Using model based PHM design to establish a business case
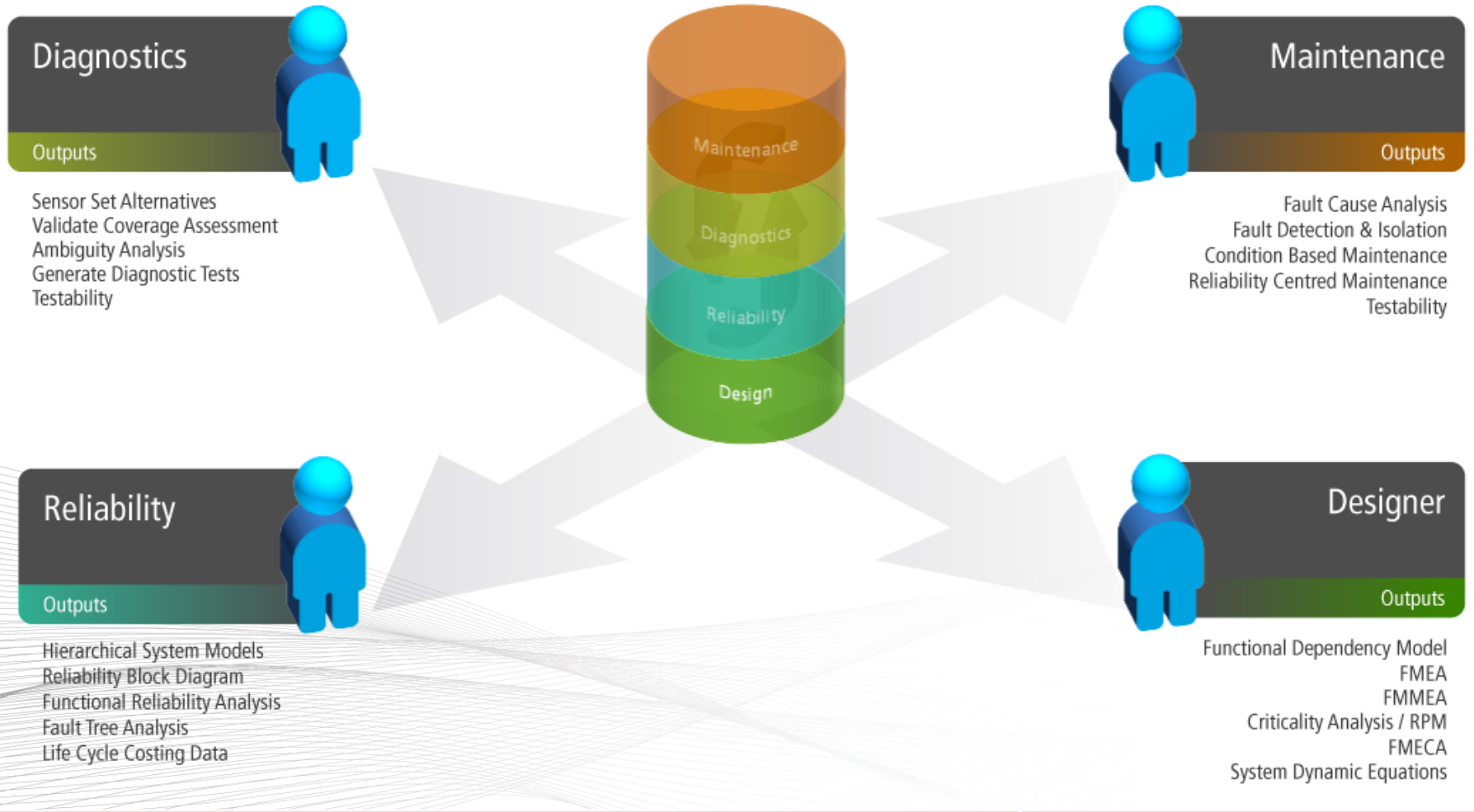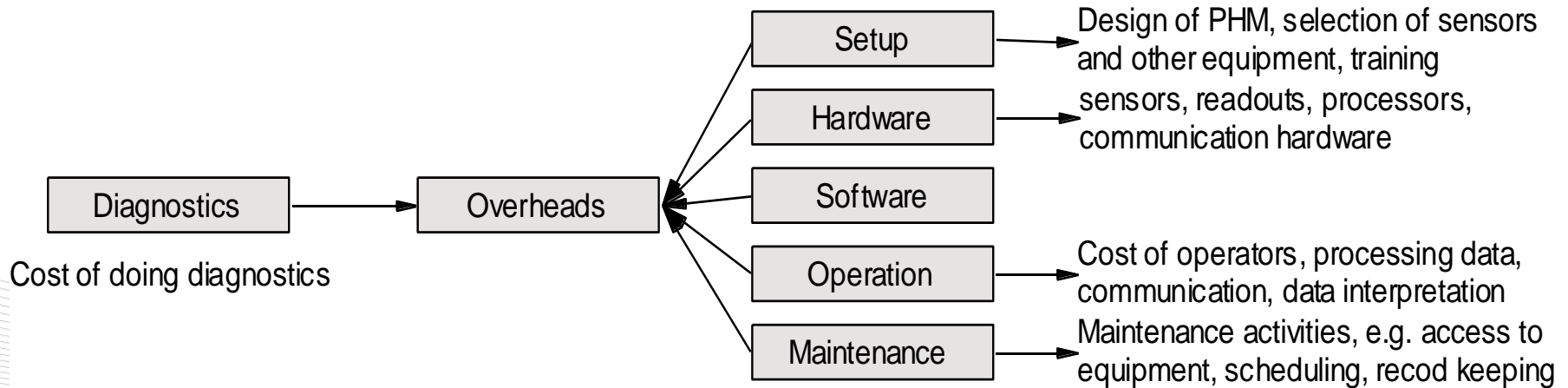
Presented at
Affordability / ROI Benefits Panel
IEEE PHM 2011
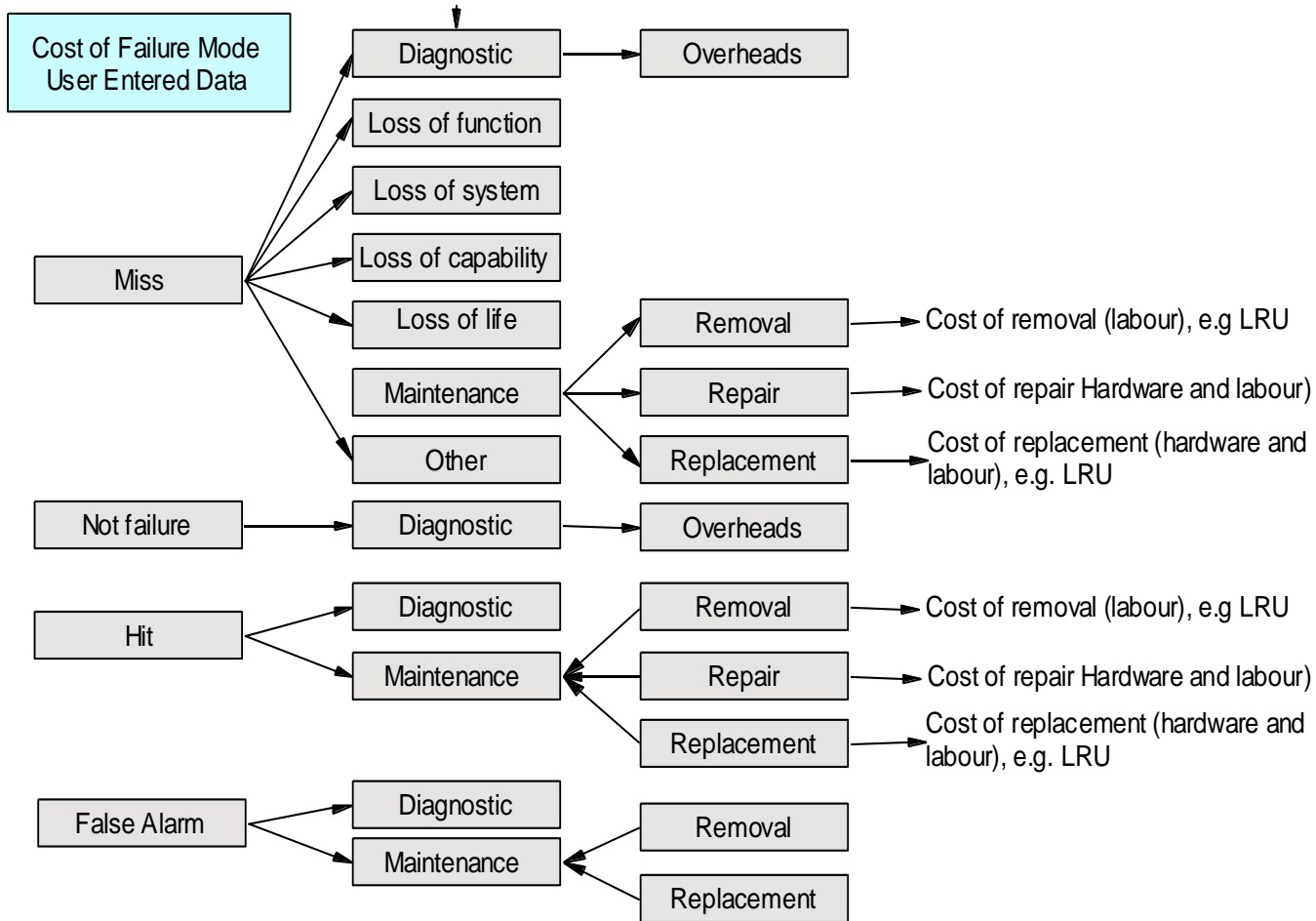
PHMTechnology

# PHM capability development stakeholders

Diagnostics

Outputs

Sensor Set Alternatives
Validate Coverage Assessment
Ambiguity Analysis
Generate Diagnostic Tests
Testability

Maintenance

Outputs

Fault Cause Analysis
Fault Detection & Isolation
Condition Based Maintenance
Reliability Centred Maintenance
Testability

Reliability

Outputs

Hierarchical System Models
Reliability Block Diagram
Functional Reliability Analysis
Fault Tree Analysis
Life Cycle Costing Data

Designer

Outputs

Functional Dependency Model
FMEA
FMMEA
Criticality Analysis / RPM
FMECA
System Dynamic Equations

Maintenance
Diagnostics
Reliability
Design

PHMTechnology

PHM capability cost inputs

Diagnostics → Overheads

Cost of doing diagnostics

Overheads → Setup, Hardware, Software, Operation, Maintenance

Design of PHM, selection of sensors and other equipment, training

sensors, readouts, processors, communication hardware

Cost of operators, processing data, communication, data interpretation

Maintenance activities, e.g. access to equipment, scheduling, recod keeping

PHMTechnology

Failure Mode costs

PHMTechnology

Current PHM design process

- spreadsheet based FMECA

- silo mentality ('dead cats')

- taxonomy issues (subjective)

- mandraulic dependency mapping

- PHM required data often not available until system design is 'locked in'

PHMTechnology
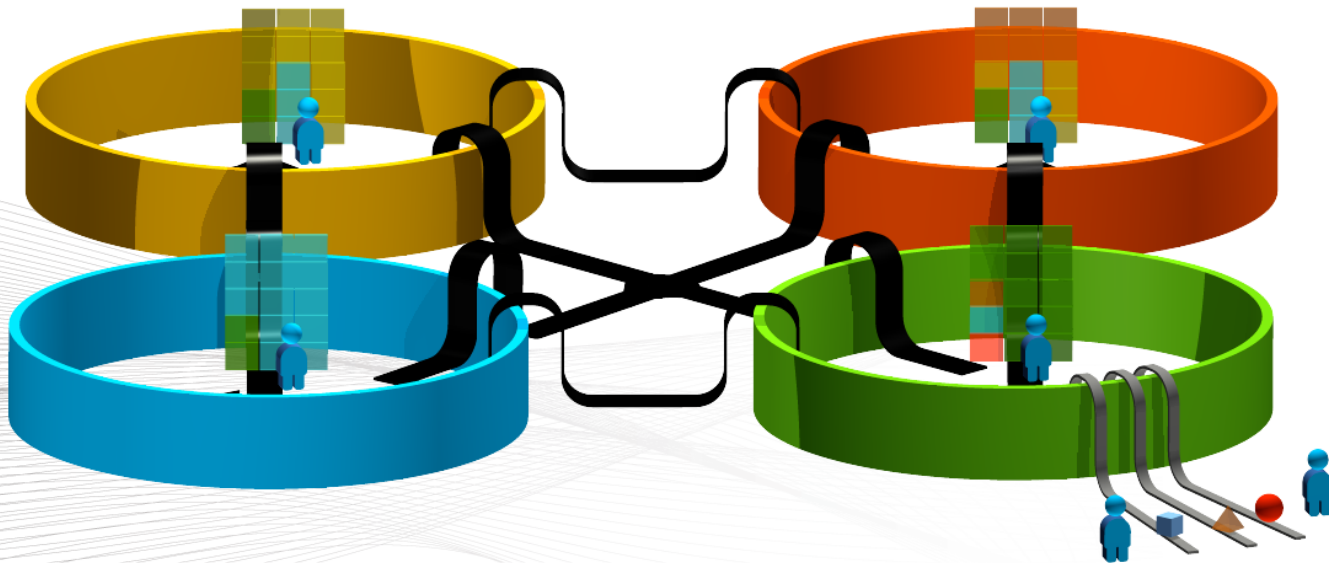
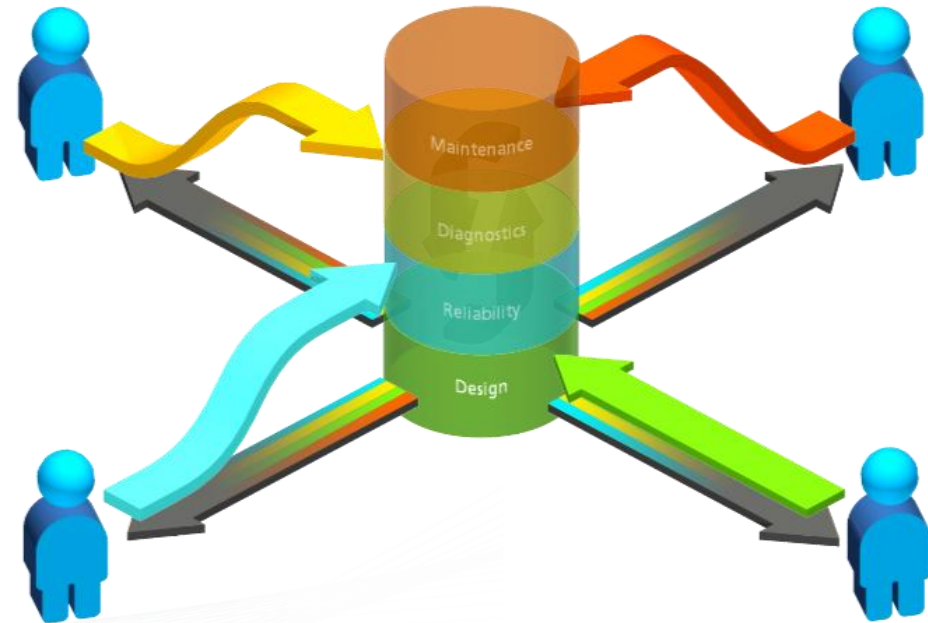# Model based PHM design process

<u>concurrent design</u>

- RAM / HM / CBM considerations and requirements integrated into the design process

- enable data currency & interoperability between functional groups (silos)

<u>data quality</u>

- standardised taxonomy of functional descriptions of components and sub systems

- standardised taxonomy of failure concepts (cause, mechanism, fault and failure mode)

<u>structural benefits</u>

- reduce data entry requirements (cost / risk)
- consolidate modeling & analysis tools

Maintenance
Diagnostics
Reliability
Design

PHMTechnology

Benefits of model based PHM design

A model based approach enables iterative and concurrent:

- assessment of PHM requirements for system designs and design variations

- conceptual design of PHM system in terms of sensor types and techniques

- assessment of predicted performance of a PHM design against requirements / specifications

- 'what-if?' analysis for PHM capability vs. design trade-offs for weight, cost etc.

- identification of additional PHM requirements for system design modifications

PHMTechnology
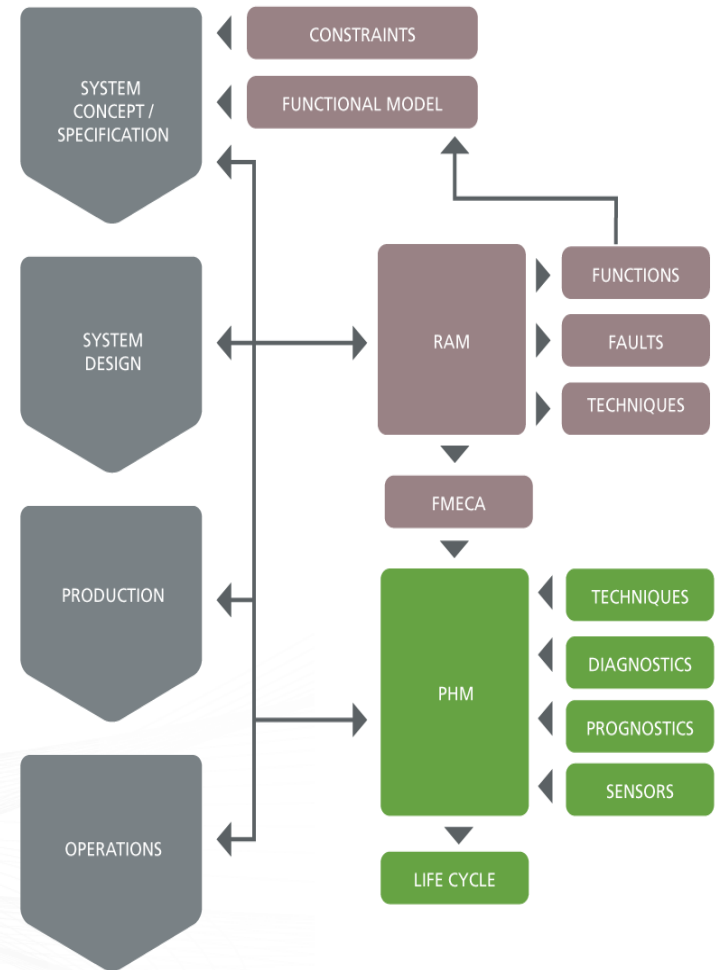
Conclusion

In order to establish the business case (including ROI) for PHM it is necessary that:

- the costs of system operation <u>without</u> the PHM capability be determined to establish a baseline for comparison

- the 'full' cost of failures is based on input from all functional stakeholders

- the efficacy of the PHM capability can be quantified early in the design process

- the potential impact of PHM on system design can be assessed <u>concurrently</u> rather than retrospectively

The business case for PHM capability can be used to determine the impact on system affordability from the system level down to the specific failure mode.

The business case will support the process of PHM 'buying its way onto the system'.

PHMTechnology