National Audit Office

Strengthening the Preparation of Project Proposals

Large Scientific Facilities

In association with
Department for Innovation, Universities & Skills and Research Councils UK

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Contents

Foreword

The UK's seven Research Councils and those university researchers they sponsor are in the vanguard of global scientific research. With less than 1 per cent of the world's population the UK produces nine per cent of the world's scientific papers which attract twelve per cent of the world's citations indicating the high output and quality of UK research.

To maintain this strong position UK researchers need continuing access to the right scientific research facilities, in the UK and abroad, at the right time and at the right cost. This calls for world class project management practice as well as the performance of world class research. The National Audit Office's 2007 report "Big Science: Public investment in large scientific facilities", showed that in many diverse areas of project management the UK's Research Councils can point to examples of best practice, but, overall there was scope for improvement and a levelling up of project management performance.

This handbook has been prepared by the National Audit Office (NAO), Department for Innovation, Universities and Skills (DIUS) and Research Councils UK (RCUK) to strengthen the effectiveness of project appraisal in particular. It focuses on those project appraisal areas where the National Audit Office findings suggested the greatest attention was needed.

We trust that by jointly providing this guide for those at the sharp end of evaluating the case for, and implementing the UK's capital investment in, world class research facilities we will help ensure continuing leadership on the quantity and quality of UK research. Our aim is also to help develop a better consideration and understanding of how our strategy for achieving scientific excellence can have a real beneficial economic impact and contribute to improving our quality of life.

Comptroller and Auditor General

Director General Science and Innovation

Chair, Research Councils UK Executive Group

Purpose of the Handbook

1 In January 2007 the National Audit Office published a report *Big Science: Public Investment in Large Scientific Facilities*. The report made a number of recommendations relating to the planning and delivery of such facilities including the preparation of project proposals. This handbook supports those recommendations by highlighting current good practice for project teams preparing proposals for large scientific facilities.

2 The handbook supplements but does not replace requirements set out in the HM Treasury Green Book[1] in relation to public sector project appraisal. Instead the handbook highlights those areas where the NAO study found evidence of a need for improved project appraisal, and highlights current examples of good practice.

3 Project teams will need to be aware of, and follow the guidance presented in the Green Book. Those provisions are reflected by the Office of Government Commerce (OGC) in its guidance on procurement, the Gateway review process[2] and the PRINCE2 project management framework.

1 All new programmes and projects should be subject to comprehensive but proportionate assessment, wherever it is practicable, so as best to promote the public interest. The Green Book presents the techniques and issues that should be considered when carrying out assessments and is available at greenbook.treasury.gov.uk.

2 The OGC Gateway process examines programmes and projects at key decision points in their lifecycle. It looks ahead to provide assurance that they can progress successfully to the next stage. Information on the process is available at www.ogc.gov.uk.

Stages in Developing Large Scientific Facility Proposals

4 All proposals must follow a structured appraisal process. The first step is normally inclusion in the Road Map of potential facilities prepared by RCUK. If funds are sought from the DIUS Large Facilities Capital Fund appraisal will then follow a four stage process:

- consideration of an initial proposal by RCUK as the basis for prioritisation of facilities listed in the Road Map. This prioritisation is used by DIUS to earmark support from the Large Facilities Capital Fund;
- consideration of a Science Case[3] by RCUK;
- consideration of a Strategic Outline Business Case – and the outcome of a Gateway 1 review of that Case – by RCUK;
- commitment of funding from the Large Facilities Capital Fund subject to a successful Gateway 2 Review and approval by DIUS.

5 If projects move forward following Gateway 1 review the Strategic Outline Business Case will be developed into a Full Business Case by Gateway 3 – the investment decision.

6 The handbook reflects the Green Book's objective of ensuring comprehensive but proportionate assessment is undertaken. To this end its overall content describes what would be expected at the Strategic Outline Business Case (Gateway 1) stage while the comments at the end of each section describe what would be expected at the initial proposal stage.

3 Details on the content of the Science Case are set out in the Road Map. This handbook concentrates on the content of initial proposals and Strategic Outline Business Cases. The Science Case builds on the initial proposal but costings are likely to have matured and option analysis is likely to have been refined by the time the Science Case is presented.

7 Project teams should ensure that they secure an appropriate level of independent scrutiny on their Gateway Review teams, taking account of their project's risk category and any specific instructions from their sponsoring research council. The National Audit Office study identified use of independent scrutiny as a key factor contributing to improving the quality of Business Cases.

8 Applications to the Large Facilities Capital Fund have a long lead time since projects are prioritised several years in advance. Research Councils and their institutes should decide at an early stage whether they are likely to need support from the Fund, and factor the timing (and uncertainty) into their project plans.

Improvement Areas for Proposals

9 The National Audit Office's Big Science study identified many strengths amongst existing project proposals and Business Cases. The study did, however, identify a number of areas where best practice needed to be more widely adopted and performance needed to be strengthened. Within the "5 case" model[4] of business planning the National Audit Office identified five areas in particular where the standard of analysis could be strengthened. This handbook focuses on those five areas:

- Strategic Case – critical success factors
- Economic Case – identiying options
- Economic Case – costs (including optimism bias)
- Economic Case – benefits
- Financial Case – affordability

4 Office of Government Commerce guidance sets out the "5 Case" model of planning – consistent with Green Book guidance on best practice – where each Business Case includes a strategic case, an economic case, a commercial case, a financial case and a management case.

Strategic Case – Critical Success Factors

The strategic outline case should specify clear critical success factors (measures of success in this context) for the project. These success factors go to the heart of the project's objectives and should be defined in terms which will allow a clear judgement on whether and when they have been achieved.

The definition of what constitutes project delivery or completion requires particular attention for large scientific facilities. Completion of building construction, machine assembly, or equipment delivery may be key milestones but for most facilities it is not until a scientific research programme is in place at the facility that the project can be deemed complete. Critical success factors should make clear what level and type of scientific research programme will mark "completion". For example, a single researcher working on one instrument for a few days is not a credible definition of "completion" for a facility investment justified as a multi-instrument project with capacity to support many scientists full-time.

Success criteria in use should reflect anticipated benefits and may include demand, supply and outcome measures of the kind set out below.

Demand Criteria

- annual number of applications for use
- annual level of use (e.g hours or days) applied for
- number of different individuals applying for use
- annual number of applications achieving specified rating at peer review
- annual level of use sought in applications achieving above rating
- level of applications for – and take up of – posts or visiting researcher access at new/refurbished institute
- occupancy levels and/or rental values of premises made available to market
- level of applications for direct use by industry
- level of applications for use by academic groups involved in collaborations with industry

Supply Criteria

- availability of instrument time (hours or % of capacity)
- machine technical performance (power, brightness)
- machine or building efficiency (energy, materials, support staff costs)
- international ranking of machine's delivered performance
- directly employed and visiting scientist capacity supported by new/refurbished institute
- floor areas and/or unit numbers of premises made available to market

Outcome Criteria

- number of publications arising from facility use
- number of citations of publications arising from machine use
- prizes or awards for work of scientists on the facility
- maintenance of safety and security at facilities
- number of industry collaborations
- number of innovative products developed and/or patented
- performance of companies or business units co-locating with facilities

Requirements at Initial Proposal Stage

Initial proposals should indicate:

- the date by which a facility needs to be available to allow UK scientists to lead (or share leadership in) the lines of scientific enquiry it is designed to support;
- the desired performance and capacity of the facility in relation to comparable international facilities, and, where applicable, the impact on global capacity for the category of facility in question;
- the level of activity that the proposed facility is designed to support, quantified in terms of the number of scientific user days per year, and – in the case of facilities where access is by competitive application – the level of applications which would be judged by the sponsoring research council as indicating a successful facility. For new or refurbished research institute buildings these numbers should reflect the number of researchers – whether employed by the institute or from outside – the building is intended to host;
- Scope for economic outputs through industry collaborations, knowledge transfer etc.

CASE STUDY 1 – DIAMOND RESEARCH COMPLEX

The Diamond research complex identified critical success factors for project delivery, scientific outcomes and value-for-money. The Business Case builds on these success factors by stating how the scientific outcomes will be measured:

- number of high quality researchers (as judged by peer review) attracted to work in the Complex;
- supply versus demand figures;
- publications (number and quality) produced from research at the Complex;
- number of new collaborative programmes developed;
- publications (number and quality) produced from cross-boundary collaborative research;
- number of training posts and future destination of training post holders;
- periodically measuring user feedback;
- outcome of management board and international advisory board review.

Economic Case – Identifying Options

Options should always include a "do nothing" or "do minimum" option. Suggested actions and examples of options are given in Chapter 5 of the Green Book. Other broad options meriting attention for large scientific facilities are:

- providing a UK facility (possibly with contributions from other sources in return for access to shares of its capacity) or contributing to a facility overseas in return for access rights for UK scientists;
- providing a new facility or developing or refurbishing an existing facility;
- providing a facility now or planning to provide a facility later;
- providing a larger or smaller facility, or providing a facility capable of expansion or increased occupancy or use;
- providing a facility in different locations.

International experience is that new large facility requirements are often of a scale which can only be met through international collaboration. It is therefore likely that the option of participating in such collaboration will need to be considered for new proposals.

Depending on the stage at which the UK interest is presented the range of collaborative options may be larger or smaller.

Options should be identified and refined to a level where alternatives can be compared taking into consideration the upfront capital investment cost, the estimated whole life or running cost (including disposal where this is expected to be significant) and anticipated benefits. The extent to which marginal variations around a specific developed option can be accommodated without compromising scientific objectives or other key benefits should be evident e.g. size of facility, facility or programme duration, proportion of facility capacity acquired.

If a location decision is needed at Strategic Outline Case/ Gateway 1 to secure stakeholder commitment or to permit site-specific planning for the facility to advance, cost-benefit analysis of location options should be sufficient and sufficiently independent, to support that decision. If a location decision is not essential at this stage the option analysis should be sufficient to confirm there is at least one viable location – with full appraisal of alternatives to be undertaken later. Where appropriate, project teams should have regard to requirements specified in guidance

from HM Treasury and Office of Government Commerce regarding implementation of the policy on location of office accommodation for public sector activities adopted following the Lyons review.[5]

Options should cover all phases of multi-phase projects. However, where decisions on further phases of a project will be made at a future date, an additional option covering only the currently proposed phase(s) may also be included (and the benefit of further expansion or development noted). Where this "early phase" option is scoped to facilitate some expansion or development at a later date, the nature and scale of the extra work to facilitate that expansion opportunity should be made evident.

Requirements at Initial Proposal Stage

The long list of options presented at this stage should be full, based on wide consultation, and include radical options. From this a short-list will subsequently be identified, partly to keep the appraisal process manageable, but still covering a wide range of potential action (so as not to eliminate prematurely the optimal solution). For large scientific facilities the options cited above for Strategic Outline Cases should be included at the initial stage, together with any others relevant to the specific facility under consideration.

For options involving facilities in the UK the initial proposal should indicate whether the sponsoring research council (not solely the promoting institute or team) believe an appraisal of potential location options will be required for the Strategic Outline Case and if not, why not – having regard to Lyons Review requirements as described above.

Even if the initial proposal indicates a preferred option a range of alternatives – including the "do nothing" or "do minimum" option should continue to be developed through to Strategic Outline Case. Nevertheless some options which do not justify further development effort may be eliminated following consideration of the initial proposal.

5 See Accounting Officer letter GEN 05/05 and supplementary guidance of 26 March 2006 from Treasury and Office of Government Commerce.

CASE STUDY 2 – RESEARCH SHIP JAMES COOK

The Business Case for the James Cook considered the costs and risks to NERC's scientific objectives of seven options:

- do nothing;
- major rebuild/refurbishment of existing research ship Charles Darwin;
- convert an existing vessel which possesses the basic attributes;
- build a new standard vessel;
- build a new vessel to a standard design developed in collaboration with others requiring the same or closely similar requirements;
- build a new "bespoke" vessel to an in-house detailed statement of requirements;
- charter suitable vessels as and when required.

Economic Case – Costs

The economic case should include estimates of all those costs which are consequent upon a decision to proceed. Only costs which give rise to the use of economic resources should be captured, including those which fall on other parties. These should include design costs, the opportunity costs of land and buildings[6], project management costs (both internal and external), construction costs, costs of plant, equipment, furniture and fittings, costs of staff to run, administer and regulate access to the facility – including any additional overheads associated with those staff – rent, utilities, insurance, security/caretaking, repairs and maintenance, and decommissioning costs. Any ultimate disposal value should be included in the economic case.

Estimates of running costs over the lifetime of the facility should be provided for each option within the economic case. An option may be for provision of a test facility only, to prove technologies, their interoperability, or their experimental value. The costs of that option would be limited to those of establishing, proving and decommissioning the test facility. If there is nevertheless an option to use such a test facility to support a programme of scientific research the running costs of that option should be presented.

As design work progresses and cost estimates for options for building or providing access to a facility are refined, the cost estimates for running the facility (or utilising the access acquired) should also be revisited in the light of the latest understanding of the nature and scale of the facility under each option.

6 See Green Book Annex 3

In developing Business Cases project teams should consider the possibility of trade-offs between capital cost and running costs. Up-front investment in energy efficient plant, robotics, or design features which cut future maintenance costs should be considered at the planning stage since this is likely to be more cost-effective than retro-fitting.

Where an option (including the "do minimum" option) involves the closure or run-down of an existing facility the costs – including decommissioning but not redundancy costs (which only feature in the financial case) – should be included in the economic case. Any disposal values arising from the closure or rundown should be included in the economic case for that option.

The source and basis of the cost estimates should be stated – including assumptions. This need not be a lengthy item by item analysis but should be sufficient for reviewers to judge the robustness of the estimate presented to them.

Costs should be stated at constant prices rather than in forecast cash terms for the purpose of the economic case.

Appropriate discount rates should be applied to costs in future years (3.5% up to 30 years ahead – reducing thereafter according to Green Book guidance).

Cost estimates should be adjusted for optimism bias according to the methodology in the Green Book. Appropriate levels of optimism bias should be included reflecting the maturity of work characterisation, remaining risks and the bases of estimates.[7] Project teams should appreciate the difference between contingency provision and optimism bias. Contingency provision covers the unanticipated and hence unmitigatable risk which may be higher than the lower bound of the range of optimism bias (which represents the average bias of projects, with effective risk management, between contract and outturn).

The economic case should include sensitivity analysis indicating how costs and benefits might vary according to differences in assumptions.

7 See Green Book Annex 4

Depreciation and capital charges should be excluded from the economic case. For the economic case options involving different VAT treatments of costs should be presented as if the same VAT treatment applied to each. Nevertheless these elements will need to be considered differently in financial analysis of the affordability of a proposal given budget availability (see below).

Requirements at Initial Proposals Stage

Cost estimates will be refined over time, but the difference between costings in initial proposals and those in Strategic Outline Business Cases will lie more in the evidence base behind them (and the number and detail of options) than their presentation.

Initial proposals should cover the costs of each option presented, should indicate the basis of – and assumptions behind – the estimates, and should indicate a range of likely costs around a point estimate for provisional planning purposes. They should also indicate the principal factors which will drive both capital and running costs where these are known, and include decommissioning costs where appropriate.

The initial proposal should show timings and cost estimates for all phases.

Initial proposals should make clear how risks of cost increases will be shared between funding partners.

The optimism bias allowance in initial proposals should be higher than the appropriate upper bound specified in the Green Book – which is for Strategic Outline Case stage.

Initial proposals should give an indication of whether costs are highly sensitive to scale or largely fixed by the choice to provide a facility at all.

CASE STUDY 3 – LABORATORY OF MOLECULAR BIOLOGY

In developing the Business Case for the new building for the Laboratory of Molecular Biology, the project team estimated the costs of a building with and without interstitial floors. The capital costs of installing such floors was higher than a conventional building but this was offset by lower maintenance costs and avoidance of shut-downs for maintenance and layout changes over the building's life.

The team's mechanical and engineering surveyors also estimated the capital and operational costs of different plant for environmental controls and demonstrated that the configuration with the lowest capital cost was not optimal in terms of lifetime costs.

The team also designed the building to be able to accommodate installation of robotic plant and equipment in laboratories should the technology and costs at the point of fitting out justify its incorporation.

Economic Case – Benefits

Benefits should be quantified whenever possible. It is often difficult to associate monetary values with the benefits of large scientific facilities. Annex 2 of the Green Book provides guidance on valuation of non-market impacts. The framework adopted by RCUK for prioritisation of proposals, and decisions on their progression, is based on weighted scores against a range of criteria covering both the generation of scientific knowledge and its exploitation, overlaid by judgements on the specific merits of competing proposals. The section below is intended to inform that decision-making process, and encourage a greater level of quantification. It is consistent with current work within the Department for Innovation, Universities and Skills on measuring the economic impact of the Research Councils.

Scientific Benefits

The framework for RCUK's assessment of initial proposals for large facilities uses a number of criteria relating to the generation of scientific knowledge including:

- importance (depth) of science knowledge delivered;
- contribution to international positioning of UK science and science strategy;
- timeliness – urgency or potential lost opportunity if delayed;
- breadth of science base that will benefit.

Strategic Outline Business Cases should aim to provide:

- a statement of which areas of scientific research would benefit from access to the facility under each option, and how;
- a statement of how these areas of scientific enquiry fit into the international positioning of UK science, the science strategy of the sponsoring research council, and the 10 year science and technology investment framework;
- an estimate of the current size of the UK scientific communities involved in these areas of research;
- a statement of whether the nature and scale of each option for the facility is predicated on serving currently evident demand from these existing UK communities, forecast increases in demand from within them, or forecast increases in their size;
- the basis of any forecast of increased demand if it underpins the nature or scale of an option;
- comment on the relative risks to realising scientific benefits from differences between options in the timing of their availability and the degree of certainty over the amount of access which can be secured and;
- a statement of the nature of the contribution of each option to the number of skilled scientists working to advance scientific knowledge, or the level of their skills relevant to that purpose.

Economic and Social Benefits

The Research Councils UK assessment framework for initial proposals includes criteria related specifically to economic and social impacts including:

- opportunity for knowledge or technology transfer and innovation, and wider benefits;
- scope for education, training and investment in the skill base
- impact on public understanding and outreach
- match with Government public policy priorities

Within practical limits Strategic Outline Business Cases should therefore aim to provide:

- a statement of the areas of economic activity which could benefit from exploitation of scientific knowledge generated through each option;
- a statement of the areas of public policy which could benefit from exploitation of scientific knowledge generated through each option;
- an indication of the extent to which scientific knowledge generated by use of the facility will be freely available internationally, as opposed to being the intellectual property of the body conducting or funding the research;
- an indication of the current scale and value of UK economic exploitation of scientific advances in the areas of research supported by the facility;
- an indication of the order of magnitude of increases in the scale and value of this exploitation activity which might be associated with the option for a new facility.
- an indication of the principal means by which it is anticipated the benefits of each option will be captured for the UK economy and taxpayers, for example:
  - direct use of facilities by industry;
  - indirect use of facilities by industry via collaborations with academic research groups;
  - spin-off companies from research institutes or higher education institutes based on knowledge gained from their research groups' use of the facility and the emerging technologies;

- generation of new economic activity in the vicinity of the facility to exploit the opportunity to interact with the researchers and commercial entities who use it;
- specific knowledge transfer agreements between host institutes of research groups and private companies;
- awareness by UK businesses of knowledge derived from the facilities and published on a non-proprietary basis, leading to:
  - informal dialogue with research groups or the firm's own scientific advisors followed by application and exploitation;
  - contractual agreements for support in application and exploitation.
- contributions to the efficiency of public service delivery;
- contributions to the effectiveness of public policy design.

Requirements at Initial Proposals Stage

Initial proposals should address the benefits assessment criteria specified by Research Councils UK. They should indicate in particular:

- the areas of research which would benefit from the facility;
- the broad nature and scale of exploitation benefits, including the "nearness to market" of scientific advances derived from facility use, the likely level of direct commercial use, and any public policy or public service benefits which can reasonably be anticipated;
- the current size of the UK scientific community which would benefit from provision of the facility, currently evident levels of met and unmet demand for any comparable facility, and the basis of any assumptions about increases in either which underpin the scale of the core proposal.

CASE STUDY 4 – DIAMOND SYNCHROTRON – SCIENTIFIC BENEFITS

The Business Case for the Diamond Synchrotron presented the following information to support judgements on scientific benefits:

- range of scientific enquiry being pursued using synchrotron radiation;
- current size of the UK user community on the existing Synchrotron Radiation Source;
- level of peer-supported demand for access to the existing Synchrotron Radiation Source;
- number of publications arising from use of the existing Synchrotron Radiation Source and UK use of the European Synchrotron Radiation Facility machine;
- achievements from UK exploitation of synchrotron radiation to date;
- future fields of research which will benefit from access to synchrotron radiation;
- outcome of a survey of the UK life science community's estimates of their future demand for access to synchrotron radiation;
- outcome of user consultations on anticipated requirements for availability of synchrotron radiation;
- projections of funding agencies of requirements for availability of synchrotron radiation.

Financial Case

While the economic case focuses on whether the benefit to the UK taxpayer exceeds the cost, the financial case focuses on whether the institution or institutions collectively bearing the cost can afford to do so within the financial regime they face.

In the financial case costs and income should be split between capital and resource and between funding agencies.

Any funding gap and responsibility for meeting any budget overrun should be allocated between funders in accordance with risk allocation principles agreed by them at the outset, and on the understanding that the Large Facilities Capital Fund contribution will not normally be increased once earmarked.

The financial case should include consideration of depreciation and finance charges, differences in taxation (including VAT), redundancy costs, and cash forecasts of expenditure and income in future years.

The financial case should consider the sources of funding for the project, both for the capital cost of building the facility and the ongoing costs of running it and meeting depreciation and capital charges.

Sponsoring councils should take account of the fact that they will bear the full costs of depreciation and capital charges for the large facility assets they acquire, even if a proportion of the capital cost is borne by the Large Facilities Capital Fund.

Resource cover for these costs is not guaranteed but the level of cover (if any) for these costs will be the subject of Comprehensive Spending Review outcomes and settlements for individual years. The same applies for operating costs where there is a degree of risk in the availability of future cover, even if costs remain as estimated at Strategic Outline Business Case.

Similarly, some large facility projects require capital commitments beyond the current Spending Review window. Research councils and other funders need to manage the risk of committing their budgets before the outcomes of future Spending Reviews are known.

The financial analysis should be updated as the Business Case develops to provide assurance that the preferred option is affordable subject to risks which the sponsoring council believes it can manage.

Requirements at Initial Proposals Stage

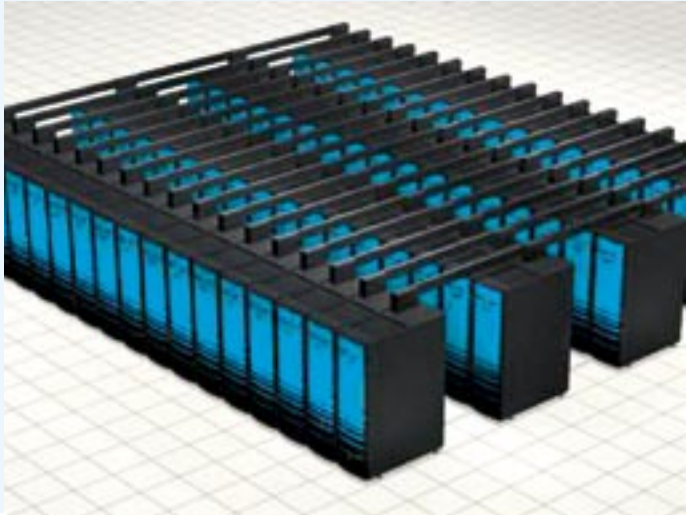
Full financial analysis need not be presented in the initial proposals submitted to RCUK, but the funding sources and estimated amounts for both construction and operating costs should be shown. Proposals should also indicate who bears the risks of costs in excess of estimates, or shortfalls in funding availability.

Preliminary judgements on affordability should have been applied by co-funders (other than the Large Facilities Capital Fund) before a sponsoring research council submits a proposal. Those judgements should have been informed by a financial analysis which parallels the cost-benefit analysis requirements at initial stage.

CASE STUDY 5 – HECToR HIGH PERFORMANCE COMPUTER SERVICE

The financial analysis within the Business Case for the HECToR high performance computer service considered not only the capital and running costs of the project in each of the six years of operation, but also the depreciation and capital charges over that period.

The funding plan covered all of these elements and distinguished between who was providing capital cover and who was providing resource cover, making the affordability of the project transparent to the research councils supporting it and the Department for Innovation, Universities and Skills. The funding plan also indicated what resources were expected from research councils existing baselines and what resources were expected from the next Spending Review settlement.



About the National Audit Office

The National Audit Office scrutinises public spending on behalf of Parliament. The Comptroller and Auditor General is an Officer of the House of Commons. He is the head of the National Audit Office, which employs some 850 staff. He, and the National Audit Office, are totally independent of Government. He certifies the accounts of all Government departments and a wide range of other public sector bodies; and he has statutory authority to report to Parliament on the economy, efficiency and effectiveness with which departments and other bodies have used their resources. Our work saves the taxpayer millions of pounds every year. At least £8 for every £1 spent running the Office.

This report can be found on the National Audit Office website at www.nao.org.uk

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