Executive Summary

1. Introduction

This document reports the discussion and findings of the ICT Infrastructure Adaptation to Climate Change Workshop held at the IET on 6th July 2010. The event was chaired by Prof. Will Stewart.

The workshop process was organised around the five key questions raised in the briefing document (Appendix 1), commencing with a brainstorming session around the primary concerns and issues before considering options and choices.

2. Issues and Operational Challenges Arising from Climate Change

Following a brief presentation on the climate change implications for telephony (Appendix 2), a round-table discussion identified and considered a variety of issues.

2.1: Fast acting, direct issues

Fast acting direct issues such as extreme weather events (storms, rainfall, floods) may have an impact on one or more of the 6000+ local telephone exchanges and myriad overhead cables and antennae. A particular concern is the effect of storm force winds on telephone poles (already an issue in exposed areas) and it was suggested that there may be an increasing vulnerability of the frequency of historically 1 in 150 year events increases. Wind loading on satellite earth stations was also considered a risk area together with the possible impact of ice storms. Flooding may impact on the ability to sustain broadcasting due to loss of energy supply, and mobile networks are similarly vulnerable having only 1 hour battery back up. The effects of precipitation on transmission capability and mobile backhaul could lead to an increase in service outages.

The resilience of non-BT exchanges, data-centres and other key installations was not fully understood and these are subject to the same risks. BT Exchanges are protected against power outages having both emergency generators and batteries – and have fire, flood and gas detectors in addition to lightning conductors. Such protection is regarded as a necessity for commercial reasons, and it is likely (although not certain) that other ICT operators have similar protection in place.

Although beyond human control and arguably beyond the scope of this workshop, solar storms and other sources of extreme radiation have a potential impact on satellite communications, including those for GPS – a system which is increasingly relied upon in both the transport and other sectors. It was recognised that protection and shielding of such devices would have a substantial lifetime cost.

Finally, there is an inter-dependence of ICT on and with other elements of the infrastructure, and weather events directly affecting these other elements may have consequences for ICT.

2.2: Slow acting direct issues

There were a number of potential effects of climate change that may have longer term, less immediate impacts on the ICT infrastructure. These particularly include effects on cables, transmission devices and transmission capability.

There could be ground heave effects, particularly on buried cables and ducting although this could also affect buildings and towers, and that there may be impacts from rising or falling ground water and/or rising sea levels in particular geographic locations. Similarly, changes in wind speed or direction could have implications for both the launching and stability of high altitude communications platforms. Mobile wireless communications could be disrupted by changes in vegetation levels and density and by changes in building design, for example the use of silvered windows.

In terms of building design, there may be a modest amelioration from the use of ‘free air cooling’ (as is used in parts of the Middle East) and through building density. BT exchanges are already designed to utilise free air cooling and are able to function at 30°C, although the precise upper limit of functioning is not known.

Large buildings generally are considered to have unknown resilience. There is no single view of their operations and the inflow/outflow of data and whilst each individual business within a multi-occupied building may have taken a view on its own business continuity arrangements, it is unlikely that a view has been taken of the whole building and its interdependencies. Such a view should be useful both to the organisations themselves and to the ‘first-responder’ community.

Humidity was seen as a particular challenge, increasing tropospheric scintillation and interference. It is recognised that this effect can be modelled and there is a need to determine whether the effect can be mitigated.

It may also be the case that some organisations may be providing services of a critical nature to maintenance of community and that their vulnerabilities and importance are not understood.

Whilst outside the scope of human control the impact of solar storms on radio based communications was considered important.

A stronger concern was the recognition that as the availability and reliability of telecommunications equipment increases, the skills available to manage, support and repair them are in decline. The working environment for engineers may become increasingly difficult as extreme weather events are also likely to be the cause of increasing numbers of call outs, i.e. the reliability of the systems is such that at the few times an engineer is needed it may not be possible to reach the fault location and/or the working conditions may be hazardous or impossible.

2.3 Interdependencies

The dominant interdependency identified is the absolute reliance of ICT on the continuing availability of electricity. This will become a more complex issue with the development of smart metering and smart power networks within the energy sector, which are reliant on ICT to function adequately.

Mobile and fixed network distribution and exchange points are believed to only have one hour battery back up in the event of main supply power loss.

Extreme rain events, flood and flash flood will have an impact on the capability of antennae to operate, and the forecast from UKCP09 that rain density and size of raindrops will increase may cause attenuation of mobile signals. Changes in flood patterns may have an impact on population locations – although this is a relatively long term effect. Should the population relocate from coastal areas to higher ground there will be a need to relocate or extend the ICT infrastructure in those locations. Forecasts of population growth and location will be important to this issue.

The panel also raised the question of the impact of changes in ocean levels and behaviour on undersea cables, particularly where they emerge onto land.

Overall the panel suggest that loss of power supply is likely to be more of a cause of failure than the ICT networks themselves.

Extreme weather events can hamper communication about the event itself, reducing the ability of the responders to deal with events as they unfold. Resilience and continued operation of the communications networks are then vital to both real-time management and to continued business as usual.

2.4: Diversity and Resilience

This as a significant area of concern with the change from copper wire to fibre optic infrastructure and the impact of indirect reliability issues. There may be network instabilities beyond the ‘official’ critical infrastructure and that the commercial imperative for efficiency may drive down the level of diversity in the overall system.

Diversity and resilience may already be declining due to reductions in the number of networks and exchanges and that with fewer major sites there may be more dispersal of signals – rendering them more vulnerable to local outages. Diversity declines the closer one gets to the end user of the system and that the absolute level of diversity may not be well comprehended.

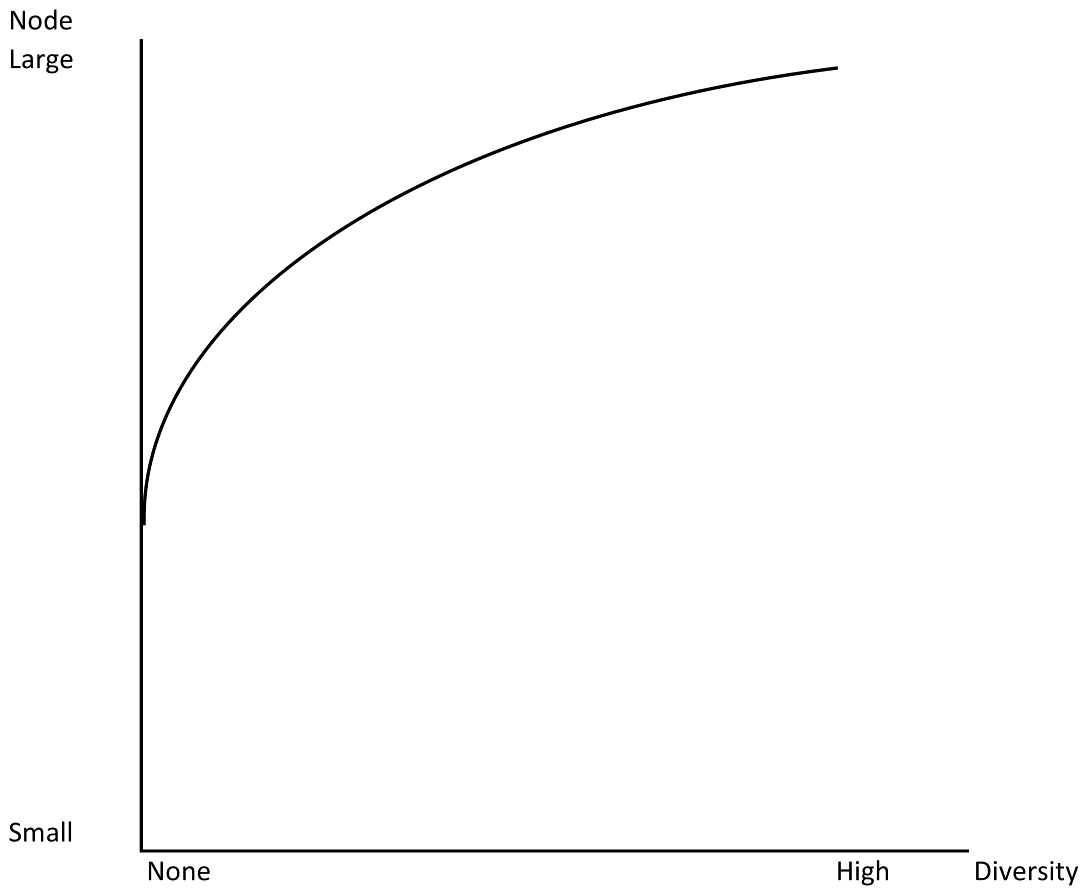
The location of elements of the infrastructure such as. shared conduits and drains may also be an issue in this regard. The following graph and table provide an insight to the impact of diversity by failure node.

Services Affected and Impact			Customers Affected	Fixed Failure Node	Scope for Diversity
Telephony	Internet	Private	Indicative Volumes		
Congestion	Congestion	Partial	millions	Oceanic Cable	Automatic High
Congestion	Congestion	Partial	millions	Satellite Link	Automatic High
Congestion	Congestion	Partial	millions	International Exch	Automatic High
Congestion	Congestion	Partial	millions	Trunk Transmission	Automatic High
Congestion	Congestion	Partial	400k	Trunk Exchange	Automatic High
Total	Total	Partial	40k	Large Exchange	Automatic Medium
Total	Total	Partial	10k	Medium Exchange	Manual Low
Total	Total	Total	2k	Small Exchange	None
Total	Total	Total	600	Street Cabinet	None
Total	Total	Total	100	Access Cables	None
Total	Total	Total	1	Single Feed	None

Impact Consequences:

Congestion	Reduced availablity, degraded QoS, slow internet response times
Partial	Loss of private services some of which will be mitigated by contractual diversity
Total	Complete loss of all services

Illustrative Graph of Scope for Diversity by Failure Node



2.5: Globalisation

The panel briefly considered the resilience of the whole world infrastructure. Little specific was recorded, but it was noted that whilst global networks create the capacity for dynamic re-routing of telecommunications this may well not deliver benefits at the local level.

It is certainly the case that this aspect needs to be more fully understood and the benefits, risks, opportunities and drawbacks of the global architecture must be addressed.

2.6: The Nation and the Suppliers

With an essentially privately owned ICT infrastructure the panel recognised that the resilience of the system is predominantly driven by the commercial imperative to maintain service – only an operating system generates revenue.

To achieve a level of infrastructure resilience which goes beyond the commercial service level agreements imparts a cost to the provider which will not be recoverable from the consumer. The question of 'who pays for non-commercial resilience' then becomes prime. It will be necessary to provide hard, quantified evidence of the commercial implications of climate change in order to engage corporate boards and gain their buy in to the solution.

The commercial model also tends towards a reactive rather than proactive stance – providers wait for a problem or challenge to emerge before addressing it. However, many organisations and consumers are increasingly aware of the need for contingency planning to meet exceptional events.

2.7: Trends in the next 100 years

It was recognised that this aspect cannot be dealt with as an exact science, however, a number of themes were considered likely.

There is likely to be increasing use of wireless transmission, coupled to the replacement of copper wire with fibre optic cables where physical infrastructure is required. This may facilitate smaller cells and a more decentralised system. Overall though the system is likely to become more complex and more comprehensively networked – and become increasingly hard to diagnose and repair in the event of local failure – although dynamic rerouting may compensate for this at some level.

Physical resources such as rare earth metals, which are essential components in much ICT equipment, are expected become increasingly scarce, which may constrain the development and deployment of solutions.

If there is a trend towards increased homeworking then the dependency on ICT will shift from corporate systems to domestic systems and local supply. Whilst potentially having high resilience (no single points of failure at a network level), continuous individual connectivity will be a prime concern. Homeworking may also increase load on local infrastructure (exchanges, distribution boxes, wireless cells) which may need to have increased capacity and resilience – and may even need systems of prioritisation for corporate over personal data and voice traffic.

3. Adaptation Options to Meet Issues and Challenges

Nothing in the range of climate conditions anticipated in UKCP09 falls outside the range of conditions already existing in other countries around the world, where existing equipment is known to function normally. From a technical perspective both network and end-user devices can be expected to cope with expected changes although it may be necessary to adopt some learning from those other locations in relation to network resilience. It is also notable that the ‘refresh’ rate of end-user devices and network elements is faster than the rate of climate change. It is reasonable to expect that from this perspective the ICT systems should remain functional and adapt at the rate necessary.

However, looking more broadly at the ICT ‘system’ a number of questions arose. The first was concerned with the role of the regulator. The panel questioned whether the regulator should be allowed to move beyond the current economic role to consider other aspects of the industry, in particular whether there should be some encouragement for the regulators of different elements of the infrastructure to co-operate/collaborate on questions of resilience. The panel also raised the question of how to encourage investment by the suppliers in network infrastructure artefacts that are purely focused on improving resilience.

It was asked whether the system resilience was properly understood and how diversity in the system was being measured and managed – particularly where there is shared infrastructure (masts and conduits). It was recognised that reliance on the ICT networks for 60/6024/7 cover is increasing (eftpos, business critical on-line applications and so on) and the sustainability of the system against this requirement was questioned.

The panel also looked at the supply chain and recognised that whilst large volume users and critical infrastructure users can be expected to have robust multi-supplier arrangements in place, this is unlikely to apply to SMEs or individuals – who form the greater part of the total economy.

Further information and reporting is required of the reliability of systems, the need for prioritisation and changes in the human interaction with the systems – how and when they are used and for what purpose. In particular, the gap between rainfall forecasts and the prediction of impact on specific elements of infrastructure and systems should be investigated. ICT operators would benefit from an early warning system to highlight the potential of live, catastrophic weather events. No suggestion was made as to how this might be done – or who might do it.

4. Barriers to Implementing Adaptation Options

The principal barriers identified to delivering adaptation are commercial and legislative although there are technical aspects.

Dealing first with the technical, the question was raised as to the challenge of small antennae and the cumulative impact of additional points. This led to consideration of the planning challenges arising if more, smaller cells are to be constructed – these challenges also extending to the cost/value proposition for the host organisations. This is especially an issue in relation to multi-use as business rates are calculated on aspects of diversity issues.

The question was also raised as to the calculation of ‘public value’ and the possible need for regulatory change in this regard. A particular concern in this area is the potential frequency of adverse events and the national impact thereof. Whilst it is entirely possible to build a completely robust ‘gold-plated’ network, the cost to value ration of such a system is hard to compute – and would probably be impossible to justify commercially.

5. Opportunities Arising from Climate Change

The ICT networks provide a great opportunity for the provision of information in relation to climate change. It can provide networks of sensors and other data points to provide information in respect of weather events (precipitation, sunshine, wind speed, humidity etc), and could integrate and assemble such data in relation to both built and natural environments. This could supplement work already undertaken by OFCom in relation to the reliability of the ICT system itself.

The opportunity also exists to share elements of groundworks with other infrastructure providers. For example, running telecoms conduits inside water pipes could have significant benefits in terms of groundworks costs and may enable increased resilience of the water pipe itself (through cost sharing) – but would have the downside of rendering both elements at risk to the same event (such as ground heave or penetration by digging equipment).

The changing climate in the UK may make it a more attractive (and lower risk) location for operations and business currently operating in other, increasingly vulnerable, locations.

The panel recognised the opportunity to raise awareness of interdependency at Corporate Board level and to promote inter-disciplinary thinking at lower levels in organisations – particularly focusing on raising awareness amongst younger engineers.

It was also thought important to track the impact of social changes on the networks and to understand how distribution of demand is shifting.

In parallel – and recognising again the absolute reliance on electricity for the continued functioning of the ICT networks, the panel recognised the need to focus on the ‘energy per bit’ measure as a device for driving up performance.

6. Interdependencies

ICT has strong interdependency with the other sectors being considered in this programme (energy, water, transport). The issues raised were diverse.

The emergent trend towards ‘cloud computing’ – a technology which supports homeworking, tele-commuting and all forms of ‘work at a distance’ increases data traffic volumes and relies on the continued operation of the ICT networks while, potentially, reducing reliance on the transport sector. The net effect on carbon emissions of this change has not been quantified within this work.

In addition, the proportion of economic value (contribution to GDP?) which is reliant on the ICT networks is increasing continually rendering the sector more important over time – and with as yet not fully quantified effects on population distribution and energy or water consumption in the home.

There are challenges around broadcast spectrum availability and potentially a need to use higher frequencies – which carries new technical challenges.

7. Next Steps

This is a draft report for consultation and discussion.

After consultation a final version will be generated and will feed into the interdependencies workshop as well as forming a final output for the sponsor.

8. Appendices

8.1: Briefing Document

8.2: Presentation by Phil Thompson

8.3: Participants

8.4: References and Bibliography