Government support for Beagle 2 : responses to the Committee's twelfth report of session 2003-04: fourth special report of session 2004-05 / House of Commons, Science and Technology Committee.

House of Commons

Science and Technology Committee

Government support for Beagle 2: Responses to the Committee's Twelfth Report of Session 2003–04

Fourth Special Report of Session 2004–05

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The Science and Technology Committee

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Fourth Special Report

On 2 November 2004 the Science and Technology Committee published its Twelfth Report of Session 2003–04, *Government support for Beagle 2* as House of Commons paper No. 711. On 3 February 2005 the Committee received a memorandum from the Government which contained a response to the Report. The memorandum is published without comment as an appendix to this Report.

The Committee also received a response from the European Space Agency. This is also published without comment as an appendix to this Report.

Appendix 1

Government Response

Introduction

The Government thanks the Science and Technology Committee for its thorough report on the Beagle 2 project. It shares the Committee's view that Beagle 2 was an exciting and important project, both in terms of its scientific merit and the wider benefits for the UK. The Government confirms the Committee's observation that while the project was recognised to be high risk—as evidenced by the historic failure rate of Mars missions—the potential scientific benefits were very high. No definitive technical explanation for the loss of Beagle 2 has so far been identified. As the Committee succinctly notes: "on another day, the lander might have made it". The recent success of the European Space Agency's Huygens probe to Titan—which relied on contributions from some of the same British universities, laboratories and industrial companies as did Beagle 2—shows that the UK can succeed in planetary exploration. Nonetheless, the Government is determined to learn the organisational and management lessons from the Beagle 2 project.

The Government welcomes the Committee's clear statement that it should not be shy about taking risks in science if the potential benefits are substantial, and that in the case of Beagle 2, the project was a risk worth taking. The Committee's report also confirms that at no time did the Beagle 2 consortium expect sole source support from Government.

While the Government accepts the report's key point that it would have been better if full funding had been provided at the outset of the project, as the Committee also notes, the relevant Research Council did not have the necessary financial flexibility at that time to consider an unplanned project of the nature and size of Beagle 2. In this regard, the Committee broadly echoes one of the published recommendations of the European Space Agency (ESA)/UK Joint Inquiry that national agencies should 'ensure that the required financing is committed at the outset' of each phase of a prospective new project. In its response to the earlier report, the Government has agreed this principle. Indeed, if such funding had been available, some of the consequences referred to by the Committee would not have arisen. In particular, a smoother build-up of the industrial team would have occurred and the schedule for development and testing programme would have been less

compressed. To an extent which cannot be precisely estimated, the overall project risk would have been reduced.

In general, a phased approach to funding such projects is a sensible one, particularly in managing risk in a step by step manner. Often large projects, or those with significant risk, undergo a preliminary study with limited initial funding in order to investigate risks, identify options and better estimate overall project costs. Suitable cost margins to cover the risks identified are also defined. On this basis a balanced and considered decision can be made whether or not to proceed to full implementation. Indeed, this approach is commonly used on spacecraft projects by ESA and other Agencies. In the case of the scientific instruments carried by these spacecraft, however, this has been less common, but it is becoming more necessary as the complexity of these instruments has increased. In the case of Beagle 2—which was treated as an instrument although had more of the characteristics of a complex small spacecraft—it is recognised that the absence of initial funding for definition and cost estimation was an unfortunate consequence of the lack of financial flexibility at that time.

The UK—through the Particle Physics and Astronomy Research Council (PPARC)—has therefore taken specific action to address this issue for future space science projects where national authorities are expected to contribute to instrument costs. It has worked closely with ESA to improve the arrangements put in place before new collaborative projects are started. The first result of this effort has been the signature in June 2004 by ESA, PPARC and the agencies of six other countries of a Multi-lateral Agreement which covers the provision of the Mid-Infra Red Instrument (MIRI) for NASA's James Webb Space Telescope. This is a project of comparable overall cost to Beagle 2 and one of equally great scientific potential. The approach which is being used marks a significant change with respect to previous ESA scientific missions.

In the past the funding and the development of the scientific instruments was agreed by the participating ESA Member States on the basis of purely informal arrangements with ESA. In this case, the Member States involved in MIRI have agreed on formally guaranteeing the required level of funding on the basis of a multi-lateral international agreement. This approach keeps the lead scientists ('Principal Investigators') in key roles. For MIRI, a preliminary study phase was executed with funding contributions from ESA Member States, including significant participation from the UK (PPARC). Risk assessment has been carried out and contingency cost allocations have been made by each national partner—for their own contributions—and also at an overall project level by ESA. Although the project is still in its early stages, progress so far has been smooth as evidenced by a successful Preliminary Design Review carried out in November 2004.

A similar formal management approach is being adopted for an instrument package to be flown on the Laser Interferometer Space Antenna (LISA) spacecraft which will subsequently lead to LISA—the world's first space-based gravity wave observatory. The instrument project also involves UK contributions and the UK delegate to ESA's Science Programme Committee will act as the first chair of the European-level Steering Committee for the project. Further, in July 2004, ESA placed an €80m industrial contract with EADS Astrium Ltd. to build the spacecraft for LISA Pathfinder. We believe that this evidence of continued active engagement with new scientific programmes and the associated changes described above will allay the Committee's fears that ESA's experience with Beagle 2 may

colour its view of the desirability of future collaborations with the UK as well as ensuring that the lessons from the project are not lost.

Response to Recommendations

1. We welcome the establishment in the 2004 Spending Review of a strategic fund to be allocated by the DGRC but are not persuaded that it will rectify the serious weaknesses which the Beagle 2 project highlighted in the Government's capacity to respond to sudden demand. In the absence of other funding streams to cater for such demand, we recommend that the Government considers earmarking this fund primarily for major projects and facilities. (Paragraph 33)

Turning to the Report's detailed Conclusions and Recommendations, the Committee believes that the Beagle 2 project has highlighted a weakness in the Government's ability to respond to a sudden demand. The Government welcomes the Committee's recognition of the move in SR04 to provide greater flexibility in responding to emerging priorities. The funding concerned (£35m pa) from 2006-07 represents a significant sum and, as outlined in the Science and Innovation Investment Framework 2004-2014, is intended for use "where it is necessary to focus research effort, build national capacity (including infrastructure) or to seize opportunities from international partnership". Major projects and facilities are therefore already envisaged as being within its scope. It is entirely possible, however, that proposals may emerge for important research effort which require relatively small investment to provide momentum and which could not properly be described as major projects or facilities, as suggested in the Report. The Government does not therefore believe that it would be right to limit the scope of the fund to such purposes. In addition, the Office of Science and Technology (OST) is in the process of developing a strategic financial framework to ensure the maximum benefit—including flexibility—is obtained from the Science budget as a whole.

2. We conclude that the pursuit of sponsorship income was an innovative and necessary attempt to meet the funding gaps which were evident in the programme from an early stage. But it did nothing to encourage a realistic assessment of the risks of the project or an open dialogue between participants. It also affected the credibility of the project, which had an impact on the degree of support for it in some quarters. Whilst in the right circumstances there may be a place for commercial sponsorship in such missions, we believe that in this case the DTI should have been focussing its efforts on finding sufficient funding for the project rather than relying upon the securing of commercial sponsorship. We recommend that in future the DTI is extremely cautious about part-funding projects which are reliant to a significant degree on the future attraction of commercial sponsorship. At the very least, DTI needs to satisfy itself of the availability of sufficient funding in the event that commercial avenues prove unproductive. (Paragraph 59)

The Committee recommends that in future the DTI is extremely cautious about part-funding projects which are reliant to a significant degree on the future attraction of commercial sponsorship. Noting the force of this argument—and while maintaining that there is a place for innovative funding mechanisms such as well-designed sponsorship—

the Government agrees that the DTI should verify at the outset that such funds are "real", and, if not, satisfy itself of the availability of sufficient funding to bridge any shortfall.

3. Had a Mars lander been part of the original mission, and managed by ESA, we suspect that it would have been given a priority commensurate with its potential scientific output, with mass levels tailored accordingly to give it a greater chance of success. (Paragraph 65)

The Committee suggests that had a Mars lander been part of the original mission, and managed by ESA, it would have been given a priority commensurate with its potential scientific output, with mass levels tailored accordingly to give it a greater chance of success. However, it was the norm in 1997/8 to treat instruments (including landers) as nationally funded items and therefore the project began in response to an open Announcement of Opportunity. One of the Recommendations of the Beagle 2 Commission of Inquiry was that "Future lander missions should be under the responsibility of an Agency with appropriate capability and resources to manage it. The lander/orbiter mission should be managed as an integrated whole. Nationally—funded science instruments should be included in the lander on the same basis as on the orbiter". The Government has accepted this recommendation.

4. The ESA leadership responded positively and flexibly in 2000 to the financial difficulties in which the Beagle 2 team found itself and helped to keep the project alive. However, there appears to have been a latent resistance among Member States to the British-led lander, no doubt in part due to a perception that this was an exercise in promoting UK national scientific interests. This made it difficult for the ESA secretariat to push for more funds when the project met further difficulties, although we are not persuaded that every effort was made on this front. (Paragraph 50)

The Committee notes that the management of ESA responded positively and flexibly in 2000 to the financial difficulties of the Beagle 2 project. However, it is not persuaded that every effort was made by ESA on this front. For its part, the Government wishes to place on record its great appreciation of the considerable contributions—both financial and personal—made by the ESA Executive and other member states towards the completion of the Beagle 2 project.

5. It is extremely disappointing that ESA, the UK Government and the project team were unable to co-operate in such a manner as to give the lander the maximum possible chance of success. We believe that both the Beagle 2 project team and the UK Government should have done more to persuade ESA to take greater responsibility for managing the lander project, if necessary, at the expense of some UK ownership. For its part, ESA should not have been influenced so much by the apparent attraction of getting a lander for free, albeit at the expense of European ownership. It should now recognise that this was a mistake and ensure that it takes full management responsibility for similar future missions. (Paragraph 69)

The Committee suggests that ESA should not have been influenced so much by the apparent attraction of getting a lander for free, albeit at the expense of European ownership. It suggests that it takes full management responsibility for similar future missions. Both Government and ESA have accepted that future lander projects would be

led by ESA or a comparable agency. However, in accordance with current practice, provision of instruments for ESA space science missions will in general continue to rest with the authorities within individual member states. Nevertheless, more formal arrangements on project funding, responsibilities and integration—as described above—are expected to reduce the risks associated with this approach by ensuring that responsibilities are clearly defined at the outset.

6. Had ESA implemented the lesson of earlier failed missions on the importance of communication between lander and orbiter, it would have secured a vast amount of information which could have been used to help establish what happened to the lander and therefore to reduce the risk of future failures. It is a pity that this lesson had not been learned from two previous missions. (Paragraph 70)

The Committee comments that ESA should have implemented the lesson of earlier failed missions on the importance of communication between lander and orbiter, and so would have secured a vast amount of information which could have been used to help establish what happened to the lander and therefore to reduce the risk of future failures. However, the event which led to a change in NASA policy (the loss of the Mars Polar Lander) took place in December 1999 and the increased priority for having communication between lander and orbiter was established later. NASA's Mars Pathfinder of 1996 had been successful using a "silent" Entry Descent and Landing System. Nonetheless, Government has agreed that future landers should have a descent communications system as recommended in the joint Commission of Inquiry.

7. The project went well beyond the normal scope of the work of a Principal Investigator. The consortium leadership was understandably keen to maintain control over what was very much the team's own initiative, which was pursued with admirable determination and considerable success. The team was perhaps unduly reluctant to accept that the project as a whole may have benefited from greater involvement from ESA, which could have provided it with the necessary financial resources. It was the absence of the guaranteed funding that made a formal agreement between participating parties difficult to achieve. This in turn was a fundamental weakness in the project management. (Paragraph 75)

8. The establishment of the Casani review was a useful means of gaining an independent assessment of the project. Having commissioned it, ESA should have taken greater responsibility for implementing the most important of its recommendations in full. (Paragraph 79)

9. For far too long the Government failed to ensure that the nature and extent of the risks were identified accurately so that the funding necessary to help mitigate those risks as far as possible could be provided. The failure by all parties to establish at the outset some quite basic elements of cost attribution accentuated funding difficulties. Once they became financially committed, both the Government and ESA took steps to monitor the project, but neither was willing or able to ensure that the recommendations of their various reviews were fully implemented. (Paragraph 88)

The Committee feels that the project went well beyond the normal scope of the work of a Principal Investigator and that the team was perhaps unduly reluctant to accept that the

project as a whole may have benefited from greater involvement from ESA, which could have provided it with the necessary financial resources. The Government believes that by following the improved approach, both to provision of instrumentation for ESA space science projects and landers described above, it is both possible and desirable for Principal Investigators to maintain a strong scientific involvement in new projects while also ensuring that the correct management and cost oversight is maintained by ESA and the UK authorities.

Government and ESA have accepted that a more extensive risk analysis should be conducted at an early stage of such an exciting and complex project. These processes are built into the improved management structure of new instrument projects as described above. The Committee however confirms that such "high risk" projects can be justified by the high science return and even where there are demanding windows of opportunity, and this point is noted by Government.

Due to the way in which the project started, the Government agrees that it was not possible to retire all risks at the outset. As the project continued, it became apparent that too much reliance had been placed on access by UK industry to US experience, accentuated by ITAR considerations. As a result, additional risk mitigation technology development had to be undertaken in partnership between Government and industry.

10. Relations between ESA and the UK side were strained by different attitudes towards the lander. Professor Southwood clearly had very strong doubts about the lander's chances of success. He should have made these reservations clear – formally – in order that they could be addressed. (Paragraph 91)

The Committee suggests that relations between ESA and the UK side were strained by different attitudes towards the lander. However, Government believes that the situation was as follows: on first arrival in post, the ESA Director of Science was concerned about the viability of the project. Subsequently, and after negotiation of the Heads of Agreement, he no longer held those severe doubts and signed that Agreement on behalf of ESA. Both ESA and Government were aware of the residual risks and in particular the critical nature of further tests of the EDLS.

11. We welcome the fact that the Government recognised the wider benefits of Beagle 2 in citing public understanding of science goals as one of the factors contributing to its support for the project. (Paragraph 98)

12. We recommend that in future decisions on support for collaborative and UK-led projects the Government sets out the weight it assigns to the wider public benefits as well as the economic analysis. (Paragraph 99)

The Committee notes that in its assessment of Beagle 2, the Government took into account the benefits to the UK beyond the specific scientific goals. It recommends that in future decisions on support for collaborative and UK-led projects the Government sets out the weight it assigns to the wider public benefits as well as the economic analysis. The Government welcomes the recognition that it sought to take into account the wider technological and societal benefits of Beagle 2. More generally, the Government recognises the importance of the wider benefits of research in society including public understanding of science. A new regime of performance management is being developed which will look

to include aspects of science in society to help government better measure the value of some of these benefits. Inspiring people and the generating public interest in science are very useful benefits, however the main driver for research is excellent science.

13. We commend the efforts of the Government and others to use the Beagle 2 project as a tool for science education. We recommend that the use made of the lessons devised is monitored and that, if successful, similar approaches are adopted with other high profile science missions. (Paragraph 100)

The Government welcomes the Committee's endorsement of the use of Beagle in science education. It will monitor and evaluate on a best-effort basis the use made of the lessons devised. It agrees that similar approaches could be used for other high-profile missions, and indeed new educational resources linking the Cassini-Huygens mission to schools' curriculum—and funded by the Department for Education and Skills (DfES)—have just been released by BNSC and by PPARC. Government is also pleased to announce that the DfES has recently joined the British National Space Centre partnership, with the expectation that space can be linked better to school education at policy and delivery levels, and that there will be a strategic framework including stakeholder organisations (Science Learning Centres, learned societies, etc) for further developments in this area.

14. We welcome the UK's full participation in the preparatory phase of ESA's Aurora space exploration programme. We hope that this engagement at the outset will help the UK shape the content of the programme and gain substantially from it in terms of industrial and academic participation. In view of wider considerations relating to the educational, industrial and science in society agenda, we believe that Government, not just PPARC, should ensure that UK plc is in a position to build on the scientific base established by the Beagle team and to support participation in future planetary exploration missions, on a well defined multinational basis. OST and DTI should examine the case for UK participation from the point of view of their different objectives and provide the appropriate support, to add to that of PPARC, in a co-ordinated way. (Paragraph 109)

Turning to the future, PPARC announced on 1 October its decision to invest £5.0m in planetary exploration, comprising of £3.5m in the preparatory phase of ESA's 'Aurora' programme, supported by an additional £1.5m in national work. This decision followed a detailed process of consultation with the UK planetary science, other interested research communities and the UK space industry on the UK's science and technology priorities. This contribution will make the UK the second largest contributor to the programme, thus precisely meeting the Committee's stated goal that future missions should be managed by ESA with strong UK participation. Moreover, it will allow the UK properly to evaluate the benefits and risks of the programme before any commitment to full funding is made. Given the likely timing of a decision on implementing the Aurora programme PPARC has also prepared, in the context of SR2004, an estimate of the likely cost of the UK achieving leadership in the programme.

The Committee suggests that in view of wider considerations relating to the educational, industrial and science in society agenda, the Government and not just PPARC, should ensure that UK plc is in a position to build on the scientific base established by the Beagle

team and to support participation in future planetary exploration missions, on a well defined multinational basis.

The OST is responsible for distribution of the science budget and normally works with and through bodies such as PPARC to deliver outputs such as research and ensuring that UK plc is in a position to build on the research funded through the budget. In keeping with this approach, PPARC is taking two actions. First, PPARC is setting up a national Aurora Advisory Committee to provide detailed advice in assigning priorities to the UK's involvement in the preparatory phase of the ESA programme. In particular, it will guide the UK's interaction with the ESA Aurora Board of Participants, which is the delegate management committee. The Aurora Advisory Committee (AurAC) will be chaired by Dr Mark Sims of Leicester University. Dr Sims was the Mission Manager of Beagle 2. The membership will be selected by agreement with the Chair and will be drawn from both academia and industry. The focus of this group will thus be on maximizing the UK's influence in the ESA programme and the return to be obtained from PPARC's investment. For its part, DTI has developed and launched a Technology Strategy to be implemented through a new Technology Board which will assign priorities and funding to priority technology areas.

Secondly, an ad hoc Planetary Exploration Assessment Group will be created comprising representatives of all the potentially interested Research Councils; government partners plus the Chair of AurAC. This will be tasked with documenting and assessing the range of benefits that could be obtained from full participation in implementing a programme of planetary exploration. This Group will build on the cross-research council consultation exercise carried out by PPARC in 2004. It will take evidence from all interested external individuals and organizations and assist in providing advice to Ministers on whether such a programme should be supported by the UK.

In order to support the decision process, DTI is providing funds to undertake a systematic assessment of the opportunities for the UK in the exploitation of technology from a planetary exploration programme into non-space applications. Possibilities in areas such as healthcare and security are foreseen and the results of this study will be available within a few months.

15. The decision not to publish Commission of Inquiry's report in full was based on the sensitivities of the parties involved rather than any convincing legal or commercial considerations. This is an affront to accountability. We recommend that the full report be published without delay. (Paragraph 116)

The report was always seen by BNSC and ESA as an internal inquiry. Its purpose was to learn lessons for the future. There were also concerns about the confidentiality of commercial information. The organisations involved were given a strong indication that the information they supplied was only for the use of the inquiry. For these reasons the report was not published. ESA and the UK did however think it right that the recommendations of the report should be published as these covered the most important issues. The Science and Technology Select Committee was also confidentially given a copy of the full report. Subsequently, in view of the Committee's strongly held view that the report should be published in full, we have discussed the issue again with ESA and have persuaded them that the report should be published. We have also had further discussions

with the other organisations involved about now publishing the report and they are aware that the report is being published today. The contents of the report have not been agreed with the parties.

Conclusion

In conclusion, the Government appreciates the recognition given by the Committee of the efforts by all concerned to make a success of the project. We affirm that substantial benefits have been secured in positioning the UK to participate in future planetary exploration; in strengthening links between the academic and industrial communities; and in connecting the UK's science community with the wider society. In its report, the Committee raised important funding and management issues. The Government believes that these have not only been recognised but are already acted upon in the preparation of major space science projects.

February 2005

Appendix 2

Response from the European Space Agency

Introduction

ESA takes note with satisfaction of the general conclusions of the House of Common Select Committee on Science and Technology, as expressed in paragraph 119, and recommendations 18, 19, 20, 22, and associates itself in praising the UK Minister for having given a rare example of keen interest and enthusiasm, which on this occasion, unfortunately, met with adverse fortune.

I. In particular 22 of the report, welcoming the UK's full participation in the preparatory phase of ESA's Aurora space exploration, is seen by ESA with particular satisfaction, hopefully setting an authoritative example for the yet undecided ESA Member States.

II. ESA feels that recommendation 22 is based on the various benefits produced by the Beagle 2 project, in spite of its failure. These benefits are listed in detail by the Select Committee and expressively summarised in the statement that "*the high public profile and ambitious nature of the Beagle 2 project is likely to have generated an interest in science that countless Research Council programmes could never match*"(99). They range from benefits to UK science and industry, by giving the UK Government a head start in Aurora, to benefits to the public understanding of space and education (96, 97, 98, 99, 100, 101, 106).

III. While being sincerely happy that the benefits noted in (II) above are recognised, ESA notes that most are direct benefits for the UK and only indirect for Europe. ESA believes that much was grounded in the fact that Beagle 2 was clearly labeled as a UK enterprise, led by a Briton, Professor Pillinger, whose talents as a scientist merge with equally outstanding talents in communicating with the general public.

IV. ESA agrees that Beagle 2 was worth doing in spite of its failure, but feels that the report discounts the fact that most of the direct benefits to the UK were due to the unorthodox way Beagle 2 was implemented. The Select Committee's recommendations, if in place before the fact, would have led to the elimination of most of the UK-specific benefits listed by the report. They would also have been likely to lead to an early exclusion of Beagle 2 from the Mars Express programme.

V. Many statements in the report, which are negative toward ESA, seem to be based on not taking account of two facts which, unfortunately, seem not to have been explained to the Select Committee:

i. Beagle 2 was never accepted by SPC as more than a valuable complement to the core payload. It thus could not have been a first priority element of the mission. The 1997 Mars Express Science Management Plan, which was agreed by the SPC, states on page 1, in bold characters:

"The Mars Express Orbiter spacecraft represents the core of the mission, being scientifically justified on its own investigations such as high-resolution imaging and mineralogical mapping of the surface, radar sounding of the subsurface structure

down to the permafrost, precise determination of the atmospheric circulation and composition, and study of the interaction of the atmosphere with the interplanetary medium, while the Lander Modules are considered a very valuable complement to the mission".

ii. Beagle 2 was only a small part of the overall responsibility of ESA SPC at the time (see also VI below).

The report gives the impression of there being only three players or groups of players, i.e. the Beagle 2 consortium, the UK Government, and the ESA Executive (with an infinite reserve of money). In fact, the ESA Science Programme had limited resources and a multi-project plan to run, in which additional resources to Beagle would have meant less resources to other, equally or more important instruments, and less resources to other, equally or more important missions.

There are two other statements by the Select Committee report that seem to ESA misinformed:

" 26. After the failure of the Mars 96 mission, ESA was in need of a success".

At the time ESA projects like the Infrared Space Observatory (ISO), Ulysses, the Hubble Space Telescope and SOHO were producing data, images and concepts which will stay with us and are seen as successes by all observers. The failure of Mars 96, being a Russian (or originally, a Soviet) mission, there was no reason for ESA to feel implicated. While proposing a re-flight of the European Mars 96 instruments, ESA wished to give a second chance to scientists who, against the advice of ESA, had dedicated years of work to put a payload on a Russian mission, which eventually had let them down. The decision to fly Mars Express took place in 1998-1999, by which time XMM and Cluster II were nearing launch, ISO had terminated its record-breaking mission and Hipparcos had produced its unique catalogue.

"117. ....ESA saw the Lander as a means of enlivening an otherwise unambitious mission to Mars...".

This remark shows a regrettable failure to explain to the Select Committee the remarkable technical and scientific successes of the Mars Express mission. The unique 3-D images taken with the (German) High Resolution Stereo Colour Camera alone show that the statement in 117 is without foundation. Moreover, at the time of the Mars Express conception, not even 50% of Mars missions had achieved their objective. Therefore *any* Mars mission was (and is) ambitious. In addition Mars Express was to be one of the very few examples of cheaper-faster-better missions, a catchword which was invented in the US, but whose most successful application was with Mars Express in Europe.

VI. The Select Committee report candidly admits that, had the recommendations of the Commission of Inquiry already been in place, Beagle 2 would not have made it on board the Orbiter (83). Also, the reports recognises that when resources were not forthcoming (recommendation 4), milestones were not met, tests were not made (recommendation 6), recommendations made by reviews were not implemented (recommendation 13 and 14), ESA made all sort of exceptions in favour of Beagle 2 (in fact more than for any other instrument). These exceptions would never have been made, were it not for the personality

of Professor Pillinger, the interest of the UK Government (unparalleled in any Member State), and the consensus wish of the SPC to take a success-oriented decision for a worthy cause, with the UK bearing a large portion of the cost. *The gradual increase of support by the UK Government was instrumental in obtaining a parallel, gradual increase of support by the SPC.*

Within this context, the Agency felt that it was appropriate to make exceptions, and—if appropriate—it might make exceptions again in the future. Ultimately, this concept seems to be shared also by the Committee (83).

However, ESA does not accept that it could have tried harder to persuade the Member States to provide the necessary support once the Lander started to experience difficulties (83). It is unfortunate that the point was not clearly made to the Committee, that the SPC had wider responsibilities, namely to run a programme which contained many missions and safeguard the interests of many communities. The introduction of Mars Express, as mentioned also in the Select Committee Report (25), was seen with displeasure especially by the astronomical community even in the UK, and could be obtained only by putting a remarkably low ceiling (150 M€) to the costs. Secondly, the mission was clearly identified from the start mainly as an Orbiter. Landers were almost immediately excluded and then re-introduced in the mission (as nice-to-have) under the assumptions that they would be financed by National Agencies. Professor Southwood (46) tried to explain the difficulty of requesting more money to an SPC, which thought that the maximum had already been done for Mars Express. Had the SPC then turned down such a proposal, that would have been the end for Beagle 2, as normally one must wait one year before presenting again the same proposal to the SPC.

ESA is convinced that the request to provide more support would have rendered the elimination of the Lander inevitable, if the SPC was the only recourse. Since Beagle 2, this is exactly what has happened with ESA's Mercury Lander, whose elimination in 2003, long before the start of the implementation of the mission (2005), many still regret. The elimination of the BepiColombo Lander also indicates that lessons are quickly learned by ESA.

Responses to Recommendations

On the basis of this introduction, it becomes easier to comment/respond to the various recommendations.

1. We welcome the establishment in the 2004 Spending Review of a strategic fund to be allocated by the DGRC but are not persuaded that it will rectify the serious weaknesses which the Beagle 2 project highlighted in the Government's capacity to respond to sudden demand. In the absence of other funding streams to cater for such demand, we recommend that the Government considers earmarking this fund primarily for major projects and facilities. (Paragraph 33)

ESA need not comment.

2. BNSC was ill-advised to rely upon ESA to bail out the project if it ran out of money rather than seeking to establish with ESA and others firmer financial arrangements at the outset. (Paragraph 37)

The difficulties explained in (V, i and ii), and clearly not properly presented to the Select Committee, indicate why, although the hope was there (37), the ESA Executive could not have asked the SPC too soon for funds, because such a request would have led to the immediate exclusion of Beagle 2.

That the hope of BNSC was well grounded is clear from the subsequent facts, i.e. the large amount of funds for Beagle voted by a large majority of Member States.

In conclusion, BNSC was not ill advised to rely upon ESA, and both ESA and BNSC proceeded in the most logical way to make sure that Beagle 2 would fly, thanks to funds to be granted by the SPC.

The need for early firm financial arrangements is recognised by ESA, also because the situation with payload funding is deteriorating. New procedures have been explored and implemented already for the provision of the Medium InfraRed Instrument (MIRI) for JWST and might well become the norm for complex payloads on ESA missions.

3. We commend the Government, and in particular the Minister for Science and Innovation, for being enthusiastic about the Beagle 2 project. It was an exciting scientific opportunity with the potential to put the UK at the forefront of space exploration. The Government should not be shy about taking risks in science if the potential benefits are there. In our view, this was a risk worth taking. Having taken this decision, it was then up to the Government to fund it properly. (Paragraph 39)

ESA joins the praise to the UK Government.

4. The UK Government gave the Beagle 2 project moral support but initially took on as little financial responsibility as it could to ensure that the lander was not thrown off the Mars Express mission. The absence of a commitment from the Government at the outset to provide the necessary funding to support the project in full made it less credible in the eyes of ESA and its Member States, not to mention potential backers of the project, the UK scientific community and the public. (Paragraph 45)

This recommendation agrees with recommendation 3 of the Joint ESA-UK Government Inquiry Commission.

5. The ESA leadership responded positively and flexibly in 2000 to the financial difficulties in which the Beagle 2 team found itself and helped to keep the project alive. However, there appears to have been a latent resistance among Member States to the British-led lander, no doubt in part due to a perception that this was an exercise in promoting UK national scientific interests. This made it difficult for the ESA secretariat to push for more funds when the project met further difficulties, although we are not persuaded that every effort was made on this front. (Paragraph 50)

In ESA's opinion, this statement is not borne out by facts. There was indeed a limit in how far the SPC (Member States) would sacrifice resources, which should be used for *"core-mission"* instruments, in favour what was declared a *"very valuable complement"* (see V above), i.e. the Lander. The nationality of the Lander leadership is not the point, as exactly the same reluctance would have been found whoever had led the Lander. The grounds of the "latent resistance" were technical and scientific, not political. It should be added that

what resistance there was, was very latent indeed. No instrument on Mars Express got anything resembling the financial and in-kind support Beagle got.

It may be added that the statements made by the Space Science Advisory Committee (the highest Science Advisory Committee of ESA) strongly supported Beagle 2 throughout its history. The main concerns raised at the SPC were:

- the uncertainties in the external (sponsorship) funding aspects;
- apparent absence of a firm and secured funding commitment from the UK government side.

This unusual way of running a project having obvious technical and schedule constraints was the main concern at the SPC. In an extraordinary SPC meeting held on 13th November 2000 mechanisms for the participation of the European Scientific Community, Communications/Outreach, Industrial Participation, Increased Oversight role by ESA and Recompense to the ESA Scientific Programme were agreed upon. After this the SPC approved with 11 votes for and only one vote against (2 abstentions) the extra support to be given to the project. This was an unusually strong support for this type of case. The leadership of the UK was never questioned or objected to in the discussions at the SPC.

6. The failure of the project's backers to provide the necessary funding for full testing had a major impact on the ability of the project team to mitigate risks, delaying development and testing until less than two years before the final launch date. It added significantly to the risks already associated with the project. (Paragraph 54)

This recommendation agrees with recommendations 13 and 14 of the Joint ESA-UK Inquiry Commission. In addition it explicitly refers to recommendation 19 of the same Commission.

It can be added that due to loss of time at the beginning of the Lander project, the model philosophy and the test programme changed many times and were driven more by 'time available' than by the actual need for comprehensive testing. Necessary tests were spread over several models preventing the team from working with a single test model having consistently undergone fundamental test activities.

7. We conclude that the pursuit of sponsorship income was an innovative and necessary attempt to meet the funding gaps which were evident in the programme from an early stage. But it did nothing to encourage a realistic assessment of the risks of the project or an open dialogue between participants. It also affected the credibility of the project, which had an impact on the degree of support for it in some quarters. Whilst in the right circumstances there may be a place for commercial sponsorship in such missions, we believe that in this case the DTI should have been focussing its efforts on finding sufficient funding for the project rather than relying upon the securing of commercial sponsorship. We recommend that in future the DTI is extremely cautious about part-funding projects which are reliant to a significant degree on the future attraction of commercial sponsorship. At the very least, DTI needs to satisfy itself of the availability of sufficient funding in the event that commercial avenues prove unproductive. (Paragraph 59)

ESA fully agrees with the analysis of the difficulties connected with the pursuit of sponsorship.

This goes with recommendation 3 of the Joint Inquiry Commission. Sponsors do not wish to be associated with failures, and would prefer to pay only when success is assured, i.e. at the end of the mission, with the result that funds could never be assured at the start of a project.

8. Had a Mars lander been part of the original mission, and managed by ESA, we suspect that it would have been given a priority commensurate with its potential scientific output, with mass levels tailored accordingly to give it a greater chance of success. (Paragraph 65)

As was pointed out above (V), since the formulation of the Science Management Plan (SMP) in 1997, at the outset the Mars Lander was no more than a "very valuable complement". The SMP is agreed by SPC collectively and then sets the perspective for the development by the Executive.

The original Beagle 2 proposal was for a 120 kg plus margins Lander, which led to its initial rejection by the original Peer Review Committee recommendation. Beagle 2 was then re-proposed with a mass of 60 kg as an answer to the second AO and was selected. However, it was considered and accepted as an "opportunity" element of the mission having strict resource limitations partially due to its late selection, but also due to the special nature of being carried as a free flyer to Mars and released before the orbit insertion. Since Beagle 2 was not part of the original mission and not originally managed by ESA, responding to this recommendation requires a lot of background assumptions on what resource scenario is envisaged.

Once selected, Beagle 2 became one of the elements of the payload. From the project point of view it was entitled to the resources as announced in the July 1998 AO. In reality, the support and help during development went well beyond that for other instruments running into difficulties during development. The Beagle 2 team exceeded their mass constraints from the beginning. It must be noted that the Mars Express project was mass critical in itself and all requests for mass increases had to be scrutinised, also the ones from the payload, and sometimes resulted in rejection. For instance, a much-needed ultra-stable oscillator critical to the radio science team could not be approved. A particularly critical aspect of a Beagle 2 mass increase was its consequential need for higher in-flight ejection accuracy from the orbiter. ESA insisted that, prior to agreeing the mass waiver, the Beagle 2 team demonstrate the ability of the Lander to survive the entry phase with the higher mass.

In summary: the Mars Lander never was an essential ("core") part of the mission and was not originally managed by ESA. In spite of that, Beagle 2 got more support than any other elements of the payload. Had it been part of the original mission and managed by ESA, and had it met with even a modest portion of the difficulties it actually met, it would have never made it on board the orbiter.

9. Given the importance of the interface between lander and orbiter and the importance of the former to the mission as a whole, it was remiss of ESA not to ensure that it had

the role of at least a close observer from the outset of the Beagle 2 project. (Paragraph 66)

ESA had to adopt new management schemes to ensure that the total cost of Mars Express did not exceed the tight budget limitation imposed at the outset of the project. One of the cost-saving measures was the transfer of the management of the interfaces between spacecraft and PI-provided hardware to Astrium SAS, France. In hindsight, it is generally accepted that this was a good decision and it worked well with all other instruments. In line with the AO, ESA treated Beagle 2 like all other instruments, applying a traditional cycle of regular meetings, reviews during development, and testing prior to final delivery.

10. It is extremely disappointing that ESA, the UK Government and the project team were unable to co-operate in such a manner as to give the lander the maximum possible chance of success. We believe that both the Beagle 2 project team and the UK Government should have done more to persuade ESA to take greater responsibility for managing the lander project, if necessary, at the expense of some UK ownership. For its part, ESA should not have been influenced so much by the apparent attraction of getting a lander for free, albeit at the expense of European ownership. It should now recognise that this was a mistake and ensure that it takes full management responsibility for similar future missions. (Paragraph 69)

Substantially, this recommendation echoes recommendation 1 of the Joint Commission of Enquiry. In the precise case of Mars Express, in consideration of everything that has been said above about the lack of priority of the Landers and the scarcity of resources, it is a safe assumption that, with these constraints, the Lander would have been eliminated as soon as problems appeared, as was the fate of the Mercury Lander.

In ESA's view, the Mars Lander was given maximum chances of success within the given constraints precisely because of the cooperation between ESA, the UK Government and the project team, as the only possibility for ESA to have a Lander on Mars Express was to have it—at least nominally—for free (see also VI).

11. Had ESA implemented the lesson of earlier failed missions on the importance of communication between lander and orbiter, it would have secured a vast amount of information which could have been used to help establish what happened to the lander and therefore to reduce the risk of future failures. It is a pity that this lesson had not been learned from two previous missions. (Paragraph 70)

There were no lessons to be learned from the two missions cited in the text (70). The Mars Climate Orbiter was destroyed in the Martian atmosphere due to well-known reasons, i.e. the confusion between centimetres and inches in the manufacturing process, which led to an erroneous (too low) altitude at the Mars orbit insertion.

The intended reference probably is the Mars Polar Lander mission, which a few months later was destroyed during its descent process. The landing was done without telecommunication capability to any orbiting spacecraft. As a consequence, the understanding of the failure in descent was left without a clear data support. This happened in late 1999, with the report made in 2000, too late to utilise any "lessons learned" aspect in the Beagle 2 design. Mars 96 had two Landers and two large penetrators onboard. None of these had descent phase telecommunication capability. However since

the entire mission never left Earth orbit due to a malfunctioning of the launcher final stage, the landing on Mars was never tested, which means that no data were available to learn any lessons in this case.

However, lessons have been learned in Europe (and outside), albeit not already for Beagle 2. All Landers since the failure of the Mars Polar Lander have been equipped with descent phase telecommunication capability. The now cancelled (French) NetLanders, which can be considered as sisters to the Beagle 2, as they originated from the Mars Express AO, were designed to give information of progress during descent phase. The same is true with the two NASA Mars Exploration Rovers successfully landed on Mars in early 2004.

ESA asserts that lessons have been learned and taken into account in later missions, but for ESA it was too late to start implementing any changes in the Mars Express Orbiter design in year 2000.

12. The project went well beyond the normal scope of the work of a Principal Investigator. The consortium leadership was understandably keen to maintain control over what was very much the team's own initiative, which was pursued with admirable determination and considerable success. The team was perhaps unduly reluctant to accept that the project as a whole may have benefited from greater involvement from ESA, which could have provided it with the necessary financial resources. It was the absence of the guaranteed funding that made a formal agreement between participating parties difficult to achieve. This in turn was a fundamental weakness in the project management. (Paragraph 75)

ESA agrees that the work of PI's in general is getting more and more complex. Early PI's could afford to be simply scientists. Now PI's are distracted from the scientific-technical aspects, because they must also manage large consortia and look for resources. Some years ago ESA requested the introduction of an Instrument Manager in each team to take care of certain aspects. Other measures are being introduced.

However one should note that the Beagle 2 Management Plan, submitted as part of their July 1998-proposal for a 60 kg Lander undoubtedly addressed the issue by exhibiting a functional breakdown for Beagle 2 exactly similar to those of a spacecraft project.

An additional fundamental problem was the withdrawal of a key industrial partner responsible for the EDLS design and manufacturing. These types of problems are typically encountered at the system level, not at PI level. Furthermore the Assembly Integration and Verification (AIV), was far beyond what a typical PI (and even a project manager) can manage and control. Hence, taking into account the extreme schedule pressure, the team can only be admired and congratulated for their achievements.

"The absence of guaranteed funding [and of a] formal agreement ….was a fundamental weakness in the project management."(Paragraph 75)

This remark is acknowledged and the lesson was learned. New procedures are being implemented since early 2003 to ensure more robustness in funding through formal agreements. BNSC was in the front line in implementing such a new policy with the European Medium InfraRed Instrument (MIRI) for the James Webb Space Telescope. The same policy is expected to be applied to all future missions with PI instruments.

13. The establishment of the Casani review was a useful means of gaining an independent assessment of the project. Having commissioned it, ESA should have taken greater responsibility for implementing the most important of its recommendations in full. (Paragraph 79)

In its recommendation 5, the Joint Commission of Inquiry report reaches the same conclusion, as mentioned in paragraph 79.

14. For far too long the Government failed to ensure that the nature and extent of the risks were identified accurately so that the funding necessary to help mitigate those risks as far as possible could be provided. The failure by all parties to establish at the outset some quite basic elements of cost attribution accentuated funding difficulties. Once they became financially committed, both the Government and ESA took steps to monitor the project, but neither was willing or able to ensure that the recommendations of their various reviews were fully implemented. (Paragraph 88)

Recommendation 4 of the Joint Commission of Inquiry goes in the same direction, as well as recommendation 2, as noted in paragraph 82.

It can be added that ESA applied a traditional review process on Beagle 2, very similar to the one for the other newly developed instruments on Mars Express. Identified discrepancies were listed and tracked in the overall project database. The closeout of Beagle related actions probably took longer than usual due to the longer-than-usual lasting design instability on Beagle 2. The restrictions imposed by access to ITAR regulated documentation and documents considered by the Beagle team sensitive for future business development, did not make it easier to achieve a timely close out of open issues.

15. Relations between ESA and the UK side were strained by different attitudes towards the lander. Professor Southwood clearly had very strong doubts about the lander's chances of success. He should have made these reservations clear—formally—in order that they could be addressed. (Paragraph 91)

There is no indication that relations were unusually strained. Some strain is certainly present when one side is bound by certain constraints of mass and cost, while the other side would be much more comfortable if they could be alleviated. However, this situation reproduces itself with increasing frequency with ESA missions, because the cost of payloads increases while national resources tend to decrease. ESA is fully aware of the situation (as the new policy put into place for MIRI-JWST and other missions demonstrates) and, beyond some necessary formal statements, is always ready to help, as amply demonstrated in the Beagle 2 story.

For example, when discussing the Beagle 2 partnership at the SPC on 13th November 2000 the Programme Director (at that time Professor R. Bonnet) stated very clearly: "If the Agency did not step in, Beagle 2 had no chance." "If the Executive was not absolutely sure that Beagle 2 could be saved given the necessary resources, the present discussion would not be taking place." "Every effort would be made to ensure that the project was a success." "Commitments to that end had been made at the highest level by the Agency and the UK." After these clear and forceful statements by the Programme Director, the SPC decided to give strong support to this approach, as indicated above in the response to recommendation 5.

Paragraph 118 and recommendation 16 unequivocally state that the decision to proceed in 2001 was the right one. Professor Southwood, who became Director of the Science Programme on 1 May 2001, saw a high-risk situation, in which however the cancellation of the Lander was no longer a realistic option. Thus, he took all available action to mitigate the risks. This lead to the negotiation of the formal Heads of Agreement and to a situation which allayed most doubts he had.

The question recommendation 15 raises is whether any advantages would have resulted, had he made his reservations clear—formally. ESA's opinion is that this would only have added one more risk, i.e. that the UK side could have cancelled the Lander. This would have been the wrong decision to take, as long as (1) risk-mitigating actions could be taken and (2) resources could be injected into the project.

16. By failing to subject the lander to sufficiently rigorous scrutiny in its early stages and to provide the necessary support, ESA and the UK Government left themselves with few options when the project ran into serious problems. The decision to allow the lander to proceed in 2001 was the right one. It was also the only one realistically available. (Paragraph 94)

ESA applied the same review cycle to Beagle 2 as to the other new instruments. ESA and industry reviewed the interfaces to the orbiter and a rolling science review team, chaired by the ESA Project Scientist, reviewed the payload. As the record shows, deficiencies and design weaknesses were identified and the Beagle 2 team was tasked with the implementation of corrective actions. As is usual in complex space systems, the resolution of one problem requires design stability for other elements. Due to schedule criticality and design changes, such a situation was hardly ever achieved on Beagle. For instance, the close out of the recommendations and actions of the Critical Design Review lasted about a year, compared with typically 'weeks' for the other instruments.

17. ESA was not a disinterested carrier of a foreign enterprise. ESA had called for proposals for Mars landers in 1997 and selected Beagle 2, in preference to two other bids, in 1998. It had allowed the project to proceed when it failed to meet key milestones and had stepped in to provide funding when the project was in trouble. It was part of the project. It cannot dissociate itself from the fate of the lander after the event. We commend Professor Pillinger and his team for the enthusiasm with which they conceived and pursued the project. For the sake of future space programmes, however, they should also learn the management lessons laid bare by Beagle 2. (Paragraph 95)

ESA tried to help wherever feasible by, for instance, co-locating an experienced mechanical engineer at Astrium Ltd. Three more engineers supported the Beagle 2 team on a full time basis. The ESA Project Manager and Project Controller spent a significant part of their time dealing with Beagle contractual issues. Given a 10-strong ESA Mars Express team, ESA can hardly be accused of lack of interest.

The selection process of Beagle 2 was not as simple and straightforward as stated in recommendation 17. The original Announcement of Opportunity for the Mars Express Mission was released on 3rd December 1997. In spring 1998 the Peer Review Committee recommended that no Lander Modules should be flown in the present Mars Express

mission. Later it was found out that the mission could accommodate a single 60 kg Lander. A specific AO was released in summer 1998, which led to the proposing of a new Beagle 2 concept (shrunk by half in mass). The concept was approved by the SPC conditionally until the end of Phase B (end of 1999). In Nov 1999, after considering carefully the technical and financial implications of the project, the SPC reconfirmed Beagle 2 for flight.

ESA fails to understand the meaning of this statement. All the efforts listed above, together with the decision of extra funding for the Beagle 2 project, which was done at the expense of the other Science projects, demonstrate that ESA, and especially the SPC, shares the disappointment of this loss and, especially, the loss in the excellent and promising science which really was the main driver behind all Beagle 2 support decisions.

On the other hand ESA shares the benefits, e.g. development of new technologies and progress in public understanding of space, which resulted from the Beagle 2 enterprise.

18. We welcome the fact that the Government recognised the wider benefits of Beagle 2 in citing public understanding of science goals as one of the factors contributing to its support for the project. (Paragraph 98)

No ESA comment needed.

19. We recommend that in future decisions on support for collaborative and UK-led projects the Government sets out the weight it assigns to the wider public benefits as well as the economic analysis. (Paragraph 99)

No ESA comment needed.

20. We commend the efforts of the Government and others to use the Beagle 2 project as a tool for science education. We recommend that the use made of the lessons devised is monitored and that, if successful, similar approaches are adopted with other high profile science missions. (Paragraph 100)

No ESA comment needed.

21. We hope that the uneasy relationship the Beagle 2 consortium had with ESA does not colour ESA's view of the desirability of future collaboration. (Paragraph 107)

ESA wants it to be understood that the "uneasy relationship" of the Beagle consortium with ESA is regularly reproduced with almost every payload on almost every scientific mission. Actually, ESA is surprised that the Select Committee felt the need to make an official plea asking that the "uneasy relationship" should not *colour ESA's view of desirability of future collaborations,* as there is no case on record in which ESA ostracised any scientist or consortia.

22. We welcome the UK's full participation in the preparatory phase of ESA's Aurora space exploration programme. We hope that this engagement at the outset will help the UK shape the content of the programme and gain substantially from it in terms of industrial and academic participation. In view of wider considerations relating to the educational, industrial and science in society agenda, we believe that Government, not just PPARC, should ensure that UK plc is in a position to build on the scientific base established by the Beagle team and to support participation in future planetary

exploration missions, on a well defined multinational basis. OST and DTI should examine the case for UK participation from the point of view of their different objectives and provide the appropriate support, to add to that of PPARC, in a co-ordinated way. (Paragraph 109)

See (I).

23. The decision not to publish Commission of Inquiry's report in full was based on the sensitivities of the parties involved rather than any convincing legal or commercial considerations. This is an affront to accountability. We recommend that the full report be published without delay. (Paragraph 116)

In conclusion, ESA has felt the need to set the record straight for the history of a project where new policies had to be invented from day to day to solve the contrast between accepted paradigms and a new, rapidly evolving situation, under tough constraints of time and resources. It should be clear, however, that ESA also appreciates the interest Select Committee itself, the thoroughness of its study and above all the positive recommendations it made.

January 2005

Reports from the Science and Technology Committee since 2001

Session 2004-05

First Report	The Work of the Economic and Social Research Council	HC 13
Second Report	Annual Report 2004	HC 199
Third Report	Office of Science and Technology: Scrutiny Report 2005	HC 8
Fourth Report	The Medical Research Council's Review of the Future of the National Institute for Medical Research	HC 6

Session 2003-04

First Report	Annual Report 2003	HC 169
Second Report	Chief Executive of the Medical Research Council: Introductory Hearing *(Reply HC 629)*	HC 55
Third Report	The Work of the Biotechnology and Biological Sciences Research Council *(Reply HC 526)*	HC 6
Fourth Report	Office of Science and Technology: Scrutiny Report 2003 *(Reply HC 588)*	HC 316
Fifth Report	*Too Little too late?* Government Investment in Nanotechnology *(Reply HC 650)*	HC 56
Sixth Report	Within REACH: the EU's new chemicals strategy *(Reply HC 895)*	HC 172
Seventh Report	Director General for Higher Education: Introductory Hearing *(Reply HC 1015)*	HC 461
Eighth Report	The Work of the Council for the Central Laboratory of the Research Councils *(Reply HC 1199)*	HC 462
Ninth Report	Director General of the Research Councils: Introductory Hearing *(Reply HC 1059)*	HC 577
Tenth Report	Scientific Publications: Free for all?	HC 399
Eleventh Report	Research Assessment Exercise: a re-assessment *(Reply HC 34, 2004-05)*	HC 586
Twelfth Report	Government support for Beagle 2	HC 711
Thirteenth Report	The Use of Science in UK International Development Policy *(Reply HC 235, 2004-05)*	HC 133
Fourteenth Report	Responses to the Committee's Tenth Report, Session 2003-04, Scientific Publications: Free for all? *(Reply HC 249, 2004-05)*	HC 1200

Session 2002–03

First Report	The Work of the Particle Physics and Astronomy Research Council *(Reply HC 507)*	HC 161
Second Report	Annual Report 2002	HC 260
Third Report	The Work of the Medical Research Council *(Reply Cm 5834)*	HC 132

Fourth Report	Towards a Non-Carbon Fuel Economy: Research, Development and Demonstration *(Reply HC 745)*	HC 55
Fifth Report	The Work of the Natural Environment Research Council *(Reply HC 1161)*	HC 674
Sixth Report	UK Science and Europe: Value for Money? *(Reply HC 1162)*	HC 386
Seventh Report	Light Pollution and Astronomy *(Reply HC 127, 2003-04)*	HC 747
Eighth Report	The Scientific Response to Terrorism *(Reply Cm 6108)*	HC 415
Ninth Report	The Work of the Engineering and Physical Sciences Research Council. *(Reply HC 169, 2003-04)*	HC 936

Session 2001-02

First Report	Cancer Research – A Follow-Up *(Reply Cm 5532)*	HC 444
Second Report	The Research Assessment Exercise *(Reply HC 995)*	HC 507
Third Report	Science Education from 14 to 19 *(Reply HC 1204)*	HC 508
Fourth Report	Developments in Human Genetics and Embryology *(Reply Cm 5693)*	HC 791
Fifth Report	Government Funding of the Scientific Learned Societies *(Reply HC 53)*	HC 774
Sixth Report	National Endowment for Science, Technology and the Arts: A Follow-Up *(Reply HC 276)*	HC 1064
Seventh Report	The Office of Science and Technology: Scrutiny Report 2002 *(Reply HC 293)*	HC 860
Eighth Report	Short-Term Research Contracts in Science and Engineering *(Reply HC 442)*	HC 1046

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