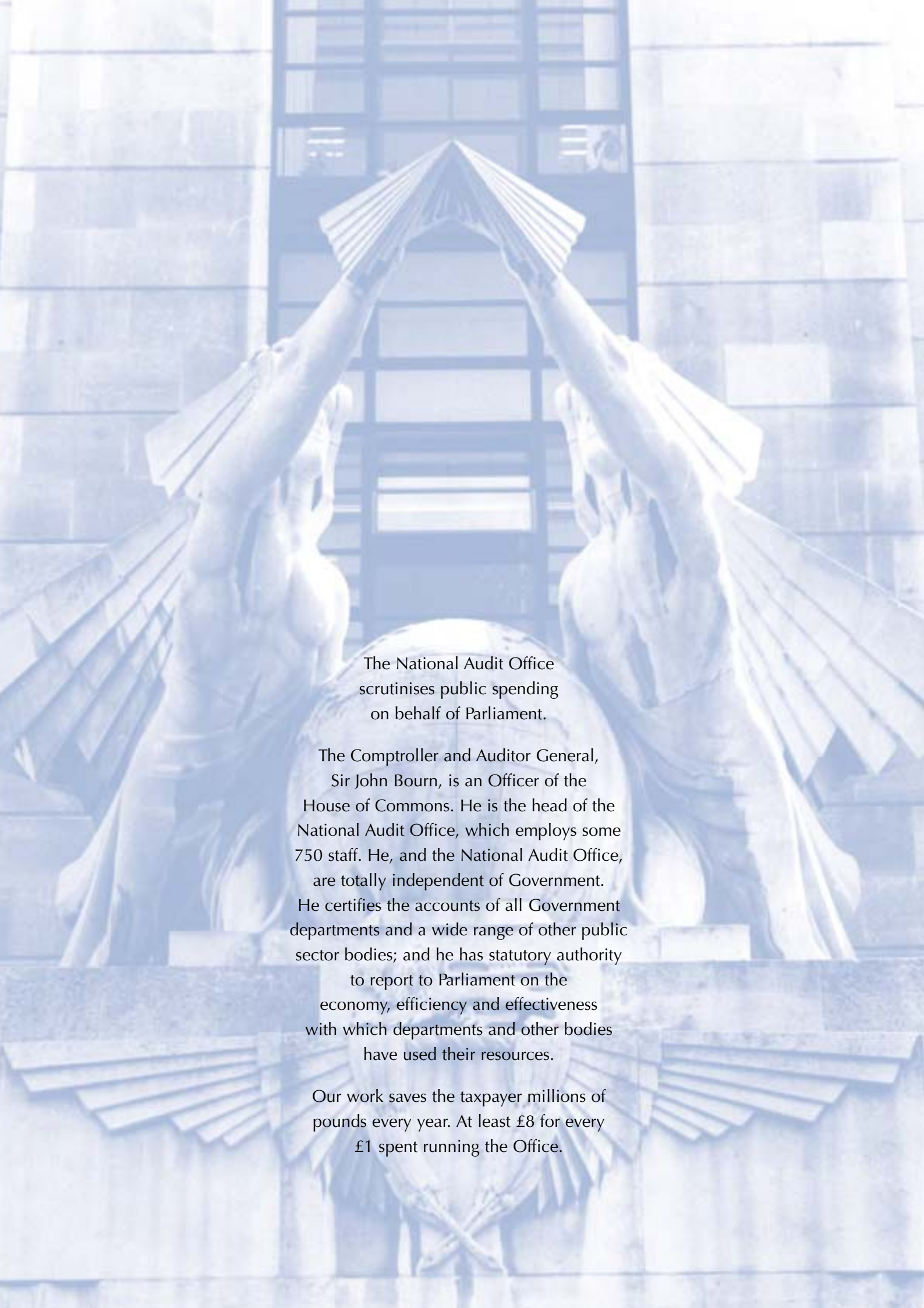


The Auction of Radio Spectrum for the Third Generation of Mobile Telephones

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL
HC 233 Session 2001-2002: 19 October 2001





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Part 4

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executive summary

- 1 In April 2000 the Radiocommunications Agency (the Agency) raised £22.5 billion from an auction of five licences for radio spectrum to support the third generation of mobile telephones, (3G). This report examines the reasons for the high proceeds, and the extent to which the Agency have promoted the main auction objectives of the efficient utilisation of the spectrum and the enhancement of competition between operators to the benefit of consumers.
- 2 The radio spectrum is a range of radio frequencies, used by the public and private sector to deliver basic services such as radio, radar, and mobile telephones. It is a finite resource of great and growing economic importance. The mobile telephone industry alone contributed £5.3 billion to Gross Domestic Product in 1999, and supported 164,000 jobs. In the UK, as in the rest of the world, spectrum is in short supply and demand for it from users is increasing, especially in frequencies most suitable for mobile communications. If demand cannot be met spectrum congestion will restrain economic growth and stifle innovation.



- 3 The first generation of mobile phones provided simple voice telephony, while the second, introduced in the UK since 1992, provides additional data facilities such as messaging services and e-mail. The next, third, generation of mobile phones offers full interactive multimedia capabilities (voice, video or data transmission). They offer a greater capacity than current mobile telephones for the fast transfer of data, enabling the provision of innovative services. Governments across Europe, including the United Kingdom, agreed to allocate the same fixed range of spectrum to accommodate 3G services. This, and the use of a common standard across Europe allows consumers to use their telephone handset in any part of Europe, and provides benefits for equipment manufacturers and operators.

- 4 The Radiocommunications Agency are an Executive Agency of the Department of Trade and Industry. They manage the civil radio spectrum throughout the UK by issuing licences to mobile telephone operators and other users of radio. The Government defined their objectives for the auction as, to:

- i Utilise the available spectrum with optimum efficiency;
- ii Promote effective and sustainable competition for the provision of third-generation services; and
- iii Subject to the overall objectives above, design an auction that is best judged to realise the full economic value to customers, industry and the taxpayer of the spectrum.

- 5 The Government's overall aim was to secure the long-term economic benefits of 3G services for UK consumers and the national economy. The first and second objectives of the auction, to promote efficient use of the spectrum, and to promote effective and sustainable competition, were of particular importance to achieving this aim. In designing the auction the Agency worked in consultation with the Office of Telecommunications, (OFTEL), which maintains and promotes effective competition in telecommunications markets.

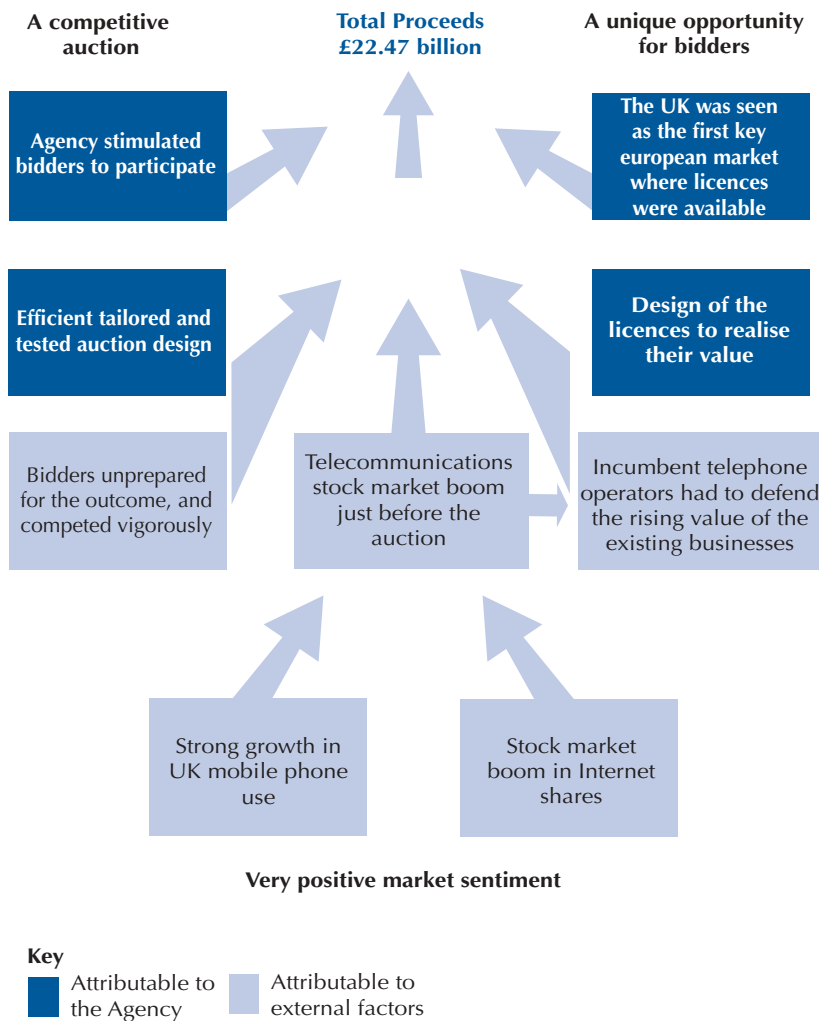
Realising full economic value

- 6 We deal with this subsidiary objective first in our report because the reasons for the high level of proceeds provide evidence with which to assess the achievement of the two other objectives. This objective was worded so as to make it clear that the interests of the industry and consumers should be taken into account, rather than to mean simply maximising the proceeds for the taxpayer. It recognised that a strong and competitive industry would generate economic growth and receipts from taxation. Any reduction in the take-up of the 3G services due to increased costs would have a compounded negative impact on the economic benefit gained in terms of taxation and employment. Therefore, the Government's aim was not to use an auction in order to maximise the level of proceeds. They decided to assign licences in this way following advice from economics consultants that auctions provide a sound economic basis for the allocation of spectrum. They considered the use of an auction to be consistent with their other objectives because by awarding licences to the highest bidders, spectrum would be allocated to the mobile telephone operator that valued it most and would be more likely to exploit it to



greatest advantage. The proceeds raised by the auction were subsidiary to the economic benefit to be derived from assigning the spectrum to those who would value it most. In this the Agency sought to strike a balance between the needs of the industry, consumers and taxpayers.

- 7 The auction raised greater proceeds than the Agency, bidders or external commentators had expected. Proceeds per head of population exceeded those in each subsequent allocation of spectrum in other countries. This outcome arose from the strong convergence of several positive factors, some of which were attributable to the actions of the Agency and others of which originated from external causes. These are summarised in the Figure below.



- 8 It was fundamental to the outcome of the auction that the five licences on offer attracted nine potential new entrants in addition to the four incumbent mobile telephone operators, Vodafone, BT Cellnet, Orange and One 2 One. This was almost twice as many bidders as in the next most competitive auction in Europe, in Germany, where seven bidders took part and secured six licences. The Agency stimulated this intense competition by:
- Offering one more licence than there were incumbent operators, so confirming that there would be at least one new entrant. If only four licences had been offered, the four incumbents, keen to protect the future of their businesses, would have been likely to use their competitive advantages from their existing market position to outbid and exclude potential new entrants;
 - Addressing some of the barriers to entry that the new entrant would encounter, for example by ensuring that the entrant's consumers would have a right to roam on incumbents' existing second generation networks while the entrant built their own 3G network; and
 - Intensively marketing the commercial opportunity of 3G to potential bidders through their advisers N M Rothschild and Sons, whom they incentivised through an appropriate success fee.
- 9 The timing of the auction was especially conducive to strong competition for the licences. The government had emphasised that early implementation of 3G in the UK would be advantageous for operators and consumers alike. Vodafone told us that winning the first licences to be made available in a key European market was important to bidders because:
- it enabled winners to approach equipment suppliers with realistic requirements before operators in other countries placed orders, allowing the licensees in the UK to influence the shape of the products and to secure supplies; and
 - it provided them with a stronger basis on which to bid for licences in other countries, whether allocated through auctions or through beauty contests.
- 10 Bidders told us that many European telecommunications companies had seen success in the UK auction as important to qualifying to be one of a small number of pan-European operators in the next decade. Bidders expected a process of consolidation in the industry. The auction also coincided with a period of very positive sentiment in global financial markets towards high technology industries, and an all-time peak in the share values of telecommunications companies. This inflated the prices that bidders were willing to pay in the auction. The values of the incumbent companies were expected to fall back if they had failed to win a licence and become vulnerable to loss of business to new entrants offering a superior 3G product. Also, the enthusiasm of the financial markets for telecommunications companies appeared to indicate a ready supply of capital with which licensees could finance their new networks.
- 11 The design and operation of the auction itself was efficient in realising this value. The Agency only selected the format for the auction once it was clear that the design of the licences would attract more bidders than licences. The format of transparent, ascending bids, as opposed to one-off sealed bids, gave the bidders greater confidence in bidding higher, since they were able to see that their competitors were doing likewise. Bidders drew assurance that their competitors shared their view of the importance of 3G telephony for the future of their industry. Also, a simultaneous ascending auction spread over seven weeks gave the bidders ample time to revise their initial budget constraints through authorisation from their top management and external financiers. Learning from US experience, the Agency required bidders to lodge initial





deposits of £50 million, rising to £100 million for bids of £400 million or more to protect the auction from frivolous bidding or default. Provision might usefully have been made for deposits to increase still further if bids went higher than expected. Reserve prices were put at a sensible level that did not deter participation. Our specialist adviser on auctions, Professor Cramton of the University of Maryland, considers the design and conduct of the auction to have been generally excellent. Bidders told us that they considered the Agency had managed the auction process very well.

- 12 The scale of the proceeds has heightened concerns that the auction will reduce the economic value of 3G services to consumers and the industry, and ultimately to the taxpayer through reduced economic activity and taxation. This issue is integral to the examination of the Agency's competition objective in paragraphs 15-22 and 27-29 below.

Utilising the spectrum with optimum efficiency

- 13 As a general principle the Agency is concerned that radio spectrum should be intensively used and that users do not allow it to lie fallow. Where users do not pay for spectrum they have no economic incentive to invest in more efficient equipment and surrender surplus spectrum. The Agency are seeking to extend the principle of charging public and private sector users for spectrum, which may be used by technically inefficient equipment and not exploited to its full potential. Intensive use of the spectrum made available for 3G services will depend on the number of mobile telephone subscribers who wish to use these services, and the extent to which these consumers use advanced services such as video and data transfer rather than simple voice or text messages. Advanced services require more spectrum than voice messages.
- 14 The Government recognised that the incumbent companies' existing networks and customer base are major barriers to new entrants, who would have to build their own networks over several years during which their service could be inferior and unattractive to consumers. The Agency allocated more spectrum for the new entrant in order to strengthen its business. Extra spectrum allows operators to reduce their investment in infrastructure, and to sell surplus capacity to other companies who wish to offer telephone services under their own brands. This is inefficient in technical terms because the new entrant, Hutchison 3G UK, starts with no existing base of customers, and the extent to which its spectrum will remain under-utilised depends on how quickly the company attracts customers and gets them using advanced, non-voice services. The Agency and OFTEL however, saw efficiency in wider terms, considering that a new entrant would roll out 3G services quickly and exert competitive pressure on the four incumbent companies to do likewise. This reduced the risk that the incumbents might otherwise defer their investment in 3G services while exploiting their spectrum only for less intensive voice telephony. The incumbents regarded the allocation of more spectrum for a new entrant as unnecessary, whereas most of the potential new entrants regarded it as helpful to their business cases and therefore their participation in the auction. Most new entrants did however bid extensively on licences with less spectrum.

Promoting effective and sustainable competition

- 15 The objective to promote sustainable and effective competition for 3G services reflected the Government's wish to see sustained competition between operators not just on price, but on the range of innovative services that could be provided. Before the auction, in July 1999, a review by OFTEL had concluded that the UK mobile telephone market was not yet fully competitive. This view is not shared by mobile telephone operators, who cite contrary

evidence that their industry is competitive compared to other sectors of the economy. The Agency, OFTEL and the Department of Trade and Industry shared a concern that competition in the early years of 3G could be dampened by defensive behaviour by incumbents, particularly if they bid for 3G licences primarily to protect their existing second generation businesses (paragraph 14).

- 16 OFTEL strongly supported the Agency's intention to achieve a fifth competitor in the market. In their view a new player should act as a further catalyst to achieving a fully competitive mobile market and by so doing provide significant benefits to consumers, by increasing the availability of new services and driving down prices.
- 17 The extent to which the increased competition from the new entrant will be sustainable depends on whether the UK market will sustain five operators in the long term. Other countries such as Spain and France have issued fewer licences, and only in the much larger German market did the authorities issue six. Given uncertainty about the likely revenues and costs of 3G services, the sustainability of five operators cannot be assumed. The new entrant, Hutchison 3G UK, faces a difficult task given that the four incumbents have already signed up two thirds of the UK population for existing mobile services. But there are indications that the company is positioned to compete effectively, for example:
 - It is backed by the resources of a major international conglomerate, Hutchison Whampoa;
 - It has an arrangement for strategic co-operation on European 3G operations with NTT DoCoMo, Japan's largest mobile communications company and KPN Mobile the leading telecommunications company in the Netherlands, allowing each party to extend substantially its customer base across Europe whilst sharing development costs. DoCoMo has successfully pioneered innovative mobile telephony services including the world's first commercial trial of 3G services, in Japan; and
 - It has negotiated £3.6 billion of finance for rolling out its services, raised from shareholders, banks and equipment manufacturers, and has negotiated deals with owners of masts to install its equipment.
- 18 The other licences were won by the four incumbent operators in the United Kingdom market: Vodafone, British Telecom Cellnet, One2One and Orange. All four have already built nationwide mobile phone networks in the United Kingdom and either own or are linked to groups with an international customer base. Telecommunications Industry analysts have forecast each to survive as separate entities in the future. Most UK licensees have announced that services should be launched in 2002.
- 19 The Agency and OFTEL have various powers to preserve the increased competition that the auction has promoted. Licences are granted to the five named companies and are not transferable. One company cannot own or operate two 3G licences and, in the case of a merger or an acquisition, the Agency can revoke a licence and transfer the rights and obligations, through a new licence, to a new operator.
- 20 The process of auctioning licences in the UK and other European countries has contributed to the increasing indebtedness of major telecommunications companies. Commentators have expressed concerns that the cost of the licences has undermined the ability of operators to invest in their 3G networks, slowing development and increasing costs to UK consumers. Although the bidders who responded to our enquiries acknowledged that they, not the Agency, had decided what the licences should fetch, they considered that the final prices were driven in part by the view of some bidders that it was essential

for the future development of their businesses to obtain a licence in the UK. They told us that the level of proceeds from the auction had made financing significantly more difficult.

- 21 Since the auction telecommunications companies have experienced a more difficult climate for investment in the next generation of networks, with finance becoming scarcer and costlier. The major European mobile telephone groups' debt broadly doubled or tripled during 2000. This has been due to a combination of factors that, as described by City analysts, include regulatory pressures, operators seeking growth by borrowing to acquire other companies, as well as acquiring licences and investment to build networks. In the case of British Telecommunications plc, only one third of the company's £27.9 billion debt by March 2001 represented the £9.4 billion cost of licences in the UK, Germany and Holland. The remainder comprised mainly the cost of acquiring interests in other companies.
- 22 Although most major telecommunication companies, including the 3G licensees in the UK, have experienced greater difficulty in raising finance, Hutchison, One 2 One, Vodafone and Orange have already arranged funding for their new UK networks. Vodafone and Hutchison told us the high cost of their licence gave them an added commercial incentive to roll-out 3G services more quickly than if the spectrum had been given away. Difficulties that remain to be overcome for roll-out to proceed are mainly technical, for example the development of suitable base station and hand-set equipment. We have therefore found no strong evidence that the level of proceeds of the auction will have a negative impact on the wider economic benefit of 3G in terms of taxation and employment in the UK.

Balancing the three objectives

- 23 The Agency faced trade-offs, when designing the licences and the auction, between the three objectives for efficient use of the spectrum, promoting competition and realising economic value. Sometimes a design feature to address one objective could detract from another objective, and the optimum balance was not entirely clear to the Agency at the time. Realising full economic value for the taxpayer, industry and consumer was not paramount. The objectives had to be balanced in terms of the key decisions the Agency made when designing the licences and the auction.
- 24 Deciding the number of licences was particularly significant and was a difficult judgement, with many opposing views being expressed, by advisers, the industry and in government. Because there were already four incumbent operators, four licences might have deterred participation by bidders wanting to be new entrants, probably leading to reduced bidding for licences and lower proceeds, as well as yielding no addition to competition and consumer choice in mobile telephony. Parcelling up the spectrum into just four licences would have provided each with enough spectrum to reduce the technical risks of a low quality of service. In the longer term however, four licences may have been less efficient because without the pressure of a new entrant offering 3G services the four incumbents may not have exploited the spectrum as intensively. Five licences reversed these advantages and disadvantages of four licences. Six licences would have intensified still further the advantages and drawbacks of issuing five licences, but it is not clear that operators would have found this more crowded market place commercially sustainable in the UK, and the resulting smaller licences, all of 10 Megahertz (MHz), might have prevented higher bandwidth services such as video from being developed.

- 25** The other key feature of the allocation was the distribution of the limited amount of spectrum available between the five licences. For technical reasons, it was not possible to create five licences of the same size. Only two licensees could be allocated 15 MHz of paired (transmitting and receiving) spectrum, which was important because this larger amount of spectrum would make it easier for operators to provide a full range of 3G services. The three other licences would only consist of 10 MHz. The Agency reserved one of the larger licences for the new entrant in order to promote competition in the 3G market. In doing so they accepted the risk that this might lower proceeds, although the premium that the incumbents placed on a larger licence could not be predicted in advance. In the event the bidding indicates that BT, the second largest incumbent in terms of customers, would have valued the reserved larger licence higher than did the new entrant. The new entrant paid some \$100 million per MHz less for this licence than the incumbents paid for each of the four unreserved licences. This may not have been the case had incumbents been able to bid for both the larger licences. The other larger licence was open to bids from incumbents and was won by the largest incumbent, Vodafone. Orange told us that they would have preferred on competition grounds an allocation of one, still larger, 20 MHz licence for the new entrant, with four licences of equal size for the incumbents.

Conclusions

- 26** The use of sophisticated auction techniques is innovative in the public sector in this country, and there is scope for other public bodies to learn useful lessons from this example. The reasons why such high proceeds were generated, equivalent to some £560 per mobile telephone in use, are more to do with the high demand for the licences caused by the strategic ambitions of bidders, further stimulated by the Agency's marketing, than with the auction process itself. The auction was well designed and efficient in realising this value. The Agency obtained high proceeds, but did not maximise them because, in pursuit of their objectives for 3G licensing, they reserved more spectrum for a new entrant to promote increased competition in the 3G market. In the event, bidding demonstrated that potential new entrants did not feel that a large licence was essential. It is also significant that the licence reserved for a new entrant, which TIW won in the auction for £4.3 billion, was subsequently acquired for some £6 billion by Hutchison Whampoa.
- 27** There has been widespread concern about the position of telecommunications companies in the aftermath of auctions in the UK and other countries. The high level of proceeds for licences, notably in the UK and Germany, undoubtedly added to a general trend of much increased indebtedness in the companies, and to a downturn in confidence in these companies' ability to develop 3G services. The operators will suffer to the extent that they have paid for spectrum, which in previous generations of telephony the government allocated to them at negligible cost. Their rates of return on their investments, and the value of their businesses, will be lower than they would otherwise have been. The operators' share values have fallen back to the pre-boom levels they reached in 1998. Some of the burden of licence costs will be transferred to other parts of the telecommunications industry, such as equipment manufacturers providing operators with low cost financing in return for work on 3G.

- 28** It is not evident that the cost of the licences will increase the price of 3G services to UK consumers. Mobile telephone services in the UK are habitually priced according to market conditions, as opposed to simply passing on costs. As the major European operators undergo consolidation and restructuring, some licence costs are expected not to stay with mobile subsidiaries but to be held with their "fixed line" parent companies. Each of the UK licensees also holds licences in several other European countries. Bidders and our advisers consider that licensees would tend to average their licence costs across each of the markets in which they operate.
- 29** It was the bidders, not Government, who decided the price that was paid. In this case bidders considered wider factors than the value to them of 3G in the UK, a value which was highly uncertain at the time of the auction, and remains so. BT and Vodafone have since stated that they overpaid. But all the licensees except BT have already announced how they will fund their 3G infrastructure. The operators face major uncertainties about the costs and performance of the new networks, what services will be provided and the extent to which consumers will pay for them. But there are indications that in the UK the potential additional competitive pressure created by a fifth operator should be sustainable. The new entrant, Hutchison, appears to be a strong one, and the four incumbents are key international players in the future of this important industry.

Recommendations

On management of the Radio Spectrum

- 1 Public sector users of radio spectrum need incentives to make efficient use of it, such as being charged for it or by disposing of surplus spectrum in consultation with the Radiocommunications Agency. Disposal through auctions should be considered.
- 2 The Agency, DTI and OFTEL should continue to be cautious in responding to pressure from the industry to reduce regulation of competition in the light of the sums paid, or calls from commentators for refunds of licence fees in recognition of the challenges facing the industry. This might open them to the risk of legal challenge from unsuccessful bidders. Bidders freely decided what they should pay, and concessions could risk unfairness to unsuccessful bidders and establish a dangerous precedent if future bidders interpreted this as encouragement to bid irresponsibly in the future.
- 3 The Agency and OFTEL can however help the operators by being receptive to proposals for network sharing. The regulators should welcome proposals for sharing "passive" infrastructure such as sites and masts, and accede to proposals for sharing of active elements such as transmitters where the alternative would be no coverage or a more limited range of services. This would be subject to competition law and the conditions of operators' licences.
- 4 Auctions can only allocate spectrum efficiently to the extent that bidders can reliably forecast the likely success of their businesses. Some licensees will be more successful than others, so an efficient allocation of spectrum will require flexibility for it to be transferable. The Agency should take early steps to make use of impending changes in European Union Directives which will allow the trading of spectrum in the future.

On the use of auctions in the public sector

- 5 Departments should recognise that auctions are a useful mechanism for allocating resources in many situations, particularly where demand for items outstrips supply; where there are likely to be more bidders than lots; and little information exists about their worth, though they are capable of being independently valued. Compared to other methods of allocation auctions can be more transparent, objective and relatively cheap to administer, and how bidders become winners is easier to understand. However, each economic environment requires an auction design and associated policy framework that is tailored to that environment - one size does not fit all.
- 6 Getting a good ratio of bidders to lots is fundamental to the success of any auction. Proactive and expert marketing of the opportunity is therefore vital, as was achieved in this case. Where there are barriers to entering the market departments may need to design specific incentives to attract new entrants. Departments and their advisers should counter pre-auction media speculation that proceeds could be high, which could deter bidding.
- 7 The single ascending bid method used in this auction is suitable when the seller expects an adequate number of serious bidders to participate and compete. An "Anglo-Dutch" method, in which the auction finishes with sealed bids, could be considered when less interest is expected.
- 8 Where lots are identical, Departments might wish to consider "combinatorial" auctions in which bidders decide how much of the asset they want, by bidding for and combining smaller pieces, as was done in the spectrum auctions in Germany. This extends the principle of letting the market decide what is an efficient allocation. In this case the Agency were right to fix the size of the licences themselves - it ensured that there would be a new entrant. And bidders welcomed the certainty of knowing exactly what bands of spectrum they were bidding for.
- 9 Requiring bidders to pay substantial deposits at the outset as insurance against default provides protection for the seller and acts a deterrent against ill-considered bidding. Departments should provide for these deposits to increase as the value of bids rises beyond the levels expected.
- 10 Departments should pay particular attention to the level of reserve prices in an auction. Where they expect sufficient competition for lots reserve prices should be set conservatively to avoid deterring interest and to minimise the risk of leaving lots unsold, but no lower than the level at which prices would have been set without an auction.

Part 1

The objectives of auctioning the spectrum

1.1 This part of the report explains the objectives that the Government set for the Agency in allocating the available spectrum through an auction, the role of the bodies involved, and the scope of the National Audit Office's examination.

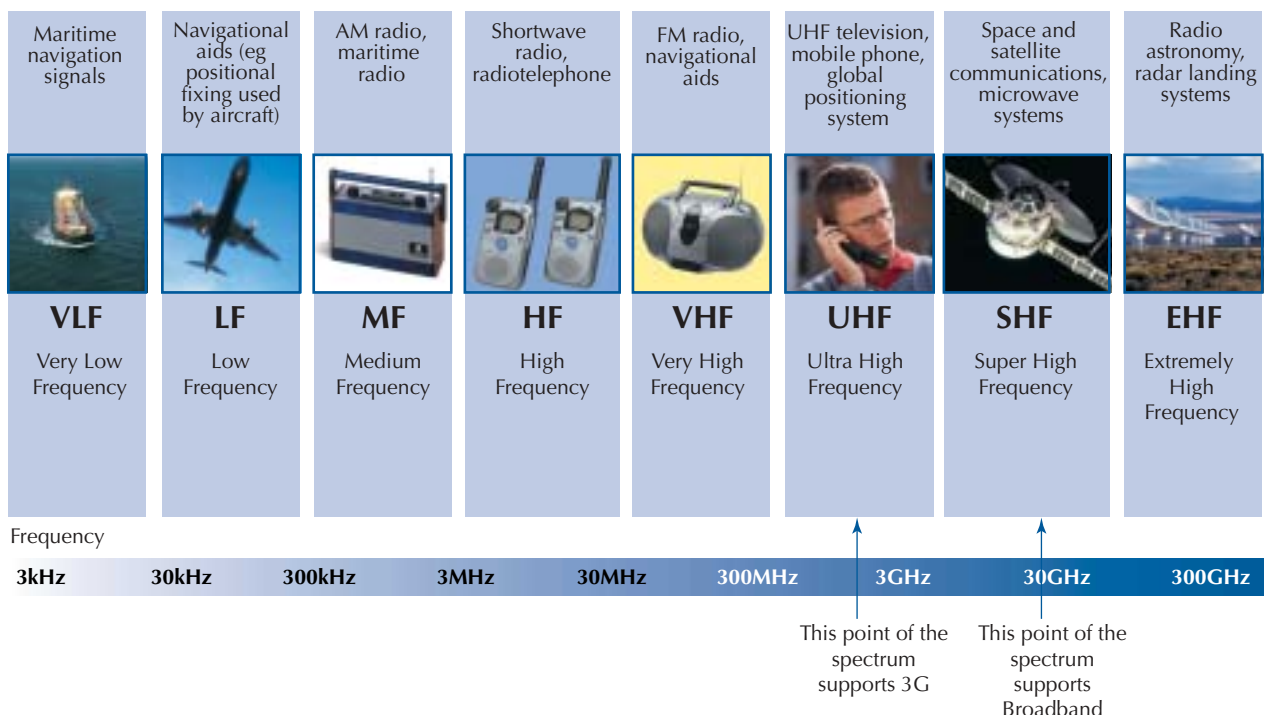
Radio spectrum is a valuable resource

1.2 The radio spectrum is a range of radio frequencies, used by the public and private sector to deliver vital services such as radio, radar, and mobile telephones, as illustrated in **Figure 1**. It is a finite resource of great and growing economic importance. The mobile telephone

industry alone contributed £5.3 billion to United Kingdom Gross Domestic Product in 1999, and supported 164,000 jobs. The UK now has over 40 million mobile telephones, compared to 28 million fixed telephone lines. Global demand for spectrum is increasing, especially in ranges suitable for mobile communications, and if this cannot be met spectrum congestion will restrain economic growth and stifle innovation. Though national governments retain the right to regulate the use of spectrum within their territories, decisions about which parts of the spectrum to allocate for which services are often made in the context of international agreements.

1 The radio spectrum

This figure shows the range of frequencies which make up the radio spectrum and the main user groups for specific points of the spectrum.



Note: kHz = kilohertz, or 1000 Hz; MHz = megahertz, or 1000 kHz; GHz = gigahertz, or 1000 MHz

Source: The Radiocommunications Agency

- 1.3 In the case of 3G telephony, Governments across Europe, including the United Kingdom, have agreed to allocate the same fixed range of spectrum, and adopted the same technical standard for 3G known as UMTS. Common standards and spectrum allocations facilitate cheaper equipment manufacture and availability, compatibility with other systems, and the use of telephones across international boundaries, benefiting manufacturers, operators and consumers. A decision by the Council of Ministers and the European Parliament required Member States to assign spectrum licences and take any other necessary administrative measures in time to allow operators to introduce 3G services in each Member State from 1 January 2002. The first generation of mobile phones provided simple voice telephony, while the second, introduced in the UK since 1992, provides additional facilities such as messaging services and e-mail. The next, third, generation of mobile phones offers full interactive multimedia capabilities (voice, video or data transmission) on a global basis (Figure 2). They will achieve this through the fast transfer of data, enabling the provision of innovative services.
- 1.4 The European Union's objective is to help develop this growing industry, where European manufacturers and operators already have a strong international presence. The United Kingdom is bound by European Directives which require that Member States should price the spectrum only to ensure its efficient use and not so as to maximise licence revenues, and they forbid the use of pricing as a form of taxation. They permit an auction as a method of allocating spectrum to those operators who will make most intensive use of it.

The Agency conducted the auction

- 1.5 Planning and management of the spectrum is necessary to avoid interference between radio signals from different users and services, both internationally and nationally. The Agency (an Executive Agency of the Department of Trade and Industry) manage the civil radio spectrum throughout the UK by issuing licences to mobile telecommunications operators and other users of radio. They aim to ensure that spectrum is used in the most efficient and effective way to the overall benefit of the United Kingdom. Their main functions, under the supervision of the Department of Trade and Industry, are to:
- formulate policy on the planning and management of radio spectrum, including pricing policy;
 - participate on behalf of the UK in international negotiations on the use of radio;

2 Facilities expected to be offered by third-generation mobile telephones

- High speed internet and intranet access and electronic mail;
- Video telephony and conferencing;
- On-line banking and shopping;
- Entertainment services, e.g. audio on demand, video games, movies; and
- Direct instant access to home or office IT systems, regardless of location.

Both individuals and industry will benefit from these services. Industries that are expected to benefit include broadcasters, media groups, supermarkets and banks as well as traditional mobile and fixed line telecommunications operators.

- authorise use of radio by licensing or by issuing exemptions; and
- enforce legislation of the use of radio, by investigating interference, monitoring compliance with licences and taking enforcement action where necessary.

In 1999/2000, the year before the conclusion of the spectrum auction, the Agency earned income of £78 million, mainly from issuing various licences, against costs of £50 million. It employs some 500 staff.

- 1.6 The Agency works closely with the Office of Telecommunications, (OFTEL), which supports the Director General of Telecommunications in maintaining and promoting effective competition in telecommunications markets, particularly through the provisions of the Telecommunications Act 1984 and the Competition Act 1998. The Director General's role under the 1984 Act includes the duty to:

- Promote the interests of consumers;
- Maintain and promote effective competition; and
- Make sure that telecommunications services are provided in the UK to meet all reasonable demands.

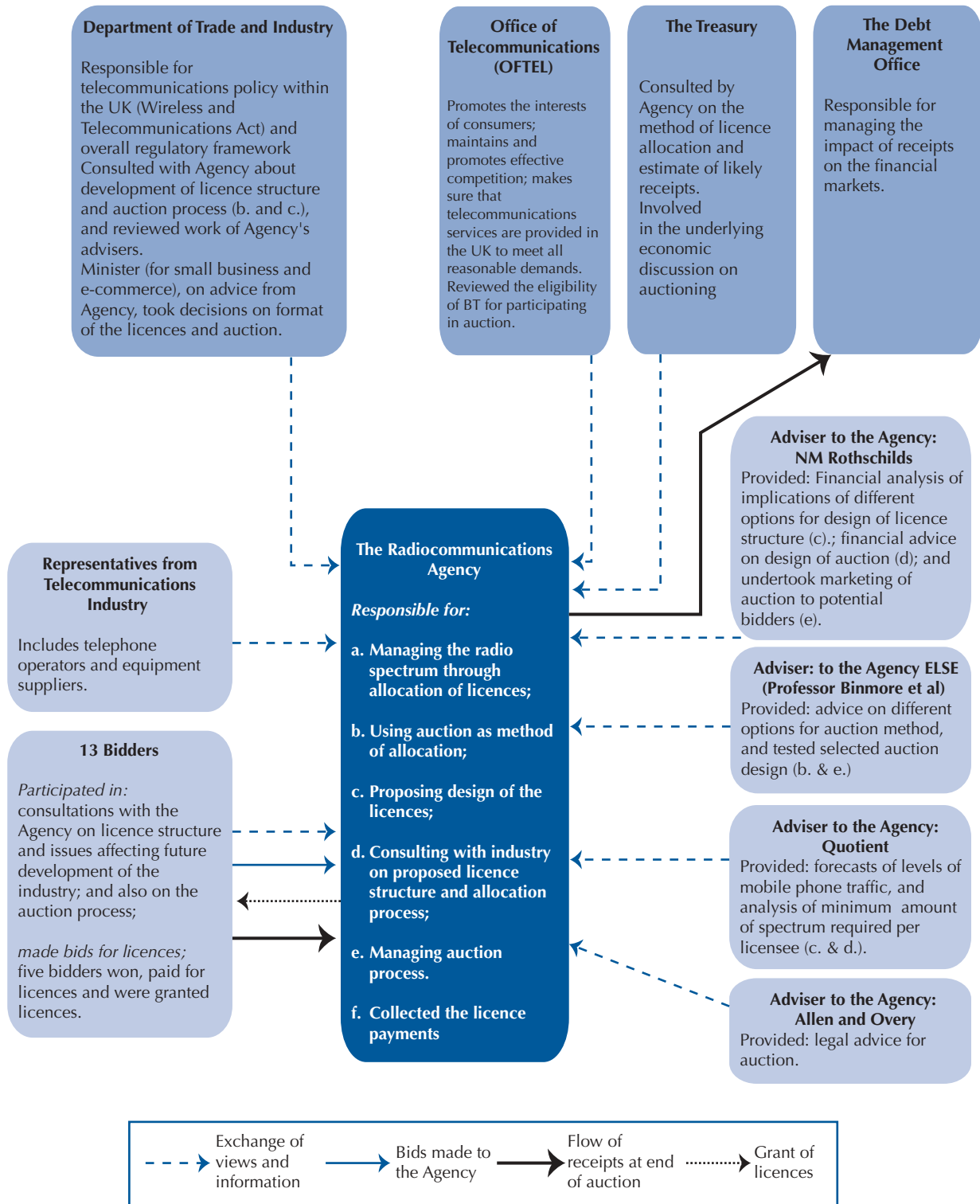
In December 2000 the Government proposed that the Agency and OFTEL should merge, along with bodies responsible for regulating standards in broadcasting and assigning spectrum to television and radio broadcasters, to form a unified new regulatory body for the communications sector, provisionally called OFCOM. They plan to bring legislation forward at the earliest opportunity.

- 1.7 The Agency were responsible for the conduct of the auction on behalf of the Government, bearing the costs of the process, consulting with OFTEL, the Department of Trade and Industry, the Treasury, and external financial, technical and legal advisors as appropriate

and advising Ministers. The Agency also led the process of consulting the telecommunications industry over the design of the licences and the auction process in the period before the auction itself. **Figure 3** shows the overall administrative context for the auction.

3 Key players involved in the design and operation of the auction

This figure illustrates the key parties to the auction and their roles and responsibilities



The Government gave the Agency three objectives

1.8 The formal objectives that Ministers set for the Agency's conduct of the auction, shown at **Figure 4**, closely reflected criteria for spectrum allocation and pricing set down in the 1998 Wireless Telegraphy Act. In designing and managing the auction, these objectives had to be balanced.

Utilising the Spectrum with optimum efficiency

1.9 The Government are concerned that spectrum once allocated should be used intensively and that operators do not allow it to lie fallow. Originally users of spectrum, including many in the public sector, did not pay for the use of this scarce resource. When fees were set these were only to recover the Agency's costs in regulating the spectrum. With this approach, reflecting circumstances when there was less demand for spectrum, there was little incentive for users to invest in equipment that would use the spectrum more efficiently or to surrender surplus spectrum.

1.10 There is increasing demand for spectrum from both existing and new uses, but the total spectrum available is finite. The resulting spectrum shortages will limit growth and delay the introduction of new services. Representatives of the telecommunications industry expressed concerns to us during our examination that the scarcity of spectrum, and therefore its price in auctions, should not be increased due to inefficient use of spectrum in the public sector. The Agency is seeking to extend the principle of charging for spectrum, which may be used inefficiently and not exploited to its full potential, to encourage the release of underused spectrum. Their current arrangements for charging also apply to government users, for example spectrum used by police radio is charged for on the same basis as taxis. Nevertheless the public sector is a major occupier of spectrum. The armed forces alone occupy more than 30 per cent of the spectrum between 9 Kiloherz and 30 Gigahertz (Figure 1), some of which could in technical terms be used for mobile telephony or other commercially valuable services. It is therefore important that the public sector shares any incentives that are placed on the private sector to use it more efficiently.

1.11 In November 2000 the Government announced an independent review of spectrum management to see what more needs to be done to ensure that all users, including those in the public sector, are focused on using their spectrum in the most efficient way possible. Led by Professor Martin Cave, Vice Principal of Brunel University, the review will consider the use of spectrum valuation, trading and pricing. Professor Cave has stated that the economic data, (**Figure 5**), suggest potentially serious mismatches in the valuation and allocation of spectrum.

4 The objectives for the auction

The Government's overriding aim was "to secure, for the long term benefit of United Kingdom customers and the national economy, the timely and economically advantageous development and sustained provision of third-generation services in the United Kingdom." Subject to this overriding aim, the Government's objectives were to:

- Utilise the available spectrum with optimum efficiency;
- Promote effective and sustainable competition for the provision of third-generation services; and
- Subject to the overall objectives, design an auction that is best judged to realise the full economic value to customers, industry and the taxpayer of the spectrum.

5 The use and pricing of the radio spectrum

The spectrum allocated for the auction is a small part of the total, but easily the most highly priced

Use	Percentage of the total	Licence fee per MHz (£,000 per annum)
Aeronautical	25	1
Defence and Emergency Services	28	20
Broadcasting - Radio	1	112
Broadcasting - TV	16	2,000
Fixed Links	5	35
Maritime	5	15
Private Business Radio	4	100
2G Mobile	8	300
3G Mobile	7	21,000
Other Mobile	1	257
Total	100	

- Notes: 1. The differences in spectrum pricing are partly due to historic reasons and to the different regulatory regimes and public policy considerations which apply.
2. Spectrum percentages are approximations that depend in part upon assumptions made about the attribution of shared spectrum.
3. The fee for 3G spectrum is derived from annualising the net present value of the £22.5 billion auction receipts, assuming a 6 per cent real interest rate.

Source: Radiocommunications Agency

- 1.12 Intensive use of the spectrum made available for 3G mobile services will depend on the number of mobile telephone subscribers who wish to use them, and the extent to which these users use advanced "high-bandwidth" services such as video and data transfer, rather than simple voice or text messages.

Promoting effective and sustainable competition

- 1.13 As well as being concerned about the development of the industry, the United Kingdom Government attached priority to increasing competition and choice for consumers in the United Kingdom mobile telephone market. They announced that they were committed to ensuring that the United Kingdom maintained its lead in the provision of competitive mobile communications to the widest possible cross section of society, and attached great importance to the further development of competition in the mobile phone market, which they thought was the best way to achieve it.
- 1.14 In July 1999 a review by OFTEL had concluded that the UK mobile telephone market was not fully competitive, although competition continued to develop. Taking a number of factors into account, including market shares, barriers to entry, prices, profitability, and the extent to which customers were switching supplier, OFTEL considered that BT Cellnet and Vodafone possessed market power. OFTEL concluded that the obligation in their licences to supply third parties should remain in place. There was a concern that competition in the early years of 3G could be dampened by defensive behaviour by incumbents, particularly if they bid for 3G licences primarily to protect their existing second generation businesses from a new form of competition in the form of innovative new services. The objective to promote sustainable and effective competition for 3G services reflected the Government's wish to see sustained competition between operators not just on price, but on the range of innovative services that could be provided. It therefore complemented the other objective, for the efficient use of the spectrum. The Agency and OFTEL recognised that in designing the licences and the auction they would have to take into account the inherent advantages the four incumbents would have over a new entrant, in terms of having existing networks serving most of the population, and their strong customer base. They also recognised that incumbents could be expected to bid strongly for a licence against potential new entrants, to ensure that their businesses would survive.

Realising the full economic value

- 1.15 This objective was worded so as to make it clear that the interests of the industry and consumers should be taken into account, rather than to mean simply maximising the proceeds for the taxpayer. It recognised that a strong industry would generate economic growth and receipts from taxation. Nevertheless, subject to the main objectives of promoting efficient use of the spectrum, and competition between operators the Government saw the potential to raise greater proceeds from the allocation of licences than they had raised in previous allocations of radio spectrum. Following economics advice from National Economic Research Associates, an international economic consultancy, that auctions provided a sound economic basis for the allocation of spectrum, they decided to allocate licences through an auction. They considered this to be consistent with the prime objectives because by awarding licences to the highest bidder, spectrum would be allocated to the mobile telephone operator that valued it most and could be expected to exploit it to greatest advantage. A bidder that had paid a market-based valuation for spectrum would be incentivised to roll-out services as quickly as possible, to achieve the returns required by its stakeholders.
- 1.16 There are other reasons for using an auction. The main alternative, comparative selection of bidders' standing and proposals through administrative "beauty contests" can have serious disadvantages:
- The award of licences can be open to criticisms of subjectivity, including favouritism, corruption or protection of indigenous firms. Complaints on various grounds have been taken to national courts in Spain and in Sweden, and to the European Union, and can result in delay in the allocation; and
 - Government officials, even when supported by expert advisers, are not necessarily well placed to pick the winners from commercial and technical proposals submitted by leading edge companies. It can be difficult for the authorities subsequently to hold winners to the optimistic promises of expanding services and usage that they made during the contest.

Bidders told us that their attitude to beauty contests and auctions was influenced by their judgement of which gave them a better chance of winning in different situations. But they welcomed the greater transparency and reduced bidding cost of auctions compared to beauty contests, where they had to submit voluminous, carefully presented proposals to the authorities. The relative advantages and disadvantages of auctions and beauty contests are described in greater detail in Appendix 1.

The National Audit Office examination

1.17 The auction merits examination for several reasons, principally:

- The use of sophisticated auction techniques is innovative in the public sector in this country, and there is scope for other public bodies to learn useful lessons from this example;
- The development of revolutionary new mobile telephone services has the potential to make a difference to the lives of many UK citizens, many of whom own one or more of the 40 million mobile phones in operation in this country; and
- commentators are divided on the outcome of the auction. Some assert that the massive sums raised by the auction will restrict the development of the industry in the UK and so undermine the achievement of the Government's main objectives. An illustration of the divided opinion on this subject is at Appendix 2.

1.18 Against this background, we have examined the extent to which the auction has promoted the achievement of the three objectives placed on the Agency (Figure 4); specifically whether the allocation of licences through the auction should lead to:

- the available spectrum being utilised with optimum efficiency;
- the promotion of effective and sustainable competition for the provision of third-generation services; and
- Subject to these objectives, the realisation of full economic value to customers, industry and the taxpayer of the spectrum.

Part 2 deals with the achievement of the subsidiary objective, to realise the economic value of the spectrum. It explains why the level of proceeds was so great in this case and draws on work from Professor Peter Cramton, an international authority on auction design, who advised us on the design and conduct of the auction (Appendix 3). It is not possible in the absence of reliable information on the likely revenues that 3G services will generate, to estimate the extent to which the auction has realised economic value for the industry and consumers. Parts 3 and 4 examine the likely longer-term outcomes of the auction, the extent to which the licence allocation should encourage efficient use of the finite spectrum, and promote sustainable competition between operators and extended choice for consumers.

1.19 It is too early to be conclusive about the future for 3G services, which are in their development stage and still face major technical and commercial uncertainties. But we have examined the likely effects of the auction itself in the UK, drawing on the views of operators and other participants in the industry, as well as the work of our specialist advisers on the telecommunications industry, the Strategis Group consultancy. Our approach is described in more detail in Appendix 4.

1.20 The auction was run on the basis that the bidders did not present the Agency with their detailed proposals for implementing 3G services. Bidders qualified to take part in the auction solely through lodging a £50 million deposit with the Agency to ensure their commitment to bidding and taking up any licence that they won. As a result neither the Agency nor the National Audit Office have had any access to successful bidders' business plans, though bidders talked to us voluntarily about the conduct of the auction and its outcome.

Part 2

The auction raised unprecedented
proceeds, of £22.5 billion

- 2.1 The auction ran between 6 March and 27 April 2000. Nine new entrants bid strongly against the four incumbents (British Telecom (BT), Vodafone, One2One and Orange) for five licences, creating stiff competition leading to revenues of £22.5 billion. This level of proceeds from a sale of assets in the UK is unprecedented although, as explained in Part 1, raising proceeds for the taxpayer was a subsidiary objective of the auction. Central to many of the discussions on the outcome of the auction, both within and outside the mobile telecommunications industry, has been a debate about the implications for the industry of the extraordinary amount of money paid by the successful bidders for the licences. This part of our report focuses on the proceeds raised for the taxpayer, whilst recognising that this objective was intended to be balanced against the interests of customers and the emergent 3G industry. Parts 3 and 4 of the report discuss how far the outcome of the auction may affect customers and the development of the industry.

It raised more than previous allocations of spectrum licences in the UK

- 2.2 The White Paper "Spectrum Management into the 21st Century, issued by the Department of Trade and Industry in June 1996 following consultation with the Agency, announced a new approach to spectrum pricing. At that time, legislation only allowed for licence fees to be set at a level to recover the costs of licensing. This did not reflect the value of the spectrum and gave little incentive to licensees to use spectrum efficiently or surrender unused spectrum. The Wireless Telegraphy Act 1998 allowed for licence fees to be related to the value of the spectrum to improve efficiency. These fees could be set administratively, or by means of an auction. Fees for Third Generation mobile spectrum licences were the first to be set by auction. The Agency's annual licence fees for current mobile telephone services raise some £40 million each year.

It raised far more than anyone had expected

- 2.3 The spectrum proved a difficult asset to value because there had been no previous auction to provide a benchmark, and the Agency's financial advisers found it difficult to obtain any valuations from the industry itself. The Agency's advisers estimated in April 1999 that the sale of the spectrum for the third-generation licences might realise in the region of £1.5 billion, and set reserve prices for the auction accordingly. They had no access to bidders' business plans to validate their estimate, but received some information drawn from the business plans of two potential bidders who did not subsequently bid. In January 2000, on receipt of 13 applications, the advisers increased their estimate to a range of £1 billion to £3 billion, (Figure 6).
- 2.4 We discussed the pre-auction estimates with the Agency and their advisers, N M Rothschild and Sons Ltd, (Rothschild). They stressed that the model, built in early 1998 and adapted over the course of that year, had not been intended to predict proceeds. It was instead designed to indicate how a new entrant and incumbent bidder's valuations would change in relation to each other if different licence conditions and policy initiatives were adopted. Both they and the Agency had considered before the auction that the huge variances in financial market conditions, and between the operators, made it very difficult to predict the likely total revenue from the auction.
- 2.5 The difficulty of estimating the scale of proceeds from the auction was shared by outside commentators. The highest external estimate of proceeds that we have seen, published shortly after the commencement of the auction by Lehman Brothers' investment analysts, was £6 billion. This late increase in estimated proceeds reflected recent developments such as a boom in telecommunications industry stocks and a steeply upward trend in mobile telephone use in the UK. Most bidders who responded to our survey told us that the

6 The value extracted by the auction

This figure shows that each licence fetched much more than its reserve price, with higher proceeds for the licences with most spectrum

Licences (1)	Purchaser	Price £ billion	Price per MHz £m	Reserve Price £ billion	Official Pre-estimate £ billion
A (largest and reserved for a new entrant) (2)	TIW	4.385	292	0.125	Not disaggregated
B (2nd largest)	Vodafone	5.964	398	0.107	"
C (small)	BT	4.030	403	0.089	"
D (small)	One2One	4.004	400	0.089	"
E (small)	Orange	4.095	409	0.089	"
TOTAL		22.478		0.499	1-3

Note: 1. Licences C, D and E are of equal size at 10 Megahertz of "paired" spectrum. "Paired" spectrum carries signals to and from telephone handsets. Though each licence except "B" also had one-way "unpaired" spectrum, this is currently of much less value than the paired, as it cannot carry signals in both directions at once. Licences A and B provide 15 Megahertz. Licence E raised slightly more than C and D because it was seen as less vulnerable to interference from adjacent users of spectrum.

2. The Agency considered that to promote competition it was important to encourage a new operator to enter the market and decided that the best way to achieve this was to reserve the largest one of the licences (A) for the new entrant, (Part 4).

Source: National Audit Office

prices paid were significantly higher than they too had expected. Our enquiries amongst financial institutions established that bidders had been seeking funding at up to £2 billion a licence. This is supported by the fact that five of the nine new entrants withdrew from the auction at around that level.

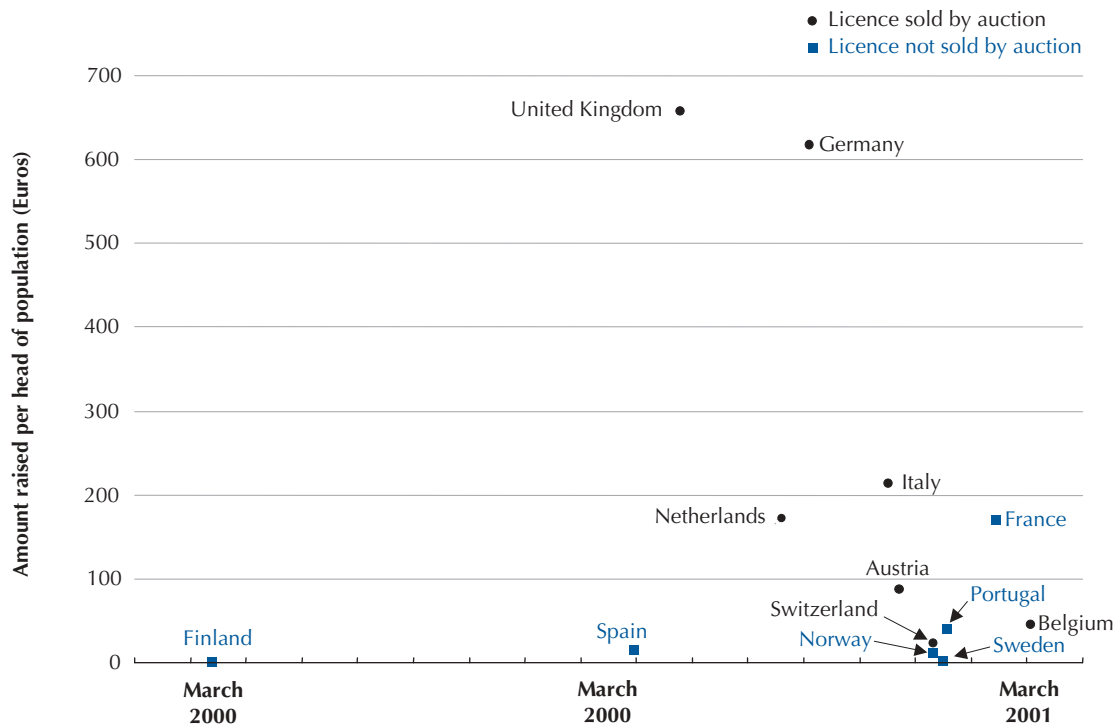
2.6 The Agency decided to auction the spectrum available for 3G as five licences, which for reasons explained in Part 3, were of different sizes. One of the larger licences was reserved for bidding by new entrants only. Bidders placed different values on each of the licences, as shown in Figure 6.

The auction raised more per head than in other countries

2.7 The United Kingdom was the first country in the world to allocate radio spectrum for 3G telephony by auction. In March 1999 and April 2000 the authorities in Finland and Spain had allocated spectrum on the basis of beauty contests - in which they assessed the standing and proposals of bidders. Though Germany raised higher total proceeds from their auction in August 2000, this reflects the higher German population, and Figure 7 shows that on a per head basis proceeds in the UK were higher.

7 Proceeds raised by allocations of 3G Spectrum in the European Community

The auction of 3G spectrum in the United Kingdom raised higher proceeds on a per head basis than allocation of 3G Spectrum in other countries in the European Community.



Notes: 1. Countries not using auctions allocated licences through "beauty contests" in which officials assessed the standing and proposals of bidders. In Sweden and Finland bidders did not pay for the licences, in the other countries governments set a fee.

2. In France two of the four licences on offer went unsold. In Belgium three out of four licences were taken up.

Source: The Strategis Group

The Agency enhanced and secured the value of the licences

2.8 The high level of proceeds from the UK auction arose from the strong convergence of several positive factors, some of which were attributable to the actions of the Agency and others of which originated from external causes. These are summarised in [Figure 8](#).

The Agency and their advisers stimulated participation by bidders

2.9 The Government's primary objective was not to maximise the level of proceeds from the auction. Therefore the Agency did not adopt certain strategies which could have had that effect, which potentially included:

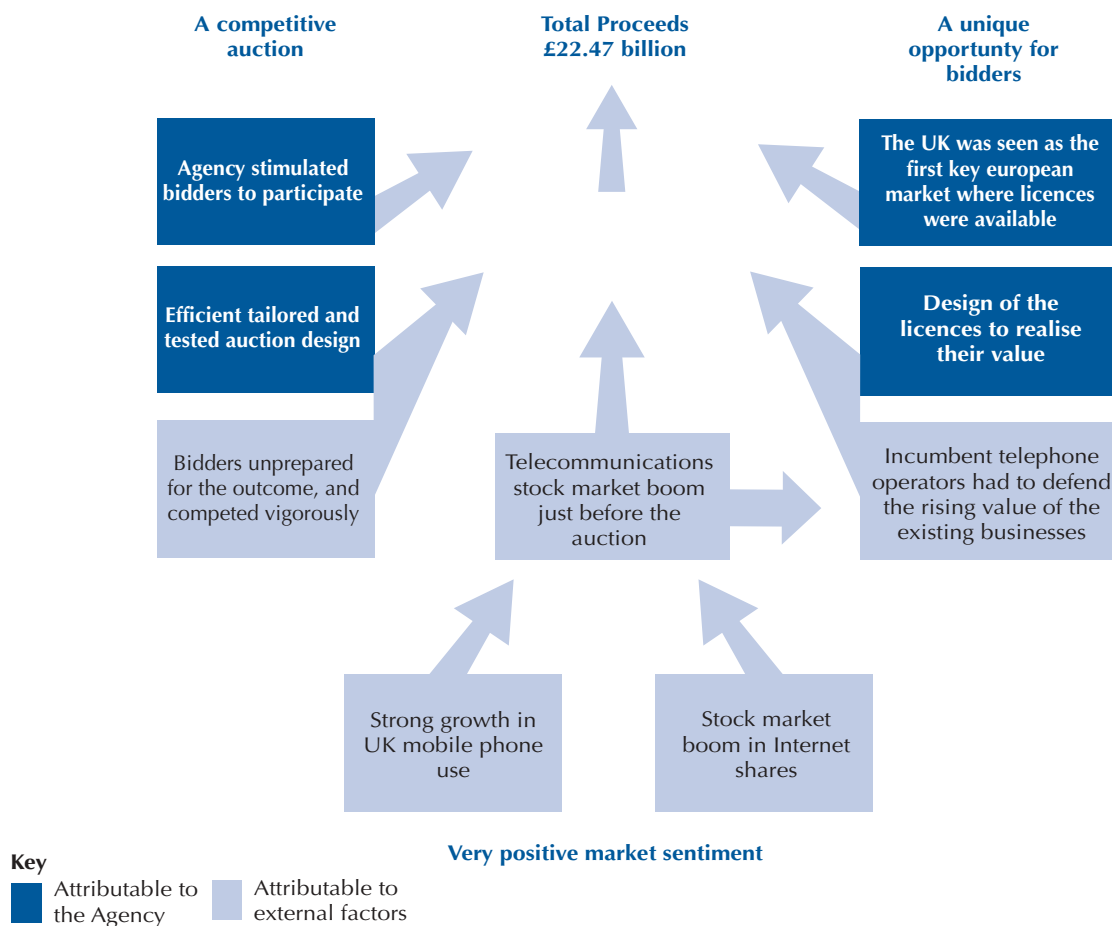
- selling three or fewer licences, forcing the four incumbents to compete in a "fight for survival";
- not reserving a licence (A) for a new entrant, but allowing incumbents to bid for this spectrum too.

Conversely, allocating this large 2x15 MHz paired licence to the new entrant created a situation in which the two largest existing operators, Vodafone and Cellnet, went "head to head" for the only remaining large licence which incumbents could bid for, sustaining its price at a similar level per MHz as the other licences.

2.10 The UK auction benefited from more competition than other later auctions of spectrum in Europe, ([Figure 9](#)). As identified by our adviser on auction practice, Professor Cramton, (Appendix 3), the decision to auction five licences was fundamental. Given that there were four incumbent operators, five licences guaranteed that a new entrant would win one, creating a strong incentive for potential entrants to enter the bidding. Setting aside the largest, best licence for a new entrant was an additional incentive to enter. In the Netherlands in comparison, where the auction design was close to that in the UK, five licences were also offered where there were already five incumbent operators and only six bidders in total. All were won by the five incumbents, bidding in partnership with potential new entrants. The only unattached new entrant soon dropped out of bidding and the auction ended at much lower proceeds than in the UK. The

8 Key factors contributing to the high level of proceeds in the auction

The high level of proceeds arose from the strong convergence of several positive factors, some of which were attributable to the actions of the Agency and others of which originated from external causes.



Source: National Audit Office

Netherlands auction therefore supported the view that new entrants could be deterred by the market strength of existing operators, (paragraph 1.14).

2.11 The Agency appointed Rothschild in December 1997 as Financial Advisers on the auction. Their role was to provide financial and specialist telecoms advice on every aspect of the policy framework, auction methodology and implementation, to assist in the overall project management and to issue the Information Memorandum on behalf of Government. A further role was to promote the 3G opportunity and market the auction. Over the next 15 months Rothschild paid particular attention, through consultation with potential bidders, to designing the auction in a way that would encourage the participation of new entrants. Rothschild told us that, besides the decision to sell five licences, it had been important to require those incumbents who won 3G licences to allow the new

entrant's subscribers to use one incumbent's telephone network for the first seven years of the licence while the entrant built their own infrastructure. This reduced a barrier to entry to the market, and helped new entrants to build a sustainable business case to obtain financing to bid in the auction. It was not easy for the Agency to impose this mandatory right to roam for customers of the new entrant. Initially all the incumbents resisted this condition, wanting to negotiate their own terms with the new entrant. Vodafone and BT Cellnet agreed to the condition but One2One and Orange mounted a legal challenge on the way the condition was imposed, which the government won on appeal. The government decided to let One2One and Orange participate in the auction and take up their licence without the obligation, considering that the new entrant would have sufficient rights to roam without them, and that further delay to the auction would be unwarranted. Hutchison told us that they considered roaming very significant, giving

9 The number of bidders in European auctions for 3G spectrum

Achieving a good ratio of bidders to lots is fundamental to success. See also Figure 7 above

Country		Number of bidders	Number of licences	Comments
United Kingdom	April 2000	4 incumbents 9 new entrants	5	Auction extended over 52 days and 150 rounds of bidding. (1)
Netherlands	July 2000	5 incumbents 1 new entrant	5	Auction extended over 14 days and 305 rounds of bidding
Germany	August 2000	4 incumbents 3 new entrants	6	Auction lasted 19 days and 173 rounds of bidding.
Italy	October 2000	4 incumbents 2 new entrants	5	Auction finished after 2 days and 11 rounds
Austria	November 2000	6 bidders	6	Auction finished after 2 days and 14 rounds of bidding.
Switzerland	December 2000	4 bidders	4	Auction was initially delayed, then lasted one day.
Belgium	March 2001	3 incumbents	4	After one round of bids the three bidders paid the reserve price only.

Note: 1. Bidding was relatively slow in the UK auction, reflecting in part that neither the Agency nor bidders had previously participated in auctions of spectrum in Europe. Our auction adviser, Professor Cramton has identified ways in which bidding might have been accelerated (paragraph 2.16)

Source: National Audit Office and Strategis, from published material

them confidence that they could get into the market quickly, which is especially important given the need to finance the high licence fee.

2.12 Rothschild found marketing initially challenging because the companies they approached considered 3G networks and services as unproven. Many questioned the demand for mobile data and were unclear as to the applications for which 3G services could be used. Accordingly, Rothschild initiated conferences, press coverage and meetings with current telecommunications operators, potential operators, mobile equipment manufacturers, consumer organisations and IT companies. Media interest increased from one mention per month to high daily coverage across a wide range of high profile journals. Rothschild told us that their approach was designed to help manufacturers and consumer organisations recognise the usefulness of 3G, and hence increase incentives on mobile phone companies to provide 3G

services. Though few operators initially expressed interest this gradually increased. In the end thirteen strong bidders took part in the auction, (Figure 10). Most of the new entrants who responded to our survey told us that the marketing had encouraged them in their propensity to bid.

2.13 The Agency consulted widely throughout the preparations for the auction, meeting regularly with user and industry groups. As early as July 1997 the Government had published its proposals for implementing 3G in the United Kingdom in a consultation document "Mobile Phones for the Next Generation: Multimedia Communications on the Move". In early 1998 the Agency set up a formal Consultative Group to act as a forum for the Government to present its proposals for the auction of 3G licences to industry and encourage discussion of the issues involved with representatives from industry.

10 Participants in the auction

Thirteen strong bidders took part, almost all were linked to substantial global telephone companies

Incumbent Mobile telephone operators in the UK

Vodafone is the largest mobile telephone operator in the UK, and is a wholly owned subsidiary of Vodafone Group Plc, which has interests in various global mobile telephone businesses.

BT 3G owned by British Telecom. British Telecom owned a majority shareholding in BT Cellnet, the second largest mobile phone operator at the time of the auction and subsequently bought out the other shareholder - Securicor. At the time of the auction Cellnet had 27 per cent of mobile phone users.

Orange - one of the four incumbent telephone operators in the UK, originally set up by Hutchison Whampoa and purchased by Mannesman, a German company, in 1999. Mannesman was subsequently purchased by Vodafone in February 2000. Vodafone's purchase of Mannesman was referred to the EC under Competition rules. The EC determined that the purchase could proceed provided Vodafone divested themselves of Orange as soon as possible. Vodafone sold Orange to France Telecom after the auction in August 2000.

One2One the smallest of the four incumbent mobile telephone operators in the UK, purchased by Deutsche Telekom, the former German national telephone operator, in 1999.

Bidders seeking to become a New Entrant

WINNER: TIW UMTS (UK) Limited was a subsidiary of TIW, a North American telecoms company. The subsidiary and therefore its licence was taken over after the auction by Hutchison 3G UK, (paragraph 4.5).

3G(UK) Limited was an Eircom company. Eircom is one of Ireland's leading providers of local, long distance and international telecommunications services.

Crescent Wireless Limited was a recently organised company whose shareholders had significant interests in Global Crossing, a major provider of international fibre-optic networks.

Epsilon Tele.Com plc was a wholly owned subsidiary of the Japanese finance house Nomura.

NTL Mobile Limited was jointly owned by NTL, a leading telecommunications provider and cable company already providing transmitters for incumbent mobile telephone companies, and France Telecom.

One.Tel Global Wireless Limited was a subsidiary of One.Tel, a global telecoms company based in Australia.

SpectrumCo Limited was largely owned by a Finnish telecoms company, Sonera, with partners including the Virgin group and Tesco.

Telefonica UK Limited was a wholly owned subsidiary of TelefonicaSA, one of the leading telecoms companies in Spain and Latin America.

WorldCom Wireless (UK) Limited was wholly owned by MCI Worldcom, a global telecoms company.

Source: National Audit Office and Radiocommunications Agency

2.14 Membership of the 80-strong Group included bidders in the auction and telecommunications firms, electronics manufacturers, and relevant trade and professional organisations in a position to strongly influence the development of 3G. The group considered spectrum packaging, competition, industry structure and licensing and regulatory issues before moving on to discuss the practicalities of the auction itself. Advisers to the Agency also attended many of these meetings, as did representatives from the Department of Trade and Industry and OFTEL.

The design and operation of the auction was efficient

2.15 The Agency only selected the format for the auction once it was clear that the design of the licences would attract more bidders than licences. Other countries that later used the same format in the absence of such competition, such as the Netherlands and Switzerland, raised much lower proceeds. The arrangements for bidding are described in **Figure 11**. The Agency, acting on advice from their advisers in game theory from University College London, elected not to invite sealed one-off bids. There is widespread evidence that single

sealed bids can produce irrational results in which similar lots realise wildly different proceeds, though sealed bids may be advisable if there are insufficient bidders to sustain an open competition. In this case, the transparent, ascending bid format the Agency adopted gave the bidders greater confidence in bidding higher, since they were able to see that numerous competitors were doing likewise, based presumably on their own business projections and strategic priorities. Also, an ascending auction spread over seven weeks gave the bidders ample time to revise their initial budget constraints through authorisation from their top management and external financiers.

2.16 Bidders told us that they considered that the Agency had managed the auction process very well. Our adviser, Professor Cramton, considered the design and conduct of the auction to be generally excellent, with only relatively minor issues arising, (Appendix 3):

- Requiring an initial deposit is a mechanism to deter unqualified bidders and reduce the risk of default by successful bidders. Bidders were required to provide a deposit of £50 million to enter the auction, which was ratcheted to £100 million when bids reached £400 million. These deposits bore no relation to the final outcome prices, and could either have been larger initially or ratcheted further as the process continued. The Agency and Rothschild decided in advance not to use ratcheted deposits as they consider these would have been disruptive to the bidding process and would add significantly to the time required for bidding;
- A slowly paced auction can lead to increased costs and reduced interest by bidders. The Agency could have quickened the auction by modifying the three main instruments of control: setting higher minimum opening bids; increasing the size of the bid increment; or increasing the number of rounds per day; and
- The Agency offered bidders the option of bidding using encrypted or clear fax and in the end employed encrypted fax to receive bids. There were advantages to using faxes in the UK's first auction; however, some bidders found them costly in terms of staff and transmission facilities. The Agency used a secure intranet facility in its later broadband auction.

2.17 The final price paid for the licences was largely determined by the point at which the last unsuccessful bidder, NTL Mobile, dropped out of the auction, (Figure 12). We asked NTL why they were prepared to bid significantly higher than all other new entrants except Hutchison. They told us that in deciding to enter the auction in partnership with France Telecom they had recognised their particular advantages in becoming a new entrant, specifically:

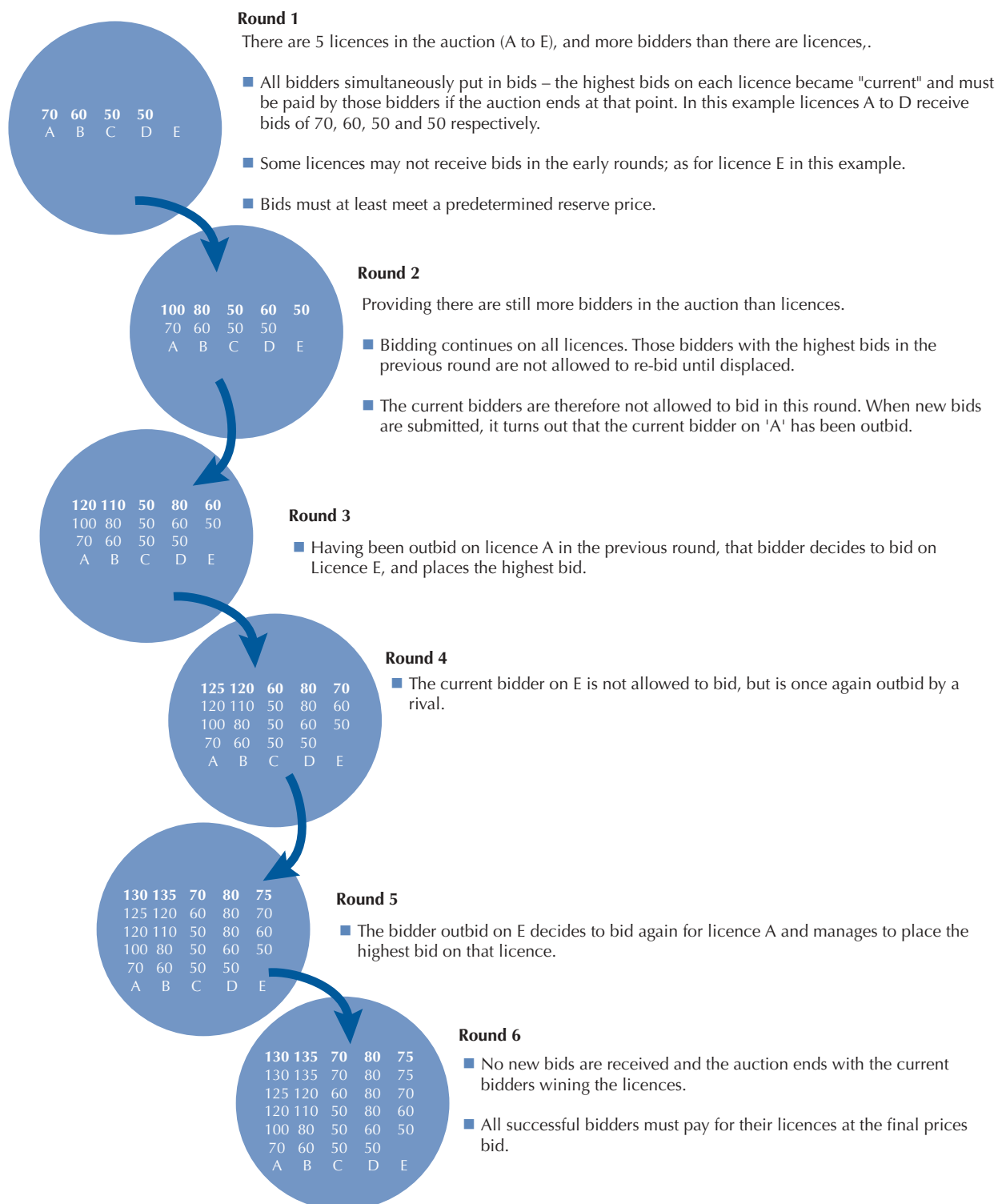
- their strong existing customer base in the UK, with cable networks covering a third of households;
- their position as supplier of transmitters to the existing mobile telephone operators, through their own network of some 2,000 base stations;
- their past experience in running a mobile telephone company in the USA; and
- their strong track record of raising finance on the scale necessary to establish a 3G network.

2.18 The requirement for £100 million deposits in the auction, which bidders would forfeit if they failed to take up a licence they had won, was a deterrent to any possible tendency to bid up the prices of licences beyond their estimated value at the expense of incumbents.

2.19 Figures 12 and 13 illustrate the pattern of bidding for licences. Licence A was the subject of bids from most of the non-incumbents, especially SpectrumCo and NTL. When TIW placed a bid that NTL would not match, NTL switched to bidding on the smaller unreserved licences, which drove the price on these up further, to the £4 billion level. Vodafone signalled their determination to win the unreserved large Licence B by bidding on no other licence and by placing bids above the minimum bid. Their main competitor for it, BT 3G, settled for Licence C at the very end of the auction. Licence E went to Orange, which signalled its preference for this licence at the end of the available spectrum by bidding only on this lot, once it was clear that Vodafone and BT would bid up the price for Licence B.

11 How bidding proceeds using simultaneous ascending bids

This figure illustrates how bidding proceeds using simultaneous, ascending bids

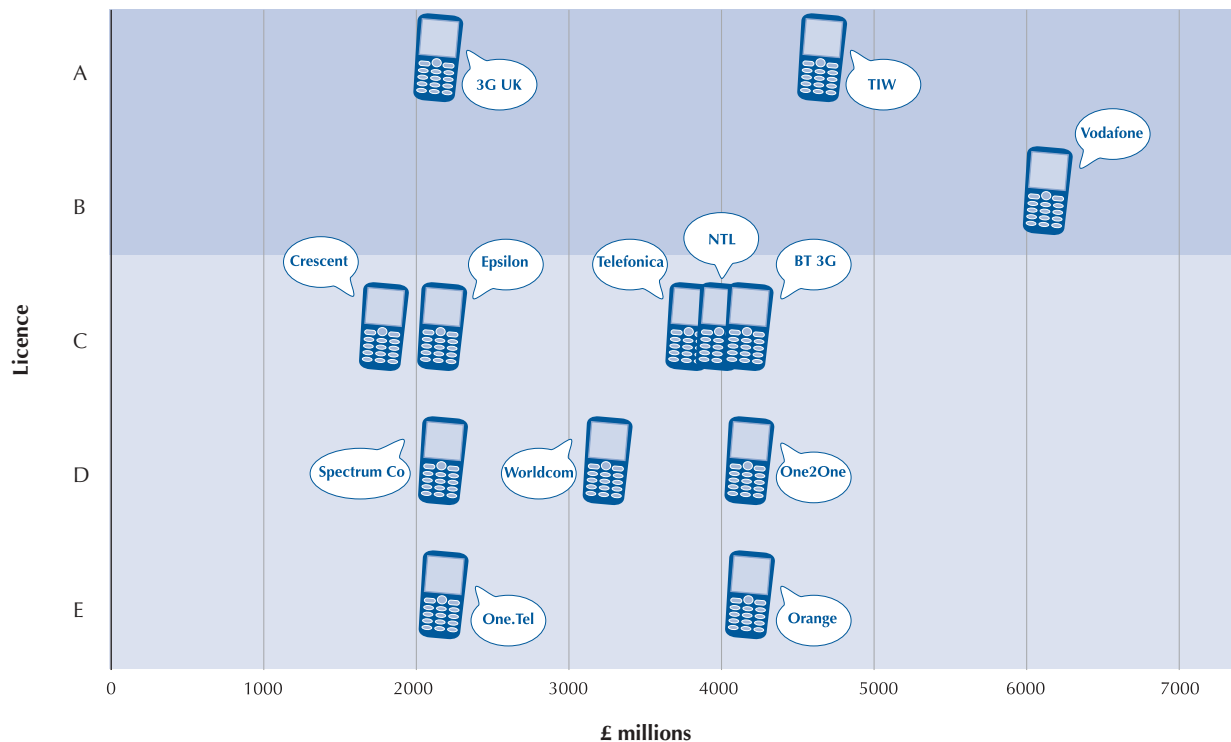


Note: The bids shown are for illustrative purposes only.

Source: Radiocommunication Auction Documentation

12 The final bids made by participants in the auction

This figure shows that five of the nine new entrants dropped out of the auction at around the £2 billion mark. Bidding by major communications companies such as NTL and Telefonica pushed prices still further towards the eventual £4 billion outcome.



Notes: 1. Licence A was reserved for a new entrant.

2. Licence B was the largest licence that an incumbent could bid for. Its wider bandwidth allowed more capacity and reduced infrastructure costs. Apart from Vodafone no bidders submitted their last bid for this licence, they moved instead to the other, cheaper licences.

3. Some unsuccessful bidders had earlier bid higher amounts on the more valuable licence A; (Worldcom £3.774 billion and NTL £4.278 billion).

Source: National Audit Office

The timing of the auction was conducive to maximising proceeds

2.20 The Government emphasised that early implementation of 3G in the UK would be advantageous for operators and consumers alike, and the auction proceeded close to the timetable set in the Information Memorandum published in November 1999. Vodafone told us that winning the first licences to be made available in a key European market was important to bidders because:

- it enabled winners to approach equipment suppliers with realistic requirements before operators in other countries placed orders, allowing the licensees in the UK to influence the shape of the products and to secure supplies; and

- it provided them with a stronger basis on which to bid for licences in other countries, whether allocated through auctions or through beauty contests.

We found a general view on the part of bidders that many European and global telecommunications companies saw success in the UK auction as important to qualifying to be one of a small number of pan-European operators in the next decade, after a process of consolidation in the industry.

13 The pattern of bidding for licences

This figure shows that some bidders demonstrated their determination to win specific licences by bidding exclusively on those, whereas other bidders moved to bid on the licences that were cheapest.

Company	Final bid in round	Number of times bid for					Licence won
		A	B	C	D	E	
TIW (later Hutchison)¹	131	12	5	12	12	10	A
Vodafone (Incumbent)	143	-	34	-	-	-	B
BT 3G (Incumbent)	149	-	23	8	13	27	C
One2One (Incumbent)	146	-	-	12	16	13	D
Orange (Incumbent)	148	-	16	-	-	8	E
NTL Mobile	145	23	0	12	13	4	
Telefonica	129	5	1	12	20	6	
Worldcom	117	4	-	14	15	7	
One-Tel	97	2	-	9	10	5	
Spectrumco	95	20	1	3	4	1	
Epsilon	94	-	-	13	9	6	
Crescent	90	-	-	8	13	6	
3G UK	89	3	-	8	10	10	
Total licence bids		69	80	111	135	103	

Note: 1. Hutchison's takeover of TIW's licence is described in Part 4.

Source: Radiocommunications Agency

2.21 The auction also coincided with a period of positive sentiment in global financial markets towards the telecommunications industry and a boom in share prices. Delays because of companies' legal challenges to the roaming proposals (paragraph 2.11), deferred the auction to a date coinciding with the peak of the internet stock bubble and an all-time peak in the share values of telecommunications companies, (Figure 14). This resulted in auction prices which were much likely billions of pounds higher than had the delay not occurred, since:

- The listed incumbent operators, Vodafone, BTCellnet and Orange, saw dramatic rises in the price of their shares on the stock market - shareholder values that had to be protected against failure to win a licence with the associated risk of loss in investors' confidence in operators' ability to offer a range of up-to-date products, and loss of customers to new entrants offering superior 3G services; and

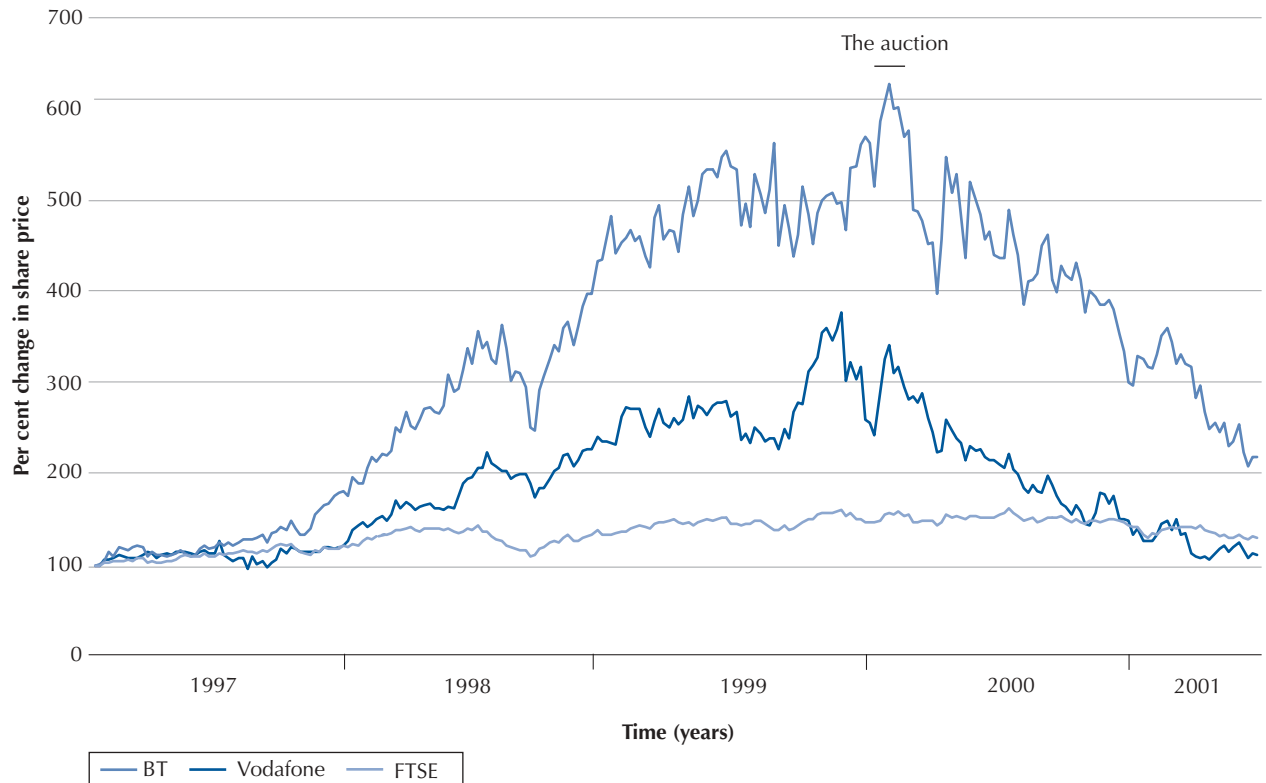
- It indicated an ample supply of cheap debt and equity funding, with which successful bidders could finance their licences and infrastructure. A subsequent downturn in the stockmarket and capital markets in the latter half of 2000 meant that these indications were not fulfilled.

The auction had a very different outcome to the subsequent auction of spectrum in the UK

2.22 In November 2000 the Agency auctioned more frequencies in other parts of the radio spectrum for Broadband Fixed Wireless Access (BFWA), to give business and domestic users access to services such as high capacity data transfer and video conferencing and fast Internet access over radio links without the need for cable or telephone connections. 3G and BFWA address different markets, although there is some synergy: 3G services are about high speed services on the move;

14 Movements in the share prices of major telecommunications companies

The auction took place at a historic peak in the share prices of major telephone operators. Since then prices have fallen to the levels that prevailed in 1998 or 1999 Auction.



Source: Tradeline

BFWA will deliver much higher data rates but only between fixed locations. The objectives and the design of this later auction were similar to that for 3G, but resulted in a very different outcome. The auction raised only £38 million against the Agency's total reserve price of £78.3 million. Of the 42 licences on offer (three in each UK region, including Wales, Scotland and Northern Ireland), 26 were unsold, leaving seven of fourteen regions without provision for services in these bands. Conversely, six new entrants were attracted to an existing competitive market for broadband access in 60 per cent of the population. **Figure 15** provides a comparative assessment of the reasons for the very different outcomes in these first two spectrum auctions in the UK.

2.23 Following this outcome, Ministers decided that the remaining licences will be made available, initially for a period of twelve months, from the second half of 2001 at the reserve prices set for the Auction. Unless there are competing demands for a licence it will be provisionally allocated to the first applicant. If there are competing demands an auction will be used to allocate the licences in the relevant regions. Auctions for different regions may be run concurrently where this would suit

bidders who would like to obtain licences in a number of regions. This process will continue until all the licences are taken up or the Government decides to withdraw the offer.

2.24 The outcome of the Broadband auction suffered, to some extent, from the adverse reaction of the wider market to the very high prices that mobile telephone operators had paid for the 3G licences. Consequently circumstances were not entirely in the Agency's control. Nevertheless there are useful lessons to be learned from it, including:

- the benefits of setting conservative reserve prices where demand is very uncertain, as was done in this case;
- the need to establish contact with senior decision-makers in bidders' organisations, (as opposed to bidding teams) in order to keep up to date with their investment intentions; and
- the case for actively countering media speculation about inflated levels of proceeds, which could deter bidders.

15 Key factors in the differing outcomes of the Agency's two successive auctions

Success factor	The 3G Auction April 2000 (1)	The 28 Gigahertz "Broadband" auction November 2000 (2)
The overall strategic situation	<p>Four incumbent operators needed to maintain their market presence by migrating from 1G and 2G phones to 3G</p> <p>Bidders saw a licence in the UK as key to building a Pan-European presence.</p> <p>No particular concern at the time about competition from other technologies.</p>	<p>This is a new market, with no market incumbent operators seeking to defend their market position.</p> <p>Licences were seen as being of regional interest only. Since licences were regional, this could have made it difficult for bidders to assemble national networks. No bidder taking part sought national coverage.</p> <p>There was concern about competition from other new technologies capable of delivering broadband access - as a result "Broadband" was perceived as a niche product with limited appeal.</p>
Sentiment in financial markets and the telecommunications industry	Very strong at the time of the auction, even towards "unproven technology".	Very weak at the time of the auction. Some bidders reported difficulty in obtaining backing of investment banks towards "unproven technology". Some had postponed fund-raising initiatives such as public share offerings. There is evidence that some bidders were deterred by the high values generated by the 3G auction and by media comments that the later auction could raise £1 billion. This heightened bidders' fears that they could not compete.
Auction rules	The major industry players who participated were not deterred by the auction rules.	Though the auction process worked smoothly, there was some evidence that the smaller companies who were drawn to this auction were deterred by the requirement to pay at least 50% of licence fees up front. Some bidders felt that auctions hindered fundraising where technologies were untried. However, reserve prices were set at a low level compared to the costs of building a network, and did not constitute a significant deterrent.
Bidding activity	13 bidders all bid actively for five licences, (a healthy opening ratio of 2.6 to 1). The auction lasted 150 rounds.	There were positive indications before the auction, with 12 applicants stating their intention to bid in aggregate on 107 licences (a ratio of 2.5 to 1). However, at the start of the auction there were just nine bidders with 76 aggregate bidding credits, (a ratio of 1.8 to 1). Although four of these notified an intention to bid in each of the 14 regions many of these rights to bid were not exercised at all, and bidding lasted only 21 rounds.

Notes: 1. National Audit Office assessment of success factors in the auction of 3G spectrum.

2. National Audit Office assessment from review of the Agency's debriefing of participants in the "Broadband" auction - bidders, non-bidders and advisers.

Source: National Audit Office

The costs of the process were well controlled

The costs of developing and managing the auction process were some £8 million, less than 0.1 per cent of proceeds

2.25 Total costs of developing and managing the auction were £8 million (**Figure 16**), equivalent to less than one tenth of one per cent of proceeds. These costs comprised mainly costs of consultants, Agency staff and legal services provided by the Department of Trade and Industry.

2.26 The Agency did not set a lifetime budget for the auction in advance. Instead, finance staff agreed annual allocations for the project to a total of some £8 million. Overall the Agency managed to keep within these.

Most of the advisers were appointed following competitive tendering and fees were well controlled

2.27 The Agency appointed all advisers following a competitive tendering process, except their advisers on auction design led by Professors Binmore from University College London and Klemperer from Oxford (**Figure 17**). The Agency engaged them initially on a single tender basis because they considered that only this team in the United Kingdom was capable of providing the level of advice required. The Agency were concerned to appoint these advisers before potential bidders engaged their services. Initially the advisers provided advice on the design of the auction assuming that the Agency would auction four equal-sized licences. When the Agency decided that it would be possible to auction five licences rather than four, they asked the advisers to re-consider their original proposals, and extend their testing of how different auction models would work with five different sized licences. This extension of the original testing programme incurred extra costs and therefore outturn costs exceeded expectations.

16 Costs of the Auction

Cost Element (£ million)	Allocated Budget (£ million)	Outturn (£ million)
External Advisers	No specific budget ¹	6.1
Staff costs (permanent)	0.9	1.1
Legal Expenses: (Department of Trade and Industry)	0.3	0.3
Other running costs (including temporary staff)	0.5	0.6
Total	No overall budget	8.1

Note: 1. See Figure 17. Two of the four advisers' contracts did not receive a specific budget.

Source: National Audit Office

2.28 The Agency wanted the auction to attract a high level of interest. They decided to include provision for an achievement fee in the contract awarded to Rothschild. Initially Rothschild proposed that such a fee should be linked to the proceeds raised in the auction. The Agency negotiated instead a fee based on Rothschild securing a minimum number of bidders participating in the auction, (**Figure 18**). The Agency intended that this fee would act as an incentive to Rothschild to deliver a competitive auction. In setting the fee in the original contract, the Agency had in mind previous NAO reports and PAC guidance³ which recommended that any criteria that measure success should be set out preferably before the appointment of the advisers. In the event, the auction attracted 13 bidders, the highest number of bidders for the allocation of 3G licences offered by any European Union states, and the Agency paid Rothschild their full success fee of £700,000.

17 The roles and costs of external advisers to the auction

Adviser appointed	Type of advice	Budget £000 (1)	Outturn £000
1st contract with Quotient and Ovum November 1997 (some of this work overlapped other projects within the Agency). 2nd contract with Quotient 1998, specific to the 3G auction	Technical advice to design the structure of the licences, and to inform the decision on the number of licences to be allocated	No specific budget	431
NM Rothschild December 1997; initial contract reviewed and extended March 1999 because of delay auction	Lead Adviser. (Note 2)	Fees fixed in advance but contract had to be extended	4070 + 700 achievement fee
University College London 1998; initial contract extended to cover work associated with auction type suitable for five licences	Advice on appropriate type of auction approach to use and on practicalities of the auction process	94	112
Allen & Overy 1998	Legal advice during the auction and also in support of legal actions taking place after the auction	875	857
Total cost of advisers		No overall budget	6.1

Notes: 1. The Agency did not set consultancy specific budgets in advance, but sums were set aside for consultants within the agreed annual budget allocation based on the teams' annual assessment of need. The contracts for all four advisers were carefully monitored.

2. Financial and telecoms advice on all aspects of the policy framework, auction design and implementation, liaison with industry and implementation. Assistance in project management, preparation of Information Memorandum, preparing financial models and marketing the opportunity to potential bidders

Source: National Audit Office

18 Achievement fee structure for NM Rothschild as financial advisers to the auction

Rothschild earned the maximum success fee for achieving 13 bidders

Fee payable if at least 7 bidders participate in the auction	£300,000
Fee payable if at least 9 bidders participate in the auction	£500,000
Fee payable if at least 11 bidders participate in the auction	£700,000

Source: National Audit Office

The Debt Management Office smoothed the impact of the payments on the financial markets

2.29 The successful bidders paid for their licences in May and September 2000, and the payments were immediately reinvested by the Debt Management Office, an Agency of the Treasury (Figure 19 below). The total of the payments represented a massive transfer of cash from the private to the public sector. The Treasury and the Debt Management Office were concerned that such transfers, conducted in a very short time period, could potentially disrupt the efficient operation of the money markets and payment systems. The Debt Management Office, working with the Bank of England and the Agency, put in place special arrangements with a number of private sector banks to manage successfully the flow of funds without disrupting the money markets.

2.30 The Agency gave successful bidders the options of paying in full for their licence when it was awarded; or to pay 50 per cent on award and equal ten per cent instalments on the sixth, seventh, eighth, ninth and tenth anniversaries. If licensees chose to defer payment, the Agency required them to provide a bank guarantee against default. All chose to pay the licence fee in full. They told us that the alternative was not viable because of the cost of as stringent a bank guarantee as the Agency required, in addition to the interest payments payable on the outstanding amount. The Agency had considered that bidders' bankers would be close to the decision making process throughout the auction, with knowledge of the bidding company's business plan, and would therefore be in a good position to provide an economical guarantee.

19 Payment for the licences

The successful bidders paid in full for their licences within five months of the auction

Successful Bidder	Payment (£ billion)	Date of payment	Award of licence
BT 3G UK	4.030	16 May 2000	16 May 2000
One2One	4.004	9 May 2000	9 May 2000
Orange ¹	4.095	1 September 2000	1 September 2000
TIW	4.385	9 May 2000	9 May 2000
Vodafone ¹	5.964	1 September 2000	1 September 2000

Note: 1. The successful bidders were required to notify the Agency that they had complied with the conditions of award of a licence, and made at least an initial payment for the licence, before the licence could be awarded their licence, and this was achieved in August 2000.

Source: National Audit Office

Part 3

The auction should promote good use of the spectrum

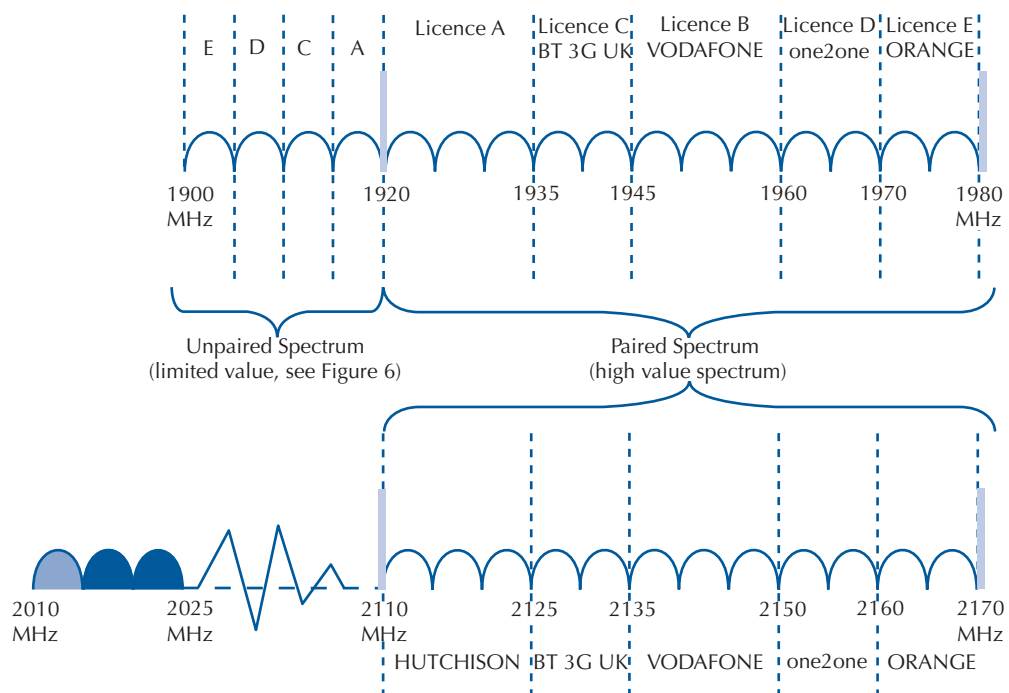
3.1 This part of the report examines the extent to which the auction has promoted efficient use of the valuable spectrum allocated for third generation telephony, drawing on evidence from the Agency, the industry and from our specialist advisers. Services will not be launched in this country until 2002 and there are still

significant technical problems to be resolved and commercial uncertainties to be clarified before the eventual outcome can be known.

3.2 The licences that were allocated are shown graphically in **Figure 20**.

20 The Radio Spectrum that was auctioned

The figure shows the range of spectrum allocated for 3G telephones by European Agreement. In the UK the Agency auctioned this as five licences all containing at least 10 MHz of "paired" spectrum suitable for transmitting and receiving signals



Source: Radiocommunications Agency

The Agency designed the licences using expert advice and in consultation with the industry

- 3.3 The Consultative Group set up by the Agency included telecommunications firms and electronics manufacturers and this group dealt in part with how best to package the available spectrum into licences. The Agency also encouraged the formation of an Advisory Group to discuss technical aspects associated with the use of radio spectrum for 3G mobile services and implications for the UK of the move to harmonisation of technical standards across Europe. This group provided input to the Agency's consideration of the structure and number of licences to allocate through the auction.
- 3.4 In addition to their own specialist staff, the Agency employed consultants, Quotient and Ovum, to advise them of operators' spectrum requirements for running a range of 3G services. These companies analysed likely spectrum requirements for services by the year 2007 for a sample of six urban conurbations. They then translated these requirements into traffic estimates, to determine the amount of spectrum required to support projected mobile telephone traffic levels, and further refined these estimates to determine the minimum spectrum allocation for each operator. This work was carried out in consultation with the Advisory Group and summaries of the work carried out by Quotient and Ovum were published on the Agency's internet site for the auction.

Most spectrum should be intensively used

- 3.5 At the time of this report no commercial 3G services have yet been launched anywhere in the world, so the extent to which the five licensees in the UK will actually exploit the spectrum they have been allocated is unclear. It has been established through limited technical trials that the technology works, but key challenges that still need to be overcome include:

- the provision of sufficient transmitters and handsets, which work sufficiently reliably and with adequate performance in terms of transmission speeds to provide a high quality service;
- the provision of supporting IT systems such those for as billing and security, which will be much more complex than in existing, more limited mobile telephony; and
- the development of innovative new services that customers will find attractive and easy to use.

Some commentators have warned of the commercial threat to 3G from other competing technologies which provide higher transmission speeds but within smaller areas, such as hotels, airports, shops or cafes.

- 3.6 Though the future development of 3G remains uncertain, the allocation of spectrum provides financial and competitive incentives on operators to make intensive use of the available spectrum. But we identified two qualifications.

- 3.7 The Agency allocated to the licences almost all the spectrum that was available. The only exceptions were a 10 MHz block of spectrum, which they held back for use by local private networks such as museum guides or sports arena and shopping centre information systems, and a 5MHz block which suffered interference from other users of the spectrum. In Germany this spectrum was allocated to the 3G licences, but the authorities in most European countries have held it back like the UK.

- 3.8 The government recognised that the incumbent companies' existing networks and customer base are major barriers to new entrants, who would have to build their own networks over several years during which their service would be inferior and unattractive to consumers. The reservation of a large licence for a new entrant is inefficient taking a short term technical view. Hutchison 3G UK starts with no existing base of customers, and the extent to which their spectrum will remain under-utilised depends on how quickly the company attracts subscribers and gets them using high-bandwidth, non-voice services. However, in coming to this decision the Agency had regard to the competitive pressure a new entrant would exert over time on the four incumbent companies to implement their own advanced services, rather than use their spectrum for traditional voice telephony.

There are still technical uncertainties

- 3.9 The key issue in the design of the licences was whether the effective operation of 3G services would require a large 15 MHz allocation of vital paired (two-way) spectrum in each licence, or whether smaller allocations of 10 MHz to some licences would be viable. By having 15MHz, operators can either offer more price-competitive services or, some analysts believe, more capable and higher value services. Only if smaller licences could be issued would there be room for five licences and a new entrant to the UK mobile telephone market. This was a difficult decision to make in advance of experience anywhere in the world of operating real 3G services.

- 3.10 The Agency received varying advice from potential bidders, some favouring four licences and others, including Orange and One2One, saying that five or six could be viable. The results of Quotient's initial work indicated that operators would need at least 2x15 MHz paired to support a range of 3G services at the traffic levels forecast. There was considerable doubt at that

time that technology would be available to support services with smaller amounts of spectrum. Only after Quotient carried out further work on their forecasts early in 1999, in the light of the latest developments in technology, could the Agency conclude that it would be possible to operate 3G services with 10 MHz, although some high quality services would require more spectrum. The judgement however was finely balanced, and both the Agency and Quotient recognised there were still risks attached to the smaller licences.

3.11 The main body representing the 3G telecommunications industry, the Universal Mobile Telecommunications Service (UMTS) Forum, expressed reservations to us about the allocation of spectrum in the UK. They had recommended that national authorities should allocate just four large licences, each with at least 15 MHz of paired spectrum. This was done in Europe by Finland, Sweden, Denmark, Norway, Spain, France, Belgium, Portugal and Switzerland. The solution chosen in the United Kingdom and some other countries, with two large and three small licences was not as recommended by the Forum. The Forum's view is that this solution provides sufficient capacity to carry the projected traffic for Europe and the full range of services. But it may not provide enough flexibility and could cause problems delivering high data rate services, like video, in some areas. In contrast, Orange told us that although having 15MHz of paired spectrum should reduce costs, it is not at all clear that it should intrinsically provide more higher value services.

3.12 The Agency and their advisers had allocated 15 MHz paired to Licence A, reserved for a new entrant, on the basis of discussions with potential bidders. The extent to which the potential new entrants bid for the smaller 10 MHz paired licences (C to E) casts doubt on the presumption that new entrants needed a larger 15 MHz paired allocation of spectrum before they would take part, (Figure 13). Also, all six licensees in the later auction in Germany accepted smaller 10MHz paired licences.

3.13 3G is a new technology that, until recently, had only been tested under laboratory conditions. Deploying it in the real world is bound to present unanticipated problems, which will take time to resolve. It is thought that the main limiting factors affecting the launch of services will be the handsets, which will have to cope with increased demands for software, power consumption and screen size, at a price the market can sustain. Fully featured 3G handsets will be expensive, with initial estimates at some £500. It is not clear as to whether the operators will subsidise consumers' purchase of telephones, and the extent to which they can afford to do so.

There will be environmental effects from the introduction of the new services

3.14 The new 3G services will require many more mobile phone transmitters than existing mobile telephony, possibly as many as 28,000, although many of the new transmitters will either be placed on existing structures or be of a smaller type. A report by Sir William Stewart published just after the auction identified possible effects of existing telephony systems in terms of public health. The policy decision to introduce a fifth operator will lead to some increase in the number of transmitters. The increase can be reduced by mast-sharing between operators, though because sharing tends to require larger, more obtrusive masts it is not practicable everywhere. The high proceeds provide an added, economic incentive for operators to co-operate. Though Hutchison 3G UK intend to provide some new base stations of their own they have already signed deals with owners of existing mast sites for access to erect their own transmitters. The company told us that they welcomed a statement from OFTEL in May 2001 that the regulator would support sharing of transmitters where the positive consumer benefits outweigh any potential disadvantages of any lessening of competition. OFTEL consider that consumers might benefit from infrastructure sharing if it allows the delivery of 3G services earlier and at lower prices than might otherwise be the case, although it might have concerns if competition were lessened, for example in network coverage or quality.

More flexibility is needed in licensing arrangements

3.15 The Agency's prime reason for using an auction to allocate spectrum was that by awarding licences to the highest bidder, spectrum would be allocated to the mobile telephone operator that valued it most and would be most likely to exploit it to greatest advantage. But an allocation of licences that was efficient at the time of the auction may not remain so indefinitely. Some licensees may be less successful than they had planned in attracting customers, or in developing advanced services that make intensive use of the spectrum they have. In such circumstances it would improve the efficiency with which spectrum is used if licensees could trade their surplus spectrum to other operators, possibly including new entrants, who would use it more intensively. Most of the bidders we spoke to during our examination were in favour of spectrum trading, for that reason.

- 3.16 The Agency are in principle in favour of spectrum trading. In October 1998, they sought the industry's views on a range of options for trading, making clear that it would have to be compatible with preventing radio interference and with maintaining competition. The responses to the consultation indicated a high level of support for spectrum trading. The Government intends to carry out further work in consultation with the industry and other interested parties to develop detailed proposals, provided that necessary changes are made to European Union Directives to enable trading to be implemented.
- 3.17 There is another variant of flexibility, in which spectrum allocated by the authorities for one purpose would be refarmed for another use. Most of the licensees we spoke to said that they would welcome the ability to refarm spectrum such as that used for second generation mobile telephony for use in 3G services, or vice versa. However, they recognised that there could be issues if bidders paid high prices for spectrum on the basis that it would remain "rationed", only to find later that the authorities made more available. Before the auction, the Agency said that the Government would not seek to delay refarming for the purpose of creating any artificial scarcity of spectrum for mobile telecommunications, and that they could not make any commitments to refarm or not to refarm in the future.

Part 4

The auction should promote sustainable competition between operators and extend choice for consumers

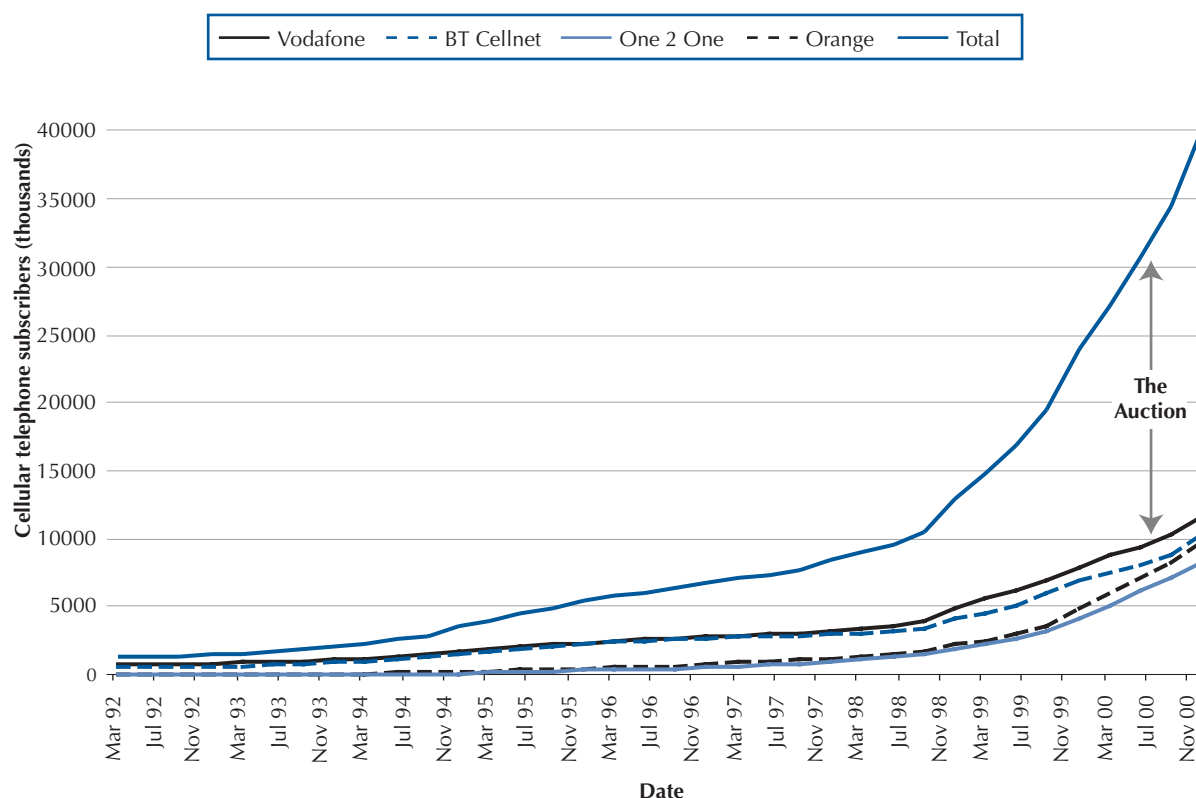
- 4.1 The exact form that 3G services will take is still unclear, and the extent to which consumers will adopt and pay for them remains very uncertain. Neither the Agency nor the National Audit Office have had access to the business plans of the five licensees, and the companies' programmes for developing their services remain commercially confidential. Though some consultants and researchers have produced indicative business models for 3G operators, the results vary greatly according to differing assumptions about the costs and take-up of the new services. So it is not yet possible to state conclusively whether there will be sustained competition and choice for consumers. This part of the report examines, however, whether the allocation of licences through the auction in the UK is likely to promote these objectives.
- 4.2 Following the launch of the second generation of mobile services by Vodafone and BT Cellnet in the early 1990s, and the launch of services by two new operators, One2One and Orange, in 1993 and 1994 respectively, the numbers of mobile phone users in the UK rapidly increased. At the time of the auction there were about 20 million mobile phone users representing some 33 per cent of the population, and the United Kingdom had the greatest market penetration of mobile services per capita in Europe outside Scandinavia. Since the auction, market penetration has increased still further to 40 million users.
- 4.3 When announcing the auction the Government stated that they were committed to ensuring that the United Kingdom maintained its lead in the provision of competitive mobile communications to the widest possible cross section of society, and attached great importance to the further development of competition in the mobile phone market. They were keen to encourage market entry and strong, sustainable competition to deliver choice to customers, to spur innovation and keep pressure on prices.
- 4.4 The Agency sought the views of OFTEL in reaching their decision on the number of licences to offer operators. In their 1999 review of the mobile phone market, OFTEL concluded that the market was showing increasing signs of competition in terms of price reductions, movements of customers between operators, and investment to improve quality. Despite this overall prices were set above the competitive level, competition was not evident across all services and the market had high barriers to entry. So OFTEL was a strong advocate of the need to make a fifth licence available to achieve increased competition in the market. In their view a new player should act as a catalyst to achieving a fully competitive mobile market and by so doing provide significant benefits to consumers by increasing the availability of new services and driving down prices. The European Commission considers that the addition of new operators tends to stimulate improved services to consumers. Markets with two or three operators, such as France, have traditionally attracted a smaller proportion of their population to mobile telephony than countries like the UK with four or more operators.

The UK mobile telecommunications market has five capable operators rather than four

The Agency and OFTEL wished to promote increased competition

21 Market share of the four incumbent companies

The period before and since the auction saw substantial increases in mobile telephone ownership, with Orange's market share closing on that of BT.



Note: These historic figures include "inactive" customers who had not made or received calls for several months. Using similar bases of counting, in mid 2001 Orange had 11.9 million active customers, BT Cellnet had 10.6 million and Vodafone 10.54 million

Source: Oftel

The new entrant, Hutchison, is a strong international player

4.5 The original winner of the licence reserved for a new entrant was TIW UMTS UK, a subsidiary of Telesystem International Wireless Inc, (Figure 10). Shortly after the completion of the auction TIW announced that it had formed a joint venture company (Hutchison 3G UK Holdings Limited) with Hutchison Whampoa, a major Hong Kong-based conglomerate. By July 2000, Hutchison had formed a partnership with two other major telecommunications groups, which bought out TIW. Other bidders expressed concern to us that they had not been made aware of Hutchison's involvement before and during the auction. Hutchison told us that before the auction they had signed an exclusive agreement to take all of the capacity from TIW's 3G network, and had informed the UK authorities of this. When TIW had decided in view of the outcome of the auction that they preferred to invest in other opportunities, Hutchison had reviewed the business case independently and decided to acquire the company, and hence the licence, themselves.

4.6 With a market capitalisation in excess of US\$ 54 billion, Hutchison is one of the largest companies in Hong Kong. With over 80,000 employees worldwide, Hutchison operates five core businesses in 24 countries: ports and related services; telecommunications and e-commerce; property and hotels; retail and manufacturing; and energy and infrastructure. Hutchison's telecommunications businesses span several continents, and include mobile telephony and fixed line telephony, cable networks and radio broadcasting.

4.7 Hutchison has an arrangement for strategic co-operation on European 3G operations with NTT DoCoMo, Japan's largest mobile communications company and with KPN Mobile, the leading telecommunications company in the Netherlands. These companies acquired 20 per cent and 15 per cent stakes in Hutchison 3G UK respectively. The co-operation covers several European markets including the United Kingdom, Germany, France and Belgium, allowing each party to extend substantially its European 3G "footprint" whilst sharing development costs. In May 2001 NTT DoCoMo launched in Japan the world's first 3G network, with around 4,500 trial users, (of 147,000 who applied), testing real 3G services.

The incumbents are experienced international players

4.8 Licences B, C, D and E were won by the four incumbent operators in the United Kingdom market: Vodafone, British Telecom Cellnet, One2One and Orange respectively. All four companies have built nationwide mobile networks in the United Kingdom and either own, or are linked to, companies with an international customer base. Our advisers, Strategis Group, advised us that other European countries had clearly weaker 3G new entrants and incumbents.

4.9 It is difficult to predict with confidence the shape of the industry that will provide 3G services and which companies will prosper. In January 2001, the leading research firm Forrester predicted a process of consolidation triggered by the migration to 3G, leaving only five mobile groups in Europe by 2008. Their forecast, shown in **Figure 22** below, indicates that the award of licences in the UK could be resistant to processes of consolidation across Europe, the four UK incumbent 3G licence holders being described by Forrester as "certain winners." Less positively, Forrester

also said that they expected no companies entering the market for the first time with new licences would survive after 2007.

There is protection against reductions in competition and consumer choice

4.10 There are two main sets of regulatory arrangements which the Radiocommunications Agency and OFTEL can use to preserve the increased competition which the auction has promoted. The Agency has powers under the Wireless and Telegraphy Acts associated with the award of the licences:

- Licences are granted to the five named companies and are not assignable. The rights and obligations are not affected by changes in the ownership of the licensee; and
- One company cannot own or operate two 3G licences and, in the event of a merger or an acquisition, the Agency could revoke a licence and transfer the rights and obligations through the issue of a new licence to a new operator.

22 Prospects for the UK 3G licence holders

The award of licences in the UK could be fairly resistant to industry consolidation.

The Groups forecast to survive by Forrester research (Jan 2001)	The Groups own 3G licences in	Group Profiles
Vodafone	UK, Germany, Austria, Spain, Portugal, Netherlands, Italy, Sweden, Switzerland	Within fifteen years of starting as a mobile phone operator, Vodafone has become the largest company in Europe by market capitalisation and the largest mobile telecommunications company of its kind anywhere in the world, with over 80 million customers worldwide and interests in network operators across 29 countries.
BT Cellnet in the UK	UK, Germany, Spain, Netherlands	BT Wireless is an international operation, reporting £2.8 billion turnover in 2000/01.
T-Mobil (One-2-One in the UK)	UK, Germany, Netherlands, Austria	A subsidiary of Deutsche Telecom, One-2-One has over 7 million customers in the UK and is part of T Mobil International, one of Europe's largest mobile operators.
Orange / France Telecom	UK, Belgium, France, Italy, Netherlands, Germany, Austria, Portugal, Sweden, Switzerland	Orange has the third largest mobile digital network in the UK with over 30 million customers (10 million in the United Kingdom), in majority-owned operations worldwide, including 13 countries in Europe.
One of: KPN, NTT DoCoMo, Telefonica (Spain) or Telecom Italia		Hutchison is part owned by KPN and NTT DoCoMo, and by Hutchison Whampoa (Paragraphs 4.5 to 4.7 above refer). The company or its shareholders own 3G licences in the UK, Italy, Sweden, Germany, Austria and the Netherlands.

Source: National Audit Office, and publications by Forrester Research

4.11 Other changes in the structure of the Industry may be addressed by powers given to regulators under the Fair Trading Act 1973 or the Competition Act 1998. If one licensee merges with, or is acquired by, another licensee during the course of the licence term the merger could be examined by the Office of Fair Trading (OFT) and the Competition Commission. The Commission rules on competition issues and would be responsible for considering any competition concerns arising from such an event under the terms of the Fair Trading Act. In addition, general powers under the Competition Act can be used if:

- companies reach an agreement that prevents, restricts or distorts competition; or
- an abuse occurs of a company's dominant position.

The actual structure of the industry that will deliver 3G services is still emerging.

4.12 OFTEL is currently reviewing the extent of competition in the mobile market. Its consultation document, issued in February 2001, notes that competition continues to develop. The document is generally positive about the prospects for the future of the industry, noting that the timing of the auction gives UK operators an opportunity to develop early 3G services to the benefit of UK subscribers. The nature of regulation in the market is subject to consultation but OFTEL is committed to a level of regulation appropriate to competitive conditions, including the risks and uncertainties surrounding 3G. Operators expressed the view to us that in the light of the high commercial risks of 3G, and the addition to competition through the advent of a fifth operator, regulation would need to be light-handed. Orange expressed concern to us that the high auction proceeds would have a negative effect on the economic benefits of 3G if future regulation were to prevent or restrict operators from recovering the licence costs in some way.

4.13 Different forms of service provision may emerge as 3G develops. Not all services will be offered by the companies who won the licences and will operate the networks. Companies can offer mobile telecommunications services to customers, without the allocation of spectrum, and without the need for their own network infrastructure. These companies are known as virtual operators, and they lease network capacity from licensed operators to resell under their own brand to their own customers. Virtual operators such as Virgin, who use the One2One network to provide their services, already provide second generation mobile services to some seven per cent of UK subscribers. Both the Agency and OFTEL hope that more commercial deals will emerge with the new licences, offering further opportunities to increase competition and choice. Some bidders told us

that the prospects for the emergence of fully fledged virtual 3G operators, who would develop distinctive new services and not just re-brand and market existing types of service, are unclear. Much will depend on the extent to which licence holders make capacity available, and the extent to which potential virtual operators like supermarkets, banks and utilities see providing innovative new mobile services as a way to attract customers. One 2 One drew our attention to the difficulties virtual operators might have in raising sufficient finance in current market conditions to provide the necessary infrastructure, develop a brand and acquire customers.

4.14 Regulators in some countries, such as Denmark and Hong Kong, have mandated 3G licensees to provide access to virtual operators. If OFTEL were to decide that the introduction of virtual operators in the UK would promote effective competition and increase consumer benefits it could propose a modification to network operators' licences requiring the services needed by the virtual operator to be provided. This would require the network operator's consent or a favourable report from the Competition Commission. OFTEL does not believe there is sufficient evidence to justify such an intervention in the UK at present.

The high cost of the licences will not necessarily restrict development of services

4.15 Many commentators within the telecommunications industry have expressed the view that the outcome of the auction will be harmful to the prospects for the development of 3G telephony in the UK, (Appendix 2 illustrates the range and strength of comment). The adverse reactions have focused broadly on concerns that:

- the cost of the licences has undermined the ability of operators to invest in their 3G networks;
- development of 3G services will be slowed or reduced; and
- prices of 3G services to UK consumers will be higher than they would otherwise have been.

The operators are still able to make massive investments in developing 3G services

4.16 Since the auction telecommunications companies have experienced a more difficult climate for investment in the next generation of networks. This climate has affected a wide range of high technology businesses and not just mobile telephony. All bidders who responded to our enquiries told us that the level of proceeds from the auction had contributed to making financing significantly more difficult. In April 2001 the credit

rating company Standard and Poors challenged the view that its recent downgrading of the financial strength of telecommunications companies like British Telecommunications and France Telecom was solely the result of licence auctions. They blamed the weakening of companies' balance sheets with greatly increased debt not just on the scramble for licences but also a combination of regulatory pressures and the need for operators to seek growth through acquisitions, as well as the building of networks. They also had regard to the highly uncertain future revenues and technological risks of 3G telephony.

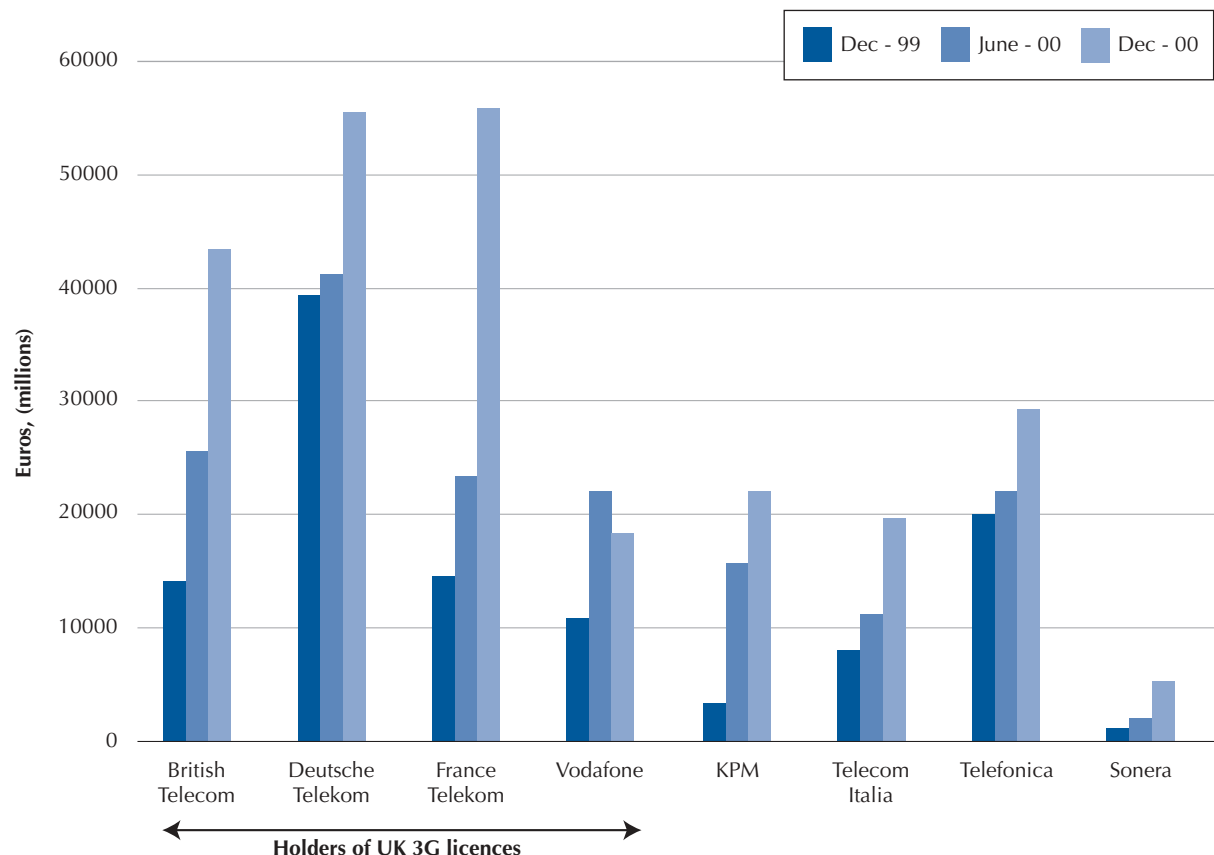
4.17 The other principal credit rating company, Moody's, has pointed out that much of the down rating of telecoms stocks reflected the industry's transition from the less competitive fixed line market, to greater exposure to more competitive, technically risky mobile services. Moody's also identified the tendency of recently privatised companies to behave more aggressively in the market, some increasing their indebtedness through cross-border investments. Nearly all telecommunications companies' credit ratings were downgraded, not just those which won 3G licences.

4.18 Companies' difficulties are not therefore solely due to auctions. For example, in the case of British Telecommunications plc, one third of the company's £27.9 billion debt following the auction represented the £9.4 billion cost of licences in the UK, Germany and Holland, the remainder comprised mainly the cost of acquiring interests in other companies. In May 2001 BT announced its first ever annual loss, of £1 billion, due mainly to a £3 billion write-down of the value of its recently acquired German subsidiary.

4.19 The licence holders in the UK have all retained their status as preferred "investment grade" companies. The most severe downgrading has been for BT, where in May 2001 the rating companies Standard and Poors and Moody's reduced their grading from the high quality A band to "A-" and "Baa1" respectively. Commentators estimated that this downgrading would increase the company's interest costs by £30 million a year. BT has undertaken a programme of restructuring its business with a view to reducing its indebtedness by at least £10 billion by the end of 2001, through a rights issue and sales of assets in Japan, Spain and Malaysia. It intends to demerge its BT Wireless Business, which intends to develop 3G networks in the UK, Germany and Holland.

23 The indebtedness of major telecommunications companies

This figure shows that the indebtedness of most major European telecommunications companies increased markedly during the period in which governments allocated spectrum



Source: National Audit Office

BT announced in May 2001 that once demerged BT Wireless will not carry more than £2 billion of net debt, which would reduce the investment pressures on the new company, and aid its flotation.

4.20 Our telecommunications industry advisers Strategis Group described all the successful bidders as well-established companies with strong revenue streams. The incumbent operators are able to "mix" their lower-risk, more profitable revenue streams from first and second generation telephone services with the higher-risk future revenues from 3G. Strategis Group considers that none of the bidders' parent companies - with the possible exception of British Telecom - have appeared to be in serious financial difficulties.

4.21 All of the licence holders except BT have already assembled financing packages for rolling out their networks. Most have announced that 3G services should be launched by mid-2002. One way in which the cost of networks is being met is through "vendor financing", loans to the operator by their chosen equipment manufacturers. This has to a degree filled the void caused by the increased scarcity of bank finance. In April 2001 the new entrant Hutchison 3G UK announced a £3.6 billion financing package, raised mainly from a combination of bank and shareholder finance. Its parent, Hutchison Whampoa Limited committed £375 million to the total package and £777 million came from Hutchison 3G's main equipment suppliers, Nokia, NEC and Siemens. This was in addition to the £4.4 billion that the shareholders earlier injected into the company to pay for the licence. Analysts have regarded it as encouraging that a new entrant facing four strong incumbent operators could assemble this financing package. Hutchison told us that it would support their development of services to a stage where it would be very well advanced and at which it would be normal business practice to refinance with longer term funding. The Orange group, backed by the resources of its parent France Telecom, has announced a similar deal with equipment manufacturers for the provision of 3G networks across Europe, including the UK.

4.22 One 2 One pointed out to us that their parent company, Deutsche Telekom, supported their incremental £2.2 billion of bank loans since the auction for developing their networks. It was unlikely that One 2 One alone would have secured such favourable terms with such funding in the current financial climate, due to the company's indebtedness and requirement for ongoing investment. They considered that the adverse impact on the ability of operators to raise finance post the 3G auctions in Europe had reduced competition in the telecommunications industry generally, leading them to conclude that the UMTS auctions were not efficient (from a business and consumer view) or effective.

4.23 Whereas commentators often identify BT as the incumbent mobile telephone operator with most debt problems, Vodafone's balance sheet is often identified as the strongest. After acquiring 3G licences in virtually all their markets the Group had £6.7 billion net debt at 31 March 2001, representing then only five per cent of its market capitalisation. This represented a halving of its net debt over the year, despite the acquisition of licences, as it sold off businesses, principally Orange which was bought by France Telecom. Vodafone has said that its development of 3G services across Europe is progressing, with spending on infrastructure starting in 2001/02 in time for commercial launch of services in the second half of 2002. It intends to finance the necessary £10 billion investment from its own resources.

4.24 Some features of the licensing arrangements in the UK should help operators to reduce the cost of providing 3G services in this country.

4.25 The regulatory framework gives operators flexibility to reduce costs through co-operation. Estimates by Analysys, a British consultancy, suggest that two operators sharing their networks could save as much as 38 per cent of capital expenditure and 14 per cent of operating costs. In Sweden, operators are allowed to share infrastructure only outside major conurbations, helping them save money, but still requiring fully competing services in major population centres. BT and One2One's owners have already agreed to co-operate in several countries, including the UK. Before the auction the Agency reminded bidders that OFTEL sought to encourage the sharing of sites and facilities by operators. OFTEL have told us that this is still the case and that they would consider applications from operators for sharing facilities as long as these proposals were in the interests of consumers. They would seek to ensure though that these arrangements would not be anti-competitive, for example that a dominant operator would not impose restrictions on others' services. Infrastructure sharing is a complex, developing issue, on which the UK authorities still await detailed proposals from the operators.

4.26 3G services are less viable to provide in rural areas than in towns because they have fewer subscribers to justify the provision of expensive transmitters. The Agency recognised that the capital costs will be much higher than they have been for earlier generations of telephony, where the minimum coverage requirement was set at 90 per cent of population. So the 3G licences require operators to provide coverage for just 80 per cent of the UK population by 2007, though it is not yet clear how it will be measured. In some European countries the authorities insisted on 100 per cent coverage, including Sweden where the population is more dispersed than in the UK.

4.27 Before the auction the Treasury confirmed that operators could offset the cost of licences against taxation of any profits earned over their 20-year duration.

It is not evident that the level of auction proceeds will restrict the development of services or significantly increase prices to UK consumers

4.28 Vodafone told us that the high cost of their licence gave them an added commercial incentive to roll-out 3G services more quickly than if the spectrum had been given away. Hutchison 3G UK agreed, saying that there was no better incentive to deliver services, which they expected to start in early 2002. This is supported by statements from companies developing new products for use on 3G networks, who have reported acute pressure from operators to develop products quickly.

4.29 There is other evidence that at the time of the auction the industry and investors regarded the prices paid for the licences as being commensurate with their commercial value and revenue earning potential. Some licensees were sold on after the auction at more than their auction value, notably when Hutchison, NTT DoCoMo and KPN bought out TIW UK including its ownership of the new entrant licence A at an implied value of £6 billion, as opposed to £4.385 billion.

4.30 The total cost of the 3G licences in the UK equates to some £380 per head of population, or some £560 for each mobile telephone currently in use, a substantial sum for the companies to recover from their customers over the 20-year duration of the licence. Some bidders told us that operators would want to recover their investment in 3G even quicker, in the knowledge that other competing technologies might pose a commercial threat well before the end of the licence period. Conversely, as shown in paragraph 4.18, the industry is undergoing a process of restructuring as telecommunications groups such as BT and Orange hive off their mobile subsidiaries, and where this is being done not all the debt that funded the cost of the licences is going with the new mobile company.

4.31 Many commentators have expressed concerns that due to the level of auction proceeds prices of 3G services to UK consumers will be higher than they would otherwise have been. Others consider that the operators will charge only what the market will bear and that lower proceeds would not have meant lower prices. Sellers in a competitive market will tend to disregard past investments, or "sunk costs", when pricing their goods and services, if their financial resources enable them to do so. An analogy illustrating this principle would be Concorde, where the UK and French governments wrote off the cost of developing the aircraft, because it was clear that customers would not pay fares at a level that

recovered the development cost but would use other aircraft instead. In the context of 3G telephony, the licensing of an additional, fifth, competitor makes it more likely that such competition will prevail.

4.32 We found the theory to be supported by what bidders told us. Each said that they expected the operators to offer 3G services at affordable prices wherever they can make a positive return before the recovery of licensing costs. If operators' business plans prove to have been over-optimistic and the cost of licences cannot be entirely recovered the effect would be on the companies' share prices rather than on their investment plans or consumers. If 3G is a commercial success, and experience in Japan based on enthusiastic consumer reaction to a precursor to 3G, DoCoMo's "I-Mode" service, is promising, operators would be able to recover their sunk licence costs anyway. Other telecommunications companies who spoke to us were less optimistic. For example, Motorola considered that the auction proceeds were so large in proportion to the business that costs could not be entirely sunk and would have to be recovered. Cost recovery would require much greater revenues from 3G than from previous generations of telephony.

4.33 Our advisers Strategis Group told us that pricing of new mobile telephony products and services tends to reflect operators' behaviour in the marketplace rather than strict recovery of costs. They noted evidence of Vodafone undercutting BT Cellnet in the pricing of early mobile internet services. They expected the larger Pan-European operators that have won licences in the UK to source large quantities of infrastructure equipment and handsets from various suppliers, bringing down the costs and sharing them across several markets. In Strategis' view these operators will average the cost of acquiring licences in their mixed portfolios of cheaper auction and beauty contest awards with that of the more expensive licences in key markets such as the United Kingdom and Germany. Bidders also told us that the cost of licences in the UK would be placed in a wider context, with the licensees spreading the costs of licences over the several countries in which they operate when pricing their 3G services.

4.34 Another difference between 3G mobile networks and previous technologies will be that 3G will offer a much wider variety of services than existing voice and text telephony. As the number of new services increases in developing 3G networks, operators will benefit from a low marginal cost of providing each extra service. The more successful operators will be able to increase revenues and reduce costs, allowing them to recoup the higher average cost of 3G licences. Our advisers, Strategis, are cautiously optimistic about the prospects for the industry. Most studies indicate that a demand will exist once coverage is adequate, and the technology has been proven to work. Whether the opportunity is large enough to justify the sums spent on licences remains to be seen.

Appendix 1

Auctions and "Beauty Contests"

When radio spectrum is allocated through an administrative process, the authorities typically conduct what is called a beauty contest: designating the spectrum lots which are to be made available, specifying the criteria under which they will make the assignment, and inviting proposals from interested parties. Typically, the successful applicants pay an administrative price designed to meet engineering and administrative costs (though the price can be set much higher). The licences are then assigned.

There are two major problems. The first concerns the perceived integrity of the process: because beauty is in the eye of the beholder, many possible decisions can be justified. This creates opportunities for bias - which can take the form of a preference for national firms.

Secondly, there is a problem of information asymmetry. A government sincerely implementing a beauty contest has to discriminate among proposals submitted by firms, each of which will want to demonstrate its suitability through optimistic projections of revenue and consumer take-up. Government officials are not necessarily best placed to make decisions on such commercial matters, even with the support of consultants, and have to use judgement in selecting criteria with which to assess proposals. Such criteria have been challenged successfully in court in previous contests, as being arbitrary and introducing bias. There are already complaints lodged with the competition authorities in Brussels that the beauty contest run by the French government for the sale of spectrum discriminates against non-French companies. And there have been occasions where firms selected on the basis of an apparently thorough contest have subsequently failed, for example Ionica, a fixed wireless access operator in 1997.

A pure auction however does not include any assessment of the technical capabilities of a company to run, in this case, mobile phone operations, nor any assessment of the financial stability and underlying strength of the company necessary to support successful development of the services. Such assessment is considered by some commentators to be an essential prerequisite for allocation of scarce resources, as in this instance.

The crucial difference claimed by supporters of auctions is that with an auction the winning bidder has to back its projections with hard cash. Thus, bidders and the financial institutions that bankroll their bids have a direct incentive to make realistic estimates. This has the effect of assigning spectrum to the firm that can use it most effectively. It is this property - the efficient assignment of spectrum - rather than maximising revenue, which is the real prize from a properly designed spectrum auction.

Auctions are transparent, can be designed to limit opportunities for collusion, and can be modified for different types of lot. There is usually no pre-assessment of the quality of the firm bidding and the market sets the price. Without safeguards however auctions may favour firms already dominant in a market in that they have the financial strength to price out weaker newer entrants.

Beauty contests are generally closed and the proceedings confidential, which has often led to claims of collusion and corruption on the part of the administrators. Assessments of the quality of bids depend to a degree on subjective judgements and there are examples of the subsequent early failure of firms following allocation of assets. The administrators set the price, which will not necessarily coincide with applicants' willingness to pay, although it is possible to follow up an initial beauty contest with competitive bidding to decide final allocation.

Appendix 2

Divided Opinion on the Outcome of the Auction

The auction generated enormous interest among external commentators before, during bidding and since completion. Opinions were divided among the commentators about what the outcome of the auction means for industry and consumers. This divergence also reflects wider uncertainty about how 3G will develop and the likely customer demand for these services given that they have not yet been launched.

Media commentary

During the auction:

"Bidding frenzy puts mobile licence auction on track to raise over £6 billion" (Independent, 24 March 2000).

"As the stakes continue to rise, all bidders face a dilemma. They have to balance the value of gaining a licence...against the negative effect on their share price if they fail. This calculation has to be made without any real knowledge of the value of the next generation services...One suggestion is that bidders should sum the potential decline in their market value from failing to win a licence and their estimate of the net asset value of the mobile data business and continue to bid up to that level".

(Alan Cane, Financial Times 29 March 2000).

"The auction has been criticised for encouraging companies to overpay at the expense of shareholders"

(Sunday Business 6 April)

"The biggest game in town: If they (the bidders) are successful in winning the licence the real danger is the cost will be so high that returns are going to be modest by telecoms standards. Yet they can't pull out of the bidding because the spectrum is seen as their life blood".

(The Sunday Times: Business Focus 16 April 2000)

Following the auction:

"Mobile licences are not as expensive as they look"

(The Independent 28 April 2000)

"Some City analysts have seen the auction as being more of consequence for customers than shareholders, as if higher than anticipated licence costs could just be passed through into higher mobile charges to consumers. This view is mistaken. Just because mobile operators pay more for their licences does not alter the prices that will maximise their revenue. What has changed is the consequences of failure. When licences were given away, an operator such as One2One could afford to make mistakes and still come out ahead. The auction has removed that cushion."

Daily Telegraph

The reason the auction is so successful is not just the fact that there is an auction. It is that since all this was first planned, people have seen the benefits of the Internet. We are on the crest of an Internet wave and the next phase is deemed to be mobile Internet. There is also a lot of consolidation in the industry and the ability to hold these licences is helpful in the extreme".

Daily Telegraph

"Maybe I'm wrong and UMTS will be a roaring success but I can't help feeling that it's all going to be a very expensive damp squib"

(The Independent 1 May 2000)

"It's a case of sheep following sheep. Everybody followed the market when it went up, now they're following it down. There will be a point when sanity returns and investors realise that people will very soon be spending real time and money using 3G services"

(The Financial Times 8 December 2000)

"The real cause of the companies' troubles is that the market has changed. They did their sums before they made their bids. They knew the risks. Who else knows what the market is worth? Hans Snook, former head of Orange, one of the British licence-buyers, said only last week: "In a few years, people will think that the prices we paid were conservative." Governments should not second-guess such an authority."

(The Economist 3 May 2001)

Views from industry

Plextek, a company advising the UK auction advisory group, surveyed opinions in the telecommunications industry following the auction. Coverage included: incumbent mobile operators and newcomers; licence winners and losers; companies which expressed an initial interest in bidding and then withdrew before the auction; financiers and industry sector analysts; and representatives from related industries such as internet service providers. The survey elicited a wide range of reactions from respondents at the outcome of the auction:

- "No argument over what happened or who won."
- "The auction generated a lot of free publicity for 3G!"
- "Beauty contests cannot help being corrupt."
- "There should have been more pre-selection of bidders."
- "A massive tax on a successful industry."
- "The licence costs mean that we need to go straight for the mass market."
- "It generated big alliances: this will create cartels which will kill competition."
- "A potential market channel has now become very expensive for us."
- "If there is a problem, it is the stupidity of the bidders, not of the government."
- "The bidders behaved like some kid in a small town auction house."

Appendix 3

Lessons Learned from the UK 3G Spectrum Auction

Peter Cramton²

University of Maryland May 5, 2001

In April of 2000, the Radiocommunications Agency of the United Kingdom completed its first spectrum auction, raising £22.5 billion for five third-generation (3G) mobile wireless licenses. This paper assesses how well the UK 3G spectrum auction did in achieving the Government's objectives.

I have been a major participant in spectrum auctions, since December 1993 when the United States was planning for its first spectrum auction. My involvement has been in all aspects of the auctions: advising governments on auction design, advising bidders on auction strategy, and conducting theoretical and empirical research. Since 1993, I have written over one-dozen research papers on spectrum auctions, which have been published in leading economic journals. I have advised several governments on spectrum auction design, including the United States, Canada, and Australia. I have also advised twenty bidders in spectrum auctions around the world. I have advised a bidder in nearly all of the 3G auctions conducted so far. In the UK auction, I advised One 2 One, which provided a glimpse of the UK auction process from design through execution.

Auctions have become the preferred method of assigning scarce spectrum to companies. The primary advantage of an auction is its tendency to assign the spectrum to those best able to use it. This is accomplished by competition among license applicants. Those companies with the highest value for the spectrum likely are willing to bid higher than the others, and hence tend to win the licenses. There are several subtleties that limit the efficiency of spectrum auctions. Still a well-designed auction is apt to be highly efficient. A second important advantage of auctions is that the competition is not wasteful. The competition leads to auction revenues, which can be used to offset distortionary taxation. Finally, an auction is a transparent means of assigning licenses. All parties can see who won the auction and why.

Since the mid-1990s, the United States has relied on auctions to award spectrum. Thus far, the Federal Communications Commission (FCC) has conducted thirty-four auctions. The auctions have performed well in assigning the scarce spectrum to its best use. Certainly, there have been some bumps along the road, but overall the auction program has been highly successful.

Many other countries, such as Australia, New Zealand, Canada, Mexico, Brazil, and India have also used auctions in the last five years. Many of these countries learned from the FCC's experience with spectrum auctions in deciding on a design of their own. The approaches taken have varied from country to country, and within a country from auction to auction. The most common approach is the simultaneous ascending auction, adopted by the FCC. Even within this broad format, there have been subtle differences that can play an important role in the auction's success.

Although the United Kingdom did not begin auctioning spectrum until 2000, it began with a bang. Its very first auction broke into the record books as the world's largest auction ever.

² This report was commissioned by the National Audit Office of the United Kingdom. The views expressed are my own.

Objective

The Government's overall aim for the auction was "to secure, for the long term benefit of United Kingdom customers and the national economy, the timely and economically advantageous development and sustained provision of third-generation services in the United Kingdom." Subject to this, the Government's objectives were to:

- 1 Utilize the available spectrum with optimum efficiency;
- 2 Promote effective and sustainable competition for the provision of third-generation services; and
- 3 Subject to the overall objectives, design an auction that is best judged to realize the full economic value to customers, industry and the taxpayer of the spectrum.

My remarks will assess how successful the auction was in achieving the objectives above. First let me define how I interpret the three objectives above. As shorthand, I will refer to these objectives as efficiency, competition, and revenues.

Efficiency. I define efficiency as putting the spectrum in its highest-valued use. There are two steps in spectrum utilization: allocation and assignment. The allocation defines the licenses (the frequency band, the geographic area, the duration, and the restrictions on use). The assignment of the licenses is then determined by auction. I will address how both the allocation and auction design decisions likely affected efficiency.

My definition of efficiency is the broad notion of economic efficiency, rather than a narrow definition of technical efficiency. Technical efficiency focuses on providing services at minimal cost. From an engineering sense, this is best accomplished by a single network that avoids any duplication. However, from a practical viewpoint, competition can enhance the economic value of the spectrum by fostering innovation and better services. Thus, I do not view efficiency as directly in conflict with competition. A smaller competitor may well value its first 10 MHz of spectrum at more than the value of the last 10 MHz of spectrum won by a dominant incumbent. If so, efficiency dictates that the incremental 10 MHz of spectrum should go to the small competitor, despite any network duplication.

Efficiency should also take into account things like flexible use, resale, leasing, roaming, all of which can serve to promote efficient use. However, these topics are beyond the scope of this paper.

Competition. Competition refers to the market structure that results from the license assignment. The allocation and auction design play a critical role in determining this market structure. More competitive market structures are preferred, since they lead to greater innovation, better services, and lower prices. Competition is an essential goal for a government seeking to maximize social welfare. Generally, more competitors means more competition. However,

because the provision of 3G services requires enormous fixed costs, there is a limit to how many competitors the market can sustain. Four strong competitors with more bandwidth may yield greater competition than six competitors with less bandwidth, especially if number five and six are weak.

Revenues. I interpret the Government's stated goal as a desire to maximize total surplus of the auction, taking into account its impact on consumers, industry, and the taxpayer. This goal is quite different from maximizing revenues. For example, one auction may attain higher revenues than another, but be inferior with respect to the government's objective if the revenue benefit to the taxpayer is more than offset by losses to industry and consumers. The goal as stated is an efficiency goal, rather than a revenue maximizing goal: create as much value as possible from the 3G auction for all participants in the economy. Raising revenues does have a potential efficiency gain, since auction revenues can be used to offset distortionary taxation. In the United States, economists have estimated the deadweight loss associated with taxation at about 33% (it costs the economy \$1.33 to raise \$1 in taxes). To the extent that auction revenues are not distortionary, then raising revenues has an efficiency gain. This is likely the case. Since the license fee is a sunk cost, it should have little impact on the 3G services or prices that are ultimately observed in the market.

For simplicity, I will define the revenue goal as maximizing revenues. However, this is not the goal as stated by the government in goal 3 above, nor do I believe that it is a desirable goal in itself. Rather revenue is a useful way to contrast alternative design choices. Efficiency and competition should be the ultimate objectives.

The UK auction format

The Government used a simultaneous ascending auction to auction five 3G licenses, A-E. The bandwidth for each license is as follows:

	Bandwidth in MHz for each License				
	A	B	C	D	E
Paired spectrum	2 x 15	2 x 15	2 x 10	2 x 10	2 x 10
Unpaired spectrum	5	0	5	5	5
Total	35	30	25	25	25

License A was set aside for a new entrant. Only potential new entrants could bid on this license. All bidders could bid on any of the remaining licenses (B to E). Licenses have a twenty year duration.

The simultaneous ascending auction used in the UK is a variation on the design used in the US. The UK design takes advantage of the especially simple license structure, namely the fact that each bidder can win at most one license. In contrast, most of the US auctions have had many regions and many licenses within each region, which greatly complicates bidding strategy. Here I provide only a brief description of the rules.

The auction worked as follows. All five licenses were up for auction at one time. The auction proceeded in a sequence of rounds. In each round, bidders that were not the current price bidder on a license could place a bid on a license, raising the price on that license by at least the minimum bid increment. At the end of the round, all bids and bidders were identified, together with the price bid (highest bid) and bidder for each license and the minimum bid in the next round. The auction continued until no bidder was willing to bid higher on any of the licenses. This format is a natural extension of the familiar English auction when selling multiple items with interdependent values.

There were several important details.

Associated bidders. The auction could have involved two phases. The first phase would have resolved conflicts among associated bidders, bidders that have an ownership interest in each other. In phase one, bidding would have occurred sequentially on a MHz basis until no associations remained. Then the group of now unassociated bidders would compete in phase two (the simultaneous ascending auction). This approach guaranteed that the five winners of the auction were unassociated. Indeed, all associations were resolved before phase one, so the auction actually began in phase two.

Spectrum cap. A company (or associated companies) could win at most one license. This guaranteed that there would be five distinct competitors for the provision of 3G services.

Deposits. Bidders were required to make an initial deposit of £50 million to enter the bidding. The deposit increased by £50 million when the bid exceeds £400 million. The deposit was intended to guarantee performance by winning bidders at the end of the auction. The deposit was fully refunded to losing bidders.

Payment. Winning bidders could either pay in full at the end of the auction, or pay in installments. However, the installment payment terms were sufficiently unattractive that all winners choose to pay in full.

Minimum opening bids. The minimum opening bids were:

Minimum Opening Bids (million £)				
A	B	C	D	E
125	107.1	89.3	89.3	89.3

Minimum bid increments. To assure that the auction concluded in a reasonable amount of time, new bids had to exceed the price bid by at least the minimum bid increment. The increment was set as a percentage of the prior price bid. Bid increments fell as the number of bidders decreased.

Activity rule. A bidder had to be active in every round of bidding. A bidder was active in a round if: (1) it was the current price bidder, (2) it placed a bid on a license, or (3) it used a waiver. Bidders were given three waivers. This rule guaranteed that the auction progressed with each round of bidding. It also facilitated price discovery. The waivers allowed bidders to briefly pause their bidding. If a longer pause in the bidding was required, the bidder could call recess, which would stop all bidding for the rest of the day, and possibly the next day. Each bidder could call up to two recess days once the number of bidders had reduced to eight. A bidder that was the current price bidder was not allowed to bid on another license or raise its current price bid.

Number of rounds per day. A final means of controlling the pace of the auction was the number of rounds per day. The Government posted a schedule for the next day. The bidding began with few rounds per day, but increased as bidders became comfortable with the process.

Stopping rule. The auction ends if a single round passes in which no new bids or waivers are submitted on any license.

Bid information. The auction was fully transparent. Each bidder was fully informed about the identities of the bidders. Price bids and price bidders were posted after each round. In addition, all bids and bidder identities were displayed at the conclusion of each round, together with information on the use of waivers or recesses.

Bid withdrawal. Bids could not be withdrawn. A bid was an irrevocable commitment. This assured that the bids were serious.

Auction outcome

UK auction outcome

The UK 3G auction began on 6 March 2000 and finished on 27 April 2000, after 150 rounds and seven weeks of bidding. Thirteen bidders competed for the five licenses. All conflicts with associated bidders were resolved before qualification, so the bidding began in phase 2. The auction was the largest auction in history, raising £22.5 billion in revenues. This amount exceeded the total revenues of all US spectrum auctions conducted over the six years prior, which is remarkable given that the US is 4.5 times the size of the UK. The total amounts to 650 euros per person or 1100 euros per current subscriber.

The final winners and prices paid were:

Auction Winners and Winning Bids					
	A	B	C	D	E
MHz spectrum	2 x 15	2 x 15	2 x 10	2 x 10	2 x 10
MHz Unpaired	5	0	5	5	5
Price Bidder	T/W	Vodafone	BT	121	Orange
Price Bid (£M)	4,385	5,964	4,030	4,004	4,095
£M/MHz paired	292	398	403	400	410

The prices exceeded the expectations of everyone: government, industry, bidders, and taxpayers. There is no question that the auction was successful in generating revenues.

Most of the bidders pursued a strategy of bidding on the license that represented the best value. Bidders thus switched from license to license as the prices changed. The exceptions were Vodafone and Orange, both of which staked out particular markets. Vodafone bid exclusively on the B license, the only large license available to incumbents. Vodafone often would use jump bids (bids above the minimum bid) to express its resolve in winning the B license. Even Vodafone's final bid was a jump bid. Orange staked out the E license, bidding exclusively on E, once the B license became too expensive.

The pricing dynamics were predictable, although certainly not the absolute level of prices. The prediction comes from understanding the existing market structure and how the auction works. First, there were four incumbents: Vodafone, BT, Orange, and One2One. Incumbents have much higher values than potential entrants. For an incumbent, the value of a license is the value of future 3G services plus the value of 2G revenues lost if it fails to secure a license. It is reasonable to suppose that consumers would prefer to get 2G service from an operator that has plans for 3G service. For an entrant, the value of a license is the value of future 3G services minus the cost of building a network. An incumbent's existing infrastructure reduces its 3G buildout cost. Finally, the more 2G customers an operator has, the easier it is to attract 3G customers. Thus, it is easy to predict that the four incumbents would each win a license, leaving the A license to the strongest new entrant. The second large license would go to either Vodafone or BT. These companies financially were the strongest and likely had the highest value for 3G services as a result of their much larger market shares compared with the younger incumbents. The two uncertainties were: (1) who was the strongest potential entrant, and (2) was Vodafone stronger than BT.

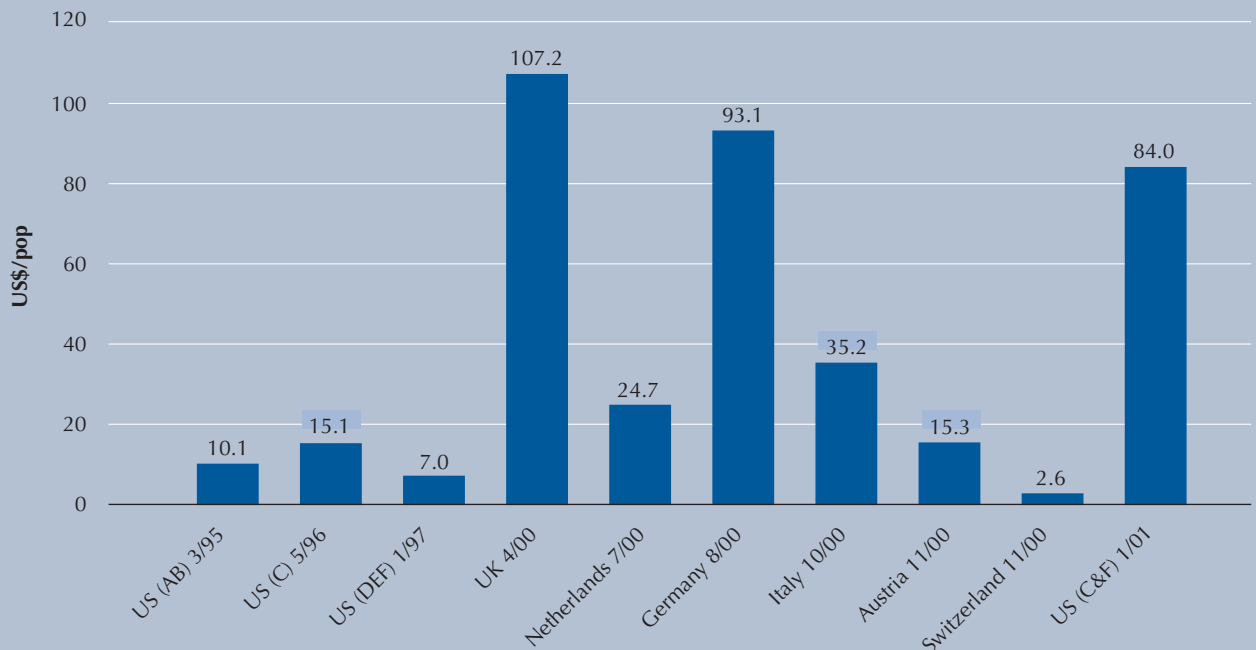
All the prices were effectively determined by two bidders: (1) NTL, the strongest among the eight unsuccessful new entrants, and (2) BT, the strongest among the three incumbents that failed to win a large license. NTL effectively set the price for C, D, E at just over £4 billion, when it dropped out of the auction in round 148. TIW's price for the A license was also set by NTL's arbitrage between the large A license and the smaller C, D, and E licenses. The bidding of NTL and the other new entrants indicated that the new entrants did not value the extra 5 MHz of paired spectrum very much. In contrast the two largest incumbents valued the extra 5 MHz a great deal. BT ultimately set the price for the B license when it placed its final bid on B in round 142. Vodafone's price per MHz was roughly equal to the prices paid for the small incumbent licenses (C, D, and E).

Contrast with other auction outcomes

Revenues in the UK 3G auction were the highest on a per person basis than any broadband spectrum auction to date. Auction prices have varied considerably over time and over markets. This is seen in Figure 1, which presents the per person price of a 20 MHz license (2 x 10 MHz paired) in several major spectrum auctions.³ For comparison purposes, Figure 1 also shows past and current US auctions of 2G spectrum. The first three US auctions occurred over three years before the 3G auctions in Europe. The fourth US auction concluded in January 2001 with a price comparable to the highest 3G prices. Part of the price variation is explained by the different times at which the auctions occurred. Part of the difference in the European prices is explained by the size of the various countries. Markets like

³ Most of the European licenses also included 5 MHz unpaired spectrum. However, these auctions have shown that the bidders place little value on this unpaired spectrum, so I ignore the unpaired spectrum in the price comparison. In the US C-block auction, bidders received attractive installment payment plans. I discount these prices by 40% to reflect the value of the installment payments.

1 Mobile Wireless Price Comparison (2x10 MHz + 5 MHz)



the UK and Germany are thought to have more value, even on a per person basis, than the Netherlands and Switzerland. Still there is much variation to explain. The primary determinant of prices appears to be the level of competition going into the auction, rather than the subtle differences in auction design across the various countries. Competition in the auction is largely endogenous, since it is the result of partnership negotiations among potential bidders.

The two most recent 3G auctions have continued the slump in 3G prices. Both the Belgian auction and the Singapore auction ended after the submission of the initial bids at the reserve price. Neither auction had excess demand.

Why were prices so high?

A critical choice impacting revenues was the decision to auction five licenses. Five licenses guaranteed that a new entrant would win a license. This certainty that an entrant would win created a strong incentive for potential entrants, especially strong potential entrants to enter the bidding. Setting aside the largest license for a new entrant further intensified the incentive to enter. Not only would a new entrant win, but the successful entrant would win the best license.

The experience in the Netherlands illustrates the importance of having more licenses than incumbents in stimulating revenues. In the Netherlands, five incumbents bid for five licenses. The logical outcome was for the five incumbents to win licenses. Recognizing the difficulty of winning a license, potential entrants had a strong incentive to partner with an incumbent bidder. This is exactly what happened. Although initially there were several strong potential entrants, all partnered with one of the incumbents before the auction

began. The strongest entrant, Deutsche Telecom, partnered with the weakest incumbent, Ben; DoCoMo and Hutchison partnered with KPN; and NTL was already effectively partnered with Dutchtone (France Telecom has a large interest in both). This left one weak entrant in the bidding. At the beginning of the auction, just six bidders were competing for five licenses: five strong incumbents and one weak potential entrant (Versatel). It was not long before the lone entrant gave up.

Two further factors were important in the high revenues achieved. Both have to do with the timing of the auction.

First, the UK auction was the first in the sequence of European 3G auctions. The largest wireless operators believed that winning a license in the UK was an important first step in becoming or sustaining a major position in Europe. The UK was the foot in the door to Europe and potentially the world. Generally, when bidding in a sequence of auctions for complementary items, the early items sell for more, since winning the early items gives the winner a competitive advantage in winning subsequent complementary items. Also, since it was the first auction, the bidders were unable to predict the extremely high prices that would result if they did not form alliances before the auction.

Second, the auction occurred at the peak of an apparent high-tech stock bubble. Wireless and other high-tech companies were being valued at all-time highs and at unheard of price-earnings multiples. Certainly for the incumbents, but also for the strongest new entrants, the question of value was transformed into a question of how much the stock price would be hurt if the company failed to win a license. With UK wireless companies being valued in

the tens of billions, paying four billion for entry into the 3G business seemed reasonable. In this way, the inflated stock market values had a direct impact on the companies' willingness to bid.

Finally, the ascending auction format coupled with the large excess demand likely contributed to high prices. First, the ascending format gave the bidders greater comfort in bidding higher, since they were able to see the large number of competitors that were willing to bid higher. In an ascending auction, dropping out is an admission of inferiority in some sense. Bidders ask themselves, "If the license is worth a lot to my competitor, why is it not worth a lot to me?" By bidding higher, the company does not concede it is inferior to its competitors. Second, an ascending auction over seven weeks gave the bidders ample time to go back to board to ask for additional money. Initial budget constraints were relaxed.

Choice of allocation

The decision to auction five licenses had a big impact on the competition objective in addition to its impact on revenues. Five licenses meant that there would be five 3G service providers. Moreover, the success of the new entrant was enhanced by setting aside the best license for the entrant. Hence, the allocation appears to be highly consistent with encouraging competition.

There were four other reasonable choices for the allocation:

- 1 Four licenses, each with 2x15 MHz.
- 2 Five licenses, two 2x15 and three 2x10, as in the UK, but without setting aside the best license for an entrant.
- 3 Six licenses, each with 2x10 MHz.
- 4 Twelve 2x5 MHz blocks, requiring that each winner win either two or three blocks.

The four-license option maintains the status quo of four incumbents. This would be desirable if the industry cannot support a fifth operator. However, the experience in the US and parts of Europe appears to suggest that five operators can operate profitably. The four license approach would likely result in the least competitive market structure. It also would likely lead to the lowest auction revenues.

The five-license option (without the best license set aside for a new entrant) does add another competitor in the wireless market. Moreover, unlike in the set-aside approach, the second large license would end up with the second-strongest incumbent (BT), rather than the entrant. This outcome is more efficient, since the second-strongest incumbent likely can make better use of the extra 5 MHz of paired spectrum. Revenues could be lower with this option, since Vodafone and BT would no longer have to compete for the only large license. The price for the large licenses would be set by Orange. Whether overall revenues would be higher or lower

without the set-aside depends on how high Orange would be willing to bid for the extra 5 MHz. Based on the observed bidding, Orange only bid on the large license when the spread between large and small was less than about £450 million. This suggests that revenues would probably be slightly lower without the set-aside. BT forced a spread of nearly £2,000 million between large and small. If without the set-aside, Orange forces a split of only £500 million, then revenues would fall.

The six-license option is desirable if adding a sixth operator does foster competition. However, one must recognize that there are significant fixed costs in this industry. It is entirely possible that the number six entrant in the market is necessarily too weak to offer much in terms of service innovation or price competition. The issue is largely an empirical question that will take time to resolve. The German and Austrian auctions suggest that at least in the major markets there is room for six. Given the overwhelming evidence that greater competition fosters both service innovation and lower prices, the Government should err on the side of two many licenses, rather than too few. Adding a new entrant after the auction by splitting up an incumbent is almost impossible. Consolidation after the auction is much easier to implement.

Total auction revenues would likely be slightly lower with six licenses. There are two reasons. First, Telefonica would become the marginal bidder. In the five license auction, Telefonica dropped out at £3,668, compared with NTL's dropout at £3,971. All six licenses would sell for approximately Telefonica's dropout point. Second, Telefonica's dropout point would be less, since it would be bidding to participate in a six-player market as opposed to a five-player market. The difference in revenues, however, likely would not be large.

The auctioning of 5 MHz blocks, as was done in Germany and Austria, lets the bidders decide how many winners there should be. The number of winners would be between four and six under this approach. This approach would appear to be highly desirable, since the number of winners is determined by a competitive process. However, one might fear that there would be a strong tendency for the four incumbents to win all the spectrum, each getting three blocks. Incumbents have substantially higher values because of their incumbent position, and they benefit from excluding new entrants. However, it is possible that the incumbents would recognize that by only bidding on two blocks the auction would end at much lower prices. The incumbents in essence make room for two new entrants in order to keep the prices down. The question is whether the benefit from reducing demands more than compensates for the reduced profits in a six-player vs. a four-player market. Given the outcome in both German and Austria involved six winners, rather than four or five, it would appear that this design does not discourage entry too much. Another potential disadvantage of the German approach is that it does not

allow the bidders to bid on particular bands of spectrum. This can introduce an inefficiency if different bidders value the different bands differently.

A variation of the German approach would be to set aside two blocks for a new entrant and then let the bidding determine whether there would be four or five winners for the remaining ten blocks. This would guarantee at least five winners, and allow a six winner if the sixth bidder is willing to bid higher than the two strongest incumbents.

Choice of auction format

Based on the objectives of efficiency and competition, the Government made a wise choice of auction format.

The simultaneous ascending auction was highly efficient. The five winning firms demonstrated that they valued the spectrum more than the eight losing bidders. The only potential source of inefficiency was setting aside a large 15 MHz license for a new entrant. The bidding revealed that BT valued the extra 5 MHz more than the new entrant TIW. However, guaranteeing that the entrant would win a 15 MHz license and not be forced to pay BT's incremental value for 5 extra MHz likely was pro-competitive, both in the auction and in the post-auction market. The set-aside surely stimulated participation by potential entrants. Post-auction competition was also stimulated, since the new entrant (TIW) will be stronger and less capacity constrained as a result of the extra 5 MHz block. On balance, setting aside the largest license for a new entrant probably was a desirable tradeoff between competition and efficiency.

Contrast with the US auctions

The differences between the UK auction rules and those in the US auctions were minor. I list them below:

- 1 In the US, the current price bidder can raise its own bid. This was not allowed in the UK auction. Raising one's own bid typically is a bad strategy. Nonetheless, bidders in the US frequently have done so, especially early in the auction to stake out particular regions. I see little advantage or disadvantage in forbidding this practice of raising one's own bid.
- 2 In the US, as the percentage increment changes, the minimum bid on a license reflects the new increment immediately, regardless of whether the license receives a new bid in the round. In the UK, the minimum bid on a license would only be adjusted after the license received a new bid. Typically, reductions in the percentage increment occur after one or more bidders

drops out of the auction. Since the licenses were all excellent substitutes it seems appropriate that all licenses should reflect the reduction in bid increment immediately, rather than waiting until after a license receives a bid. Still I do not believe that this difference had a significant impact on the outcome.

- 3 In the US, bid raises are a whole number of bid increments, from one to nine. In the UK, new bids could be any amount in tenths of a million between the minimum bid and the maximum bid. This enabled the UK bidders to make small jump bids. Since even small jumps are rare near the end of the auction, it is unlikely that this difference had any impact on the auction outcome.
- 4 The US does not use a "ratcheting deposit," as was used in the UK. Having the deposit increase with higher bids provides extra protection against default, but it does complicate the bidding mechanics. Non-performance is a serious concern. Still I believe that typically it is possible to set an appropriate deposit before the auction, and avoid the extra complication requiring the bidders to raise deposits as bids increase. In the UK auction, the complication was slight, since there was just a single increase in deposits when bidding reached £400 million.
- 5 The US auctions do not have an initial phase to eliminate associated bidders. Having the initial phase was probably a good idea in the UK, where bidder associations are more common than in the US. Although phase one was not used in the actual auction, it served as a useful threat point in the negotiations among associated bidders before the auction began.
- 6 The US does not allow a bidder to call a recess in the bidding. The recess feature potentially could add several days to the bidding. In fact, only one recess was used. This was by Telefonica when key members of the auction team were tied up in a major shareholder meeting. It is possible that recesses could be useful for bidders that need extra time to make critical decisions. However, in this particular auction, I believe that recesses were not important, since it was straightforward for bidders to estimate where prices were likely to be after another day or two of bidding and take appropriate actions.

None of the differences between the US auctions and the UK auction were significant. The outcome would have been essentially the same without any of the subtle differences.

Contrast with other 3G auctions

Three basic auction formats have been used in the 3G auctions.

- 1 The UK format. Used in the UK, the Netherlands, Switzerland, Belgium, and Singapore. Bidders bid on particular licenses in a simultaneous ascending auction.
- 2 The Italian format. Used in Italy. Bidders do not bid on specific bands. Hence, all licenses are identical at the time of bidding. A simultaneous ascending auction is used. When no one is willing to bid higher the auction ends with the four highest bidders receiving a license and paying their bids. The particular bands won is set at the end of the auction.
- 3 The German format. Used in Germany and Austria. Like in Italy, the bands are determined at the end of the auction. All blocks are identical at the time of bidding. Bidders bid for two or three 5 MHz blocks in a simultaneous ascending auction.

The Italian format only makes sense if the licenses are identical at the time of bidding. This was not the case in the UK, since the licenses were of different sizes. Moreover, bidders typically care about the particular band that they receive. To the extent that bidders preferences among the bands differ, then the Italian format introduces an inefficiency that is not present with the UK format. In most cases, the differences are small, so that the potential inefficiency is small. Otherwise, there is little difference between the UK and Italian formats.

As discussed above, the German format has the benefit of endogenous determination of license size and market structure. However, the bidding strategies are more complex and it is unclear whether the outcome is more or less efficient than with the UK format. Another important difference between the UK and German formats is that the German auction was not fully transparent. Only the current price bids and bidders were reported after each round, rather than all the bids. This made it more difficult for the bidders to observe when other bidders dropped from three blocks to two blocks. This may have stimulated auction revenues in Germany.

Denmark intends to conduct a sealed bid auction. I believe such an approach raises a significant possibility of an inefficient outcome.

Hong Kong is using a simultaneous ascending auction, but the bids are a combination of royalties and fixed fee. Royalties are problematic because they distort future business decisions and they require that the government monitor 3G revenues.

Auction implementation

The implementation of the auction was generally excellent.

My one complaint was the use of encrypted fax for the communication of bids, rather than using the Internet. Encrypted fax is a little used technology that is at best cumbersome. Software for conducting simultaneous ascending auctions using secure Web technologies is now readily available. The UK should use such software in future auctions.

Other matters of implementation are discussed below.

Qualification and deposits

The UK wisely kept qualification simple. Complex qualification makes sense in a beauty contest, but has no place in an auction. Rather substantial deposits were sufficient to keep out unqualified bidders. As it turns out, the initial deposits probably should have been larger. However, it was impossible to predict how high prices would ultimately go. The ratcheting deposits corrected this problem to some extent, but the maximum deposit (£100 million) was less than 2.5% of the final bid amount. Although a larger deposit may have been desirable, I do not believe that the small deposit adversely affected the outcome.

Pace of the bidding

The Government controls the pace of the auction through three main instruments: the minimum opening bids, the bid increments, and the rounds per day.

Minimum opening bids

In retrospect the Government could have set substantially higher minimum opening bids. However, given that this was the first 3G auction in the world, there was little information to gauge where prices would end up. The fact that the minimum opening bids were too low had essentially no adverse consequences. It simply meant that the auction continued for much longer in both rounds and days.

Low minimum opening bids can definitely be a problem in auctions where competition is weak. This was not the case in the UK.

A more serious mistake in setting minimum opening bids is setting the prices too high. Indeed, perhaps in response to the 3G auction, the UK Government may have set minimum opening bids too high in its next auction for fixed broadband wireless access. Many licenses went unsold in that auction.

Bid increments

Bid increments began at 5% and ultimately fell to 1.5%. There was little reason to begin with such a small bid increment. Given that there were eight extra bidders in the auction, the auction easily could have begun with an increment between 10% and 20%. Then the increment could be dropped to 5% once five or six bidders had dropped out. Higher bid increments would have meant that the auction could complete in about 50 to 75 rounds, rather than the 150 that was required. The auction would then have taken three weeks to conclude, rather than seven weeks.

Higher increments would not have hampered efficiency in any way. The increments still could have been dropped to the 2% level once the bidding was down to six bidders for the five licenses.

The cost of an excessively slow auction were not large. Given the enormous stakes, one can argue that the bidders needed time to assess how high to bid. Hence, although the auction could have been completed more quickly, taking 150 rounds and seven weeks did not result in any significant loss.

Rounds per day

The auction began with few rounds per day. This was gradually increased until a steady state of about six rounds per day was reached. It was difficult to have more rounds per day given the rather cumbersome bidding method using encrypted fax. In contrast, much larger and more complex auctions in the US have been conducted with many more rounds per day. Eight to twelve rounds per day has been common in recent US auctions.

Although the auction could have been conducted much faster, there was little economic loss from the gradual pace. The high stakes and great uncertainty about value probably justified the conservative course taking by the UK Government.

Impact on 3G roll-out

A major concern with the European 3G auctions is the enormous debt that has been acquired by the winners. Many fear that the high debt will adversely impact the timely roll-out of 3G services. As a result of the high auction prices, especially in the UK and Germany, companies have seen their share prices drop. Drops in debt ratings have also occurred, making it more difficult for companies to fund the cost of building the 3G infrastructure.

Payment for spectrum in the UK auction, as in all the European auctions, is structured as a one-time fixed fee. In theory this has the advantage that the fee, once paid, is treated as a sunk cost. Hence, its magnitude should not affect subsequent decision making by the companies. If the firms overpay for the spectrum, the predominant affect is a drop in share price. What services are provided and how they are priced should be independent of the fixed fee paid for spectrum.

In practice, excessive spectrum fees can have a negative impact on services. The reason is that at least in a short period of time capital markets cannot absorb an unlimited amount of debt. When there is excess demand for debt, then the terms become less attractive for the companies requiring debt. Companies may slow the pace of buildout in order to limit the acquisition of debt. This problem may be especially severe for new entrants that have greater buildout costs and only the prospect of future revenues. This is unfortunate since if the new entrants are weak the post-auction market will be less competitive. Excessively high auction prices can slow the roll-out of 3G services and reduce competition in the market for these services. The weaker operators may go bankrupt leading to a consolidation in the industry and a further slowing of access to 3G services.

If spectrum prices were excessive in the UK auction, it is difficult to blame the UK Government. The auction process was structured in such a way that the prices were largely determined by the strongest new entrant that failed to win a license. This bidder was NTL. The fact that incumbents were in a position where they had to win a license did not impact prices. Prices were determined by the marginal new entrant. Even if the UK auctioned six licenses, the price per license only would have been slightly less, and indeed total revenues may have increased.

Conclusions

The UK auction was highly successful in achieving the objectives of efficiency and competition. At the same time it raised considerable revenues. Even with 20-20 hindsight, it is difficult to make any suggestions that would have improved the outcome significantly.

The UK Government took great care in its choice of auction format. The auction was carefully designed and implemented. The Government made excellent use of outside experts throughout the auction process. The Government also made good use of the wealth of experience in other countries. The reward for the care taken was a highly successful auction process.

Appendix 4

The National Audit Office's approach to the examination

Scope

Our work was aimed at enabling us to understand how far the outcomes from the auction meet its objectives: focusing on the Agency's approach to allocating radio spectrum for the next generation of mobile phones; the advantages and limitations of using an auction as the allocative mechanism with lessons that can be learned from this for the future; and how the Agency's approach compares to the approach taken in other European Union member states.

Our examination covered the extent to which the auction has promoted the achievement of the Government's three objectives (Figure 3), specifically whether the allocation of licences through the auction should lead to:

- the available spectrum being utilised with optimum efficiency;
- the promotion of effective and sustainable competition for the provision of third-generation services; and
- Subject to the overall objectives, the realisation of full economic value to customers, industry and the taxpayer of the spectrum.

Main aspects of the National Audit Office's Methodology

In undertaking this examination we:

- Designed the examination using experience acquired on earlier studies of privatisations and disposals of public assets;
- Reviewed information about the design of the licence structure, the Agency's consultation process on the proposed licence structure, the design of the auction and the management of the auction process.
- Used external expertise to advise us on telecommunications issues, the design of the auction, the allocation of 3G licences across European member states, and on the implications of the outcome of the auction on the roll-out of 3G services; and
- Obtained the views of parties participating in the auction and of interested parties throughout the telecommunications industry.

Collection of information

We gathered relevant information from a number of sources including:

- an extensive examination of the Agency's papers, bidders' submissions, documentation prepared by advisers, the Agency's internet web site for the auction;
- interviews with Agency senior management, officials and advisers, on how they approached the development of the auction and management of the auction process;
- monitoring of reports and commentary in specialist telecommunications industry and finance websites and news "feeds";
- interviews with officials at the Treasury, the Department of Trade and Industry and OFTEL about their role in the development of the auction; and
- a survey of bidders participating in the auction, supplemented in the case of winners by detailed interviews.

Use of external expertise

We commissioned two groups of consultants.

The Strategis Group, specialist consultants in the telecommunications industry, carried out:

- An evaluation of the decision to allocate five licences;
- Review of allocation of licences in other countries; and
- A review of the rollout of 3G mobile phone services

We engaged Professor Peter Cramton of the University of Maryland to produce an authoritative commentary on the design and operation of the auction and lessons to be learned.

Survey of bidders in the auction

We surveyed the 13 bidders in the auction. The survey was supplemented with a small sample of face to face interviews. The main purpose of the survey was to gain an understanding of the extent to which the allocation of the radio spectrum was carried out in a transparent, efficient and effective manner, and to identify lessons that might be learned for future auctions of public assets. Of the unsuccessful bidders One.Tel and Telefonica declined to take part in the survey and of the subsequent five licensees British Telecommunications and TIW declined to be interviewed or to complete a survey response.

The survey sought bidders' views on the following key issues:

- The extent to which the Agency consulted potential bidders about the allocation of the radio spectrum;
- Whether the design of the licences offered encouraged efficient utilisation of the spectrum;
- Whether the decision to allocate five licences encouraged a sufficient range of qualified bidders to participate in the auction and should lead to an increase in sustainable competition in the mobile telephone market;
- The extent to which bidders were provided with timely information both before and during the auction;
- Whether bidders were surprised at the level of interest in the auction and the prices achieved;

- Whether bidders believe that the outcomes from the auction are likely to make it difficult for companies to fund the development of networks and lead to higher prices for the consumer; and
- Whether the outcome from the UK auction has influenced the behaviour of companies competing to win licences in other European markets.

Seeking views of interested parties

We established an e-mail address to receive views on the auction from interested parties, which we advertised on the National Audit Office internet web site and through contact with representatives of industry groups involved in the consultation process undertaken by the Agency and the marketing programme undertaken by Rothschild. Views were received in this way from a number of industry representative bodies and companies, leading to useful discussion.

Evaluation of information and advice received

Our evaluation proceeded whenever possible through corroboration of independent sources; for example our interpretation of the evidence of our advisers was cross-referenced to evidence from interview evidence from the specialist media and bidders representatives. As is our standard practice, we circulated copies of the draft report in confidence to the Agency and to the bidders identified in the report. We asked for and obtained comments from them, and after a process of clearance, received confirmation from them that the facts contained in the report, their presentation and the conclusions we had reached were fair.

Appendix 5

Key events in the allocation of licences

Event	Date
Decision to allocate the spectrum for 3G mobile phone services	1996
Publication by the Department of Trade and Industry of the Consultative Paper for 3G, "Multimedia Communications On the Move"	July 1997
Appointment of Project Director for the licence allocation	October 1997
Appointment of external Advisers:	
■ ELSE, as auction designers	January 1996
■ Quotient and Ovum as technical advisers	Early 1997
■ NM Rothschild & Sons as Financial Advisers	December 1997
■ Allen & Overy, as legal advisers	February 1998
First meeting of the Auction Consultative Group	March 1998
Announcement of auction:	March 1998
■ Passing of the Wireless and Telegraphy Act (allowing licences to issued by auction);	
■ Intention to auction in Summer 1999 and statement of objectives for the auction	May 1998
Announcement of independent expert working group under Professor Stewart to report on health aspects of mobile phones	March 1999
Announcement by Secretary of State for Industry that 5 licences will be allocated with one of the largest licences reserved for a new entrant to the market, and measures to ensure a new entrant's customers would be able to roam on an existing Second Generation network.	6 May 1999 ⁴
Invitation stage:	
■ Agency publish Information Memorandum	1 November 1999
■ Date on which potential bidders had to submit their applications	12 January 2000
Mannesman Aktiengesellschaft buys Orange plc.	22 November 1999
Vodafone makes offer for Mannesman Aktiengesellschaft	23 December 1999
Announcement that 13 bidders have pre-qualified to bid	15 February 2000 ¹

⁴ The start of the auction was delayed by three months while One2One challenged the legality of the roaming agreements. (paragraph 2.11)

Event	Date
Secretary of State publishes on the auction internet web site an undertaking by Vodafone with regard to the participation by Vodafone and Orange Limited in the auction, and to dispose of its entire interest in Orange as soon as practicable.	10 February 2000
Auction stage:	
■ Announcement of the start date for the auction	21 February 2000
■ Commencement of the auction	6 March 2000
■ Completion of the auction	27 April 2000
Grant of licences to:	
■ One2One and TIW	9 May 2000
■ BT 3G (exercised its option under auction rules to delay paying in full until 16 May at a cost of a penalty of £50,000)	16 May 2000
■ France Telecom announced it had agreed terms with Vodafone for the purchase of Orange.	30 May 2000
■ Sale of Orange to France Telecom	25 August 2000
■ Vodafone and Orange	1 September 2000
Publication of the report from the Independent Expert Group on health aspects of mobile telephones (the Stewart report)	11 May 2000

Glossary

1G, 2G and 3G	The First Generation (1G) mobile phones provided simple voice telephony, while the Second Generation (2G) provided additional data facilities ranging from short messaging services and data services like fax or electronic mail. The third generation of mobile phones will allow customers to access the internet on the move or watch broadcasts, at transmission speeds greatly faster than the current phone standard.
Bandwidth	The range of frequencies occupied by a radio signal. Frequency, measured in Hertz, denotes the number of complete cycles of an electromagnetic wave in a second. Radio frequencies are conventionally taken to range from 3 kHz to 3,000 GHz. A higher bandwidth is required to support more advanced services such as video.
Base Stations	A facility providing transmission and reception for radio systems. The infrastructure comprises either roof or mast-mounted antennas and an equipment cabinet or container. The base station transmits/receives signals during a phone call to a customer within a designated area. Once the customer moves out of the designated area of one base station, another base station takes over in the new area.
Beauty Contest	A method of pre-qualifying bidders for a sale by tender whereby the seller sets out a set of criteria it will use to judge the merits of an application. The criteria chosen are set to test aspects such as the history of a bidder in running a telecommunications operation, their technical skills and ability to be innovative, the bidder's financial viability and ability to attract future investment. The pre-qualification stage is then followed by negotiations over price. Traditionally firms have to complete an extensive pre-qualification questionnaire and submit detailed business plans.
Bidder	A company or consortium that participated in the auction bidding for a 3G licence.
Broadband	A general term used to describe the capacity of equipment or networks which, in the case of digital technology, can carry bit rates equal to or in excess of 2 Mega bits per second. Broadband telecommunications networks can carry a large number of voice, video and data channels simultaneously.
Deposit	In this case, £50million in cleared funds lodged with the Office of the Paymaster General on the Application Date. Later increased to £100 million for bids of £400 million plus.
Game Theory	<p>A game is a situation of strategic interdependence, where the outcome of a player's choices depends upon the choices of another person or persons. Games arise in many different situations, for example:</p> <ul style="list-style-type: none"> ■ In business, where firms compete against each other; ■ In labour relations, where firms and unions negotiate over pay and conditions of workers; ■ In politics, where politicians or nations seek to gain advantages over rivals. <p>Game theory is an economic theory that can be used to understand and evaluate situations where people and organisations have to take into account the actions of others, before deciding on a particular course of action.</p>
Market Power	The ability to raise prices above the competitive level for a non-transitory period without losing sales to such a degree as to make this unprofitable.

MHz and GHz	Hertz, or Hz, is a measure of frequency. MHz represents Megahertz or one million hertz (10 ⁶); GHz represents Gigahertz or 10 ⁹ Hz.
New Entrant	A company, or consortia of companies, which was not licensed to provide second-generation mobile telephone services in the UK as at the time of the auction.
Notice	The notice issued pursuant to the Wireless Telegraphy (Third Generation Licences) Regulations 1999, setting out the rules and procedures of the auction and related matters.
Paired spectrum	Paired spectrum is required to both make and receive phone calls from one handset. One block from the pair is used to transmit information from the base station to a customer handset, while the second block is used to transmit information from the customer handset to the base station. It is much more valuable therefore than one-way "Unpaired" spectrum, given existing technology.
Regulations	The Wireless Telegraphy (Third Generation Licences) Regulations 1999 issued under powers conferred by sections 3 and 6 of the Wireless Telegraphy Act 1998 authorising the assignment by auction of five Wireless Telegraphy Act Licences for Third Generation mobile telecommunications.
Roaming	The use by a customer of one mobile network operator of another mobile operator's network to make or receive calls, usually because the customer is out of range of his own mobile operator's network.
Simultaneous ascending auction	An auction for multiple items in which bidding occurs in rounds (first introduced in 1994 to sell licences to use bands of radio spectrum in the United States). In each round, bidders simultaneously make bids for an item, offered in the auction, in which they are interested. After bidding, the identity of the current highest bidder for each licence is made available to all bidders together with the amount bid, and the minimum and maximum bids for the next round.
Spectrum	A continuous range of frequencies of electromagnetic radiation (for example, radio waves).
UMTS	UMTS (Universal Mobile Telecommunications Service) is a technical standard developed in Europe and elsewhere for third generation mobile communications. It is one of a family of mobile standards for third generation agreed at international level.
Unpaired spectrum	Blocks of 5MHz of spectrum, which stand-alone and are not paired with blocks of spectrum at other frequencies. At the time of this report, this spectrum, although allocated to mobile phone operators, remains unused.
Vendor financing	The means by which telecommunications manufacturers sell products to their customers by investing in their business or lending them money.