
Quantifying the value of RFID in product recovery decisions

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Agenda

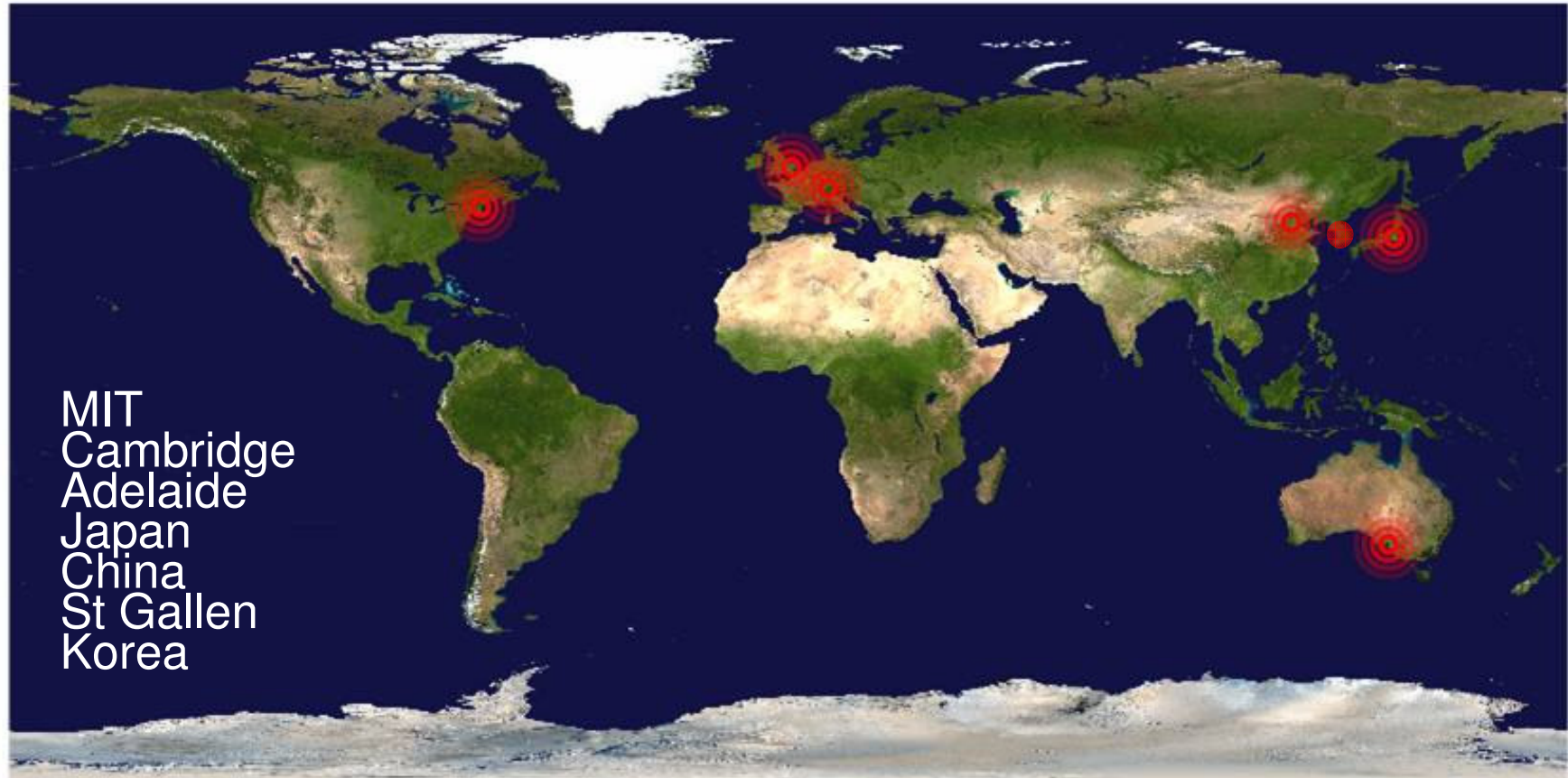
- Introduction
- Background to the problem
- RFID Impact quantification in PRD
- Case example



Introduction

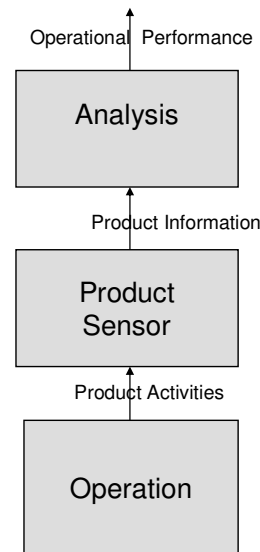


Auto-ID Labs - a global network

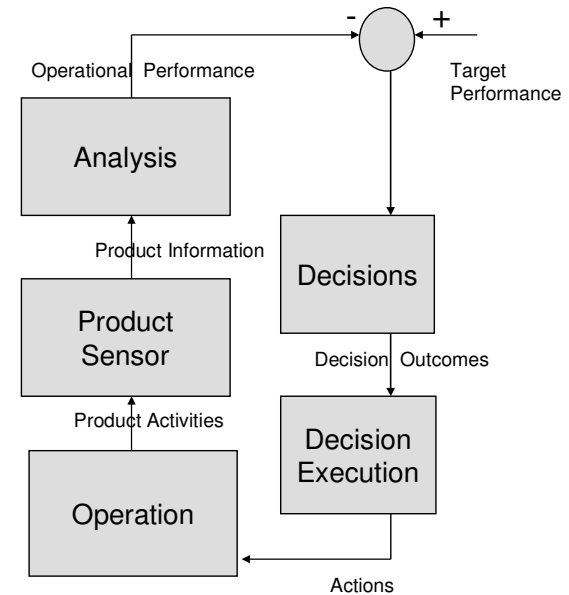


Cambridge research focus

- Focus on managing ID information once on the network
 - Networked RFID
- Closed-loop ID Systems:
 - ID → product information → decisions
- RFID impact quantification



a) Open-Loop RFID

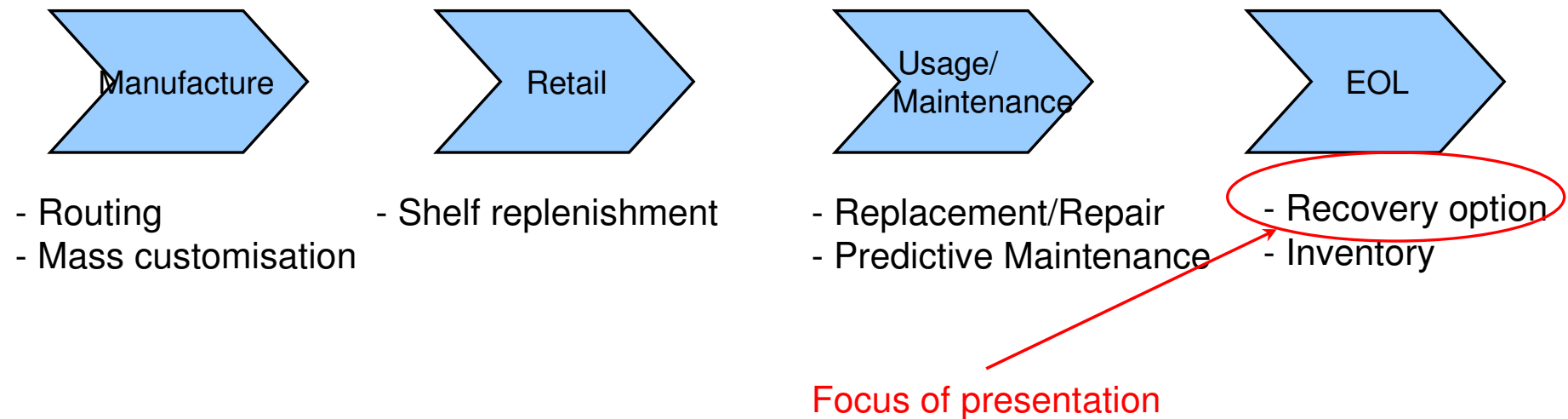


b) Closed-Loop RFID

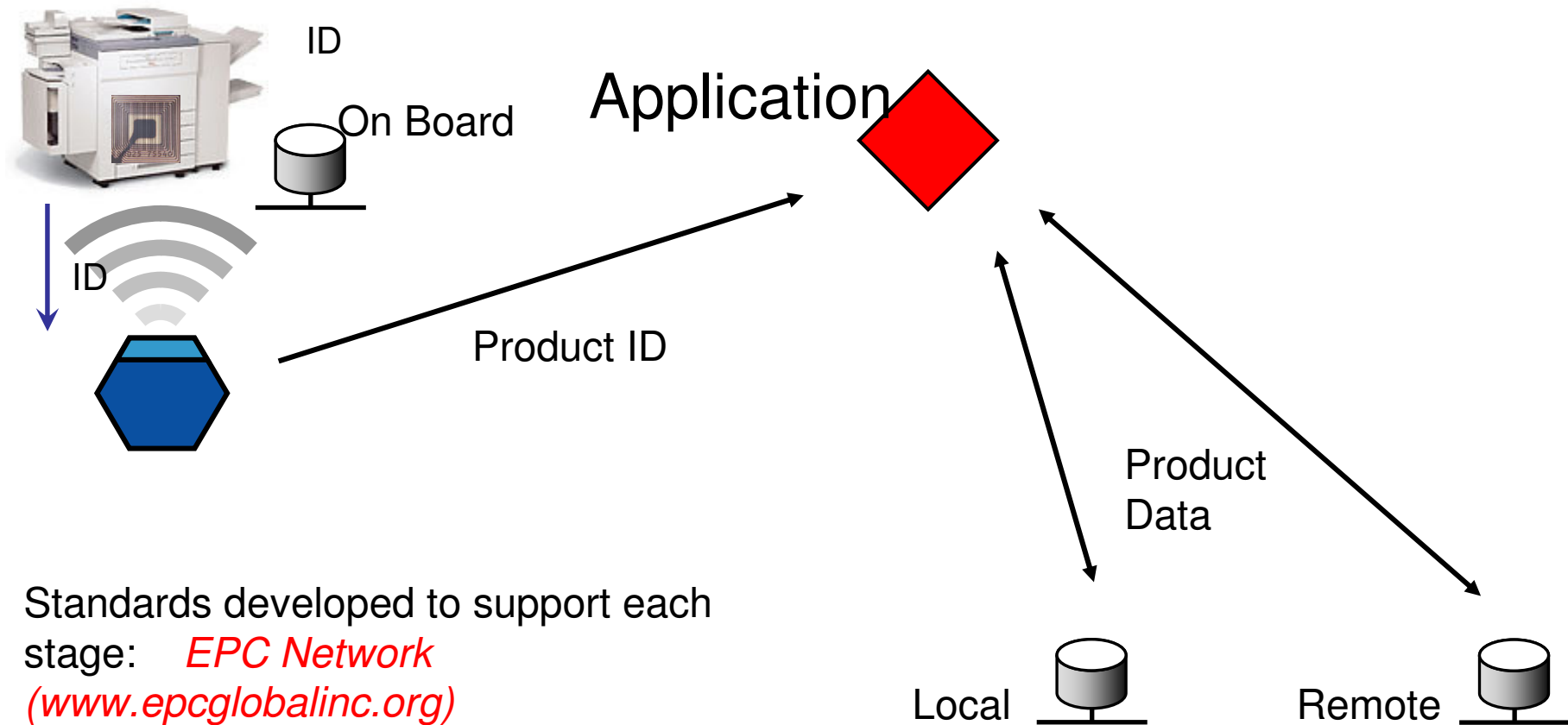
... *information is only useful where it influences a decision*

Decision effectiveness = f (information quality)

Focus on RFID impact quantification

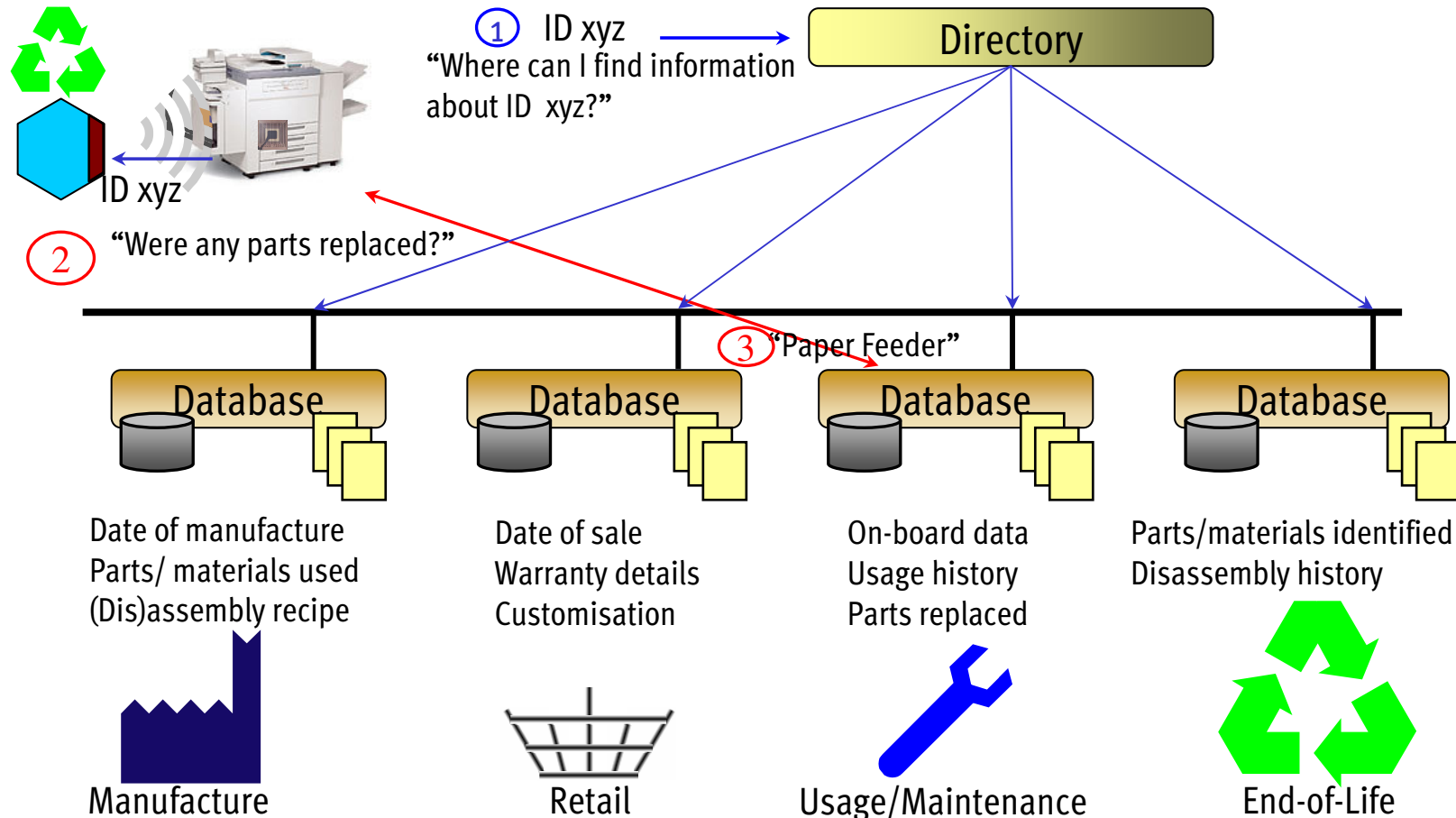


Background: Networked RFID



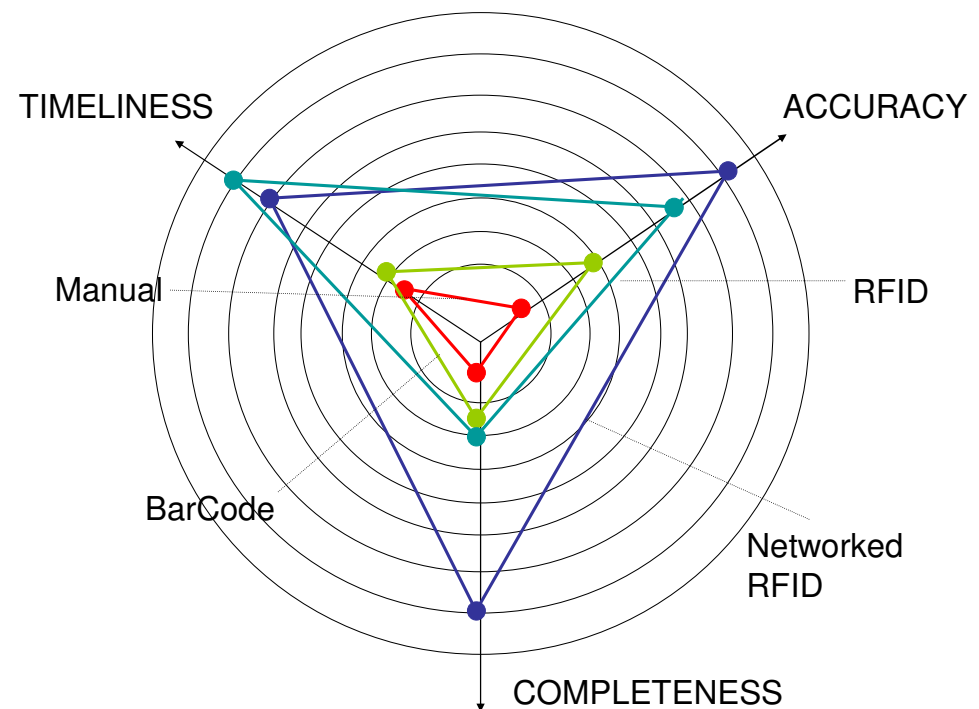
Standards developed to support each stage: *EPC Network* (www.epcglobalinc.org)

Networked RFID: Product Lifecycle Information Management



Essence of RFID: *Information Quality*

- Impact of networked RFID is in enhancing the quality of product information available
- Information quality dimensions
 - completeness
 - accuracy
 - timeliness (ready availability)



Background to the problem



Problem Statement

Research Question:

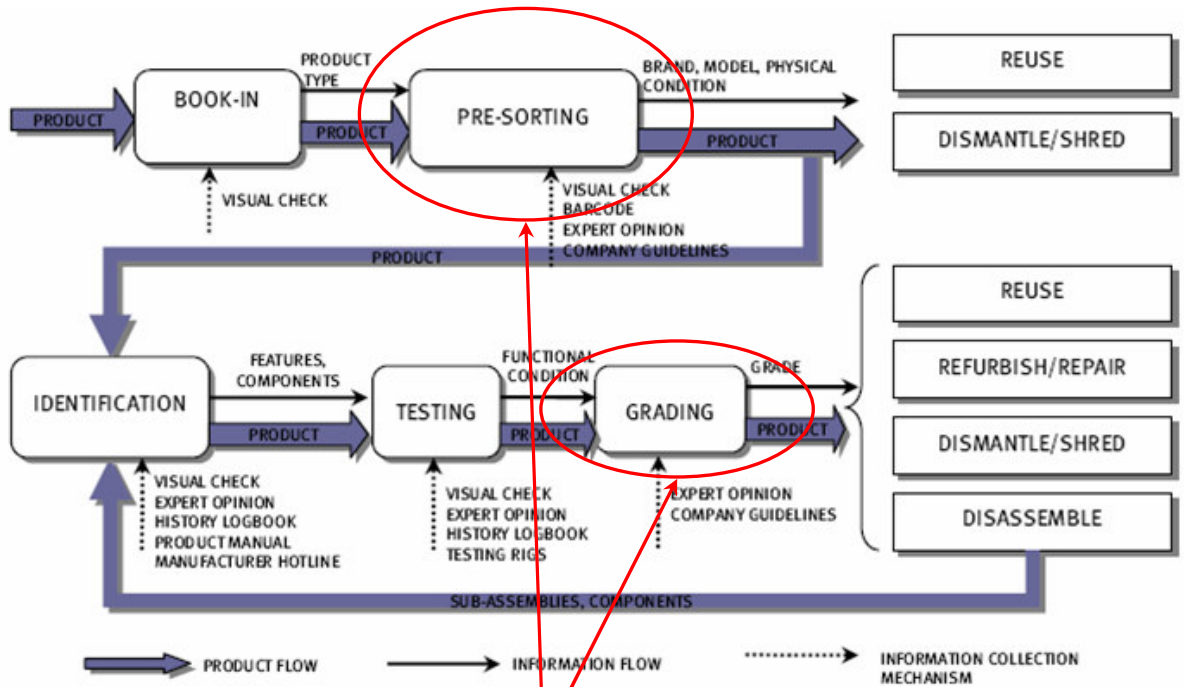
What is the role of product information in product recovery decision-making?

Key objectives:

- Quantify the role of product information on product recovery decisions
- Examine how ready availability of product information affects product recovery decisions



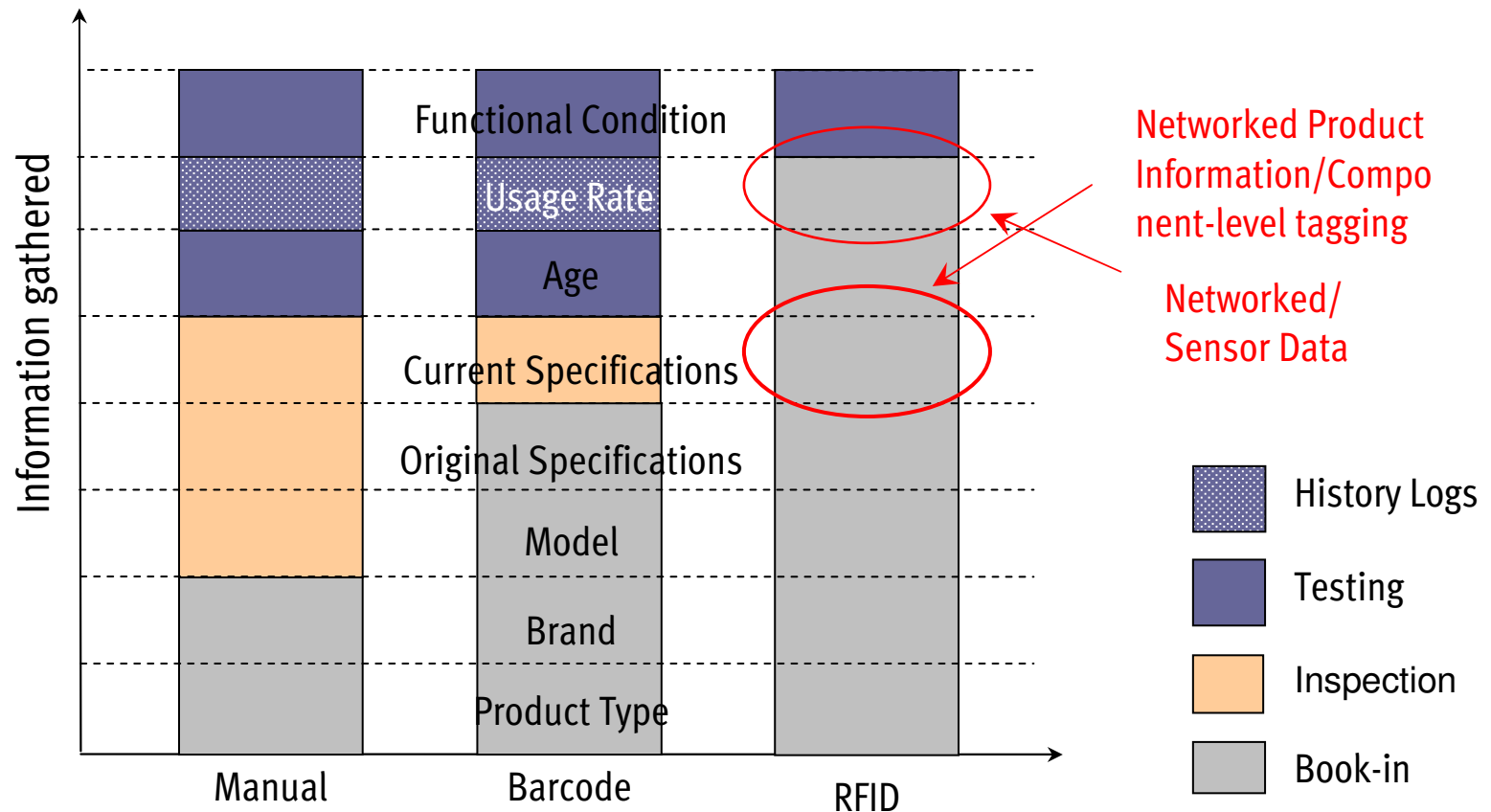
Product recovery operations



Key decision points



RFID-enabled Product recovery



RFID Impact quantification in PRD



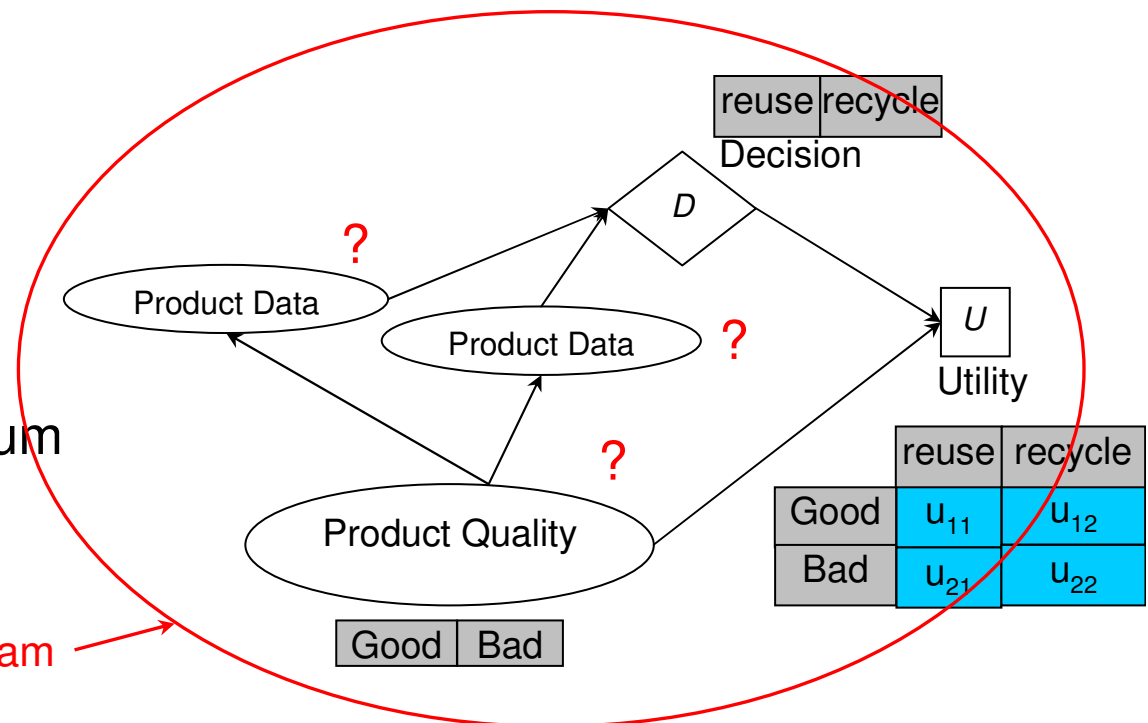
Modelling product recovery decisions

Effectiveness of PRD → expected utility (EU) of the PRD outcome.
 $EU = f(\text{Uncertainty, Utility})$

Modelling approach

- Probabilities to represent uncertainty
- Bayesian inference
- Decisions based on Maximum expected utility

Influence diagram



Benefit of product information availability

- Product recovery decisions under uncertainty in product state
 - Maximise expected utility

$$EU(d_j) = \sum_{i=1}^{N_H} p(h_i) \cdot u(h_i, d_j)$$

Best decision $d^* = \arg \max_{d_j} \sum_{i=1}^{N_H} p(h_i) \cdot u(h_i, d_j)$

Annotations: utilities (pointing to $u(h_i, d_j)$), Product states (pointing to h_i), Recovery options (pointing to d_j).

- Benefit of observing product information E_k

$$EBI_E(E_k) = \sum_{l=1}^{N_{e_k}} p(e_k^l) \cdot \left[\max_{d_j} \sum_{i=1}^{N_H} p(h_i | e_k^l, E) \cdot u(h_i, d_j) \right] - \max_{d_j} \sum_{i=1}^{N_H} p(h_i | E) \cdot u(h_i, d_j)$$


Annotations: Observed parameter value (pointing to $p(e_k^l)$), Revised belief (pointing to $p(h_i | e_k^l, E)$).

Impact of ready availability

- Consider cost incurred in information access

$$u(b_i, d_j, \tau_x) = u(b_i, d_j) - C(\tau_x)$$

Cost of information access

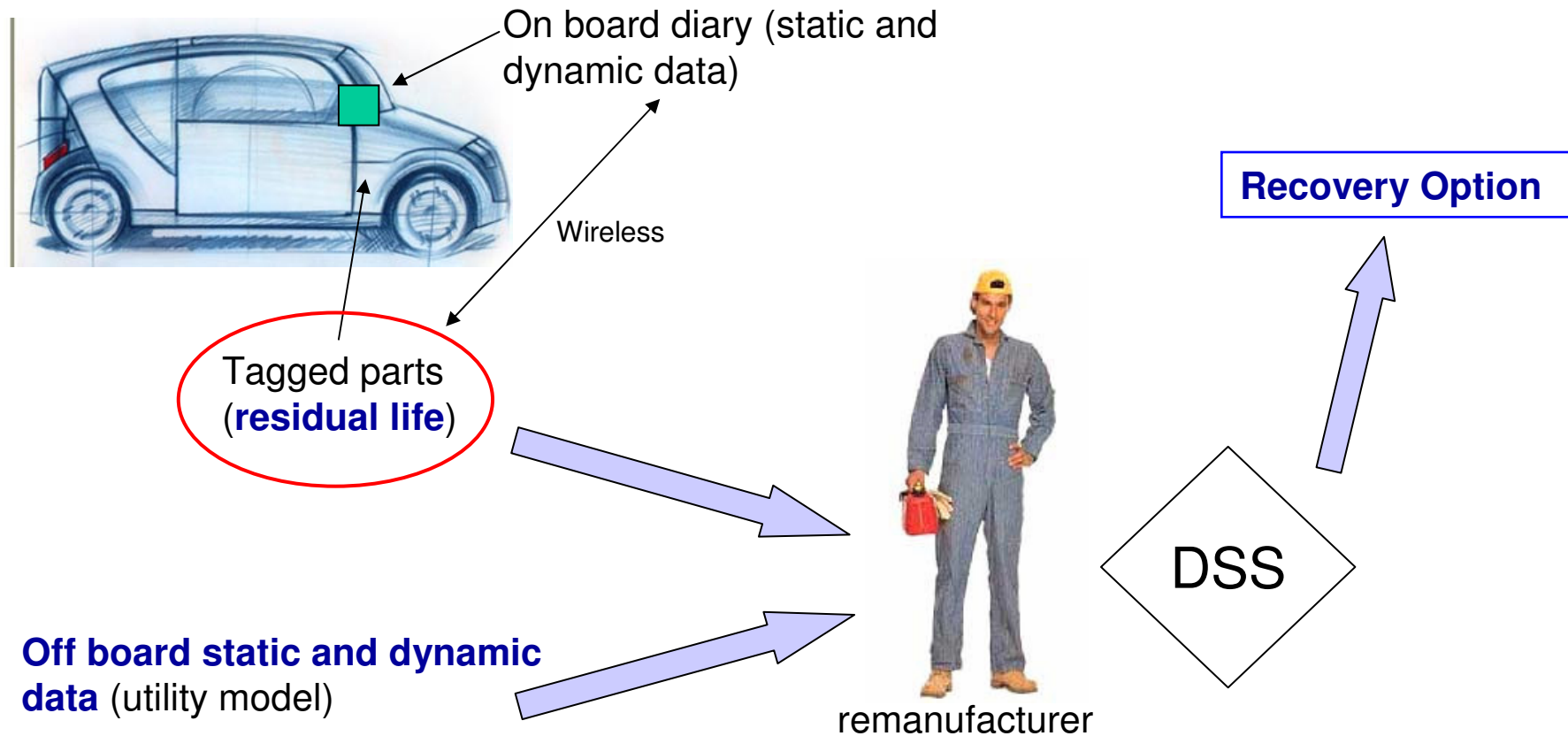


$$EU(E_k, \tau_x) = \sum_{k=1}^{N_{e_k}} p(e_k) \cdot \left[\max_{d_j} \sum_{i=1}^{N_H} p(b_i | e_k) \cdot (u(b_i, d_j, \tau_x)) \right]$$

Case example



Automobile recovery



Clutch recovery – impact of readily available information

- Two decisions
 - Test decision – based on readily available information
$$T = \{t_1, t_2\} = \{test, no\ test\}$$
 - Recovery decision
$$D = \{d_1, d_2\} = \{reuse, discard\}$$
 - If tested - Based on test outcome
 - If not tested – Based on quality perceived on the bases of readily available information

- Clutch states $H = \{h_1, h_2\} = \{good, defective\} = \{0.4, 0.6\}$

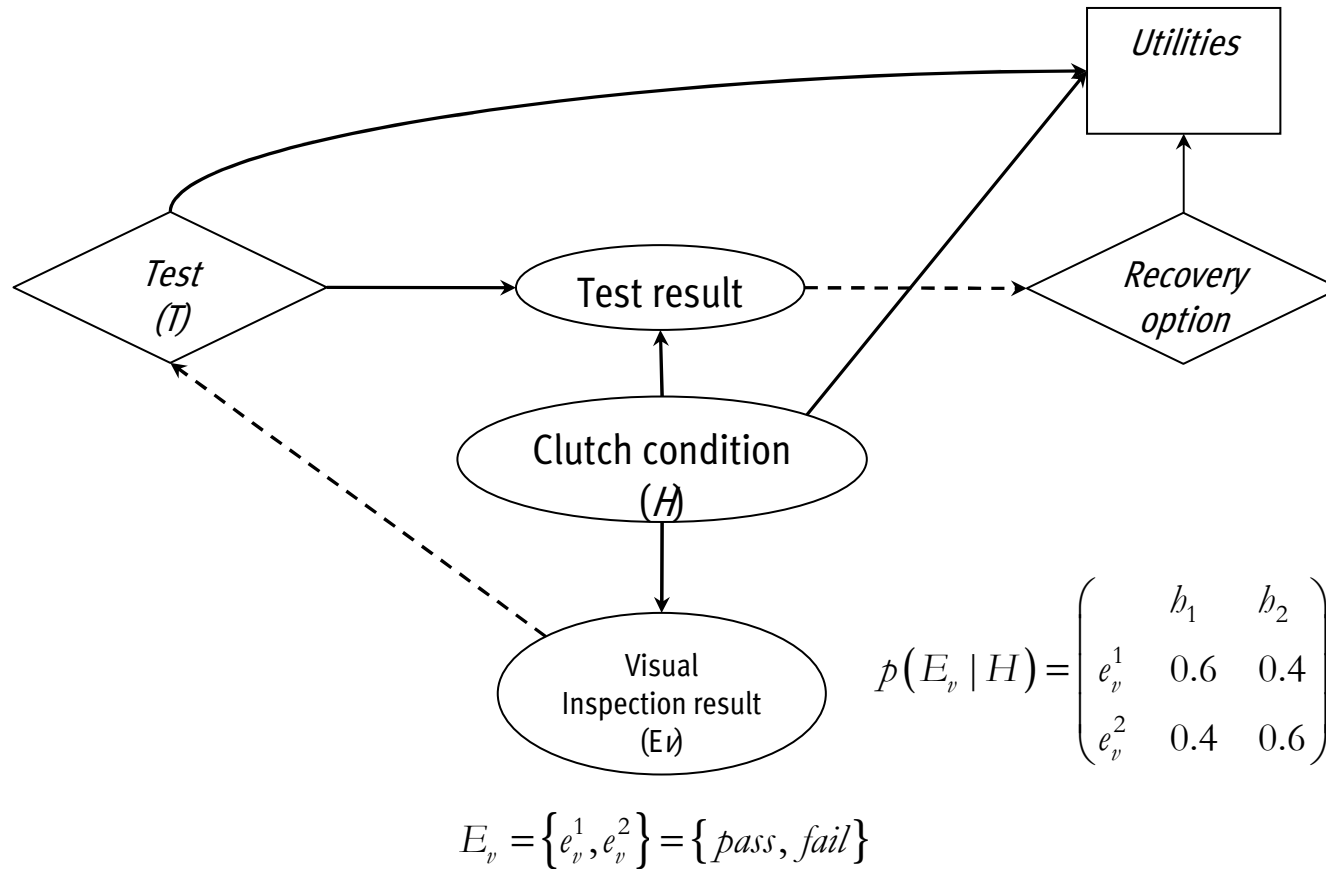
- Utilities

$$u(h_i, d_j, t_1) = \begin{pmatrix} u(ok, reuse) & u(ok, dispose) \\ u(defective, reuse) & u(defective, dispose) \end{pmatrix} = \begin{pmatrix} 60 & -70 \\ -570 & -70 \end{pmatrix}$$

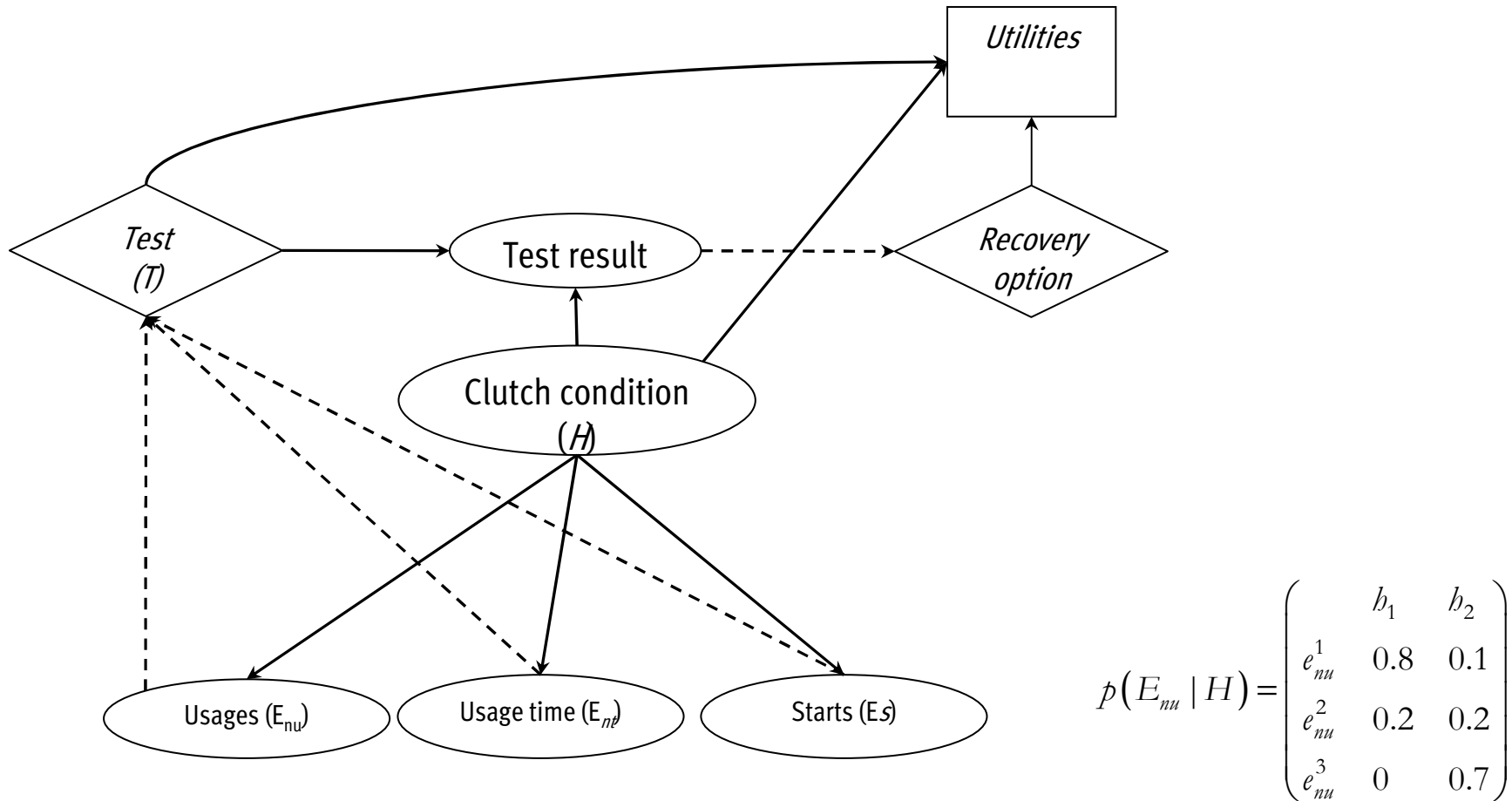
$$u(h_i, d_j, t_2) = \begin{pmatrix} u(ok, reuse) & u(ok, dispose) \\ u(defective, reuse) & u(defective, dispose) \end{pmatrix} = \begin{pmatrix} 100 & 0 \\ -530 & 0 \end{pmatrix}$$



Case 1 – visual inspection



Case 2 – Lifecycle data



Results

- Simulated decisions over 500 clutches

	Visual Inspection	Lifecycle data
Total number of good clutches rejected	68	0
Total number of good clutches reused	138	206
Number of good clutches reused without testing	0	197
Total Utility	2260	17220

Increase in reuse

Improved effectiveness

Decrease in tests



CONCLUSIONS

Benefits of ready information availability

- Process improvements
 - Quick and possibly automated identification & sorting
 - Error reduction
- Decision improvements
 - Better estimation of residual life and value
 - Rich information leads to better decisions



Questions?

