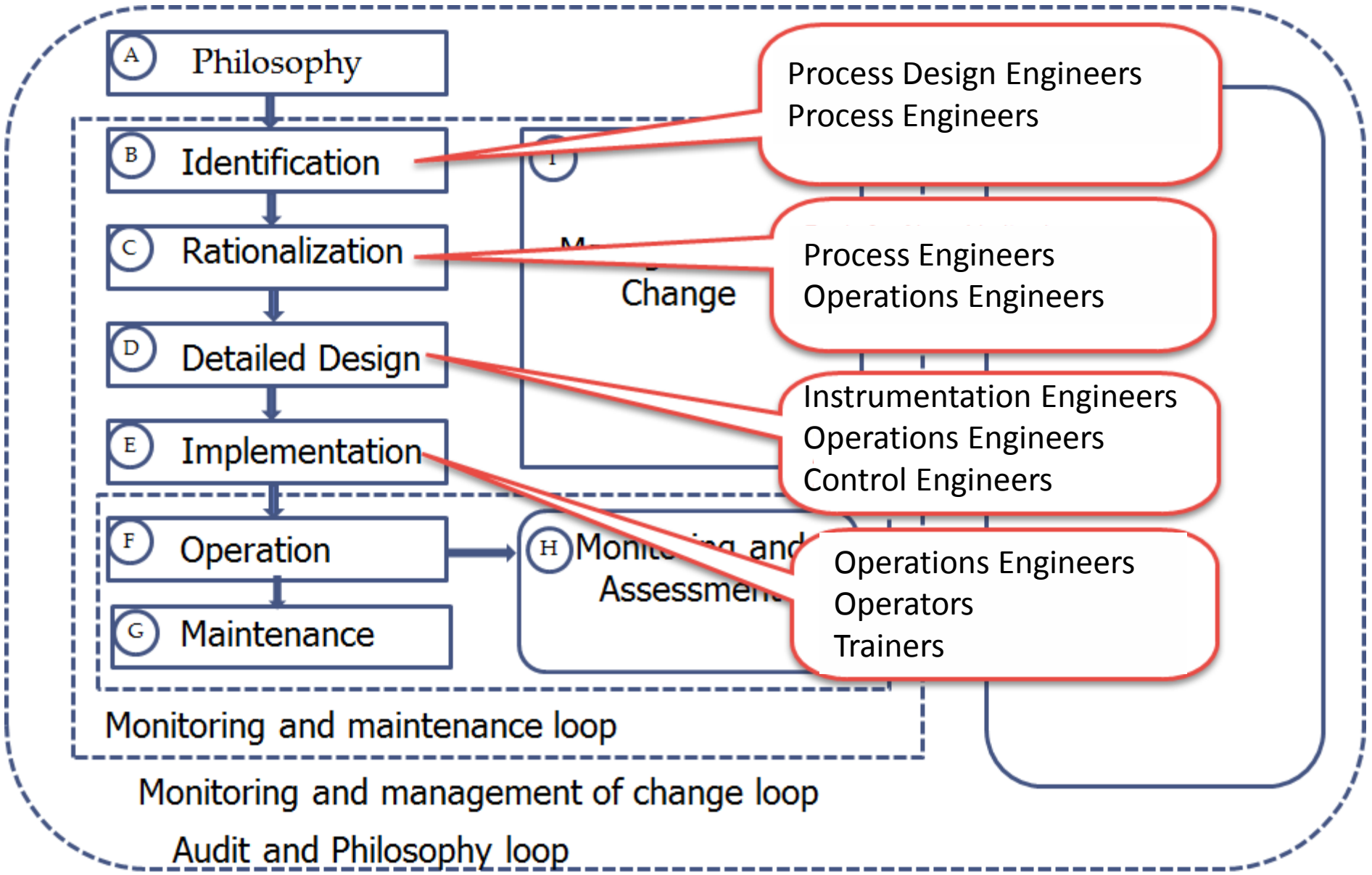
Process History in Alarm Management



Process input is normally only used in the form of the event log: determining the performance of an alarm system by “Try-and-see”

With CVE, we can easily bring this into the Rationalization limit review step, and know before we try!

Modern Alarm Management – Who does what?



Traditional vs Modern Alarm Rationalization

Traditional Rationalization

- Each alarmed variable top-to-bottom one at a time
- All discipline experts in one room – 7-15 people
- Takes weeks supposedly with 15 people full-time
  - Excessive demands for time, esp. from busy operations personnel, makes staffing difficult and projects likely to stall
- Inconsistent decision rationale and documentation
- Alarm log driven

Modern Rationalization

- Recognizing that alarms are inter-related rationalize in horizontal slices by engineering disciplines
- 2 largely independent Teams of 2 people
- Alarm Limits team - Red
  - Unit process engineer and assistant process engineer, sometimes a PPCL consultant
- Alarm Actions team - Blue
  - Operations engineer, Senior operator
- Efficient full-team review of recommendations
  - Easy overview
  - Ability to answer what-ifs with performance prediction
- Weeks rather than months
- Process history driven
- MAD Updated after Review and forms a Functional Specification for the Detailed Design step leading to further reduction in man-hours

Red and Blue Sub-Team activities

Red Team – Alarm Limits

- Unit Process Engineer (20%) and Assistant Process Engineer or PPCL Consultant (80%)
  - For multiple units there may be multiple teams Assistant Engineers can move from Team to Team
- Establish Operating Objectives and feed-to-product Operating Envelope. Re-identify only where necessary
- Set alarm limits for all alarms.
- Deliverables
  - Alarm Performance / operator workload predictions for immediate issue identification and correction
  - Analysis of past alarm floods for changed performance
  - Alarm priority tuning
  - Process sampling interval optimisation
  - On-line analyser recalibration interval optimisation
  - Effect of change to operating objectives
  - Identification of controllability issues
  - Identification of dynamic alarming opportunities
  - Weekly review with Blue Team

Blue Team – Alarm Actions and Priorities

- Unit Operations Engineer and Senior Operator
- For each alarmed variable validate alarm action for appropriateness and practicality
- Deliverables
  - If No action not an alarm, HAZOP to remove
  - Is Action suitable for automation?
  - Time needed to perform Action
  - Condition protected against
  - Consequence of condition occurring
  - Alarm Priority initial configuration
  - Weekly review with Red Team

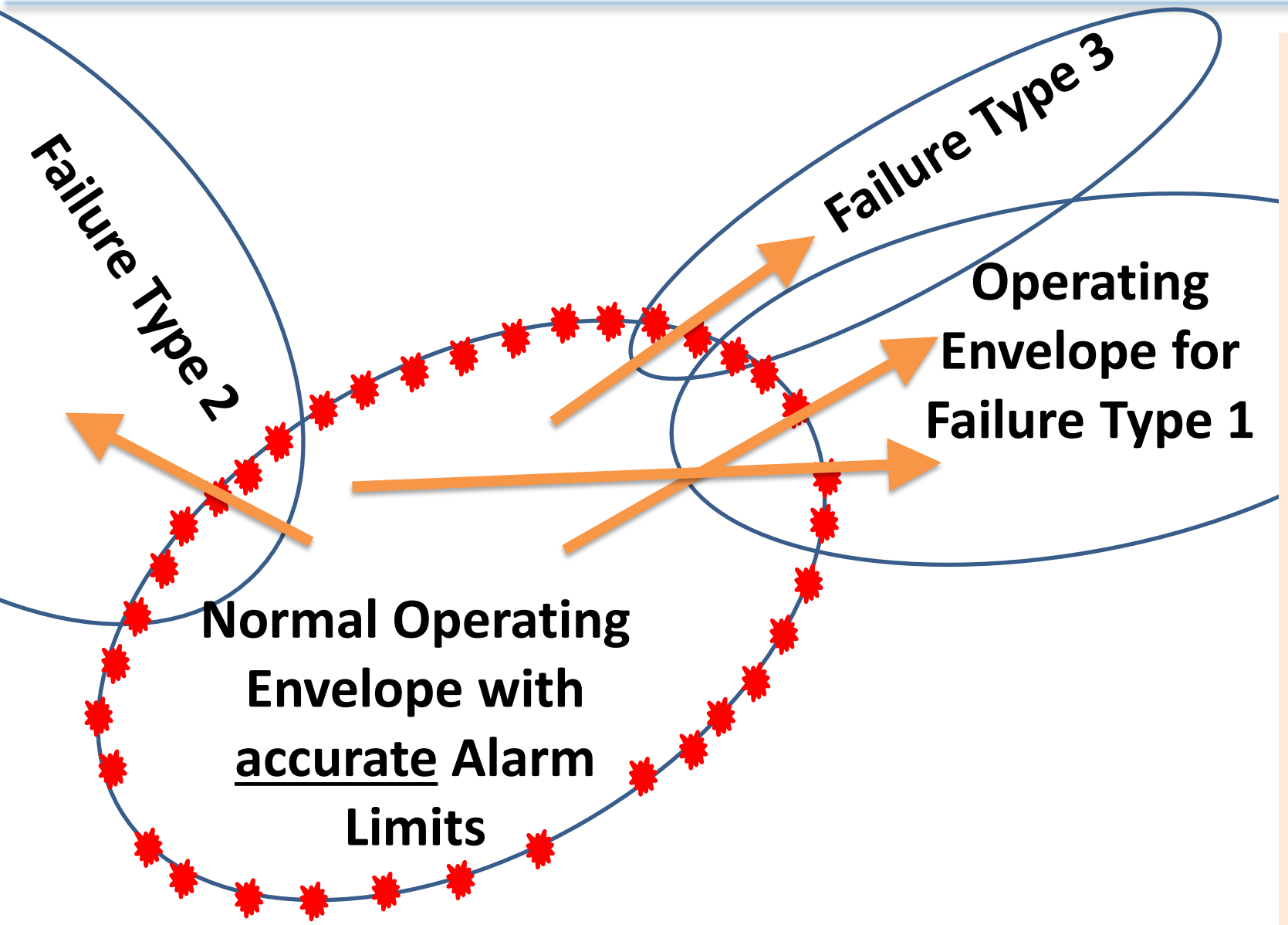
Alarm Improvement – RED Team only

Alarm Rationalization – RED and BLUE Teams

Rationalization Performance

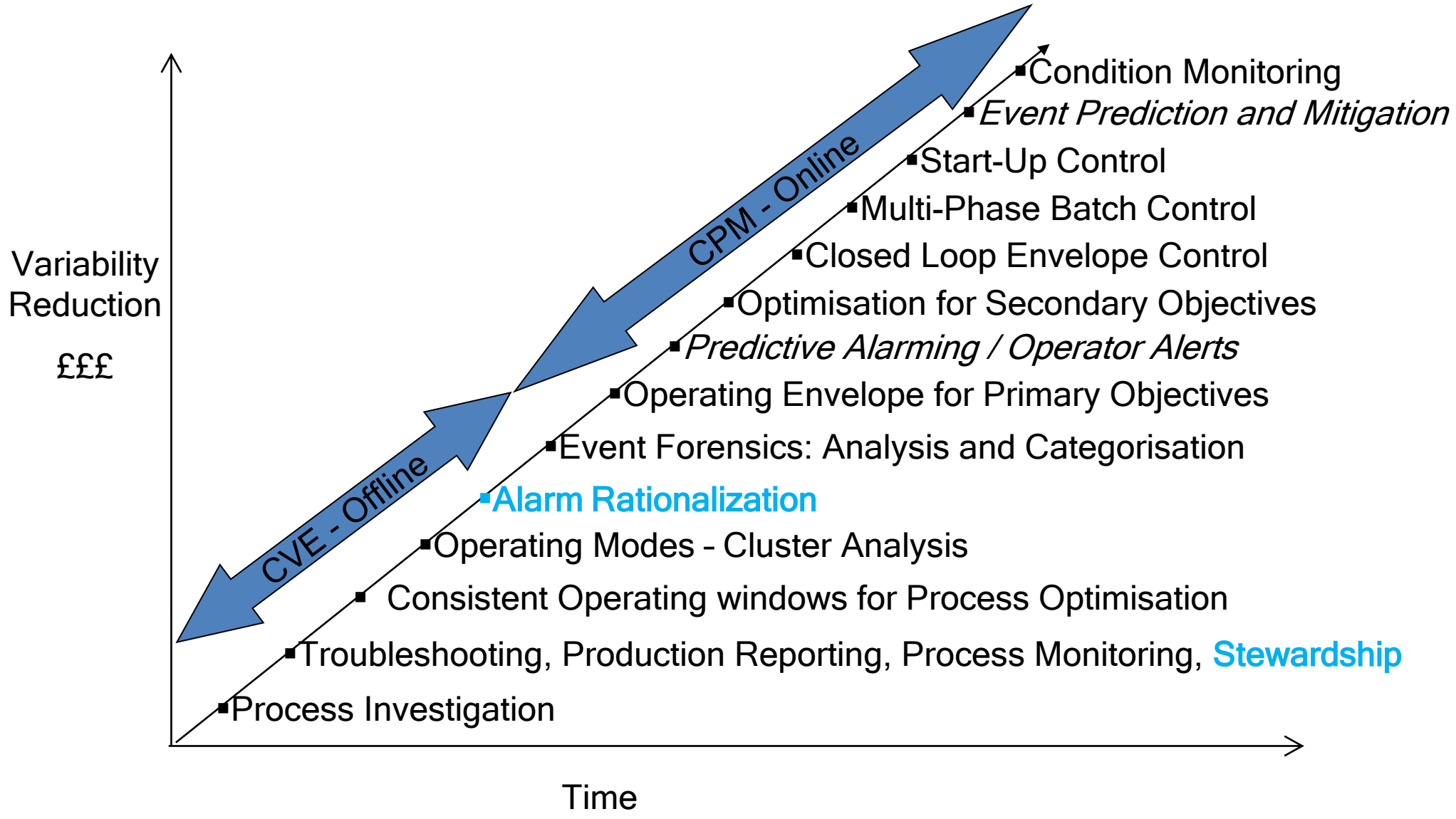
- LNG Plant
  - 4 trains, 8600 alarmed variables
  - Team 1 Rationalization completed in 700 hours
  - Awaiting final review after implementation
- Oil refinery
  - 6 units, 3,600 alarmed variables
  - 4 Unit Process Engineers
  - Team 1 Rationalization in 320 hours
- GTL plant
  - 4,500 alarmed variables
  - Rationalization in progress

Alarm Floods – a geometric view



- An event causes process capability to change
- Operating point starts moving into the events unique but unknown operating envelope
- As the operating point crosses the normal envelope/Alarm boundary to reach the event envelope many alarms may be triggered and will remain in alarm
- Which alarms trigger varies with movement starting point, direction and Normal Envelope shape

Applications of C Visual Explorer and C Process Modeller



PPCL

Questions/Discussion