Annex

A20.11 Enterprise Network Refresh Engineering Justification paper

December 2019

nationalgrid

As a part of the NGGT Draft Business Plan Submission

Engineering Justification Paper Enterprise Network Refresh			
Asset Family	IT Infrastructure		
Primary Investment Driver	Asset Health		
Reference	NGGT_A20.11_Enterprise Network Refresh		
Output Asset Types	Enterprise WAN/LAN @ 307 locations supporting National Grid services in UK		
Cost	£46.26m Capex, £9.3m Opex		
Delivery Year(s)	2021/2-2025/6		
Reporting Table	GTO 3.07, GSO 3.08		
Outputs included in RIIO T1 Business Plan	N/A		
Spend Apportionment	**T1**	**T2**	**T3**
		£46.26m Capex, £9.3m Opex	£42.52m Capex, £8.5m Opex

Contents

1. Executive Summary

National Grid's Enterprise Data Network which comprises the wide area network (connections between sites) and the local area network (the network within sites including wireless networks) supports data and voice communication services that are essential for the safe, secure, reliable and economic operation of the high voltage electricity transmission system in England and Wales and the GB gas transmission network. Failure of these services will compromise our ability to deliver on our commitments to customers and consumers and the productivity of our workforce.

The majority of our network infrastructure will reach end of life during the T2 period and will require asset replacement. Our strategy to assure the continued secure, efficient operation of these network services is to:

- Leverage the operational telecoms Optel network to avoid duplicated costs when connecting to operational sites where possible
- Shift from expensive private/dedicated connections to leverage lower cost shared public connections
- Adopt a technology agnostic approach that ensures flexibility in the choice of technologies and the adoption of future technologies and does not force technology or individual supplier agendas on to NG
- Use virtualised compute hardware rather than dedicated network appliances to reduce the cost of proprietary hardware, simplify service upgrades, and shift focus from hardware to software- based solutions.
- Migrate the local area networks within our sites and offices from a predominantly manually configured wired network to an auto-provisioned wireless network to reduce the cost of our LAN infrastructure and enable a Smart Workspace environment maximising our office space/occupancy and promoting collaboration.
- Maintain a competitive network partner eco-system to deliver the best service and value for our customers.
- Leverage existing investments in laptops and mobile devices to support the deployment of soft-phones for employees to replace expensive office phones to reduce costs and improve colleague productivity.
- Maximise the secure and useful life of our data network assets in line with our network refresh policies to balance the cost of data network services and the performance for customers
- Simplify the network design to focus on transport and support the implementation of a ZeroTrust security model where security controls are present at the end user devices and at the edge of datacenters and cloud.

We identified six options (3 for the wide area network (WAN) and 3 for the local area network (LAN)) and evaluated them against specific criteria - total cost of ownership, business strategic fit, the extent to which the option meets customer needs, overall risk perspective and our capacity to deliver. Following this evaluation and detailed cost benefit analysis (CBA) two credible options were identified, with the other options being rejected as either not affordable for customers or failing to meet the minimum operational / compliance requirements for the secure and performant operation of the network. All options considered are detailed in section 4 with option 2 for both WAN and LAN recommended as representing the appropriate balance in terms of costs and benefits for our customers and users.

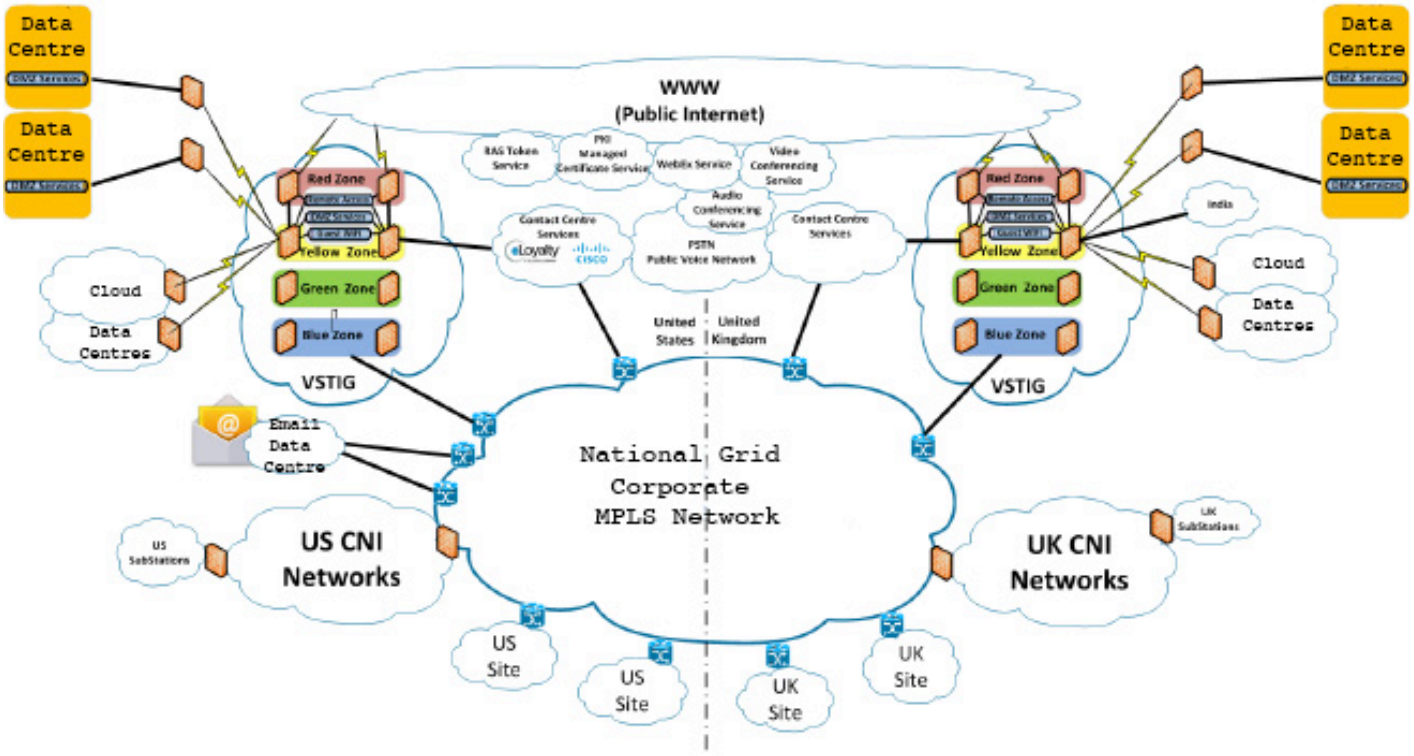
Our recommended approach is to invest a total of £46.26m capex and £9.3m opex during the RIIO T2 period with early investment across all network services to maximise the benefits for customers, network security and operational performance. We will ensure competitive commercial advantage by balancing the term of our contracted third-party provision and negotiated efficiency commitments for customers. We have reviewed our investment plans internally and worked with Gartner to challenge how we plan to execute our strategy efficiently, and all investments benchmarked well within Gartner's independent assessment. This investment is consistent with and complimentary to our Business IT Cyber plan and our IT Operations and Tooling investment proposals.

2. Introduction

Enterprise Data network services enable the connectivity (virtually transparent to the user) that facilitate virtually all IT activity. Rather like the ubiquity of electricity where we don't give a second thought to the fact the lights will come on when we "flick the switch", so it is the case with enterprise networks, we simply connect! The network provision can however have a profound effect on the efficiency and productivity of the user. Poorly implemented or aged network infrastructure can add delay to each process or operation undertaken, even an additional second or two to each action a user takes in a day would significantly detract from productivity. It is therefore essential to the safe, secure reliable and efficient operation of the electricity and gas transmission networks that IT network infrastructure is maintained and updated.

The Enterprise Network is comprised of the wide area network and local area network (including wireless networks) that support voice and data communication services across the business. This is illustrated in the figure below.

Picture 1: Enterprise Network Topology

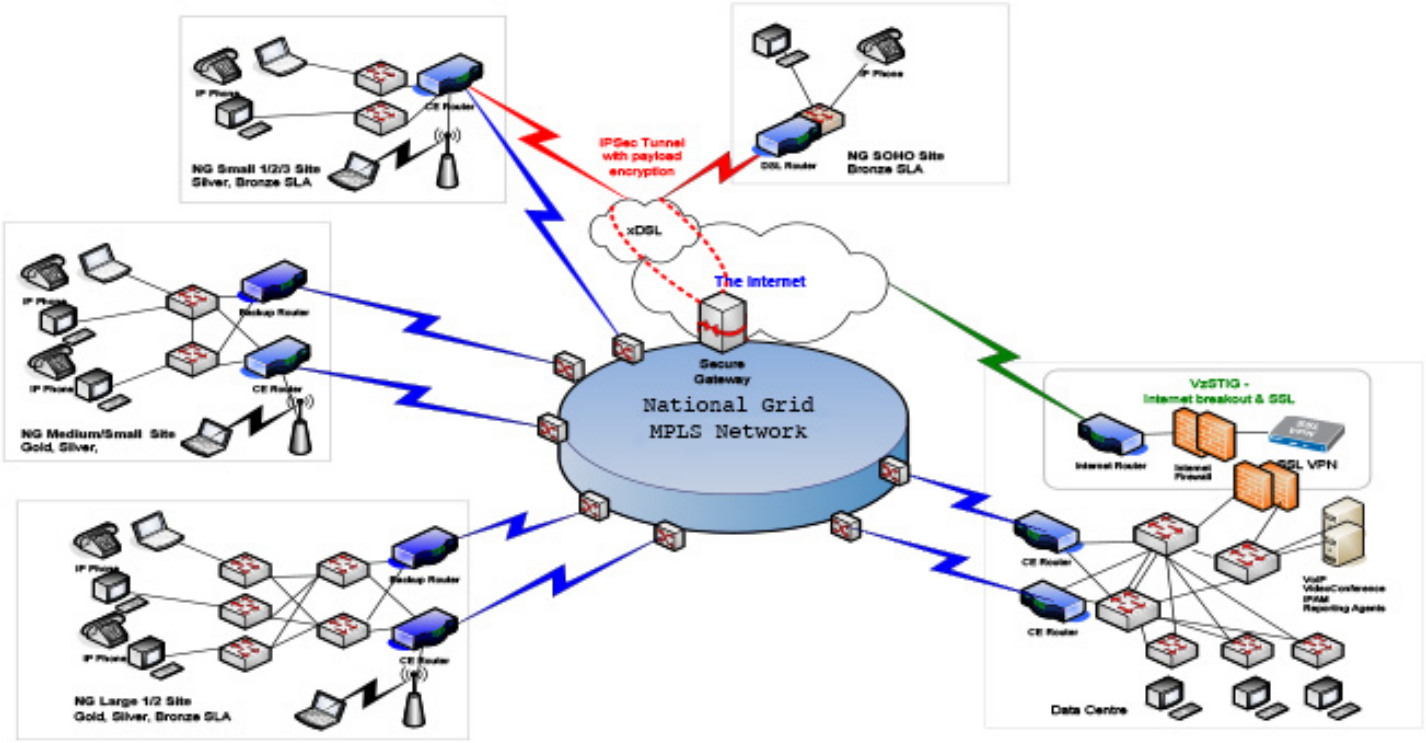


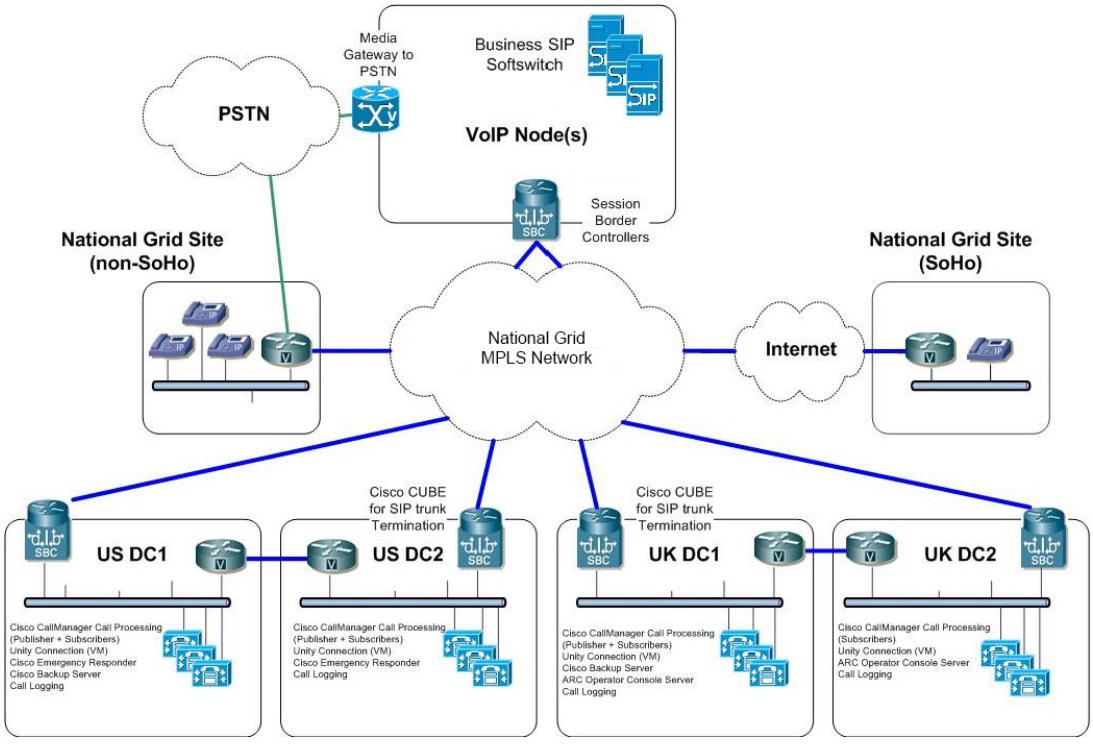
The scope of the network services is summarised in the table below –

Network Service	Description	Volume	Value
WAN	The wide area network (WAN) provides connectivity between National Grid sites/offices, control rooms, data centres, internet and cloud. The WAN supports both the transmission of data and voice services allowing our employees to utilise shared applications, shared data, telephone (voice) systems and Internet (cloud) services. This supports the day-to-day running of the business.	307 UK NG and Partner Sites 413 Routers	Provides access to shared compute resources and applications. Supports all IT processes and services across the enterprise.
LAN including WiFi	The local area network (LAN) provides access for end user devices (e.g. desktops and laptops) to the enterprise network and resources in the WAN and LAN. Access to the LAN can be both wired and wireless. The wireless local area network (WLAN) provides access for end user devices (e.g. desktops and laptops) with WLAN or wireless LAN capability to the National Grid Enterprise Network. To support WLAN access, the installation of wireless access points (WAP) at the user locations is required. WAPs are essentially small radios that are connected to the Enterprise Network that transmit information between wireless user devices and the Enterprise Network to eliminate the need for the user devices to be wired to the network	1015 LAN switches 912 wireless access points	Reliable and flexible access method through which employees and other users gain access to the network and other IT resources.
Voice	National Grid's business telephony is provided by an IP Telephony service where voice services are transported over the WAN	6,000 user accounts	Reliable, high quality voice services. In addition to individual voice

	and LAN data network. This is enabled by the use of QOS (quality of service) tagging on the network that prioritises voice services over other traffic. In additional to standard office voice services, contact center services are operated over the data network. By providing these voice services over the data network, we have eliminated the need to manage both a voice and data network and therefore reduced its cost of connectivity and management.		services, supports reception and conference phones and reliable service for safety and security use cases. Also enables use of hunt groups and other group calling features.

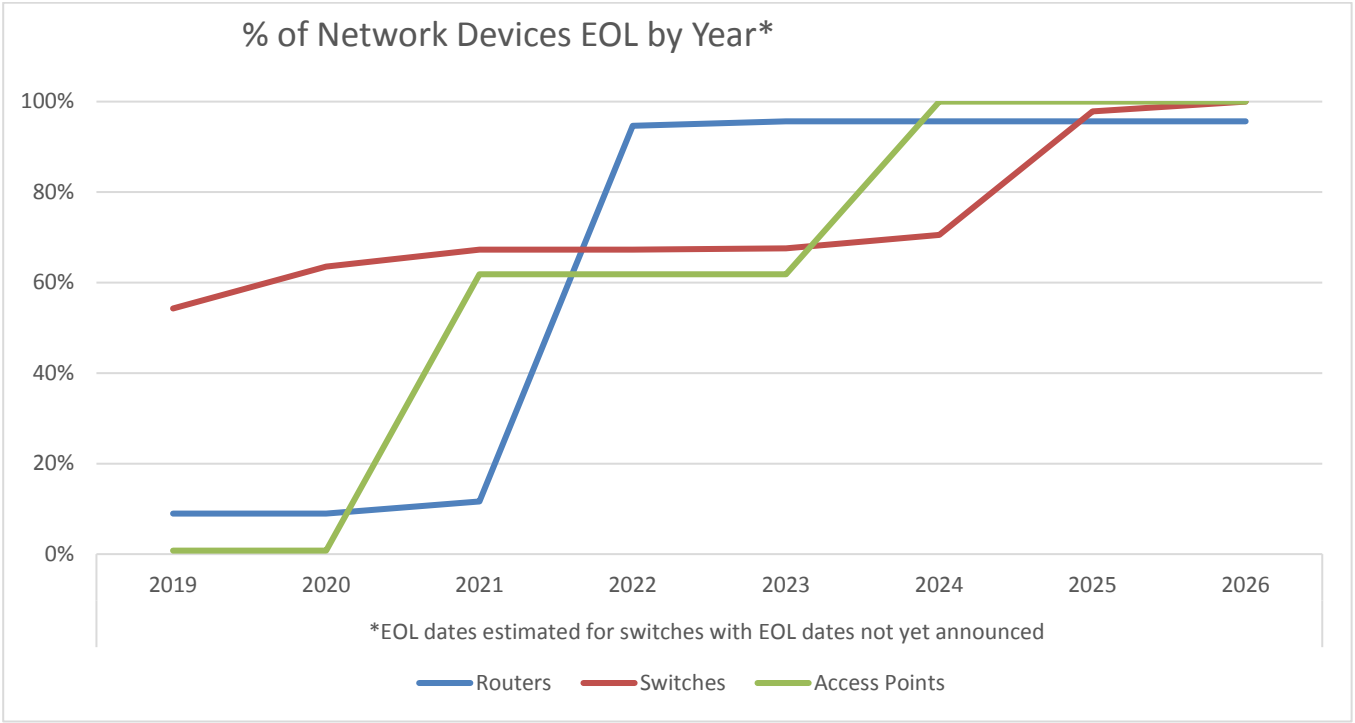
A diagrammatic representation of the National Grid wide area network (WAN) in the UK and global voice network is included below.





Failure of these services would severely impact the ability of National Grid to deliver on its commitments to customers, the general public and other business partners. Our network infrastructure is largely of legacy configuration, requiring substantial monitoring and manual change management effort in its day to day operations and is at or approaching end of life from an asset management perspective.

The figure below shows the age profile for our network infrastructure assets, which shows that 90%+ of Routers reach end of life by 2023, and 100% of Switches and Access Ports reach end of life by 2025/26.



Implementation of a modern, software defined network architecture and a redesigned LAN capable of proactive monitoring and automated provision would de-risk the aged assets, enable the adoption of cloud-based services and drive greater efficiency within our network services.

3. RIIO-T1 Background Information

At the start of T1, we responded to the efficiency challenge from Ofgem by reassessing and extending the technical lives of our IT infrastructure assets, accepting higher levels of risk whilst maintaining levels of availability. This has led to higher levels of risk of network outages, with over 300 network incidents with a severity of high or critical from 2017 to September 2019. Due to the variability of the nature of these outages we have not quantified the cost impact, but each one of these is an impact to the business that results in a delay or potential failure to meet our commitments. In the short-term consumers benefitted financially from the deferral of this investment in our infrastructure, but our aging IT infrastructure has begun to impact the productivity of our workforce and will represent an unacceptable cyber security risk.

Additionally, as we continued through T1, our employees fed back that IT was becoming a significant blocker to their effectiveness. Specifically, users need to be able to collaborate, access more cloud services and utilise large scale analytics. The National Grid WAN and LAN have constrained how our business can take advantage of these services and they require modern, efficient networks to remove these constraints.

Over the same period, the escalating threat of cyber-attack on our IT systems meant that we had to look again at how we managed our infrastructure so that we could proactively monitor and remediate cyber threats.

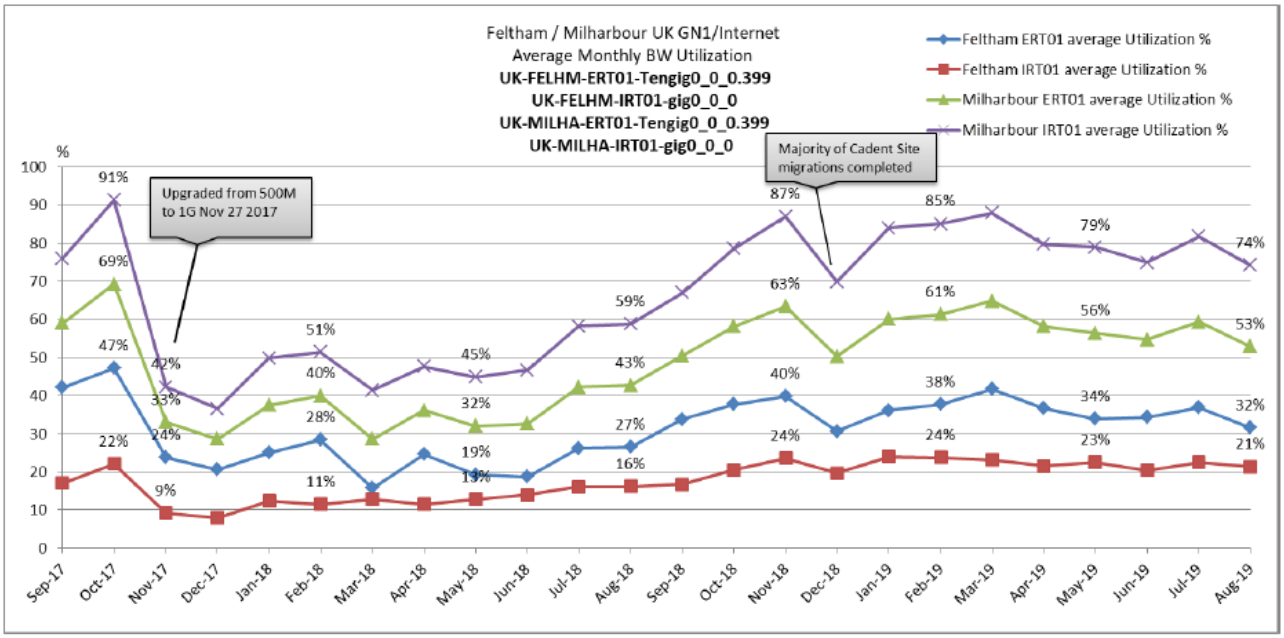
As we look forward to the T2 period, we are proposing an asset refresh with ongoing lifecycle asset management to address these challenges. In addition to the reliability, operational and security benefits provided by network refresh, the convergence of IT virtualisation, proliferation of wireless devices, and availability of low cost internet services, has created a generational opportunity to not only refresh, but to transform the network architecture to support the rapid adoption of cloud-based services and the transition to a mobile user workforce.

Benefits arising from this opportunity include:

1. Utilisation of public networks (wired and wireless) for network transport to lower WAN circuit costs and improve resilience and provisioning time
2. Prioritised traffic flow based on central policy to meet application SLAs
3. Reduced management overhead through central policy management
4. Simplified network that focuses on data transport to deliver greater availability
5. Supports the implementation of a ZeroTrust security model where security controls are present at the end user devices and at the edge of datacenters and cloud.
6. Migration away from high cost proprietary network hardware and appliances on to general compute platforms
7. Transforming to a wireless work environment to improve user efficiency, improve collaboration and reduce the cost of office IT infrastructure.
8. Delivers proactive monitoring and sensor devices to allow detection of problems before they impact users, improving service uptime, performance and user satisfaction.
9. Supports anticipated increase in network traffic. Given the growth of connected devices and cloud services, we will be able to support the anticipated 15%-20% year on year growth in network traffic.

National Grid IT have identified options and undertaken a detailed technical and cost benefit analysis and concluded a need to invest £21.5m in the WAN and £34.1m in the LAN/Voice environments during the RIIO-T2 period by implementing:

1. A virtualised, software defined wide area network (SD-WAN) infrastructure that utilises generic compute platforms to deliver network routing and security functions. SD-WAN has the capability to provide WAN connectivity via both the private network using private transport technologies such as MPLS, 5G and/or direct Internet access. This architecture allows us to take advantage of lower cost public networks for WAN connectivity and provide direct Internet access in support of cloud and SaaS services. This local Internet access will also enable us to reduce the frequency of bandwidth upgrades to our centralised Internet gateways. As shown in the chart below, Internet bandwidth utilisation has continued to grow during the RIIO-T1 period. The use of SD-WAN with local Internet access will provide a more cost effective and better performing solution than continuing to upgrade our central Internet bandwidth and secure gateway (VSTIG) facilities.



2. A redesigned LAN environment that leverages automation and proactive monitoring that enables the delivery of high density wireless local area networks (WLANs) and supports Smart Workplace environments that provide connected user mobility throughout a site/location to enable user collaboration and more effective use of the building space.

Aged equipment increases risk of failure that impacts user productivity and consumes increasing support resources and budget with diminishing return. The investments proposed are a vital component of the modernisation of the overall IT estate to deliver:

- Up to date infrastructure, which is an essential pre-requisite for maintaining the right levels of security for a company running critical national infrastructure.
- Modern flexible technology, which supports new business demands and the digital workplace
- End Users equipped with effective IT tools and connectivity, enabling them to do their jobs safely and efficiently.

The Asset health policies that underpin these investments and the level of investment required were benchmarked by Gartner, a recognised expert in IT benchmarking. The feedback from Gartner is that our asset health policies are in line with recognised industry best practice. We also tested each individual investment portfolio against the industry benchmark, our Enterprise Data Network portfolio is positioned within the range.

What is Different for RIIO T2

- Under the current RIIO T1 structure, National Grid has continued to support the delivery of its network services, renewing the existing architecture where appropriate and modifying the services to address new requirements in the area of cloud, wireless, and security. T1 investments totaled £4.61m and £11.31m for WAN and LAN respectively, and effectively resulted in an erosion of capability and performance across the period, which is unsustainable as we move into T2. As we move to a future based on cloud services and mobility, the existing network architecture that we have in place needs to be fundamentally changed to meet the demands of the business and our customers. In the T2 period we plan to execute on our updated strategy and deliver a high capacity and cloud enabled software defined WAN (SD-WAN) and a redesigned LAN with automation that supports the delivery of high-density wireless network. This asset refresh and change in capability will require additional funding during the T2 period as compared to the T1 period to achieve our objectives.

How Does this Align with the IT and National Grid Strategy?

- The IT Mission within National Grid is to provide technology thought leadership, focus on the customer and end users and deliver reliable and secure services and solutions. The evolution of the network proposed in this document is a direct reflection of this mission. Rather than delivering more of the same, the National Grid IT team has reflected on the user challenges in this area and proposed solutions that align with our strategic priorities. The proposed SDWAN and its capability to use both public and private network and performance-based routing to deliver an optimal experience for our users is unlike anything we have utilised before. In addition, the delivery of the SDWAN along with a redesigned LAN that supports a Zero Trust security model, ubiquitous WiFi services for data, voice, and video will meet our needs today and help secure and future-proof our business as technology and value shifts in the future.

Drivers for change?

- The key drivers for these changes are security and performance. We need to provide our employees with the tools they need to undertake their job and meet our commitments to our customers and stakeholders without being constrained by the technology. The technology needs to be an enabler for our business to deliver. Through the delivery of this architecture the network will provide the capacity and security required to leverage cloud services, will expand the WiFi network to allow employees to be always connected, will automate and simplify changes to reduce outages and Run the Business (RTB) costs, and by keeping our infrastructure current we will be able to keep up with the pace of change and proactively address possible failure points. To ensure the network meets these performance requirements, LAN based management platforms and sensors will be implemented and used on the network. Therefore, in addition to focusing on availability as we always have, we can now also measure and focus on performance.

In addition to the new functionality provided by this platform, we will continue to ensure we do not overlook the mission critical nature of the network and continue to ensure service availability, security and asset health.

Our key stakeholders are the users of this technology, our employees, customers and 3rd parties who receive services through our networks. Customers and key stakeholders are engaged through Regular cNPS surveys and we survey our employees annually, and throughout the RIIO-T1 period they have told us that IT has become a significant blocker to working as effectively as possible. This is reflected to some extent in our employee opinion survey enablement score, which is 57%, compared to a peer group comparator of 73%.

Direct quotes from the cNPS survey regarding the network included:

"*but our network is so slow causing us to waste time and not utilise our time to the full";*
"We've had difficulty with IT systems including slow networks and laptops simply not being usable";
"but the platforms, networks, and laptops are flaky and in comparison to other companies I have been in";
"we have video conference capability and no one activates video as its unreliable due to network speed";
"have some network reliability and performance issues. Many of my team report that their laptop works better when connected from home via VPN than in the office!"

4. Optioneering

To help us to define the problem and develop appropriate options, we have used available information in the form of performance and fault metrics and have listened extensively to feedback from our users and stakeholders. We have also engaged with our service partners to gain their insight into developing and evaluating options. This has enabled us to identify the following criteria to assess our options against:

- Total cost of ownership – capital investment and associated operating costs borne by consumers
- Capacity to deliver - the level of risk associated with the ability of NG and our supply chain to deliver the option
- Business/strategic fit - the alignment of this option to our overall business direction and other planned investments
- Addressing the problem – how well the option resolves the identified issue
- Risk – the overall risk to the business associated with this option

To simplify the review of potential options, we identified a range of options, evaluated them against the criteria and eliminated non-credible options. We then took forward a baseline option, a do nothing/do minimum option and other credible options for a cost benefit analysis. The WAN and LAN/Voice have been broken into two separate analysis described below.

<u>WAN Options Analysis</u>

Today, the enterprise network is designed based on a traditional WAN/LAN architecture using purpose-built routing and switching hardware connected via private MPLS (Multi Protocol Label Switching) circuits using a LAN with wired endpoints. Due to the critical nature of these services, it is imperative that aged hardware is upgraded and replaced to ensure it can be maintained and remain operational with a very high level of availability. In addition, due to the application delivery approach migrating to cloud, users being more mobile, and cyber security threats being on the rise, it is critical that we include these requirements into our refresh strategy and build a network that supports these changing business requirements. To meet these business requirements, an SD-WAN environment is planned for the WAN with a ubiquitous WLAN environment planned for LAN.

The fundamental building block of the WAN is the router, this is the device that supports connectivity between the various National Grid locations. National Grid has 413 routers in service today and 391 will reach end of life by 2022. Today National Grid utilises purpose- built devices for this capability. After a detailed review of current market services and technology offerings it was concluded that as part of the WAN refresh strategy, we should migrate to a software defined WAN (SD-WAN) that utilises a generic compute device in support of the SD-WAN routing function. The SD-WAN provides several benefits over a traditional WAN. The most notable benefits are the ability to use multiple access methods like a private MPLS connection or Internet connection to support site connectivity, the inclusion of a performance-based routing engine that selects the most optimal routes for each application, and the ability to access Internet and cloud services directly from a site via a local Internet connection without having to backhaul the traffic to the main data centre. This will improve access performance at a reduced operational cost.

The credible options to deliver this service are evaluated in the table below:

Table below examines the options available for the provision of the Enterprise Wide Area Network.

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the Problem	Risk	Overall
Option 1 **Retain wide area network equipment and replace upon failure.** **Refresh existing SD-WAN hubs at EOL due to the potential for widescale impact.**	**Amber** • Maintenace costs will reduce as EOL devices are no longer eligible for maintenance. • No bandwidth upgrades. WAN bandwidth costs typically drop over time. • Investment required to replace failed equipment which will increase over time. • User productivity impacted due to unscheduled outages and extended repair times due to hardware replacement and lack of management tools.	**Amber** • Existing technology already in place. • Established industry standards, well understood to operate and maintain. • Replacement of failed devices will result in lengthy service outages.	**Red** • Utilizes established technologies from multiple network equipment vendors • Does not address today's immediate EOL risks. • Does not support future requirements of leveraging lower cost network transport and reducing operational complexity through central policy management. • Does not support large scale move to cloud and use of SaaS applications.	**Red** • Does not address EOL hardware support and compliance • Does not address large scale move to cloud and use of SaaS applications.	**Red** • Does not address EOL hardware support and compliance • Does not address future requirements in the area of cloud and centralized management.	**Rejected** • Does not provides a supportable and maintainable infrastructure. • Does not position to meet future business requirements.

Option 2 **Migrate WAN to and SD WAN architecture to realise cost savings and performance improvements (through policy based traffic routing) over three years**	**Amber** • Opportunity to replace MPLS links with Internet to reduce WAN charges • Implementation of multiple access methods (MPLS and Internet) at sites may result in increased WAN charges • Local Internet services will reduce the cost of future VSTIG infrastructure upgrades.	**Green** • Initial SD WAN and cloud-based security deployments are underway at National Grid • Utilisation of market leading SD WAN software and trusted virtual compute platforms will support the delivery of a reliable solution. • Internet service provides access to cloud services without being constrained by WAN and Internet bandwidth • Virtual routers are capable of additional functions as service evolves.	**Green** • Supports current and future business requirements • Supports move to cloud services • Supports user mobility and collaborative working • Reduces the need to upgrade VSTIG Internet bandwidth	**Green** • Addresses the problem with respect to the underlying hardware being supported. • Addresses the problem with respect to the increased use of cloud services. • Addresses the problem with respect to the increased WAN bandwidth requirements. • Address the problem with respect of the VSTIG bandwidth being risky and expensive to upgrade.	**Amber** • New technology and virtual routing devices have a higher configuration complexity than traditional network devices. • Removes risks around EOL infrastructure in the NG environment • Removes risk of bandwidth capacity for private and cloud services.	**Green** • Meets current and known business requirements • Provides greater control of applications and bandwidth utilization • Maintains security

Option 3 **As per option 2 plus –** **Accelerated SD WAN schedule over 1 year**	**Red** • Opportunity to replace MPLS links with Internet to reduce WAN charges • Implementation of multiple access methods (MPLS and Internet) at sites may result in increased WAN charges • Local Internet services will reduce the cost of future VSTIG infrastructure upgrades. • Delivery in one year may not be fiscally prudent.	**Red** • Accelerated timeline may overtax National Grid and 3rd party suppliers to deliver. • Accelerated timeline provides less time to self analyse services during delivery that could improve deployed solution. • Initial SD WAN and cloud-based security deployments are underway at National Grid • Utilisation of market leading SD WAN software and trusted virtual compute platforms will support the delivery of a reliable solution.	**Green** • Gets National Grid to the targeted end state faster than Option 2. • Supports current and future business requirements • Supports move to cloud services • Supports user mobility and collaborative working • Reduce the need to upgrade VSTIG Internet bandwidth	**Green** • Addresses the problem with respect to the underlying hardware being supported. • Addresses the problem with respect to the increased use of cloud services. • Addresses the problem with respect to the increased WAN bandwidth requirements. • Address the problem with respect of the VSTIG bandwidth being risky and expensive to upgrade.	**Amber** • Accelerated timeline may overtax National Grid and 3rd party suppliers to deliver. • New technology and virtual routing devices have a higher configuration complexity than traditional network devices. • Removes risks around EOL infrastructure in the NG environment • Removes risk of bandwidth capacity for cloud services.	**Rejected** • Delivery in one year may not be fiscally prudent. • Gets National Grid to the targeted end state faster than Option 2 • Accelerated timeline may overtax National Grid and 3rd party suppliers to deliver.

Option 1 is rejected because it does not refresh the estate as it reaches end of life, nor does it address the future business requirements that will require additional cost-effective bandwidth and greater use of cloud services. In additional, the traditional approach to delivering WANs utilises the same resource dependent support model with little opportunity to reduce costs through central configuration and policy management.

Option 2 and Option 3 are technically identical, delivering a complete SD-WAN solution that meets all long term and short-term requirements. The difference between the two options is the delivery cycle. While Option 3 accelerates the delivery of the benefits, Option 2 is a more measured approach due to the current maturity of SD-WAN within its product lifecycle, the overall cost of the program, and requirements that the implementation of the service places on our business resource with regard to onsite support and impact of change.

Looking beyond the T2 period and into T3, it is anticipated that we will continue to utilise this foundation and refresh the equipment on a five year cycle to meet required availability requirements, security compliance and to take advantage of new features and capabilities. Furthermore, we will invest in new tools and physical site upgrades to ensure we continue to meet the needs of the business and our customers.

LAN Options Analysis

The fundamental building block of the LAN is the switch, this is the device that supports connectivity between the end user device and the network. National Grid has 1015 switches in service today, all of which will be end of life by 2025. Today we utilises purpose-built devices for this capability and do not foresee this changing in the immediate future. After a detailed review of current market services and technology offerings it is concluded that as part of the LAN refresh strategy, we will need to replace aging end of life switches with similar devices that support automated configuration and additional security capability such as network segmentation. It is anticipated that a LAN infrastructure that supports automated deployment will reduce time to provision and repair as well as costs.

The fundamental building block of the WLAN is the wireless access point (WAP), this is the device that supports connectivity between the end user device and the network via a wireless connection. We have 912 WAPs in service today, all of which will be end of life by 2025/26. Today we primarily uses wired LAN connections for IP phone and desktop/laptop connectivity supplemented by wireless services where required. However, the needs of the business and users have changed, and it has been determined that a wireless first environment is required delivering wireless services that provide complete building coverage, capacity to support 3 wireless devices per user, and the use of soft-phone over WLAN replacing physical desk phones. Due to these requirements, in addition to refreshing aged access points, the number of access points will need to be expanded. Since the expanded number of access points will eliminate the need for WLAN users to wire into the network, the addition of these access points will have the benefit of reducing the number of required LAN switch ports.

The fundamental building block of the Voice Infrastructure is the PBX and Voice Gateway infrastructure serving all telephony infrastructure in use by National Grid to deliver its services. Our plan is to replace the infrastructure as it reaches end of life, thereby maintain services at an efficient cost.

The credible options to deliver these services are evaluated in the table below:

Table below examines the options available for the provision of the Enterprise Local Area and Wifi Network.

Option	Total Cost of Ownership	Capacity to Deliver	Business / Strategic Fit	Addressing the Problem	Risk	Overall
<u>Option 1</u> **Retain local area network equipment and replace upon failure.** **Refresh voice platform at End of Life (EOL) due to the potential for widescale impact.**	**Red** • Maintenance costs will reduce as EOL devices are no longer eligible for maintenance. • WLAN support charges remain steady due to no additional WAPs • Does not support switch port reductions possible due to WLAN expansion • Does not deliver network automation which would reduce support charges. • No opportunity to utilize lower cost wifi hardware. • Investment required to replace failed equipment which will increase over time. • User productivity impacted due to unscheduled outages and extended repair times.	**Amber** • Existing technology already in place. • Established industry standards, well understood to operate and maintain. • Replacement of failed devices will result in lengthy service outages.	**Amber** • Functionally supports most of today's business requirements but will not deliver required availability. • Leverages established technologies from mature network equipment vendors • Does not address today's immediate EOL risks. • Does not support network automation and improved delivery and incident response times. • Does not address on site cabling limitations to provide increased campus backbone speeds.	**Red** • Does not provide the wifi capacity required to support collaboration, flexible work styles and office hoteling. • Does not address EOL hardware support and compliance • Does not address the EOL refresh of critical systems (eg DNS) • Does not update campus cabling infrastructure to support increase LAN capacities.	**Red** • Does not address EOL hardware support and compliance • Does not address the EOL refresh of critical systems (eg DNS) • Does not addresses the problem with respect to wifi capability and the need to support collaboration, flexible work styles and office hoteling. • Does not update campus cabling infrastructure to provide required capacity and mitigate failure risk.	**Rejected** • Does not provides a supportable and maintainable infrastructure. • Does not position to meet future business requirements. • Does not address the costs of operating both a fully wired and wireless LAN. • Does not take advantage of potential cost reductions that can be achieved through LAN redesign and automation • Does not provide support for flexible work styles and office hoteling.

Option 2 **As per Option 1 plus –** **LAN redesign to reduce RTB over five years**	**Green** • Reduction in switch ports will reduce LAN costs • Automation of LAN provisioning will reduce support costs and restoration time • Implementation of management and performance tools will proactively identify issues and reduce outages. • Migration to an alternate wifi hardware manufacturer will reduce capex and opex run costs.	**Green** • Proven Technology from the incumbent network providers. • Adopt established Industry Standards, therefore better understood to maintain and expand.	**Green** • Delivers a supportable environment capable of meeting business requirements. • Improves the time to deliver services. • Leverages established technologies from mature network equipment vendors • Good availability of skills and knowledge internally to exploit.	**Amber** • Addresses business need to deliver a high performing WiFi environment to support collaboration, flexible work styles and office hoteling. • 5-year schedule delays the benefit of the network redesign. • Delivers the required improvements to the LAN and associated management tools to provide proper support to the environment.	**Green** • Removes risks around EOL infrastructure in the NG environment • Proven Technology from the incumbent network providers. • Supports most business requirements	**Green** • Provides a fully supported LAN/ WiFi environment with the proper design and operational tools and processes. • 5-year time frame allows for assets to depreciate but delays the delivery of service and cost benefits.

Option 3 **As per Option 2 plus -** **LAN redesign to reduce RTB over 3 years**	**Red** • Replaces assets before they are fully depreciated • Reduction in switch ports will reduce LAN costs • Automation of LAN provisioning will reduce support costs and restoration time • Implementation of management and performance tools will proactively identify issues and reduce outages. • Migration to an alternate WiFi hardware manufacturer will reduce capex and opex run costs.	**Green** • Proven Technology from the incumbent network providers. • Adopt established Industry Standards, therefore better understood to maintain and expand.	**Green** • Delivers a supportable environment capable of meeting business requirements. • Improves the time to deliver services. • Leverages established technologies from mature network equipment vendors • Good availability of skills and knowledge internally to exploit.	**Green** • Addresses business need to deliver a high performing WiFi environment to support collaboration, flexible work styles and office hoteling. • 3-year schedule better meets the need of the business and opportunities for savings. • Delivers the required improvements to the LAN and associated management tools to provide proper support to the environment.	**Green** • Removes risks around EOL infrastructure in the NG environment • Proven Technology from the incumbent network providers. • Supports most near-term business requirements • Introduces operational risk of large scale WiFi environment without proper management tools.	**Rejected** • Replaces assets before they are fully depreciated • Provides a fully supported LAN/ WiFi environment with the proper design and operational tools and processes. • 3-year schedule better meets the need of the business and opportunities for savings.

Option 1 is rejected because it does not refresh the LAN estate as it reaches end of life, nor does it deliver the LAN redesign required to deliver automation and proactive management capability.

Option 2 and Option 3 are technically identical, delivering a redesigned LAN that delivers improved uptime using proactive monitoring and performance tools. In addition, this solution will include provisioning and support automation that will allow us to change our process to reduce operating costs. While Option 2 delays the delivery of the benefits, it is a more responsible approach given its alignment with both the delivery of SD-WAN and the depreciation of the existing LAN assets.

Looking beyond the T2 period and into T3, it is anticipated that we will continue to utilise this foundation and refresh the equipment on a five-year cycle to meet required availability requirements, security compliance and to take advantage of new features and capabilities. Furthermore, we will invest in additional WLAN capacity to meet the expected increasing demand for wireless access to meet the needs of the business and our customers.

5. Detailed Analysis & CBA

We have developed our IT investment justification including cost benefit analysis.

Aligned with the information provided above, the preferred WAN option (Option 2) is to implement Software Defined WAN (SDWAN) across all National Grid sites supported by private and public network connectivity with local Internet breakout.

This option will:

- Enable the rapid adoption of cloud technologies.
- Support the implementation of Modern Workspace.
- Enhance the Cyber security of our networks.
- Ensure efficient operation of network services.

The investment costs profile for WAN and associated benefits is set out in the table below.

£m	2022	2023	2024	2025	2026	Total
WAN Preferred Option - Costs	-3.52	-8.56	-3.52	-2.84	-3.08	**-21.52**
WAN Preferred Option - Benefits	3.05	0.19	0.19	0.38	0.38	**4.19**
WAN Net Cost	**-0.47**	**-8.37**	**-3.33**	**-2.46**	**-2.70**	**-17.33**

The table below summarises the output from the CBA.

Option	NPV @ 2.9%
Baseline - Do Nothing	-6.0
Preferred Solution	-16.1
Accelerated Replacement	-16.6

The baseline do-nothing option is not credible and therefore the preferred option is the SDWAN solution.

The table below includes sensitivities for a 5% discount rate, and costs at plus and minus 10%. This indicates that the preferred solution is resilient to a credible level of change.

£m	NPV @ 2.9%	NPV @ 5.0%	Costs -10%	Costs +10%
WAN - Preferred Solution	-16.10	-16.58	-14.08	-18.12

Aligned with the information provided above, the preferred LAN option (Option 2) is to implement a redesigned local area network over 5 years that supports automation and proactive monitoring and provides ubiquitous high density WiFi that supports real-time data, voice and video services.

This option will:

- Enable the migration to soft phones and cloud-based telephony.
- Support the implementation of Modern Workspace.
- Support flexible workspace and user collaboration
- Enhance the Cyber security of our networks.
- Ensure efficient operation of network services.

The investment costs profile for LAN and associated benefits is set out in the table below.

£m	2022	2023	2024	2025	2026	Total
LAN Preferred Option - Costs	-7.28	-5.76	-11.26	-5.28	-4.56	**-34.14**
LAN Preferred Option - Benefits	0.15	0.29	0.44	0.44	0.44	**1.76**
LAN Net Cost	**-7.13**	**-5.47**	**-10.82**	**-4.84**	**-4.12**	**-32.38**

The table below summarises the output from the CBA.

Option	NPV @ 2.9%
Baseline - Do Nothing	-8.6
Preferred Solution	-30.2
Accelerated Replacement	-30.6

The baseline do-nothing option is to ‘fix on failure’ and this is not credible and therefore the preferred option is to implement a re-designed local area network at all locations.

The table below includes sensitivities for a 5% discount rate and costs at plus and minus 10%. This indicates that the preferred solution is resilient to a credible level of change.

£m	NPV @ 2.9%	NPV @ 5.0%	Costs -10%	Costs +10%
LAN - Preferred Solution	-30.24	-31.13	-27.05	-33.42

As can be seen from the tables above, in each case the preferred option is more expensive than the baseline “fix on failure” option. However, unquantifiable benefits would need only have a relatively small value to make the preferred option the most beneficial from a CBA regard. As such, we believe the investment represented by

the preferred option is appropriate.

Following RIIO T2 and entering the T3 period, we have anticipated additional investment that will refresh our T2 investment over a five-year cycle. This asset refresh ensures that our WAN and LAN equipment remain supported to address hardware and software failures, security exposures, and feature upgrades. Additionally, we have assumed that the need for wireless LAN access points will continue to grow and that physical network facilities at key locations will need to be upgraded to support bandwidth growth and resilience requirements

6. Key Assumptions, Risk and Contingency

- It is assumed that the current engineering and safety constraints will continue to apply throughout the RIIO T3 period.
- Costs and options are based on current available technical solutions. The availability of new or disruptive technology may provide additional technical alternatives at the time of implementation.
- It is assumed that all IT projects are progressed and funded, removal of one or more deliverables may impact the options analysis and cost assumptions associated with the remaining deliverables.
- There is a risk / opportunity that the level of coordination between Enterprise Network Refresh and other National Grid IT projects will vary from the levels assumed. Where possible we will leverage projects to deliver efficiencies. with a resultant impact to cost.
- The proposed approach for enterprise networks is consistent with and complimentary to our investments in our Business IT Cyber plan and our IT Operations and Tooling proposals.
- The primary contingency built into these proposals is in the form of additional configuration complexity, increased bandwidth provision or additional access points.

7. Conclusion

The Enterprise Network is a critical business service that underpins the safe and reliable operation of our business. After a detailed review of current market services and technology offerings it was concluded that:

1. a network refresh to ensure the secure operation of the services is essential to health of the business, and
2. the requirements of National Grid could best be met through a network refresh that implements an SD-WAN environment with user LAN access provided by a redesigned LAN that supports automation with ubiquitous WLAN access at all National Grid locations.

Key operating constraints limiting other options are:

- Cloud access is limited by MPLS and centralized internet gateway sizing constraints
- Wired LAN environments do not support user mobility and collaborative work
- Limited opportunities for cost reductions using current network architecture without replacing existing devices.

Key operating benefits of the selected options are:

- Local Internet circuits provide direct access to cloud apps and alternate route to corporate apps
- Local Internet reduces the need to increase MPLS and Internet gateway bandwidth
- Local WAN and Internet services provide greater carrier resilience
- Performance based routing provides additional control over application performance
- Using generic compute devices to provide the routing function reduces vendor hardware dependency and potentially supports additional capabilities (e.g. local firewall)
- Allows sites to be stood up more quickly through the use of broadband Internet or LTE service

Our enterprise networks are essential for the safe, secure, reliable and economic operation of the high voltage electricity transmission system in England and Wales and the GB gas transmission network. Failure of these services will compromise our ability to deliver on our commitments to customers and consumers and the productivity of our workforce. To ensure we maintain effective network capabilities and services we intend to invest a total of £46.26m capex and £9.3m opex during the T2 period, with early investment across

all network services to maximise the benefits for customers, network security and operational performance.

The Implementation of the Enterprise Network refresh will be phased across the RIIO-T2 regulatory period due to the scale and complexity associated with deploying the architecture across the National Grid estate. The pace of migration is controlled by the installation of the circuits, routing hardware, LAN switches and wireless access points. The LAN and WLAN upgrades are independent from the WAN upgrades but opportunities for joint site access will be pursued to limit user impact and to realise delivery efficiencies.

8. Outputs included in RIIO T1 Plans

N/A