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Risk-based maintenance backlog

Authors:
Harald Rødseth[1],
1: Norwegian University of Science and Technology (NTNU)

Norwegian University of Science and Technology

Agenda

1. Introduction
2. CPS as a potential in Industry 4.0
3. Description of example case
4. Risk modelling
5. Result
6. Adapting RISK OMT with CPS

1 Introduction

- Integrated Operations: New way of doing business in Oil & Gas (O&G) industry, increasing oil production, lowering operating costs and life extension.
- Transferring the IO principle into the planning domain leads us to the concept *integrated planning* (IPL).
- *Maintenance backlog* (MB) is of relevance in IPL.
- In risk modelling, the Risk OMT (Risk modelling – Integration of Organisational, human and technical factors) has been developed.

1 Introduction

- Due to different view of the term “maintenance backlog” and how it is modelled, a novel model for MB has been recently developed.
- It remains to model MB as a RIF itself.
- With the potentials from Industry 4.0 it would be expected that enterprises establish cyber physical systems (CPS).

1 Introduction

- The main objective of this article is to develop a model of MB in QRA. To achieve this main objective following sub-objectives have been outlined:
  1. Develop a general model that connects MB with QRA.
  2. Test the model with a case example.
  3. Propose how the model can be improved with support from the potentials in Industry 4.0.

2 CPS as a potential in Industry 4.0

- Cyber physical systems (CPS) is an essential element in Industry 4.0.
- Maintenance clearly positions in Industry 4.0.
- 5C architecture seems promising as a CPS architecture for maintenance.
- Has been proposed for the maintenance model deep digital maintenance (DDM).

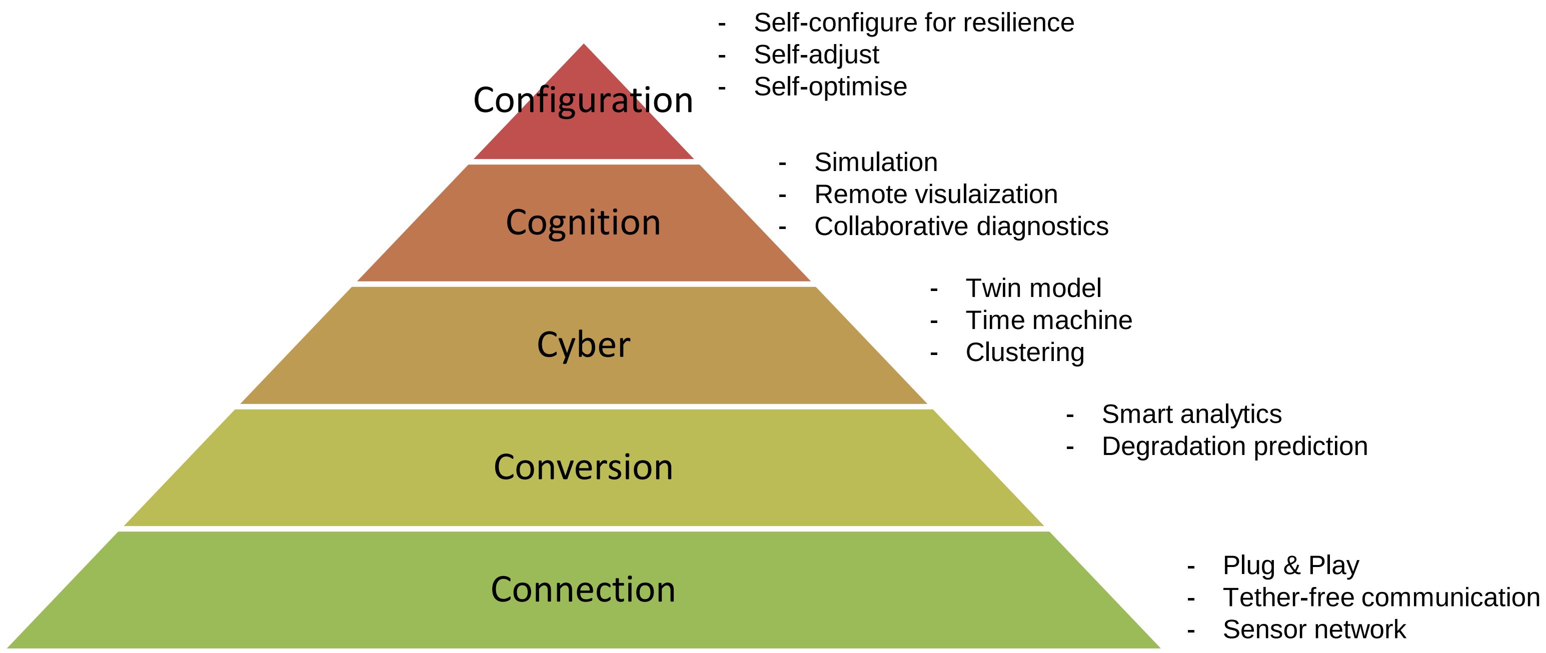

Figure 1: 5C Architecture of CPS.
Source: Lee et.al. (2017)

3 Description of example case

- The example case is a heat exchanger and a barrier system

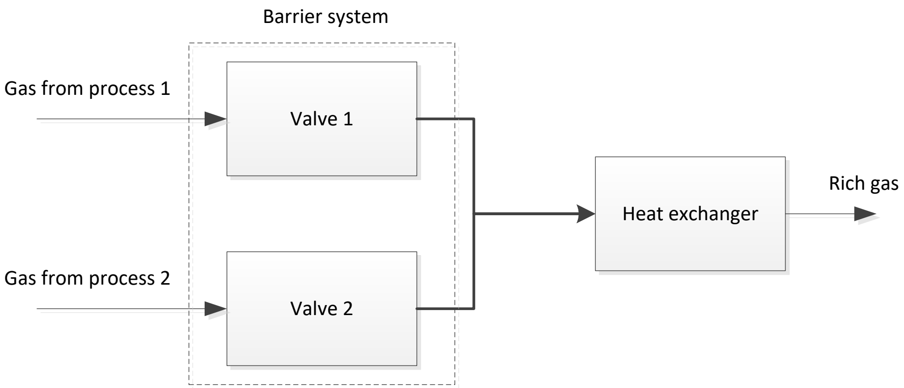

Figure 2: Heat exchanger with a barrier system

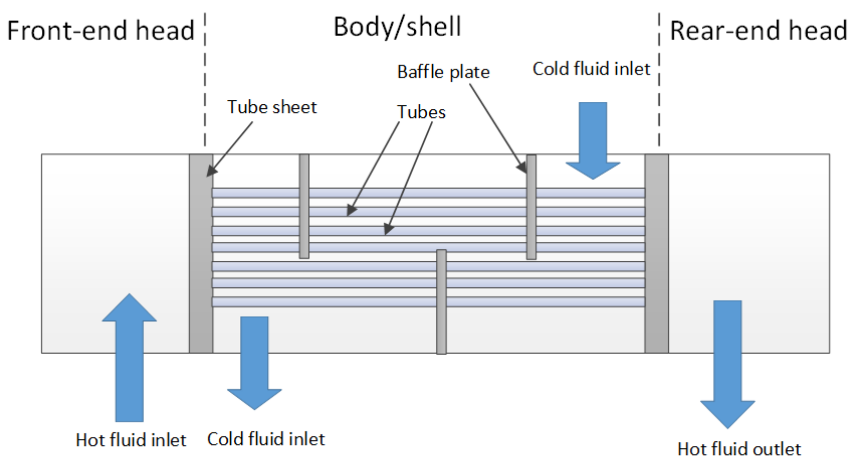

Figure 3: Heat exchanger

4 Risk modelling

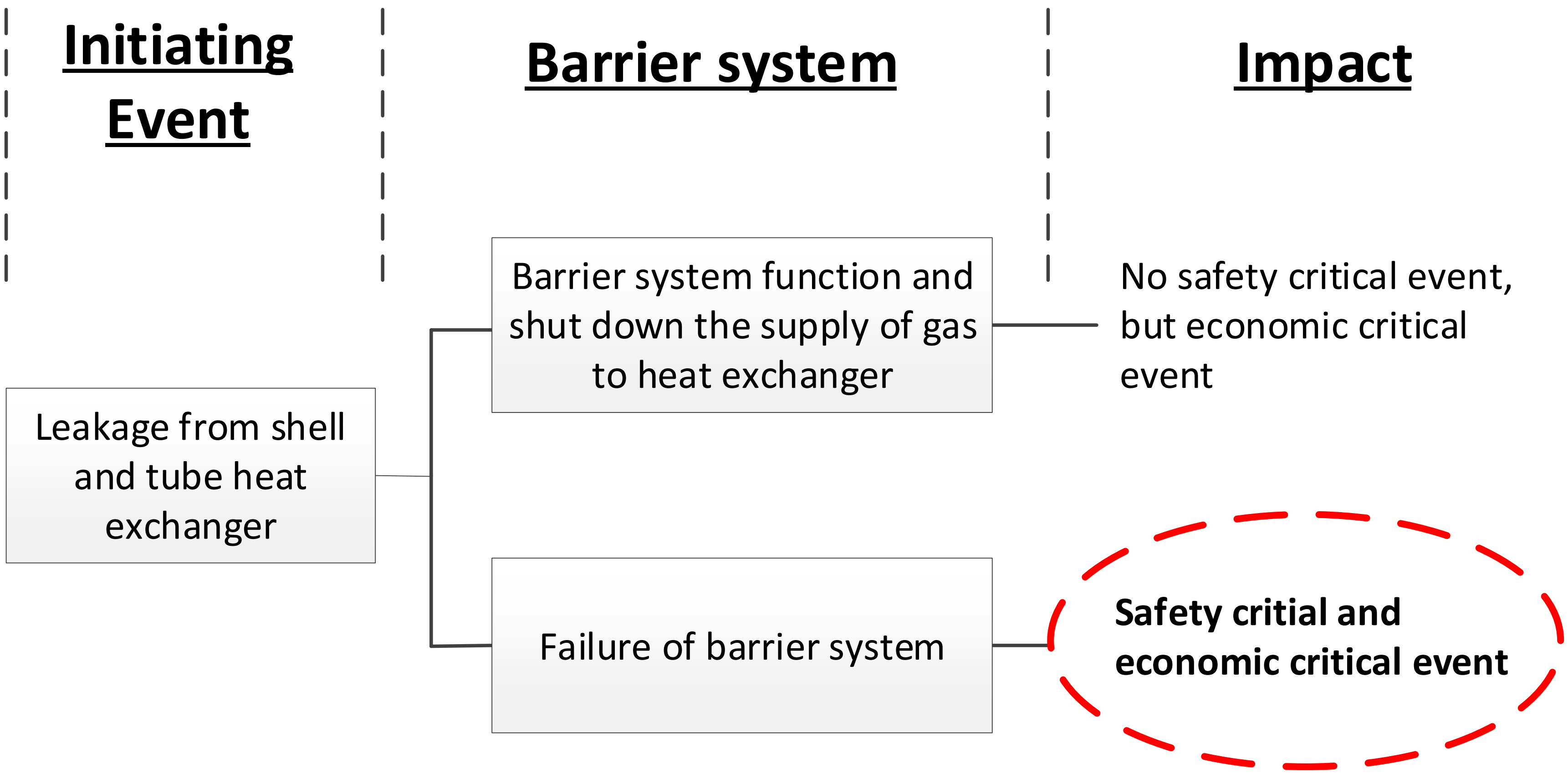

Figure 4: The total risk picture in QRA

4 Risk modelling

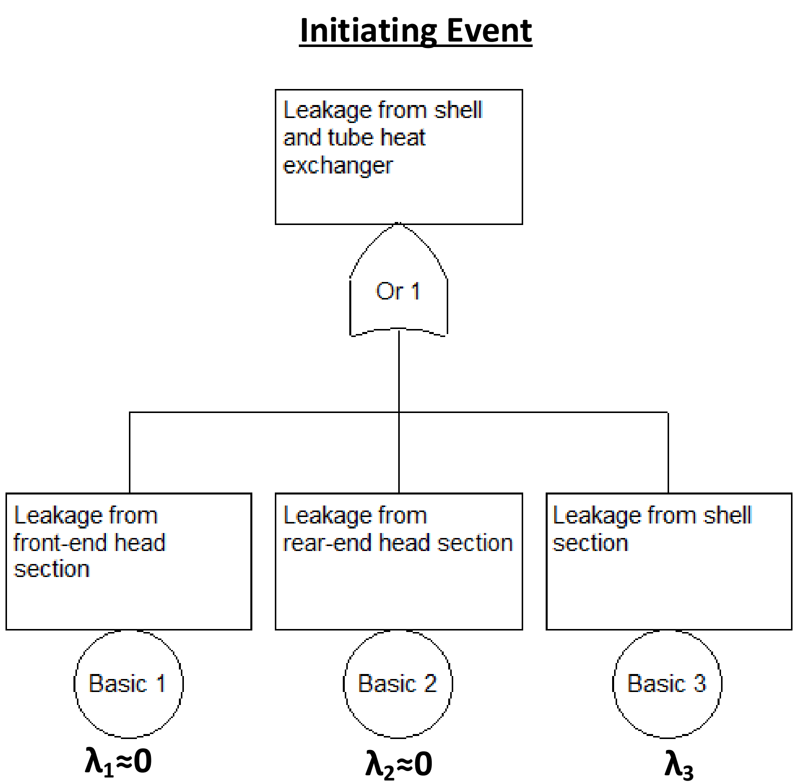

Figure 5: FTA of initiating event.

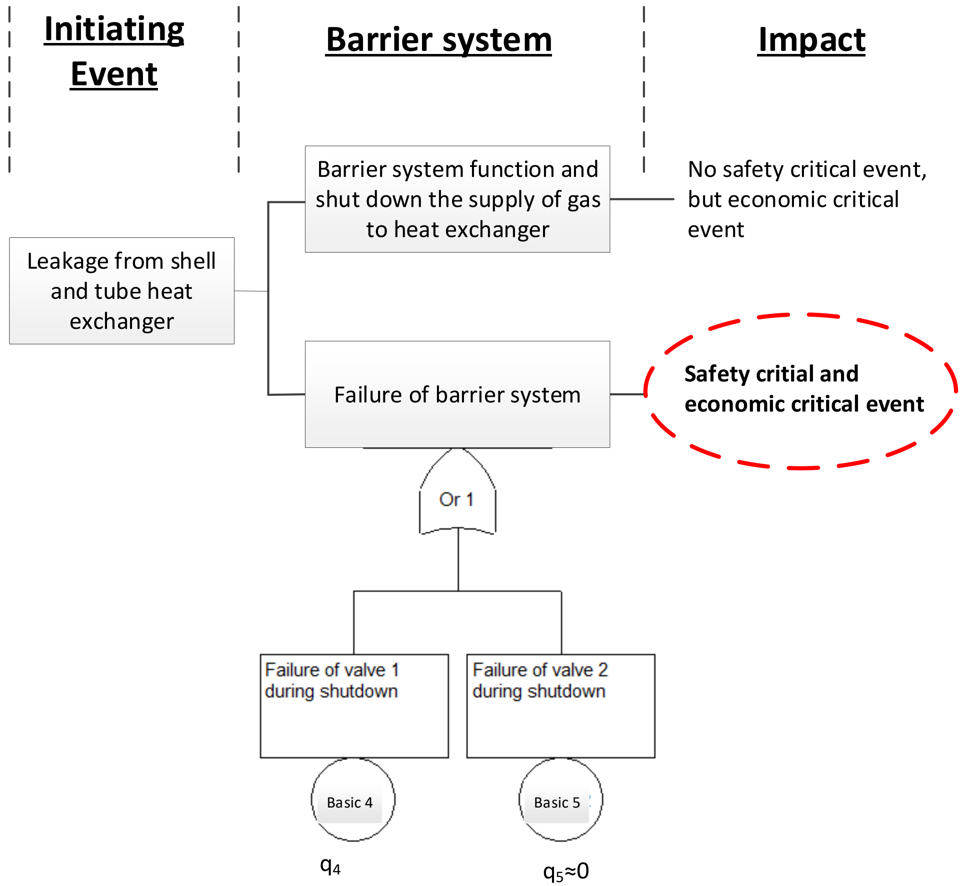

Figure 6: FTA of barrier system

4 Risk modelling

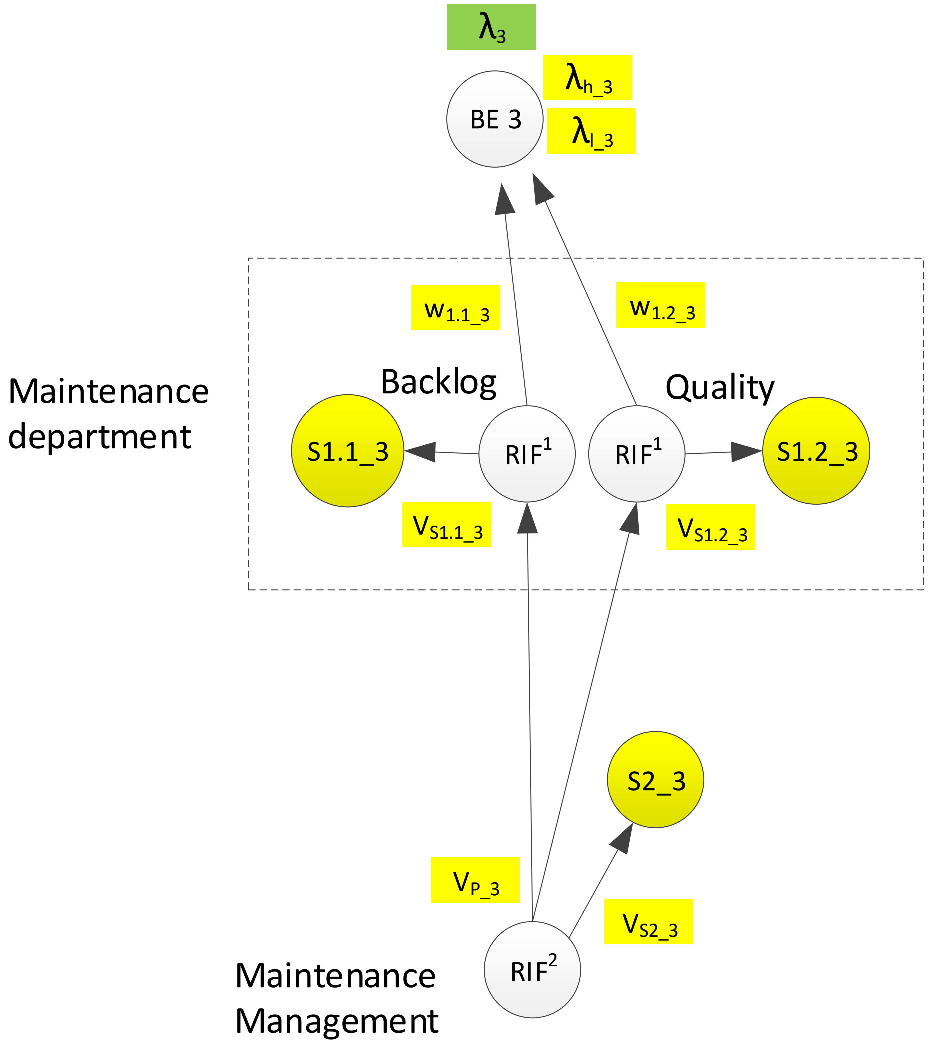

Figure 7: RIF structure

Score	Evaluation criteria
A	«Best case» score
B	
C	«Normal case» score
D	
E	
F	«Worst case» score

4 Risk modelling

- Approach for calculating the basic events:
  1. Expert judgement of each RIF with score A-F
  2. Map the scores in the interval [0,1]
  3. Calculate the posterior distribution of parents RIF
  4. Calculate the prior distributions of child RIFs
  5. Calculated the weighted sum
  6. Apply the law of total probability

5 Result

Input data for basic event 3

Parameter	Value
$S_{1.1\_3}$	D=0.58333
$S_{1.2\_3}$	B=0.25000
S_{2_3}	C=0.41667
$w_{1.1\_3}$	0.3
$w_{1.2\_3}$	0.7
$VS_{1.1\_3}$	0.01
$VS_{1.2\_3}$	0.04
VS_{2_3}	0.04
$VP_{\_3}$	0.0025
$MTTR_{\_3}$ (hours)	3.0
λ_{l_3} (/hours) from (Sintef and Oreda, 2009)	$0.39*10^{-6}$
λ_{h_3} (/hours) from (Sintef and Oreda, 2009)	$23.87*10^{-6}$

Input data for basic event 4

Parameter	Value
$S_{1.1\_4}$	C=0.41667
$S_{1.2\_4}$	C=0.41667
S_{2_4}	C=0.41667
$w_{1.1\_4}$	0.3
$w_{1.2\_4}$	0.7
$VS_{1.1\_4}$	0.01
$VS_{1.2\_4}$	0.04
VS_{2_4}	0.04
$VP_{\_4}$	0.0025
q_{h_4}	10^{-3}
q_{l_4}	10^{-4}

5 Result

Initiating event, (/hours)	Barrier system	Frequency in QRA (/year)
λ_3=λ_{IE}= **2.9500*10^{-6}**	q4=0.0030	F_2=λ_{IE}*q4 **=7.75*10^{-5}**

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6 Adapting RISK OMT with CPS

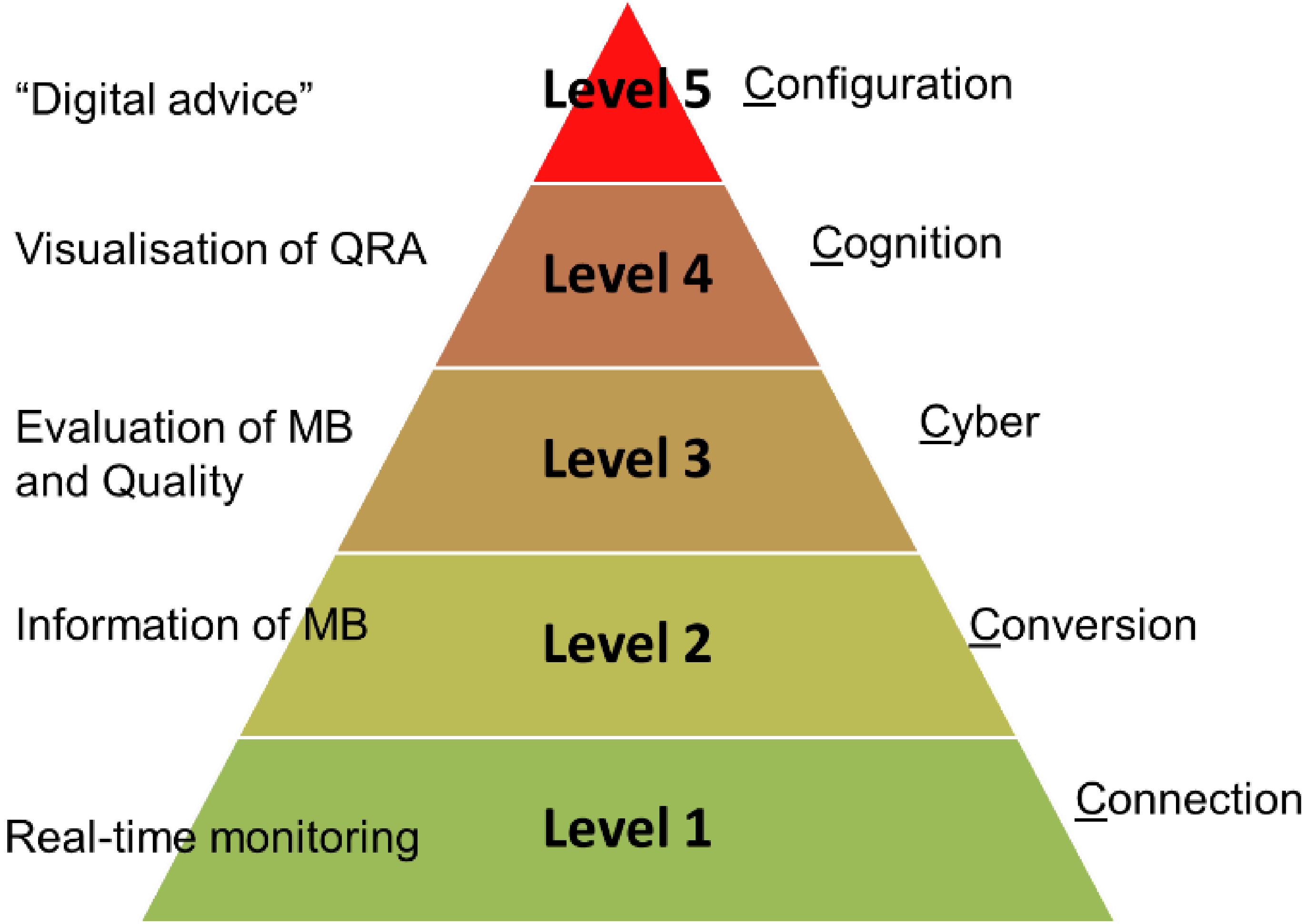

Figure 7: CPS architecture proposed for Risk OMT.

7 Concluding remarks

- Need for improving the model, in particular the decision criteria.
- Should be included in the maintenance model DDM.
- Should be performed in other industry branches in addition to O&G industry.

The End

"Success is not final, failure is not fatal: it is the courage to continue that counts."

-Winston Churchill

Thank you for your attention!