Costing *for* Avionic Through-Life Availability (CATA)

Innovative *design* Manufacturing Research Centre (I*d*MRC)

"World-leading research in engineering design, manufacture and verification."

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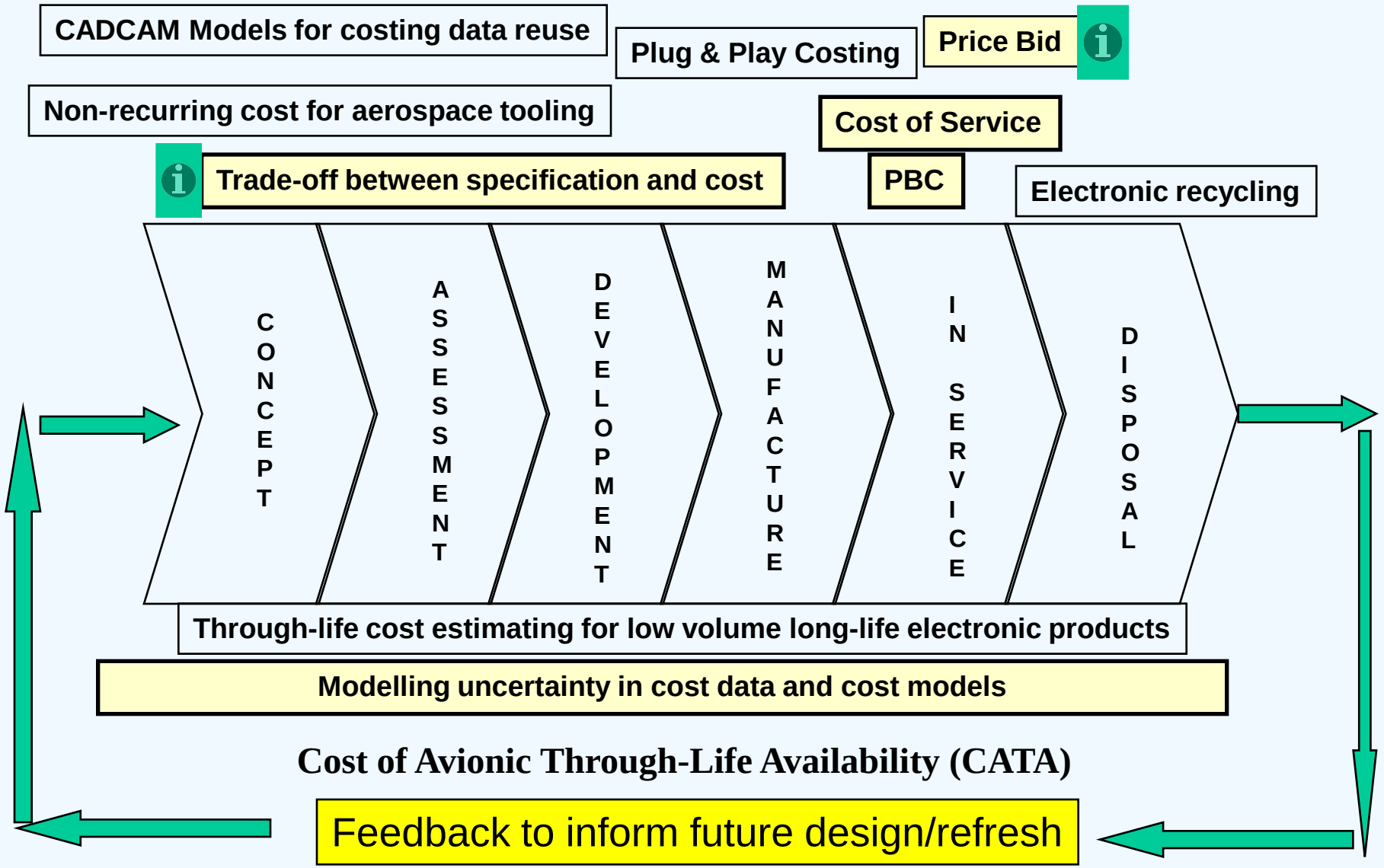
EPSRC
Engineering and Physical Sciences Research Council

Phase 1 - Through Life Costing - I*d*MRC

- Our focus is on concept design through to disposal
- Emphasis on information and knowledge management for cost estimation
- Importance of '*servitisation*' in cost estimating (PSS)
- Collaborators e.g.; Ministry of Defence, BAE Systems, GE Aviation, Airbus UK, medical device manufacturers, oil & gas and wind turbines.

The overall aim is to provide methods and tools for managing TLC from concept design to in-service/disposal

Current Research



Summary of Baths' Expertise

- Work with industry at the leading edge on Through Life Cost Estimating.
- Have transferred our research outcomes into industrial practice.
- Cross-sectorial working.

Future Focus of Cost Estimating

- Some different options:
  - Sell the product and spares
  - Lease the product
  - Availability contracting

- Future contracting of many products are now performance based contracts (capability, service, availability etc.)

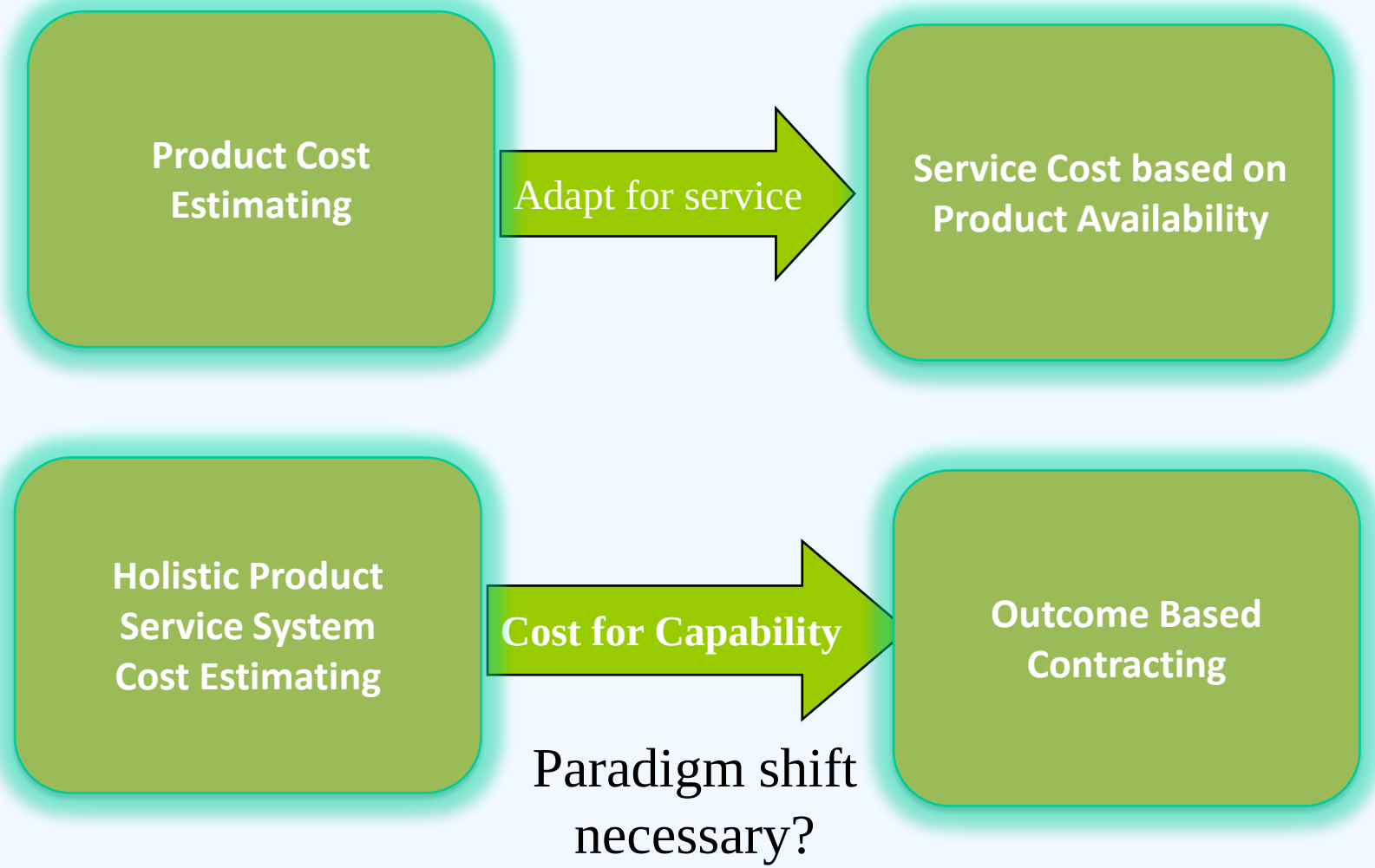
Focus of our research is on this leading edge activity – CATA

Estimating the cost of a service

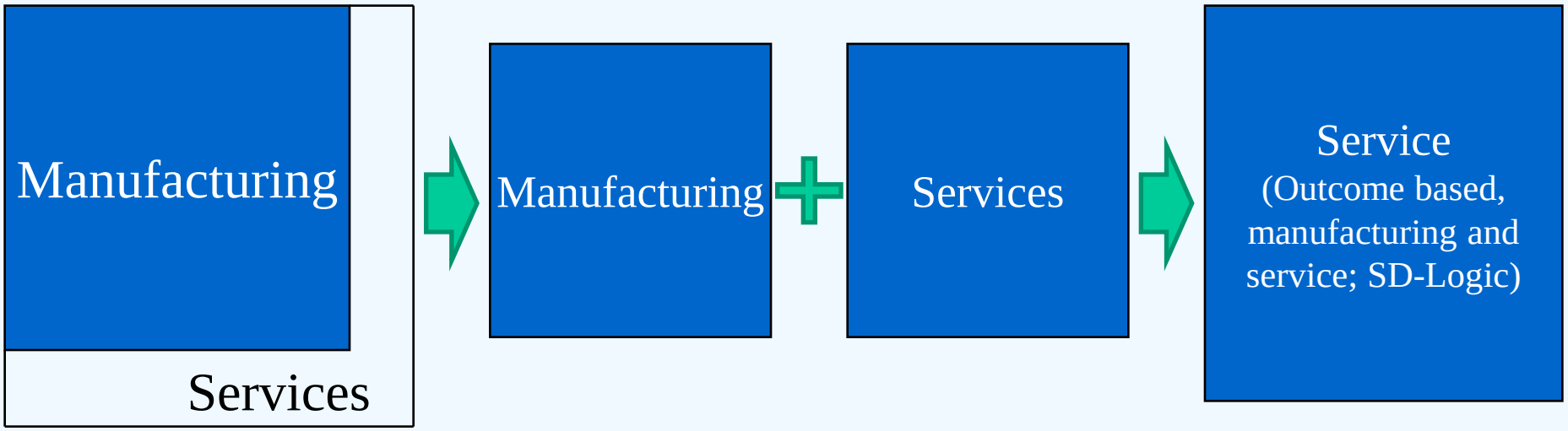
- Cost modellers are experienced in costing products
- Commercial systems are in general still product based
- Little evidence of in-service/utilisation modelling
- Products have been defined and understood since Smith* 1776 provided a definition
- Understanding of service is still being developed
- Availability contracts already in place
  - Rigour in cost estimating has lagged behind implementation

*Smith, Adam. (1776). *The Wealth of Nations*, Books I-III, Chichester: Wiley.

What is required



What are the challenges



Currently industry is absorbing the cost of repair within their manufacturing operations or duplicating facilities

How do we assess the appropriate approach for managing manufacturing and service provision from the supplier of the service

Challenge

How do you cost for through life availability or capability?

- How do we undertake a cost estimate for Product Service Systems?
- Can we do this in an holistic manner?

Aims to provide novel approaches to predict the through-life costs for in-service avionic systems

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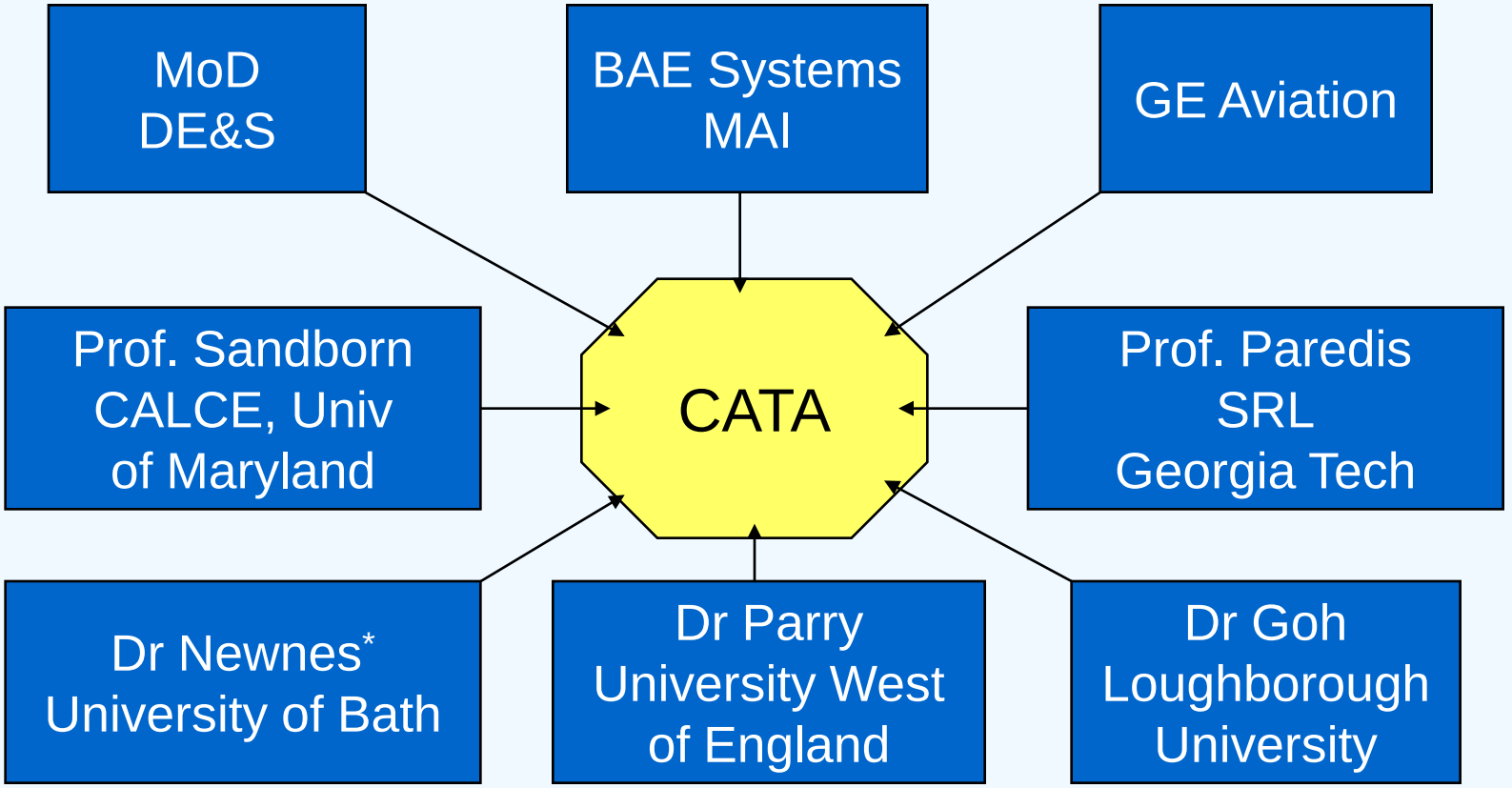
Aims to provide novel approaches to predict the manufacture and repair costs through life for in-service avionic systems

- How can we predict ‘should costs’ for through life manufacturing and service at the early design stage?
- *How do we manage the uncertainty within such long-life products?*
- *How does the supplier performance impact the cost of providing availability?*

Team required to achieve this?



CATA

- Pilot activity product focus
- Current activity Using an operations based approach for the cost of availability

Industry wanted an academic view of way forward

transfer this into a useable solution

Pilot Study – data analysis and availability

- Identify and classify current and future manufacturing techniques used for the repair and maintenance of avionic systems

- Cost estimating relationships, based on industrial data and knowledge, for predicting the cost of maintaining availability

Utilised Current Aircraft Data

Cost Estimating Relationships (CERs)

- CER1 – Indicative failure rate – 23%
- CER2 – Probability of 2nd fail
- CER3 – Identified probability of failure in lifecycle phase (majority in build and test)
- CER4 – probability of a particular fault code
- CER5 – failure rate for particular aircraft users

Limited detailed trace back to manufacturing history

- Not yet known
- MTBF
- Flying hours
- Select fault code – avoid selection of ‘other’
- Time to failure

Pilot Study

- Pilot study gave a product focused view.
- Product reliability.
- Traditional approach
- Challenges in terms of quality data for Through Life costing.
- Companies at this stage are not realising their expected benefits.

So,

- We need a paradigm shift on how we undertake TLC.

What would I do differently now when designing for service?

What should be done differently

Need to provide evidence based decisions in terms of:

- Identifying a methodological approach that can be utilised to model cost of availability.
- Model a true representation of ‘cost of availability’
- Encompass the factors that influence the cost of providing a service.

CATA – where we are

- Current status
- Four research strands
  - An ‘illustrative’ example
- Requirements for future research

IPS^2: paradigm shift

- Understanding-driven;
- Costs: emergent property;
- Object: through-life service enterprise;
- All stages potentially covered.

TLC: Stable Paradigm

- Data driven;
- Cost: observable feature;
- Object: individual durable product;
- Mainly in-service stage covered;
- 80/20 stage-gate mind set: different techniques at different stages

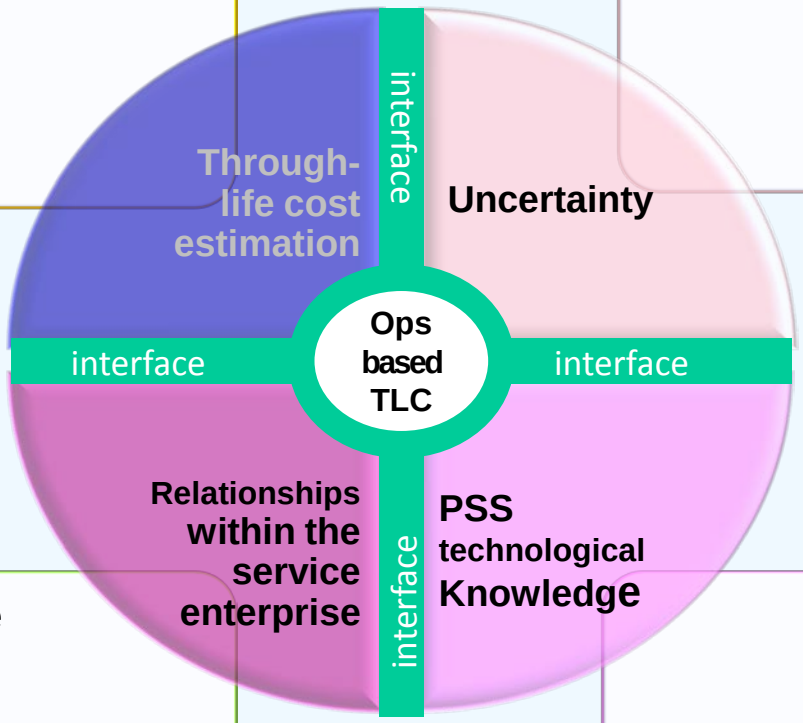
Conflict or TLC paradigm shift

- Validation problem related to 80/20 stage-gate mind set;
- Service cannot reduce to the in-service stage of a product;
- The cost is in the flow, not in the end-item;
- Process ownership and control affect TLC methodology

CATA themes and interfaces

- Activity-based approaches to TLC
- Hybrid cost estimation
- Strategic: IOCM, Open-books, Target Costing

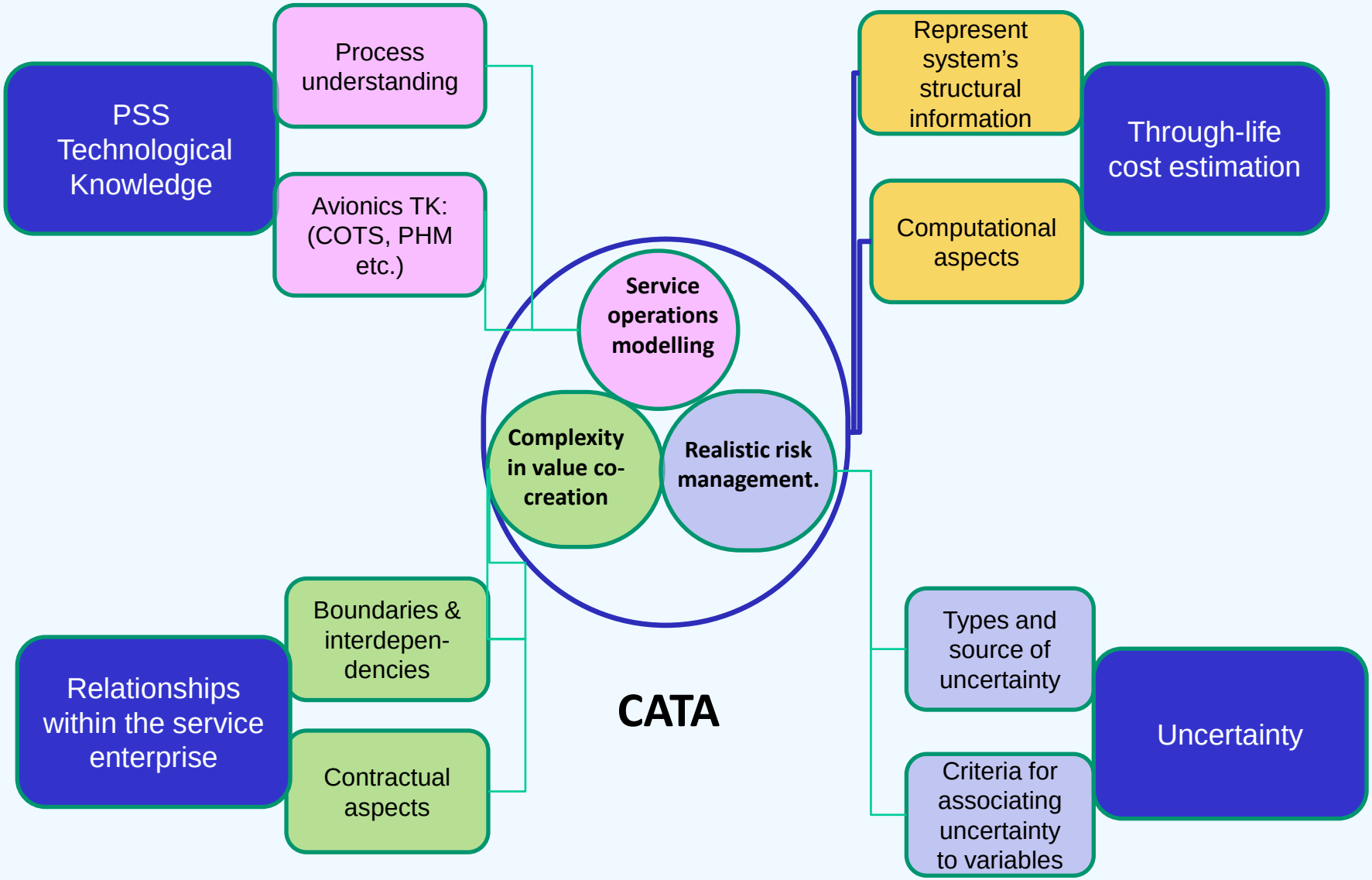
- Layers of uncertainty
- Subjective and imprecise probability
- Frequentist / Discrete event simulation
- AHP



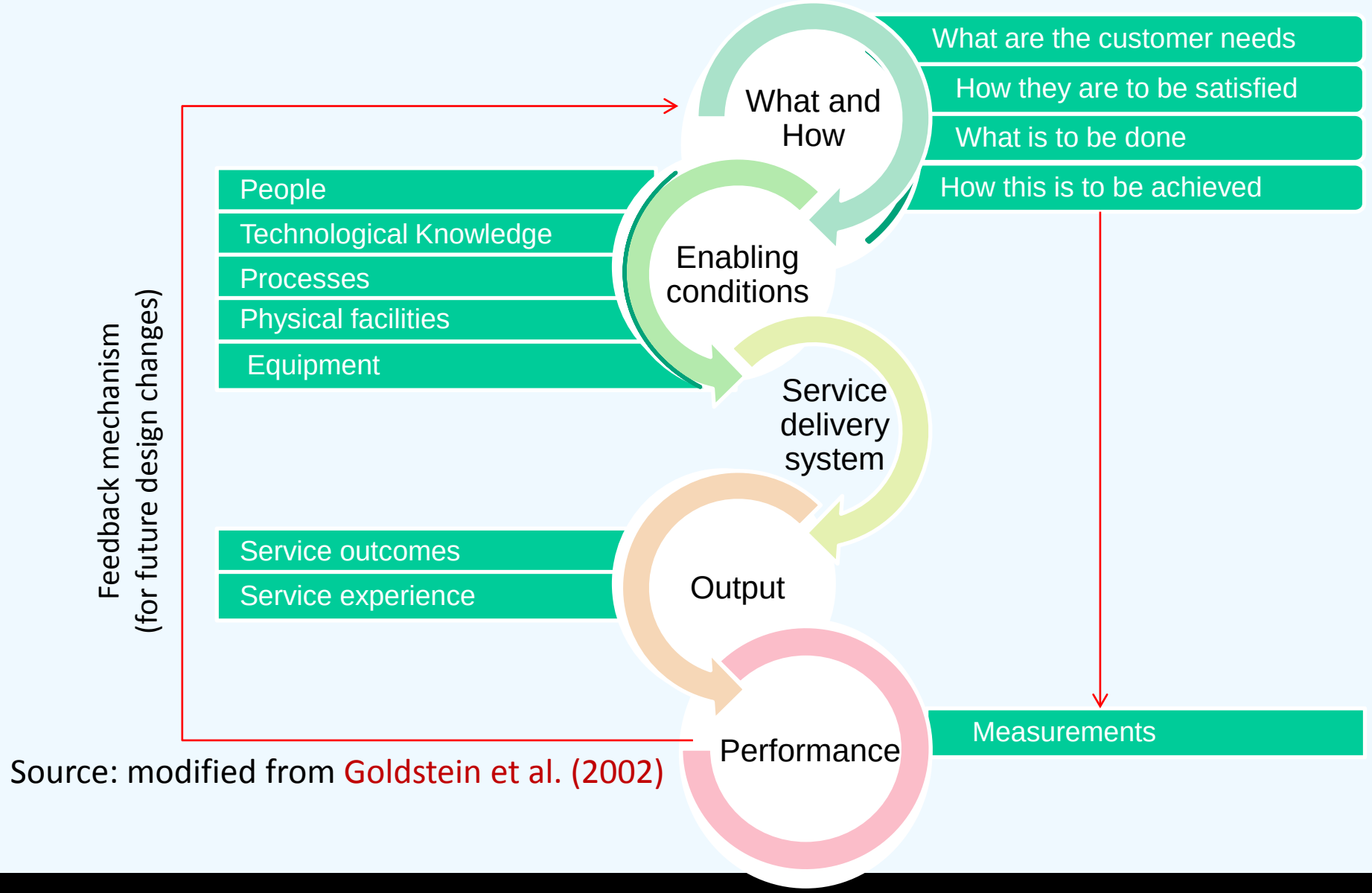
- Extended enterprise mapping
- Analysis of dependencies and interdependencies in performance management (ATTAC)

- Process-based approaches
- RAM, Obsolescence and TRL
- Lessons Learned

Overall View



Common view of PSS



Source: modified from Goldstein et al. (2002)

Example to illustrate Logic

- Current status
- Illustrative example
- Requirements for future research

A "neutral" example

- Have 100 pairs of customer's hands dried on an average business day
- pay per pair of dried hands

Technological knowledge

Servitization

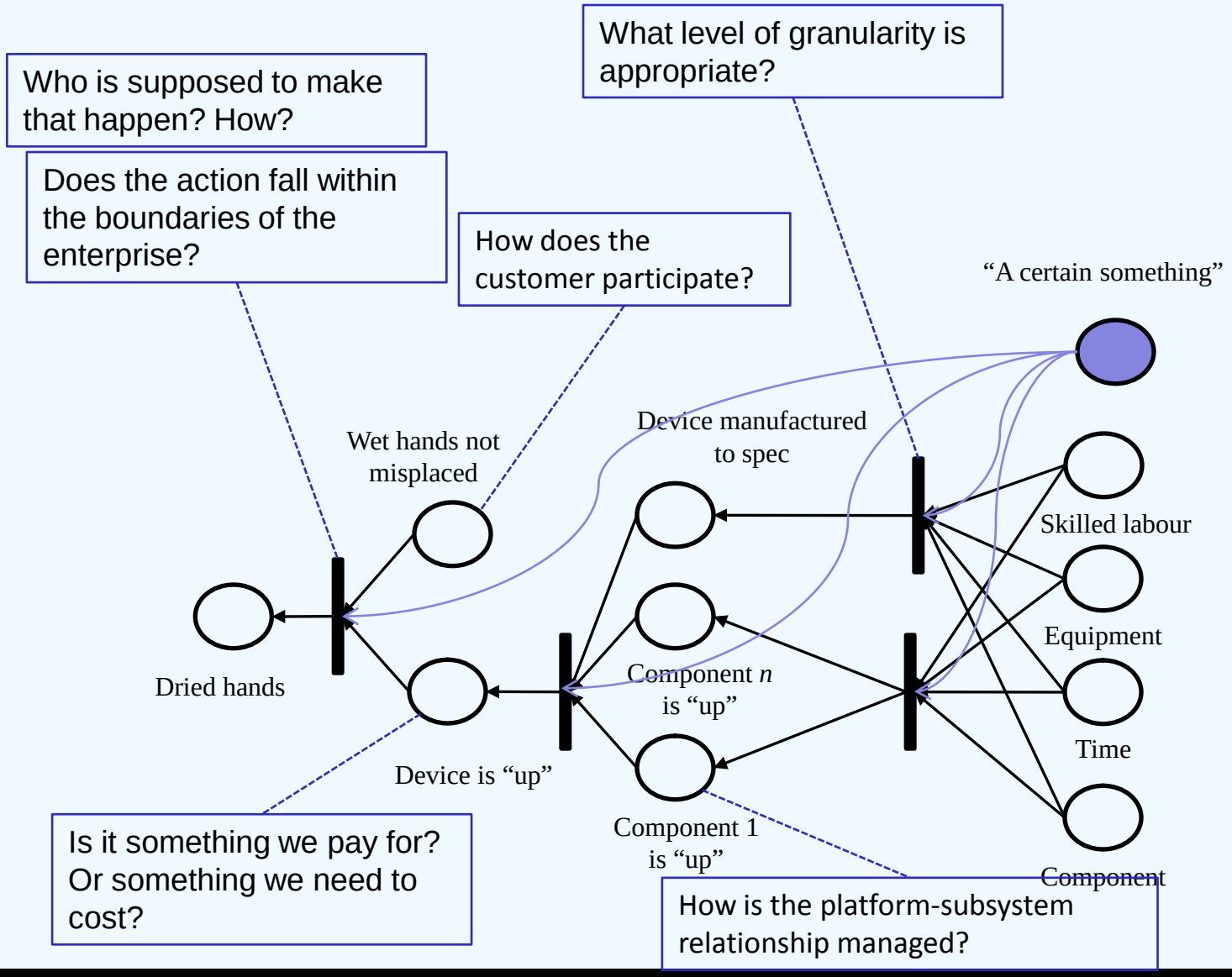
Uncertainty

- What is known about the service delivery system;
- What are the available competencies;
- What competencies may be necessary in the future

- How value in exchange is replaced by value in use;
- How customer, provider and supplier cooperate to manage complexity and meet expectations;
- How success and performance are measured across the enterprise.

- What are the uncertainties at both the individual PSS and the enterprise level;
- Which uncertainties are endogenous, which are exogenous;
- How the availability contract is executed

The ‘cost’ is in the ‘flow’



What do we enable?

Performance?

Availability?

Future Research

- Current status
- Illustrative Example
- Requirements for future research

Future research activities

- Quantitative research on the interfaces between research areas and the cost model.
- Operations based approach for Availability modelling.
- Gathering data, information and knowledge from industrial partners.

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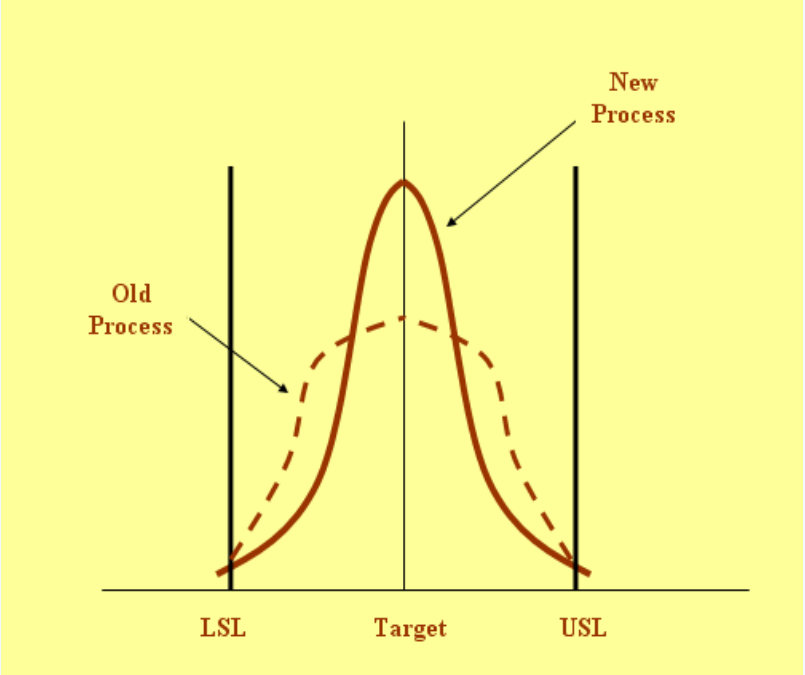
Any Questions

Trade-off Between Specification and Cost

- Uses Delphi approach to identify requirements.
- Requirements into specification and rated with QFD with key metrics.
- Manufacturing cost estimated.
- Taguchi approach used to rate the metrics in terms of their impact on cost.
- Output –cost variance reduced

and specification finalised.



Before Optimisation		After Optimisation	
Cost	Variance	Cost	Variance
330.86	318.20	325.24	46.18

Price Bid Modelling

Research outcome matrix with probability of winning the bid and probability of making a profit