A Real-time & Predictive Process Safety Dashboard

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Vision / Business case

- Offering a ‘safety dashboard’ for the process industry
- Real-time information wrt the actual, previous and upcoming (predictive) safety ‘level’
- Combine data / information sources beyond the ‘DCS/SIS’
- Deterministic as well as probabilistic
- How to make use of IoT and BIG data?

HOW SAFE IT IS AT A CERTAIN PLACE AT A CERTAIN MOMENT IN TIME?

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BP Texas, March 2005

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Buncefield oil depot, December 2005

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Buncefield, December 2005

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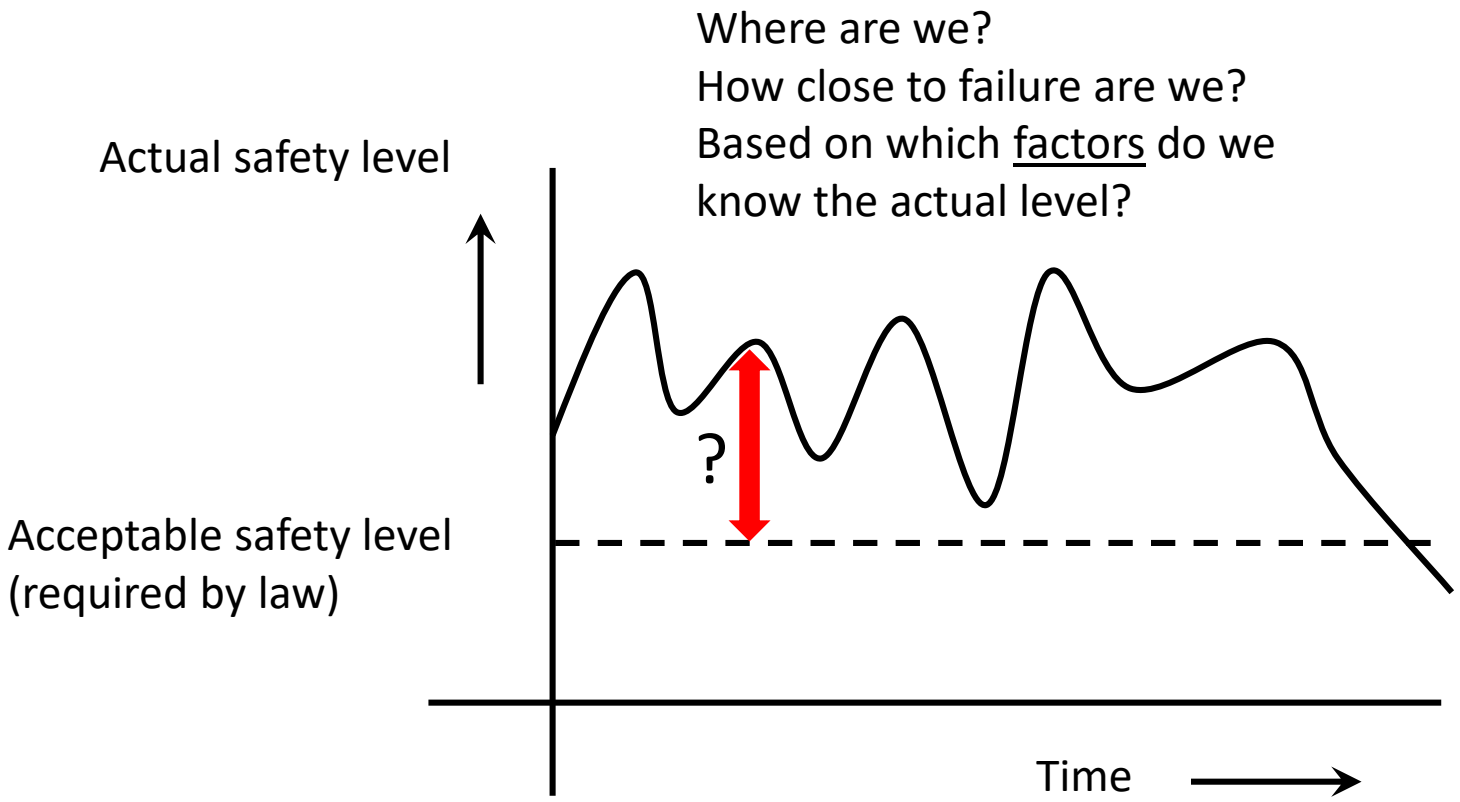
Dynamic safety level



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Common characteristics of major accidents

1. None of the accidents were the result of unknown ‘new’ physical or chemical hazardous situations. In all cases, chemical substances were involved of which its hazardous characteristics are known for decades.

2. None of the accidents happened due to a single problem or failure, but in multiple perspectives, flaws, lacks and deficiencies are observed, which together have formed the fundament for the accident.

3. The fundament for having these accidents is mainly characterized by technical, organizational and human factors. The remaining issues related to the complexity of the process installations are observed as well but not dominating.

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BP-Texas investigation

Major conclusion:
Better measuring!

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A relative unsafe situation

- Maintenance behind schedule
- Over-rides on various actuators
- Various leakages
- Welding activities
- Production backlog
- Corrosion problems
- Postponed plant shut-down
- …

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Dynamics…

- Seasons
- Aging, wear-out
- Production capacity
- Office hours / weekend
- Wind directions
- Construction work
- Maintenance work
- Inspection rounds
- Vegetation, bush and trees (Gexcon)

➢ What is the actual safety level at a specific moment in time at a particular place?

Safety indicators

Safety-KPI's, risk parameters, Safety factors, etc.

- 1989: Center for Chemical Process Safety (CCPS),
- OSHA 1910.119 Process safety management of highly hazardous chemicals
- Tripod Condition Survey: Basic Risk Factors
- 2008: CCPS - Lagging and leading indicators
- 2010: CCPS - *Guideline for Process Safety Metrics*

But also:

- British Health & Safety Executive
- ASM consortium (safety metrics review)
- American Petroleum Institute (practice 754)
- Step Change in Safety (UK oil and gas industry)
- Hopkins, thinking about process safety indicators
- …

CCPS Safety Metrics, 2010 - 1

21 categories, 393 factors

- Process safety culture
- Compliance with standards
- Workforce involvement
- Process safety competency
- Stakeholder outreach
- Process knowledge management
- Hazard Identification & Risk Analysis
- Operating Procedures
- Safe Work Practices
- Asset Integrity & Reliability
- Contractor Management
- Training & Performance Assurance
- Management of Change
- Operational Readiness
- Conduct of Operations
- Emergency Management
- Incident investigation
- Measurement & Metrics
- Auditing
- Management Review & Continuous Improvement
- Incident Reporting

Centre for Chemical Process Safety – Guideline for Process Safety Metrics
Wiley, 2010 ISBN 978-0-470-57212-2

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CCPS Safety Metrics, 2010 - 2

Extensive system with 21 categories and 393 indicators

Too much, not practicable and not realistic

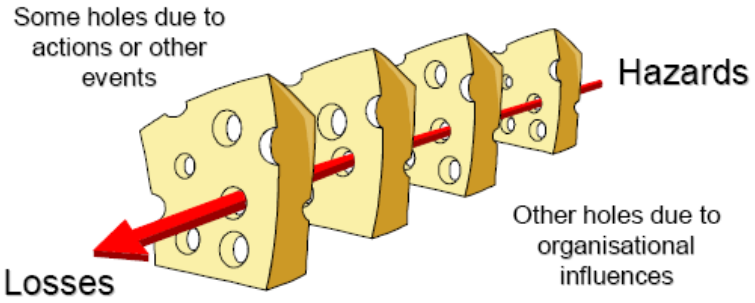
What then to do?

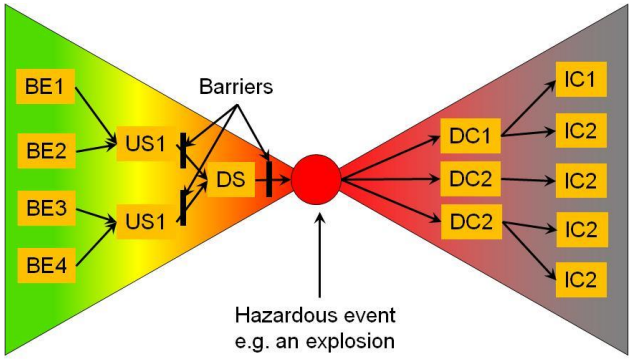
- Research still required…
- Risk-Safety Modeling / Analyzing Methods

Is it going into the right direction? (Why serious accidents in the process industries continue to happen…)

Risk-accident models

Visual - Conceptual





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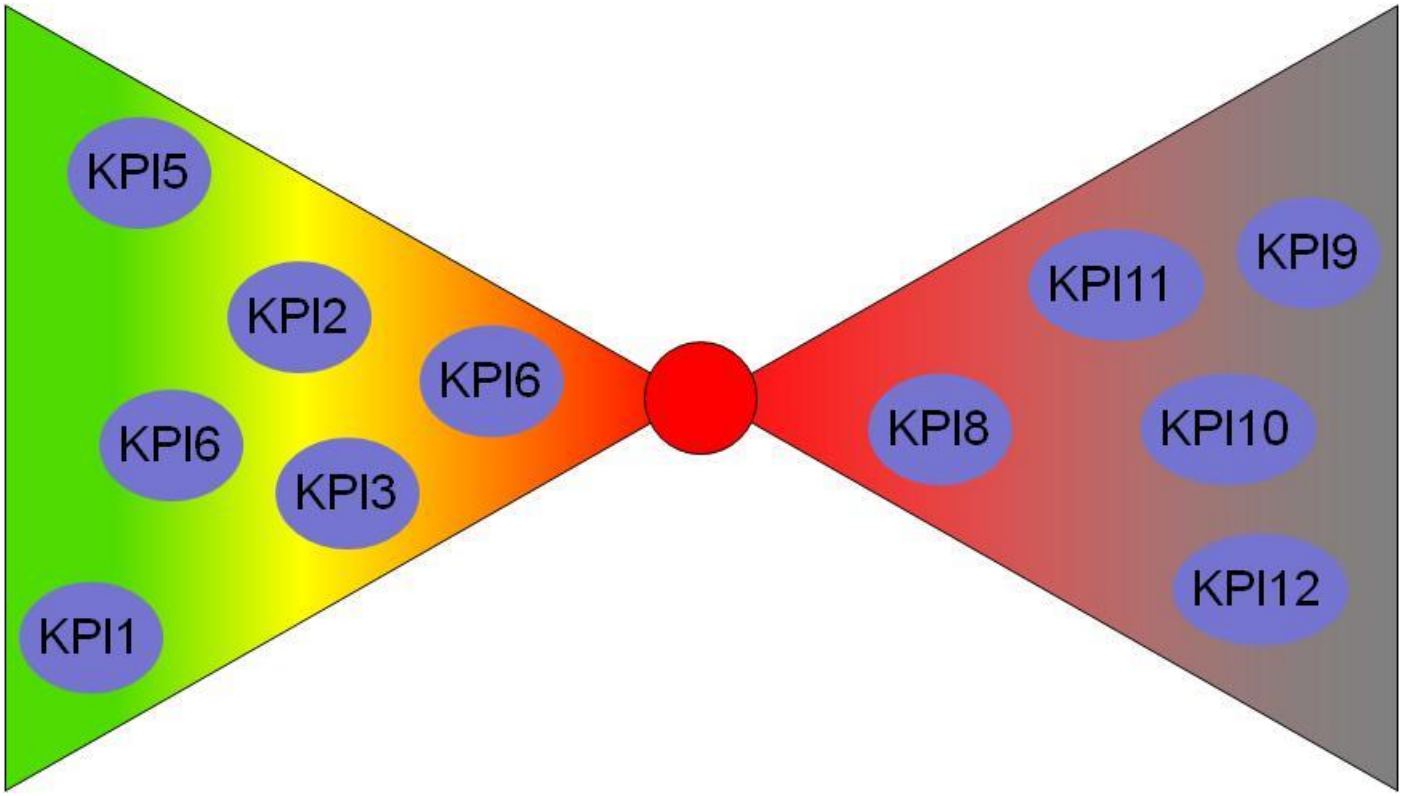
Safety KPI's

Leading & Lagging metrics (CCPS process safety metrics 2010)



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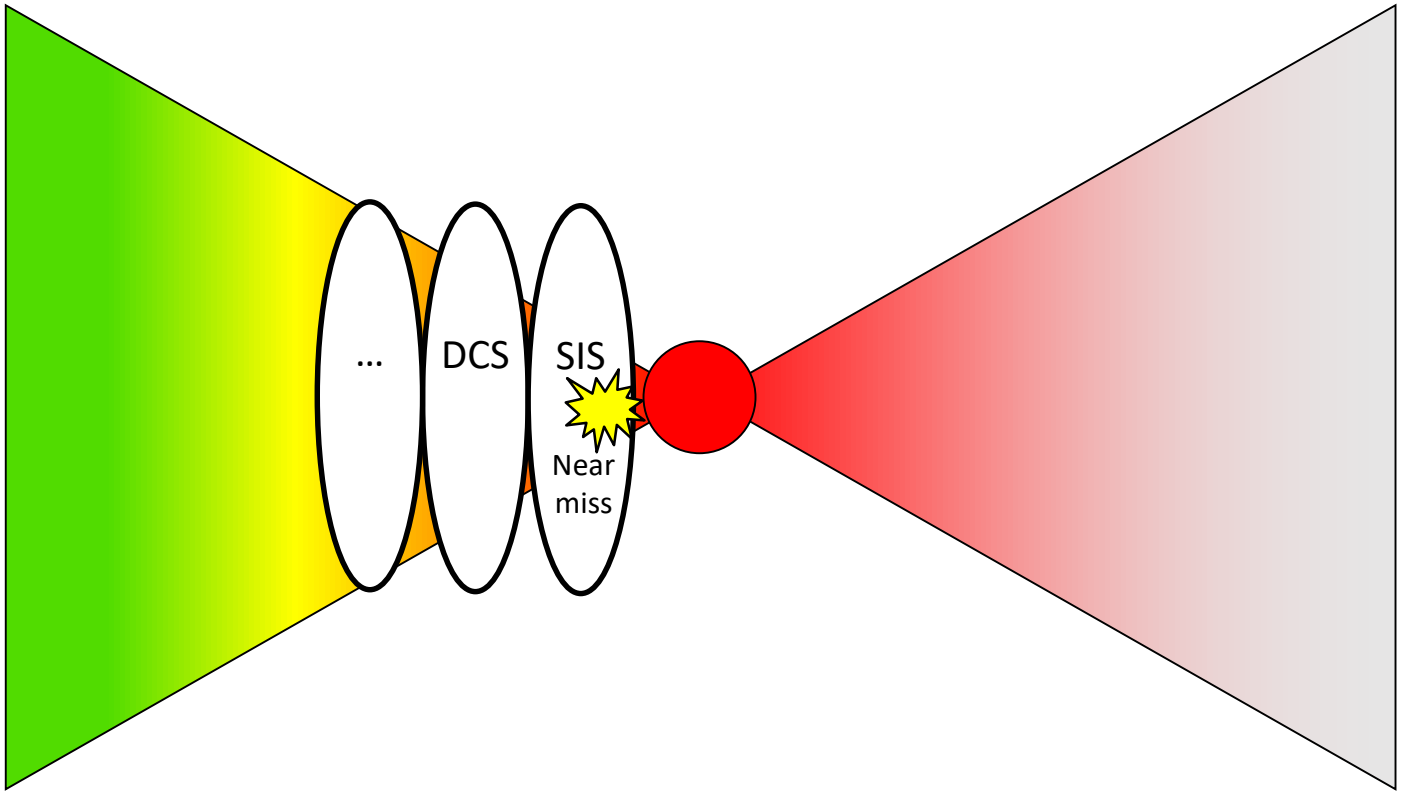
Technology - The SIS; your last line of defense



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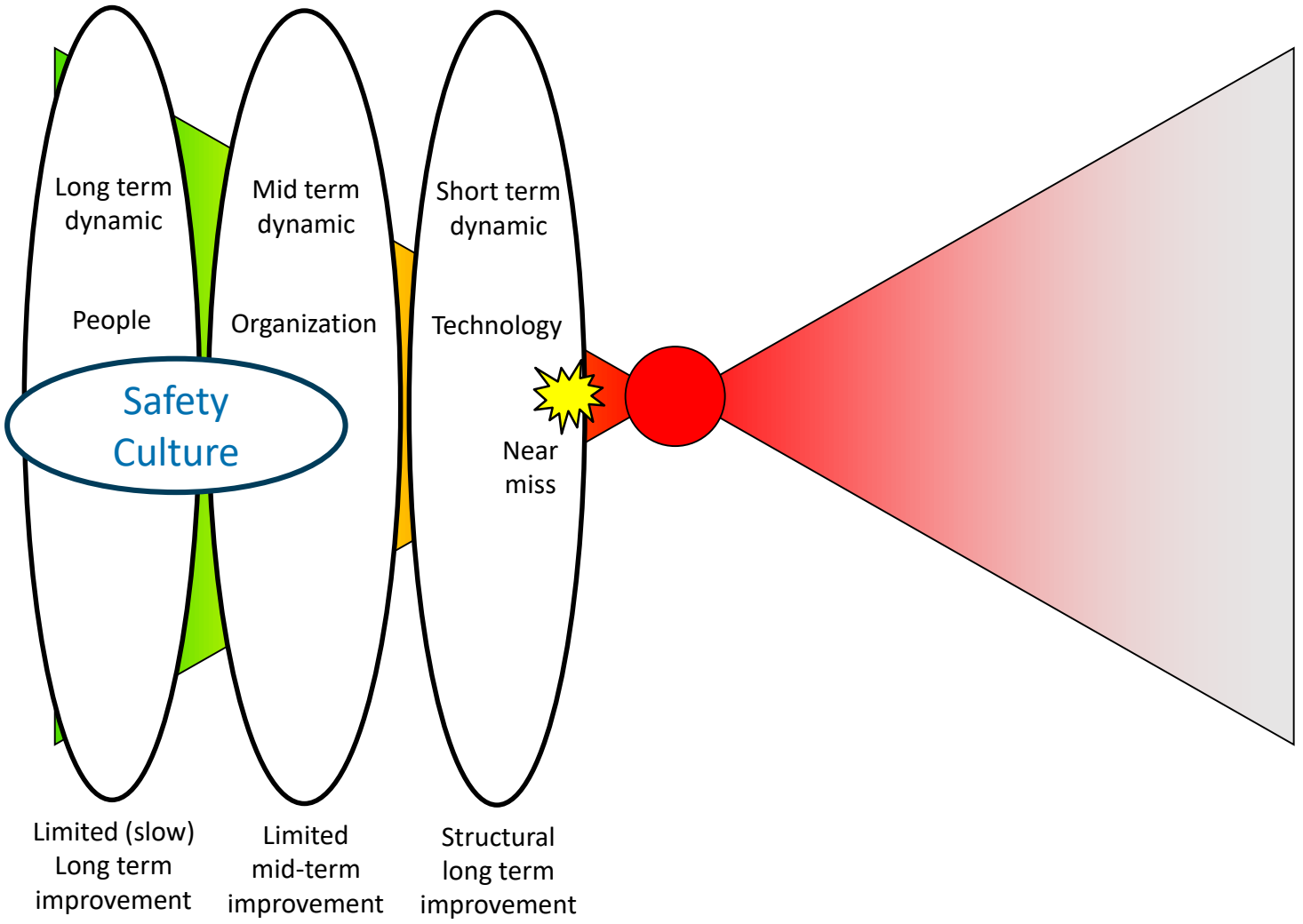
The Bow-Tie redefined



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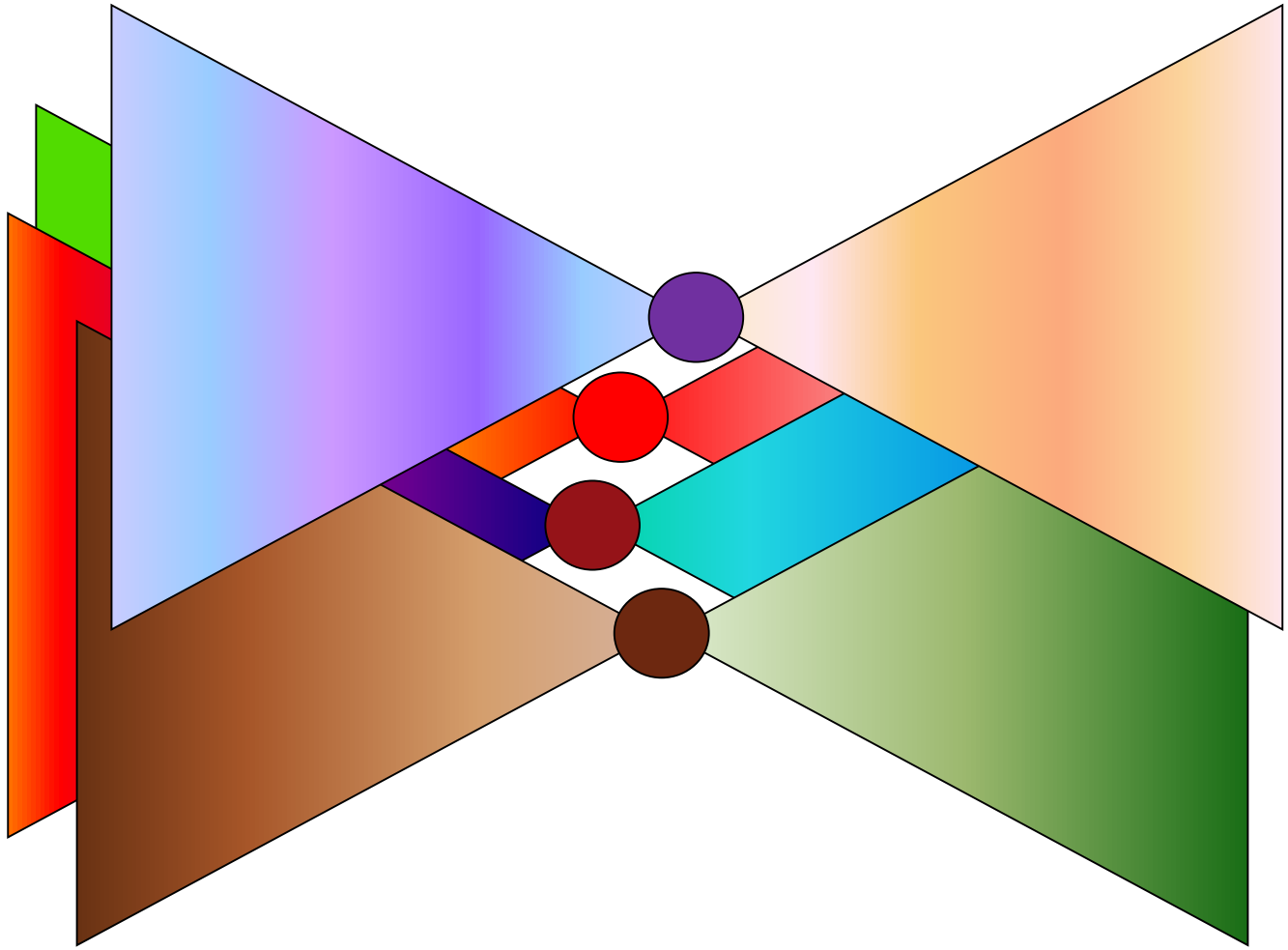
Many bowties – Shell HEMP experiences

‘Infinite’ variety of hazardous event scenario’s



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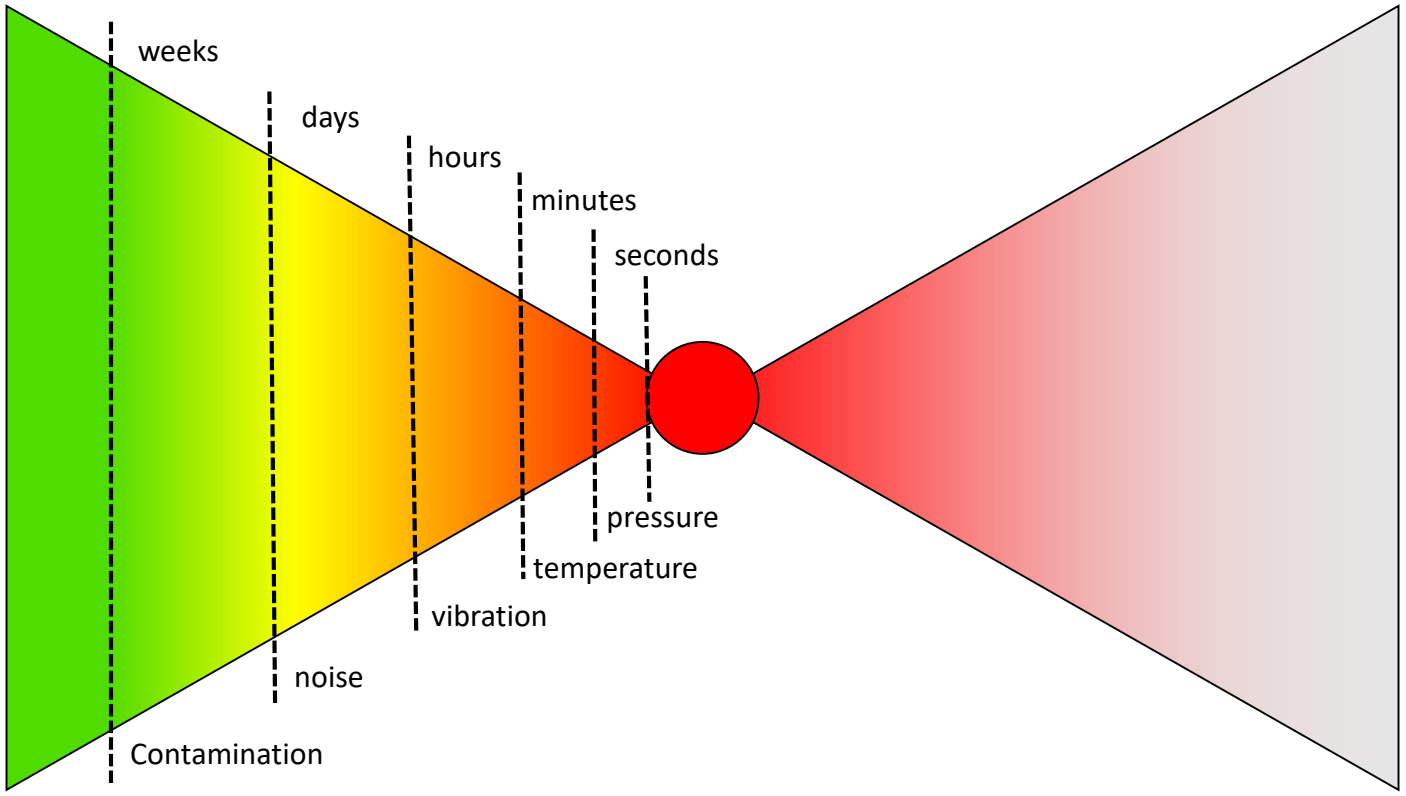
Bowtie-model with time dimensions



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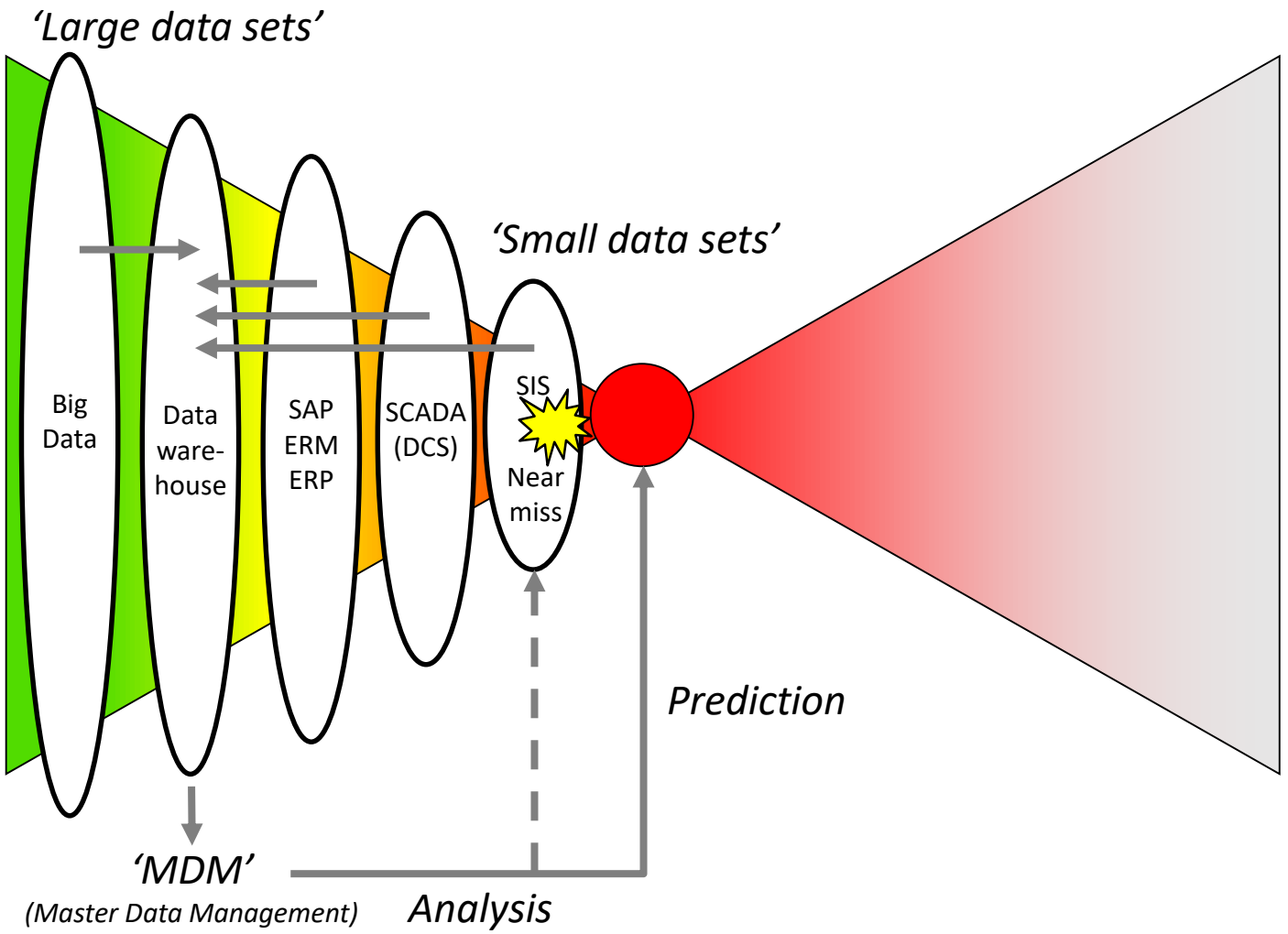
‘Remote’ large datasets – precursors?



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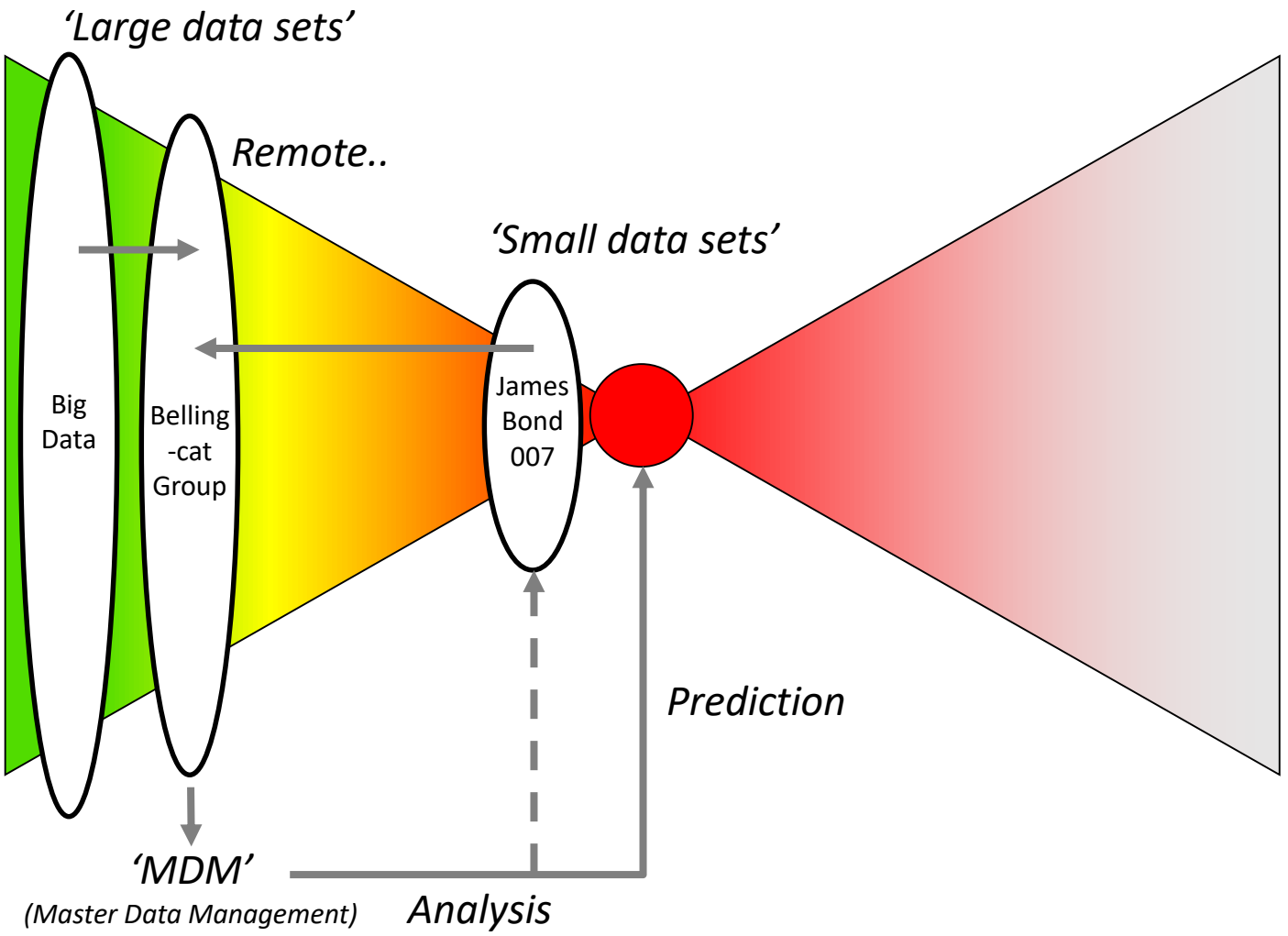
Indirect precursors vs. direct indicators



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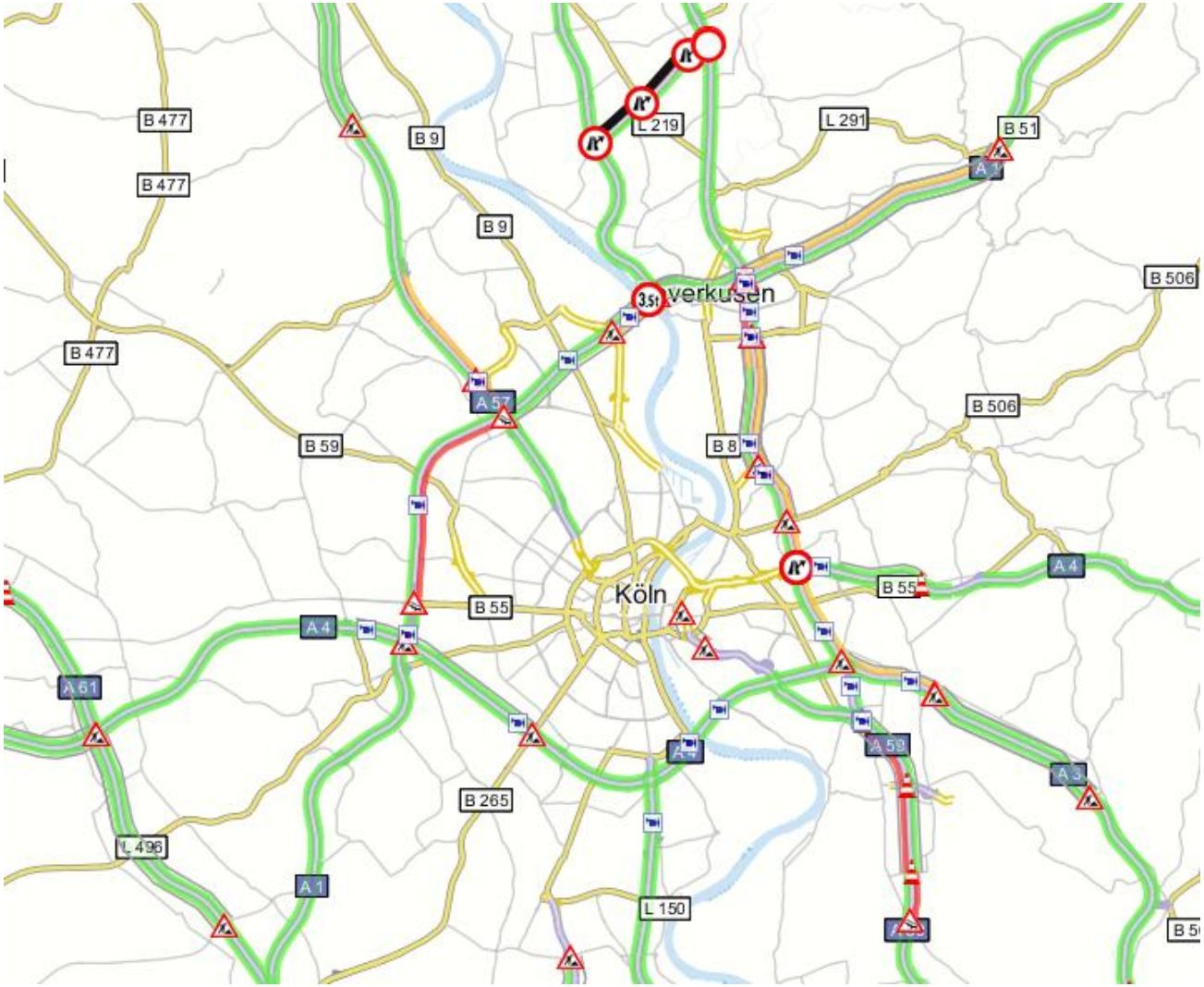
Tracking traffic with GPS-enabled cell phones

Crowd sourcing - Traffic information



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What to measure?

What do you want to know?

Short term;

Traditional HAZOP parameters; level, flow, pressure, temperature,…

More to date; dust, acoustic, vibration, weather, … **BIG DATA?**

Mid-term;

Seasons, corrosion, aging, maintenance, testing,…**BIG DATA?**

Longer term;

Aging, wear-out, knowledge, culture,… **BIG-DATA?**

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Overview - #1 Data

Data sources ⇢
SAP
BPCS
Maximo
SIS
Weather stations
Hand-held devices
Test reports
Human observations
Big Data

Activities ⇢
Welding
Testing
Maintenance
Modifications
Road blocks

Location of ⇢
People
Vehicles / trailers

Symptoms ⇢

Equipment:
Vibration
Smoke
Leakages
HH-L/F/P…
Low-voltage

Human observations:
Humidity
Vibration
Dust
Smoke
Corrosion
Noise
Leakages
Discoloration

Physical failure / error / problem ⇢

Bearing damage
Wear-out
Fire
Run-away
Valve stuck
Power-down

Functional failure / error / problem

Effect:
Device failure
Available / Unavailable
Safe / Dangerous
Detected / Undetected

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Overview - #2 Performance of the Safety Management System (SMS)

Data & Information

Identification of Safety-KPI's
Measurable
Controllable?

KPI Characteristics

Data collection / Measurement:
Automatically
Manually
Instantaneously
Periodically

'System Safety-KPI's oriented' → Safety Barometer

Inputs,
Safety KPI's

Safety management system

- Explosions
- Injuries, FAR, LTI
- Production loss
- ...

Modelling…

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Dynamic risk parameter - time : mapping Matrix

Process safety indicators / risk parameters inventory matrix

How many and which indicators / parameters?

	years	months	weeks	days	hours	minutes	seconds
pressure							
temp							
corrosion							
leakages							
vibration						??	
Weather							

SIS

DCS

SAP

IoT / BIG data

Unknown (black swans)

Uncertainty (unsure)

Probabilistic (approximately)

Deterministic (precise)

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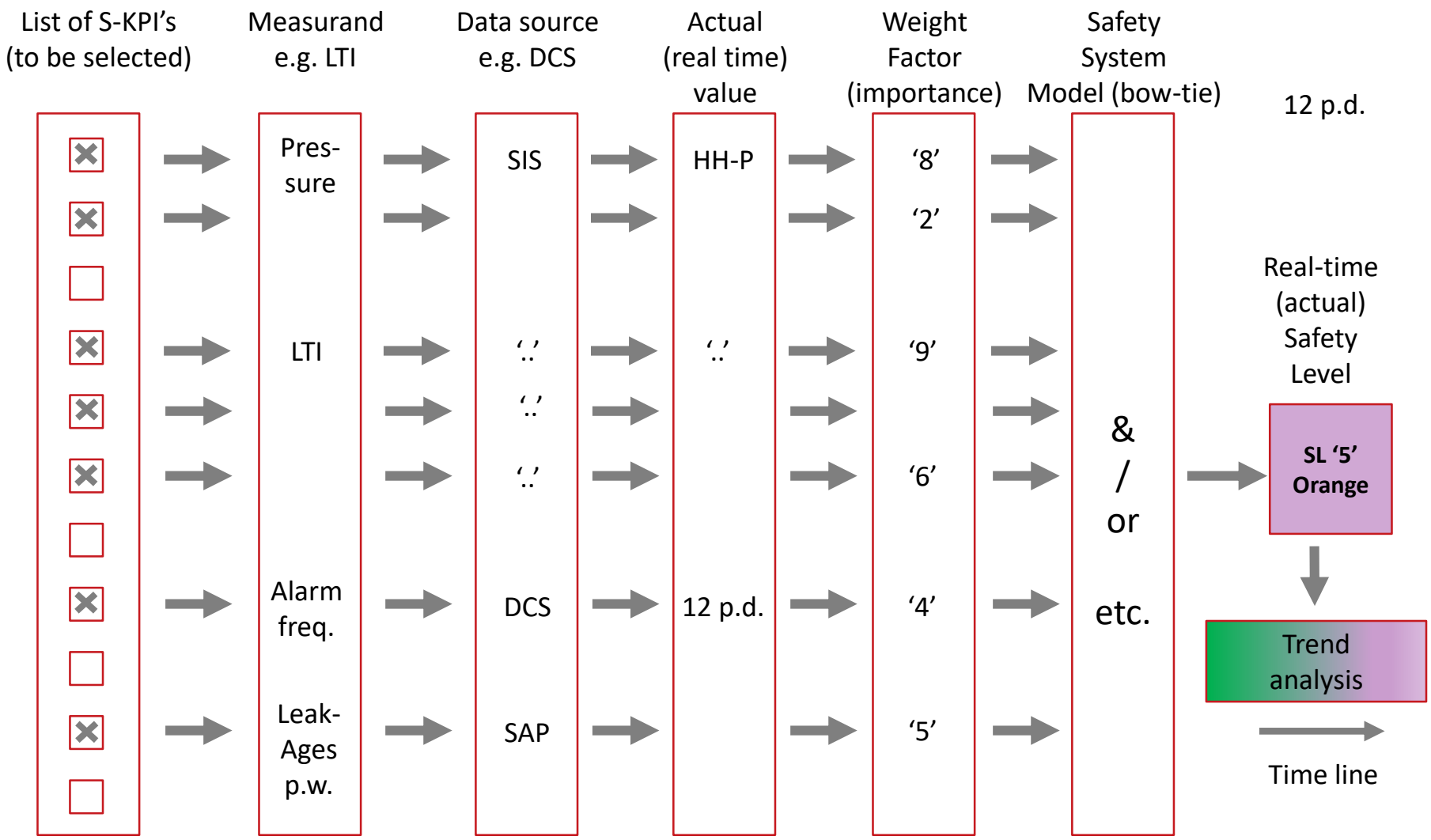
Data transition – Safety Level model



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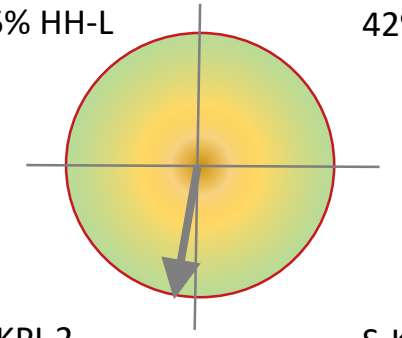
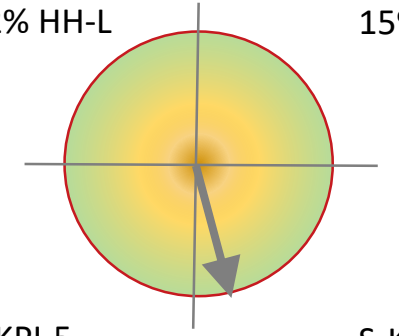
Dashboard Real time Safety-KPI's View

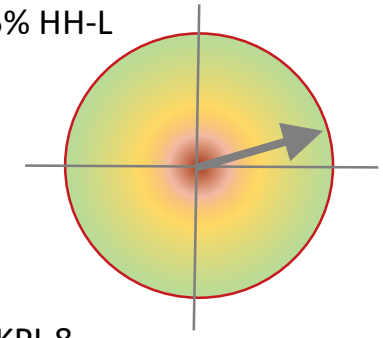
S-KPI-1
45% HH-L



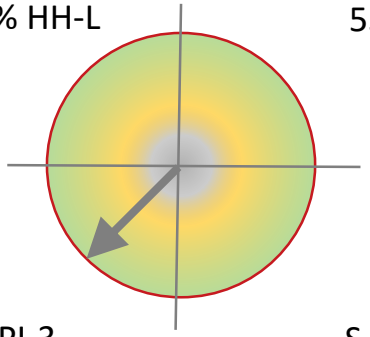
S-KPI-4
42% HH-L



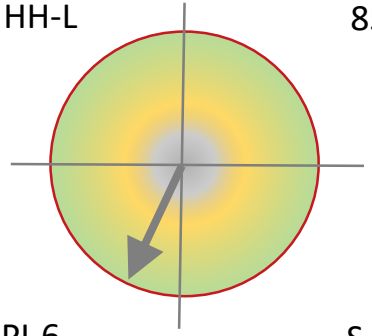
S-KPI-7
15% HH-L



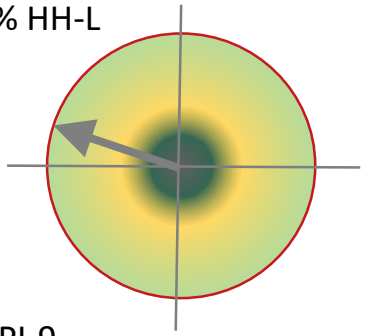
S-KPI-2
55% HH-L



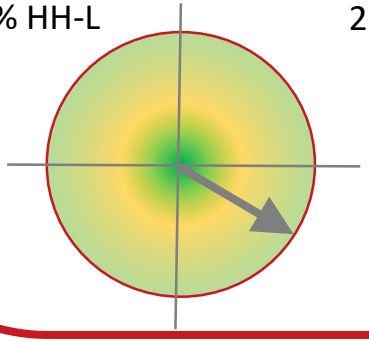
S-KPI-5
53 HH-L



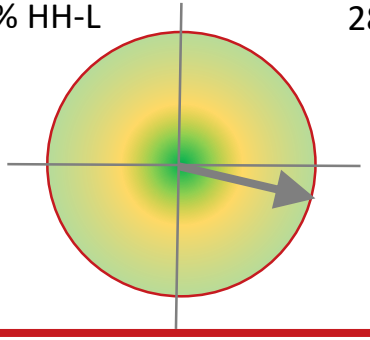
S-KPI-8
85% HH-L



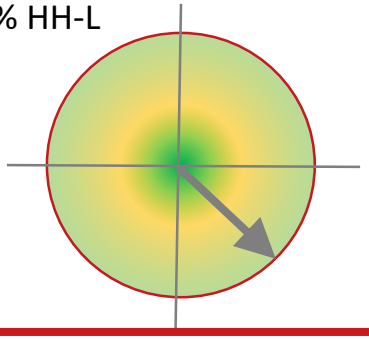
S-KPI-3
25% HH-L



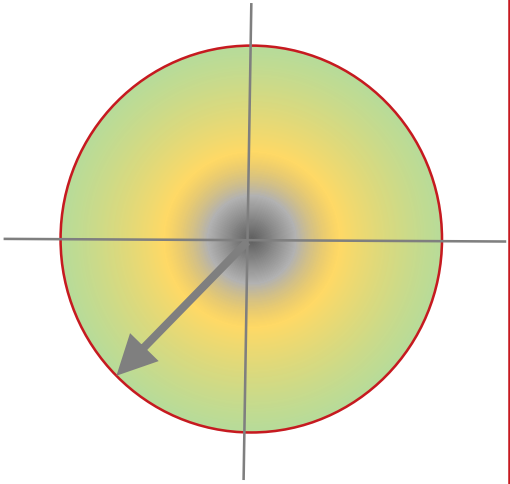
S-KPI-6
23% HH-L



S-KPI-9
28% HH-L



Overall
Real Time
Safety Level
63% of Max.



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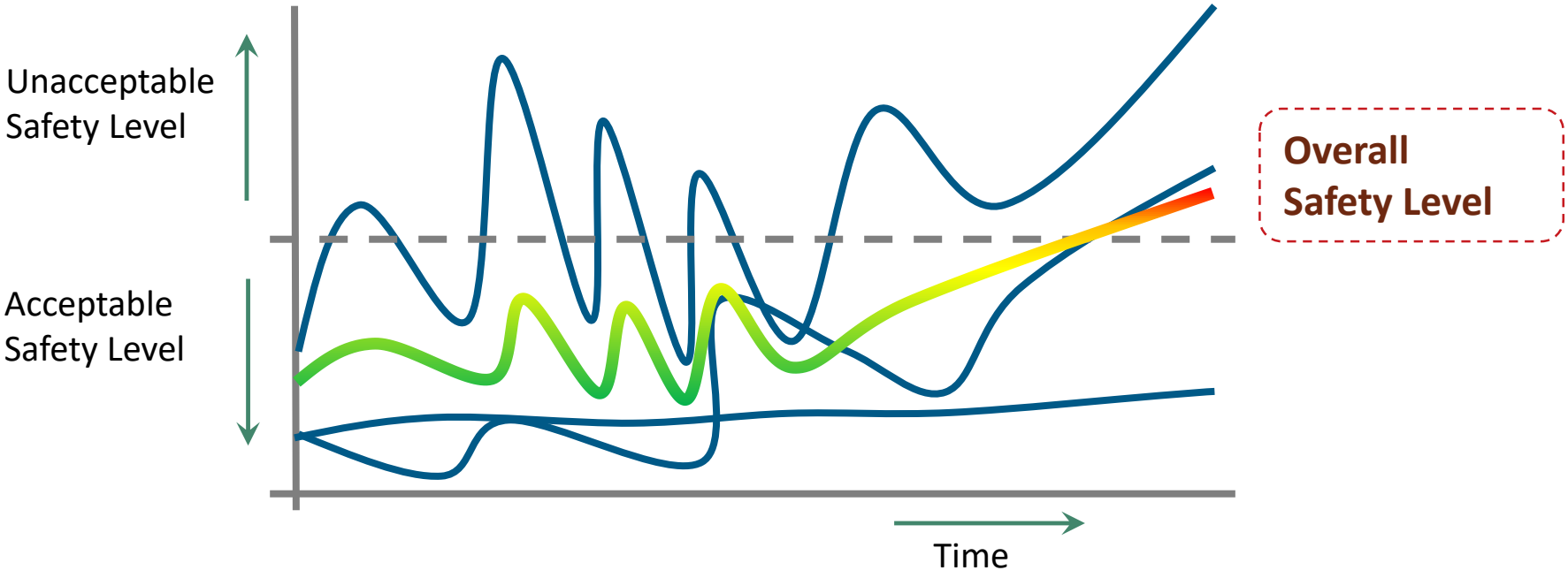
Safety KPI's – Overall Safety Level



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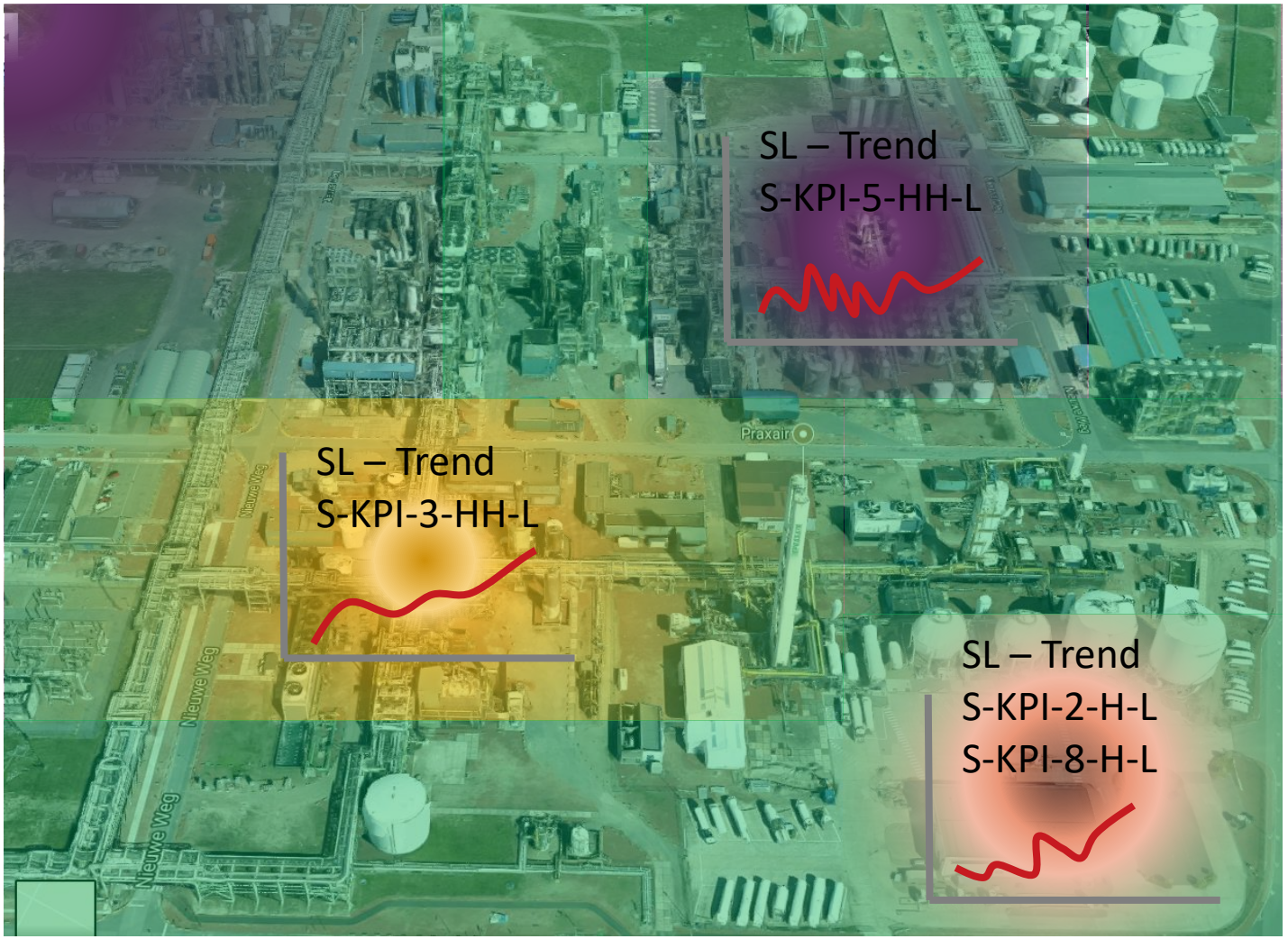
Dashboard ‘landscape’ real-time SL-view



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Research challenges…

Innovation areas

- Parameter identification (Safety-KPI's)
- Measurable / measurement
- Data sources
- Data selection / filtering / security
- Data (warehouse) storage
- Modeling / analyzing methods-tools
- Disorder measurement
- Uncertainty handling
- Real-time measurement
- Control/Improvement strategy

More info? Please contact

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Questions?

Safety-KPI's critical stage definitions

To be calibrated (site-, plant-, unit specific):

S-KPI	Normal	H-level	HH-Level	Shut-down	Collapse
Pressure	50~55 PSI	60 PSI	65 PSI	70 PSI	80 PSI
Time		10 sec.	20 sec.	35 sec.	50 sec.
Alarms	10 per day	25 per day	50 per day	100 per day	?
		1 hour	2 hours	4 hours	?
Corrosion	#3 problems per week	#7 problems per week	#15 problems per week	#25 problems per week	?
		1 month	2 months	4 months	?
Maintenance	On schedule	90% on time	75% on time	60% on time	?
		4 weeks	6 weeks	8 weeks	?
Training	On scheme	85% on scheme	75% on scheme	60% on scheme	?
		Half year	One year	Two years	?
…					

Time flow - dimension

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Ultimate goals and achievements summary

'Prevention of hazardous events by Prediction of hazardous situations and circumstances, based on long term, mid term and short term focal points and strategies'

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Trends – Time measurement

1. Time-depending trends
    - Short term
    - Mid term
    - Long term
2. Correlations between process parameters
    - Strong / weak correlation
3. Degree of Disorder
    - Data pollution / noise
    - Uncontrolled situation / process
4. Unexpected deviations
    - Uncertainty
    - Black swans / white spots (unknown)