Second Annual Report and Strategic Recommendations

Wireless Report

November 2002

SECTION 4.5 – Wireless Systems

Contents – Wireless

1. Introduction

The work of the BSG, and in particular the BSG Wireless Group, should be seen as an ongoing activity since the barriers and regulatory challenges relating to wireless broadband delivery mechanisms and services are changing and evolving continuously. It is also almost impossible to adequately anticipate the nature and pace of technological advances in this area.

The recommendations contained in this part of the report have been developed taking into account the short, medium, and long-term issues facing wireless broadband services and delivery.

Wireless is a very important delivery medium for broadband applications and services in urban and rural environments. It is therefore important to understand the implications of using broad-brush population statistics and demographic interpretation. In large urban conurbations this approach is relatively effective but beyond the fringe of these large conurbations the data no longer relates well to the geographical dispersion of the population. Nationwide some 35% of the population live in non-urban areas; within regions this can increase to 45% of the region's population. Within national statistics this population is treated as homogeneously dispersed within the data collecting area.

Some 85% of the non-urban population resides in communities of greater than 100 homes; the vast majority of those are in communities of greater than 500 residences. These "smaller" communities tend to be satellites of market and coastal towns; the population densities are no longer 30 – 151 people per sq km but 2500 people per sq km with surrounding space and very low population counts.

The majority of the rural population live in communities that can indeed be serviced by the use of appropriate wireless technologies and in a manner conducive to long term commercial viability i.e. through sustainable revenue levels.

It has long been recognised that the deployment of broadband capability by means of wireless transmission schemes offers several potential advantages. It is widely accepted that one of these key advantages is the ability to economically deploy moderate-high data rate systems at attractive prices. By this means it should be possible to better provide broadband services to a greater number of people as well as encouraging a competitive environment.

In response to this the Broadband Stakeholders Group created the Wireless Group in July 2002 to focus on the particular issues and barriers relating to these schemes with a view to defining some key recommendations for action to actively encourage wireless systems. Of particular interest is the possibility of extending broadband services into 'grey' and even 'red' areas. Of course, encouraging competition in 'green' and 'white' areas is also considered important.

The Wireless Group were given broad terms of reference to examine issues and opportunities relating to Spectrum; Licensing; Rights of Way and Planning; Impacts of other Recommendations; with particular reference to the expansion of the objectives of Broadband Britain into areas not otherwise well served.

2. Executive Summary

Estimates suggest that up to 40% of the UK population may remain unable to get broadband services through wired means by 2005. Even the majority of those who are well-served are only receiving services positioned at the very bottom end of the broadband scale. Therefore it seems that at least 24 million people will have to rely on other means of delivery. The "wireless" recommendations contained in this report, if implemented, will assist the deployment of broadband services to address these potential customers, increase competitive delivery in better-served areas and achieve the Broadband Britain objectives.

To facilitate wireless deployment there is apparently a wide range of frequencies and technology platforms that caters for a number of flavours of wireless, whether the end user is static or wishes to be mobile. There is the possibility for so-called "ad-hoc" community networks based on portable wireless products essentially offered as consumer items, right up to more wide area fixed, mobile or portable wireless network installations requiring a more substantial commitment from an operator. On an even larger scale, non-terrestrial based system proposals exist offering even wider area coverage. Each variant displays a variety of both positive and negative technical and financial characteristics.

Yet despite all these possibilities, there still seem to be difficulties in finding the right approach to provide ubiquitous broadband service coverage and availability. Perhaps this is in part because no single technology platform or licensing regime can provide the complete solution in its own right.

This report examines some of the detail behind these subjects and makes recommendations that reflect consideration of both the short and long term in terms of the governmental objective to make broadband services more widely available. In the shorter term, more ready access to radio spectrum would facilitate the possibility for a more strategic and evolutionary use of the resources available; these measures should be nurtured in the longer term by a stronger governmental priority for Wireless Access. These would help foster the conditions for Wireless Access to become the solution of choice for the rural and under-served areas of the UK and a viable source of healthy competition in other areas.

2.1. Summary of Recommendations

Recommendation 1: Prioritise More Spectrum for Broadband in Appropriate Bands

The Government should give priority to the support of broadband services when deciding policy on spectrum allocations in the bands appropriate to the service intended.

Wireless technology enables broadband services to be provided in a complementary manner to users in areas where wired technologies are unavailable and in a competitive manner where wired technologies are available. Overall, wireless schemes offer the most attractive means of providing broadband facilities to large sections of the population and their timely deployment will be crucial to the achievement of the Broadband Britain objectives by 2005. Recognising that the commercial viability of a proposal is dramatically affected by the operating frequency (because the laws of physics affect virtually everything), it is crucial that the right band is made available for the particular service intended.

Recommendation 2: Spectrum Assignment on the Right Terms

Spectrum assignment processes must result in terms and conditions that enable the deployment of broadband services to 'grey' and 'red' areas to become viable.

Access to the spectrum prioritised for broadband wireless will be significantly improved through appropriate radio spectrum assignment processes that balance the wider objectives of Broadband Britain with the commercial realities in the current economic climate.

This will stimulate the timely rollout of extensive wireless technologies. New and innovative approaches for achieving this should be explored immediately and implemented in a defined, appropriate manner. Any approaches should take account of the opportunities afforded by the variety of the frequency bands, technologies; delivery mechanisms available; the possibilities for cross-service provisioning; different licensing frameworks; and CEPT / International harmonisation.

Recommendation 3: Innovative Approaches for Backhaul Infrastructure

Government, working with Regulators, Regional Development Agencies, Local Authorities and industry, should examine ways to improve the availability of backhaul infrastructure to address areas that are currently underserved.

In order to meet the Government's objectives by 2005, and in common with all access technologies, wireless delivery requires adequate back-haul infrastructure, much of which may also be provisioned by wireless systems. Recognising that subsidised infrastructure already exists to support specific public service connections, e.g. education, the Government working with RDA's, Local Authorities and Industry need to immediately explore ways of extending this concept to increase capacity and availability through appropriate partnerships. This would encourage competition in currently served areas (green and white) and provision broadband in more difficult to reach areas (grey and red).

Recommendation 4: Government Services Online in "Grey" and "Red" Areas

Given the UK Government is a major user as well as provider of broadband services and infrastructure, and given the need to ensure that these services are available in "grey" and "red" areas, it is essential that the Government provides leadership in the use of wireless broadband.

Recommendation 5: Planning and Rights of Way

The Government must ensure that planning and rights of way issues do not impede the deployment of broadband services to people in 'grey' and 'red' areas.

Noting the ODPM review is near conclusion and a consultation will be soon issued as part of a process of addressing these maters. We support this process and look forward to this approach in addressing all other similar matters of this nature.

Recommendation 6: A Strategic Plan for Wireless Broadband

In order to ensure that the objectives for Broadband Britain are met by the 2005 deadline a time-plan with wireless broadband milestones should be included in the UK Government's Broadband Strategic Plan.

To enable Broadband Britain objectives to be achieved by 2005, the Government needs to adopt in full the five inter-related wireless recommendations immediately and implement an appropriate, co-ordinated Government action plan in pursuit of these recommendations to capitalise on the significant Industry investment in recent years.

The BSG is keen to work with Government, RDA's, and Local Authorities in implementing these objectives.

3. Radio Spectrum – The Basics

3.1. Radio Frequency Aspects

In this report consideration has been given to the frequency range in which most "broadband" wireless access systems are expected to operate. This includes specific frequency bands identified within the approximate range 1 to 40 GHz lying in what are known as the microwave and millimeter-wave regions of the radio spectrum. These are not absolute frequency limits for wireless access applications and examples exist of lower frequency "interactive" wireless services adding a two-way capability alongside broadcast delivery and operating in UHF spectrum below 1 GHz and of Point-to-Point (P-P) systems operating in frequency bands above 40 GHz.

Across this wide frequency range the spectrum exhibits differing characteristics that need to be accounted for when frequency planning the deployment of wireless access systems. These differences are also reflected in specific aspects of system design that mitigate the effects of any spectrum constraints or radio propagation impairments.

Generally at the lower frequencies, although semiconductor device technology and physical dimensions can lead to comparatively lower technology costs, the availability of spectrum is proportionately less at the lower frequencies. This potential reduction in cost could be counter-balanced by a drive for greater system complexity in order to maximize the capacity of the spectrum for broadband delivery. Higher performance and lower propagation losses can help to increase the range of systems and facilitate non-line of sight transmission, although often this could be counter-balanced by increased susceptibility to, and potential to generate, interference over a larger area.

Generally at the higher frequencies, even though comparative technology costs can be higher, this may be mitigated by the greater amount of spectrum available and a less compelling requirement for greater complexity to maximize traffic throughput. With wider frequency assignments possible, there is a greater amount of spectrum to provide capacity for broadband services. Although operational ranges may be reduced, more compact, more directional antennas and higher propagation losses can lead to an opportunity for greater re-use of available frequencies.

Additionally across the entire frequency range, spectrum is generally shared and allocated to other services, and this includes both terrestrial and space-borne systems that carry both telecommunications and non-telecommunication services. A key consideration is the bandwidth that can be devoted to the proposed system and where that is located within the overall spectrum. This can greatly influence the system design and economics.

Therefore the suitability of any particular frequency band identified for wireless access systems requires a complex consideration of both positive and negative characteristics. No single frequency band offers all the advantages or suffers all the disadvantages, and each may be optimum under different scenarios.

Spectrum has been identified for Wireless Access on a national and international basis, with the major bands considered so far in the UK listed in the Technical Annex.

3.2. Radio Service Categories

Underpinned by international treaties and regional agreements, the radio frequency spectrum is generally divided for administrative purposes into sub-bands allocated to specific services (and not application). The service definitions at the highest level appropriate to terrestrial Wireless Access constitute Mobile Service and Fixed Service. Satellite systems are categorised as Fixed Satellite or Mobile Satellite Service. Often the same spectrum is allocated to more than one service and, for example, in many cases the Fixed Service and Fixed Satellite Service share common spectrum.

- **Fixed Service**

  In this case, the wireless system connects two (or more) fixed locations. There is no mobility associated with operation of the wireless system and it is usual for the service to connect to premises rather than specific individuals. Under these conditions the operational environment is reasonably stable and normally the quality and availability of the link is assured. This type of terrestrial application is termed FWA (Fixed Wireless Access), or more strictly BFWA (broadband FWA) in the context of this report.

- **Mobile Service**

  In this case, the wireless system connects users that are capable of movement whilst communicating. This leads to a more variable environment with less control over the location and relative positioning of the mobile users with respect to physical features or potential interferers. In this case the availability and quality might be sacrificed to some extent but in favour of the convenience of mobility.

- **Broadcast**

  Formally for radio regulatory purposes, this is a service “in which transmissions are intended for direct reception by the general public”. In the case of TV, a separate link can supplement the broadband broadcast channel to effect a very useful inter-active or multimedia service, and although this link is today usually supplied by means of a low capacity wired PSTN connection, other wireless arrangements could be possible to extend this multi-service, multi-platform approach.

An attractive sub-set of the Mobile Service category has emerged in recent years labelled informally as "Nomadic" and applied to most portable systems. These are mobile in the sense that at least one end of the system is capable of portability although operation whilst moving (at least at any significant speed) is not anticipated. Provision of a service in specific localised areas is expected rather than wide area service coverage. When inside a service area the environment again tends to be more stable, leading to the possibility of a better quality connection. These broadband systems are termed RLAN (Radio Local Area Networks).

Another variant effects wide area coverage with true portability and handover, albeit generally only at speeds of travel lower than, say, 2G / 3G systems; informally these might be termed Portable Wireless Access (PWA).

3.3. Licensing

In most cases wireless services are "regulated" by licences issued to control the number of user locations and ensure that interference between users is minimized. Once a licence is issued the frequencies concerned within any geographic location or area are available to the licence holder for his exclusive use in line with any associated licence conditions. Licences can be classed as "equipment" licences, whereby a specific channel is licensed for occupation by specific equipment or as "spectrum" licences whereby a block of frequencies or channels is licensed over an area for use by a class of equipment. The former is most common for microwave Point-to-Point licensing, whereas the latter has been the norm to date for Wireless Access licensing where Multi-Point architecture is envisaged.

Fees are levied for licences through a variety of processes, including spectrum pricing (applied usually to individual frequency licences) and competitive auction procedures (applied usually for spectrum block licences where perceived demand exceeds the spectrum supply). These auction procedures have often / generally replaced comparative selection (so-called "beauty contests") as a means of selecting appropriate licence winners.

Operation in so-called licence-exempt bands has become increasingly popular for the provision of telecommunications services, due in part to the ease of access to the spectrum. Only very recently has the UK regulatory framework been amended to allow commercial use of licence-exempt spectrum, and then only at 2.4GHz. Originally, these bands being designated for Industrial Scientific and Medical systems and with the resulting unpredictable interference environment, were considered as unsuitable for telecommunications purposes. However technological advances have facilitated systems that can mitigate the effects of interference to some degree. Together with the possibility of operation without a specific licence, (and the consequential fee), a variety of systems have been attracted into these bands. However the licence-exempt status means that users have no right to expect protection from interference from other licence-exempt users of the spectrum who would be sharing use of the entire band.

4. Technology Considerations

4.1. Technology Terms

Terms used to describe different Wireless Access technologies can be confusing as they sometimes refer to a particular system standard, network architecture or perhaps to operation in a designated frequency band.

Whether technology is designated to operate in either licensed or licence-exempt frequencies, it shares the requirement to comply with certain standards that are linked to the regulatory assignment processes. For licensed Broadband Fixed Wireless Access bands any requirement is usually based on a minimum "coexistence" standard specific to the frequency band and is cited to underpin specific regulatory inter-operator co-existence constraints. Air interface details have generally been proprietary as there is less of a driver for such a comprehensive standard in the fixed environment.

For licensed mobile systems and licence-exempt operation there is no control over terminal station location. To manage potentially damaging interference may require compliance with specific air-interface standards that include frequency "etiquette" and / or other measures to specifically tackle co-existence and frequency band sharing. Statutory Instruments are usually put in place to authorise use of specific licence–exempt frequencies that are linked to the appropriate standards.

In this case the technology or frequencies tend to become known by the standard. Examples include "IEEE802.11b cards" or "the HIPERLAN band".

4.2. Fixed, Transportable, Nomadic, Portable and Mobile Wireless.

The range of available wireless technologies can uniquely be applied to all these applications, whereas conventional wire-line and cable are of course restricted to fixed operation only. The section on "Radio Frequency Aspects" and "Radio Service Categories" and "Licensing" describes the basic differences, and here we simply list the broad categories of system approach, as necessary background to the recommendations

Wireless Access systems may be satellite or terrestrially based. In the context of this report, satellite schemes are normally of fixed type, or at most transportable. Inherently uplink capacities are more limited, and generally equipment and running costs are somewhat higher. Major attempts in recent years to establish wide-area broadband satellite based Wireless Access systems have as yet not been realised.

Terrestrial Wireless Access systems can include traditional mobile, fixed, broadcast, and portable or nomadic systems. Nomadic systems are normally taken to apply to more localised scenarios, termed RLANs. Broadband portable systems have appeared only recently, and are applicable to situations where the user is not moving at high speed, unlike the case for truly mobile type systems such as 2G / 3G.

UMTS is part of a family of wireless technologies that were developed to provide high data throughput, operator-class mobile broadband connectivity to a broad range of users. Rather than compete, UMTS complements WiFi/802.11 and FWA in the UK's broadband infrastructure. UMTS makes other Wireless Access technologies, as well as fixed broadband networks, more powerful by offering a mobile component.

UMTS is specifically interoperable with Wireless-LAN networks. Equipment manufacturers have already demonstrated seamless handover between UMTS and Wireless-LAN, including integrated billing, which is an essential factor for ensuring easy and effective use of broadband resources. By linking to UMTS networks, "hot spot" coverage in dense business traffic locations (e.g. airport lounges, hotels and conference centres) can be automatically extended to other places where users actually find themselves, making both technologies more useful, and therefore more successful.

Without doubt, recent advances in technology have transformed our ability to realistically implement reliable, broadband wireless technology solutions. Potential operators / users can be offered a variety of solutions ranging from bespoke systems to ad-hoc operation on licence-exempt bands. Wireless systems can be deployed relatively quickly (depending on the particular technology) and offer an attractive range of competitive solutions which address the key market needs in a range of mixes of key features; no single solution is appropriate for all circumstances, as is the case for conventional wired technology.

It is not appropriate to provide an exhaustive description of the various technologies that are currently under consideration. However, brief explanation of the broad categories of system architectures and other key factors may be helpful.

4.3. Traffic Offered and Duplexing

Conventional voice telecoms / telephony systems assume traffic (content) is approximately symmetric (equal demand each direction on average). In an increasingly data-centric world, and to accommodate trends in the convergence of broadcast and telecoms functions, this requires re-examination. Wireless Access systems may in principle be designed to offer such symmetry in capacity; others may be designed for some degree of pre-determined or flexible traffic asymmetry. Importantly this subject is also related to the technical choice of spectrum, which is normally allocated or assigned as either single portions of the possible frequency range, or otherwise in designated pairs. In the case of conventional paired spectrum, each portion is used exclusively for uplink or for downlink (termed Frequency Division Duplexing, FDD), whereas a single portion of spectrum exploits very fast, electronic time-slicing of the signals (Time Division Duplexing, TDD).

4.4. Wireless Access Architectures and Other Factors

Wireless Access system architectures include Point-to-Point (P-P), Point-to-MultiPoint (P-MP), MultiPoint-to-MultiPoint (MP-MP, mesh) or variants. In the case of nomadic, portable or full-mobility systems, the P-MP approach dominates. It should be noted here that UWB (Ultra Wide Band) technology is technically inappropriate for applications relating to Broadband Britain.

The main system factors and types are as follows -

- Cellular configurations: this is the basic arrangement familiar to users of 2G / 3G mobile systems, for example. But is also the basis for most fixed Wireless Access systems (including broadcast). Here a wide area is covered with base stations on a P-MP basis, with the over-the-air-traffic to and from the terminals (customers) aggregated efficiently (concentrated) and the connections to other systems made by the back-haul structure (fibre, leased-line, microwave P-P). Only some of the frequencies assigned are used in each cell (base station area), but over the whole area all the allowable frequencies are used over and over again by means of a suitable multiple-cell repeat (re-use) pattern.
- MP-MP systems are a variation on this. Here the customer premises equipment itself is used to relay traffic on to the desired location. This mitigates the need for high capability base stations and also allows the scheme to grow organically as the users are added to it.
- P-P systems have been deployed for many years to provide both customer access and backhaul applications. P-P is particularly appropriate (cost) where the number of users in a geographical area is limited or where high capacity is required to service specific customers.
- Satellites offer coverage over the whole country. In the absence of obstructions (which can block the signal from low Earth orbit satellites) it is possible to pick up a signal practically anywhere outside. Indoor coverage can be poor or non-existent and so arrangements are normally made to have the antenna outside and route the signal into the building by other means. They remain an attractive option in situations where the traffic is mostly downlink and not user-selectable. They have a natural application for broadcast or multicast type schemes.
- Proposed High Altitude Platforms (HAPs) could be based on either unmanned floating platforms or a long-duration aircraft system, using an altitude of some 20 km. These would offer very wide area coverage, and likely best for relatively high user populations. Due to difficulties with the platforms, no imminent deployments now appear likely.

Some of the key design/implementation factors that are relevant include the following -

- Various signal modulation schemes are used, largely tailored to the particular system needs and taking into account such factors as propagation environment, frequency range, quality of service targeted, relative cost of base station and user terminal, degree of mobility required or not, etc..
- Important factors include the cost of user equipment; service quality and availability; operation and maintenance regimes and costs; degree of support for IP functionality; suitability for different terrain types – especially rural or low user-density coverage; strength of encryption and other security and authentication measures; requirement for customer installation or not, and the time and skill level required; whether it is desired that in-building coverage be offered, etc..

At present content providers, both commercial and public service entities, are not using multicast technology to advantage. This is largely a “chicken and egg” situation resulting from inadequate, widespread broadband take-up of any technology. But it should be noted that this situation will change dramatically once a sufficient threshold of accessible, broadband-capable users is established. If adequate aggregate system traffic capacity and per-user capacity were pervasive, the situation would be transformed, In the meantime, such wireless technologies as so-called one-way satellite internet provision can help overcome and encourage a much-needed move from a fully “pull” – orientated assumption to a situation where “push” delivery is more commonly available and indeed used, to the benefit of both consumers, commerce and public service efficiencies.

For satellite (so-called one-way) systems, or others in the future of mixed-services category, there appears to be a need for research to better accommodate issues related to IP addressing and authentication, including proxy server provisions – all of which have hitherto been configured for a wired world and thus cause extra cost for these particular wireless arrangements.

It is increasingly recognised that wireless in-home networks built on WLAN's popularity represent an important enabler to broadband take-up. It is therefore considered important to ensure that spectrum is kept available for these generally licence-exempt applications in addition to the urgent need for spectrum for access networks.

4.5 Regulatory framework

The technical implementation of any wireless transmission system must take into consideration the regulatory framework applicable to the spectrum and also other requirements such as lawful interception, billing and other requirements.

To operate a commercial wireless telecom network it is currently necessary to have a licence to use the spectrum under the WT-Act (unless the scheme is using the licence-exempt spectrum at 2.4 GHz) and also an appropriate licence under the T-Act.

It should be noted that there are more general regulatory conditions which must be adhered to, flowing down from international (ITU-R) and European obligations, including unwanted radio emission and interference related aspects, and there is no issue here in terms of any suggested change or non-compliance for any wireless access system addressed by the BSG.

5. Enablers

5.1. EU Directives

The recent Directives provide a framework whereby a significant amount of the current complexity surrounding telecom regulation could be removed. This would be extremely helpful to operators and others. Of particular significance are the principals behind an emphasis on 'general authorisations' rather than individual licensing. Not only should the procedures and difficulties associated with licensing (say) be significantly reduced but also the costs involved should be less. The UK is in process of implementing laws that could move in this direction. However, the amount of simplification that is actually to be achieved for the UK is yet to be seen. The draft Communications Bill establishes OFCOM and gives a structure for certain aspects of the proposed regime. However, the detail will be established through other means than the (draft) Bill and so, until these are disclosed it is not known how much improvement there will actually be.

5.2. Standards

As mentioned earlier there is a clear drive for licence-exempt technologies to prepare air interface standards. However the wireless industry has also invested heavily in the production of air interfaces for fixed wireless access technology normally associated with licensed bands. These activities have been progressing within ETSI in Europe and the IEEE 802.16 committee in the US. ETSI has published the so-called "HIPERACCESS" standard for broadband fixed wireless access systems operating in higher frequency bands like 26 / 28 GHz or 40 GHz and 802.16 has published a similar standard for the same frequency range. Both groups are continuing with standards for lower frequency systems and in ETSI the HIPERMAN standard is under development with interest in extending its use to licence-exempt bands at 5.8 GHz. These activities require considerable commitment from industry and can result in the basis for widespread commercially available equipment with known and predictable characteristics.

5.3. Licensing Regime

The licensing regime and processes must be responsive and adaptable to the fast pace of changing economic and technological developments in the Wireless Access arena. In the longer term and as mentioned above, many fundamental changes to the UK and European regulatory frameworks are underway. Recent changes to "cordless" or "class" T-Act licences have helped but still impose constraints that result in delays and bureaucratic burden. However there are also steps that could be taken in the shorter term to encourage wireless provisioning of broadband services that require investigation of some more imaginative procedures to unlock access to spectrum.

There are certainly some frequency allocation table inflexibilities which are reflected in the current UK license system. It is as yet unclear to what extent changes in the spectrum management role of the Radiocommunications Agency / OFCOM resulting from the deliberations following the "Cave Report", will improve matters. The UK frequency allocations and associated national policy are together encapsulated in the current edition of the Radiocommunications Agency document "Strategy for the Future Use of the Radio Spectrum in the UK", and this has been carefully addressed by the BSG in formulating its recommendations.

We note that technological advances have been very great in recent years, in part driven by a wide variety of advances in other disciplines. Equipment is now becoming available which is much more resilient to interference and has algorithms which use spectrum much more efficiently than ever before. Much of this modern equipment performs measurements on the applicable radio spectrum and propagation conditions to dynamically ensure that it operates in the most efficient manner.

5.4. Skills

The level of skill and expertise required developing resilient and scaleable wireless networks should not be underestimated.

6. Previous Successes

Case studies can be found on the Telecoms Advice website www.telecomsadvice.org.uk

7. BSG Wireless Group Recommendations

7.1. Recommendation 1: Prioritise More Spectrum for Broadband in Appropriate Bands

7.1.1. Justification

To facilitate the widespread deployment of Wireless Access systems and achieve the Broadband Britain objectives, identification and access to appropriate radio spectrum is required. Many frequency bands have already been formally recognized for Wireless Access of some sort, both internationally in the ITU and ECC and nationally. These bands include frequencies that can be assigned to many of the technologies touched upon in this report under either licensed or licence-exempt regimes, for fixed or nomadic or mobile. However in a number of instances, the availability of these frequencies in the UK has been (and continues to be) delayed by unresolved issues associated with existing occupiers of the spectrum or by policy that may not reflect latest technologies and raised market expectations.

These delays are extremely damaging to the commercial exploitation of the spectrum concerned, leading to uncertainty that is detrimental to both the take up by industry and the governmental objectives.

To facilitate the widest roll out of wireless access requires considerable frequency resources with the requisite amount of bandwidth in both the short term and long term to provide appropriate solutions.

7.1.2. Recommendation 1 – Prioritise More Spectrum for Broadband in Appropriate Bands
The Government should give priority to the support of broadband services when deciding policy on spectrum allocations in the bands appropriate to the service intended.

Wireless technology enables broadband services to be provided in a complementary manner to users in areas where wired technologies are unavailable and in a competitive manner where wired technologies are available. Overall, wireless schemes offer the most attractive means of providing broadband facilities to large sections of the population and their timely deployment will be crucial to the achievement of the Broadband Britain objectives by 2005. Recognising that the commercial viability of a proposal is dramatically affected by the operating frequency (because the laws of physics affect virtually everything), it is crucial that the right band is made available for the particular service intended.

7.2. Recommendation 2: Spectrum Assignment on the Right Terms

7.2.1. Justification

It has been recognised that[1] the greatest benefit to the Nation from the radio spectrum comes from its use and not from any licence charges that may be applied. Therefore gaining access to appropriate spectrum under the right conditions must be a key policy objective.

There are a variety of different Wireless Access technologies available, and up to now most UK licensing has concentrated only on certain Fixed Service bands. The frequency tables presented in the Technical Annex show around 1 GHz of spectrum that has been made available for licensing, yet many hundreds of MHz remain unassigned over vast areas of non-urban UK locked in either delayed or stalled licensing processes. In addition to improving access to these frequencies, there needs to be a greater sense of urgency to provide faster and cheaper access to suitable spectrum, fixed and mobile, and to better embrace the different types of systems and technologies.

Cost of the spectrum is a crucial factor. The whole point about wireless is that it is sufficiently cost effective that it allows the possibility of deployment of broadband services into the 'GREY' and 'RED' areas of the country. If the cost of the spectrum needed to support the service is so great that the service cannot be established, there will be no service and the Nation will have lost out.

Recently, both the Radiocommunications Agency and the Treasury have issued documents confirming that the greatest benefit to the Nation from the radio spectrum comes from the use of the spectrum and not from any licence charges that may be applied. The key policy driver therefore must be to get the spectrum used.

A more flexible view needs to be taken, under a regularly reviewed policy which recognizes that as compared to wired systems and the radio regulatory regime in some other countries, the situation is less transparent than is desirable, more protracted and does not seem *in toto* to fully reflect the best match to the technological and market factors. Given the numerous uncertainties surrounding broadband wireless access, operators need the opportunity to gain access to spectrum in a manner that will allow them to evolve networks in terms of spectrum, coverage and services over time.

Within the Spectrum Management framework there should be room for the possibility of access to spectrum for system proposals that challenge traditional approaches to BWA provision. Many of these newer technologies may not fit squarely into assignments based upon existing technologies and should be encouraged with opportunities to demonstrate their technical and commercial possibilities. For example so-called Portable Wireless Access (PWA), entailing high spectral efficiency with good wide-area coverage, with no user installation and relatively low equipment costs, makes deployment in urban through rural situations attractive, provided the flexibility exists in the spectrum management framework.

A strategy for licensing needs to consider that:

- Some systems are area co-ordinated, some not, some are ad hoc, some are localised and others wide-area or ubiquitous.
- Some systems cover in-building operation, others not
- Some bands are identified but license conditions are questionable
- Some spectrum needs to be made available that is not currently designated for WA
- Terrestrial WA service could also be used to better supplement one-way satellite
- Other asymmetrical arrangements are feasible, inc. multi-frequency and multi-service category types

[1] The Economic Impact of the Radio Spectrum, RA Feb 2001 and The Independent Review of the Management of the Radio Spectrum, Professor Cave.

- There are other attractive fee-based license regimes as alternatives to auctions with high front-end payment schemes
- In some cases the notion of a "community" or consortium, even Public / Private Partnership based operator can be attractive
- Whilst spectrum efficiency is important in effective management of the spectrum, and retaining flexibility, this should be weighed against technological cost and opportunities to foster new innovation particularly when looking to open new higher frequency bands.
- There is recognition that nevertheless the benefits of CEPT / International harmonisation are real.
- Short-term and long-term developments in markets and technologies need to be considered, and regularly reviewed.

The licensing process needs to stimulate wireless broadband delivery. Spectrum trading and / or auctions are not the answer to recommendation 2.

7.2.2. Recommendation 2 – Spectrum Assignment on the Right Terms
Spectrum assignment processes must result in terms and conditions that enable the deployment of broadband services to 'grey' and 'red' areas to become viable.

Access to the spectrum prioritised for broadband wireless will be significantly improved through appropriate radio spectrum assignment processes that balance the wider objectives of Broadband Britain with the commercial realities in the current economic climate.

This will stimulate the timely rollout of extensive wireless technologies. New and innovative approaches for achieving this should be explored immediately and implemented in a defined, appropriate manner. Any approaches should take account of the opportunities afforded by the variety of the frequency bands, technologies; delivery mechanisms available; the possibilities for cross-service provisioning; different licensing frameworks; and CEPT / International harmonisation.

7.3. Recommendation 3: Innovative Approaches for Backhaul Infrastructure

7.3.1. Justification

Wireless is seen as one of the most appropriate methods of extending the reach of existing infrastructure. Cost is lower and speed of deployment quicker than wire line alternatives. Infrastructure is capital intensive and often prevents the roll-out of rural broadband services in a commercial environment because the business case is not as strong as that for urban deployment.

A competitive environment exists in some areas of the UK but communities in rural areas of UK are underserved by competitive infrastructure. In many instances even major operators are sometimes unable to supply high capacity to customer premises in a timely fashion.

Existing infrastructure needs to be extended into rural communities, or, to put in another way, build out is required from rural areas back to a suitable point of presence. This is a prime way that 'grey' and red' areas will be served.

Public / Private Partnerships (PPP) may be a solution to extend present infrastructure, particularly where current Government subsidised activities exist.

7.3.2. Recommendation 3 - Innovative Approaches for Backhaul Infrastructure
Government, working with Regulators, Regional Development Agencies, Local Authorities and industry, should examine ways to improve the availability of backhaul infrastructure to address areas that are currently underserved.

In order to meet the Government's objectives by 2005, and in common with all access technologies, wireless delivery requires adequate back-haul infrastructure, much of which may also be provisioned by wireless systems. Recognising that subsidised infrastructure already exists to support specific public service connections, e.g. education, the Government working with RDA's, Local Authorities and Industry need to immediately explore ways of extending this concept to increase capacity and availability through

appropriate partnerships. This would encourage competition in currently served areas (green and white) and provision broadband in more difficult to reach areas (grey and red).

7.4. Recommendation 4: Government Services Online in "Grey" and "Red" Areas

7.4.1. Justification

A joint initiative between UK Government and Industry www.ukonlineforbusiness.co.uk is looking at the potential impact of a 'multi-channel' world, where broadband services will be available through more than one delivery channel such as wired, broadcast and mobile. It is estimated that the total value of this 'multi-channel' market by 2006 could be around £[160] Billion.

Many of the Government information services are already available on-line through wired mechanisms with ambitious targets set for 2005. It suggested that in order to realise the benefits of this multi-channel world then these services should also be available via broadcast (terrestrial as well as satellite) and mobile, appropriately packaged for the type of device that the user has. Targets for Government services to be available by wireless mechanisms, in addition to wired, should be introduced. Some proposed targets are suggested.

Equally, it is apparent that many of the activities of public service bodies and Government agencies may take advantage of the unique attributes offered by wireless broadband access. Examples include such areas as rural and small-town offices and facilities (rapid provisioning); ambulant and mobile workers involved in health care delivery or the utilities etc.

In terms of infrastructure, again UK Government (with all of the various departments and organisations) is a major user and purchaser. A proactive and early, co-ordinated approach is essential to driving forward the infrastructure deployment.

7.4.2. Recommendation 4 - Government Services Online in "Grey" and "Red" Areas

Given the UK Government is a major user as well as provider of broadband services and infrastructure, and given the need to ensure that these services are available in "grey" and "red" areas, it is essential that the Government provides leadership in the use of wireless broadband.

7.5. Recommendation 5: Planning and Rights of Way

7.5.1. Justification

Wireless access systems, usually require some form of elevated base station installation. In recent years a growing number of Local Authorities are obstructing or even preventing development of the mobile radio service in their localities. This is achieved through the issue of supplementary planning restrictions on the siting of base stations even though existing guidelines are available. Some Local Authorities have issued a moratorium on base stations on their land and buildings.

In the 2G (GSM) schemes this has to some extent (but not entirely) been countered by site-sharing agreements between some of the operators. The introduction of 3G (IMT-2000 / UMTS) and broadband systems however, calls for significantly more base stations than were previously needed, therefore planning difficulties will present a very significant barrier to the deployment of these services.

Apparently some planning regulation calls for a limit on the number of antenna it is permissible to have on a property. The rationale for this decision should be reviewed since it effectively means there is only one service available to those users.

7.5.2. Recommendation 5 - Planning and Rights of Way

The Government must ensure that planning and rights of way issues do not impede the deployment of broadband services to people in 'grey' and 'red' areas.

Noting the ODPM review is near conclusion and a consultation will be soon issued as part of a process of addressing these maters. We support this process and look forward to this approach in addressing all other similar matters of this nature.

7.6. Recommendation 6: A Strategic Plan for Wireless Broadband

7.6.1. Justification

As highlighted previously the work of the BSG and the BSG Wireless Group should be seen as an ongoing activity since the barriers and regulatory challenges relating to wireless broadband delivery mechanisms and services that need to be overcome are changing and evolving continuously. The pace of technology enhancements and evolution in this area is very rapid. This recommendation stresses the importance of having a short to long-term strategy relating to wireless broadband services, applications and delivery.

There has been significant investment by Industry, not just in monetary terms, but also in resources and commitment in pursuit of achieving Broadband Britain objectives. The Government needs to ensure this investment is maximised. The industry drive that has created European and global interoperability standards for BWA should be supported. These standards provide the basis for widespread commercially available equipment with known and predictable characteristics. They will boost the availability of affordable systems more appropriate to lower density rural applications.

Using wireless systems the time taken for deployment can be significantly reduced while at the same time maximising faster deployment and penetration in underserved and / or less accessible areas that would not be easily covered by other delivery mechanisms.

With a strategic plan, capable of evolving as markets mature and barriers change, the Government will have ensured Broadband Britain objectives are achieved and a economic environment will have been established which will in turn increase competition.

7.6.2. Recommendation 6 – A Strategic Plan for Wireless Broadband

In order to ensure that the objectives for Broadband Britain are met by the 2005 deadline a time-plan with wireless broadband milestones should be included in the UK Government's Broadband Strategic Plan.

To enable Broadband Britain objectives to be achieved by 2005, the Government needs to adopt in full the five inter-related wireless recommendations immediately and implement an appropriate, co-ordinated Government action plan in pursuit of these recommendations to capitalise on the significant Industry investment in recent years.

The BSG is keen to work with Government, RDA's, and Local Authorities in implementing these objectives.

Technical Annex

Frequency Band Tables

The following tables provide a summary of the relevant parts of the radio spectrum as they currently are arranged. The tables are split into four parts. Parts 1 and 2 are nominally divided by fixed or mobile wireless access service classification. Part 3 details frequencies that are currently under consideration.

In addition to the specific "wireless access" system frequencies there are many frequency bands allocated to Fixed Service point to point (P-P) applications. Those most suited for access applications are detailed in Part 4. Licences for these systems are assigned individually on a link-by-link basis and capacity is available in any of these bands for assignments. These systems have been used in access applications and although in recent years (i.e. since the BT/C&W duopoly) there are currently no blocks of channels assigned to any specific operator there have been occasions where "preferential" frequencies have been identified for one operator although individual application is still required for a licence.

These bands comprise the 18, 23, 26, 32 and 38GHz bands and they detailed along with references to specific characteristics in the Radiocommunications Agency publication RA [365].

The Part 1 table includes bands that are generally not currently fully assigned. However short term access to the frequencies concerned is generally blocked for three reasons. Either a previous licensing process has not resulted in activity and returned licences have not been re-offered, spectrum is locked into a current stalled licensing process or all licences have been awarded.

The Part 2 table details those bands associated with mobile access systems and includes frequencies employed by "nomadic" portable systems generally in licence-exempt spectrum. Clearly there remain opportunities to gain access to the licence –exempt band, but the 3G frequencies are all assigned.

The 5GHz band is subject to ECC Decision 99/23. This served to open up the 5GHz band for SRD's. This decision required the use of Transmit Power Control (TPC) and Dynamic Frequency Selection (DFS) neither of which are as yet accurately defined. Under normal circumstances, placing a radio product on the market in Europe requires the product to comply with the R&TTE directive. To do this, the simplest process is to self certify the product to the relevant harmonized European standard. As of today there is no such standard. ETSI are working on one (draft EN 301 893), which will be available some time in early 2003. This standard will include TPC and DFS. The equipment available in the US is to standard 802.11a which does not call for DFS and TPC. It therefore does not meet the longer-term plans for the spectrum at the close of the interim arrangements. However, further versions of the US standard are in progress (802.11g/h) which are designed to meet these requirements.

The Part 3 table details frequency bands currently not definitively allocated to wireless access but are under consideration. These include frequencies under consideration for increasing the capacity available to 3G systems and those under consideration for licence-exempt fixed wireless access and so-called "portable" wireless access.

Part 1: Fixed Wireless Access Bands

None of these bands (except 3.8GHz) are currently fully assigned.

Freq Band / Lic / Lic Exempt	UK Assignment	Assignment per operator / Licensing status	Equipment Standards	Remarks	Spectrum access opportunity
2 GHz Lic		2x90 MHz One licence returned.		Geographically limited to remote areas. Recent consultation on allowing greater data rates. Originally licensed for 144kbit/sec to 2Mbit/sec services.	Only one licence in force.
3.5 GHz Lic		2x20MHz Consultation (delayed)	301-021 etc... ETSI HIPERMAN under development	Good equipment availability. Lower frequencies translate to lower cost systems. Up front licence cost and equipment costs difficult in economic climate. Bandwidth available may limit broadband capability in dense deployments.	One licence only on a (different) regional UK basis (to that at 28GHz). Access denied once sold.
3.8 GHz Lic	3.605-3.689GHz paired with 3.925-4.009GHz	2x36MHz Licensed nationally to a single operator		No further licences anticipated. Sharing with other services causes difficulties in certain areas.	No further licences anticipated.
10 GHz Lic	10.125-10.225GHz paired with 10.475-10.575GHz.	2x30MHz, 3 operators nationwide. (Some exclusion zones – MOD issues.)	Licensed in 1997. Only one licensee still operating (NTL). RA considering new licensing process. Pending MoD issues.	Low equipment availability. Narrow current assignments restrict capability for broadband services over about 2Mbps on any large scale. Uncertainty regarding future proposals for 2 x 60MHz. Originally licensed for >2Mbps services.	Spectrum available but re-licensing process stalled.
28 GHz Lic	28.0525-28.4445GHz paired with 29.0605-29.4525GHz	2x112MHz	First round sold all 3 licences in urban areas plus some others. Second round has failed to attract buyers for remaining licences.	Reasonable equipment availability although lower than fore adjacent 26GHz band assigned over most of Europe. Up front licence cost and equipment costs difficult in economic climate. Assignments adequate to support broadband services.	Lots of spectrum available outside major conurbations of London, Midlands and North West. 3 licences on offer on a (different) regional UK basis (to that at 3.5GHz). Access denied once sold.
40 GHz Lic	40.5-43.5GHz	Undefined at present	EN 301 997, HIPERACCESS Consultation	Low equipment availability maintained by uncertainty regarding future licensing process. Propagation	Vast amounts of spectrum available. Commercial Trial operation

				characteristics best suited to short links. Bandwidth suited to high capacity broadband and streaming services.	under consideration.

Part 2: Mobile Wireless Access Bands (including "Nomadic")

These bands are currently fully assigned except the licence –exempt bands that are not subject to licensing.

Freq Band / Lic / Lic Exempt	UK Assignment	Assignment per operator / Licensing status	Equipment Standards	Remarks	Spectrum access opportunity
2 GHz '3G Bands' Lic	1900-1980 / 2110-2170 MHz	5 operators bought a varying amount of spectrum each Licensed	IMT-2000, 3GPP. All operators have chosen ESTI UMTS Harmonised Standard.	Fully mobile service with data rates up to 2Mbps per user anticipated decreasing as speed of mobility increases.	All licences awarded.
2.4 GHz Lic Ex	2.4 – 2.4835GHz	N/A Coexistence enabled through spread spectrum technology/ Exempt for nomadic devices. (T.Act licence reqd for public services) One operator licensed for FWA.	EN 300 328, 802.11b, Bluetooth	Sharing with Industrial and S M devices. Public services allowed but limited power at 100mW eirp[2] restricting range. Broadband "nomadic" devices offering up to 11Mbps.	Free access but proliferation of devices may cause congestion in the future. The technologies include some degree of mitigation against interference.
2.5 GHz '3G Extension Bands' Lic	2500-2670 MHz	Europe (CEPT) to make available by 2008 at latest Licensed	IMT-2000	3GPP / IMT-2000 specifications are planned for this band but it is currently occupied by other services	The organisation of this band is a key issue, under study internationally.
5 GHz Band A Lic Ex	5.15-5.25GHz	N/A Coexistence enabled by air interface.	HIPERLAN, 802.11g/h variants under development. Lic. Exempt for mobile devices. Public services expected later in 2002.	Interim acceptance of 802.11a devices pending DFS and TPC (Transmit Power Control) implementation. Indoor use only. Limited power at 200mW eirp. Sharing through DFS (Dynamic Frequency Selection).	Not an outdoor solution. The whole area of 5GHz regulation is currently under study.
5 GHz Band B Lic Ex	5.47 – 5.725 GHz	N/A Coexistence enabled by air interface.	Lic. Exempt for mobile devices. Public services expected later in 2002.	Limited power at 1W eirp restricting range.	No outdoor restriction.

[2] Compare to eirp of typical FWA Central Station of about 40Watts.

Part 3: Further Frequency Bands under Consideration

Freq Band / Lic / Lic Exempt	UK Assignment	Assignment per operator / Licensing status	Equipment Standards	Remarks	Spectrum access opportunity
5.8 GHz Band C Lic Ex	5. 725-5.875GHz GHz	N/A Coexistence enabled by air interface.	ETSI HIPERMAN under Development. Lic Exempt anticipated	Frequency band yet to be sanctioned and under consideration in ECC for FWA use. Some operators / customers may feel uncomfortable about non-exclusive right to spectrum. Bandwidth good for broadband services. EIRP limitations.	Licence-exempt in the USA, many studies underway internationally.
2.5 GHz '3G Extension Bands' Lic	2500-2670 MHz	Europe (CEPT) to make available by 2008 at latest Licensed	IMT-2000	3GPP / IMT-2000 specifications	
Around 2 GHz Lic "(PWA)"	None at present	5MHz single block per operator. Not yet under consideration.		Portable, wide area, high capacity for direct ADSL wire-line equivalence. All-IP, high spectral efficiency, TDD	Candidates include: - TFTS band pair (say lower) - TDD UMTS slot (one of four) - 2.0 GHz UMTS (one of three) - 2.1 GHz (small part of one of pair)

Part 4: Frequency Bands for UK P-P assignments suitable for access applications

Freq Band Lic/Lic Exempt	UK Assignment	Assignment per operator / Licensing Status	Equipment Standards	Remarks	Spectrum access opportunity
18 GHz Lic	17.7 – 19.7 GHz	Frequency assigned on link-by-link basis. 3.5 – 55 MHz Licensing to commence Q4/03 Current BT exclusive	EN 300 430, EN 301 128	Possible sharing in the future with FSS broadband systems (if developed) Suitable for access links of up to 20Km This range is a crucial advantage for backhaul in grey and red areas.	Frequency assignment by RA via RA8 link application envisaged
23 GHz Lic	22.0-22.6 paired with 23.0-23.6 GHz	Frequency assigned on link-by-link basis. 3.5 – 56 MHz Applications accepted on a link by link basis via the RA	EN 300 198	Band has several 1000s of mobile infrastructure links + several 1000 CW links Suitable for access links of up to 15Km	Frequency assignment by RA via RA8 link application
26 GHz Lic	24.5 – 26.5 GHz	Frequency assigned on link-by-link basis. 3.5 – 56 MHz Applications accepted on a link by link basis via the RA	EN 300 431	Band has low link deployment and is considered as a 23 GHz spill over band Suitable for access links of up to 12Km	Frequency assignment by RA via RA8 link application
32 GHz Lic	31.8 – 33.4 GHz	Frequency to be assigned on link-by-link basis. 3.5 – 56 MHz Licensing to commence Q2/03 in third of band	EN 300 197	New band with 1/3rd allocated for P-P and 2/3rds unallocated awaiting future requirement Suitable for access links of up to 8Km	Frequency assignment by RA via RA8 link application envisaged
38 GHz Lic	37 – 39.5 GHz	Frequency to be assigned on link-by-link basis. 3.5 – 56 MHz Applications accepted on a link by link basis via the RA	EN 300 197	Band has several 1000s of mobile infrastructure links Suitable for access links of up to 5Km	Frequency assignment by RA via RA8 link application

2 Technology Summary

Technology	IEEE 802.11b 11Mbps Wireless LAN
Technical Profile	
Relevant Standard	IEEE 802.11b Ratified December 1999
Spectrum Requirements	2.4GHz, ETSI 11x22Mhz channels, 3 non-overlapping
Effective Range	Bridge-Bridge links can achieve several miles, PC to Access point is around 100m maximum
Effective Throughput	6-7Mbps Maximum (manufacturer dependent)
Antenna Characteristics	Residential antenna typically small (<30cm) patch type. Various antenna types, omni, patch, yagi. Parabolic can all be deployed
Security	802.11b (128 bit WEP) and 802.1X (manufacturer dependent), also manufacturer enhancements such as dynamic keys and EAP types. IPSec VPN's can be overlayed independently.
QoS - Supported Services	No standards based QoS mechanisms in current 802.11 standard. Standards based QoS under IEEE 802.11 TGe due Mid 2003. Typically WLAN last mile has been used to deliver broadband data access only, although significant bandwidth increase over DSL enables greater video capability.
IP Networking Services	
Regulatory Profile	
Spectrum Licence Requirements	No licence required for public or private use
Planning Requirements	Residential antenna in accordance with local regulations (council, residential complex etc)
Max EIRP	100mW
Max Bridge/Coax/Antenna EIRP	+20dBM (ETSI)
Industry Commercial Profile	
Industry Body	Wireless Ethernet Compatibility Alliance www.weca.net Industry alliance set up by manufacturers to provide base level interoperability certification (WiFi compliance). Currently 147 members and over 300 certified WiFi compliant products
Number of Manufacturers	150+
Service Providers	Recent relaxation of UK RA regulations[3] has enabled Service Providers to consider using this technology for commercial services.
User Commercial Profile	
Costs/Packages	Typically the equivalent of £30-40pm depending on bandwidth offered
Install costs inc. CPE	£200-400 (includes WLAN bridge and antenna)
Contention Ratio	Packet burst system – Worst case contention ratio defined max aggregate access bandwidth vs backhaul bandwidth
Summary	
802.11b WLAN has experienced massive growth since standardised. Principally used as a wireless overlay to fixed Local Area Networks within offices and homes to enable flexibility and mobility inside buildings, but also used as a bridging technology to interconnect buildings in a campus. The largest users of the technology are Education, Healthcare and Retail. 802.11b is the wireless networking technology of choice for PC manufacturers. The large installed base in laptops has resulted in the technology also being deployed in 'hotspots' such as	

[3] Refer to SI 2002/1590 for this relaxation in relation to 2.4GHz licence-exempt spectrum

airports, hotels, conference centres in order to deliver connectivity initially to business travellers. Venue operators and Service Providers have recently been allowed to provide commercial 'hotspot' networks (e.g. BT Openzone).

Attempts have also been made in various countries to use the technology for last mile connectivity, however inherent limitations of the technology (e.g. limited number of non-overlapping channels) severely restrict the scalability of any network deployment, hence why no major service provider uses WLAN to deliver last mile connectivity. The technology has however been used in community based networks for backhaul, local distribution and last mile connectivity in low-density urban and remote/rural areas. This is an obvious area of interest for alternative Service Providers given the recent regulatory changes, which now permit commercial network deployment.

Technology	3.5 / 10GHz/ 28 GHz / 40GHz Band Broadband Fixed Wireless Access
Technical Profile	
Network topology	Fixed Point-to-multipoint (P-MP) or multipoint proposals (mesh)
Relevant Standards	EN 301-021/080/124/253/744/213-1 to 5/997(non-interoperable, coexistence stds), ETSI-HIPERMAN, ETSI- HIPERACCESS IEEE 802.16 and 802.16a (interoperable air interface MP stds) ETSI/DVB/JTC EN 300-748, EN 301-199
Spectrum Requirements	Standards allow channel spacings up to 56MHz. Typically 4 channels for reasonable P-MP re-use planning. Broadband systems at 28GHz tend towards 28MHz channels.
Effective Range	3 – 25kms. Non Line of Sight systems proposed at 3.5GHz. Dependant upon availability target.
Effective Throughput	Up to around 3 Mbps per MHz. Per user figure is heavily dependant on traffic profiles and user density.
Max EIRP	Around 15dBW (30-40 Watts)
Antenna Types	Sectorised CS, Directional TS or "mesh" node. EN 301-215
Security	TS are logically 'attached' to CS so are inherently more secure than nomadic solutions which must 'roam' across CS
QoS - Supported Services	Guaranteed and best effort
Regulatory Profile	
UK Spectrum Environment	1 individually licensed paired block totalling 40MHz proposed for the 3.5GHz band on a regional basis. 1 individually licensed paired block totalling 120MHz proposed for the 10GHz band supplementing the already assigned 60MHz block. Individually licensed paired blocks of 224MHz per region at 28GHz. 40GHz band available but technology and commercial development immature so "formal" licensing postponed.
UK Licensing Environment	Auction anticipated for 3.5GHz and new 10GHz Licences. Regional 28GHz Licences awarded by auction. (Ongoing process) At 40GHz WT Act Licences required, but formal process postponed. Commercial trials may be allowed.
European Regulatory Framework	ECC Recommends all three bands (amongst others) for FWA use. National licensing implementations. At 40GHz, ERC Decision identifying use of the band for MWS (Multimedia Wireless Systems). ECC Recommendation on frequency planning considerations for MWS.
Spectrum Licence Opportunity	Licensed channels available for exclusive use.
Planning Requirements	Outdoor antenna in accordance with local regulations (council, residential complex etc)
Industry Commercial Profile	

Industry Body	ETSI BRAN for HIPERACCESS and HIPERMAN. WiMax for 802.16 systems.
Number of Manufacturers	Between 6 and 12. No HIPERACCESS/HIPERMAN/802.16a compliant systems yet. No commercial 40GHz systems – development underway 2-3 players.
	Licence winners / Wireless ISPs, larger Telcos and Local service providers.
User Commercial Profile	
Install costs inc. CPE	Very variable depending on building/ customer type. P-MP Base Stations require substantial locations. Customer radio equipment generally requires on building location.
Summary	
4GHz band is UK specific. 40GHz band use originally seen as an opportunity for Telecoms and Broadcast convergence.	

Technology	5.8GHz Band Fixed Wireless Access (Licence exempt)
Technical Profile	
Network topology	Fixed Point-to-multipoint (P-MP) or multipoint proposals (mesh) Fixed Point to point
Relevant Standards	ETSI-HIPERMAN, IEEE 802.16a (interoperable air interface MP stds under development)
Spectrum Requirements	Standards allow channel spacings up to 20MHz. Typically 6 channels are required for P-MP re-use planning.
Effective Range	Up to 10kms
Effective Throughput	Up to around 3 Mbps per MHz. Per user figure is heavily dependant on traffic profiles and user density.
Max EIRP	Typically +3dBW (2 Watts)
Antenna Types	Sectorised CS, Directional TS or “mesh” node.
Security	TS are logically ‘attached’ to CS so are inherently more secure than nomadic solutions which must ‘roam’ across CS
QoS - Supported Services	Adaptive MAC features enable QoS features
Regulatory Profile	
UK Spectrum Environment	Use of band for licence-exempt FWA under study.
UK Licensing Environment	Licence –exempt proposed with basestation registration to control interference environment.
European Regulatory Framework	Sharing between services under Study within ECC. License exempt FWA is proposed.
Spectrum (Licence) Opportunity	150MHz of shared spectrum. Channel is selected either manually or automatically by CS.
Planning Requirements	Outdoor antenna in accordance with local regulations (council, residential complex etc)
Industry Commercial Profile	
Industry Body	ETSI BRAN for HIPERMAN
Number of Manufacturers	Around 6
Service Providers	Wireless ISPs, Telcos, Local service providers.
User Commercial Profile	
Install costs inc. CPE	Very variable depending on building/ customer type. P-MP Base Stations require substantial locations. Customer radio equipment generally requires on building location.
Summary	

Allows small/ local deployments as spectrum channels are used as required from the available licence exempt band. License exempt UNII Band in the US.

Technology	2 GHz nom. Portable Wireless DSL (PWDSL)
Technical Profile	
Network topology	Point-to-multipoint, SDMA[4], portable; all-IP with direct connectivity through nearest PDSN or tunnel switch.
Relevant Standards	N/A yet. New i-Burst Forum formed to co-ordinate global standardisation strategy. TTA standard planned[5]. IEEE 802.11 and 802.16 will plan new MBWA[6] work, for which PWDSL is a candidate. Also may be candidate for EP-MESA (joint TIA/ETSI)
Spectrum Requirements	Single 5 MHz (TDD) anywhere between 1.5 – 2.5 GHz. AIP[7] uses TDMA, multiple modulations.
Effective Range	1 km dense urban to 15 km rural[8]. Fully exploits LoS; budget incorporates in-building loss[9] so indoor as well as outdoor.
Effective Throughput	20 Mbps now, 40 Mbps in 2004. Per user figure is 1Mbps now, 4 Mbps in 2004. Further evolutionary path planned.
Max. EIRP	18 dBW
Antenna Types	CS: 12 omni, 10 dBi ea. in 'sectored' circular array (integrated) TS: stub omni (integrated)
Security	Session-based AIP encryption & authentication + mobility authentication (in handover) + IPSec + L2TP tunnel authentication. IPv4 & IPv6 addressing support through PPP encapsulation.
QoS - Supported Services, Billing etc.	Full mobility support inc. hand-over to/from IEEE 802.11b. Full DiffServ, Radius, MPLS etc. fully supported. <35 ms latency to high confidence for VoIP.
Regulatory Profile	
UK Spectrum Environment	TBA – there are several suitable candidate bands possible, MS rather than FS service category.
UK Licensing Environment	TBA.
European Regulatory Framework	Two candidate bands are UMTS (TDD), for which no system implementation appears planned. Another is the TFTS bands, usage for which has now been abrogated. Another 2 bands are relatively large, v. limited FWA usage.
Spectrum Licence Opportunity	Licensed 5 MHz for exclusive use, but a consortium / wholesale / utility approach to ownership may be more appropriate.
Planning Requirements	CS: in accordance with local regulations (council, residential complex etc) TS: stub omni integrated within PC card, modem, camera etc.; external directional or higher antenna possible for improved indoor or outdoor use. No installation, alignment as such.
Industry Commercial Profile	
Industry Body	i-Burst Forum initially[10] – see Standards entry above.
Number of Manufacturers	2 Asian OEMs initially; UK and European TBA, esp. for TS

[4] spatial domain multiple access (re-use is sub-unity via AA technology).
[5] Korea.
[6] mobile broadband wireless access.
[7] air interface protocol
[8] per standard 3GPP/2 RF link budget methodology, using standard COST propagation models.
[9] at least as conservatively as 2G/3G cellular mobile at like frequency.
[10] system OEMs, ISPs, content suppliers, infrastructure deployment cos., s/w suppliers, trade bodies, modem manufacturers, semiconductor, camera / PDA / PC etc manufacturers …..

	(modems).
Service Providers	See entry in Spectrum Licence Opportunity above.
User Commercial Profile	
Install costs	TS: none, modems are fully portable. CS: similar installations as 2G/3G cellular mobile, but no complex RAN architecture (see Network Topology entry above)
Comments	
Australia deployment will use UMTS TDD 1.9 GHz (5 MHz). Korea will soon deploy, also likely Russia and USA. All national.	

Technology	Fixed Radio System point-to-point (Access or Backhaul) 6 – 38 GHz
Technical Profile	
Network topology	Fixed point-to-point
Relevant Standard	ETSI EN 301 216, EN 300 234, EN 301 128, EN 300 198, EN 300 431, EN 300 197
Spectrum Requirements	7400 – 7900 MHz, 12.75 – 13.25 GHz, 14.5 – 15.35 GHz, 22 – 23.6 GHz, 24.5 – 26.5 GHz, 37 – 39.5 GHz in 3.5, 7, 14, 28, 56 MHz depending on capacity/modulation and frequency band
Effective Range	Typically between <1Km – 80Km depending on frequency band and path budget
Effective Throughput	2Mbit/s (E1) – n x 155Mbit/s (STM-1)
Antenna Types	Slip fit or remote mount parabolic ranging from 0.18 – 3m depending on frequency band.
Security	Point-to-point communication with radio beam widths of less than 3 degrees. Proprietary air interface.
QoS - Supported Services	QoS guaranteed, P-P links are planned individually to ensure no in-band interference.
Regulatory Profile	
Spectrum Licence Requirements	An Individual frequency assignment is required through a standardised application procedure (RA8) to the RA.
Planning Requirements	Installations in accordance with local regulations (council planning rules)
Max equipment EIRP	1W (equipment design constraint)
Max Bridge/Coax/Antenna EIRP	48dBi (antenna design constraint)
Max system EIRP	55dBw
Industry Commercial Profile	
Industry Body	ETSI TM4 responsible for development of co-existence Standards. No interoperability standards exist, air interface is proprietary.
Number of Manufacturers	6 - 10
Service Providers	>150 includes private and public operation
User Commercial Profile	
Install costs inc. radio equipment	Costs vary according to the capacity. Typical cost range is £11K per link (2Mbit/s) to £50K per link (155Mbit/s)
Summary	

Technology	IMT-2000/DS (UMTS-FDD)
Technical Profile	
Network topology	Mobile cellular broadband
Relevant Standard	M.1457
Spectrum Requirements	Varies; minimum 2x5MHz
Effective Range	Varies; typically 3km in an average deployment for 384Kbps downlink per user.
Effective Throughput	Initially 384kbps peak per downlink user in fully mobile applications and in the near future up to 6Mbps over a restricted range to nomadic terminals. Higher data rates to 10Mbps possible available over full cell area if the user has a suitable terminal and antenna.
Max. EIRP	62 dBm
Antenna Types	Normally embedded in radio access terminal or higher efficiency device mounted on vehicle.
Security	Embedded in radio access network plus overlay i.e. IPSec VPN, User or operator based.
QoS - Supported Services, Billing etc.	QoS implemented in all network layers; Seamless handover between GPRS (green, white, grey, red areas) through IMT/WCDMA (initially green, white, some grey areas) coverage but with full mobility) to WiFi (IEEE802.11x, green, some white areas and hotspots); interoperability with other IMT-2000 services; integrated billing possible; supports voice, HSIA and data in fully mobile applications
Regulatory Profile	
UK Spectrum Environment	1920-1980MHz paired with 2110-2170MHz
UK Licensing Environment	Spectrum licensing process completed; national licenses required for mobile operators
European Regulatory Framework	UMTS deployment pursuant to UMTS Decision and other EU rules and regulations
Planning Requirements	CS: in accordance with local regulations (council, residential complex etc) TS: PC cards (initially) and special UMTS devices. No installation, alignment as such.
Industry Commercial Profile	
Industry Body	3GPP; UMTS Forum
Number of Manufacturers	Competitive environment—approximately 10 manufacturers of infrastructure
Service Providers	5 currently licensed
User Commercial Profile	
Install costs	TS: none beyond acquisition (300-600GBP for devices/ >180GBP for PC cards), PC cards and devices are fully portable. CS: Reflect significant capital expenditure
Typical Tariffs	None formally available; but expected initially to reflect a high-value mobile product in the range of 55-85 GBP/month. Only service in Italy priced at 85Euro/month (w/o device) or 140Euro/month (w/device)
Residential and SME	Targeted at all sectors, initial market for broadband data is expected to be business market; access devices likely to be PDAs and laptop computers in first instance
Comments	
UMTS is part of a family of wireless technologies that were developed to provide high data	

throughput, operator-class *mobile* broadband connectivity to a broad range of users. UMTS offers a wide and range of characteristics and features including: mobility, high speed/data throughputs, security, and convenience. It complements other broadband access networks.

Plug-in UMTS modem cards may initially provide mobile workers' current generation laptops and PDAs with secure wireless data connectivity to existing applications running over their office intranets. Re-use of existing end-user devices to access readily available office applications means that adoption of mobile services need not be delayed by lack of availability of UMTS handsets or special purpose applications.

In the longer term, as UMTS handsets become commercially available and consumer-centric mobile multimedia services are launched, adoption by the mass market will begin, complementing the fixed broadband services available in homes across the UK.