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Costing Future Complex & Novel Projects

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ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

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Panel 18. Forecasting and Controlling Costs in Weapons Systems Procurement

Thursday, May 5, 2016	
1:45p.m. – 3:15 p.m.	**Chair: Todd Calhoun,** Director of Program Assessment & Evaluation, Programs & Resources Department, Headquarters Marine Corps ***Costing Future Complex & Novel Projects*** Michael Pryce, Centre for Defence Acquisition, Cranfield University ***Controlling Costs: The 6-3-5 Method—Case Studies at NAVSEA and NATO*** Bruce Nagy, President/CEO, Catalyst Technologies Morgan Ames, Senior Advisor, Catalyst Technologies ***Costing for the Future: Exploring Cost Estimation With Unmanned Autonomous Systems*** Ricardo Valerdi, Professor, University of Arizona CPT Thomas Ryan, Jr., U.S. Army, Professor, U.S. Military Academy

Costing Future Complex & Novel Projects

Michael Pryce—is a Lecturer in defence acquisition at Cranfield University. He teaches across a range of subjects, including the use of costing in acquisition and planning at the master's level. His research focuses on the use of cost as a design tool. He is currently leading a second costing research project with colleagues from UCL, Imperial College, and DSTL and developing the Low Cost by Design (LCxD) network. Prior to joining Cranfield, Dr. Pryce worked at Manchester Business School, where he carried out two NPS-funded projects looking at the role of costing and business models in operations and support. [m.pryce@cranfield.ac.uk]

Abstract

A program of current research funded by the United Kingdom (UK) research councils and supported by the UK Defence Science and Technology Laboratory (DSTL) is reported. The work involves pioneering data collection, analysis, and tool development to support future air combat systems. The role of a community of users and developers of the data and tools is reported, as well as the underpinning philosophy of the work and future prospects for its wider application.

Summary

The United Kingdom National Audit Office *Major Projects Report 2014* states that "Project teams continue to be over-optimistic in their forecasts of both procurement and support costs" and that "Budgets set using over-optimistic forecast costs could result in overall budgets for procurement and support being significantly understated" (Great Britain, National Audit Office, 2015). Correcting the causes of such failings is the aim of this research, with the outputs being intended for use by a wide range of stakeholders.

The research will lead to enhanced methods, tools, and understanding of costing in defence. This will be realised through the creation of a database of historic defence costs, a set of project histories, and other contextual information. An associated viewer tool, and a rating and health check tool for use by practitioners, will be developed.

The project will take work that has previously been at a largely conceptual level through to initial field trials and validation. Later phases leading to full deployment are also planned.

The end users for the work will be in the Aerospace, Defence, and Manufacturing sectors. The successful delivery of this project will allow users to easily organise and access key contextual information that will support more accurate forecasting of project costs and schedules. This will allow more efficient decision making.

During the period of active research, the DSTL provides the initial customer and significant support in informing the development of the work. The project is currently planned to run July 1, 2015, to June 30, 2016.

Project Overview

The research involves the collation of a large, varied data set on historic defence project costs, as well as associated qualitative information in the form of project histories. The work will lead to a wider understanding of the root causes of cost in defence, as well as enhancing knowledge of how to improve the accuracy of early stage project cost estimates.

The research findings will be linked semantically and interpreted through a viewer tool that relates data to projects interactively, based on HTML5, allowing users to contextualise cost data. A second tool to allow project teams to carry out costing "health checks" is also being developed. This will allow users of the viewer to focus their interests on the data and examples that matter. The project's top level structure is shown in Figure 1.

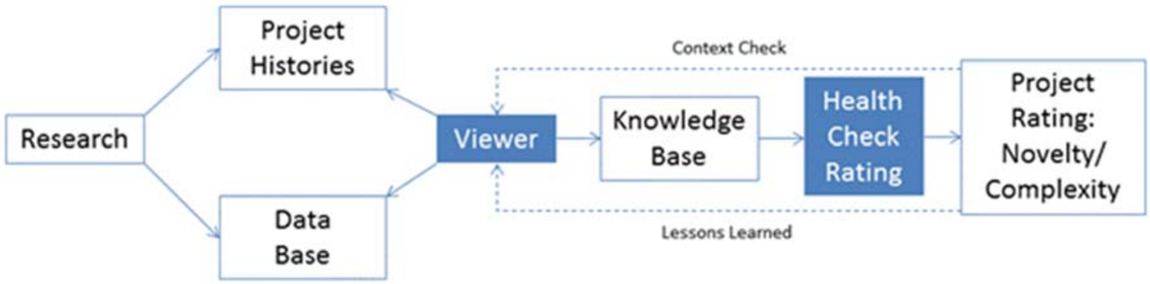

Figure 1. Top Level Structure
Note. Tools are shown in blue.

The project will focus its initial data collection on a number of combat air systems. These have already been partly researched by the team in prior work, and therefore the context is reasonably well understood. This will allow the work to focus on more in-depth data gathering and the development of the key outputs. A key focus of the work will be in tackling variety in the data collected, one of the "3 Vs" of Big Data. The outline programme is shown in Figure 2.

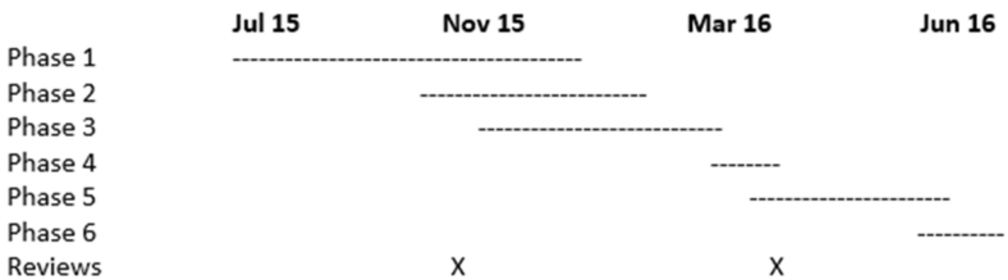

Figure 2. Programme of Work
Note. Project phases: 1 = Data collection, 2 = Data presentation and evaluation, 3 = Initial development and testing of viewer tool, 4 = Development of health check tool, 5 = User trials, 6 = Revision and expansion plan.

The project reviews are carried out by Professor David Kirkpatrick, who acts as an "external examiner" of the thinking behind the project, as well as contributing his own extensive experience in this field to help guide the work and its application.

End-Users

User trials involve a range of potential end users, with informal meetings held ahead of the planned trials. The initial end users for the work are in the defence sector, including the UK Ministry of Defence (MOD), particularly Defence Equipment & Support and Air Command, and UK defence companies such as BAE Systems and Rolls Royce. The work also has the potential to meet already articulated needs from the Australian Department of Defence and the Norwegian MOD.

The successful delivery of this project will allow end users to easily organise and access key contextual information that will support more accurate forecasting of defence project costs and schedules, especially complex and novel ones such as unmanned combat systems.

Technology Readiness

The project will take work that has previously been at a largely conceptual level and develop it to initial field trials. For the tools discussed, this would equate to going from TRL 1 to TRL 6.

Outputs

The project is intended to lead to facilitated workshops, the creation of a network of cost researchers and end users, a number of high-quality academic publications, and the development of a database of defence costs and project histories.

The findings will be used to develop teaching material for the Cost Estimating and Planning module of Cranfield University's Defence Acquisition Management MSc. Students on the MSc. are mainly senior managers from potential end user organisations inside defence. The work will also be relevant to the UK MOD's Financial and Military Capability management environment, which provides the high-level planning framework for UK defence acquisition.

Outcomes

Beyond the completion of the proof of concept work represented by this project, a number of additional outcomes are being pursued:

- Licensing of tools in a wider range of user organisations
- Database to be openly accessible within the costing community
- The development of new decision making approaches in the pre-concept phase
- Better understanding of organisational learning and corporate memory
- Links to existing costing methods that rely on data similarity
- Further development to other domains beyond air, and sectors outside defence

Rationale for the Research

For many years, the UK has struggled to maintain an extensive, coherent and useable set of project costing data for the development of major new platforms. Organizational changes within acquisition, contracting strategies and the high turnover in defence project staff have contributed to both the loss of data and low numbers of experienced staff able to interpret such data (Gray, 2009; Levene, 2011).

These problems have been exacerbated by the focus in the last 15 years on the support and sustainment of existing equipment. This has led to the widespread use of commercial costing tools that, while acceptable for the costing of in-service platforms, are of less use for the development of highly novel platforms, especially when the proprietary nature of the tools' databases means that it is difficult to make allowances and adjustments for novelty. The "bottom up" approach to costing works well for established designs, but is almost impossible for novel ones.

At the same time, the understanding of the need to cost "through life" that has been engendered by the focus on support and sustainment has made the challenges of generating realistic costs at an early stage of a project, when major commitments may be entered into, increasingly important, though no less difficult.

While prior work has shown that the operation and support costs are not necessarily fixed early in the life cycle (Pryce, 2011), the need to capture their likely range, as well as to ensure that the full range of issues outlined by Pugh (1992) for development and production are also addressed, indicated that current data sets and methods in the UK were inadequate. The research was developed on the basis of creating a new method with related data and tools that can be generated dynamically and sustained by a wide community over a long period of time.

This new approach is not intended to deliver a model. Rather, it is aimed at creating a heuristic or "therapeutic" set of data, tools and the necessary understanding to use them that will enable better decisions to be made by project teams in defence acquisition. Philosophically, it differs from many approaches that are currently used, but aims to do so in a complementary way. Such aspects will be explored through later work on a related project, which will seek to add a degree of modelling capability to some of the data being generated, and the idea of Bayesian belief networks will also be explored in this additional work.

The ultimate objective is to help support the "smart customer" inside the UK MOD, and to provide an approach that promotes dialogue between government and industry.

The Project Described

The project is made up of a number of activities and phases as shown in Figures 1 and 2 above. A more detailed description of these is given below in order to understand the intent of each.

Figure 3 shows how the work begins with field research. This consists of the extensive collation of information and data from archives across the United Kingdom. The National Archive at Kew, BAE Systems Heritage archives, the Royal Air Force Museum, Brooklands Museum, and others are the sources of a large amount of historic material that has been lost to the United Kingdom MOD over the years. A key part of the research is not just the collection of this data, but the central recording of the location and source of the material from the archives. Frequently, information from one source helps make sense of information from another. It is these cross connections that provide one of the key strengths of the research.

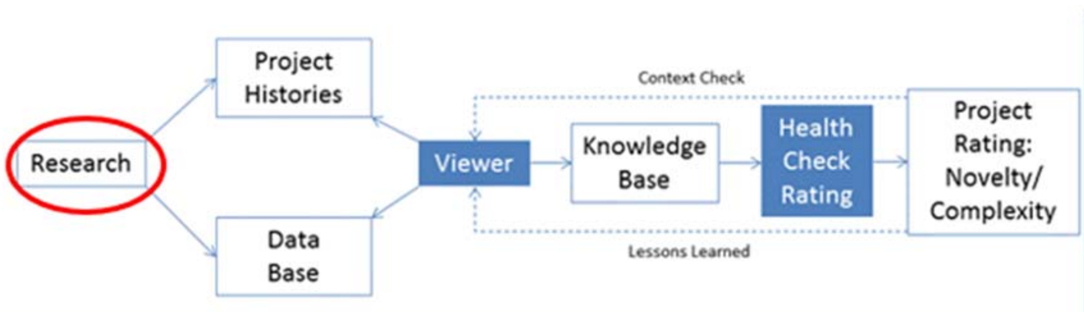

Figure 3. Research

The material obtained from the research is broken down into two basic elements (Figure 4). Qualitative information is used to develop project histories for past platforms. These are not simple case studies, but contextually rich histories of past projects. They can be used as stand-alone histories for one project or platform or related to others to give a programme or portfolio view.

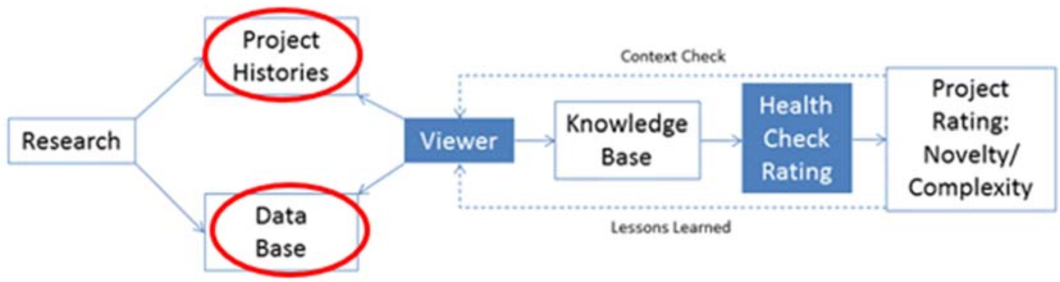

Figure 4. Project Histories and Data Base

The project histories can also be related to the quantitative data sourced from the research. This is data in both raw and semi-processed form. One of the key methods in the generation of the recorded data is its connection to its historic context to ensure factors such as exchange rates, inflation, etc. are properly accounted for, and that suitable recording of the derivation of the presented data ensures it is fully explicable to end users.

The end users explore the histories and data obtained from the research using a viewer tool. This is intended to provide their main method of generating a knowledge base for their own immediate needs (Figure 5). The viewer tool acts as the main, IT based resource that project teams can utilise over time to help them work with the data and histories. It is intended to show the data, histories and associated project timeline information in a single screen. A conceptual version is shown in Figure 6, and a mock-up is shown in Figure 7.

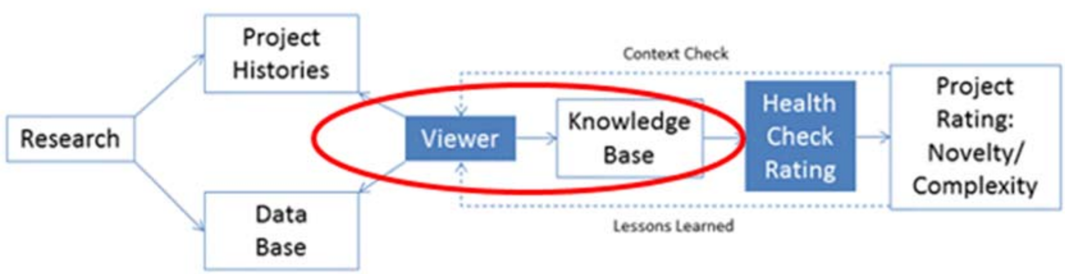

Figure 5. Viewer Tool and Knowledge Base

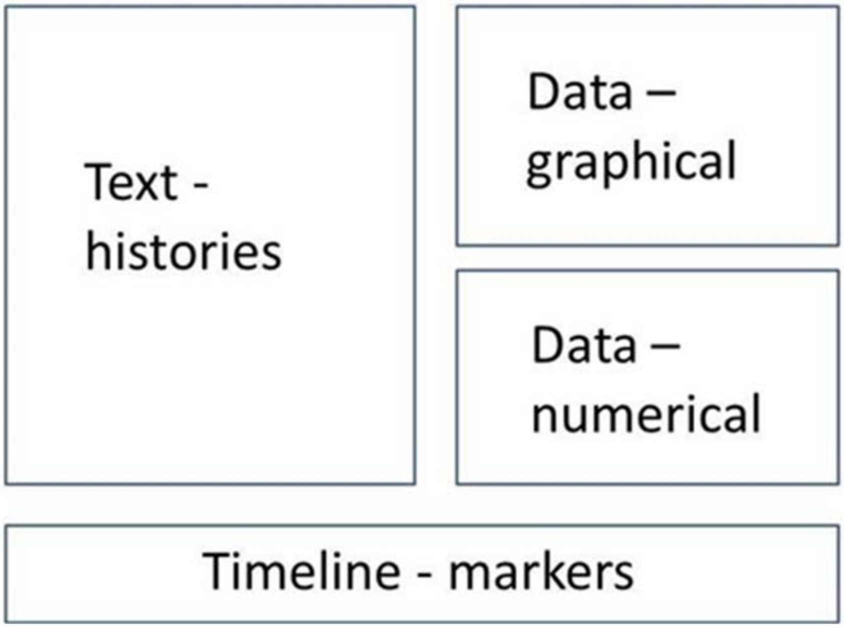

Figure 6. Viewer Tool Concept

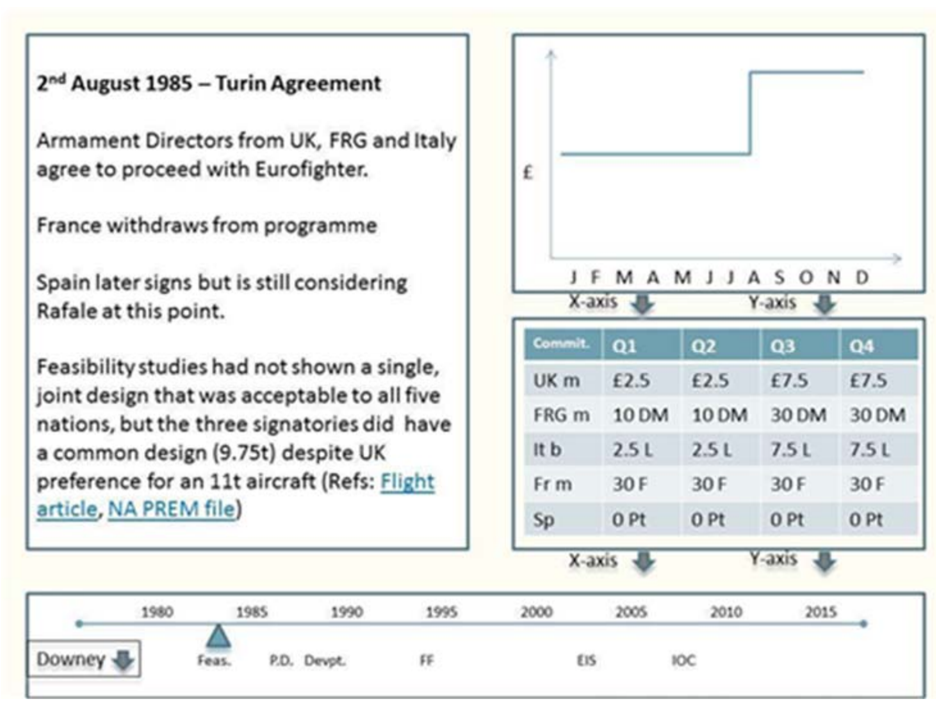

Figure 7. Viewer Tool Mock-Up (Indicative Data)

The viewer tool is being developed using HTML5. This is intended to make it platform agnostic and “future proof.” A search function, using meta-tagging and standard web search engine methods, allows intuitive, adaptable use with minimum functional training.

HTML5 will also allow for development of the viewer tool by project teams using in-house or external resources that only require common, standard technologies. Such an approach also means that the viewer tool can run in secure/shared/stand-alone modes defined by the user's own IT environment. Desktop/tablet use is possible, as is networked and online use.

Before using the viewer tool, the data and histories that are most relevant to the user are identified through a health check tool. This is intended to identify the characteristics of the user's current project and to help map this across to the histories and data shown by the viewer tool (Figure 8).

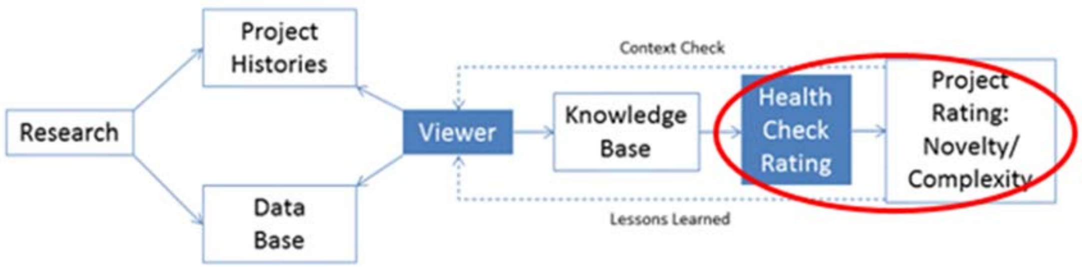

Figure 8. Health Check Tool and Project Rating

The health check tool uses qualitative/subjective inputs and relies on "polling" of the user project team to identify the characteristics of their current project. This is intended to capture diverse views using a rating system conceptually similar to the "Cooper Harper" style hierarchy used for piloting aircraft. Alphanumeric outputs are used to identify "true likeness" projects from which learning can occur and to help identify if the context of the user's project is similar to the one(s) explored using the viewer tool. These activities are usually carried out through an on-site facilitation with the user (Figure 9).

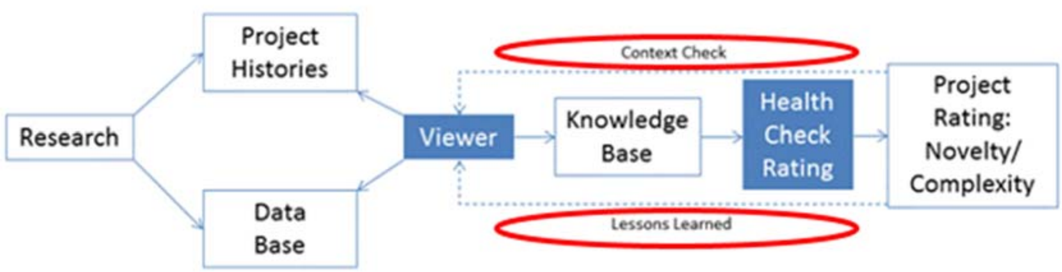

Figure 9. Context Check and Lessons Learned

Discussion

The description of the project illustrates how the project is being developed in an essentially linear fashion. However, this masks the interactive, incremental and innovative ways that the tools, data, histories and basic research can be used.

For users, their knowledge base can be constantly reinforced and updated by repeated use of the tool, forming a loop that links their learning from the tool with the changed perception and performance of their project. This can be allied to adaptation of the viewer tool to their own specific needs. Both aspects are intended to go some way to compensating for the loss of skills and data that has happened in the UK MOD costing community in the last 20 years with regard to cost forecasting for complex and novel projects.

For the research team, involvement in users' activities through data provision, tool set up and facilitation helps to refine the further development of the research outputs, as well as helping to focus the collection of further data. It has already been found that much more data and information exists in archives than was expected, and that the corporate memory on projects such as the Eurofighter Typhoon and F-35B (i.e., projects still in development but decades old) can be usefully refreshed using archival sources.

Although the work is currently focussed on air combat systems, a second project, funded by the DSTL (called Air Systems Programme Data) is now beginning that will start to address how an approach that works in the air domain can be extended, notably to the maritime sector. This will also widen academic participation, with the research team involving staff from University College, London (David Andrews), Imperial College (Dr. Michael Weatherburn), and industry (Andrew Dakin, 649 Ltd.).

The approach taken to this project mirrors many of the techniques becoming increasingly prevalent in the emerging field of digital humanities (Burdick et al., 2012), while aiming to avoid some of the identified pitfalls. As such, it represents a new approach to costing, in which the subjective understanding of contextualised information and data is used to assist decision making, rather than the supposed objective evidence given by "hard" data.

As the work continues, it is becoming increasingly clear that the information and data provided on a screen is only the tip of the iceberg of potential benefits. Re-building, through digital humanities type techniques, the institutional capacity to understand cost as part of the early stage design process is a trans-disciplinary activity. To benefit from it requires a diverse set of engagements with users in a truly open and innovative manner.

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Acknowledgments

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Tim Jefferis at the DSTL has been important to the development of the work reported here as the DSTL lead user for the work, providing an initial focus for its outputs as well as carrying out some of the data gathering. Alexandra Bush of Isis Innovation Ltd. has played a key role in the refinement of the IP issues underlying the project. Staff at BAE Systems (Mick Porter), BAE Systems Heritage (Peter Hotham and Tony Wilson), Brooklands Museum (Chris Farara), and the National Archive have also been supportive in providing material and support for the work.

All views expressed, and errors made, remain the author's.

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Costing Future Complex & Novel Projects
Acquisition Research Symposium

Dr Michael Pryce, m.pryce@cranfield.ac.uk

5 May 2016, Monterey, California

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- Project funded by EPSRC
- Carried out with Dstl (Jefferis)
- Parallel work – co-ordinated
- Reviews by Prof. David Kirkpatrick
- 1 July 15 – 30 June 16: proof of concept
- Develop 'public good'

EPSRC Pioneering research and skills

dstl

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Disclaimer

- All views my own
- Do not represent those of other participants
- Do not represent those of third parties
- Work in progress – this is last week's version!

The problem

- Cost matters
- BBP – Consciousness (DARJ)
- Leadership – FinMilCap - flex
- Cost is a design issue – Rosetta stone
- Corporate memory lacking – cost ‘lens’

The project

- Concept/pre concept forecasts
- RDT&E, Procurement, O&S and links
- Database of historic defence costs
- Project histories & contextual information
- Air systems initially (ASTOVL/UCAV)
- Maritime and systems (carrier strike)

The project

- Not a model – complements
- Heuristic/‘therapeutic’ (blinders off)
- Create ‘smart customer’
- Link to current methods
- Proof of concept
- User trials (MOD/industry/aerospace etc.)

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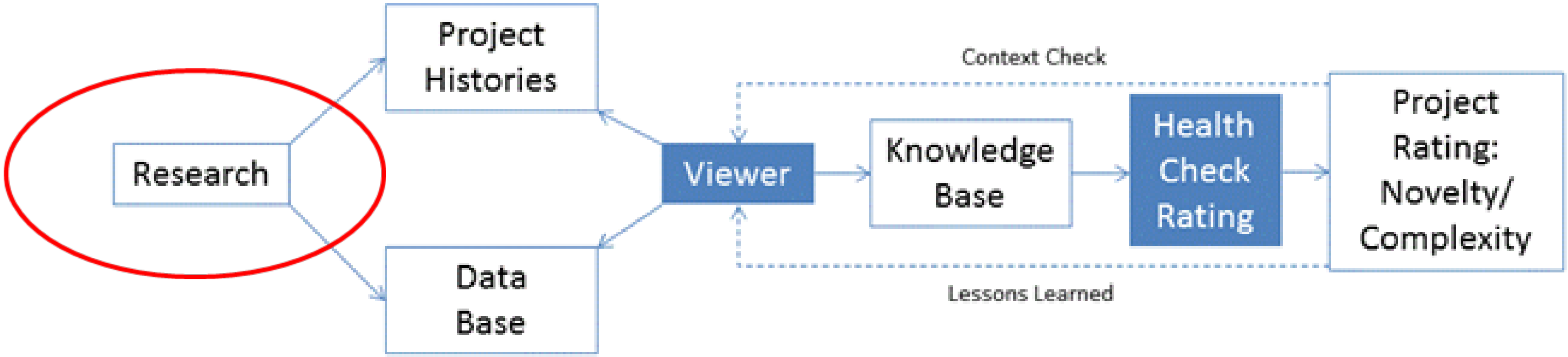
The project



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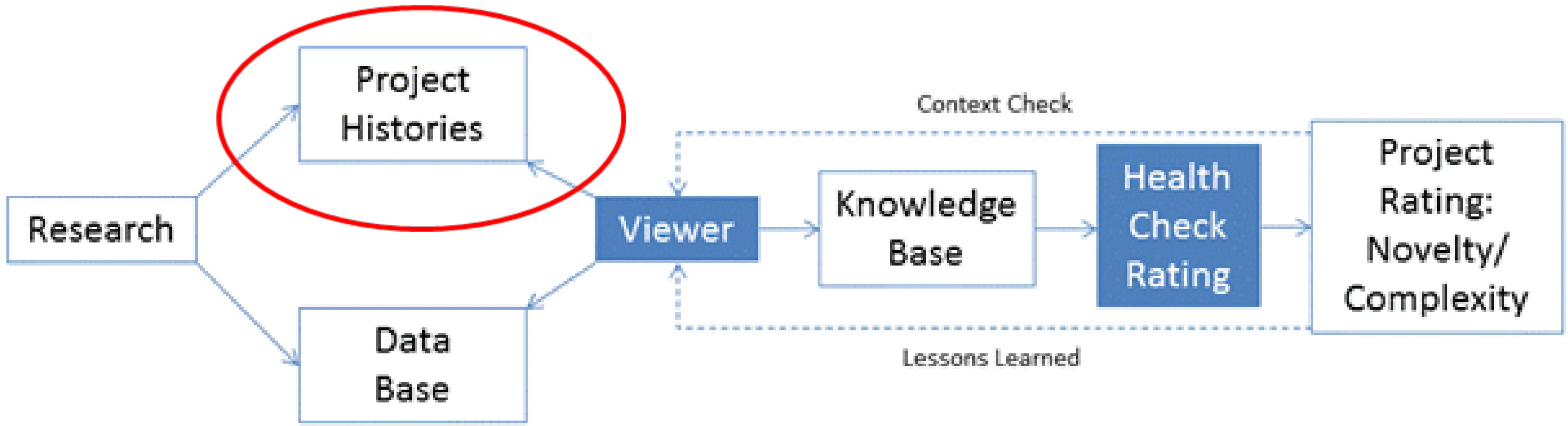
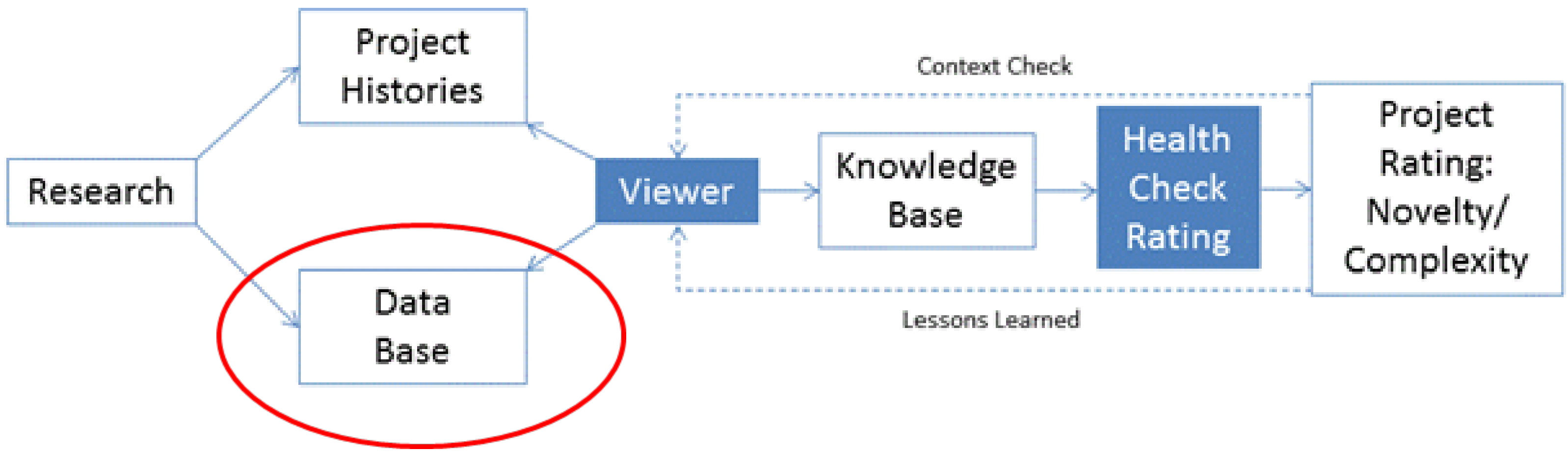


Project Histories
Research
Data Base
Viewer
Context Check
Knowledge Base
Health Check Rating
Project Rating: Novelty/ Complexity
Lessons Learned

The project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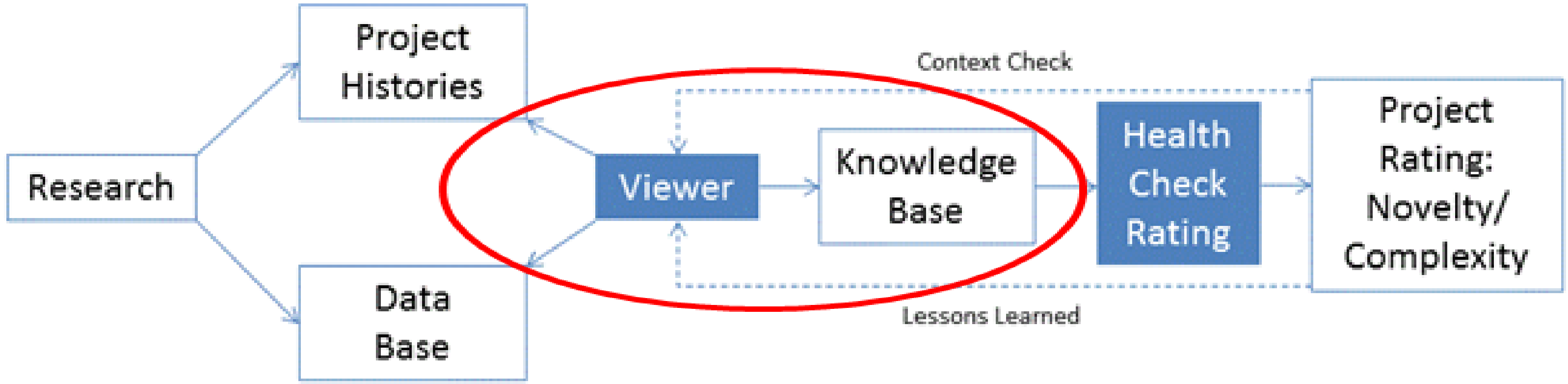
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Context Check
Lessons Learned

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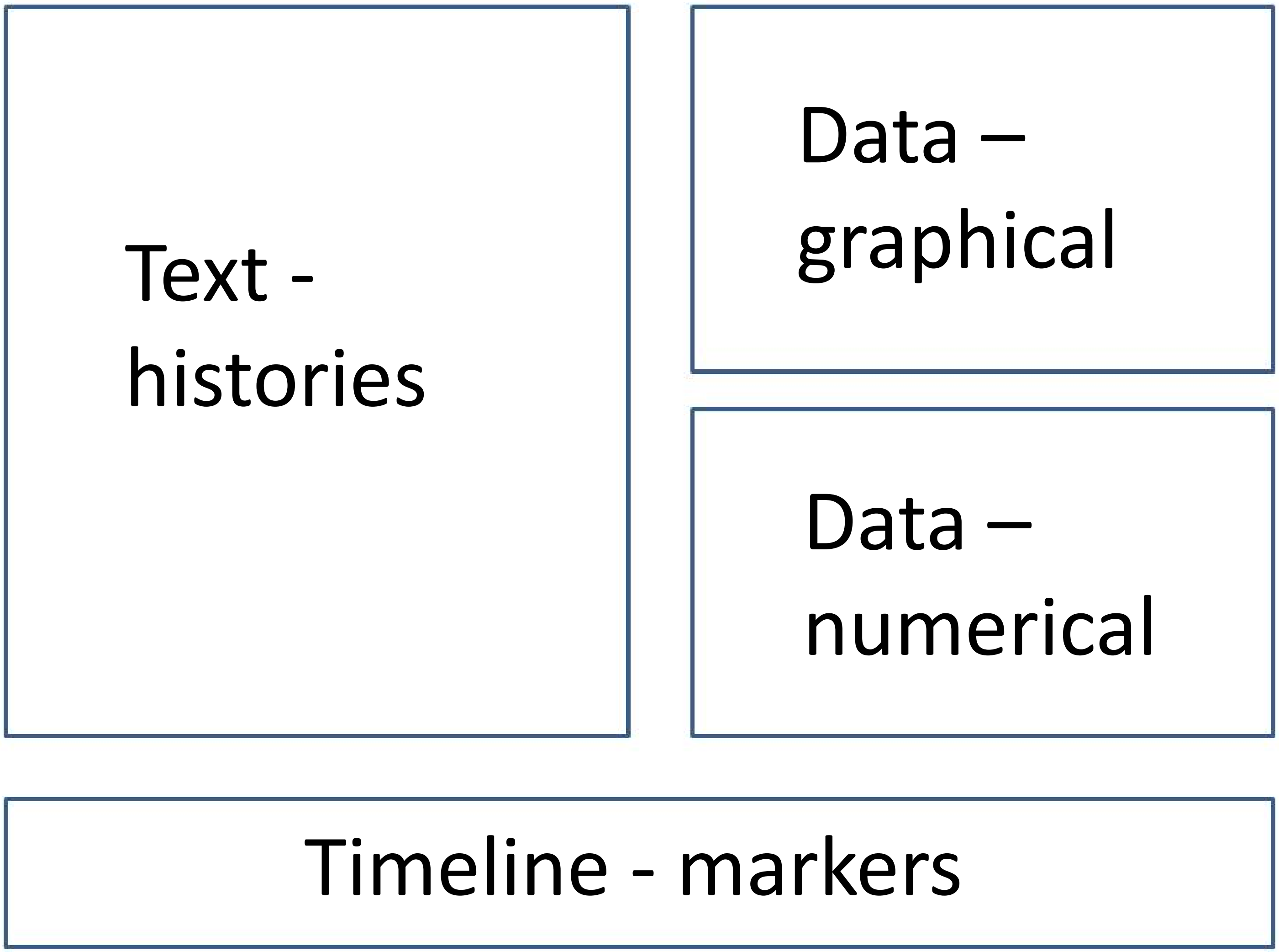
Viewer tool



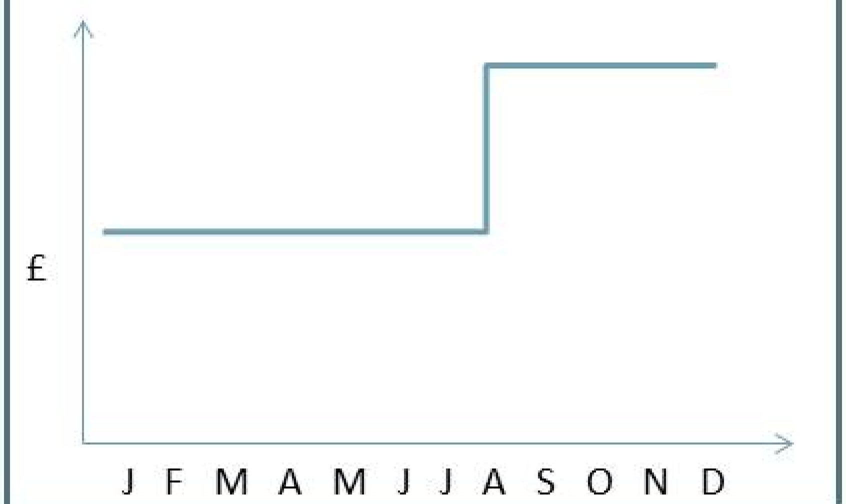
2nd August 1985 – Turin Agreement

Armament Directors from UK, FRG and Italy agree to proceed with Eurofighter.

France withdraws from programme

Spain later signs but is still considering Rafale at this point.

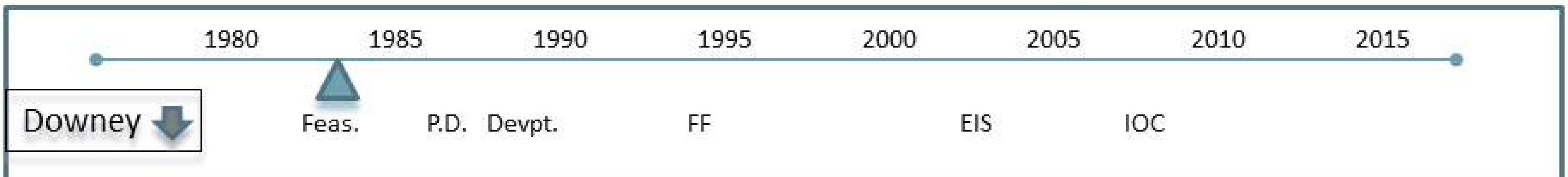
Feasibility studies had not shown a single, joint design that was acceptable to all five nations, but the three signatories did have a common design (9.75t) despite UK preference for an 11t aircraft (Refs: Flight article, NA PREM file)



X-axis Y-axis

Commit.	Q1	Q2	Q3	Q4
UK m	£2.5	£2.5	£7.5	£7.5
FRG m	10 DM	10 DM	30 DM	30 DM
It b	2.5 L	2.5 L	7.5 L	7.5 L
Fr m	30 F	30 F	30 F	30 F
Sp	0 Pt	0 Pt	0 Pt	0 Pt

X-axis Y-axis



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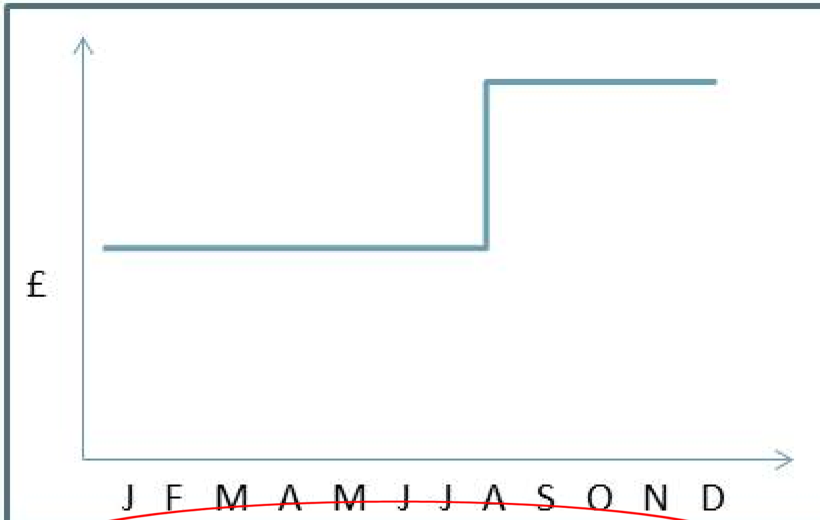

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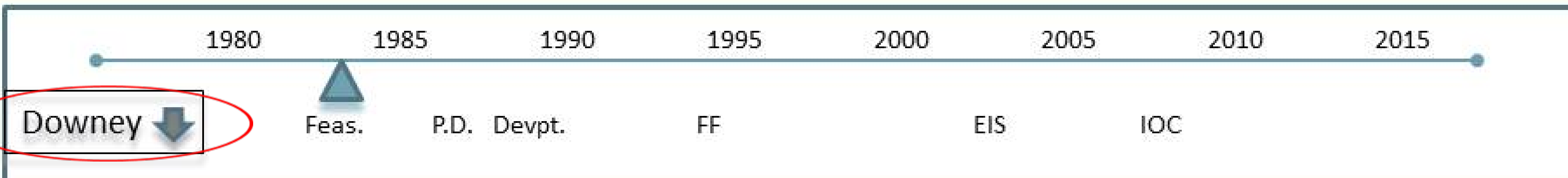

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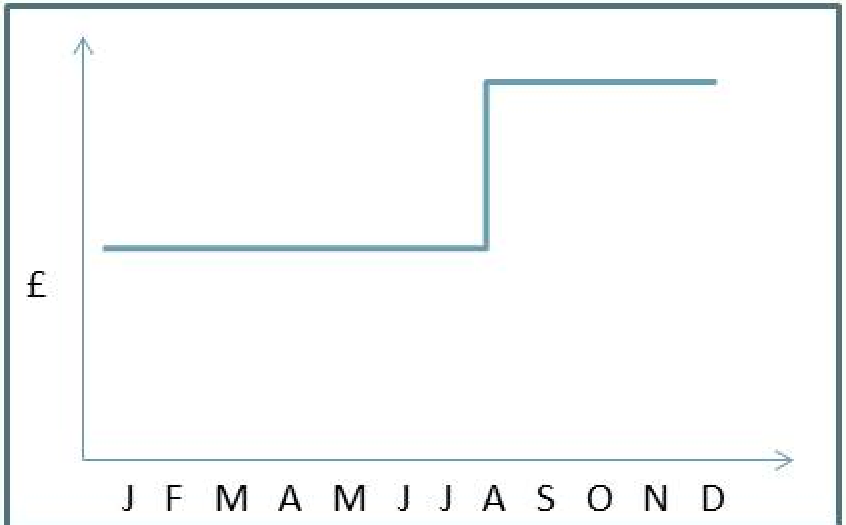

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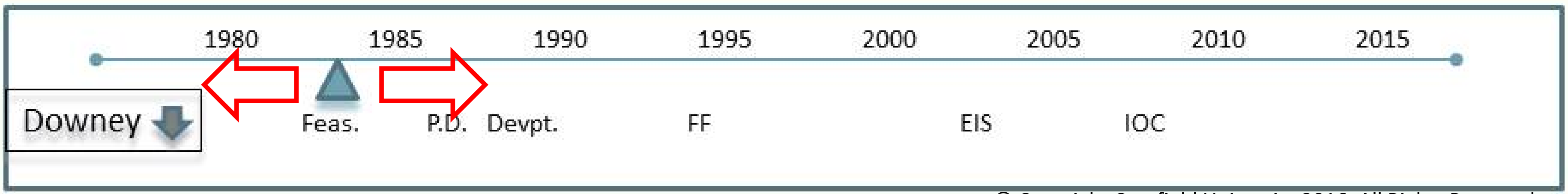

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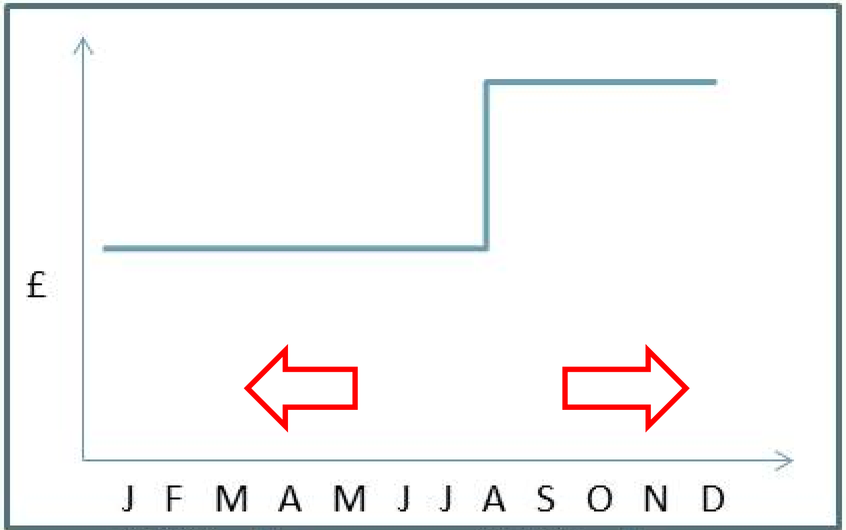

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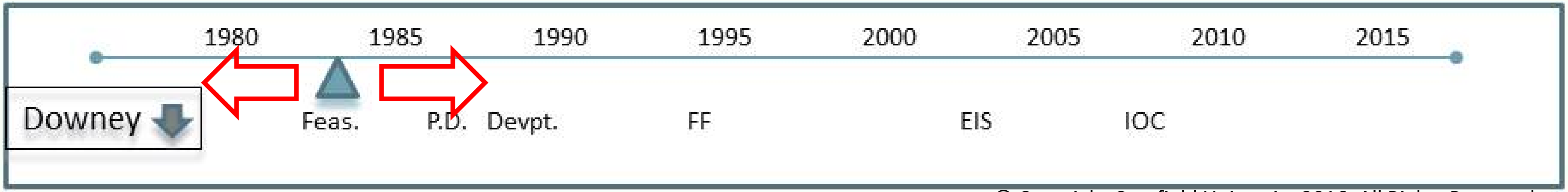

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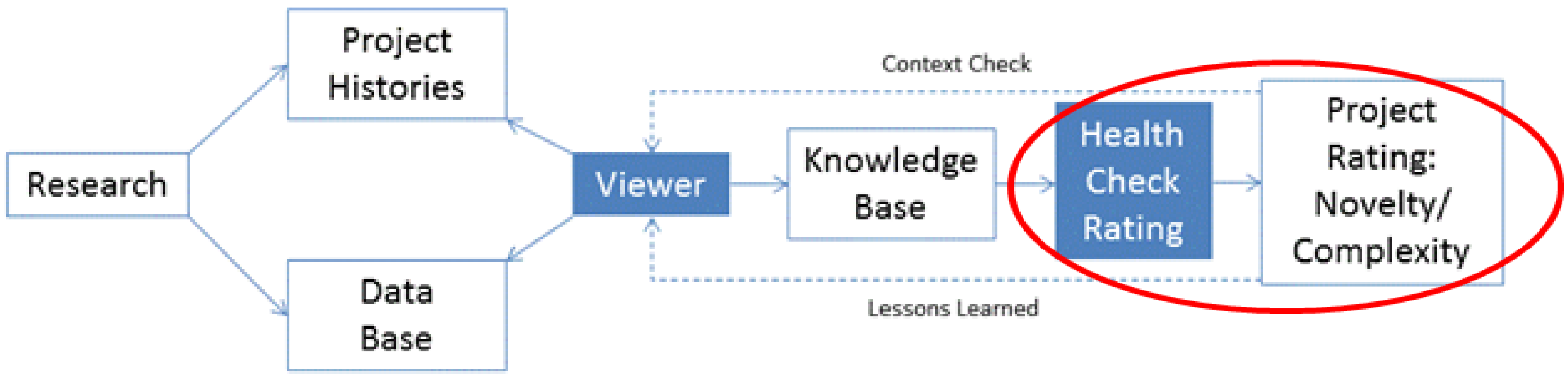
The project



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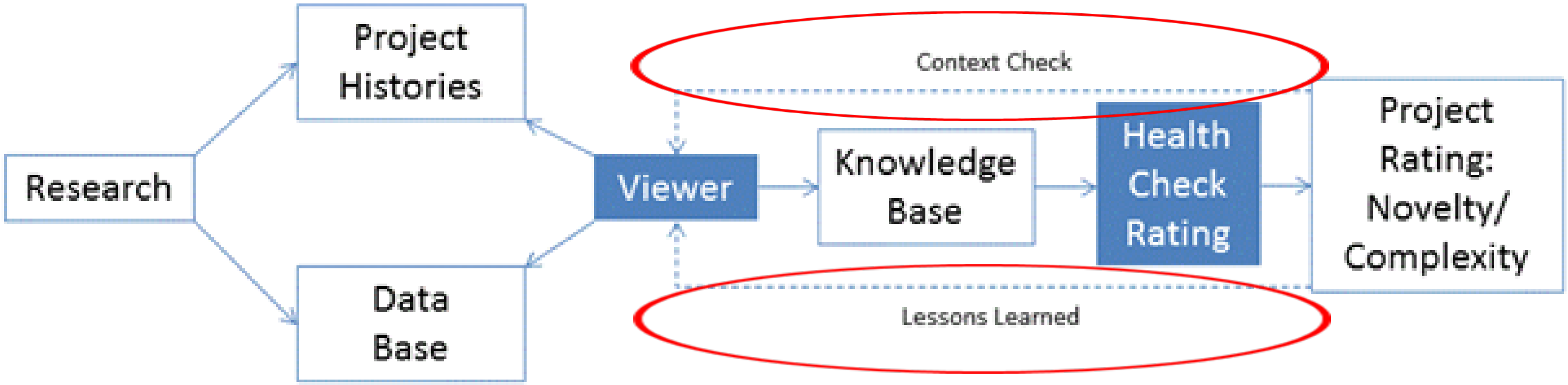
Rating

- Qualitative/subjective inputs
- ‘Polling’ of group(s)
- Capture diverse views
- ‘Cooper Harper’ style hierarchy
- Alphanumeric output
- Acts to identify ‘true likeness’

The project


Research
Project Histories
Data Base
Viewer
Knowledge Base
Health Check Rating
Project Rating: Novelty/ Complexity
Context Check
Lessons Learned

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Technologies

- HTML5 – platform agnostic/future proof
- Meta tagging – ‘Google’ type searching
- Open development by users
- Runs secure/shared/stand-alone
- CD/network/online
- Simple/intuitive/adaptive

Currently 'vanilla' proof of concept

ICE CREAM

Users' preferred flavors

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Future

- "We haven't got the money, so we've got to think!" Rutherford, Manchester

R.V. Jones, Bulletin of the Institute of Physics (1962)13

- Air Systems Programme Data
- Low Cost by Design network
- Oxford – Newton Project
- Forecasting/contracting
- Method works for US?

LCxD

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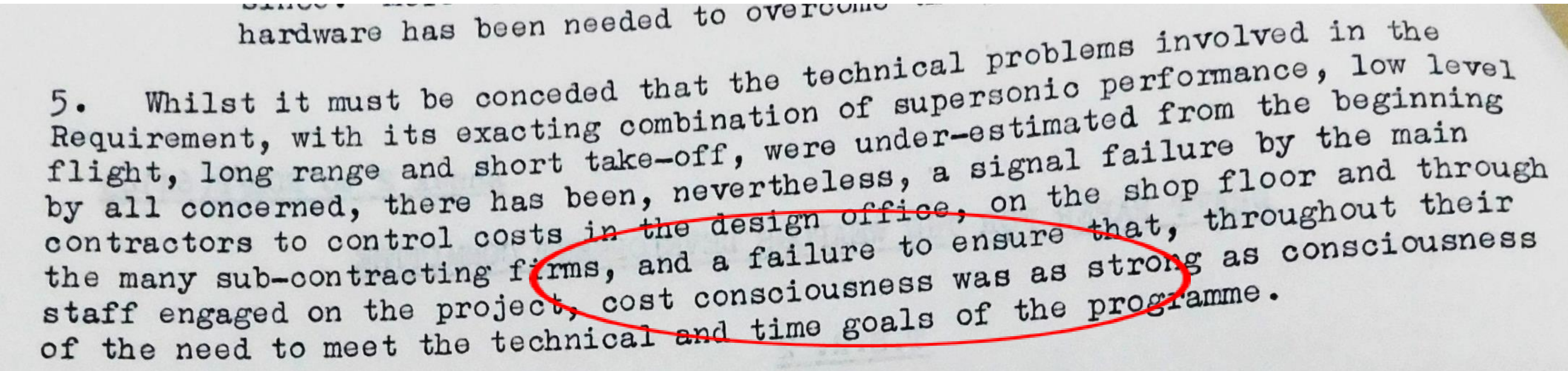

hardware has been needed to overcome

5. Whilst it must be conceded that the technical problems involved in the Requirement, with its exacting combination of supersonic performance, low level flight, long range and short take-off, were under-estimated from the beginning by all concerned, there has been, nevertheless, a signal failure by the main contractors to control costs in the design office, on the shop floor and through the many sub-contracting firms, and a failure to ensure that, throughout their staff engaged on the project, cost consciousness was as strong as consciousness of the need to meet the technical and time goals of the programme.

Source: UK National Archive, AVIA 65/1826

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Thank You.

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