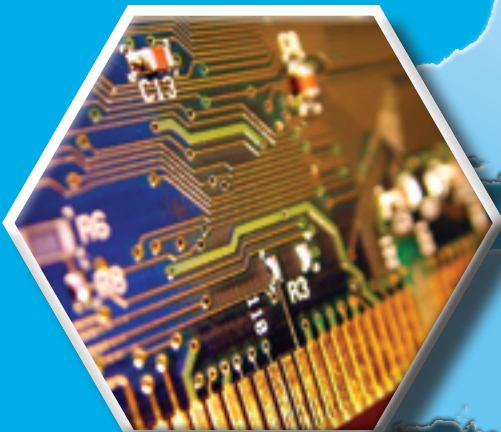




COUNCIL FOR
SCIENCE AND
TECHNOLOGY

A National Infrastructure for the 21st Century



June 2009

Executive Summary

A high-quality national infrastructure (NI) is essential for supporting economic growth and productivity, attracting globally-mobile businesses to the UK, and for promoting social well-being. This report addresses the major issues facing the national infrastructure, focusing on communications, energy, transport and water, i.e. those sectors that transport key resources around the UK and provide global links.

An increasingly mobile business community relies on the NI to function and compete effectively in global markets. The effects of serious NI failures on business and public confidence are likely to be far-reaching and long-lasting, with inevitable economic and political consequences if that failure is localised in the UK.

Much of the national infrastructure – railways, roads, energy production and supply, water and sewage works – was constructed in the nineteenth and early twentieth centuries. Their robustness and resilience provided the basis for subsequent economic and population growth far beyond what was envisaged at the time. More recent infrastructure developments in information and communications technologies (ICT) now underpin the operation of the other sectors. The major change over the last 50 years has been the gradual, but ultimately seismic, shift from a series of unconnected structures to an interconnected NI where failure in one part has a direct and damaging knock-on effect in others.

The UK national infrastructure is now a network of networks. It operates within a social context and the interface between the NI and users is crucial. Most of the NI is owned, operated, built and maintained by the private sector, and is mainly embedded in a regulatory framework within a wider government context. Therefore both the private sector and Government have major and complementary roles to play in delivering a 21st century national infrastructure: business primarily in terms of investment, innovation and operating the network; and Government helping to create the climate for investment, and overseeing the NI as a network of networks.

We do not believe that the NI can continue on its current trajectory, for three main reasons:

- it is highly fragmented, both in terms of delivery and governance, which means that:
 - there is no overall vision of what the NI should look like
 - investment in the NI occurs in an *ad hoc* way with the emphasis very much on *replace* and, to a certain extent *renew*, rather than *modernise*
 - responsibilities and accountabilities are silo-ed within Government departments, agencies and regulators, with little coherence or connectivity across the network of networks
 - no-one has the responsibility or accountability for looking across the NI as a whole i.e. across the network of networks
 - there is little or no knowledge of vulnerabilities and risk arising from interdependencies across the NI which means that investment in adequate resilience will always be low priority
 - little or no expenditure occurs on a precautionary basis, instead the approach is to perform heroic acts in times of crisis

- its resilience against systemic failure is significantly weakening through a combination of:
 - ageing infrastructure components
 - greater complexity and interconnectivity between the different infrastructure sectors
 - nearing maximum capacity as a result of increased social and economic pressures
- the significant challenges posed by climate change and socio-demographic changes, which mean that:
 - there is an urgent need for a major change in devising low carbon solutions to meet the 80% target for reducing greenhouse gas emissions by 2050
 - core pieces of infrastructure need to be ‘future-proofed’ against extreme natural events
 - they need to be able to respond to future demographic, social and life style changes

Despite significant levels of investment by the private sector in recent years, we do not believe market forces by themselves will deliver a resilient NI fit for the 21st century. A partnership between business and Government is needed.

A modern national infrastructure needs to be:

- optimised in terms of cost, low-carbon footprint and service quality
- robust, resilient and adaptable to changing patterns
- innovative across all the sectors, driven by business in partnership with government

The NI needs a skilled workforce, not least in terms of trained engineers and technicians able to design, operate and service it. The responsibility for championing and developing a skilled workforce must be shared by business and Government.

Public engagement and dialogue is needed to understand more clearly people’s expectations of the NI.

We recognise the challenges that the current economic environment is creating in terms of investment and understand that this may limit the ability of Government to address the issues identified in the short-term. However, in the current economic situation it is even more important for Government to create sufficient long-term certainty and coherence across the NI landscape. This will enable and maximise the opportunities for sustained private sector investment in circumstances in which global competition for funding will be particularly intense.

Given the need to plan for the long term, it will be important to identify quickly those aspects which will need cross-party support, at least in terms of identifying where the problems lie.

Recommendations

Recommendation 1

Government needs to appoint a lead body to deliver a clear and consistent vision for the future of the NI in order to create certainty, address both short- and longer-term pressures and changes, and attract investment to the UK.

Government needs to decide where the lead should be. We believe BIS, Treasury and Cabinet Office are all well-placed to act as the focal point within Government, but working with an independent stakeholder group of business and other major players.

The vision should look forward to 2050, clearly setting out the objectives and the rationale for decision-making. The core objective should be both to modernise and coordinate the NI to make it fit for purpose so that it:

- underpins future prosperity, in a world which is adjusting to a new economic order
- averts the danger that the UK will become increasingly unattractive to investment as its infrastructure becomes ever more unreliable
- supports the government's aspirations in relation to targets for mitigating the effects of climate change
- is resilient to the effects of climate change
- supports the quality of life which citizens rightly expect
- is suited to future population changes, including a larger number of older people, changing patterns of migration across Europe, and the likely urban/rural balance in residence patterns
- ensures alignment between the vision and the national policy statements
- acts as a road-map (see recommendation 3)

The vision needs to encompass social factors, such as future residence preferences, and how far it is necessary to plan for any or all of the following:

- more home-based working
- a possible preference for living in smaller towns or rural areas as quality of daily life becomes an important issue for more people, especially with more older people in the population – or alternatively, a move to living at higher population densities in large cities, as a response to economic, work and social pressures
- changes in health care which focus more on individually managed health care and telemedicine, and less reliance on attending health centres or hospitals

The stakes are high. Failure to develop and implement such a vision will mean that the UK falls increasingly behind its competitors, with increasing risks of major infrastructure failures that could have enormous costs to the economy and social well-being.

Government needs to decide where the lead should be. We believe BIS, Treasury and Cabinet Office are all well-placed to act as the focal point within Government. BIS has a leading role in delivering the UK's economic, innovation and skills agendas which underpin, and are underpinned by, the NI. At the same time, Treasury is at the heart of

economic decisions including investment in infrastructure. In deciding where the lead rests, Government will need to recognise that the NI involves a combination of expenditure by (i) private companies; (ii) companies which are themselves regulated; and (iii) Government itself via public expenditure. Whichever department leads will need to work closely with other departments, not least Cabinet Office which has much expertise on civil contingencies, and put in place an independent stakeholder group of business and other major players.

We believe the independent stakeholder body needs the following characteristics: independence, permanence, credibility, and having cross-cutting and other expertise.

Recommendation 2

Government must address urgently the silo-based approach to NI, in particular:

- agree that the lead department, working closely with Cabinet Office and the independent stakeholder group, should take the overall policy lead in co-ordinating across Government, and that the overall objectives should be to:
 - develop mechanisms for achieving a more joined-up approach across Government in order to deliver the vision and prioritise the resilience and interconnectivity issues that need to be tackled
 - improve knowledge-sharing across Government, its agencies, business and the regulators to enable better risk assessment and alignment of regulation with policy objectives, as well as delivering better analysis and ensuring innovative solutions are transferred between the different sectors of the infrastructure
 - implement the provisions of the Planning Act as a matter of urgency

The various parts of the NI operate in silos, with significant fragmentation of responsibilities and accountabilities across Government, its agencies, the regulators, its operators and at a geographic scale. Each sector is regulated separately without regard to interdependencies and with a historic rationale for scope and remit. The tendency to focus on specific infrastructural components rather than on interconnected infrastructural systems leads to financial and operational inefficiencies, a poorer service to citizens and business, and unintended negative consequences. Silos at the level of the individual, as well as at the organisational and legislative levels, need to be cleared away.

A quick win would be for Government to join up more closely the approaches it takes to natural hazards, security and environmental threats, which are all highly inter-related.

There is a need for quick and effective communication, co-ordination and knowledge-sharing at national, regional and local government levels and between Westminster and the devolved administrations to ensure co-ordination and to minimise the potential adverse consequences of the fragmented provision of the national infrastructure. We welcome both the Pitt Review findings that the NI operators, Government and regulators need to work together to foster a collective responsibility for enhancing resilience in line with the National Security Strategy and the concept of a National Plan to drive up resilience by reducing the most substantial risks, to provide appropriate economic incentives and, where necessary, to enable quick action. An efficient planning process is essential for the timely development of the NI.

Recommendation 3

The lead department, working closely with Cabinet Office and the independent stakeholder group, should collaborate with senior business leaders and the regulators to scope out and deliver by 2010 a road map setting out the priority actions in the short-term (5 years) and for the longer-term, that are needed to enhance or maintain the resilience of the NI, paying particular attention to:

- points of weakness, especially vulnerabilities at the interconnections and how best to build in the necessary safeguards and redundancy into the systems to mitigate weak points
- conflicts created by different strategic and legislative frameworks, and understanding the effects of sector-specific interventions on other components of the NI
- stimulating better understanding of the complexity and resilience of the national infrastructure, by commissioning research into scenario planning and modelling NI systems, from physical, economic and social perspectives
- human factors, so that individuals operating in one sector of the NI consider the effects of what they do on other sectors of the NI
- technology and skills needs (see recommendations 5 and 7)

Our report highlights significant deficits in the levels of resilience of the national infrastructure. It also shows up particular 'points-of weakness' where localised failures could trigger a cascade of wider consequences across different sectors or components of the NI.

There is a lack of understanding of the vulnerabilities, particularly where one sector of the NI is dependent on another. Unless addressed, such dependencies can lead to a misplaced level of reliance on other systems that could also have serious consequences e.g. ICT networks which are used to control parts of the NI and which operate through the internet. There needs to be a robust analysis of these interconnections, plus a more pro-active approach to managing the interdependencies.

Modelling and simulation techniques are important ways of enabling complex systems to be understood and manipulated in a virtual environment. It is particularly important that interactions between different components of the NI are modelled in an integrated fashion to ensure that system sensitivities are identified and understood. Such system models are powerful tools for design and planning of infrastructure to ensure that it is optimised to key policy constraints such as minimal energy loss, cost, carbon emissions, efficiency of supply and flexibility to demographic and climate change. Simulation and modelling are areas where the UK has academic strength. There is a need for more investment by business, the regulators and Government in modelling techniques, including supporting the best R&D in modelling techniques within universities. There should also be support for the social sciences to increase understanding of human behavioural interactions with the NI.

Recommendation 4

Government, working closely with the Regulators and the major business stakeholders, should ensure that the remits of regulators are fit for purpose, and in particular whether they:

- provide incentives for modernisation and innovation
- deliver the necessary resilience and interconnectedness within and between the different sectors of the NI
- stimulate innovative solutions where appropriate
- are joined-up in terms of how they work across boundaries between their respective regimes, and at the interconnectivities between different sectors of the NI

We recognise that this work will need to be carried out at a strategic level and avoid creating unnecessary uncertainty

Regulation of national infrastructure is needed because market forces alone may not provide all of the essential features of the NI, for example the appropriate level of security, resilience, interconnectivity and co-ordination between infrastructures, research and development investment and future-proofing.

The current regulatory framework has lasted well over 20 years, and was designed for particular purposes, separately for the individual sectors within the NI. We are not convinced that as it currently stands the regulatory system is optimally designed to meet 21st century challenges e.g. to address the pressing challenges for increased resilience; for reducing carbon footprints; or for encouraging longer-term investments in innovative solutions by business. We acknowledge that some regulators are taking a more proactive approach to addressing this problem, e.g. Ofgem's self-initiated review of energy network regulation. It is important to ensure that the regulatory regime encourages innovative solutions from business. It is important that the regulatory regime underpins policy objectives and that these are aligned across the NI sectors.

The review should address the House of Lords' Select Committee finding that: *"action is necessary to improve regulators' joint working. There needs to be a more structured and formal co-operation between the regulators if it is going to be meaningful"*.

Recommendation 5

Government departments, the Regulators, the Research Councils and bodies such as the TSB need to incentivise the infrastructure operators to connect better to the science and engineering base to develop innovative solutions using best technology. To do this, they should come together to address the following core questions:

- is procurement being used optimally, or indeed at all, to balance low risk/low cost solutions with the need to innovate?
- whether there should be more, or more effective, Innovation Platforms, Knowledge Transfer Networks and other types of collaborative R&D projects between infrastructure operators, academia and the other stakeholders?
- what technologies are available now and are they being exploited effectively within NI?
- what are the barriers to deployment e.g. the need for technology demonstration?
- what are the priority areas for underpinning R&D?
- how to encourage more cross-disciplinary research to clarify the interconnections and interdependencies of infrastructure components, including the human dimensions?
- what scenario planning is needed?
- what roles the professional bodies and learned societies might play?

Meeting the challenges for a 21st century NI will require innovative solutions, drawn from the science base. This will include developments to existing systems, such as moves to active networks and smart metering.

Supporting innovation in key infrastructure sectors by means of direct procurement will create markets for new high-tech businesses in the UK, stimulate innovation throughout the supply chains and act as a mechanism for pulling through R&D from the science and engineering base. The TSB therefore needs to press forward with the Small Business Research Initiative and extend the pilot programmes beyond Health and Defence into other areas of the NI.

Regulators should consider carefully the effectiveness of the mechanisms they have in place to encourage innovation, which should be folded into the overall review of the regulatory regimes highlighted in recommendation 4.

The TSB and the Research Councils need to do more to stimulate collaborative R&D between business and academia in key areas of the NI. Government, business, Research Councils and the TSB, and regulators need to come together to address key issues around technology availability and deployment and the priority areas for R&D including new cross-Council multidisciplinary programmes.

Government should work in collaboration with the research community, technology developers and investors to develop scenarios and potential roadmaps e.g. for the UK low carbon landscape for 2050.

Recommendation 6

Government should put in place ongoing mechanisms for gathering social intelligence for example public engagement and dialogue for key issues on the national infrastructure.

The general business community and the wider public need to understand the challenges that will be faced by NI over the next 30-50 years. It is essential that the long-term provision of national infrastructure be informed by a better understanding of users' needs and expectations. These needs must be factored into all stages of the design, development and operation of infrastructure as strategies and policies develop, regulations evolve and investments are made.

We believe that Government, infrastructure businesses and regulators should put in place mechanisms for public engagement and dialogue on key issues such as:

- the value placed on infrastructure whose provision entails significant investments and costs
- its significant carbon footprint
- future challenges and the role customers can play in helping to address them
- levels of investment in the UK NI
- how tolerant society is to risks resulting from infrastructure failures
- how to achieve the necessary skills sets by attracting people to key industries
- how Government can better act as an intelligent customer

There needs to be a clearer understanding of the social context in which people make decisions, for example to use less water on a routine basis. Such decisions will affect the future resilience of the NI but they are not simply a response to the market, though that clearly plays a part, nor are they simply a series of individual decisions. People are influenced by the behaviour of those around them, by expectations created through the media, by their own commitments, and many other factors which are part of the social fabric. Analysis of this, based on the best social science data available, is essential for effective planning and operation of the NI.

Recommendation 7

The Sector Skills Councils, working with business, BIS and professional bodies urgently need to address the short-term gaps in the skills market needed to deliver a 21st century NI, and provide clear forecasts of the skills needed in the longer-term, and how these can be met. The operators of NI need to identify their needs to ensure they attract, retain and develop the skills of their workforces.

A clear vision of the skills required to operate, maintain, develop and modernise the national infrastructure needs to be developed. The operators of the NI have the central role in driving this forward. Engineering skills across all the major engineering disciplines will be central to delivering a modernised NI, on a major scale not seen in the last 50 years.

The Sector Skills Councils and other bodies representing industry and professions, such as learned societies, professional associations, higher and further education institutes, need to continue working together to provide the Government with this essential information. But the lead must be with the employers themselves, and in a co-ordinated way.

Encouraging the supply of science, technology, engineering and mathematics graduates should continue to be a Government priority. Putting in place more high-level apprenticeships and training and development of technician engineers should be an important component of the skills mix needed. The development of multidisciplinary skills sets to design, install, operate and maintain the NI will be essential.

There is a question of whether a more focused approach to skills training is needed for strategically important sectors such as the low carbon economy, and major infrastructure projects such as nuclear build and retrofitting of low-carbon solutions. There are other skills bottlenecks needing urgent attention, for example in transport planning and operational research.

Social science skills will be essential at many stages of planning and implementing change in the NI. These include:

- researching, and gathering together the findings from existing research, on the social dimensions of modernising the NI
- informing modelling and simulation on a more interconnected NI
- operational management of the NI systems in a way which takes the social dimensions fully into account
- managing public engagement

The skills relevant to the above can be found across a range of social science disciplines: demography, social statistics, anthropology, geography, sociology, social psychology. There needs to be an exercise to identify how generic skills in these disciplines need to be developed to produce a cadre of social scientists suited to working on NI projects and within those industries. The Economic and Social Research Council will have an important role in ensuring that these skills and the relevant research is undertaken to support a modernised national infrastructure.

