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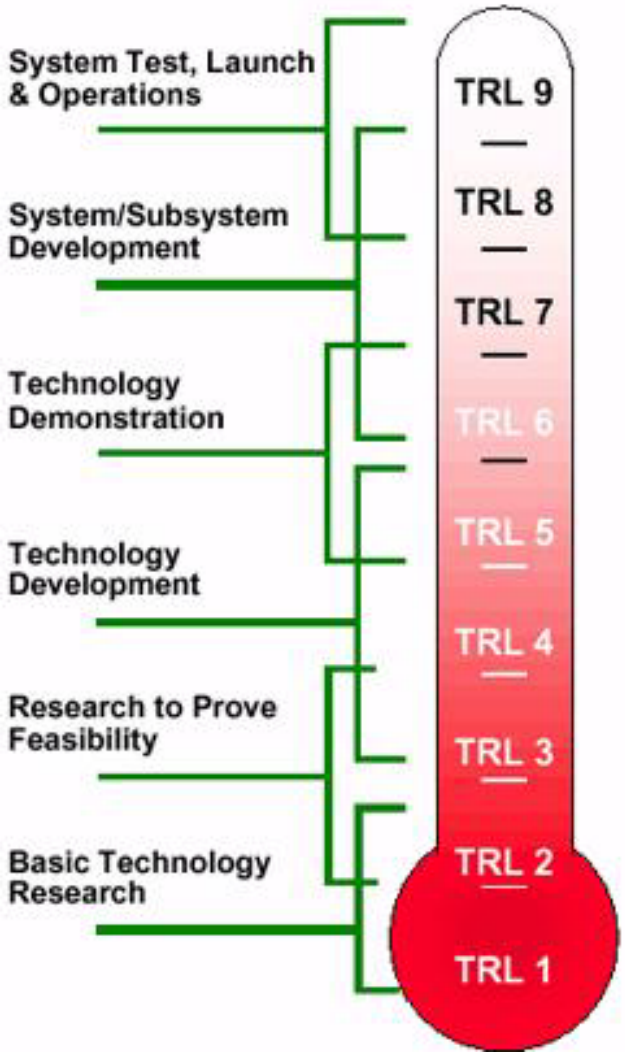
A Manufacturing Technology Maturity Impact Assessment Framework: An Application within the Aerospace Manufacturing Industry

Introduction

- Mark Jones: Second Year PhD student working in collaboration with Cranfield University and Airbus in the UK
- Based within Airbus, Filton
- Project must fulfil industrial and academic deliverables; a challenging requirement
- Framework at the conceptual stage
- Keen to discuss work with anyone involved in similar topics, please don’t hesitate to discuss further after the presentation

Introduction

- Technology Readiness Levels (TRLs) have been available for more than 25 years, first developed by (NASA) to ensure appropriate technology was reliable enough to be integrated into space systems
- This TRL scale has now been developed and adapted to suit Airbus and consists of 9 Technology Readiness Levels, as with the original NASA TRL system
- These range from ‘Basic Technology Research’ (TRL1) through to ‘Actual system flight proven through successful mission operations’ (TRL9)
- Due to Airbus confidentiality the basis of this presentation will be geared around the generic, readily available NASA TRL system

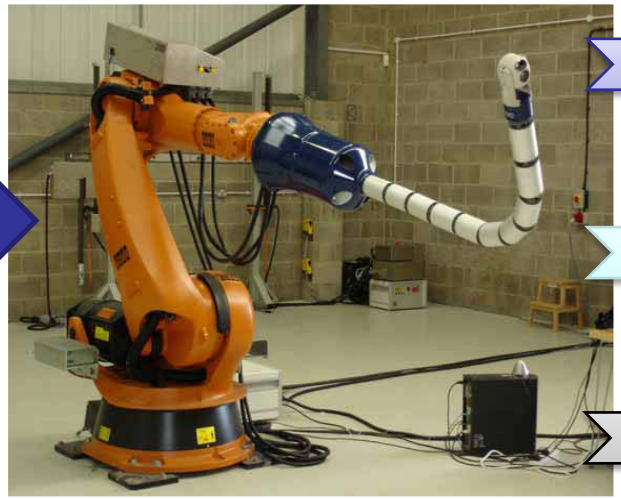


Airbus Pre-TRL Harmonisation

- Pre- and early 2009 TRL reviews were not harmonised throughout the business and with Airbus being global, the TRL panel would have different criteria

- This would lead to a TRL panel discussion based around the TRL structure question, **NOT** the Technology under assessment

TRL Panel



Technology Under Review: Snake Arm Robot

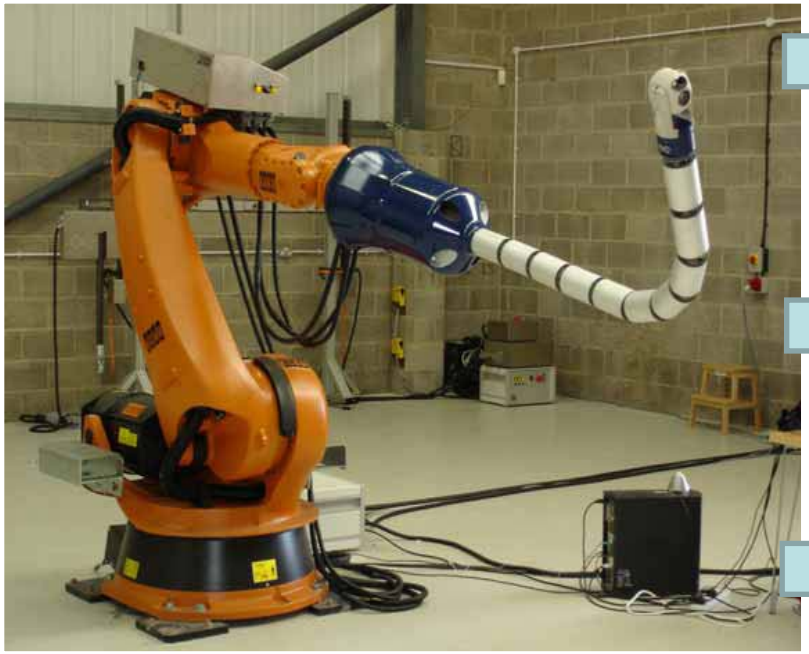
Criteria Airbus France

Criteria Airbus UK

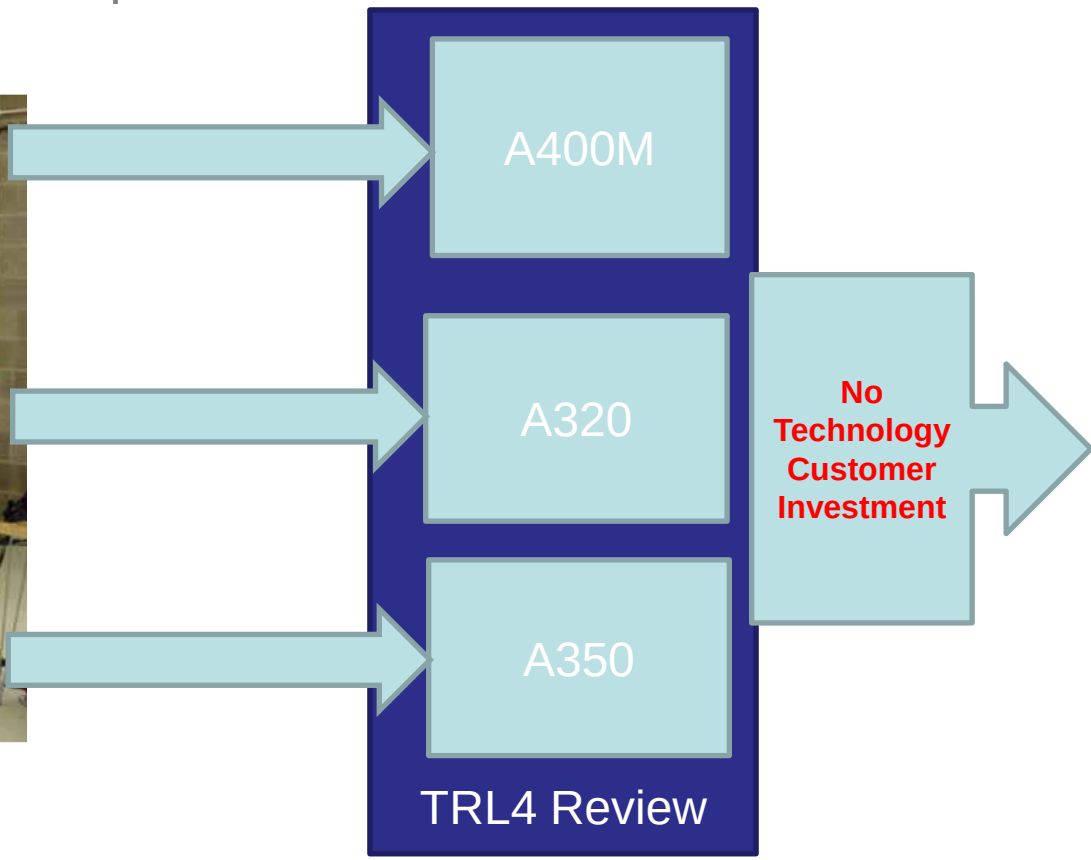
Criteria Airbus Germany

Airbus Pre-TRL Harmonisation

- Furthermore, research was conducted without assigning a direct customer for the technology and could typically consist of multiple internal customers



Technology Under Review: Snake Arm Robot



TRL Harmonisation within Airbus

- Since 2009 the TRL process has been successfully rolled out within Airbus in the form of a generic standardised structure

- The researcher has helped assist the successful implementation of this TRL structure, consulting when required

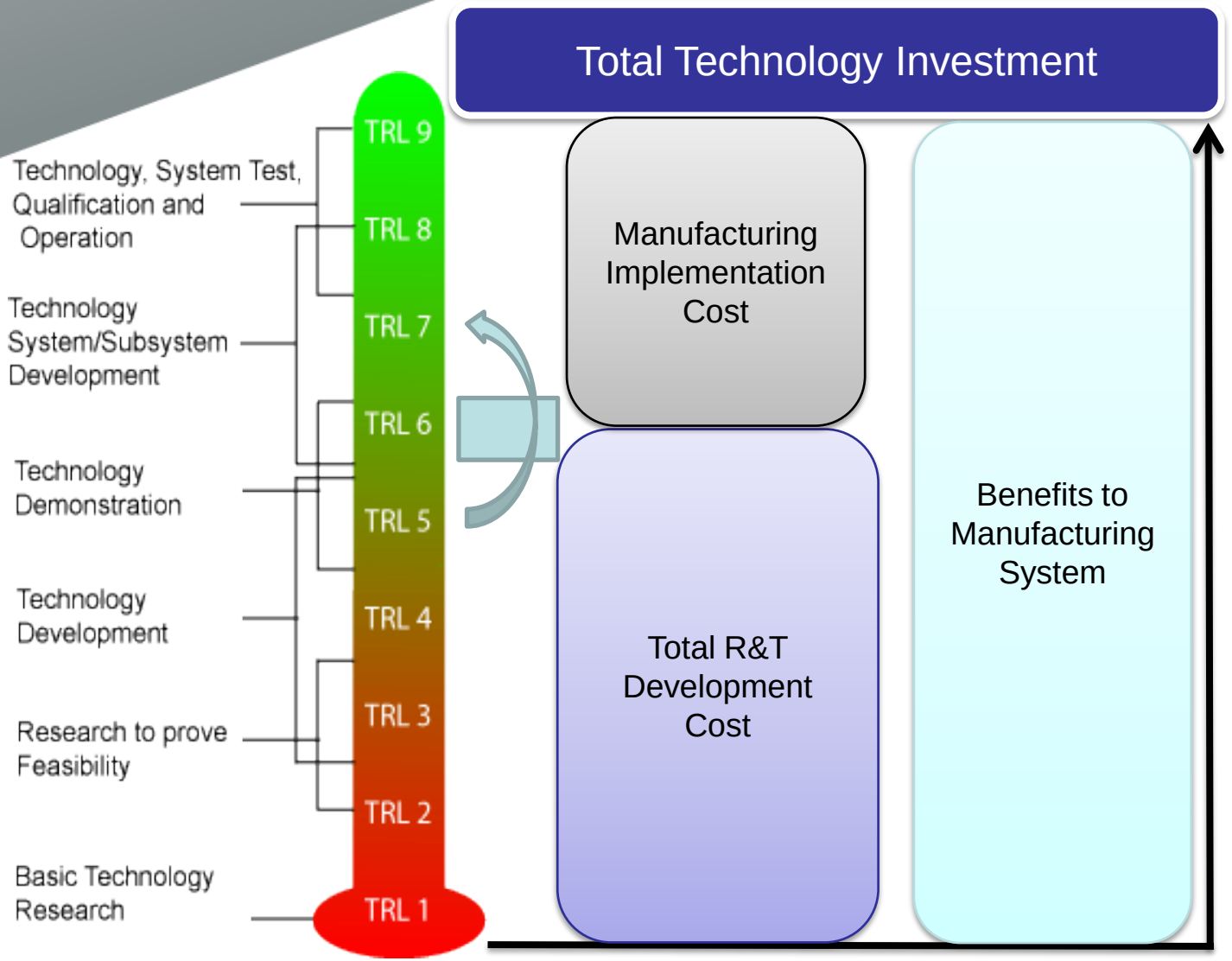
Problem Definition

- However, since implementation of this standardised process, the researcher carried out a Delphi survey and concluded; when driving technologies from TRL1 through to TRL9, the estimated costs and perceived tangible and intangible benefits involved when moving the technology forward are not coherently quantified and qualified

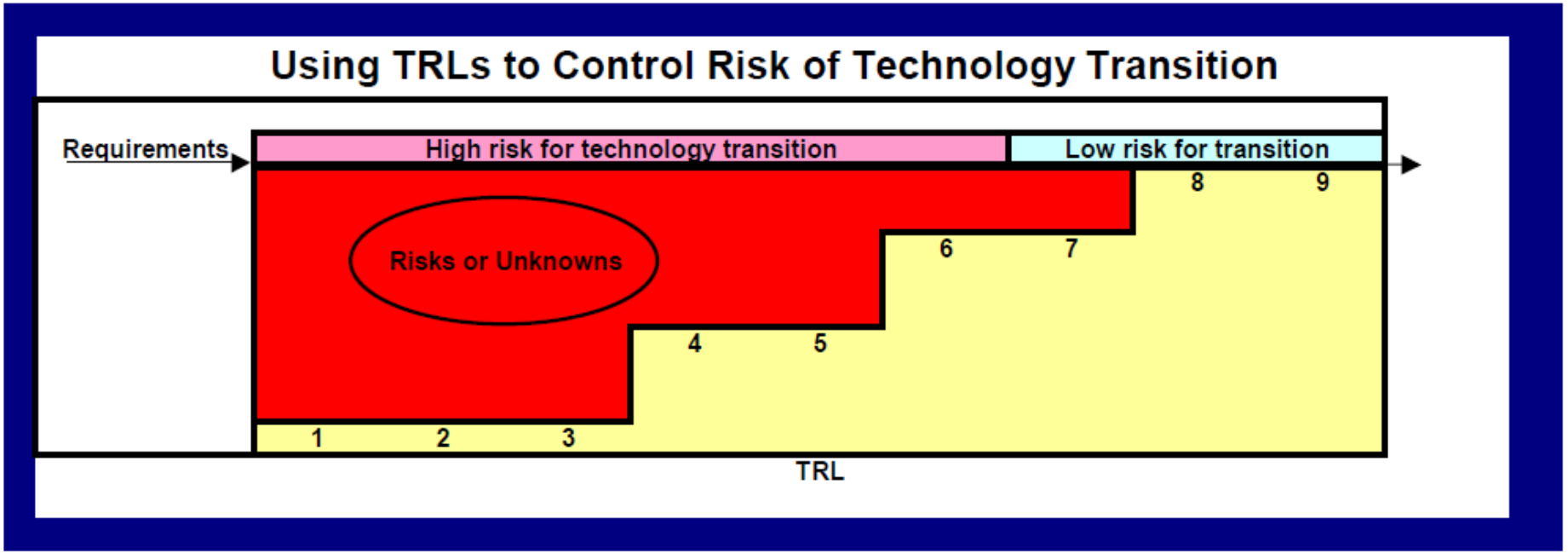
- In an attempt to respond to this, a unique framework is under development to validate technology investment at each incremental TRL gate; TRLs 3-9

- The secondary output of the research involves the development of a knowledge based preliminary TRL and early TRL (TRL1-3) impact assessment framework using an expert system in the form of Fuzzy Logic

Problem Definition



Problem Definition



Research Initial Approach-
Cost Estimation

- While use for technical readiness is well understood, their application to cost estimating still consists of a fragmented collection of factors and approaches

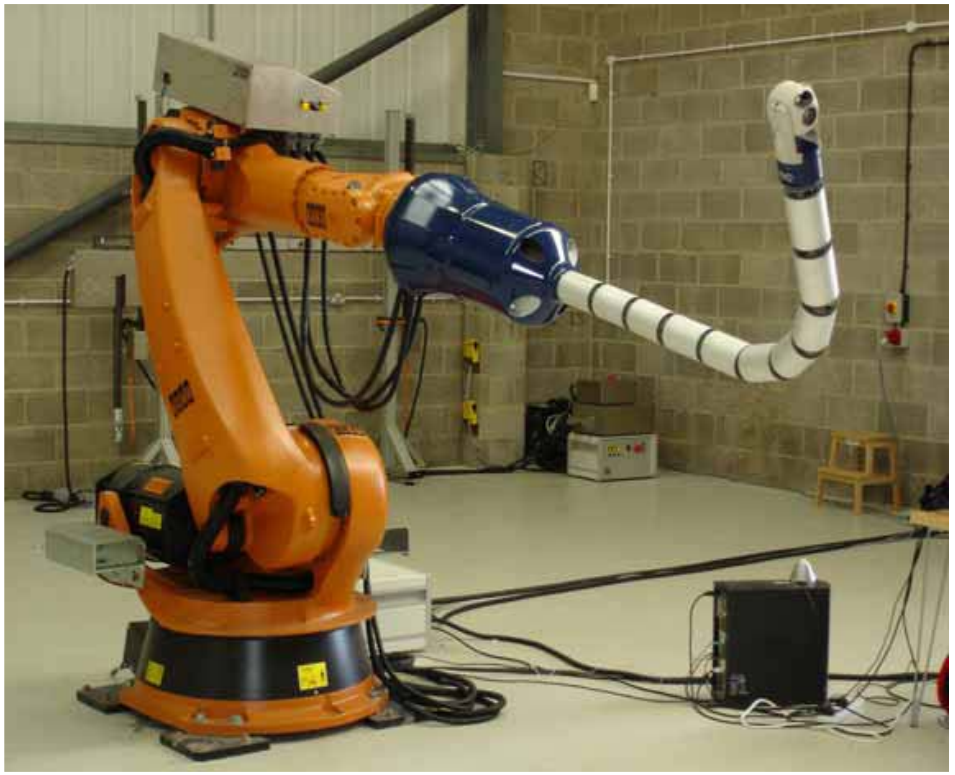
- External literature and industrial best practice benchmarking investigation was carried out and concluded that the best approach to model the cost of each TRL level was the Parametric Cost Estimation Technique

- Data from various internal TRL reviews was then captured in order to try and generate the required Cost Estimation Relationships (CERs)

- However, on further analysis, when estimating for innovative technologies, historical data was not available and estimates became irrelevant and unreliable, generating the requirement for a more suitable process

Research Initial Approach-
Cost Estimation

Kuka Industrial Robot



OC Robotics Snake Arm Robot

New Research Approach- Cost Estimation

- In order to meet the business objectives, the conducted research concluded to use the Delphi Group Meeting Technique to estimate the investment costs at each TRL maturity gate

- This method is suited to each TRL review as the panel members will be asked to estimate the cost to proceed to the next TRL level based on the information given at the review itself (work breakdown structure)

- The median estimate is then computed from the individual estimates giving the estimate output

Research Solution

- Development of a unique framework to assist manufacturing organisations in the technology investment validation through manufacturing impact assessment at each of the later incremental TRL gates, from TRLs 3-9

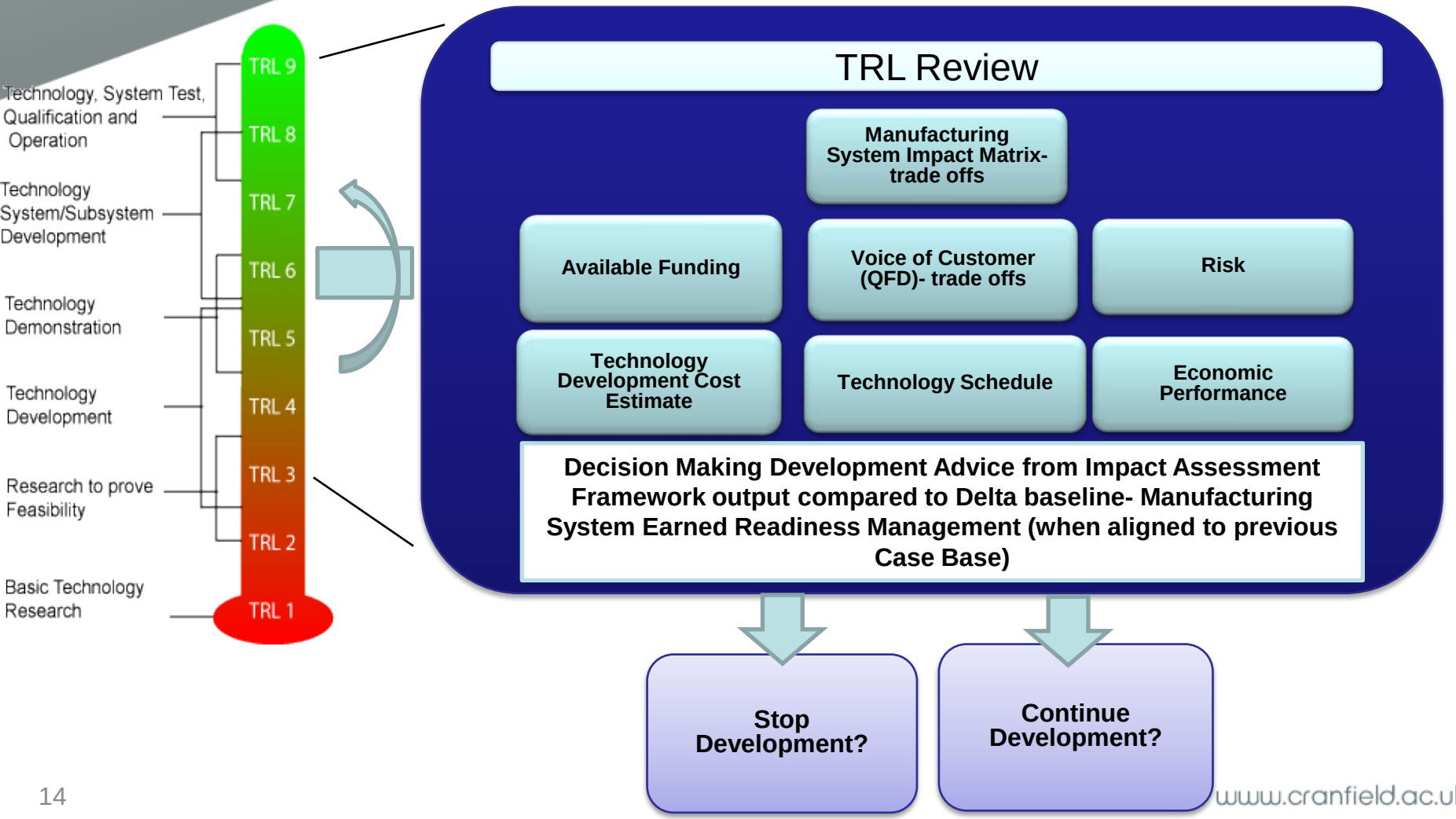
- At each post TRL3 incremental maturity gate the development costs are estimated

- The impact/benefit of the advanced manufacturing technology are quantified for application to the applied manufacturing system (manufacturing customer application)

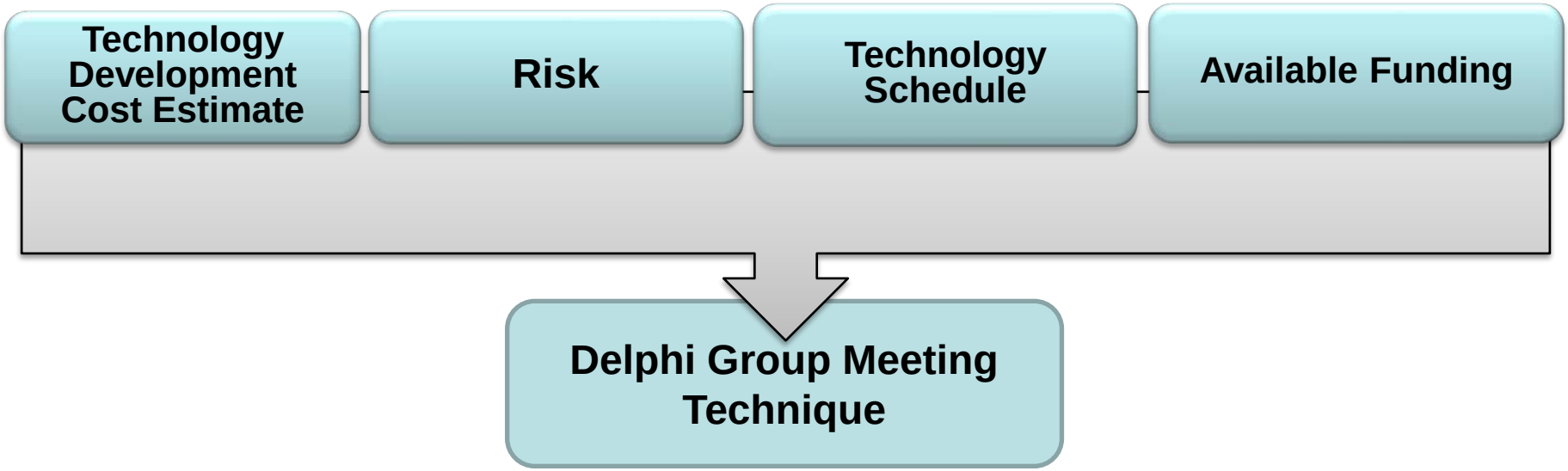
- Quantification at each TRL gate reduces investment, technological and performance risk; ensuring customer satisfaction, a crucial TRL factor

- The secondary output of the research intends to develop a knowledge-based preliminary TRL and early TRL (TRL1-3) impact assessment framework validating investment when costs and benefits can't typically be quantified

Framework Solution



Framework Breakdown



- Each estimator independently creates an estimate, in this case each member of the TRL panel

- The median estimate is computed from the individual estimates giving the estimate output

Framework Breakdown

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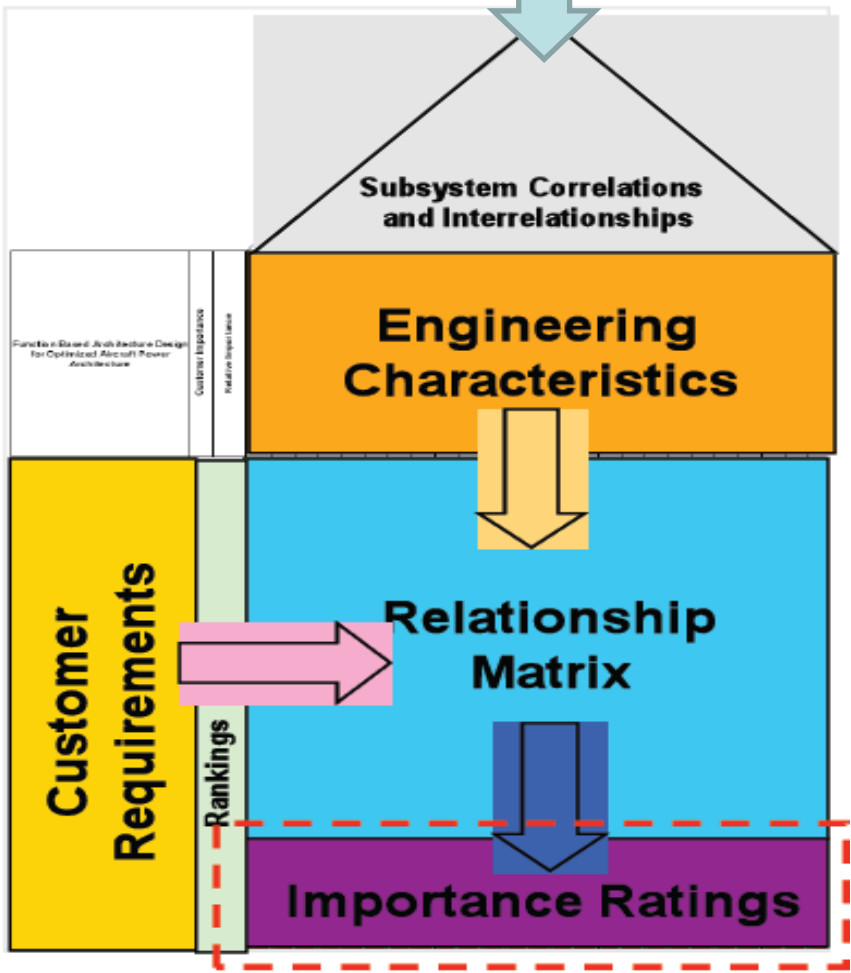
Manufacturing System Impact Matrix- trade offs

Technology	*System Level Impacts*			
ID	Metric 1	Metric 2	...	Metric *m*
Tech #1	Δ_{11}	Δ_{12}	...	Δ_{1m}

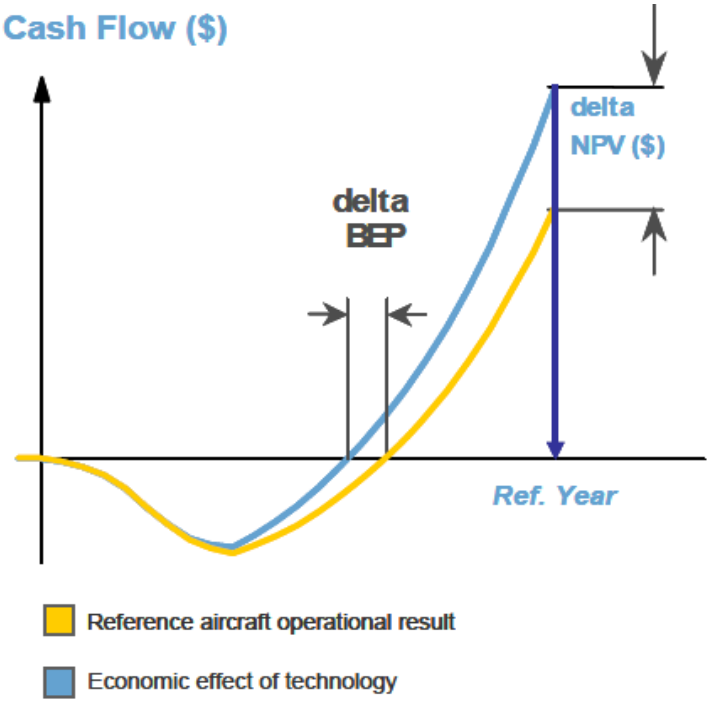
Voice of Customer (QFD)- trade offs



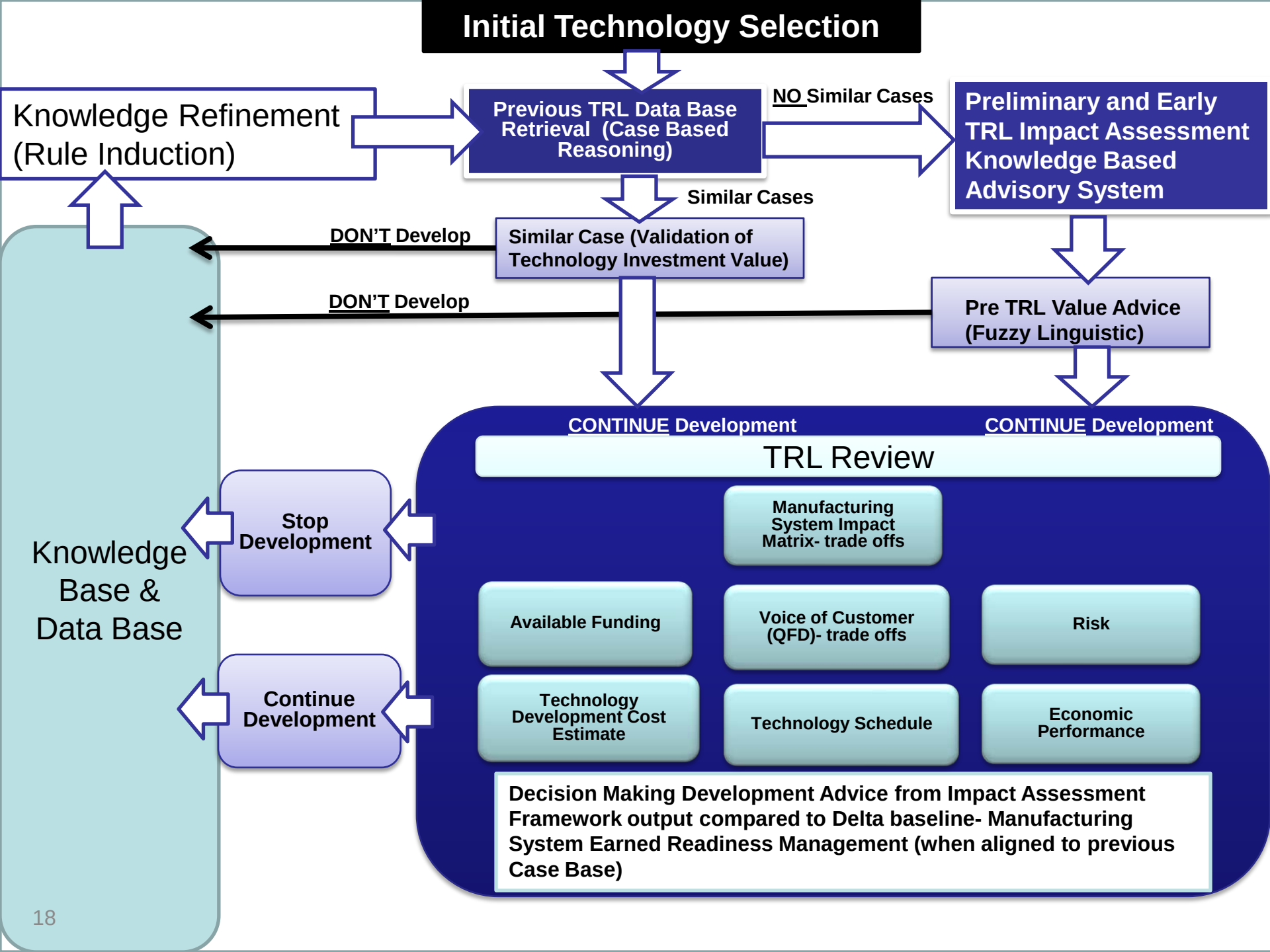
Framework Breakdown

Economic Performance

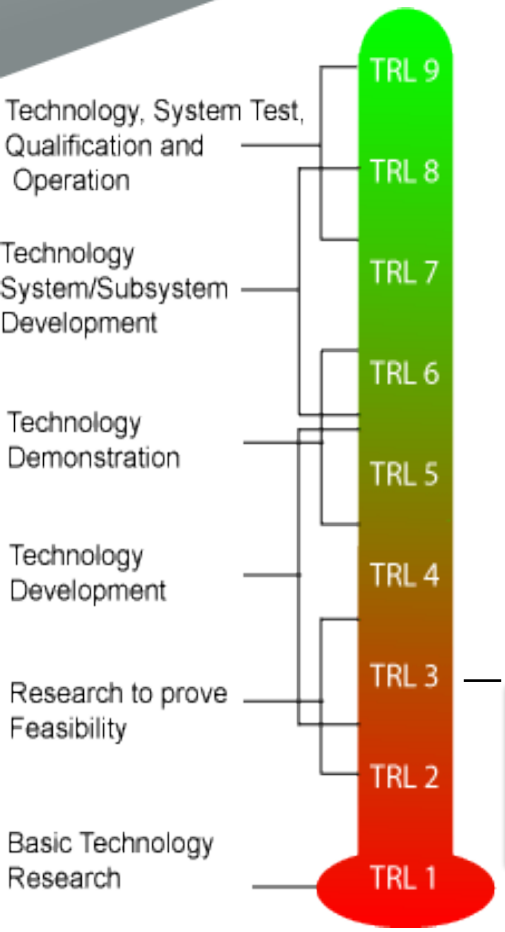
- In order to look at the suitability of an economic impact of a selected technology a **cash flow based evaluation** method is carried out capable of comparing the economic effects of a technology compared to the delta baseline reference within a common metric



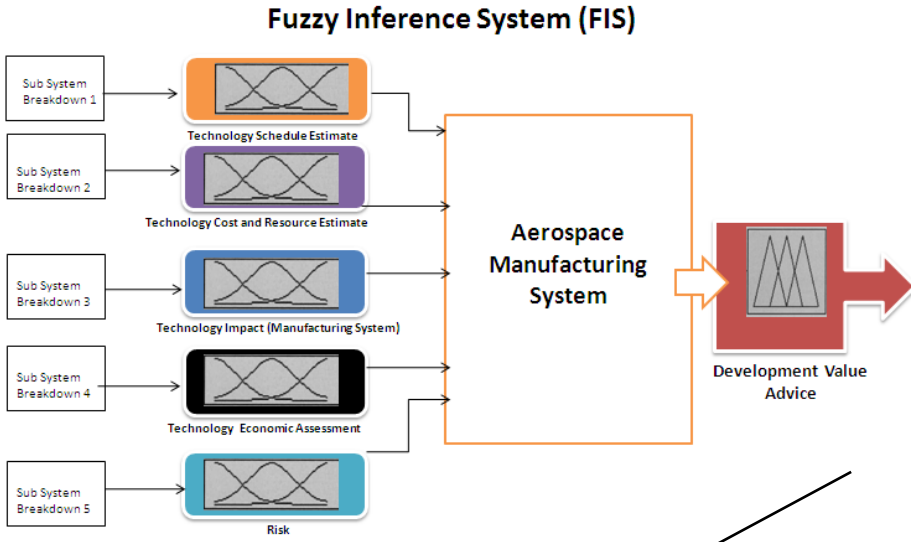
- **Net Present Value (NPV)**
  - The Net Present Value measures the present value of a sum of discounted cash flows in the future
- **Break Even Point (BEP)**
  - The point when the technology pays back its investment cost by providing the required return on investment
- **Internal Rate of Return (IRR)**
  - The Internal Rate of Return is equivalent to the discount rate for which the NPV is equal to zero


Initial Technology Selection
Knowledge Refinement (Rule Induction)
Previous TRL Data Base Retrieval (Case Based Reasoning)
NO Similar Cases
Preliminary and Early TRL Impact Assessment Knowledge Based Advisory System
Similar Cases
DON'T Develop
Similar Case (Validation of Technology Investment Value)
DON'T Develop
Pre TRL Value Advice (Fuzzy Linguistic)
CONTINUE Development
CONTINUE Development
TRL Review
Manufacturing System Impact Matrix- trade offs
Available Funding
Voice of Customer (QFD)- trade offs
Risk
Technology Development Cost Estimate
Technology Schedule
Economic Performance
Decision Making Development Advice from Impact Assessment Framework output compared to Delta baseline- Manufacturing System Earned Readiness Management (when aligned to previous Case Base)
Stop Development
Continue Development
Knowledge Base & Data Base

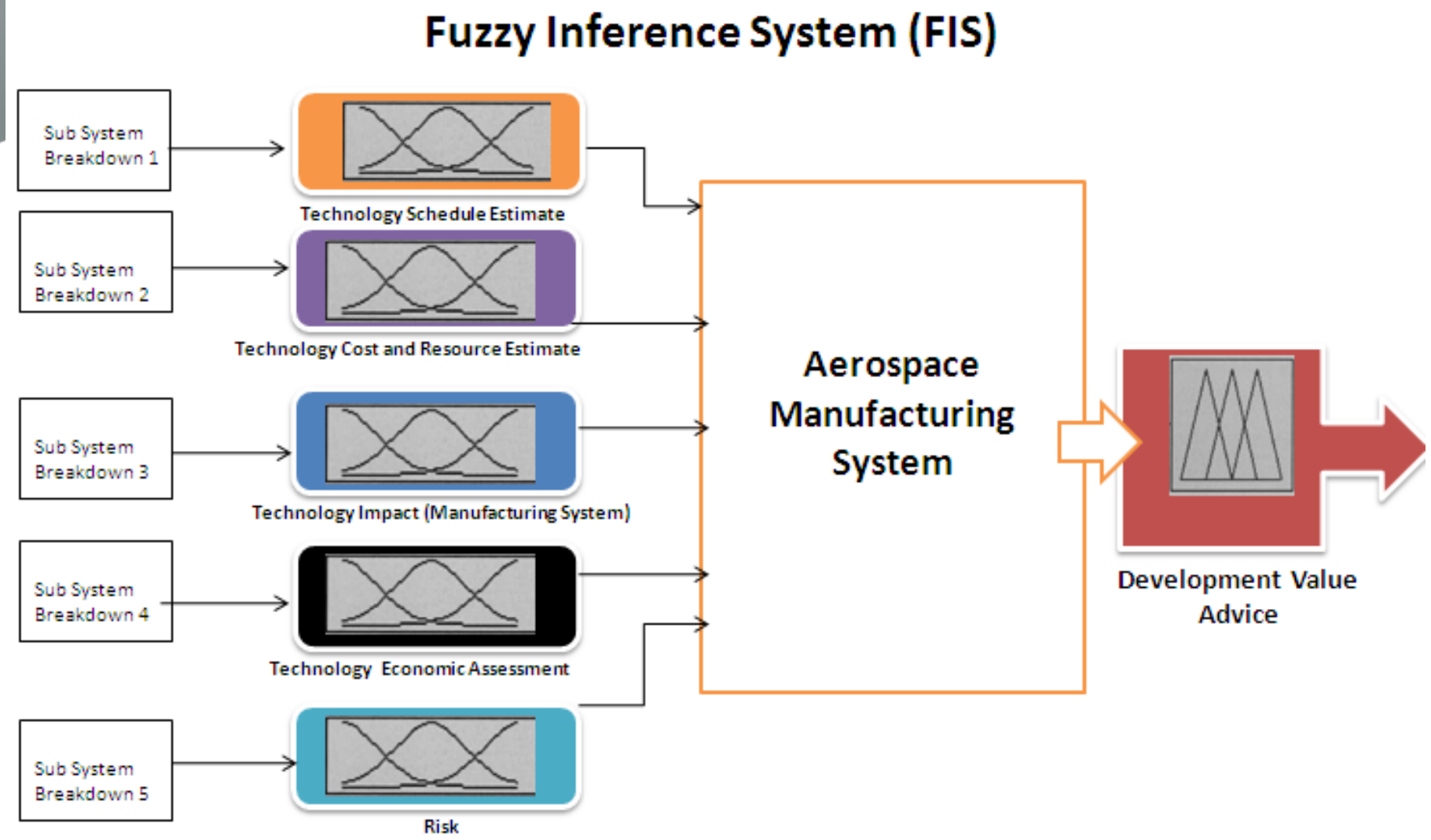
Framework Solution



Preliminary and Early TRL Impact Assessment (Fuzzy Inference Forecasting System)



Framework Solution



Conclusions

- The research initially focused heavily on literature by understanding the whole cost estimation domain and aligning with the TRL process
- This originally concluded that the most suitable technique was Parametric Cost Estimation
- However, since the discussed Delphi survey was carried out, it became clear that this technique was not suited due to technology diversity and lack of data

Conclusions

- Furthermore, technology managers require more than just the cost of development and stated that clarifying the tangible and non tangible benefits coherently would significantly enhance the current TRL process

- To fulfil this requirement a technology impact assessment framework is currently under development

- The data base and knowledge based advisory system will further the use of the toolset within the business by capturing all technologies run through the TRL process

Future Work

- Future work will initially focus on the development and validation of the TRL Review Development Advice Framework

- The secondary research focus will concentrate on the development of the preliminary and early TRL fuzzy inference system

- Keen to discuss work further post conference

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Questions?