ASML-Hi Risk management / FMEA seminar

FMEA AS LIVING DOCUMENT

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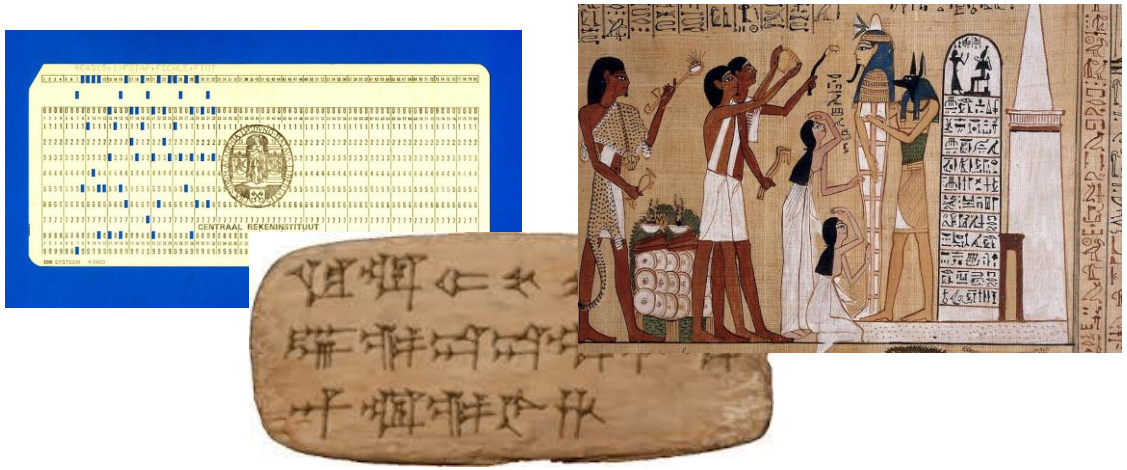

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CONTENTS KEYNOTE

- FMEA as part of RCM
- Reasons for the need for maintaining FMEA documents
- Asset Management and the difficulty of Asset information Management
- Understand the problems behind Asset information and FMEA feedback information – Research on the use of feedback
- Principles for managing FMEA feedback in a maintenance feedback process

ABOUT JAN BRAAKSMA

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- Associate professor chair Maintenance Engineering & Asset Management
- PhD on Asset information for FMEA-based Maintenance
- FMEA as enabler of continious improvement in Maintenance concepts

RESEARCH FUTUREPROOF MAINTENANCE

CHAIR MAINTENANCE ENGINEERING & ASSET MANAGEMENT UNIVERSITY OF TWENTE

- Sustainable Asset Management
- Advanced Maintenance concepts
- Incl. Predictive Maintenance and FMEA
- Resilience and Risk Management
- Life Cycle Planning /Life Cycle Analysis
- High Reliability Organizations
- Systems Integration

RELIABILITY CENTRED MAINTENANCE

FMEA AS PART OF RELIABILITY CENTRED MAINTENANCE

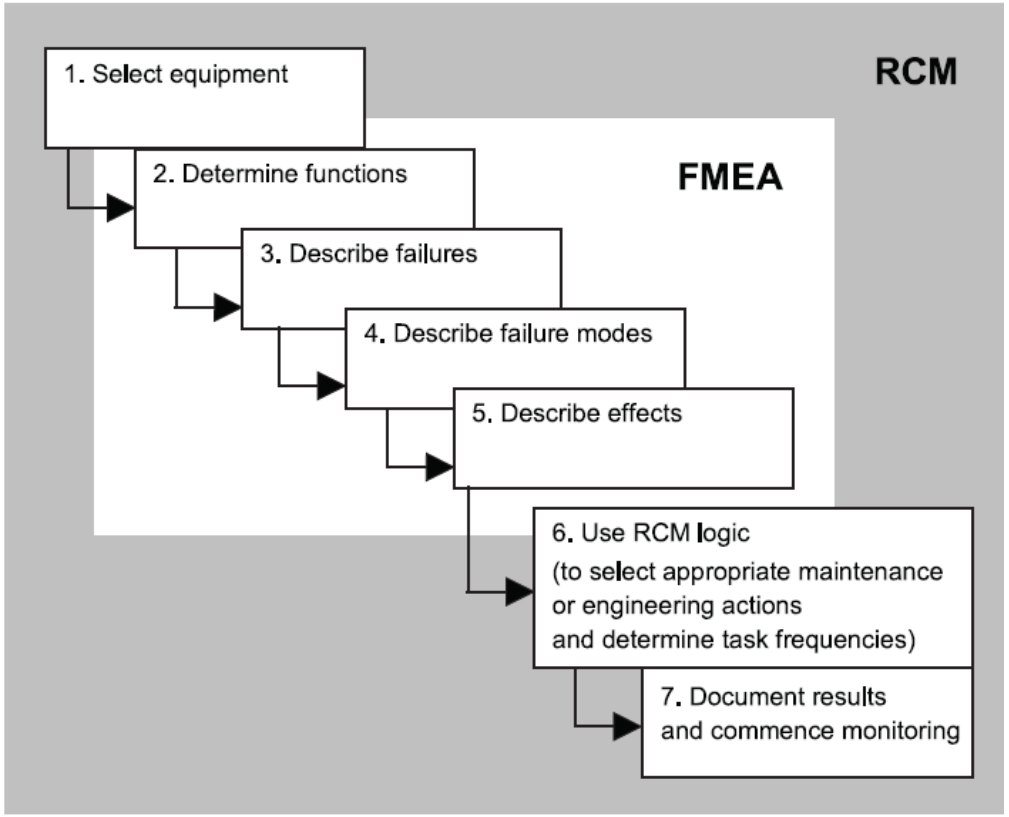
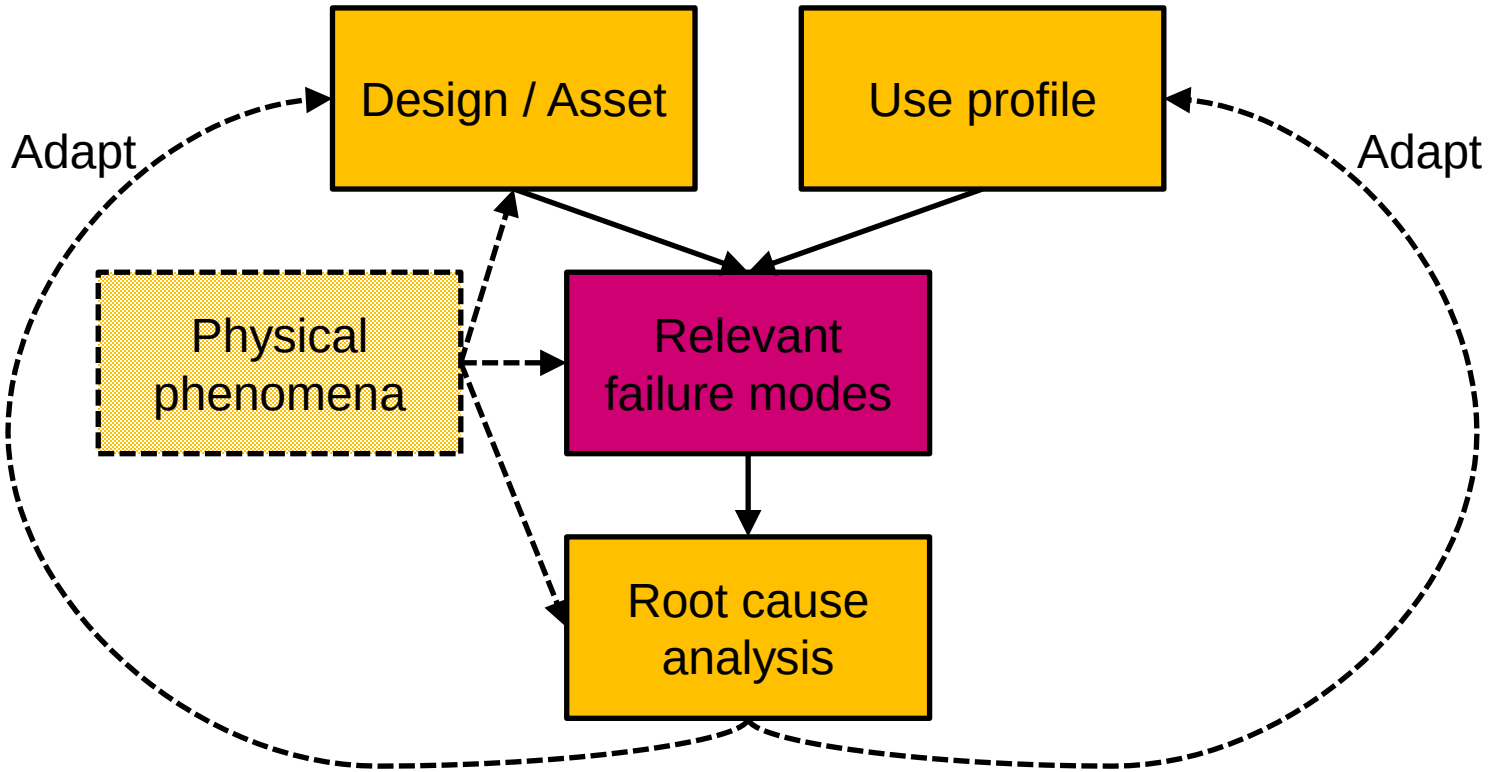


Figure: FMEA as part of RCM, amended from Picknell (1999)

FAILURE MODES

CONTINIOUS IMPROVEMENT



(Basten 2010)

REASONS FOR THE NEED FOR A LIVING FMEA DOCUMENT

- Understanding of failure modes improves over time
- Changes in use / different usage profile

THE PROBLEM OF ASSET MANAGEMENT (IN MEMORY OF PROF. HANS WORTMANN)

- Asset management consists of decisions on:
  - Asset requirements specification and/or design
  - Asset acquisition, installation and commissioning
  - Asset use (for its mission)
  - Asset maintenance
  - Asset refurbishment
  - Asset dismantling and/or disposal

- For all these decisions, information is needed
- However, the supply of information is often poor
- Why?

THE PROBLEM OF ASSET INFORMATION SYSTEMS (PROF. HANS WORTMANN)

- Why is the supply of asset information information poor?

- The initial phases are *project based*: after project closure, no party is responsible for documentation
- The miracle being performed, look for the next miracle
- Nobody is interested in the rabbit after the show

THE PROBLEM OF ASSET INFORMATION SYSTEMS (PROF. HANS WORTMANN)

- Again, why is the supply of asset information poor?
- Only the initial phases are focussed on documentation
- Later phases are *mission based*: manufacturing, transport, service, maintenance etc.
- During the mission, focus is on success of the mission, not on documentation

THE PROBLEM OF ASSET INFORMATION SYSTEMS (PROF. HANS WORTMANN)

- To conclude on phases:

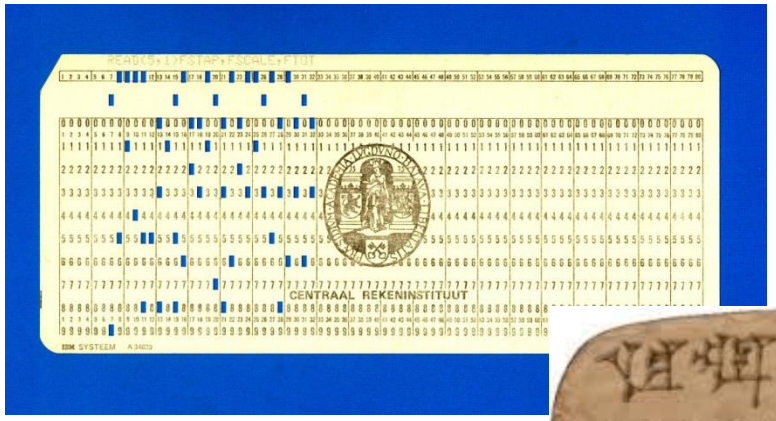
  the initial phases are project based. After closure, no party is responsible for continuing LC documentation

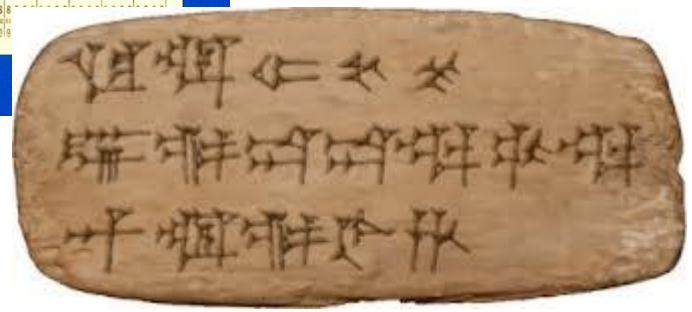
- The later phases are mission-based:
  - The use phase is focused on the mission to be executed, not on the asset information or documents
  - The maintenance phase is focused on restoring the fitness of the asset for use, not on documents

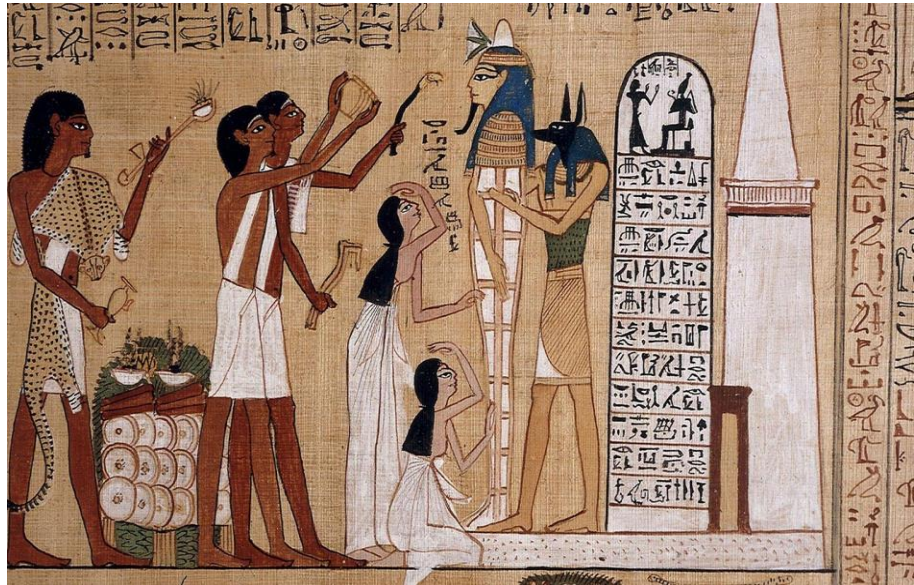
- Asset refurbishment and asset dismantling and/or disposal are again project based

THE PROBLEM OF ASSET INFORMATION SYSTEMS (PROF. HANS WORTMANN)

- Maintaining information over the whole life cycle (sometimes decades!) is difficult
- Often, crucial information such as asset configuration, failure history, mission-related productivity, value of the asset, etc. are lacking
- Information from the past is not always future-proof







THE PROBLEM OF ASSET INFORMATION SYSTEMS

Are life-cycle phases the only root information problem?

Babylonic language confusion

Multiple parties “own” the asset information

Multiple languages, multiple concepts, multiple views,

Multiple content maintenance policies, …

COMPARING ACADEMIC LITERATURE TO PRACTISE

Research gap

We were not able to identify a broad study comparing the descriptions in the academic literature to industrial practice.

Research goals:

1. Examining whether a number of common assumptions found in the literature on FMEA and its use for (preventive) maintenance can be supported by empirical evidence
2. To explore reasons why companies would deviate from what is generally assumed in the literature.

MULTIPLE CASE STUDY ON MAINTENANCE FMEA

	1	2	3	4	5	6
Main output	**Fossil fuel**	**Fillers and cleaning chemicals**	**Pharmaceuticals**	**Electricity**	**Fossil fuel**	**Minerals**
Asset owner	No	Yes	No (group is owner)	Yes	No	Yes
# Plants	>5 production locations	1 production plant	1 production plant	5 electricity production plants	>5 production locations	1 mineral production plant
Main equipment (per plant)	Fossil fuel processing equipment	Mixing equipment and packaging equipment	Bio reactor vessels, chillers, process (=fermentation) air compressors	Steam turbines, generators, steam condensers, machine transformer, kettle	Fossil fuel processing equipment	Boilers, condensers, centrifuges, packaging equipment
Object of analysis	Multiple FMEA's conducted in 1995 for initial maintenance plans and FMEA's carried out for new pieces of equipment.	Last FMEA conducted a year ago, FMEA every two years new equipment for the preventive maintenance program.	FMEA recently (2009) conducted existing preventive maintenance program.	FMEA's conducted ten years ago for initial preventive maintenance program and FMEA at the time of study being conducted for two new plants	Ten FMEA's conducted during a ten-year period for planning preventive maintenance and prioritizing corrective maintenance.	FMEA conducted in 2010 and FMEA at the time of study being conducted as part of a new preventive maintenance program.

(Braaksma, 2003)

POSTULATES AND RESULTS

Nr	*Postulate*	*Results*
1	Failure Mode and Effect Analysis is applied to a limited quantity of capital equipment/components	**Supported**
2	Failure modes are identified and analyzed with sufficient accuracy	**Limited support**
3	Failure Mode and Effect Analysis is applied based on a clear procedure described on paper or in software	**Limited support**
4	Following the FMEA ensures consistency in maintenance decision making (e.g., the design of maintenance routines and maintenance planning)	**No support**
5	FMEA enables continuous improvement	**Limited support**
6	FMEA is particularly dependent on expert knowledge. The use of historical data and or measured data is generally not possible when an FMEA is performed.	**Supported (Except one company)**

(Braaksma, 2003)

RESULTS CASE STUDY ON RCM/FMEA (1/2)

- It is confirmed that capital goods are analyzed based on the criticality of assets (not all assets are selected)
- Identification of capital goods and parts for analysis is possible, but selection process is not always transparent and objective
- Lack of procedures and consistency in application of FMEA
- FMEA regarded as a one-off exercise while in literature it is viewed as a continuous activity

(Braaksma, 2013)

RESULTS CASE STUDY ON RCM/FMEA (2/2)

- FMEA/RCM logic is not used for changes in the maintenance plan
- No quality improvement cycle of the FMEA
- FMEA is based on expert knowledge, minimal use of quantitative data (such as failure and process data)
- Problematic registration of FMEA results hinders re-use

(Braaksma, 2013)

MAINTENANCE FMEA

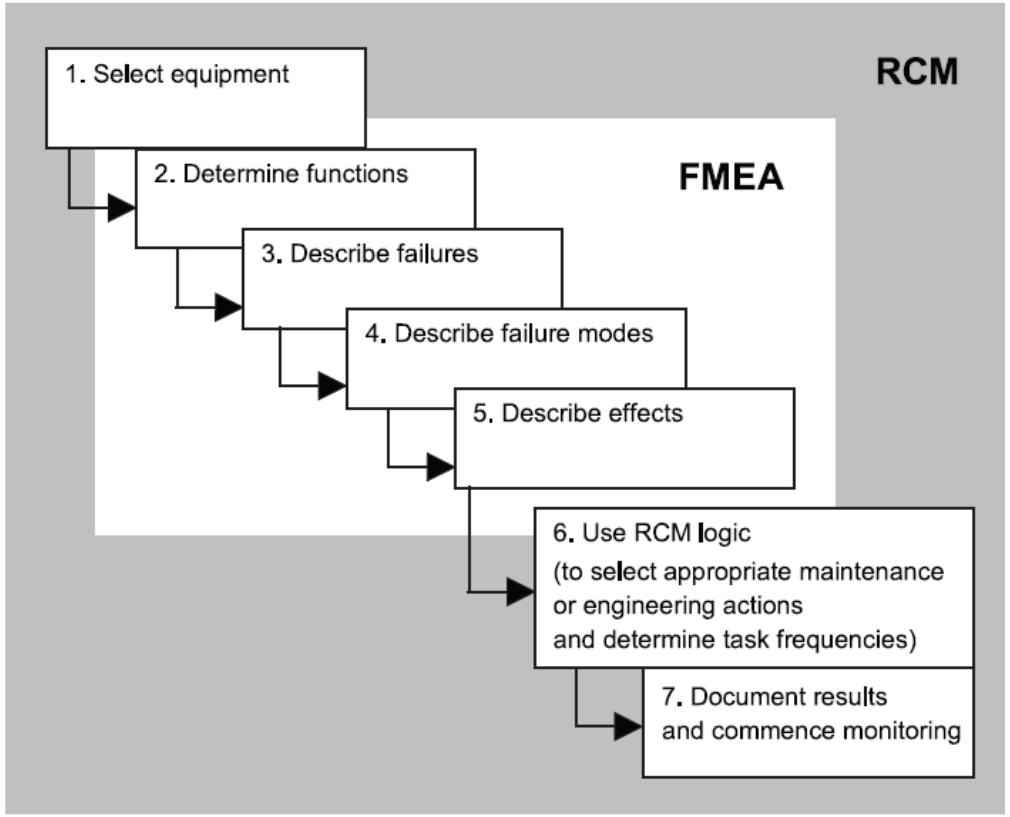


Figure: FMEA as part of RCM, amended from Picknell (1999)

ENABLERS OF CONTINUOUS IMPROVEMENT OF FMEA

- **1) Think early about future improvement** and associated data collection
  - Use FMEA as a **recurring basis** for adjusting maintenance programs (what and why then remain linked)
  - Offer quantitative possibilities **in addition** to qualitative estimates
  - Information management **based on criticality** of capital assets aids in focusing effort and early wins and increases efficiency
- **2) Information architecture** improvements for FMEA
  - use of standards for FMEA, e.g. RPN scales, RCM logic, failure mode description,
- **3) Human factor**
  - sensitivity for failures → high reliability organisation
  - motivate better registration → mission based improvement instead of project based

PROPOSED DESIGN PRINCIPLES FOR MAINTENANCE FEEDBACK PROCESS

- Goal: Trigger feedback by proactive management and registration of future needed data

- **Improved description rationale** behind FMEA decision process
  - e.g. scope, team participants, knowledge and backgrounds of experts,
    RCM logic answers, RPN tables for severity, detection and occurrence,
  - Configuration Management: FMEA and connection to usage profile, failure mode description
  - Reporting uncertainties in all phases of analysis

- **Criticality** based information management
  - Demand based and business case driven information gathering/analysis

MAINTENANCE FEEDBACK ANALYSIS (MFA)

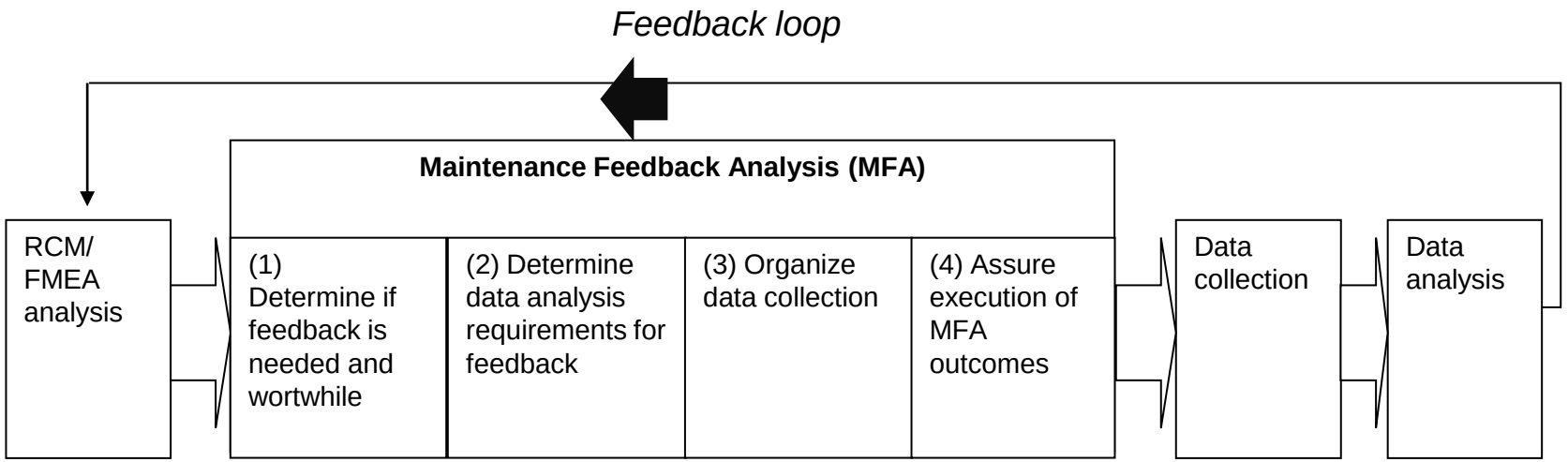


Figure: MFA steps as part of extended FMEA process (Braaksma, 2012)

Questions?