BridgeWave
COMMUNICATIONS

Gigabit Ethernet Wireless Links

Response to Public Consultation on the bands 60, 70 and 80 GHz

Revision 1.2
Dated February 12, 2010

Purpose

This document provides the BridgeWave Communications Incorporated (hereafter known as BridgeWave) response to the ARCEP Public Consultation on the bands 60, 70 and 80 GHz. BridgeWave would like to thank ARCEP for the opportunity to respond.

Founded in 1999, BridgeWave Communications, Inc. is the leading supplier of wireless gigabit connectivity solutions. BridgeWave's point-to-point wireless bridges are widely deployed in mainstream enterprise and service provider network applications and are poised to play a key role in the migration to 4G mobile network backhaul.

Utilizing the upper millimetric radio spectrum in the 60-90 GHz range, the company's exclusive AdaptRate technology and Forward Error Correction capabilities deliver the highest availability at the longest distances for full-rate GigE connections. BridgeWave's solutions provide fibre-comparable performance without the delay and cost associated with leased-lines.

BridgeWave is a U.S.-based company headquartered in Santa Clara, California, and a growing UK based team focused on the International market, especially within the EU. The company has strong global presence with over 5,000 radios deployed in more than 30 countries. BridgeWave has a network of experienced distributors and resellers worldwide, making it today's primary vendor of high capacity, high frequency solutions. For more information, visit www.bridgewave.com.

Response.

The consultation was provided only in French, however ARCEP confirmed that responses could be offered in English. An approximate English translation of each question is shown below, along with BridgeWave’s response. In the event of any queries, or clarifications being required, please contact steve.odell@bridgewave.com

Q1 Does Making the European recommendations mandatory seem overly stringent, or useful to the development of applications in these frequency bands?

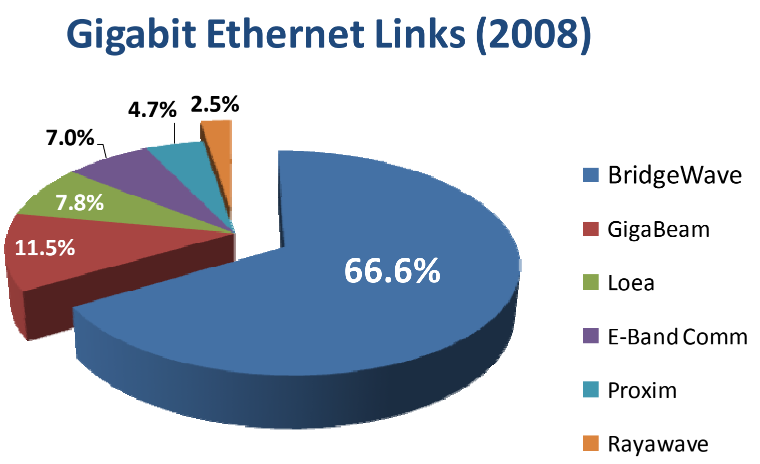
BridgeWave believe that fully implementing ECC REC (05)07 in the 80GHz band is warranted. The 80GHz band is likely to be utilized extensively by LTE and WiMax operators, and as such band utilization could be very high.

In the 60GHz band ERC REC(09)01, is actually very non specific. There are no fixed duplex frequencies, any multiple of 50MHz channels can be allocated (with no prescribed maximum) and BridgeWave believe that the mandatory utilization of ECC

REC (09)01 would not be problematic, dependent on any supplementary licensing rules defined by ARCEP.

Whilst the question mentioned only recommendations, BridgeWave would also like to state that it believes compliance to the essential requirements of EN 302 217-3 to be mandatory. BridgeWave would like to point out however that the essential requirements do NOT include a suite of receiver parameters, as the band is intended for "light licensed" approach, and that if ARCEP adopt a fully licensed approach, it may need to mandate the non essential parameters as well. In doing so, this may preclude many existing vendors, and whilst BridgeWave support this, it may severely limit the amount of equipment available for deployment in France.

Q2. Has your company undertaken projects for the supply or use of equipment or point-to-point fixed services in bands above 39.5 GHz, and more particularly in the sub-bands of this consultation?
Yes, BridgeWave are the market leaders in the supply of 57-64GHz and 71-76/81-86Ghz equipments worldwide, and have supplied in excess of 5,000 radio's to both carriers, and enterprise users since 2005. A review of the EJL Wireless Research Report released September 2009 which reviews worldwide 2008 data for true Gigabit Ethernet links shows:-



It can be seen from this that BridgeWave have unparalleled experience in these markets, industry leading products, and a clear view of the market direction, which we are very happy to share with ARCEP

Q2bis. If yes, please specify your project:

- sub-band or sub-bands targeted

BridgeWave supply equipment in both the 57-64GHz and 71-76/81-86Ghz bands, as these have quite different characteristics, costs and applications.

- frequency need (amount, bandwidth etc)

Generally the ETSI standards and ECC Recommendations recognize the fact that in these ultra high frequencies, there is significantly more bandwidth available, and this when coupled with the highly directional antenna patterns, and excellent frequency reuse characteristics, mean that simple and robust modulation schemes can be used. Typically most vendors offer 2 level modulation, and BridgeWave have recently released a 4 level system in the 80Ghz band. Generally we anticipate that 16 level systems may become prevalent, however to maintain adequate distances for LTE/WiMAX cell radii, it is considered unlikely that in the short term, links in these bands will exceed this.

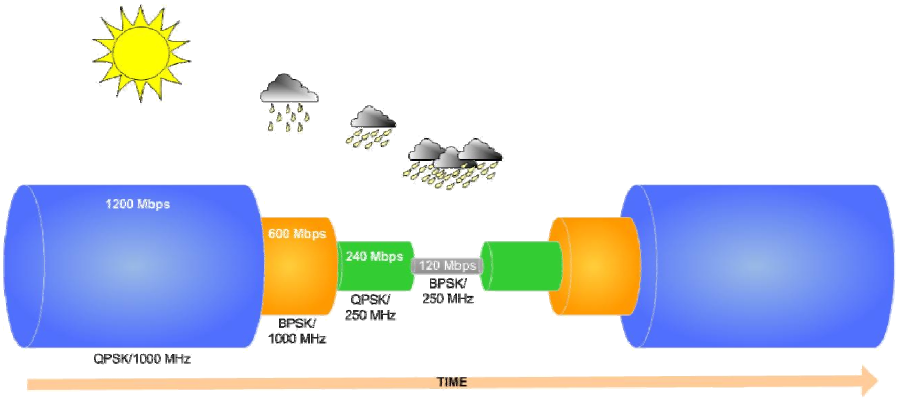
BridgeWave offer two ranges of product, the first which operates in the 60/80Ghz ranges, utilizes 2 level modulation only, and occupies 1400MHz of bandwidth for 1Gb/s full duplex transmission, or 140MHz bandwidth for 100MB/s full duplex Transmission. These products (along with every other vendors FDD products currently available) operate on a single FDD pair.

BridgeWave's recently released FlexPort platform, which currently only operates in the 80Ghz band, brings several new innovations to the market, two of which are particularly relevant here.

The first of these is that the system offers the option of Adaptive Rate and Modulation (ARM), switching between BPSK and QPSK, and two bandwidth settings. The occupied bandwidths can be seen below.

Data Rate [Mbps]	Modulation	Occupied BW [MHz]	Number of 250MHz Channel used	Available channels (No overlap)	Available channels (With overlap)
120	BPSK	193.2	1	19	19
240	QPSK	193.2	1	19	19
600	BPSK	966	4	4	16
1,200	QPSK	966	4	4	16

This switching allows greater link distances to be achieved for a target percentage availability, in cases where customers can tolerate lower throughout during rain fades, with typical operation being in the following form.



The second essential feature for regulators such as ARCEP who are planning a fully coordinated approach to the band is frequency selection. As previously stated, all first generation 60/80GHz links operate on a single duplex pair, with no way of altering the frequency. This relies entirely on the bands spectral reuse characteristics to ensure no interference to other links. FlexPort follows a more traditional format as seen in the bands below 39.5GHz and can be electronically set to any 250MHz centre within the entire band 71-76/81-86GHz.

-the target market (Target commercial, private testing laboratory etc)

The key target markets are Enterprise, as well as Fixed Operator & Mobile Operators

To date most civil deployments of 60/80GHz equipments have been to Enterprise customers wanting to reduce their ongoing OPEX by replacing existing fibre circuits, or for those requiring a back up to fibre, and this market is expected to flourish. 60GHz in particular is often considered as a more reliable replacement for Free Space Optics technology. It is ideally suited for short distance applications, as is is considerably less affected by airborne particulates. One of its major advantages to many customers is that in many countries, it is license exempt, and can therefore be deployed rapidly.

More recently there is considerable interest in the 80GHz band for deployment within LTE and WiMax networks, as well as fibre replacement in many smaller networks. This is expected to be the target market with the highest volume of deployments over the next few years.

- What Hop length and availability can be associated with each band

Typically for such high capacity, mission critical applications, links are designed based upon an error threshold of $1E^{-12}$ errors, rather than the more usual $1E^{-6}$ or $1E^{-8,}$ and to a minimum of 99.99% availability, more usually 99.995% or 99.999%,

A table showing three different cities in France chosen to demonstrate a variety of precipitation levels, and the expected maximum link distance in metres for availabilities of 99.99%, 99.995% & 99.999%, is shown below.

Paris	**99.99%**	**99.995%**	**99.999%**
60GHz 1ft Antenna 1Gb/s (GE60)	855	785	630
60GHz 2ft Antenna 1Gb/s (AR60X)	1185	1080	850
80GHz 1ft Antenna 1200Mb/s (FP80)	2055	1685	1120
80GHz 2ft Antenna 1200Mb/s (FP80X)	2980	2395	1535
Lyon			
60GHz 1ft Antenna 1Gb/s (GE60)	820	750	595
60GHz 2ft Antenna 1Gb/s (AR60X)	1135	1025	800
80GHz 1ft Antenna 1200Mb/s (FP80)	1885	1540	1020
80GHz 2ft Antenna 1200Mb/s (FP80X)	2710	2175	1390
Marseilles			
60GHz 1ft Antenna 1Gb/s (GE60)	795	720	570
60GHz 2ft Antenna 1Gb/s (AR60X)	1095	985	760
80GHz 1ft Antenna 1200Mb/s (FP80)	1760	1440	950
80GHz 2ft Antenna 1200Mb/s (FP80X)	2525	2020	1290

-the geographic area (rural, cities, industrial zones etc)

Typical “Enterprise” deployments are likely to be in cities and industrial zones. Given the propagation characteristics of both bands, rural deployments are considered to be less dense, however there are likely to be opportunities for campus network interconnects, as well as last mile fibre extension to rural communities. Carrier deployments are likely to be widespread

-schedule within which your project is mapped

BridgeWave have a full portfolio of products already available, and in fact all of the 80GHz products have already been notified under the R&TTE regulations, in the hope that the Public consultation will lead to a rapid decision on these bands.

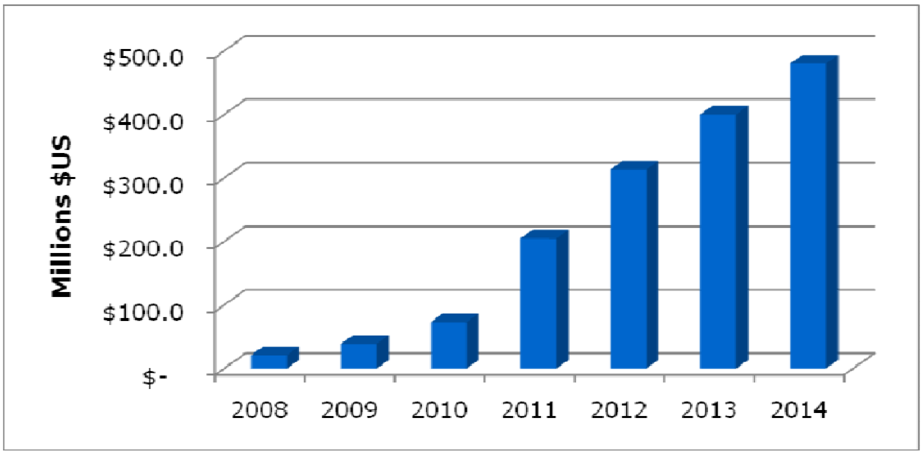
BridgeWave have been approached on many occasions by French companies wishing to deploy Gigabit radio systems over the last 2 years, and unfortunately we have to date had to turn down these opportunities, and explain that ARCEP have not yet made the bands available. It's clear to us that there is already a large market opportunity for such systems, and we urge ARCEP to release spectrum, as soon as possible.

Q3. The minimum width of a channel in the proposed plan CEPT is 250 MHz. How much minimum spectral occupancy do you assign to each user?
The above statement is true in the 80GHz band. In the 60GHz band however the minimum is 50MHz.

FlexPort 80 can occupy a single 250MHz channel, however this only yields approximately 240Mb/s of full duplex throughput. Four 250MHz channels can be combined, providing 1200Mb/s full duplex throughput. Realistically the increased cost of 80GHz systems means that unless a customer needs in excess of 310Mb/s the cost model will not be clear cut, and 60/80GHz systems really come into their own at Gb/s capacities, where they have no realistic radio alternative. FlexPort also has a built in switch, so for instance a service provider could have a 1200Mb/s link, serving several customers simultaneously, which allows sharing of spectrum.

The enterprise products require 1400MHz bandwidth for 1Gb/s FD throughput, or 140MHz for 100Mb/s FD throughput.

Q4. What are your long term needs in the use of these bands?
As a supplier, this question is not directly relevant to BridgeWave. We would comment however that the worldwide requirement for ultra high capacity 60/80GHz systems is growing very fast, as can be seen from the graph below.



60/80 GHz GigE - UHFUHC* market, 69% CAGR
* Ultra High Frequency Ultra High Capacity *Data from Visant Strategies (5/09)*

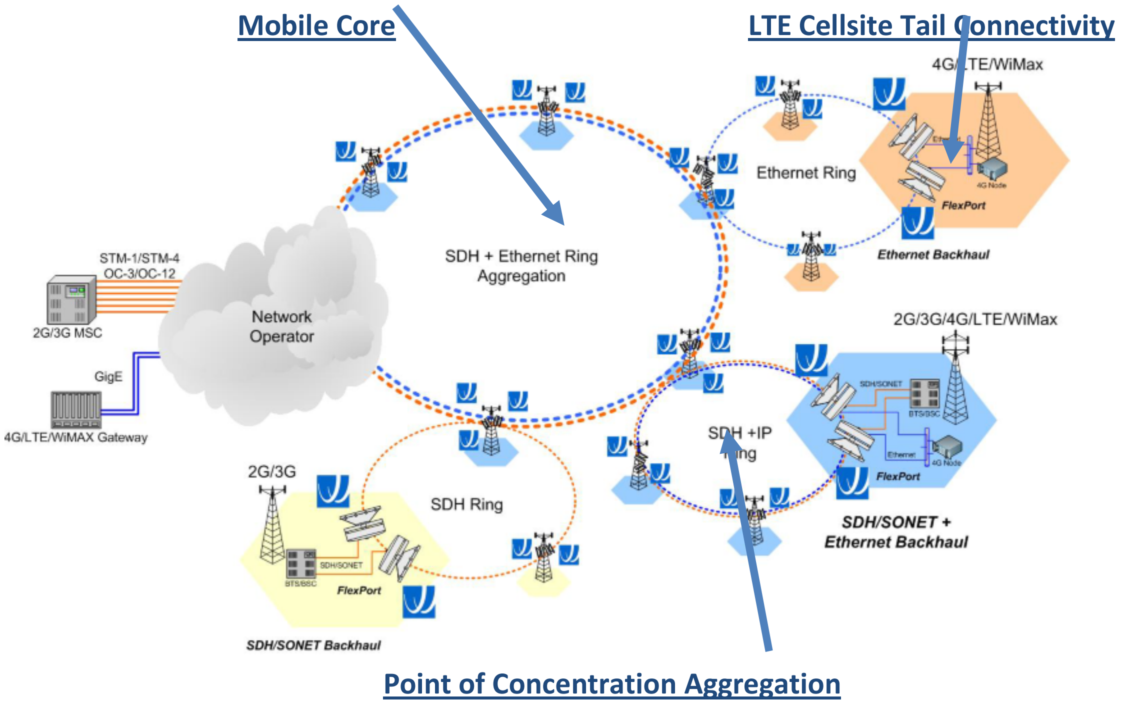
BridgeWave and our partners are in discussion with several French operators, as well as countless Enterprise users, and could already have deployed 10’s if not 100’s of links within France, had the 80Ghz band been available. LTE trials in particular are starting worldwide, and 80GHz technology in particular is being included in most of not all carrier RFP’s and tenders so we consider it paramount to have spectrum available as soon as possible, certainly within 2010, if France is to remain at the forefront of technological development.

Q5. Specify for each band: -possible applications

Given that ARCEP’s current proposal is to have both bands managed on a frequency coordinated basis, rather than the simplified coordination (80GHz) or simplified /uncoordinated (60GHz) approach envisaged by ETSI/CEPT, BridgeWave anticipate that the applications in both bands will be essentially the same, with distance and cost defining the choice of band for individual users. Typical applications may include:-

Cellular Networks

Applications in cellular networks are many and varied, and in dense metropolitan area’s both the ever expanding throughput requirements, and the scarcity of multiple 28MHz channels of 23-52GHz systems means that operators are keen to identify new bands and technologies. This is predicted to be the largest usage of Millimetric radios over the next few years, with applications in the mobile core, as well as LTE Cellsite tail connectivity, and aggregation points, especially where 2/3G services are collocated with LTE .



DSL Backhaul

As DSL speeds increase & Operator deploys VDSL, a requirement is arising to provide high capacity backhaul of the DSL traffic. Some of the challenges and issues being faced by operators include:-

- Facilities may be in less centralised locations with limited fibre infrastructure.
- High capacity required (> 500 Mbps) which are not readily supported by existing radio systems, due to limited spectral availability..
- Existing copper solutions do not scale to the capacities required.

Deploying a Millimetric system in this application means that rollouts are not delayed for months on end awaiting the civil works required to deploy fibre, and bring numerous additional benefits, such as:-

- Comprehensive QOS capabilities provide for prioritization of voice, video, data traffic to meet end user expectations or SLAs.
- Low latency ensures rapid system response & support for video services.
- Leverage SNMP capabilities for management, troubleshooting, loopback capabilities.
- Immediate ability to provide 1.2 Gbps, with 2.4 Gbps systems predicted to be available at the end of 2010).

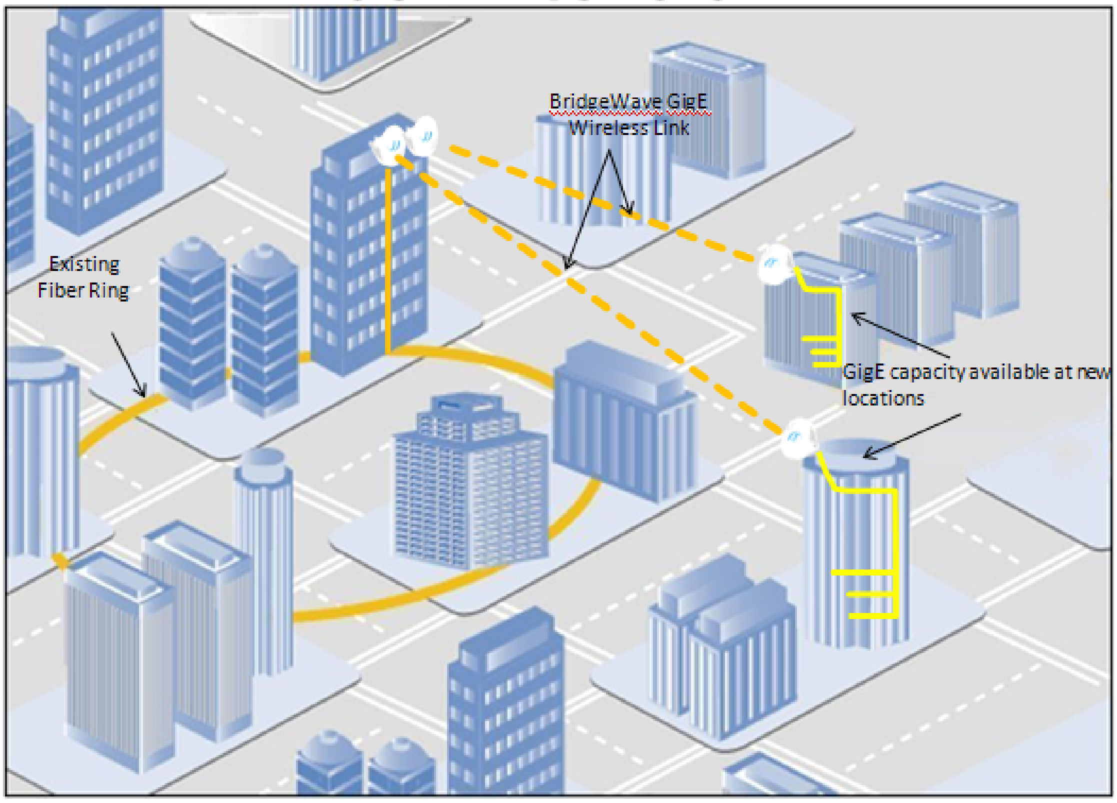
Fibre Extension

Typically these are applications where an Operator has fibre facilities to some buildings in a metropolitan area but need to fill in coverage gaps. Some of the challenges and issues being faced by operators include:-

- Fibre is deployed to some buildings within a given region.
- High capacity services required for corporate customers who are not covered by existing fibre connections.
- Fibre deployments to gain coverage to additional premises can be costly, prone to delays or sometimes simply not available due to planning requirements.

Deploying a Millimetric system in this application means that rollouts are not delayed for months on end awaiting the civil works required to deploy fibre, and bring numerous additional benefits, such as:-

- VLAN QOS support ensures ability to meet different customer SLAs.
- GigE+ throughput for point-to-point connectivity.
- AdaptPath feature allows for path diversity.
- 1+1 configurations provide for enhanced system reliability.
- Port trunking for efficient aggregation of multiple customer services.



Fibre Redundancy or replacement

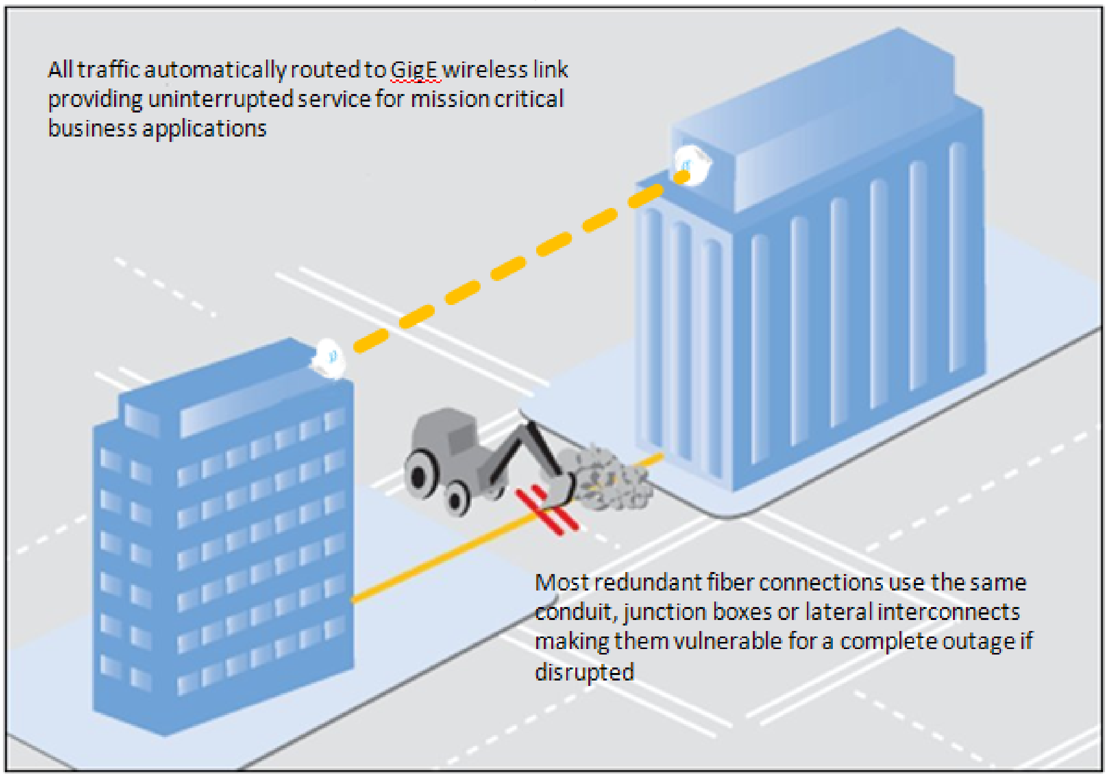
These are two similar applications where an Operator or end user has a single fibre connection but either the mission criticality of their application requires geographic diversity, or they wish to reduce Opex and reduce downtime by owning and managing their own connection. Some of the challenges and issues being faced include:-

- Alternate paths between facilities not available.
- Application requirements include geographic redundancy.
- Costs of leasing fibre becoming prohibitive

Deploying a Millimetric system in this application allows:-

- GigE+ & SDH throughput for point-to-point connectivity.

- All-ODU platform allows for low footprint backup system.
- Integrated switching capability allows for easy integration into customers network.
- VLAN QOS support ensures ability to meet different customer SLAs.
- Leverage SNMP capabilities for management, troubleshooting, loopback capabilities.
- Immediate ability to provide 1.2 Gbps, with 2.4 Gbps systems predicted to be available at the end of 2010).



-the types of equipment and antennas and their main technical characteristics (gain, power antenna, speed, modulation type, ...) considered

Performance of FlexPort 80GHz radio

Data Rate	B/W	Mod	Tx Power	Rx Sens 1E-12
120 Mbps	250 MHz	BPSK	+18 dBm	-73 dBm
240 Mbps	250 MHz	QPSK	+18 dBm	-70 dBm
600 Mbps	1000 MHz	BPSK	+18 dBm	-66 dBm
1200 Mbps	1000 MHz	QPSK	+18 dBm	-63 dBm

Antenna Size	Gain (Low/Mid/High)	XPD	3dB BW	F/B Ratio
30cm	43/43.8/44.6 dBi	30 dB	0.9°	64 dB
60cm	50/50.8/51.6 dBi	30 dB	0.4°	66 dB

Performance of Adaptive Rate 60GHz radio

Data Rate	B/W	Mod	Tx Power	Rx Sens 1E-12
100 Mbps	140MHz	BFSK	+10 dBm	-71 dBm
1000 Mbps	1400 MHz	BFSK	+10 dBm	-60 dBm

Antenna Size	Gain (Low/Mid/High)	XPD	3dB BW	F/B Ratio
30cm	41/42/43 dBi	30 dB	1.2°	64 dB
60cm	46.5/47.5/48.3 dBi	30 dB	0.6°	67 dB

For comprehensive datasheets on all BridgeWave products, please visit http://www.bridgewave.com/solutions/datasheets.cfm

-supplier

As the market leading supplier worldwide for both 60GHz and 80GHz equipments, BridgeWave hope to be considered for any ongoing projects.

Q6. What do you think of maturity of equipments in these bands?

Gb/s Equipment has been available in the 60GHz band for at least 5 years, and in the 80GHz band for at least 3 years from several different vendors. BridgeWave alone have over 5,000 radios deployed in the field, and have extensive field MTBF data. There are now systems available with electronic frequency selection, ATPC, and there are no reasons that we are aware of that would delay a decision on opening these bands.

Q7. What type of duplexing you think that the most appropriate (eg mode FDD duplex 70 / 80 GHz)

The most commonly used 70/80 GHz band products today are based on split-band designs; these products use the 71-76 GHz band to transmit in one direction, while transmitting in the 81-86 GHz band in the opposite direction. Five of the seven worldwide original equipment manufacturers use split-band designs and these products accounts for over 80% of the worldwide deployments to date (based on data from EJL Wireless Research). To preclude split band operation would severely compromise ARCEP's opportunity to implement Gb/s transmission systems cost effectively.

Split-band FDD systems can utilize the entire 70/80 GHz spectrum allocation with a single hardware design. These split-band products employ diplex filters with a 10 GHz Tx/Rx separation, with the unused spectrum between 76-81 GHz providing the separation between the transmit and receive channel ranges that is required by the diplex filter. Single-band FDD systems must leave a sizeable unused guard-band at the centre of each sub-band (around 73.5 GHz and 83.5 GHz), in order to permit a given single-band design to tune the complete frequency range within a sub-band. In order to avoid wasting the centre spectrum in each sub-band, multiple single-band hardware models are required, each utilizing a different diplex filter. Of course, single-band products must already have different versions for the 71-76 GHz sub-band versus the 81-86 GHz sub-band, so it is likely that at least four different hardware versions must be created in order to efficiently use the entire 70/80 GHz allocation. With a split-band design, the entire allocation can be covered with a single hardware model. Having a single hardware model is a significant benefit to the users of these links, since they need only stock a single version of the product. This allows users to carry smaller inventories, while providing better field sparing capabilities; this is especially important for network operators who utilize many links in their networks and need to maintain multiple sparing stocks throughout their service area.

For a given channel size, split-band designs offer twice the maximum data capacity, since a single link can utilize both sub-bands. Today, one gigabit per second is the mainstream data rate for links using this spectrum, however over the next several years, up to ten gigabits per second will become routinely used for private LAN services and core network applications. Single-band FDD designs will be forced to utilize high-order modulation (32- or 64-QAM) to reach ten gigabits per second within a single sub-band, which will result in a reduction in the maximum number of links that can be deployed within a given area; the reduction in maximum link deployment density due to the use of high-order modulation is discussed below.

A working assumption is that spectrum policy should strive to offer the full set of users the highest *aggregate* number of "megabits per second per square kilometre" in a given area. The issue with using high-order modulation is that as the modulation index increases (above QPSK), the required distance separation between links (to prevent interference between them) increases faster than the data capacity increases. Using higher-order modulation, a single link can carry more data in a given RF channel, however many fewer total links (using that same channel) can be deployed before hitting RF interference limits. This reduced spectrum re-use effect becomes increasingly severe as modulation index increases, and favours the use of lower-order modulation.

In the 60GHz band, there is no specified duplex specified in ECC REC(09)01, and BridgeWave believe that a flexible FDD based system be allowed, in order to best fit in with the varying channel plans in each individual administration, given the constraints of pre existing uses of parts of the band such as 57-59GHz 63-64GHz). If a particular duplex is defined in the overall 57-64Ghz band, then manufacturers may need to develop country specific equipment, and without a clearly defined market opportunity this is unlikely to happen.

Q8. Do these allocation schemes seem adapted to the market needs?
ARCEP's current proposal is to have both bands managed on a fully frequency coordinated basis, rather than the simplified coordination (80GHz) or simplified /uncoordinated (60GHz) approach envisaged by ETSI/CEPT. BridgeWave would ask ARCEP to reinvestigate the possibility of reducing the amount of coordinate required (especially in the 60GHz band) and if this proves possible, then reflecting this in the band charges. Any decisions on licensing costs need to consider the following points.

An alternative to full frequency coordination could be a small number of geographical exclusion zones around for instance military locations , or radio telescopes to mitigate against any potential interference, and a light licensed approach.

Even if full frequency coordination is adopted, the bands are largely empty at present, and 60GHz in particular has very short range due to the oxygen absorption figures. Consequently the number of interference calculations required are low. Therefore the initial charging could be lower, and ramped up later as the band becomes more highly utilized.

The current license fee algorithm has been developed based around the 7-42GHz bands, where 128/256QAM systems offer ≥155/310Mb throughput in 28MHz. Spectrum is relatively scarce in these bands, and the propagation characteristics are such that complex modulation schemes are the norm. This is not however true in the 80GHz band, where there is 10GHz of spectrum available or 60Ghz band where there is 7-9GHz of spectrum available. This has shared allocations to fixed service, and 2/4 level modulation are the only realistic way of delivering the link distances required for even 4G (LTE) cellular interconnection, which is assumed to be the highest user of fixed link radio spectrum over the next few years.

As an example, using ARCEP's license fee simulator obtained at the following link http://www.arcep.fr/index.php?id=8082#8082 a 2.5Km Bi directional 80GHz link occupying 1000Mhz with 4 level modulation, and offering full duplex 1200MB/s throughput would cost €1892. This is based upon BridgeWave's state of the art FlexPort system. It should be noted that most 80GHz systems are only 2 level modulation, and would therefore occupy circa 1500MHz for 1Gb/s. In comparison the same link, in the 23GHz band at 256QAM, which would deliver up to approximately 400Mb/s is only €427. Deploying two links in parallel in ACCP or CCDP would cost only €854. Given that both systems offer state of the art performance in their own bands, the cost differential seems inequitable. This situation is even less equitable in the 60B band where the same link would cost €6361, meaning that usage of this band would be very unlikely to be adopted at all.

The algorithm currently proposed places a great emphasis on occupied bandwidth, but little on the expected bandwidths for these bands. BridgeWave strongly recommend that this be reconsidered in light of the intended usage of this band, and modified to at least provide parity with the 7-42GHz bands in terms of cost vs throughput.