A Framework to support Condition Based Maintenance Management.

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AGENDA

- Introducción to based condition maintenance
- Maintenance evolution
- CBM Management: Treatment of data
- A framework for CBM management
- Data model for PHM/CBM solutions: References to international standards used
- Conclusions

INTRODUCTION TO BASED CONDITION MAINTENANCE

What is condition based maintenance (CBM)?

"Preventive maintenance that includes a combination of physical condition assessment, analysis and possible subsequent maintenance actions"

European standard EN 13306: 2017

INTRODUCTION TO BASED CONDITION MAINTENANCE

CBM (Condition Based Maintenance) solutions are increasingly present in industrial systems due to:

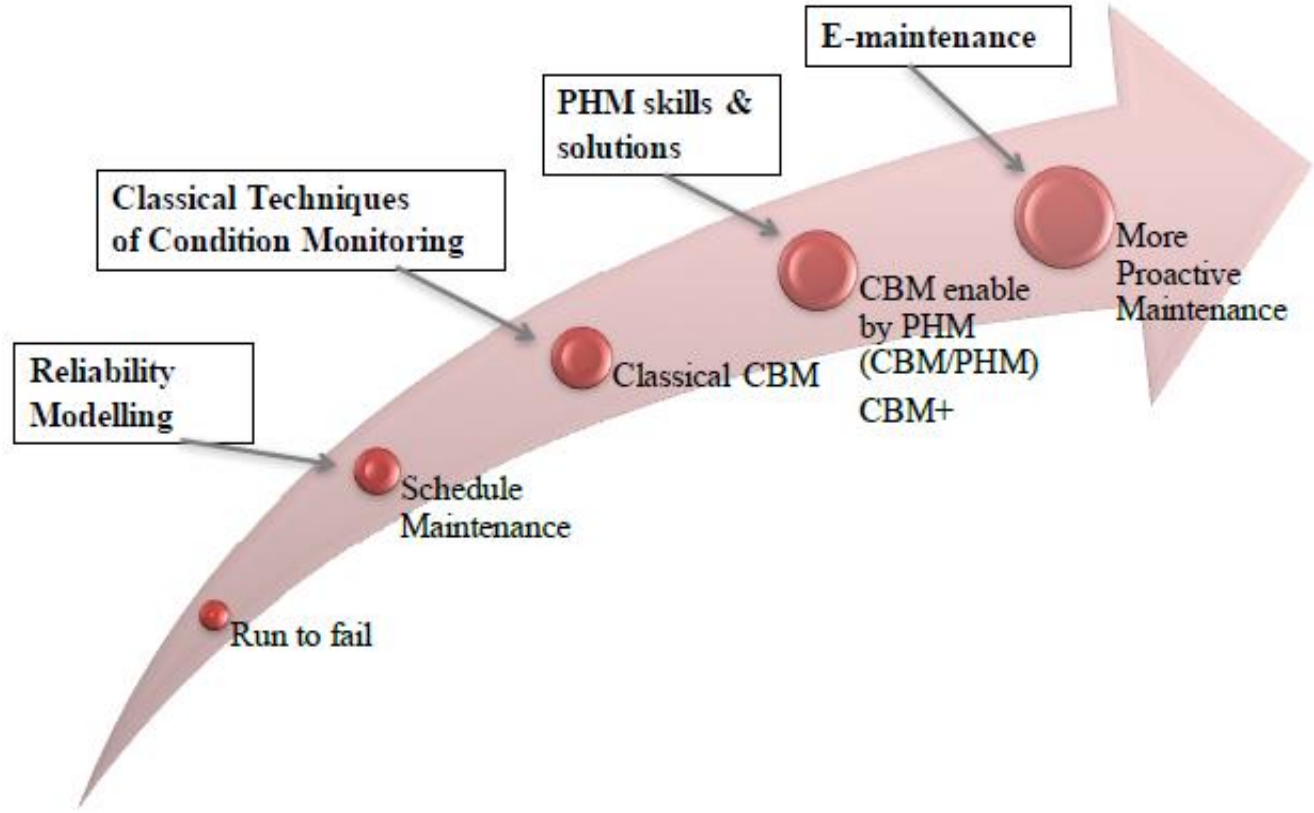
- Rapid evolution in the capture and analysis of data and
- Significant cost reduction of supporting technologies

This situation permit:

- To improve the transition from traditional maintenance approaches to more efficient maintenance approaches
- To emergence of more economical and reliable information and communication technologies (ICT) (smart sensors, personal digital devices, wireless tools, etc.) has allowed an increase in the efficiency of CBM programs.
- The classic industrial vision of CBM focused on the use of Condition Monitoring (CM) techniques evolve towards the development of the PHM discipline (prognosis and health management) is promoting a new CBM, that provides capabilities for the physical understanding the life of a system

MAINTENANCE EVOLUTION

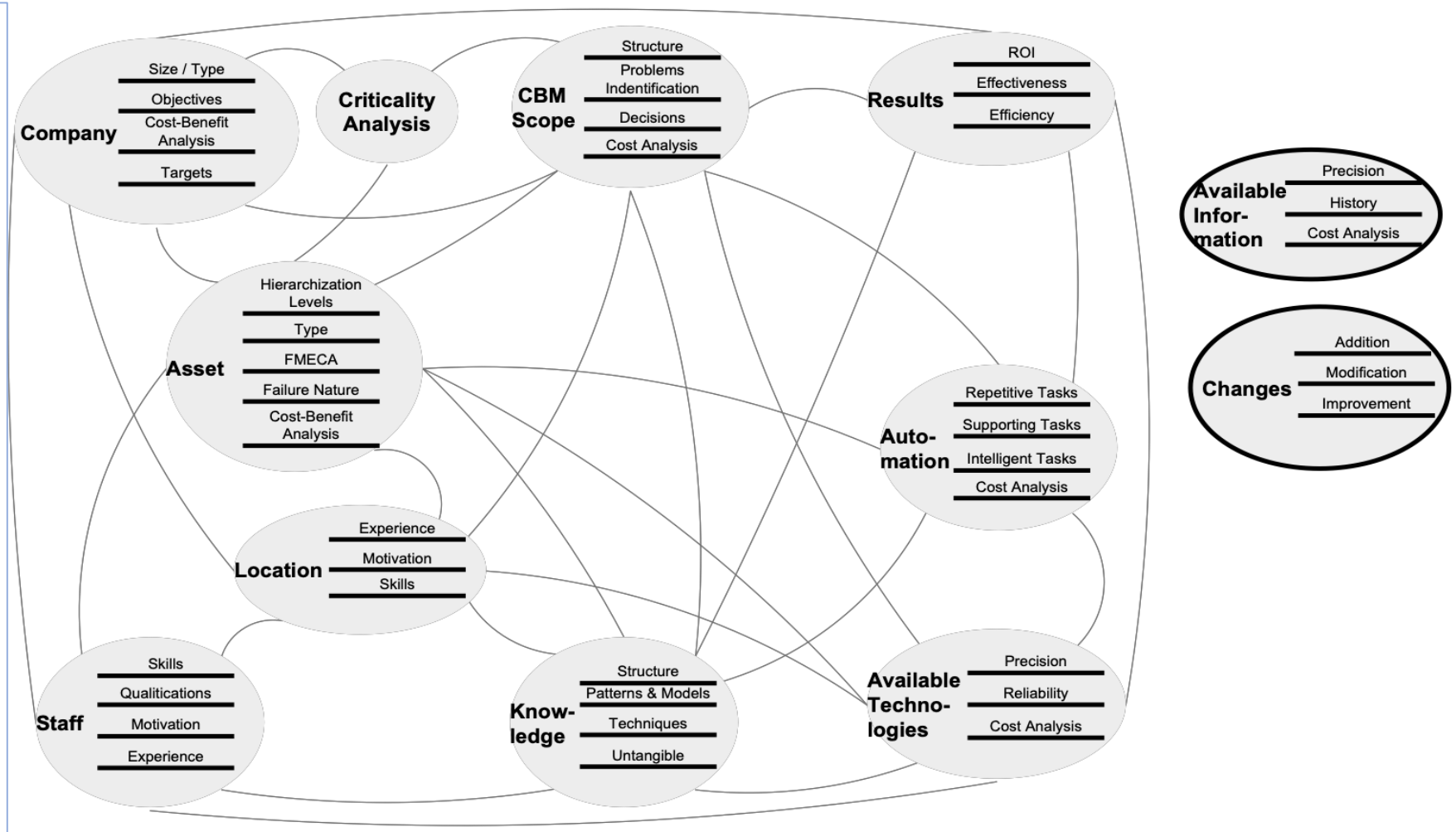
The evolution of maintenance types and shows how the evolution of CBM is enabled by PHM capabilities



CBM COMPLEXITY GRAPH.
Entities, attributes and relations.

1.-Every entities are correlated with all the rest of the entities,
This figure shows that concepts should be considered in a correlational and descriptive manner, both from a technical and financial point of view.

2.- The CBM program requires updated data, information and, knowledge about the assets, of which there may be a large amount dispersed, unknown, inaccessible or low profitable to obtain



CBM MANAGEMENT: TREATMENT OF DATA

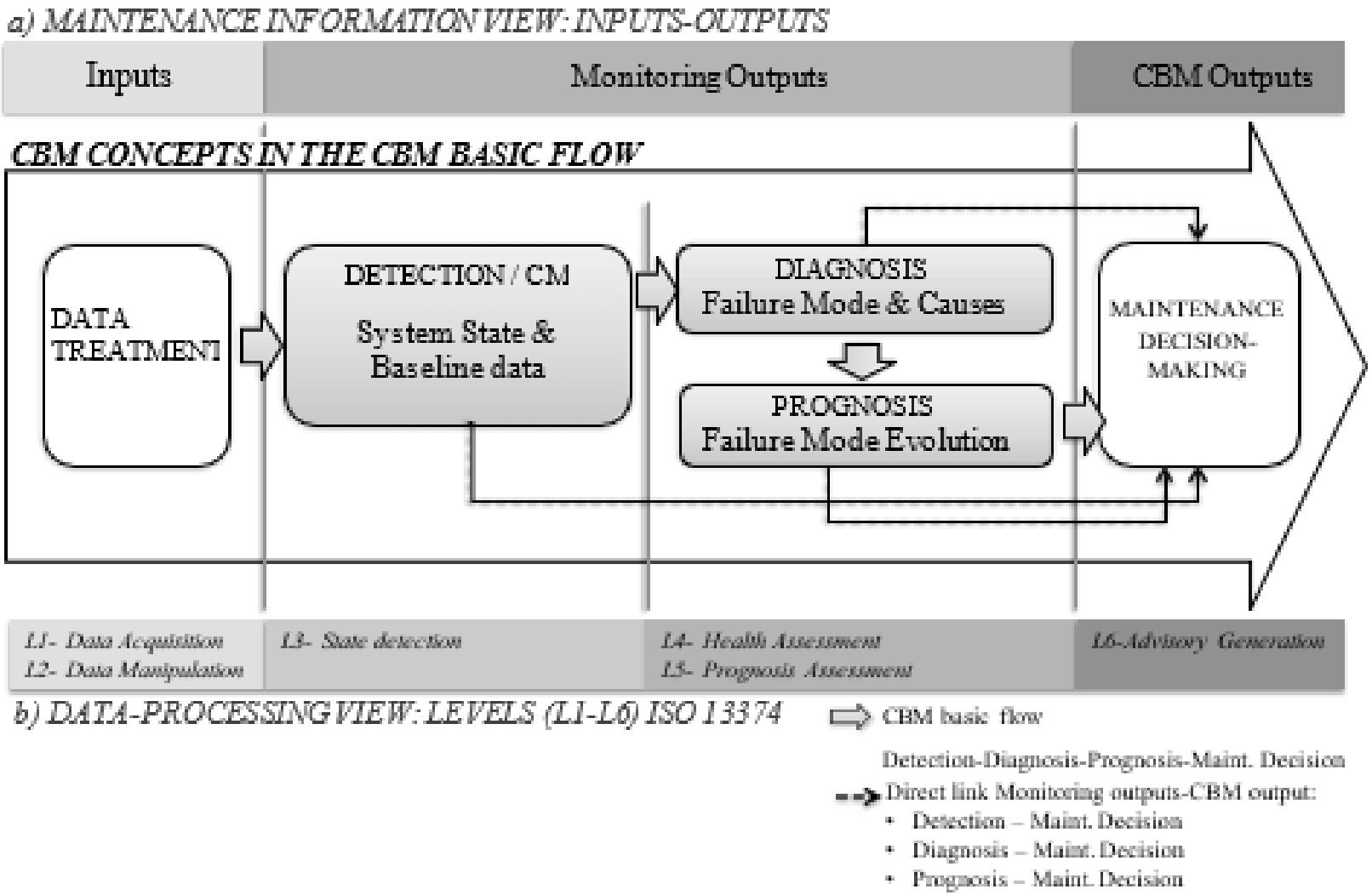
1.- Data is the CORE of CBM

2.- CBM Systems have focused on the requirements on:

- collection, transmission, storage and processing

3.- CBM is a maintenance activity align with business maintenance:

- Basic concepts within the flow of the CBM: (detection, diagnosis, prognosis)
- Data processing (Flow of CBM and adaptation of data processing requirements
- Maintenance information. Translation maintenance requirements

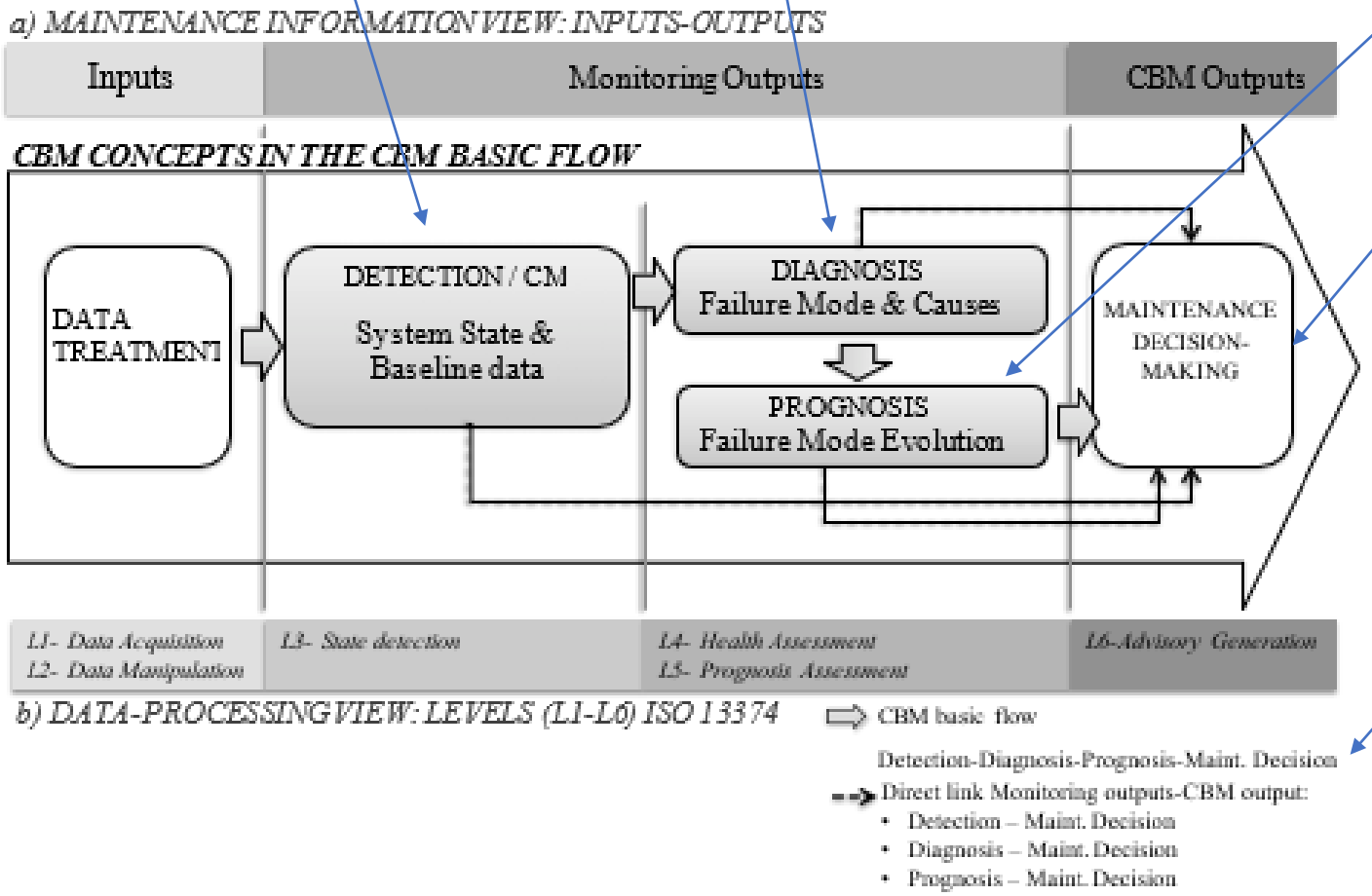


CBM MANAGEMENT: TREATMENT OF DATA

State of systen

The location of the failure mode & causes

Evolution of the failure mode or its future behavior (risk of failure and remaining useful life)



The maintenance decision is usually based on the use of a threshold which, when reached, means that maintenance action is to be carried out.

CBM outputs: Knowledge management: generation and management of the company's knowledge about the behavior and problems of assets

Monitoring outputs: Basic information for making maintenance decisions

A FRAMEWORK FOR CBM MANAGEMENT. (1)

CBM application: Is complex of administer (characterization and treatment of the key points of CBM solutions)

Challenges:

- Integrated detection, diagnosis and prognosis treatment.
- The correct interpretation of monitoring techniques and their results.
- The integrated treatment of different possible CBM solutions and different sources of information.
- The integration of CBM results with the rest of the maintenance types and strategies.
- The definition of a set of groups or blocks of conceptual elements, which can then be easily modeled and implemented by software systems

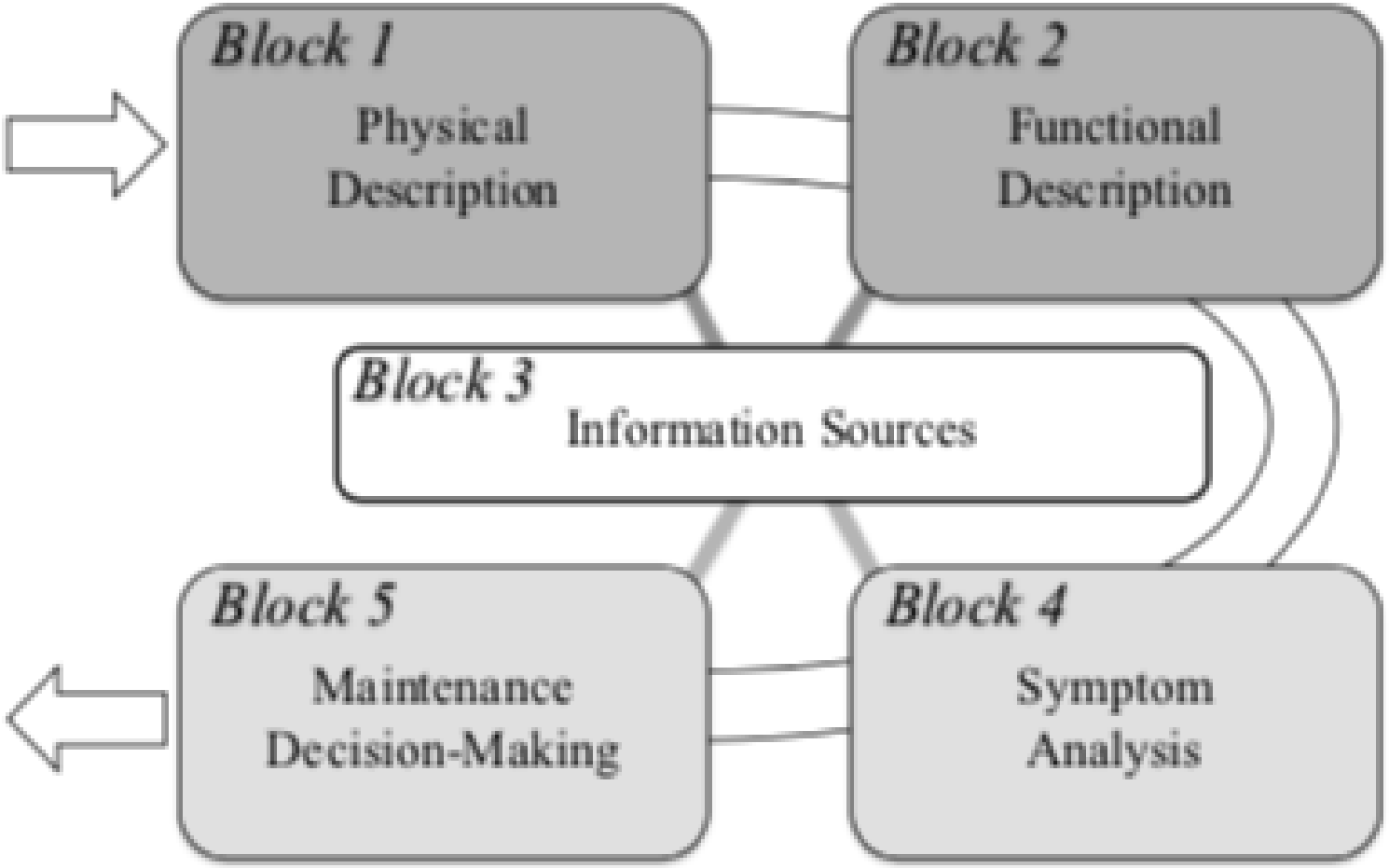
The proposed CBM solution

The proposed structure comprises five blocks with the following characteristics:

- each block introduces a specific perspective or technical area that should be considered for a CBM solution,
- each block requires specific knowledge and skills and also specific tasks and,
- each block produces specific results that can be managed and recorded.

A FRAMEWORK FOR CBM MANAGEMENT. (2)

- Blocks1,2,4 and 5 correspond to maintenance processes
- Block 3 that deals with all information resources

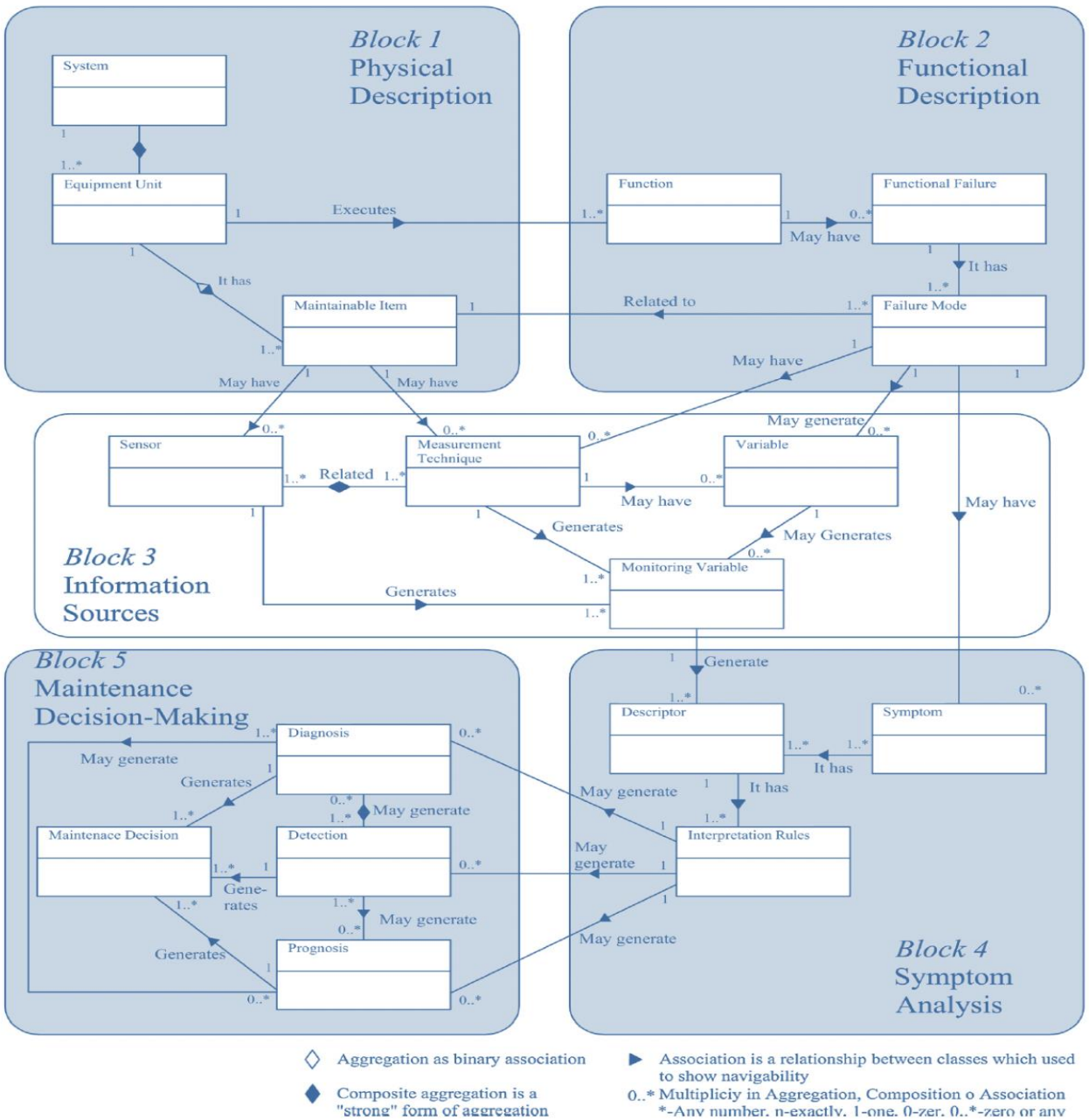


FRAMEWORK FOR CBM MANAGEMENT (3)

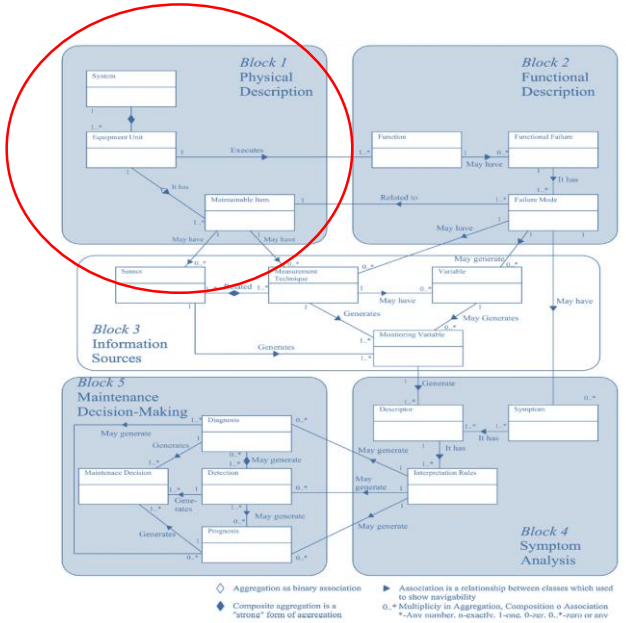
Block	Elements	Objective	References: methods & standards
B1	-System -Equipment -Maintainable Item	Physical Description from system to indenture level	ISO 14224
B2	-Function -Functional Failure -Failure Mode	Functional description and failure mode definition	RCM/FMEA/ FMECA, ISO 17359, IEC 60812
B3	-Sensor -Measurement Technique -System Variable -Monitoring Variable	Information source management and technical resources.	ISO 13374, OSA-CBM, ISO 17359
B4	-Symptom -Descriptor -Interpretation Rule	Symptom description. Descriptors definition	FMSA, ISO 13379, ADS-79D-HDBK
B5	-Detection -Diagnosis -Prognosis -Maintenance Decision	Monitoring outputs and decisions about maintenance (CBM outputs)	ISO 13374, OSA-CBM, ISO 13381, ISO 17359

Table 1. Summary of the blocks in the framework for CBM management

FRAMEWORK FOR THE CBM MANAGEMENT (4)



FRAMEWORK FOR CBM MANAGEMENT: BLOCK 1



Block 1. Physical description

Physical structure is the way of observing the reality of the system

- Element 1.1: **System.**
- Element 1.2: **Equipment unit.**
- Element 1.3: **Subunit.**
- Element 1.4: **Maintainable item**

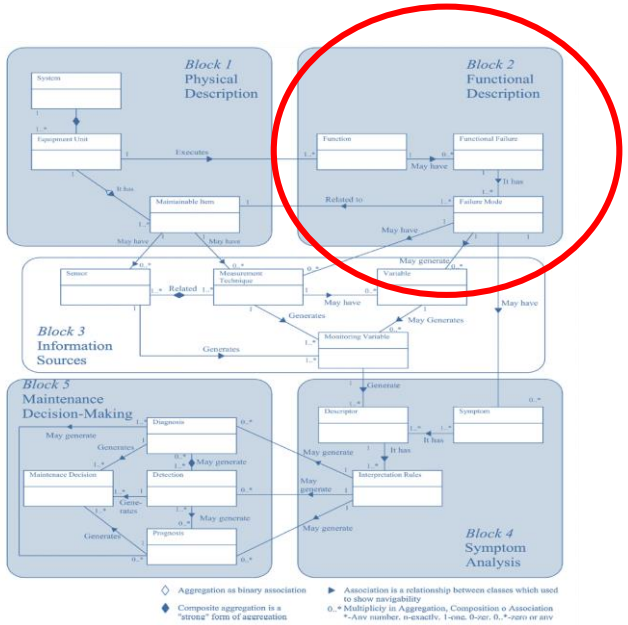
This block define hierarchically according to ISO 14224: 2018

FRAMEWORK FOR CBM MANAGEMENT: BLOCK 2

Block 2. Functional description

The fault is used to indicate functional failures of the elements-

- Element 2.1: **Function.** The action and activity assigned, required or expected of a system. The precise definition of the functions includes the determination of standards or operating ranges.
- Element 2.2: **Functional failure:** the way in which a system can not fulfill a function with the acceptable performance level.
- Element 2.3: **Failure mode**: event that is reasonably likely to cause each functional failure. It is also defined as the effect by which a failure is observed.

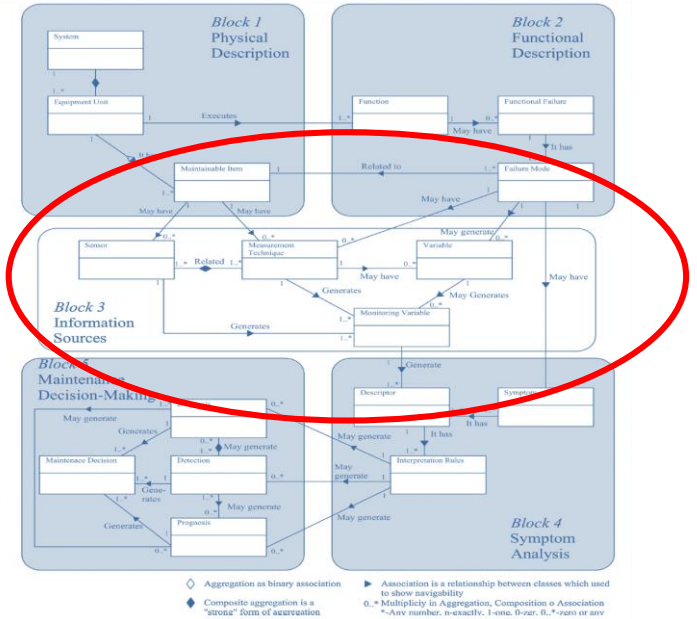


The relationship between blocks 1 and 2 is represented by joining the elements of the physical structure and the functional logical elements

FRAMEWORK FOR CBM MANAGEMENT: BLOCK 3

Block 3. Information sources

This block provides a model to organize and interconnect the different types of information available that will be used in the treatment of symptoms



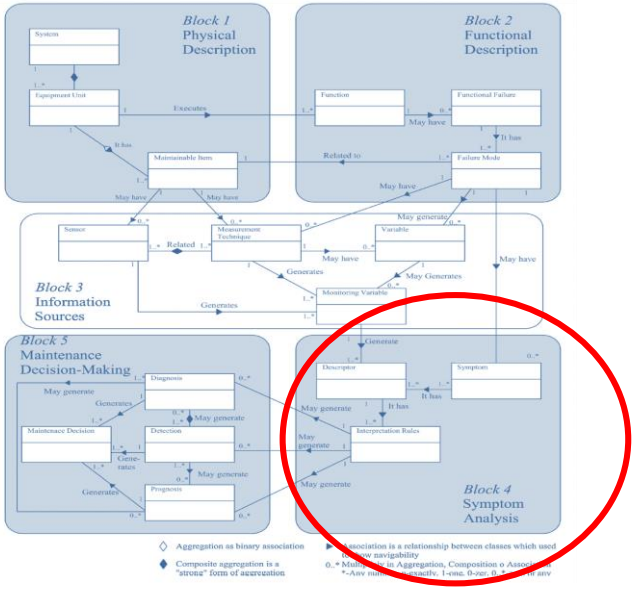
- Element 3.1: **Sensor**. The term "sensor" is related to the physical measurement process and its communication
- Element 3.2: **Measurement technique**: It refers to the technical knowledge and equipment necessary to observe a particular phenomenon.
- Element 3.3: **System variable** This element includes any variable presented in any system-related database that can model the behavior of good or bad system performance
- Element 3.4: **Monitoring variable**. include the variables that will be used in the CBM solution
  - (i) result of signal processing variables (of sensors),
  - (ii) results of analysis of measurement techniques expressed as variables;
  - (iii) System variables that use CBM solutions

The processed signals of the sensors and the processed variables of the measurement techniques can produce one or more monitoring variables.

FRAMEWORK FOR CBM MANAGEMENT: BLOCK 4

Block 4.- Symptom análisis

Symptoms, is managed and interpreted in relation to the failure mode, disaggregating the general concept of symptom into three elements: the symptom, the descriptor and the rule of interpretation.



- Element 4.1: **Symptom.** A qualitative description of the specific effects or causes that can be measured by giving information about the failure mode.
- Element 4.2: **Descriptor.** It is the specific measurement characteristic or parameter that really provides symptom monitoring. A descriptor is related to a coded symptom and a symptom can have one or more descriptors.
- Element 4.3: **Interpretation rule**: it is the description of how the descriptor values should be interpreted or treated to obtain the monitoring outputs (detection, diagnosis, prognosis) for a failure mode.

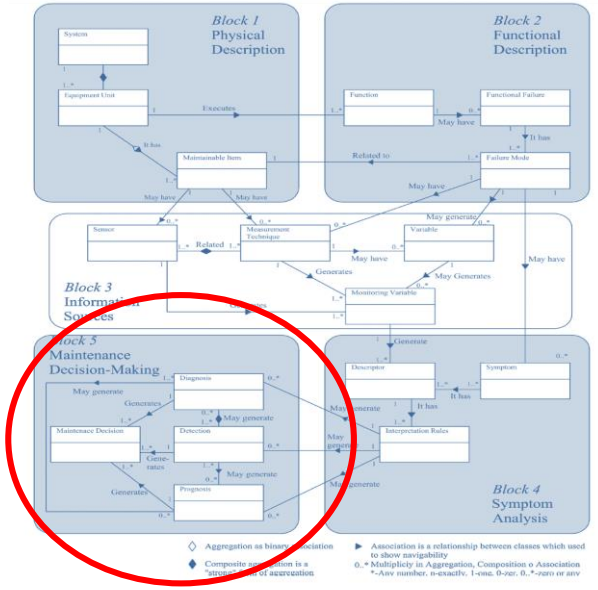
The treatment of the element of the interpretation rule can be extended on a recurring basis, that is, an interpretation rule can be based on one or another interpretation rule

FRAMEWORK FOR CBM MANAGEMENT: BLOCK 5

Block 5.- Maintenance decision making

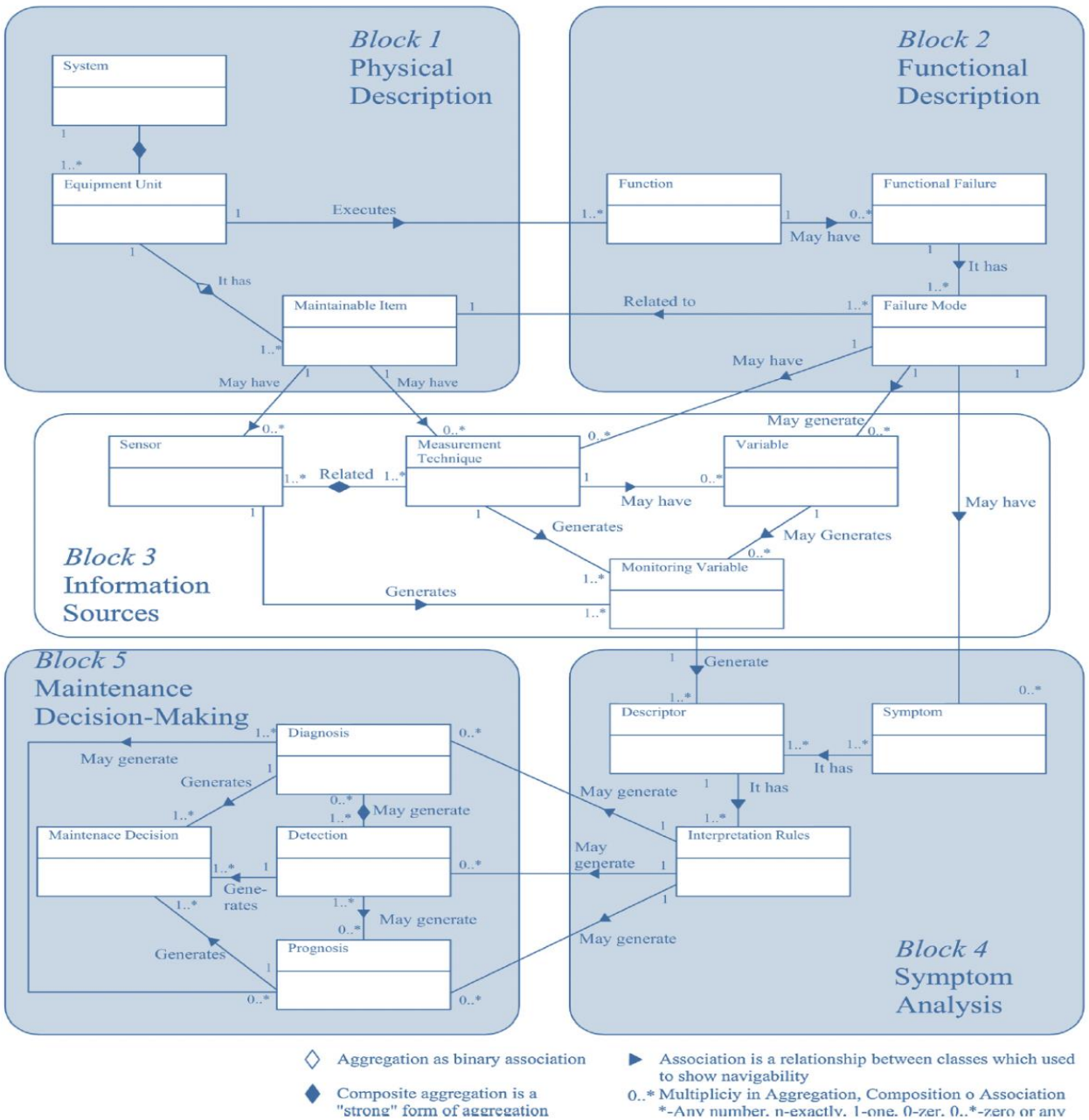
This block supports the two different types of CBM outputs process: monitoring outputs and CBM outputs.

- Element 5.1: **Detection element**. It focuses on the state of the machine or system. It allows distinguishing anomalous behaviors, comparing data collected with baseline parameters detecting and reporting abnormal events
- Element 5.2: **Diagnostic element:** It is defined as the determination of the nature of the failure, considering two different stages in the diagnostic process:
  - isolation, determining what failure mode is affected; and
  - identification, determination or estimation of the nature (or causes) and scope (size and time) of failures
- Element 5.3: **Prognosis element:** The forecast focuses on the evolution of the failure mode.
- Element 5.4: **Maintenance decision**. This element describes the CBM outputs. Maintenance tasks and general actions that are triggered as a result of monitoring results

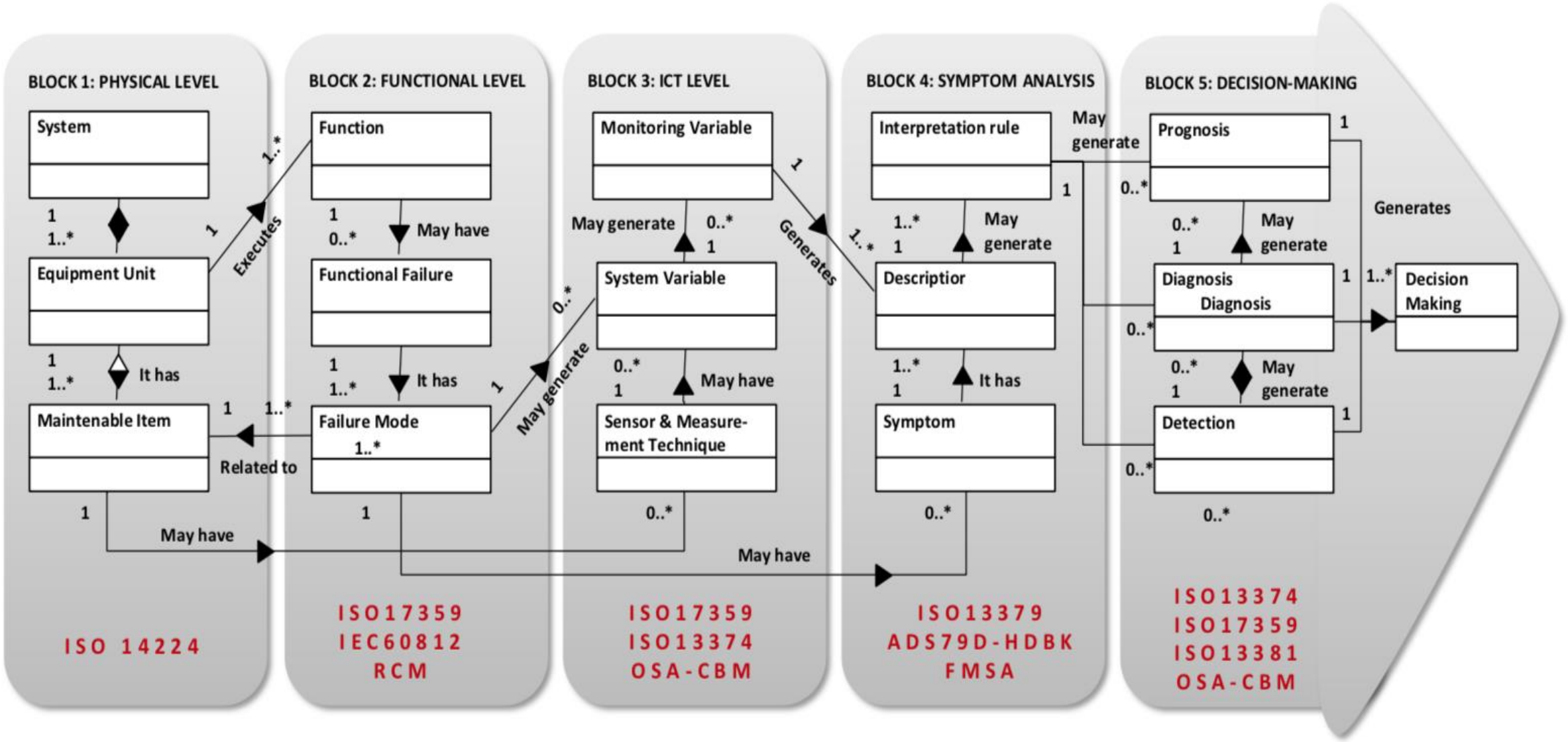


Knowledge about the decision that a maintainer can make has great value.
The entire CBM process is based on this knowledge

FRAMEWORK FOR THE CBM MANAGEMENT (4)



DATA MODEL FOR PHM/CBM SOLUTIONS: References to International Standards Used



CONCLUSIONS

1. Has been presented a framework to clarify the concepts and structure and document the generation of knowledge
2. This framework meets precise **standards and requirements** of well-known methodologies
3. The CBM framework emphasizes the **importance of concepts** (such as fault detection, diagnosis and prognosis
4. The **five blocks are consistent with the standards** that have been included in each block definition and represent different knowledge topics
5. These blocks are traditionally supported by isolated software systems to manage your information, so the main contribution of our framework is **to balance knowledge using four hinges to join the blocks**: failure mode item, symptom item, descriptor item and item of rule of interpretation
6. CBM's knowledge can be improved and evolved with the possibility of capturing new information as monitoring variables within e-maintenace strategies.

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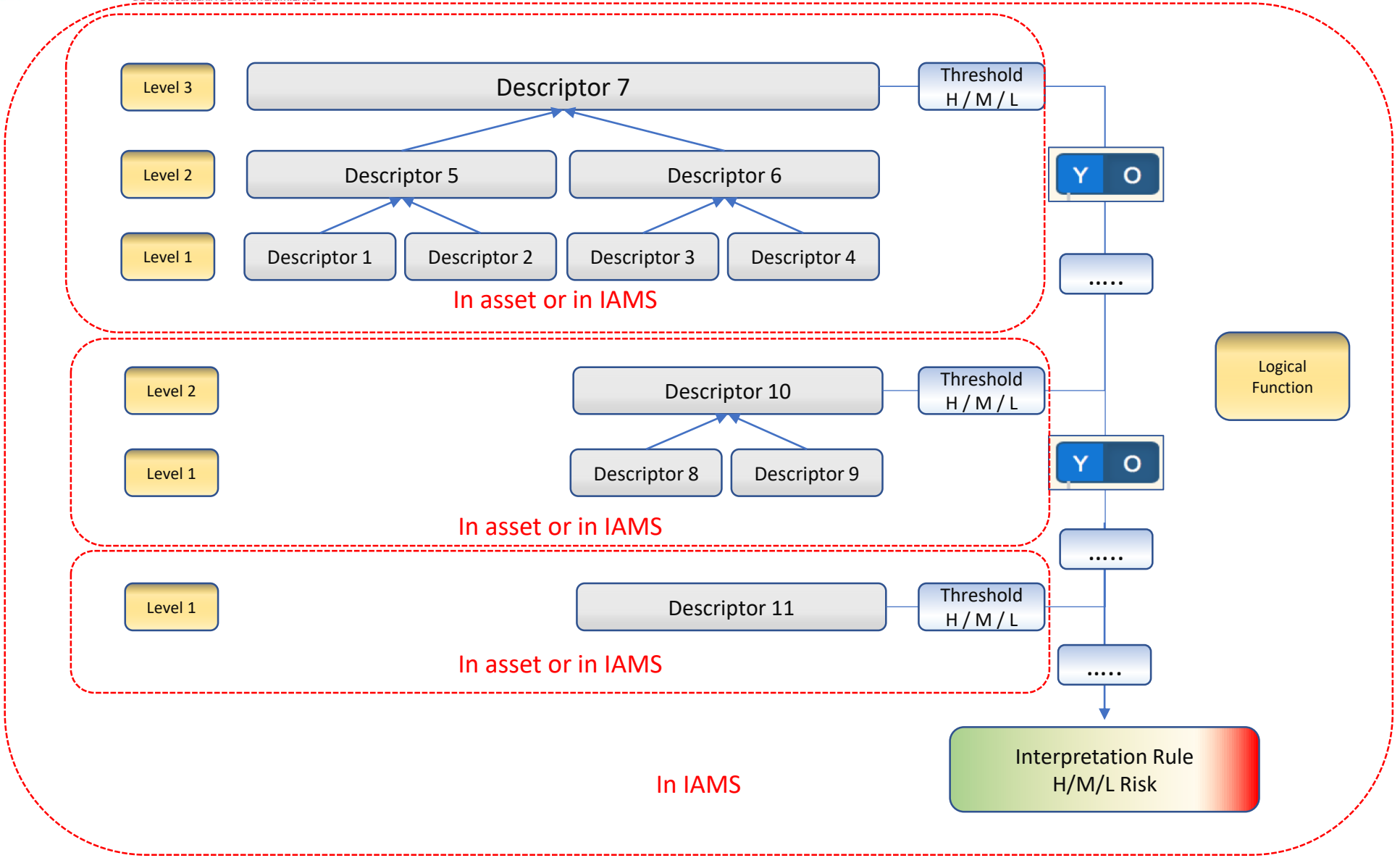
Thank you very much for your attention

CONCLUSIONS

1. Se ha presentado un marco para aclarar los conceptos y la estructura y documentar la generación de conocimiento
2. Este marco cumple con estándares y requisitos precisos de metodologías conocidas
3. El marco CBM hace hincapié en la importancia de los conceptos (como la detección de fallas, el diagnóstico y el pronóstico
4. Los cinco bloques son consistentes con los estándares que se han incluido en cada definición de bloque y representan diferentes temas de conocimiento
5. Estos bloques son tradicionalmente soportados por sistemas de software aislados para administrar su información, por lo que la principal contribución de nuestro marco es equilibrar el conocimiento utilizando cuatro bisagras para unirse a los bloques: elemento de modo de falla, elemento de síntoma, elemento descriptor y elemento de regla de interpretación
6. El conocimiento de CBM puede mejorarse y evolucionarse con la posibilidad de capturar nueva información como variables de monitoreo dentro de las estrategias de e-maintenace.


Level 3
Descriptor 7
Threshold
H / M / L
Level 2
Descriptor 5
Descriptor 6
Level 1
Descriptor 1
Descriptor 2
Descriptor 3
Descriptor 4
In asset or in IAMS
Y
O
.....
Logical
Function
Level 2
Descriptor 10
Threshold
H / M / L
Level 1
Descriptor 8
Descriptor 9
In asset or in IAMS
Y
O
.....
Level 1
Descriptor 11
Threshold
H / M / L
In asset or in IAMS
.....
Interpretation Rule
H/M/L Risk
In IAMS

- Monitoring Data Gathering
- Historic Information
- Physical Description:
  Indenture Level Definition
- Value Factors Definition
  Automatic & Dynamic Assessment, Criticality Analysis
- Functional Analysis
  Failure Mode & Causes, Maintenance Task
- Condition Based Maintenance Analysis:
  Interpretation Rules: CI, HI and Risk Indicators
- Risk Management & Decision Making
  Risk Levels, Costs, Maintenance Tasks
- Performance Control

Information and Data Management

System Analysis

Knowledge Management

Interface and Control