

National Grid Gas Transmission

nationalgrid

RIIO-1 NOMs Performance Report

30 July 2021



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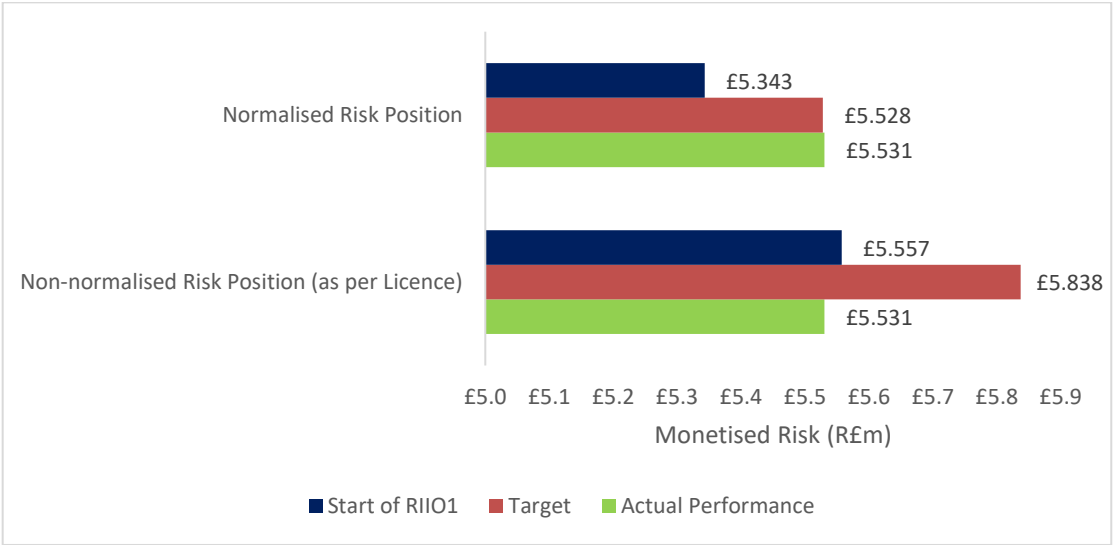
Introduction

1. This report is submitted in line with Special Condition 7.6 (SpC 7.6), Close out of the RIIO-1 Network Outputs (NOCOt) of our gas transporter licence, paragraph 7.6.3 and the Network Outputs Measures (NOMs) Incentive Methodology published by Ofgem on 18th June 2021. The NOMs Incentive Methodology sets out how Ofgem will assess performance against our Network Replacement Outputs as part of the closeout of the RIIO-1 price control. Our RIIO-1 targets were rebased into monetised risk targets, which were approved by Ofgem in July 2020. This performance report constitutes stage 1 and 2 of the NOMs incentive mechanism process.
2. This report is divided into four sections, a performance overview (section I.), table narrative to explain trends in the closeout data template (section II.), reports on individual secondary asset classes (section III.) and the associated cost proposal (section IV.). All financial values are in 2020/21 price base unless stated otherwise.

Executive Summary

3. In line with our licence obligations National Grid Gas Transmission (NGGT) has managed its assets effectively and delivered its RIIO-1 monetised risk target. Overall, consumer risk has been lowered by our targeted asset health plans which have delivered a proactive programme of works, focused upon achieving legislative compliance and addressing identified asset safety and reliability issues.
4. Following application of relevant risk changes to the target (normalisations), we have delivered on target performance with 99.95% of our normalised, monetised risk target of R£5.528m being delivered through asset health capital expenditure actions. We invested a total of £545.9m of asset health capex during RIIO-1 to deliver our monetised risk target on our gas conveying assets.
5. Operational expenditure to disconnect five NTS compressor units delivered 1.42% (R£0.081m) of the monetised risk target which has been discounted through the normalisation process. These disconnections removed the need for us to undertake additional maintenance, including statutory works, to ensure that the units complied with the relevant legislation. Cost savings associated with these works are shared with customers through RIIO-1 and beyond.
6. We invested a further £111.1m of asset health capex on our “non lead” assets. These assets are ten Secondary Asset Classes (SACs) which are necessary to maintain the safety and integrity risk of our network, but do not convey gas and therefore carry indirect risk. Whilst integrated as part of the RIIO-1 asset health business plan (RIIO- 1 BP), this work does not count towards our monetised risk target.
7. We invested a further £37.7m of asset health capex on partial asset interventions. Certain SACs represent a very large system e.g. all above ground pipework or the whole electrical system, on an individual gas transmission site. Where we have undertaken partial refurbishment or intervened on these systems without re-living the whole system, we have not been able to claim a monetised risk benefit. Whilst this work cannot be counted against our monetised risk target, it has delivered improvements in safety and reliability at a lower cost outcome than full asset replacement for customers and consumers.
8. The normalisation process has removed the monetised risk benefits of all work delivered prior to the start of RIIO-1 and that which was delivered through budgets other than baseline asset health. Although the monetised risk target was applied retroactively in year 6 of the regulatory period, our investments have targeted the assets that pose the most risk overall, delivering a safe and reliable service, ensuring our customers were able to take gas and off the network as and when required.

Figure 1 NGGT monetised risk performance



I. PERFORMANCE OVERVIEW

Performance

9. In line with our licence obligations National Grid Gas Transmission (NGGT) has managed its assets effectively and delivered its RIIO-1 monetised risk target. Overall, consumer risk has been lowered by our targeted asset health plans which have delivered a proactive programme of works, focused upon achieving legislative compliance and addressing identified asset safety and reliability issues.
10. Following application of relevant risk changes to the target (normalisations), we have delivered on target performance with 99.95% of our normalised, monetised risk target of R£5.528m being delivered through asset health capital expenditure actions. We invested a total of £545.9m of asset health capex during RIIO-1 to deliver our monetised risk target on our gas conveying assets.

Operational expenditure to disconnect five NTS (National Transmission System) compressor units

11. 1.42% (R£0.081m) of the monetised risk target delivered by the disconnection of the five NTS compressor units has been discounted through the normalisation process. These disconnections removed the need for us to undertake additional maintenance, including statutory works, to ensure that the units complied with the relevant legislation. Cost savings associated with these works are shared with customers through RIIO-1 and beyond.
12. When considering our overall monetised risk performance, we would like to highlight that this does not include the disconnection of five compressor units delivered through opex budgets. These disconnection costs were not recorded in Regulatory Reporting Pack (RRP) table 4.2 cost reports as these only include capital costs.
13. These disconnections were accounted for in previous table 6.6 RRP returns, as there was no distinction between capex and opex for Network Replacement Outputs. These disconnections and positive isolations are required under a range of legislations including Control of Major Accident Hazard (COMAH) and Dangerous Substances and Explosive Atmosphere Regulations (DSEAR), under which we are required to undertake measures to prevent and mitigate hazards.
14. The compressor unit disconnections should be considered when taking a view of our overall RIIO-1 monetised risk performance, as the risk posed by these assets has now been removed from the network. These five units had asset health issues that were non-economical to repair and were also non-compliant with the Industrial Emissions Directive (IED), limiting the unit's remaining lifetimes and hence the long-term benefit arising from any investments.
15. If we did not reference these benefits, we would be communicating an incomplete and misleading picture of our totex risk performance over RIIO-1 to stakeholders, especially as our performance excludes £37.7m of asset health expenditure for

which there has been a reduction in risk, but we are unable to turn into a quantified value (see paragraph 7).

16. If we included the disconnection of these five compressor units, and their associated ancillary assets, our overall performance would be 101.37% of our normalised, monetised risk target and remains as on target performance. Further detail is provided in paragraph 141.

Asset Health Investment Prioritisation

17. Early survey work in RIIO-1 informed a worse than expected risk profile. As a prudent asset manager, decisions were required to re-prioritise the investment portfolio to manage network risk, reducing the likelihood of customer outages and impacts.
18. Our performance, along with our improved asset management maturity provides us with confidence going into RIIO-2, that our decision-making and enhanced risk management capabilities, will deliver value for customers and consumers aligning with Network Asset Risk Metric (NARM) principles.
19. Our RIIO-1 delivery was largely prioritised based upon:
 - Resolution of known defects, where these defects had a substantial risk of legislative non-compliance and/or service disruption to customers
 - Proactive action based on asset condition surveys, where these proactive interventions were deemed deliverable based on the availability of suitable NTS outages to undertake the work
 - In line with existing, documented company policy to achieve legislative compliance
20. It should be noted that:
 - Work delivers monetised risk benefits, recognising the need to deliver safety risks and achieve compliance whilst ensuring system access to meet our supply and demand levels. Therefore, our reduction levels represents what can be achieved in terms of monetised risk reduction accounting for these factors.
 - Monetised risk is a short-term benefit; it does not necessarily deliver the maximum long-term risk benefit to customers as the risk benefit is capped over the 8-year RIIO-1 period. It is possible that an investment that does not deliver a significant monetised risk benefit over RIIO-1 would be justifiable using the NARM (long-term) risk benefit, which is measured over the life of the intervention.
21. 17 SAC specific commentaries are detailed in part III. of this report and capture the performance of our decisions together with reasoning in support of any deviations to plan. These selected SACs collectively account for 94% of our monetised risk performance and 86% of our RIIO-1 capex investment.

RIIO-1 Asset Intervention Drivers

The NTS Asset Base

22. The NTS assets are grouped into five Primary Asset Categories (PACs) - Entry points, Exit points, Compressor stations, Pipelines and Multi-junctions. There are 47 SACs which support the operation of the primary assets. It is possible for a specific SAC asset type (e.g. Locally Actuated Valves) to be present in multiple PACs. At St Fergus, there are Compressor SACs within an Entry Point PAC as well as at the obvious Compressor station PACs. These SAC assets are used to quantify current/future risk and the benefits of asset health investment using the risk valuation approach detailed in our RIIO-1 Methodology for NOMs. Each network operator maintains a sector specific NOMs Methodology to assess and report on the benefits delivered by improving of network condition and risk outcomes to Ofgem. These are defined in monetary terms (also known as monetised risk).
23. The strategy adopted for asset health investment is to avoid costly replacement through maintaining the condition of the primary assets, minimising the risk of disruption to customers through unplanned outages by maintaining the reliability, performance and condition of the secondary assets. The continued safety and integrity of the primary assets allows them to deliver the outputs they were designed to provide. The level of investment required on each secondary asset group varies each year, as the level of work and subsequent investment is determined.

Investment Drivers

24. There are multiple drivers for asset health related investment including legislation compliance, asset condition, obsolescence, supply and demand changes. The safety and environmental legislation that drives the need to maintain, re-life or replace secondary assets includes the Control of Major Accident Hazard (COMAH), Pipeline Safety Regulations (PSR), Pressure System Safety Regulations (PSSR), the Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) and the Industrial Emissions Directive (IED).
25. The NTS is categorised by the Health and Safety Executive (HSE) as a system of major accident hazard pipelines and installations; all subsequent assets are captured either by the PSR or the COMAH regulations. Both legislative documents are strictly enforced by the HSE and the COMAH Competent Authority.
26. Legislative changes may trigger investment where there is a need to improve the performance or safety of an asset, and may also trigger an investment need periodically, for example, a Pipeline Inspection Gauge (PIG) trap requires a major inspection and re-validation every 12 years under the PSSR. It should also be noted our compliance activities are currently not always targeted using both the probability and consequence of failure, which means that achieving compliance does not always deliver significant monetised risk benefits. This is an area of future discussion with Ofgem and other non-economic industry regulators, such as the

HSE and Environment Agency, and customer representatives such as Citizens Advice.

- 27. A large proportion of the primary assets on the NTS are now reaching or exceeding their original design lives. Timely refurbishment and replacement of the associated secondary assets can prolong the life and avoid costly wholesale replacement of the primary assets they support and protect.

RIIO-1 Business Plan

- 28. In our 2012 RIIO-1 BP, we proposed investments totalling £615.8m. Of the 47 SACs, there was specific detail provided on investment programmes for SACs with proposed investments greater than £10m.
- 29. Our plan was based on a forecast of asset condition and predicted utilisation over the RIIO-1 period and beyond. Whilst our planned investments were provided by individual SAC categories, we specified that we would manage the total planned asset health investment under a single budget to allow us to adapt to unforeseen events and address new risks where necessary. This network level approach was essential to allow work to be re-prioritised where deemed to be more critical and reduce the likelihood of asset failure.
- 30. As agreed with Ofgem, our business plan detailed investment justifications for SACs where our anticipated plan value was greater than £10m in the regulatory period, 14 SACs in total. Ofgem then applied specific deductions to 8 of these SACs at final determination, generating a 14% reduction on average to the SACs assessed. This same percentage reduction was then applied to the remaining SACs where our business plan had proposed investment.
- 31. Our business plan presented Bacton rationalisation works under the driver of Network Flexibility, as our investment needs were driven by changing behaviour of existing capacity. We advised significant asset health issues were present at the terminal and that a like-for-like replacement would be inefficient. Rationalisation was therefore proposed as it would be more efficient but would change the site capability. Ofgem did not believe we had made the case and no specific allowance was granted to enable Bacton rationalisation.
- 32. The initial NOMs methodology at the start of the price control was a volumetric methodology, and allowances were set to deliver work across 47 SACs. As part of the rebasing of the RIIO-1 asset health NOMs targets in 2018 (approved by Ofgem in July 2020) to a monetised risk-based approach, only 37 SACs directly contribute towards our monetised risk target. The remaining 10 (also known as 'non lead'

assets¹), whilst integrated as part of the RIIO-1 BP and incurring significant amounts of spend, do not directly contribute towards the monetised risk target. For the purposes of this report, these 10 SACs are not in scope, as they do not contribute towards our monetised risk performance.

33. For most of the RIIO-1 period, our NOMs target and associated regulatory reporting has been on a volumetric basis. The monetised risk benefits associated with each intervention were developed through the rebasing process ² and the new targets became effective in our licence in September 2020.
34. Several assumptions had been documented in the RIIO-1 business plan in relation to the IED compressor investments. Asset health works were assumed not to be required on several compressor sites as existing units would be replaced by new emissions-compliant assets to meet emissions targets under the IED. This work had a different cost driver and would be subject to an uncertainty mechanism. Funding for most of the IED work was not granted through reopeners in RIIO-1, so where asset health works were required on these units, this had to be prioritised over other work in the plan, contributing to under or over delivery for individual SACs.
35. The output defined for the RIIO-1 price control was to keep network risk levels constant (based on the numbers of Replacement Priority (RP) 1 assets per primary asset class). The licence specified the original volumetric NOMs methodology and targets for each PAC on a volume basis, with requirement to progress to monetised risk.
36. RRP table 6.6 presented the numbers of assets in each RP band on a volumetric basis each year. Each year the numbers of assets moving between Asset Health (AH) bands due to deterioration and/or intervention was published. Criticality bands were set at the start of RIIO-1 using a qualitative assessment of failure consequence, which were fixed over time. In 2020 these volumetric targets for primary asset classes in the licence were replaced with monetised risk equivalents which form the basis of assessment for this report.

¹ These assets do not have easily measurable, or have non-existent, relationships between condition and/or age and the likelihood of failure. Examples include, security fencing or pipe supports, where there is a detached or uncertain relationship between asset condition and a measurable service risk consequence. This category also includes assets which provide a “binary” benefit, for example marker posts or impact protection, where if the asset exists it generally provides the desired protection regardless of condition or age.

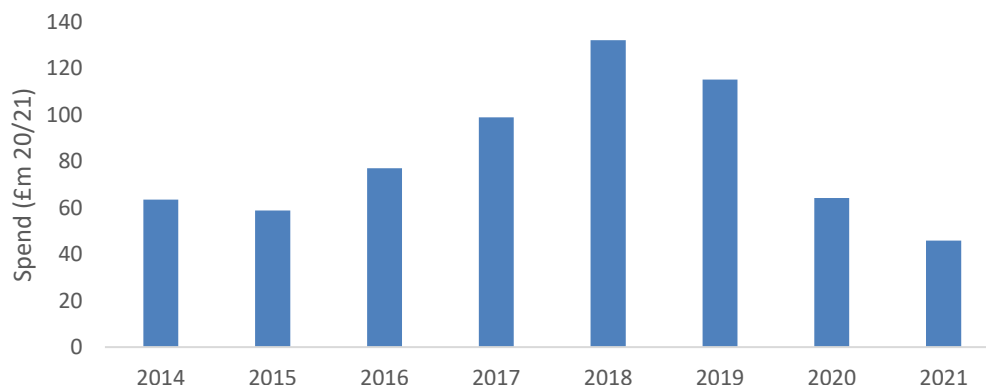
² <https://www.ofgem.gov.uk/publications-and-updates/statutory-consultation-proposal-approve-rebased-network-replacement-outputs-and-modify-special-condition-7e-gas-transporter-licence-held-national-grid-gas-plc>

RIIO1 Delivery & Performance Review

Profile of Spend

37. Broadly, the overall profile of activity in terms of spend has consisted of a slow ramp up in the first two years followed by a peak in the middle of the regulatory period and ramp down over the final two years.

Figure 2 RIIO-1 Spend Profile



38. During the first two years of RIIO-1 we developed a greater understanding of asset condition and the true extent of deterioration through extensive survey and defect analysis. This phase also saw the development of condition capture processes such as internal policy T/SP/CM/4³, enabling a more granular and detailed classification of condition information. As our risk intelligence grew, it was apparent that the actual condition of the network at the beginning of the regulatory period in 2013, was worse than the modelled view of asset health/condition, which was based on population level assumptions and an assumed aging profile. As such, asset management programmes were established to enhance our asset data and enable us to prioritise the required investments. This was the next phase of the RIIO-1 period, where delivery of defect resolution was a priority, in order to manage the immediate integrity of the network. The final phase of RIIO-1 saw the introduction of the asset health fitness challenge, where a campaign approach was established, and intervention decision making was put through robust prioritisation principles.

³ The assessment and reporting of plant coatings, painting & cladding inspections for National Transmission System assets

2013 | RIIO1 Start

2021 | RIIO1 End

Analysis Phase Year 1-2

- Recognising the extent of deterioration at St Fergus terminal
- Recognising the extent of investment required at Bacton terminal
- Evolution of delivery approach from individual asset interventions
- Establishing new condition capture processes eg. T/PM/CM/4 to better understand asset risk levels

Risk Management Phase Year 3-5

- Increased levels of investment, in order to achieve stable level of risk.
- Full extent of asset condition realised through data collection exercises including GAINS & ADEPT
- Asset Health Acceleration Project established campaigns to deliver large volumes of interventions

Prioritisation Phase Year 6-8

- Asset Health Fitness Challenge established prioritisation principles to control performance
- Campaign approach fully established delivering targeted programmes of work efficiently
- ORAM process was embedded in order to proactively manage and mitigate risk at a site level.

Change in asset condition intelligence

39. There are three key examples of how the actual condition of the network influenced our programmes of work and brought about changes from the original RIIO-1 plan:

- St Fergus terminal – Commissioning of the new compressor units allowed the first intrusive survey of the site for many years. Normally online 24/7, an extended outage on Plant 2 in 2016 brought to light the condition of assets on the site, which were in significantly worse condition than expected. Allowances were insufficient to manage asset condition and therefore prioritisation was required.
- Above Ground Pipework – No capital investment was proposed in RIIO-1 as risk had previously been managed via routine/non-routine painting of the above ground pipework assets. This was historically carried out as an opex activity and as such only a small amount of opex allowance was requested in the RIIO-1 BP. During the first phase of RIIO-1, and as reported within the RRP, it became increasingly apparent through the application of our enhanced corrosion survey policy that the actual condition of our above ground pipe assets was considerably worse than understood when the RIIO-1 BP was submitted. We prioritised defects to manage risk and invested £32m to mitigate the effects of corrosion on our above ground pipe at specific sites.
- Bacton terminal – Actual asset condition at the site was found to be worse than understood when the RIIO-1 plan was submitted. Additionally, as there were no allowances in the business plan to complete a rationalisation exercise, we adjusted our strategy and a decision was taken to invest beyond allowances to reduce the whole life cost of maintaining the terminal mitigating significant outage risks. This activity continues through to RIIO-2 and business case proves this to be prudent.

Prioritisation and Trade-offs

DORAM at St Fergus Terminal

40. Whilst robust risk assessment and planning principles have been applied to all reasonably foreseeable risks, with an ageing asset base there can never be complete knowledge. There will always be individual assets which sit outside of the risk profile of their peers, and have the potential to impact on network safety, reliability or environmental performance. To address this issue the Defects

Operational Risk Assessment & Mitigations (DORAM) process was established as a pilot project at St Fergus. The DORAM provides a mechanism to track emerging asset-based risks and overcome the historical limitations of using plant status logs by:

- Providing a visual representation of site asset risk profiles;
 - Ensuring suitable mitigations are identified and implemented; and
 - Providing assurance that works deferred to RIIO-2 are appropriately managed, including re-prioritising emerging issues as necessary.
41. The DORAM process was rolled out to all compressor stations, terminals and many Above Ground Installations (AGIs) by the end of RIIO-1. The DORAM is updated monthly and is subject to a more detailed quarterly review by Subject Matter Experts (SMEs) where: risks may increase, decrease or be closed; control and mitigation measures are reviewed; and new risks may be identified. This promotes the consistent application of risk assessment principles and overcomes the limitations of the PSI (Plant Status Item) approach.
42. The initial St Fergus DORAM identified the highest risks to achieve compliance as:
- Corrosion to small diameter piping systems (driven by the corrosion issues on the actuating gas system)
 - Cyber security
 - External corrosion of transformer oil radiators
43. These were managed via appropriate control measures and asset health interventions.
44. Investment across the site was prioritised through the DORAM process, and for St Fergus this was in late 2016. The site investment approach focusses on issues that pose a potential safety risk, whilst in parallel retaining appropriate levels of compression capability and meeting environmental targets. Once established, the DORAM prioritised corrosion remediation and restoration of compressor cabs to full operational capacity as critical work. These themes, along with the initiation of the valve actuator refurbishment programme, and completion of Plant 2 metering formed the most significant areas of investment at St Fergus Terminal during the later years of RIIO-1. It is these unplanned interventions that albeit tackled the greater risks, were not foreseen as part of the initial RIIO-1 BP process and were a key reason for deviation from plan.

The Asset Health Fitness Challenge

45. The Asset Health Fitness Challenge was initiated in year 5 of RIIO-1, specifying prioritisation principles to ensure a managed and controlled level of output

performance to achieve a stable risk position at the end of RIIO-1 whilst effectively managing the asset health budget. The DORAM process was an output from this and was implemented at all terminals and key AGI's to supplement risk intelligence and ensure a level of local management of asset risk, particularly with defects that did not meet the immediate prioritisation principles. This approach proved to be effective in driving mitigatory risk management whilst avoiding costly intervention. The prioritisation principles that were adhered to were:

- Do not put staff, contractors or public at an unacceptable level of risk
- Prioritise compliance interventions e.g. DSEAR
- Deliver all statutory work e.g. PSSR
- Identify lowest cost mitigation or intervention
- Address only above-ground corrosion issues that could lead to loss of containment within six years
- Address only reliability issues that could lead to a capacity restriction
- Work scope prioritised by safety and reliability risk rather than modelled NOMs. (Manage network risk in the interest of consumers based on latest asset data)
- Is the asset operationally required? Review the needs case.

46. The coming together of ongoing asset deterioration and network level risks, resulted in a major portfolio level prioritisation in 2019. This ensured that we effectively managed the prevailing risks at a network level, whilst controlling expenditure to an acceptable level in the interests of consumers. Whilst decision making towards the end of RIIO-1 was primarily based on actual risk and reactive needs, the resultant proximity to the monetised risk target demonstrated excellent asset management decision making, particularly in being able to prioritise asset interventions effectively.

Closure of investments, COVID-19 impacts and RIIO-2 preparation

47. Focus in the final years of RIIO-1 was on the closure of existing investments in preparation for RIIO-2. Progress on this was somewhat slower than forecasted, partly due to the impacts of the COVID-19 pandemic including:
- Robust site working controls were put in place to minimise the risk of infection to and from site operational staff.
 - All construction activity was risk-assessed against government guidance during the pandemic, reducing progress to essential work only.
 - Progress of closure activity was impacted by the re-focusing of work to operationally critical activity only

SAC Performance Reports

48. For a more detailed commentary in relation to SAC performance please refer to part III. of this report where we have provided more granular performance detail for 17 SACs. These SACs collectively account for 94%⁴ of monetised risk performance and 86% of our RIIO-1 capex investment⁵. The NGGT NOMs framework is such that most of the monetised risk is associated with the pipeline SACs whilst work on other SACs contribute significantly less monetised risk benefit.

Table 1 SACs with individual performance report provided

SAC Number	SAC	SAC Number	SAC
15	Cathodic Protection	33	Below Ground Pipelines and Coating
16	Electrical - including standby generators	34	Power Turbine
18	Filters and Scrubbers (including Condensate Tanks)	35	Preheaters
21	Flow or pressure regulators	36	Station Process Control System
22	Gas analyser	37	Unit Control System
23	Gas Generator	43	Locally Actuated Valves
27	Fiscal Metering	45	Safety valves (Remotely Operable Valves)
31	Pig Trap	46	Process Valves
32	Above Ground Pipework and Coating		

⁴ From table 4.2, includes costs attributed to the 10 SACs that aren't part of the monetised risk target and includes Feeder 9 planning cost.

⁵ For Investment on the 37 SACs that contribute to our target, not including GTO Other including PWS

II. TABLE NARRATIVE

Summary

50. The table narrative describes the process for completing the RIIO-1 closeout data template and any assumptions required to be made to meet the requirements of the Ofgem NOMs Incentive Methodology.
51. The table narrative also provides a summary of the underlying trends in the performance data and a high-level overview of the reasons behind these observed trends. A more detailed narrative of SAC delivery can be found in section III. of later in this document.
52. In summary, we have achieved a monetised risk performance of R£5.531m, against a normalised target of R£5.528m. This corresponds to achieving 99.95% of our normalised target. This does not include R£0.081m worth of monetised risk benefit from five asset health related compressor unit disconnections, which were not capitalised. The value of these disconnection is R£0.081m and if included our normalised target would change to R£5.606m⁶ and we would have achieved 101.37% of the normalised target. See paragraphs 91 to 95 for further details.
53. Against the non-normalised target published in our licence, we have achieved 105.26% which includes work delivered prior to RIIO-1, but does not include work funded outside of the baseline asset health allowance (this was explicitly excluded through NOMs target rebasing).

Asset and Intervention definitions

Asset Definitions

54. All monetised risk calculations are based on the assumptions contained in our agreed NOMs Methodology (and the NARMs Methodology for RIIO-2 which is currently under consultation), except for errors or improvements identified through the validation exercise.
55. As described in the Rebasing Overview report and Long Term Risk & Network Risk Outputs supporting document, monetised risk is calculated at individual equipment asset level, using data from our maintained asset register (Ellipse). The SAC asset used for RIIO-1 reporting (as retained to date for RIIO-2 NARM reporting to ensure consistency) is much less granular than the equipment asset level we use to calculate monetised risk. Therefore, aggregation is required to create the SAC

⁶ The total monetised risk removed by not including them is not directly equivalent to the amount that would be added to the target if they were included. Some of these removed assets would have been required to have been intervened upon during the period and so contribute towards the normalised target.

assets used as the basis for monetised risk calculations (see General Assumptions section).

56. As per RIIO-1 rebasing and RIIO-2 NARMs, all SACs with predominantly non-condition driven failure modes have been excluded to ensure alignment with the licence. These excluded SACs are listed below. It should be noted that there is £111.1m worth of RIIO-1 asset health investment associated with these assets that are excluded from the monetised risk target. Further detail on how we propose to report on cost and allowances as part of a potential stage 5 submission can be found in our methodology to calculate associated costs which forms part of our NOMs performance report submission (section IV.).

- Civil assets – drainage (SAC 7)
- Civil assets – access (SAC 8)
- Civil assets - buildings/enclosures (SAC 9)
- Civil Assets – ducting (SAC 10)
- Civil assets - pipe bridges (SAC 11) – the risk is modelled on the associated pipeline
- Civil assets - pipe supports and pits (SAC 12) – the risk is modelled on the associated pipework
- Impact Protection (SAC 24) – including nitrogen sleeves, slabs and depth of cover
- River Crossings (SAC 25) - the risk is modelled on the associated pipeline
- Marker Posts (SAC 26)
- Security Fences (SAC 39)

57. A further £37.7m of asset health expenditure was delivered that claimed zero monetised risk benefits, as the work undertaken did not extend asset life by the required 5 years. Our internal capitalisation policy requires only a 2-year asset life extension. This issue is partly due to the large size of some of our SAC assets, such as above ground pipework and electrical where the “asset” is the whole site and clearly a significant and costly intervention is needed in order to claim an output.

Intervention Definitions

58. We have assumed that all outputs reported and validated through previous RRP returns are correct. Through this work we have identified that the following outputs were omitted and have been included for accuracy. The same rules and principles for claiming NOMs outputs were applied consistently throughout RIIO-1 and are based on evidence of 5 years or more asset life extension.

59. The benefit for the asset must be at the same level of measure as the SAC (i.e. for SAC 32 Above Ground Pipework which has a per site unit of measure, the NOMs output must also be per site). Our internal policy for capitalisation states that only a two year (or more) asset life extension is required.
60. A considerable amount of investment has been capitalised that has not delivered the 5-year life extension required to claim any monetised risk outputs, particularly when the SAC asset is quite large, and the work needed to extend the life of the whole asset is extensive (e.g. cab infrastructure; electrical).

Non-Load Asset Removals and Additions

61. Where assets were added to or removed from the network through a non-load driven investment or intervention, their monetised risk values in the start position, with intervention position and without intervention position, was excluded from our delivered position.
62. As part of the template guidance, we have now monetised this and reported on all risk and volumes in the Total Network Asset Base (i.e. asset base at the end of RIIO-1) (position A), allowing volumes associated with load-related (non-asset health) interventions to align with previous RRP table 6.6 reporting. The monetised risk associated with these interventions are treated as normalisations to target delivery (not actual delivery), following Ofgem guidance on consideration of relevant risk changes as part of stage 1 of the NOMs Incentive Methodology.

Benefits of Intervention

63. The same assumptions used to set targets through rebasing were used to define the benefits of each intervention:
 - For non-Below Ground Pipelines (SAC 33) Replacements (a new asset) a 90% reduction in PoF and reduction in asset age to zero
 - For non-SAC 33 Refurbishments (a re-lived asset) a 50% reduction in PoF and a SAC-specific reduction in asset age was assumed
 - For SAC 33 refurbishments (ILI survey and subsequent dig and repair) the risk reduction is applied to the whole pipeline section, should defects be identified and rectified
64. The interventions are applied initially by choosing the median asset within the AH5 band and subsequent assets chosen by iterating either side of this median asset until all interventions are applied. If all AH5 assets are chosen for intervention, this approach will then apply to the assets in the next available band (e.g. AH4) until all the actual interventions have been applied. This approach is necessary because the RIIO-1 SAC asset register does not align to specific assets on a site. We have necessarily used this same asset base for RIIO-2 planning and outputs setting to

align with RIIO-1 reporting, but a plan is in progress to rectify this prior to RIIO-3 plan submission⁷.

65. As per the RIIO-1 target rebasing exercise, SACs have the same intervention type applied, based on what was the most likely for that SAC. This intervention-type data was not required for historic table 6.6 reporting and was not recorded. This is likely to be immaterial as the same policy was generally adopted throughout RIIO-1 (e.g. all pipeline interventions, dig and repair corrosion/mechanical defects, are treated as Refurbishments; all compressor train overhauls are also all Refurbishments) and the same assumption applied to both target setting and outputs reporting.

General Assumptions

66. The rebased target was generated using our original RIIO-1 BP, using a 2010/11 asset base baseline. As the RIIO-1 period did not formally begin until the 1st April 2013, this leaves a 2-year period between the setting of the target and the start of the price control period. Many investments had taken place over this period, using TCPR4/Roll-over funding, and the asset base was significantly different at the start of RIIO-1 than assumed in the RIIO-1 BP. To ensure that RIIO-1 spend and outputs delivery are aligned we have needed to remove the impact of this pre RIIO-1 investment from our performance as a normalisation.
67. Much of the process adopted to undertake our RIIO-1 monetised risk analysis is documented elsewhere^{8,9} but is summarised here for completeness.

Calculation of Initial Monetised Risk per Asset

68. There is no direct correlation between a SAC asset and our Ellipse asset register and so gap filling is required. This is because the Ellipse asset register, used for monetised risk analysis, was implemented during the RIIO-1 price control and after the confirmation of RIIO-1 targets. This gap filling was carried out using a nearest neighbour analysis, whereby if a specific Ellipse asset (or assets) could not be directly matched to a SAC asset, a similar Ellipse asset was used, based on its probability and consequence of failure (PoF and CoF)¹⁰.

RIIO-1 Start Position

69. As described previously, there was a 2-year gap between submission of the RIIO-1 BP (which was based on a forecast RIIO-1 start position) and the actual start of RIIO-1. We have assumed that the 2012/13 RRP return represents the true start

⁷ Long Term Risk and Network Risk Outputs supporting document, Section 5

⁸ Methodology for Network Output Measures (May 2018); Methodology for Network Asset Risk Metrics (May 2021)

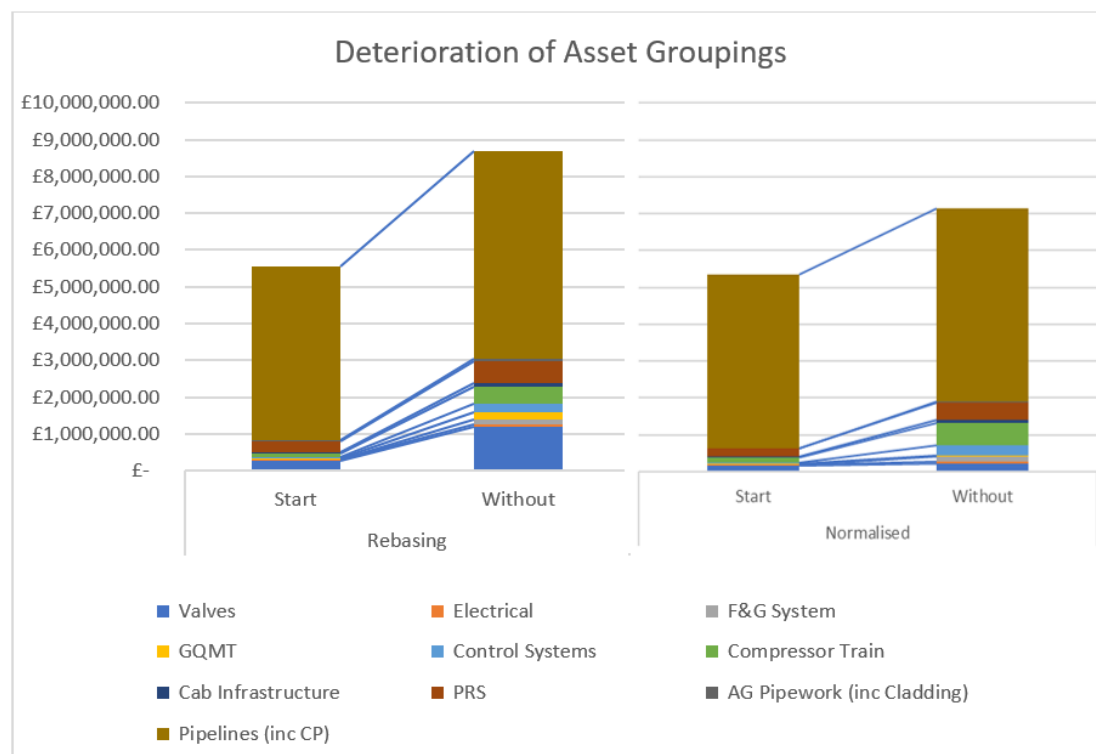
⁹ Rebasing Overview Report, July 2019

¹⁰ Rebasing Overview Report, Section 2.6

of RIIO-1 and any differences between RIIO-1 BP and 2012/13 RRP are due to asset health and non-asset health interventions. The monetised risk benefit of these was calculated using the same process as described later for measuring the RIIO-1 investment benefits. Applying these pre RIIO-1 interventions has the following implications. As more interventions were carried out than forecast, the true monetised risk position at the start of RIIO-1 was lower than assumed in the RIIO-1 BP.

70. As these interventions were carried out on the higher risk assets, this has the impact on the risk benefit delivered by each subsequent intervention during RIIO-1. This reduction in the rate of deterioration by the intervention on high-risk assets prior to the start of RIIO-1 means that the monetised risk delivered by each investment is lower than assumed in the RIIO-1 BP and rebasing. The graph below shows that the rate of deterioration is visibly reduced by normalising for the pre RIIO-1 interventions (right graph) when compared to the unnormalised rate of deterioration assumed for rebasing (left graph).

Figure 3 Deterioration of Asset Groupings



71. Because of this it is necessary to undertake a normalisation to ensure that the benefits of pre-RIIO-1 investments are not counted and the reduced monetised benefit arising from RIIO-1 investments is also considered. This impact can be seen in the Pre-RIIO-1 true-up column ('3.3.1_Normalisations_Targets' sheet) where depending on the difference between the forecast and actual pre-RIIO-1 work, there can be a positive or negative impact on the normalised target.
72. An illustrative example of this is provided for clarity. For a SAC **Y** say we have two assets **A** and **B**, with a 'without intervention' value of R£4.0m and R£3.0m in Year 8 respectively. We had planned to do a single intervention in SAC **Y** to

reduce the monetised risk by 90% (PoF and deterioration reduction). Through rebasing we had assumed this would take place on asset **A**, giving a final position of R£0.4m. However, if asset **A** had already been intervened upon prior to RIIO-1 starting, so in RIIO-1 we would intervene on the next highest, asset **B**, again with an assumed 90% reduction in monetised risk. This would then give a final Year 8 position for asset **B** of R£0.3m, but this intervention now delivers less benefit than assumed for rebased target setting. Previously it was worth R£3.6m but is now only worth R£2.7m because of the lower deterioration rate enabled by the pre RIIO-1 interventions.

Banding of Asset Health and Consequence Values

73. As per the rebasing exercise, it was necessary to re-band assets into Health and Consequence bands based on these normalised start RIIO-1 monetised risk positions. The banding process used is identical to rebasing and is summarised below.
74. To consider low or high value outliers¹¹, a banding approach was agreed with Ofgem to incorporate extreme values into the top and bottom ends of the Health and Consequence bands. First, the upper and lower 10th percentiles were separated out, then the remaining values divided into five equal bandings. In the example for Heath below, the bottom and top percentiles are then included in AH1 and AH5 bands, respectively.
75. It should be noted that as all these bandings are relative to the highest and lowest Health and Consequence values per PAC and SAC, that **the risk banding could be different between target setting and actuals for the same asset**. This could be the case even if the start risk position and deterioration rates are identical as the banding is impacted by other assets in the same PAC/SAC population. Banding is unreliable for assessing risk and performance expressed in quantitative, rather than qualitative terms.

AH1	AH2	AH3	AH4	AH5
Includes bottom 10 th percentile, plus the next fifth of the PoF values	Equally Banded	Equally Banded	Equally Banded	Includes the top 10 th percentile plus the previous fifth of the PoF values

76. It should be noted that when calculating monetised risk benefits, the pre- and post-intervention band is based on pre- and post- monetised risk values. Because the spread of Health and Consequence values can be quite wide, and the probability distribution not normalised, the pre- and post- intervention bandings can be the

¹¹ Health and Consequence values within a specific SAC grouping are not Normal distributions, which poses statistical challenges for banding

same (e.g. a refurbishment can see the asset remain in AH4), although there is a reduction in monetised risk. The position of an asset in a band should be viewed as indicative of its PoF and CoF values relative to other assets in the same PAC/SAC population. For an absolute quantification of asset risk the actual PoF and CoF values should be used.

77. Assets can move between CoF bands, this is because some failures have no monetary impact so the POF increases with no MR increase. COF is then decreased as CoF is the MR divided by the PoF. This gives a lower CoF value later in the period and so the asset moves consequence band.

Fair Comparison of Asset Base

78. To accurately compare and assess our performance. our delivered outputs need to be on the same asset base as the normalised target. To do this we have started baselined the asset base from the start of RIIO-1 as per our 2013 RRP table 6.6 return. To do this we:

- Did not consider load-related removals for interventions and baselined their risk value at the start of RIIO-1
- Did not value any load-related additions to the NTS; these were considered to set the baseline risk position for RIIO-2 NARMS assessment
- Applied the asset health interventions using the same rules as used for the rebased target setting

79. This means the normalised target and the delivered outputs now have the same start point and end point **without intervention**, which is a true baseline for assessing the with intervention outcomes.

Changes Made to Data Template for NGGT specific Requirements

80. As discussed in our bilateral meeting held with Ofgem on the 22nd June 2021, any changes required for the data template to align to NGGT's specific requirements can be made with accompanying mark-up and narrative. These have been discussed with Ofgem and comprise of two parts, both of which are in formulas and relate to the differences between the *Total Network Asset Base* (i.e. the asset base at end RIIO-1), or position **A**, and *Original (Start RIIO-1) NOMs Asset Base*, or position **B**.

81. These changes are outlined in *0.5_Submission_Version_History* of our template but are expanded on in more detail here. The changed cells are highlighted in Red to show where we have made changes to the published template. They are required due to the way we have aligned our data to the two categories.

- Position **A** contains all our assets, including the load-related additions and removals

- Position **B** contains only assets which were available for asset health interventions, i.e. doesn't include load-related removals or additions which were discounted as part of the normalisation.

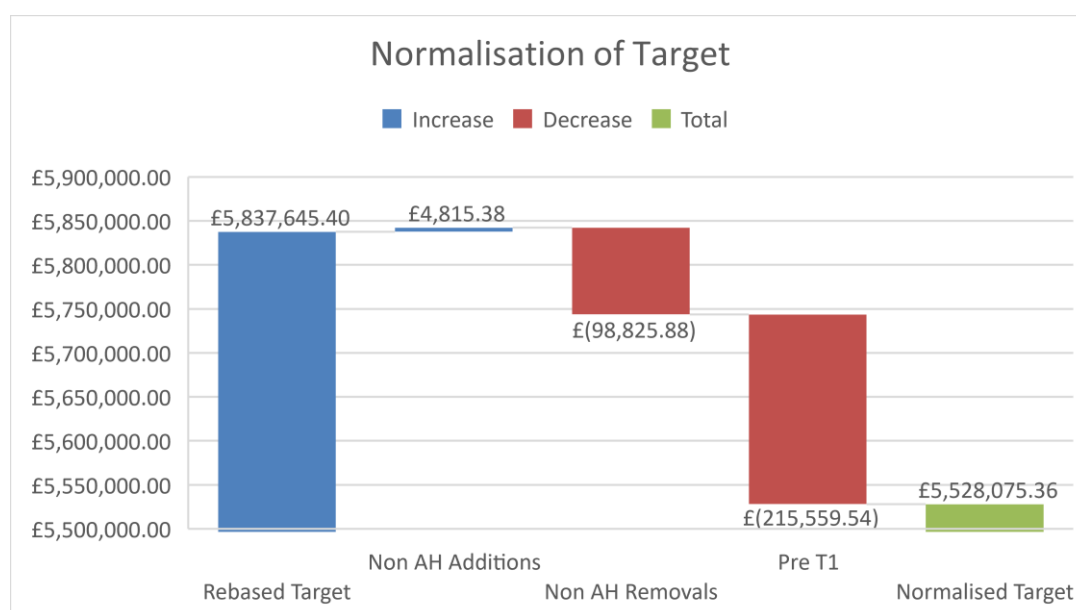
82. There is also the position *Impact of Change in Asset Base Over RIIO-1*, or position **C**, which is **A** minus **B**, i.e. the value of load-related removals and additions to the network.

- In the *Tab 3.3.1_Normalisations_Targets*, the normalisation called Impact of Change in Asset Base Over RIIO-1 in Column O, this has carried position C from the delivery sheet and applied it to the Without Intervention target as an addition
- For Position **C**, the only assets that appear in **A**, but not **B**, are the load-related removals value in 2020/21 as the new additions are only added in the with intervention position. As these are removals and they have been discounted in position **B**, these should be negative rather than positive. The cells have had their formula multiplied by -1 to make the additions removals.
- An illustrative example of this is provided for clarity. For a specific SAC **G** contains only two assets **X** and **Z**, with a 'without intervention' value of R£4.0m, R£3.0m in Year 8 (2020/21) and we had planned to do a single intervention in SAC **G**. Asset **X** is removed in the period through a non-asset health removal, and so is removed from our **B** position at all positions and not available to intervene on in the process used to normalise our target. The asset **X** is monetised and reported in our **A** position as per the guidance provided. For the SAC **G**, the target is set only around the **Z** asset, so the without position is R£3. To normalise the target from our licence to our normalised, we need to deduct the value of Asset **X** as we have done to our actuals and in our normalisation.
- For our reporting the true delivered position is **B**, this aligns with the assets available to do interventions on and discounted the load-based removals and additions. Reporting of delivery is through multiple tabs in the template, and so we have implemented the change in the tab *2.2.1_Delivery_Pre_Norm* as this appears to be the start of the sequence to report the delivered position. Previously, the data template pulled this information through from position **A** which is different from position **B**, as the load-based addition and removals risk changes must be discounted from delivery and target as per the rebasing principles. For the With Intervention scenario, the difference between positions **A** and **B** is minor (~£5k), and accounts for load-based new additions arising through new customer connections and connection of IED compliant units (new assets have minimal monetised risk), however for the start and without position the difference is considerably different and so any uses of these positions would be incorrect and would be incomparable to our normalised target as the start and end position would be markedly different and we would not be comparing the RIIO-1 BP interventions to our delivered interventions on an equivalent asset base.

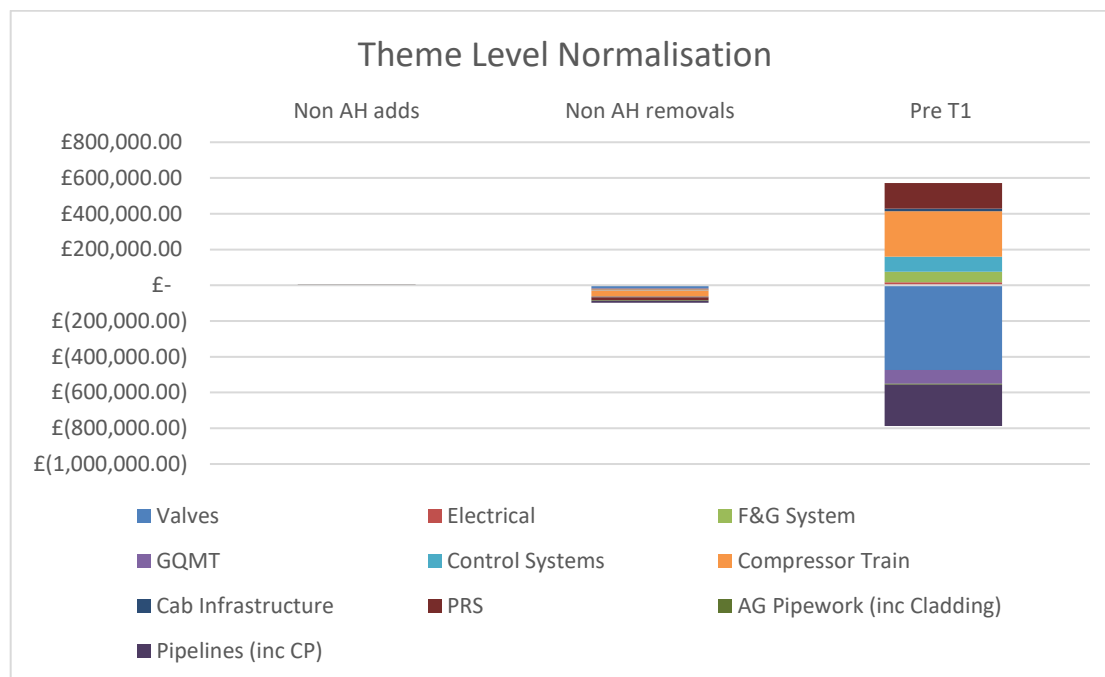
RIO-1 Targets

83. Several core assumption and principles were agreed with Ofgem for setting the rebased target¹². The impact of these assumptions was largely tested through the equally challenging tests leading up to agreement of the rebased target. Identical assumptions were used when quantifying the monetised risk benefit of actual outputs.
84. The assumptions to quantify and exclude the monetised risk benefits associated with load-related interventions (normalisation of target) are described below. These are the principles used to undertake normalisation to ensure that both target and actual risk positions are compared on an equivalent basis, pre- and post- exclusion of load-related interventions.

Figure 4 Value of the Steps taken to Normalise the Target



¹² Rebasing Overview Report, Section 2.3

Figure 5 Theme level Values of the Normalisations

Load-related Asset Additions

85. The monetised risk associated with forecast additions to the NTS over RIIO-1 have been ignored when normalising the target as they were excluded from the rebased target. The logic for this is as follows:

- These additions effectively add risk to the NTS and do not contribute to transparency of actual performance against the rebased position.
- This principle means that the new asset will not contribute to NTS risk profiles, including the 2020/21 forecast. These new assets do appear in the baseline defined for RIIO-2 NARMs assessment.

Load-related Asset Removals

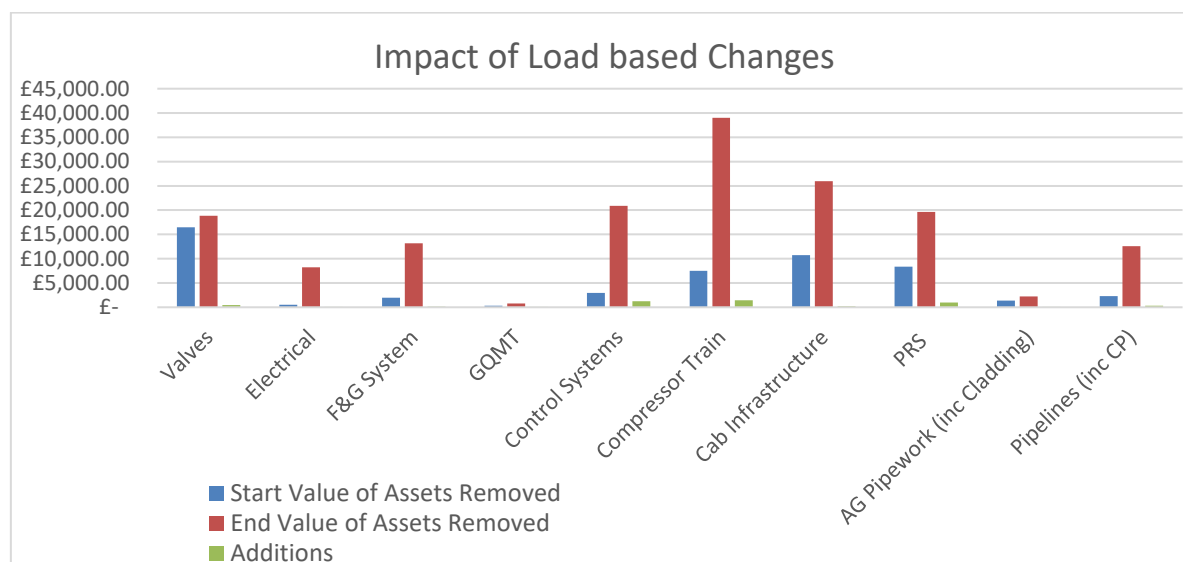
86. Assets forecasted to be removed (either disconnected or decommissioned) from the NTS over RIIO-1 may be considered, depending on the driver for removal. Removals will effectively remove risk from the network and may or may not reduce overall system resilience:

- If driver for removal was asset condition all risk benefit will be claimed in Year 8 (consistent with how the rebased target was set)
- If the driver for a removal was not explicitly asset condition-driven, and funded through baseline capex asset health (which is a valid asset management decision), the monetised risk associated with this removal will be ignored (as per new additions)

- We have assumed zero impact on overall system resilience from removals (as a decision to remove is unlikely if it puts at risk overall NTS availability/reliability)

87. This approach prevents load-related removals, such as customer requested disconnections, from confusing our actual performance against the rebased target whilst accounting for the risk benefit delivered by condition-driven removals (e.g. a block valve pipe-through).

Figure 6: Value of Load Asset Changes by Theme



Monetised Risk Calculation Assumptions

88. All assumptions used to derive asset monetised risk and the benefits of investment are equivalent, for both target and actual values. These assumptions and valuations are as documented in the current Methodology for Network Output Measures¹³. All values and assumptions used are consistent between:

- RIIO-1 rebasing and monetised risk target setting
- Cost benefit analysis supporting the RIIO-2 asset health business plan submission
- RIIO-2 NARMS submission and target setting

¹³ The Validation Report contains the most detailed and current record of assumptions used. The new Methodology for Network Asset Risk Metrics (currently undergoing consultation) has been updated such that consistent assumptions and valuations are used throughout the Methodology document suite

89. We have highlighted in our new Methodology for Network Outputs Measures that several updates to assumptions and valuations will need to be incorporated prior to RIIO-3 planning¹⁴.

Asset Data Improvements

90. During the rebasing exercise SAC 47 Slam-shut valves were excluded as the asset register data we had was not suitably coded to allow slam-shut valves to be separated from other valve assets, as a slam-shut operation is a function and the valve asset itself is not distinguishable (other than the association with a control mechanism to trigger the slam-shut operation). As such we were not able to monetise them and they were combined with other valve SACs. Following a data improvement exercise, we can now separately identify slam-shuts and monetise them. For clarity, this is not a change to targets (or delivery) but means that slam-shuts can be reported separately from other valves assets.

RIIO-1 Delivery

91. This section explains our overall performance against our normalised targets. References to specific sections of the RIIO-1 closeout data template are included, where necessary.

Overview

92. It should be noted that the modelled monetised risk benefits were not used to specifically target our RIIO-1 investments (most obviously as this data did not exist until recently). Our RIIO-1 delivered programme of work (which is explained in the Performance Report) was generally targeted based on:
- Resolution of known defects, where these defects had a high risk of legislative non-compliance and/or service disruption to customers
 - Proactive action based on asset condition surveys, where these proactive interventions were deemed to be deliverable based on the availability of suitable NTS outages to undertake the work
 - In line with existing, documented company policy to achieve legislative compliance
93. Compliance activities are driven by the consequences of any failure and do not directly account for the likelihood (probability) of those consequences occurring. Therefore, delivery of compliance work does not necessarily generate significant

¹⁴ Main Overview Document (Section 5.2) and Long Term Risk & Network Outputs Measures supporting document (Section 5)

quantifiable risk reductions. This is one of our key challenges for delivering our NARM outputs in RIIO-2.

94. An example of this is our PSSR requirement for below ground pipelines inspection, where we have an internal policy to intervene where the feature/defect has effectively reached or exceeded the limit of the superficial category. Without intervention, it could still be many years until a corrosion leak occurred, and even then, the physical location of the pipeline could suggest that an actual ignition and explosion event, causing death or injury, is unlikely. Regardless of this, we are still required to undertake the defect repair to ensure compliance and this would deliver only a small risk reduction benefit.
95. A similar requirement exists to undertake corrosion repairs on above ground pipework, which has incurred significant spend over RIIO-1 but delivers a small risk benefit. The need to investigate and repair these pipework corrosion defects is again in accordance with policy (e.g. defects in severity category 4, 5 or 6 are subject to further investigation and depending on the outcome, any defect not classified as superficial requires intervention to rectify).

Impact of Compressor Unit Disconnections

96. When considering our overall monetised risk performance, we would like to highlight that this does not include the disconnection of five compressor units delivered through opex budgets. These disconnection costs were not recorded in RRP table 4.2 cost reports as these only included capital costs.
97. These disconnections were accounted for in previous table 6.6 RRP returns as there is no distinction between capex and opex delivered outputs. The disconnections and positive isolations are required under a range of legislations including COMAH and DSEAR, under which we are required to undertake measures to prevent and mitigate hazards. If the units had remained connected, but accrued zero hours, we would have been required to undertake maintenance, including statutory works, to ensure that the units complied with the relevant legislation.
98. These disconnections should be considered when forming a view of our overall RIIO-1 monetised risk performance as the risk posed by these assets has now been removed from the network. These five units had asset health issues that were non-economical to repair and were also non-compliant with the IED, limiting the unit's remaining lifetimes and hence the network's benefit from any investments. These units were:
 - Churchover A
 - Churchover B
 - Kirriemuir D
 - Carnforth A

- Kings Lynn A

99. If we did not reference these benefits we would be communicating an incomplete and misleading picture of our totex risk performance over RIIO-1 to stakeholder, especially as our performance excludes £37.7m of asset health expenditure for which there has been a reduction in risk, but we are unable to turn into a quantified value through the NOMs methodology to be able to claim an appropriate monetised risk benefit.
100. If we included the disconnection of these five compressor units, and their associated ancillary assets, our overall performance would be 101.37% of our rebased, normalised target.

Normalised Performance

101. A SAC by SAC summary for all significant contributions to spend and outputs is included within the Performance Report. As the definition of a SAC asset is in some cases very large (e.g. a whole site) or very small (e.g. starter motor).
102. The overall risk to the network is associated with the overall system, not a specific asset, we have grouped several SACs logically to analyse monetised risk performance over RIIO-1. This provides a clearer picture of the trends underlying our overall performance, when compared to examining individual SACs. These are broadly in line with the Campaigns used for financial reporting in RRP table 4.2a, but the National AGI Renovation Campaign (NARC) programme has been split out for clarity. Please note, the monetised risk values are absolute risk values, not risk removed as per the NARM metric.

Table 2 Normalised performance

Asset Grouping	SACs Included	Start MR	Target MR	Actual MR	% Act. vs Target
Pipelines (inc. CP)	15,33	£4,702,427 (88%)	£4,339,994 (79%)	£4,199,081 (76%)	-3.25%
Compressor Train	14,23,28,34,38,40,41	£126,840 (2%)	£413,567 (8%)	£406,987 (7%)	-1.59%
Pressure and Flow Regulation	18,21,35,47	£210,769 (4%)	£282,756 (5%)	£375,051 (7%)	32.64%
Valves	43,44,45,46	£173,392 (3%)	£184,957 (3%)	£192,956 (3%)	4.32%
Control Systems	5,29,36,37	£49,000 (1%)	£115,662 (2%)	£140,051 (3%)	21.09%
Fire and Gas Systems	19,20	£21,856 (0%)	£91,497 (2%)	£84,702 (2%)	-7.43%
Cab Infrastructure	2,3,4,6	£31,230 (1%)	£40,541 (1%)	£82,719 (1%)	104.03%
Electrical	16,17	£8,366 (0%)	£37,095 (1%)	£30,409 (1%)	-18.02%
Above Ground (AG) Pipework (inc. Cladding)	1,13,32	£12,902 (0%)	£11,447 (0%)	£12,101 (0%)	5.71%
Gas Quality and Metering (GQMT)	22,27,30	£6,305 (0%)	£10,560 (0%)	£6,592 (0%)	-37.58%
Totals		£5,343,087	£5,528,075	£5,530,649	0.05%

103. Our overall reported performance of R£2,574 below a target of R£5.528m (99.95%) comprises both under- and over-achievement against the rebased target for each logical asset grouping. A short summary of reasons for these trends follows, based on the individual SAC reports. Again, it should be noted that investments were not targeted based on monetised risk reductions and were generally focused on resolving known defects to comply with legislation or mitigate potential risks to service (e.g. restoring valve operability).

Pipelines (including Cathodic Protection (CP))

SAC specific narratives for SAC 15 Cathodic Protection, SAC 31 Pig Traps and SAC 33 Below Ground Pipelines are included in section III.

104. Our statutory inspections and regime of ILI digs allowed us to understand the integrity of our pipelines and for any necessary remediation to be targeted; this delivered an 8% reduction in monetised risk over RIIO-1 due to increased volumes than expected at the time of the RIIO-1 business plan submission. This has meant that less was available to be invested in cathodic protection system improvements (SAC 15) resulting in a 71% achievement of our rebased target for the SAC.

- 105. Investment in pig traps (SAC 31), through our statutory PSSR inspection and rectification programme, has delivered an overall over-delivery against rebased target for this asset grouping of 3%.
- 106. The pipelines asset grouping contains by far the largest proportion of the overall NTS monetised risk target (79%), and we have delivered 103% of the normalised target for the SAC. This has compensated for some under-delivery in other asset groupings.
- 107. As highlighted to Ofgem through the RIIO-2 NARM submission, the SAC 33 Below Ground Pipeline category is too large for useful outputs reporting and should be disaggregated in the future (to individual feeders, or pipeline sections).

Compressor Train

SAC specific narratives for SAC 23 Gas Generators and SAC 34 Power Turbines are included in section III.

- 108. Investment in this category is largely driven by actual compressor run-hours and Original Equipment Manufacturer (OEM) recommended overhaul frequencies and regimes. There were greater running hours than expected over RIIO-1 and more start-stop cycles were required. Consequently, we have had to adapt our overhaul programme.
- 109. More gas generators (SAC 23) were overhauled than forecasted in the plan, resulting in a 43% reduction in monetised risk. Fewer power turbines (SAC 34) were overhauled due to several being flagged for replacement through the IED programme, but those that were delivered reduced risk by 4% more than the normalised target for the SAC.
- 110. Risk increases on the remaining SACs with relatively small asset health allowances, and those with predominantly a cyber security driver for intervention, resulted in an overall 2% more than the normalised target for the compressor train asset grouping.
- 111. For SAC 42 Variable Speed Drives (VSDs), in many cases the delivered intervention was not enough to deliver the 5-year life extension required to claim an output.

Pressure and Flow Regulation

SAC specific narratives for SAC 18 Filters & Scrubbers and SAC 21 Flow & Pressure Regulators are included in section III.

- 112. Investment in this category was primarily driven by our statutory requirement to undertake inspections under PSSR legislation and follow-on remedial actions to achieve compliance. The compliance driven work was anticipated to result in an increase on monetised risk over the period.

113. With the availability of long-term monetised risk data, it is now obvious that proactive intervention to prevent failure is more economically justifiable than inspecting and reactively intervening to resolve identified defects, as was the policy in RIIO-1. The defects identified through this policy-driven approach delivered significantly less monetised risk reduction than anticipated when setting the target.
114. As PSSR inspections are time-, rather than risk-based, and the volumes and unit risk benefit depend on what is found during the survey (and not known up-front) performance in this grouping is largely outside of our control, especially given the late transition to a monetised risk-based target. Delivery of the necessary PSSR compliance works resulted in only 67% of the normalised target for this asset grouping being achieved.

Valves

SAC specific narratives for SAC 43 Locally Actuated Valves, SAC 45 Safety Valves and SAC 46 Process Valves are included in section III.

115. Valve interventions have been mostly delivered through our NARC programme which has sought to maximise delivery efficiency through works bundling. This programme has been targeted based upon:
- Availability of outages to degas the site and undertake intrusive works
 - Assessed asset condition
116. We have not directly considered the modelled asset condition, nor was monetised risk data available at the time the programme of works was developed. As a result, although we have delivered significantly more than the RIIO-1 business plan funded volumes we have nevertheless under-performed against the monetised risk target. For all valve types, this we have delivered 4% less than the rebased target.
117. In the case of locally actuated valves (SAC 43) we have delivered 6-times the volumes of work but have delivered only 51% of the normalised target, as a result of the need to undertake work where there was a real asset condition issue to be addressed, but a low monetised risk benefits.
118. For process valves (SAC 46) we delivered around 80% more volumes than funded and only delivered 87% of the rebased target, again due the need to intervene based on actual rather than modelled condition.
119. For remotely operational valves (SAC 45), we delivered a lower volume of work than planned but a 106% of the rebased target by intervening on higher risk assets. This was mostly due to the increased awareness of the potential for cyber-attacks and unauthorised operation of these assets, which changed our approach and a move towards a lower number of ROVs on the network overall to mitigate this threat.

- 120. The relatively low monetised risk benefit per valve intervention arises because in many cases there would need to be several LAVs non-operational in combination for a material service risk to materialise, and the NOMs Methodology does not fully take account for inter-asset dependencies at the sub-site level.
- 121. Our RIIO-2 approach will seek to maximise long term risk benefit, but in many cases low value interventions will be unavoidable to ensure the safe and effective operability of the network.

Control Systems

SAC specific narratives for SAC 36 Station Control Systems and SAC 37 Unit Control Systems are included in section III.

- 122. The RIIO-1 strategy for Control Systems (including Telemetry) was to minimise proactive interventions to sustain the operability for enough time for systems to be replaced alongside the IED legislative works. To maximise bundling efficiency and take advantage of outages made available for other works, this work was undertaken in combination with other types of asset investments and did not take direct account of the overall site criticality.
- 123. Control systems failure modes are largely due to obsolescence and reactive failure (utilising grey spares, where available, to rectify any defects or failures) and it is not possible to identify trends leading to future failures needed to plan proactively. In 2016, the new NIS Directive (which became UK law in 2018) impacted upon our thinking and reduced the volumes of control systems investments delivered. These works are now subsumed into our cyber security programme and prioritised based on cyber-threat rather than asset health (condition).
- 124. This approach meant that we delivered less monetised risk per intervention than forecasted in the rebased target, and 21% less monetised risk delivered than the rebased target.
- 125. Station control system (SAC 36) and unit control systems (SAC 37) under-delivered only 30% and 62% of the rebased target respectively, based on the adopted prioritisation approach. Recovery of this risk performance is a major secondary benefit of our RIIO-2 cyber security investment programme. Network control and instrumentation (SAC 29) and boundary controllers (SAC 5), mitigated some of this shortfall by delivering 165% and 113% of the normalised target respectively.
- 126. Future investments on these assets will be delivered as part of our overall cyber security strategy and are not directly included in the RIIO-2 NARMs target.

Fire and Gas Systems

There is no SAC specific narrative for these assets as they have not generated material costs or monetised risk outputs.

- 127. Deferment of investment in fire and gas systems associated with compressor train assets, is a result of considering the future challenges posed by the IED directive.

This has required consideration of future opportunities to deliver efficiency through bundling or assessing whether there is a need to invest on compressor units which may be decommissioned in the near future.

128. Investment on fire and gas detection (SAC 19) has resulted in a 4% over-delivery of risk whereas fire suppression systems (SAC 20) has delivered 120% of the normalised SAC target by 20%, resulting in 107% of the target being achieved for this asset grouping. These offset a proportion of the overall monetised risk under-delivery for the associated compressor cab infrastructure asset grouping (below).

Cab Infrastructure

There is no SAC specific narrative for these assets as they have not generated material costs or monetised risk outputs.

129. As per fire suppression, this deferment in expenditure is due to the changing requirements of the IED directive and uncertainty over future investment requirements, resulting in an overall 104% under-delivery for this asset grouping. This is partially offset by over-delivery in the associated Fire & Gas Systems asset grouping (which forms part of the overall compressor cab infrastructure).
130. As a result of the above, there have been risk increases on all SACs within this grouping, namely:
- Aftercoolers (SAC 2) only delivered a small proportion of the normalised target, as the future investment need is dependent on the overall St Fergus site strategy. There were also interventions delivered that did not extend asset life enough to be counted
 - Air Intakes (SAC 3) achieved 71% of the normalised target for the SAC
 - Cab Ventilation (SAC 6) achieved 83% the normalised target for the SAC
 - Exhausts (SAC 4) only achieved a small proportion of the normalised target

Electrical

A SAC specific narrative for SAC 16 Electrical (including Standby Generators) is included in section III.

131. The failure modes driving investment on electrical assets are generally obsolescence and/or compliance standard and legislative requirements, such as the DSEAR, rather than increases in failure rates due to age and/or condition.
132. Use of grey spares allowed us to defer capital expenditure where possible and to offset the lack of allowances in other areas (such as Bacton and above ground pipework). Overall, we delivered 82% of the normalised target for this asset grouping, comprising 176% of target for Electrical Systems, including Safe Shutdown (SAC 17) and 48% of target for Electrical Systems, including Standby Generators (SAC 16).

133. Due to the site-level unit of measure for this SAC, several investments were delivered that did not contribute towards the monetised risk output.

Above Ground Pipework (including Cladding)

A SAC specific narrative for SAC 32 Above Ground Pipework is included in section III.

134. A significant amount of asset health expenditure has been diverted to our above ground pipework assets, despite there being a zero allowance in the RIIO-1 final determination. We had previously believed that routine inspection and site painting was enough to manage risk and maintain integrity, but it became obvious that this was not sufficient to address the observed rate of deterioration and a more aggressive approach was adopted by bundling site remediation works through the NARC programme.
135. Above ground pipework does not contribute significantly to monetised risk, largely due to the relatively low consequence of failure (particularly at unmanned, rural sites) and this is another example of where our HSE-agreed policy is not fully aligned with our regulatory commitments to maximise monetised risk benefits.
136. We have delivered 93% of the normalised target for Above Ground Pipework (SAC 32), and 94% of target for the wider asset grouping (including SAC 1 Cladding and SAC 13 fuel tanks and bunds).
137. Due to the site-level unit of measure for this SAC, several investments were delivered that did not contribute towards the monetised risk output, including much of the CM/4 defect resolution work at St Fergus Terminal.

Gas Quality and Metering

SAC specific narratives for SAC 22 Gas Analysers and SAC 27 Fiscal Meters are included in section III.

138. Gas quality and metering is another asset grouping where we have incurred significant spend which contributes only a small amount towards the monetised risk target. Again, the need to invest is primarily driven by compliance with legislation, such as the Gas Safety (Management) Regulations and Gas (Calculation of Thermal Energy) Regulations rather than condition/age deterioration.
139. We were required to deliver more investments than proposed in the RIIO-1 business plan and delivered 140% of target for this asset grouping, comprising a 146% of target for gas analysers (SAC 22), 121% of target for fiscal meters (SAC 27) and only a small proportion of target for odourisation plant (SAC 30).
140. Future investments on these assets will be delivered as part of our overall cyber security strategy and are not directly included in the RIIO-2 NARMs target.

Five compressor unit disconnection data

141. When considering our overall monetised risk performance, we have noted that in paragraph 5, that the data table has not include the disconnection of five compressor units delivered through opex budgets. How this change would have impacted delivery is discussed in paragraphs 96 onwards. The mechanism of this action is described through the table narrative with an example of the impact of non-load removals described in paragraphs 78 onwards. Presented below is the monetised risk data associated with that work:

Table 3: Compressor disconnections

SAC	SAC Name	Count	Monetised Risk Value R£		
			Year 0	Year 8 With Intervention	Year 8 Without Intervention
3	Air intake	4	£ 343.2	£ -	£ 1,417.6
4	Exhausts	4	£ 327.9	£ -	£ 532.2
6	Cab ventilation	4	£ 66.0	£ -	£ 451.9
14	Compressor	4	£ 548.4	£ -	£ 3,083.9
18	Filter and scrubbers	6	£ 40.0	£ -	£ 128.3
19	Fire and gas detection	3	£ 1,564.9	£ -	£ 8,160.5
20	Fire suppression	1	£ 246.7	£ -	£ 2,861.4
21	Flow or pressure regulator (incl. measurement)	4	£ 3,008.9	£ -	£ 10,246.7
23	Gas generator	5	£ 2,210.4	£ -	£ 11,967.8
28	Fuel gas metering	3	£ 4.7	£ -	£ 25.0
34	Power turbine	5	£ 3,649.5	£ -	£ 16,089.1
35	Preheaters	1	£ 165.5	£ -	£ 561.0
37	Unit control system	4	£ 1,894.5	£ -	£ 17,978.8
38	Anti-surge system	4	£ 740.7	£ -	£ 6,856.5
40	Starter motor	3	£ 319.5	£ -	£ 978.3
43	Locally actuated valves	64	£ 3.7	£ -	£ 8.6
44	Non return valve	3	£ 20.7	£ -	£ 52.4
46	Process valves (Remotely Operable Valves)	11	£ 14.9	£ -	£ 36.0
47	Slam shut system	3	£ 8.7	£ -	£ 8.9
Total		136	£ 15,178.7	£ -	£ 81,445.0

Conclusions

142. We have explained the key assumptions made to complete the RIIO-1 NOMs closeout data template, including:
- A recap of how the RIIO-1 monetised targets were set, including key assumptions made

- A description of how we have normalised to exclude pre RIIO-1 delivered work and non-load interventions delivering NTS risk changes. As per Ofgem guidelines, these normalisations have been applied to targets rather than delivery
143. A summary of our RIIO-1 performance, by asset grouping, explaining the trends in the reported monetised risk numbers and performance against normalised targets (more detail to be found in section III.)
144. We have delivered a RIIO-1 monetised risk performance of R£5.531m, against a normalised target of R£5.528. This corresponds to a 99.95% of this normalised target. This does not include R£0.081m worth of monetised risk benefit from five asset health related compressor unit disconnections, which were not capitalised.
145. We believe that this performance corresponds to a material achievement of our RIIO-1 monetised risk target, assuming a reasonable dead band value of $\pm 5\%$.

III. SECONDARY ASSET CLASS (SAC) REPORTS

i. SAC 15 Cathodic Protection

Executive Summary

146. The proportion of Total Monetised Risk (TMR) on the network attributable to our cathodic protection assets is 0.05%. In RIIO-1 we have invested £12.0m in Cathodic Protection (CP) and have under-delivered on this SAC monetised risk target by 71%, which is a result of less work delivered compared to our RIIO-1 BP.

Table 4 Cathodic Protection Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention Position (Normalised) - 31st March 2021		Actual Monetised Risk - 31st March 2021	
Entry Point	£ 53.84	8%	£ 320.85	12%	£ 454.60	10%
Exit Point	£ 221.15	33%	£ 1,038.25	40%	£ 1,298.85	29%
Compressor Station	£ 192.03	29%	£ 813.70	31%	£ 1,236.63	28%
Pipeline	£ -	0%	£ 1.45	0%	£ 189.37	4%
Multijunction	£ 193.48	29%	£ 424.08	16%	£ 1,262.52	28%
Total	£ 660.50		£ 2,598.34		£ 4,441.97	71%

Introduction and investment drivers

147. The key deterioration mechanism of buried steel pipe is external corrosion which is protected primarily by a pipeline coating and supported by a CP system. CP systems are designed to provide protection to the steel where there are defects in the coating, however, where these defects are significant, the CP system may no longer provide the required level of protection to alleviate external corrosion, which in turn will reduce pipe wall thickness. If the external corrosion is not addressed and wall thickness continues to erode, the pipeline will eventually fail. Depending upon the operating pressure and extent of corrosion, a failure could result in a major gas release.
148. CP is therefore an essential asset, providing a secondary level of corrosion protection for pipelines where the coating systems have started to fail, mitigating the need for significant interventions and ensuring that the pipelines do not deteriorate beyond acceptable levels of integrity.
149. The key assets that make up CP systems on the NTS are transformer rectifiers, ground beds, CP test posts and remote monitors. To remain effective, the system needs to maintain the required voltage across the length of the pipeline it is protecting. The voltage provided by the system reduces as the distance increases from the transformer rectifier and is also affected by ground conditions surrounding

the pipework. As the number of coating defects increase, the voltage needed for protection also increases. Also, as components within the CP system deteriorate, they require refurbishment or replacement to ensure that the performance of the protection system is maintained at an acceptable level.

150. Close Interval Potential Surveys (CIPS) are used to assess the level of CP being provided by the system and are completed every 10 or 15 years depending upon the internal inspection frequency of the pipeline. Where we are unable to inspect pipelines internally, CIPS, Direct Current Voltage Gradient (DCVG) and Pearson Surveys are completed on a maximum of five-year intervals.

RIIO-1 Business Plan

151. The RIIO-1 BP made a modest investment associated with this SAC that had been based upon the requirement to address any known defects at the time.

RIIO-1 Delivery

Interventions

152. Through RIIO-1 we have undertaken CIPS surveys to establish whether there is enough protection of our buried pipelines and AGI pipework. We use defined assessment criteria to determine whether the system is performing within the ranges that are needed for effective cathodic protection to be in place. A system that is not performing effectively does not provide protection to all surfaces of pipework coating, and so there is an increased risk of coating breakdown. For underperforming systems, it is often possible to adjust or modify the existing assets, however through RIIO-1 we have been required to replace existing transformer rectifier and insulation joint assets in order to maintain performance, where adjustments are not effective.

Transformer Rectifiers/Groundbeds

153. Impressed current cathodic protection systems on the NTS consist of a DC source, provided by transformer rectifiers and an inert anode known as a groundbed. Cathodic protection is achieved by applying direct current to the buried steel of pipework through the anode (groundbed) so that only the anode corrodes, and the pipework remains cathodic and therefore reduces likelihood of corrosion taking place. Over time, the condition of some groundbeds and transformer rectifiers on the NTS has deteriorated leading to reduced performance of the cathodic protection system. When transformer rectifiers have no longer been able to provide enough coverage to a section of pipeline, they were replaced along with the groundbed.

Insulation Joints

154. Insulation Joints (IJ) are in place to separate the CP system of a buried pipeline feeder from an AGI’s CP system. They are installed at the boundaries of an AGI CP system to prevent any interaction between the two systems, ensuring that the requirements of each individual system do not impact upon the other’s performance for the pipework it protects. During surveys completed in RIIO-1, some insulation joints were identified as passing current, which can lead to under protection of the buried pipework if not rectified, therefore these have been replaced. There are several IJs installed at sites and so if multiple have failed, they were all replaced at the same time, often as part of other works being delivered onsite.

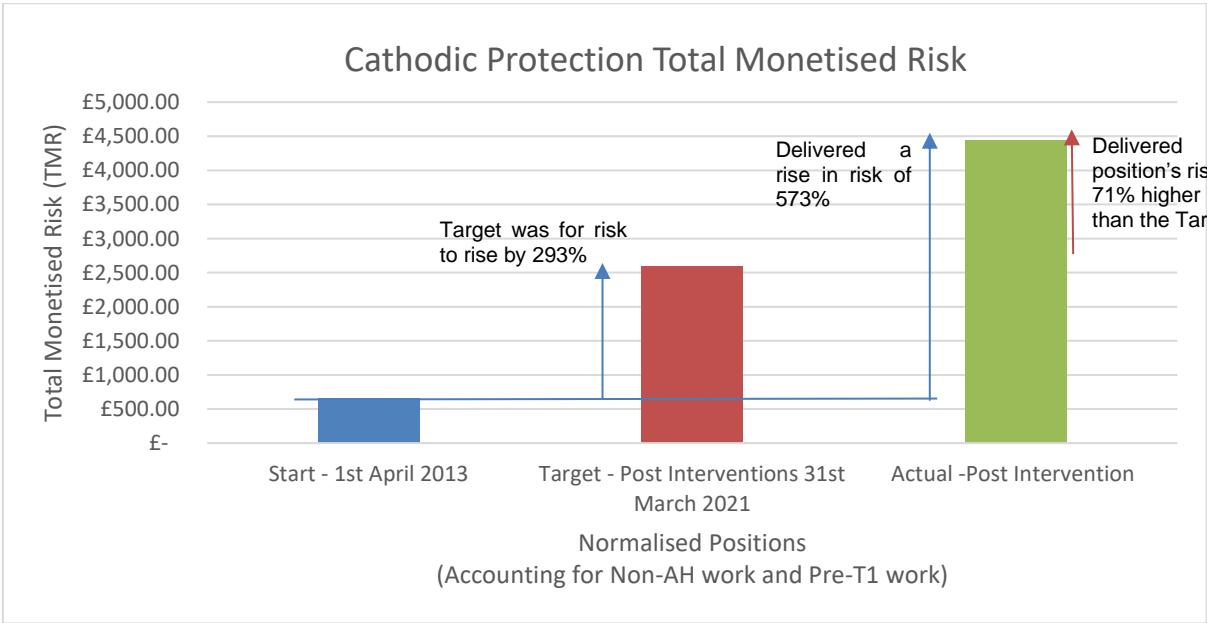
Efficiencies

155. CP investigative and remedial work on defects identified during RIIO-1 have been sanctioned together in a way that has allowed the most appropriate interventions to be chosen for maintaining performance of each relevant CP system. Through the NARC campaign, CP interventions at sites in scope, have been delivered with other works taking place, realising efficient delivery through bundling of works during outages.

Monetised Risk Position

156. The volume of work proposed for RIIO-1 allowed monetised risk to increase by 293%. The actual interventions delivered has allowed risk to increase by 573%. Relative to the target, this is an under delivery of 71%. The new NARMs approach has properly quantified the TMR benefits delivered through CP investment and this work has taken on greater priority in our RIIO-2 plan.

Figure 7 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

157. During RIIO-1 there has been a small net increase in the volume of Cathodic Protection assets on the NTS. This increase has been driven by the addition of CP systems at new sites and additional Transformer Rectifiers at new locations on the NTS.

Table 5 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	15	4	0	0	0	0	0
Exit Point	15	20	0	0	6	1	0
Compressor	15	10	0	0	2	0	0
Pipeline	15	191	0	0	63	0	4
Multijunction	15	29	0	0	2	0	0

Table 6 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	31	13	12	2	3	-1
Exit Point	31	51	51	1	1	0
Compressor	31	25	26	2	1	1
Pipeline	31	411	417	6	0	6
Multijunction	31	42	40	1	3	-2

Variance against Plan

158. Whilst we have delivered a reduced volume of work than originally anticipated in our RIIO-1 BP, we have continued to prioritise interventions on our buried pipework assets to ensure that we remain compliant with the Pressure Systems Safety Regulations. Our cross-country pipelines pose the greatest potential safety hazard to the general public and carry 76% of the TMR on the network, the prioritisation of these interventions has therefore been essential. When considering both SAC 15 (CP) and SAC 33 (Below Ground Pipe and Coating) against their collective TMR, we have over-delivered by 3%.

Conclusion and Learning

159. Whilst we have delivered a reduced volume of work than originally anticipated in our RIIO-1 BP, we have continued to prioritise interventions on our buried pipework assets that ensure we remain compliant with the Pressure Systems Safety Regulations. Our cross-country pipelines pose the greatest potential safety hazard to the general public and carry 76% of the TMR on the network, the prioritisation of these assets has therefore been essential. Investment in CP will take on a greater priority in RIIO-2 now the MR benefits have been properly quantified by the new NARMS approach.

ii. SAC 16 Electrical

Executive Summary

160. The TMR on the network attributable to our electrical assets is 0.30%. In RIIO-1 we invested £12.7m in our electrical assets and under-delivered on our monetised risk target by 52% for this SAC, which is a result of delivering a reduced volume of interventions compared to our RIIO-1 BP.
161. This SAC 'Electrical – including Standby Generators' facilitates the safe and effective operation of the primary assets ensuring the network meets customer and consumer requirements but contributes very little to the network's total monetised risk.
162. At the start of the period most of our asset base had aged beyond its design life, investment was therefore required to ensure that our sites had a safe, effective and reliable electrical supply while also maintaining our compliance with legislation.

Table 7 Electrical – Including Standby Generators Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention Position (Normalised) – 31st March 2021		Actual Monetised Risk – 31st March 2021	
Entry Point	£ 245.12	4%	£ 1,206.81	7%	£ 1,124.53	4%
Exit Point	£ 866.16	15%	£ 5,845.07	35%	£ 8,691.10	34%
Compressor Station	£ 3,492.92	61%	£ 8,670.62	52%	£ 5,999.94	24%
Pipeline	£ 108.24	2%	£ 556.82	3%	£ 250.70	1%
Multijunction	£ 1,022.70	18%	£ 475.99	3%	£ 9,446.12	37%
Total	£ 5,735.14		£ 16,755.31		£ 25,512.39	52%

Introduction and investment drivers

163. Electrical systems are in operation on almost all our operational sites including compressor stations, multi-junction sites, entry points and exit points. They vary in size and complexity, depending upon the site-specific power requirements of the operational plant/site, but they will typically consist of the following equipment; power transformers, switchgear and distribution boards, earthing and lightning protection, standby generators, Motor Control Centres (MCCs), lighting and small power, power factor correction.

Condition and Legislation

164. By their nature many electrical assets tend to have a more limited lifespan. Many of the electrical systems within the NTS were installed when sites were first constructed and are therefore over 40 years old. We undertake visual inspections, together with functional and electrical integrity testing in accordance with the

frequency and requirements of standards BS7671 and IEC60079/17 to assess the condition of our electrical assets. The DSEAR which are the implementation ATEX directives cover much of our electrical assets due to the requirements to operate in hazardous area zones. In the period, there have been instances of failures of standby power supplies and standby generators that have prevented compressor units starting, reducing the resilience of the NTS.

RIIO-1 Business Plan

- 165. The RIIO-1 BP detailed that most of our electrical equipment and systems had exceeded their originally intended design life; we were experiencing challenges associated with equipment obsolescence, reliability and safety. The investment profile supported a steady increase across RIIO-1 as we prioritised the replacement of these unsupported assets.
- 166. Two standby generators were replaced in 2011/12; we had therefore assumed in our plan the replacement of one every two years at the start of RIIO-1, increasing the frequency to one every year by the end of the period. We also assumed the replacement of one large low voltage switchboard every year. This generated 84 expected refurbishments across all PACs in the RIIO-1 period.

RIIO-1 Delivery

Interventions

- 167. RIIO-1 final determination allowances drove the requirement for an immediate change in approach to our proposed business plan. This was necessary to ensure we could continue to manage risk across the entire network. As non-gas conveying assets, investment on electrical (including standby generators) assets was deprioritised, however, we delivered approximately half of the monetised risk target by delivering 25% of our planned investment volumes.
- 168. The investments delivered on the electrical (including standby generators) SAC focused on higher criticality sites and assets, predominantly compressor stations to ensure that these power supplies were maintained for critical network operations. We have invested to ensure that our assets can receive the power required and the assets whose operation that electrical (including standby generators) supports can function as intended.
- 169. Our electrical work has been bundled into a single project known as the National Electrical Asset Health Campaign, which focused on both compliance requirements and known asset health issues. This project initially involved a more detailed assessment of the condition of electrical equipment in order to formulate a prioritised plan for replacement and obsolescence management. Replacement work began at the end of RIIO-1 and is set to continue throughout RIIO-2, forming the basis for how we will deliver electrical work.
- 170. As the unit of measure is at a site level, there are campaigns that have delivered work on electrical (including standby generator) assets that did not result in an

output being claimed. To comply with DSEAR, a national campaign was conducted to demonstrate and maintain compliance. This campaign covered all sites on the network and where required, minor remediation works was completed which was beneath the claimable level to maintain the integrity of our assets. The earthing and lightning protection project consisted of survey work all compressor stations and major terminals to assess our compliance with internal policies and UK legislative requirements, this was followed by rectification works as necessary. The interventions completed by this project ensured the safe operation of the network despite being unable to claim outputs.

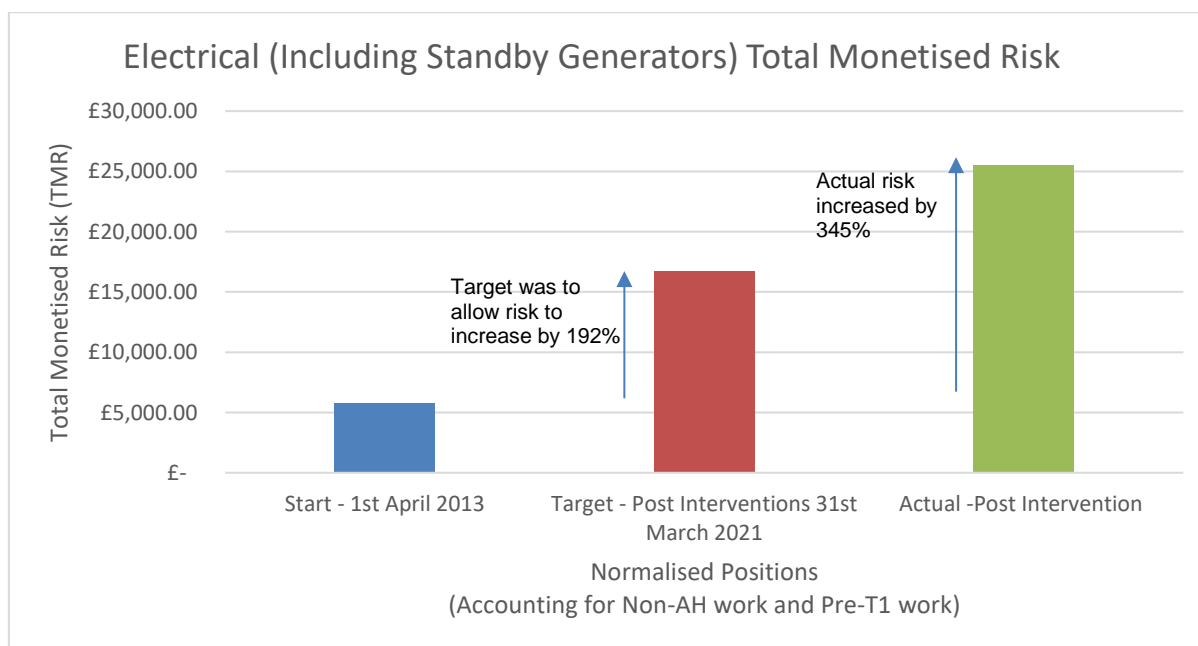
Efficiencies and innovation

171. Efficiencies have been realised through the campaign approach, bundling inspection and remedial works together at multiple sites to enable efficient delivery. Where multiple campaigns were delivering interventions at the same sites, further opportunities to bundle deliverables were sought/realised where contractors with the appropriate skills/resource had already been mobilised.
172. We have faced significant obsolescence issues on our electrical assets which we have managed in part through grey spares, this approach has also allowed us to defer capital expenditure to ensure that these assets still perform as required. This approach is unsustainable into RIIO-2 and beyond.

Monetised Risk Position

173. The monetised risk target established based upon the RIIO-1 BP was to allow the TMR on electrical (including standby generators) to increase by 192% across the 8-year regulatory period; we under delivered this target by 52.3%.

Figure 8 RIIO-1 Risk Performance against Start Position and Target



174. Our actual TMR position is greater than our target position due to the lower number of interventions completed. The 2021 TMR without intervention position is R£35,401, meaning that the limited number of interventions completed, were among the most risk beneficial to do with a limited opportunity, as they reduced risk by ~R£10,000. The work which we deferred was mainly on smaller sites with less consequence, e.g. multi-junctions and as such would have delivered a smaller benefit.

Asset base changes

175. In RIIO-1 there was a net loss of one electrical (including standby generator) asset, which caused very little change in the asset base value as deterioration of existing assets dominates the risk profile, see tables below:

Table 8 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 business plan			Actuals		
		Refurbish	Removal	Addition	Refurbish	Removal	Addition
Entry Point	16	6	0	0	1	0	0
Exit Point	16	17	0	34	2	2	2
Compressor Station	16	12	0	0	10	0	0
Pipeline	16	3	0	48	2	0	1
Multijunction	16	46	0	0	3	0	1

Table 9 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	16	17	16	1	2	-1
Exit Point	16	95	96	4	3	1
Compressor Station	16	22	23	1	0	1
Pipeline	16	16	16	1	1	0
Multijunction	16	78	76	1	3	-2

Variance against Plan

176. As non-gas conveying assets, investment in electrical (including standby generator) assets has been deprioritised in RIIO-1 to facilitate other essential works to ensure we maintain the integrity and safety of the network. Investments focused on higher criticality sites and assets, predominantly compressor stations to ensure that these power supplies were maintained for critical network operations.
177. We have actively managed the de-prioritised assets through maintenance and compliance programs, completing repairs where necessary. This will require greater investment in RIIO-2 and RIIO-3 though as investment can only be deferred so long. When defects have been identified, the equipment has been scheduled for replacement on a risk priority basis. Focus is on assets which are no longer

deemed safe or where performance has deteriorated to a level where the primary asset function is affected.

Conclusion and Learning

- 178. Given the requirement to rationalise spend, we deprioritised this area in preference to gas conveying assets. We have maintained our assets through minimal investment utilising grey spares, and increased maintenance spend where available to ensure the assets continue to work safely, effectively and remain compliant with all relevant legislation. In RIIO-2 using the campaign approach and the intelligence gathered in RIIO-1, we will invest in these assets to ensure the primary assets continue to have the reliable electrical supply they need.
- 179. Use of a whole-site unit of measure for reporting monetised risk outputs has meant that several investments have consumed budget but delivered no measurable outputs as they do not contribute to the minimum 5-year life extension for the whole SAC. This will be addressed through ongoing work to restate our asset base in terms of an ISO-standard taxonomy.

iii. SAC 18 Filters and Scrubbers

Executive Summary

180. The TMR on the network attributable to our filters and scrubbers assets is 0.13%. In RIIO-1 we have invested £12.3m in filters and scrubbers and under-delivered on this SAC monetised risk target by 300%. This is a result of prioritising our compliance with PSSR and not always intervening on assets that deliver the most monetised risk reduction on the network.
181. The timing of these inspections can be estimated with a high degree of accuracy, however, the extent of remedial work identified required does vary.
182. The recent transition to NARMS however, has provided increased visibility of assets that are of high monetised risk value on the network; going forward this shall enable improved prioritisation of investment, intervening to reduce increased levels of risk going forward.
183. We have however, continued to maintain our legislative compliance by inspecting and remediating filter and scrubber assets when necessary; in line with our rolling PSSR campaigns.

Table 10 Filters and Scrubbers Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position – 1st April 2013		Monetised Risk Target with Intervention Position (Normalised) – 31st March 2021		Actual Monetised Risk – 31st March 2021	
Entry Point	£ 5,131.32	11%	£ 2,854.84	40%	£ 1,079.94	4%
Exit Point	£ 290.65	1%	£ 91.21	1%	£ 85.66	0%
Compressor Station	£ 39,231.23	88%	£ 4,257.89	59%	£ 27,670.65	96%
Multijunction	£ 50.02	0%	£ 14.96	0%	£ 37.27	0%
Total	£ 44,703.23		£ 7,218.90		£ 28,873.51	300%

Introduction and investment drivers

184. High pressure filters and scrubbers are important assets which ensure downstream equipment is kept free of debris, dust and liquids. These assets exist on four of the five primary asset classes, with most monetised risk associated with filters and scrubbers being on the 'Compressor Station' primary asset.
185. The function of filters, scrubbers and strainers¹⁵ is to remove contamination from the gas flow that could damage plant equipment downstream which could result in a loss of gas supply or reduction in the capacity of the network. Failure to invest adequately will lead to a loss of performance allowing liquids and other

¹⁵ Strainers are not captured under the PSSR

contaminants to flow with the gas and potentially damage our or our customers' downstream equipment.

- 186. The inspection of filters and scrubbers are mandated in the PSSR with the mandatory requirement for 6 yearly visual and 12 yearly major¹⁶ inspections, which are in place to prevent serious injury from the hazard of stored energy as a result of the failure of a pressure system or one of its component parts. Where defects are identified during the PSSR inspections then the appropriate intervention will be undertaken to restore the asset to operation.
- 187. As an owner of pressure systems, we have a duty to ensure these systems do not give rise to danger. This is achieved through correct design, installation and maintenance, provision of information, operation within Safe Operating Limits (SOLs) and, where applicable, examination in accordance with a Written Scheme of Examination (WSOE) drawn up or approved by a competent person. Consequently, our WSOE contains minimum inspection and maintenance requirements that it must undertake to demonstrate compliance with PSSR.
- 188. These assets will deteriorate over time and with use, which leads to their inability to perform their required function which may result in them no longer complying with direct legislative requirements. Asset deterioration might include breakdown of coating, corrosion of both internal and external surfaces, pressure cycling or vibration fatigue.

RIIO-1 Business Plan

- 189. The RIIO-1 BP made a modest investment associated with this SAC that had been based upon the requirement to complete our statutory PSSR inspections and revalidations for all our high-pressure filters and scrubbers on the NTS and any known defects at the time.

RIIO-1 Delivery

Interventions

- 190. The work completed was predominantly delivered in order to satisfy our PSSR obligations, via inspection and revalidation of the filter and scrubber assets. A small volume of our compressor station scrubber assets has been replaced based on condition issues.

¹⁶In addition to the elements of the visual inspection, the coating is removed during the major inspection to allow a detailed examination of the pressure vessel body and welds using Magnetic Particle Inspection (MPI).

191. The timeline for our PSSR Campaign was determined by the requirement for 12 yearly major inspections on our high-pressure filters and scrubbers. Non-compliance with this inspection regime is reportable to the Health and Safety Executive; throughout RIIO-1 we have maintained statutory compliance.

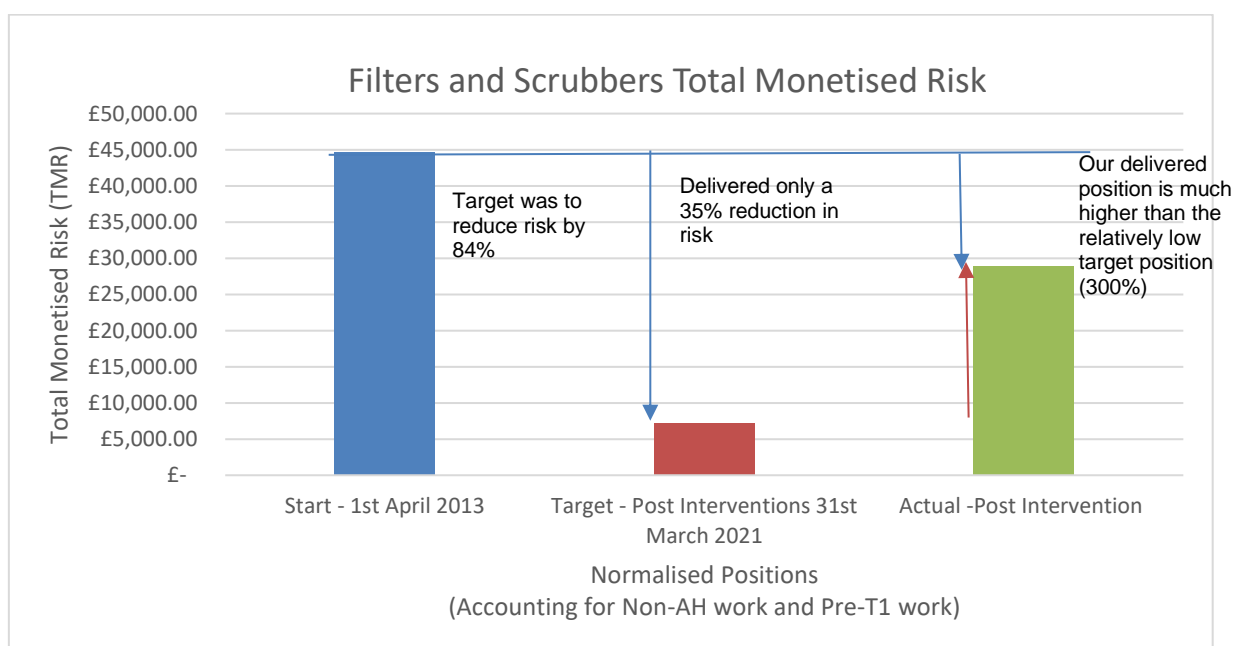
Efficiencies

192. All our PSSR driven inspections have been sanctioned on a rolling basis within our campaigns approach, typically covering the preheater, filters/scrubbers and pig trap SACs, in order to meet our major inspection obligations across the NTS.

Monetised Risk Position

193. The monetised risk target established based upon the RIIO-1 business plan was to reduce the TMR on filters and scrubbers by 84% across the 8-year regulatory period; we under delivered this target by 300%.

Figure 9 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

194. In RIIO-1 there was a small net decrease of filters and scrubbers assets and the vast majority was in relation to non-asset health driven investments, see tables below:

Table 11 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	18	54	0	0	56	3	1
Exit Point	18	40	0	0	36	3	0
Compressor Station	18	167	0	0	80	0	0
Multijunction	18	10	0	0	5	0	0

Table 12 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	18	78	70	2	10	-8
Exit Point	18	63	57	2	8	-6
Compressor Station	18	225	224	5	6	3
Multijunction	18	18	14	0	4	-4

Variance against Plan

195. All required interventions have been completed to maintain legislative compliance, however, we have delivered a reduction in the planned volume. This reduction was mainly associated with the compressor station primary asset group, where we did not need to replace as many filters as originally anticipated.

Conclusion and Learning

196. Our filters and scrubbers investment has been primarily based upon legislative compliance, through delivery of the PSSR Campaign. The visibility provided by NARMs going forward, shall help identify the asset interventions on the network that deliver increased monetised risk value on the network.

iv. SAC 21 Flow or Pressure Regulators

Executive Summary

197. The TMR on the network attributable to our flow or pressure regulators (including measurement) assets is 4.80%. In RIIO-1 we invested £6.6m in flow/pressure regulators and under-delivered the monetised risk target for this SAC by 15%. Whilst we delivered a reduced volume of work compared to our business plan, the interventions completed delivered a significant monetised risk reduction.
198. We have always prioritised compliance with PSSR, by completing the necessary inspections and remediations. The timing of these inspections can be estimated with a high degree of accuracy, however, the extent of remedial work identified required does vary.
199. The recent transition to NARMs however, has provided increased visibility of assets that are of high monetised risk value on the network; going forward this shall enable improved prioritisation of investment, intervening to reduce increased levels of risk going forward.

Table 13 Flow/Pressure Regulators Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention Position (Normalised) – 31st March 2021		Actual Monetised Risk – 31st March 2021				
Entry Point	£	26,135.02	17%	£	4,012.03	2%	£	28,364.52	9%
Exit Point	£	21,193.65	14%	£	36,334.36	14%	£	43,687.97	14%
Compressor Station	£	99,828.19	64%	£	214,952.94	81%	£	219,138.74	72%
Multijunction	£	7,640.85	5%	£	9,844.47	4%	£	13,157.71	4%
Total	£	154,797.72		£	265,143.80		£	304,348.94	15%

Introduction and investment drivers

200. The purpose of flow or pressure regulation is to allow control over gas pressure/flow characteristics to achieve desired customer pressures, actuation of valves or to provide fuel gas to compressors. A flow control valve allows the Gas Network Control Centre (GNCC) to remotely control the flow of gas and pressure between two or more sections of pipeline. In some circumstances this equipment is situated on a pressure boundary and depending on the pressure differential between the sections of pipeline there could also be a pressure control valve installed. Pressure reduction streams are pneumatically operated installations and control the pressure between two different pressure tiers; their prime purpose being to control and regulate the pressure into the downstream pipeline or pipework.

201. Flow or pressure regulators can be divided into the following groups:
- Pressure or flow control valves
 - Pressure regulator streams
 - Compressor station pressure reduction
202. Pressure/flow control valves have a significant effect on the flow and pressures in the NTS. Their performance is critical to managing the flexibility, operation and line-pack of the NTS. For each flow control valve, GNCC have several remote operating modes available to them. Lack of investment in the remediation of failures found during inspections would render the assets unable to be used in a pressurised environment. In some cases, they will not be able to be used at all. Loss of main line pressure/flow control can lead to failure to meet network demand.
203. Loss of offtake pressure regulation streams can lead to loss of customer supply or gas being supplied at the incorrect pressure. Loss of a compressor station (fuel gas) pressure regulators would lead to compressor unit unavailability. Incorrect pressures may also lead to damage to the integrity of any downstream equipment.

RIIO-1 Business Plan

204. The RIIO-1 BP made a modest investment associated with this SAC that had been based upon the requirement to complete our PSSR related investments and any known defects at the time.

RIIO-1 Delivery

Interventions

205. These assets are captured by PSSR that requires periodic inspection to comply with legislation. These inspections enable us to continue to operate the asset, by confirming the integrity, and allowing the re-declaration of capabilities. Failure to complete these inspections and any associated repairs could result in prosecution by the HSE and the equipment affected would need to be isolated and depressurised until it could be inspected and revalidated. This could have a major impact on our ability to meet capacity requirements and to maintain the reliability of the network.
206. During RIIO-1 we have been required to overhaul regulator assets in order to ensure we have abided by the terms of our contract with customers. Due to the nature of legacy customer contracts for some NTS offtakes, we often provide pressure reduction capability and so have needed to respond to changes in customer requirements in order to continue meeting our customer's pressure requirements by investing in these assets.

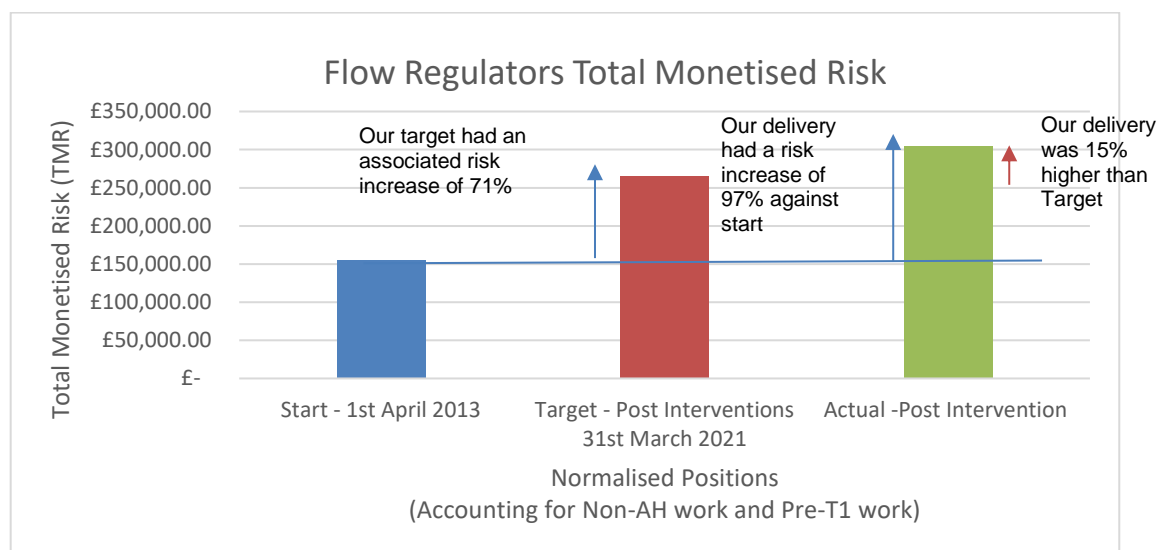
Efficiencies and innovation

207. All our PSSR driven inspections have been sanctioned on a rolling basis within our campaigns approach, typically covering the preheater, filters/scrubbers, flow/pressure regulator and pig trap SACs, in order to meet our major inspection obligations across the NTS.

Monetised Risk Position

208. The monetised risk target established based upon the RIIO-1 BP was to allow risk to increase on flow/pressure regulators by 71% across the 8-year regulatory period; we under delivered this target by 15%.

Figure 10 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

209. During RIIO-1 there was a net reduction of flow/pressure regulator assets, see tables below:

Table 14 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	21	31	10	0	7	0	0
Exit Point	21	10	0	0	2	1	0
Compressor Station	21	19	0	0	2	0	0
Multijunction	21	7	0	0	4	0	0

Table 15 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	21	51	45	0	6	-6
Exit Point	21	44	41	0	3	-3
Compressor Station	21	122	120	2	4	-2
Multijunction	21	29	27	0	2	-2

Variance against Plan

210. Whilst we have delivered less interventions than planned, we have completed all that are required to maintain legislative compliance.

Conclusion and Learning

211. Our flow/pressure regulator investment has been primarily based upon legislative compliance, through delivery of the PSSR Campaign and where we have needed to refurbish assets to continue meeting our contractual obligations on the NTS. The visibility provided by NARMS going forward, shall help identify the asset interventions on the network that deliver increased monetised risk value on the network.

v. SAC 22 Gas Analysers

212. Gas quality asset health issues are driven by the need to ensure that aging and obsolete equipment is repaired or replaced in order to meet regulatory and legal requirements including those arising from the Gas Safety (Management) Regulations and Gas (Calculation of Thermal Energy) Regulations.
213. The TMR on the network attributable to our gas analyser assets is 0.14%. In RIIO-1 we invested £43.2m in our gas analysers and over-delivered on our network risk target by 46%, which is a result of more targeted investment being delivered.

Table 16 Gas Analyser Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013	Monetised Risk Target with Intervention (Normalised) 31st March 2021	Actual Monetised Risk – 31st March 2021
Entry Point	£ 1,605.72 38%	£ 6,425.99 83%	£ 2,095.97 50%
Exit Point	£ 674.73 16%	£ 133.46 2%	£ 713.14 17%
Compressor	£ 197.82 5%	£ 49.89 1%	£ 117.85 3%
Multijunction	£ 1,697.69 41%	£ 1,160.40 15%	£ 1,248.03 30%
	£ 4,175.96	£ 7,769.74	£ 4,174.99 46%

214. Increased intervention volumes were necessary to ensure we continued to satisfy both our legislative and contractual obligations. The monetised risk associated with gas analyser assets are greater on entry points, therefore the prioritisation of works on these sites has realised an increased monetised risk benefit.

Introduction and investment drivers

215. A gas analyser has many purposes, it is used to determine the Calorific Value (CV) of the gas to enable accurate customer billing, to ensure regulatory compliance, provides data to enable fiscal volume metering and compressor engine emissions to be calculated and to measure the quality of gas entering the system to ensure that it can be safely transported and used by consumers.
216. A wide range of analyser systems are required; a single measurement point can have between one and seven different analysers connected to measure the gas properties for that location. These analyser systems comprise different technologies, typically using gas chromatography.
217. Gas quality asset health issues are driven by the need to ensure that aging and obsolete equipment is repaired or replaced in order to meet regulatory and legal requirements including those arising from the Gas Safety (Management) Regulations and Gas (Calculation of Thermal Energy) Regulations. We must also ensure these assets continue to provide accurate and reliable metering, measurement and NTS flow management in line with customer requirements.

218. In some cases, there are also safety implications, for instance, in relation to analytical systems used to detect non-compliant gas within the network from onshore storage sites or gas fields, ensuring gas is safe to transport and use.

RIIO-1 Business Plan

219. A large proportion of our gas analysers were operating beyond their originally intended design life at the time of developing the RIIO-1 business plan. Obsolescence was a real issue; maintenance spares were no longer available to support all gas analysers on our system and the equipment was no longer supported by the OEM. We were also experiencing issues with contamination, liquid and solid carryover from several entry points.
220. The RIIO-1 BP included proposals for the replacement of metering gas analysers at exit points. This was investment for the replacement of approximately 75% of our metering gas analyser population. These systems were to be installed and operated in parallel with existing systems until proven to avoid customer disruptions.
221. The measure of gas composition for gas generators was limited; the plan proposed the replacement of one system every year starting halfway through the RIIO-1 period, in line with the age and predicted performance of the analysers. These works would be aligned where possible to unit or station outages.

RIIO-1 Delivery

222. Our RIIO-1 delivery of the metering analysers at exit points has been broadly in line with the plan. Investments have taken place at entry points and compressor stations. We also undertook several replacements at Flow Weighted Average CV (FWACV) sites. On certain other exit points, interventions were undertaken in as part of a bundled delivery with the metering works at the sites which was efficient and minimised disruption.
223. There were two key projects underpinning our RIIO-1 delivery:
224. The Enhanced Gas Measurement Project (EGMP) had been a long-running programme to replace obsolete and failing analyser systems on entry points across the network. Fast and accurate analysis of gas entering the NTS is a fundamental part of our compliance with the Gas Safety (Management) Regulations (GSMR). Existing technology was obsolete and experiencing high failure rates. Systems at entry points were designed to analysis multiple samples consecutively, e.g. three feeders on a 12+ minute cycle one after the other. Long cycle update times of 40 minutes were typical for control room personnel to react to potential problems with incoming gas quality, equivalent to many millions of cubic metres of gas passing through onto the NTS.

225. The EGMP project took a highly innovative approach, installing a measurement system incorporated both slow and fast analysers. System integrators use data from the slow but more accurate system, combined with the frequent, but less accurate analysers to calculate and transmit 'bias corrected' data. The data trended in this way gives the control room maximum time to make decisions and reduce both the probability and consequence of uncompliant gas entering the network.
226. There have been challenges with the project, particularly as our requirements are relatively unique in the market. Other gas network companies do not require the full suite of gas properties as, for example properties such as water content and oxygen limits are not measured once the gas has entered the transmission system. Gas distribution networks have no requirement for equivalent systems. The market has affected our ability to pre-empt technology developments and optimise timing. However, we found two different options using Siemens and Emerson's technology, which with 26 installations, have delivered significant operational benefits.
227. Replacement of Flow Weighted Average Calorific Value (FWACV) This second project focussed on analyser investment at FWACV sites. These sites are measurement systems at key locations across the NTS, where CV data is a key input in the billing process. The analyser technology at these sites, the Danalyser 500, was an end of life product at the start of the RIIO-1 period. The proposed investments were replacement of these units with the Danalyser700. 22 installations were completed across the period.
228. Outside of these two projects we have also completed the following works:
- Seven new systems at compressor stations. We chose to install inferential devices which are cheaper but less accurate than full measurement analysers. The performance of these devices is however, good enough to drive better engine management and emissions calculations.
 - New analysers at industrial and power stations exit points. This delivery was bundled together with the metering upgrades at those sites.
229. There was one key challenge at the start of the RIIO-1 period. There was a worldwide shortage of helium which is used as a carrier gas in the analyser systems, and without which they cannot operate. Hydrogen was identified as a suitable alternative and as such several the systems installed replaced helium with hydrogen. However, this replacement has resulted in a shorter life on the sensors within the analyser. The risk associated with helium supply is no longer material, and as such, a second replacement programme, conversion back to helium is underway and will continue into the RIIO-2 period.

Efficiencies and innovation

230. The bias corrected integrated system developed as part of the EGMP project is a real example of innovation delivered as part of this SAC - a unique and novel approach which optimises the performance from two different analysers. We have

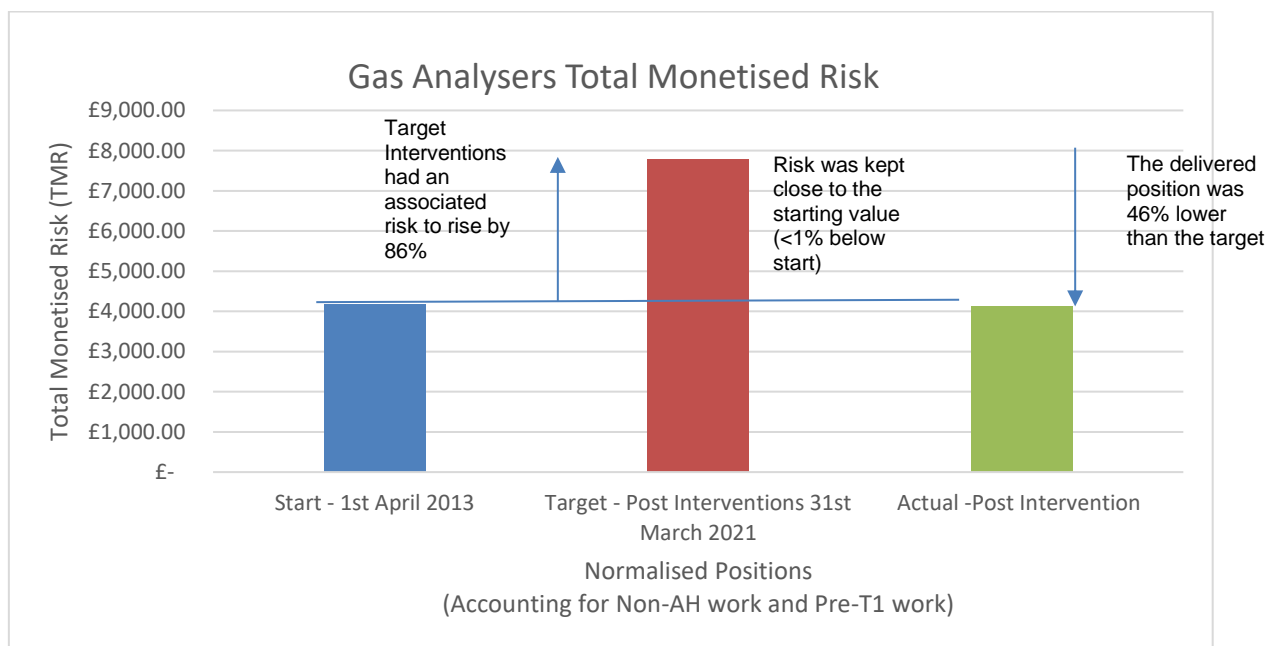
also undertaken a Network Innovation Allowance (NIA) to improve the design and therefore the efficiency of the system sample lines. This involved working with Swagelok to map the assets with an infrared camera system, develop designs and update our GQ9 specification accordingly in readiness for RIIO-2.

231. We have undertaken two NIA projects both seeking to develop and trial a device that is suitable for the detection and quantitative measurement of liquid contamination at the entry points to the NTS gas transmission system. Although initially anticipated this would be available for the early part of the RIIO-1 period, this work has been complex and developing a robust, reliable and accurate technology suitable for deployment in the field has only now been successfully completed.

Monetised Risk Position

232. The target established based upon the RIIO-1 business plan was to allow risk on gas analyser asset to increase by 86% across the 8-year regulatory period; we over-delivered this target by 46%.

Figure 11 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

233. In RIIO-1 there was a small net increase of gas analyser assets and most intervention changes were replacements, as seen in the table below:

Table 17 Asset Health (only) intervention driven changes

Primary asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	22	11	0	0	26	0	3
Exit Point	22	15	0	0	9	1	0
Compressor Station	22	8	0	0	8	0	0
Multijunction	22	14	0	0	27	0	5

Table 18 Total asset base changes (including non-Asset Health drivers)

Primary asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	22	57	59	3	1	2
Exit Point	22	25	24	0	1	-1
Compressor station	22	11	12	2	1	1
Multijunction	22	48	57	9	0	9

Variance against Plan

234. Increased intervention volumes were necessary to ensure we continued to satisfy both our legislative and contractual obligations. We have been able to deliver a substantial monetised risk benefit, alongside operational benefits through the entry point investments.

Conclusion and Learning

235. This has been a priority SAC as part of our RIIO-1 delivery which in turn has delivered a significant monetised risk benefit.

vi. SAC 23 Gas Generators

Executive Summary

236. The TMR on the network attributable to our gas generator assets is 1.72%. In RIIO-1 we have invested £33.4m in gas generators and over-delivered on our network risk target by 43%, which is a result of delivering an increase in work compared to our RIIO-1 Business Plan (BP).
237. We have continued to inspect and manage our fleet of Gas Generators through an overhaul regime that follows guidance from OEMs and maintains desired levels of reliability. The function of gas generators on the NTS means that their operation is sensitive to changes in demand and flow patterns, so we have had to adapt our overhaul programme to meet changing requirements. Higher than expected running hours due to increased demand levels and flows through St. Fergus, changes in our approach to managing compliance with the IED, has led to us overhauling more gas generators during RIIO-1 than originally anticipated.

Table 19 Gas Generators Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013	Monetised Risk Target with Intervention (Normalised) - 31st March 2021	Actual Monetised Risk - 31st March 2021
Entry Point	£ 4,106.38 11%	£ 7,618.83 8%	£ 9,627.26 18%
Compressor Station	£ 33,095.49 89%	£ 87,256.95 92%	£ 44,349.14 82%
Total	£ 37,201.86	£ 94,875.78	£ 53,976.40 43%

Introduction and investment drivers

238. A gas driven compressor train consists of a gas generator, a power turbine and a gas compressor. The gas generator combusts air and fuel gas, generating energy. This energy is used to propel the power turbine, driving the gas compressor which then increases the pressure and flow rate of the gas through the transmission pipeline. We currently operate a fleet of 61 gas generator driven compressor trains.
239. Due to the pattern of gas flows required by our customers and consumers becoming increasingly variable, the patterns of gas movement across the network have changed with increased, and much more complex demand on the compression fleet. This has increased the stress on compressor machinery due to greater frequency of start-stop cycles and more volatile running hour periods. Changes in usage, especially increasing start-stop cycles of the compressor train has resulted in the need to increase the number of gas generator overhauls. These interventions ensure that compression assets remain supported by the OEM and continue to operate at an acceptable level of availability. The frequency of overhauls and general maintenance on the compressors can be further increased by the poor performance of the associated assets.

240. Most of the investment associated with gas generators is derived from duty profiles (run hours and number of starts stops) that have been agreed with other EU-based gas generator operators. These are described in best practice integrity management policies based on OEM guidelines which we always aim to adhere to as a safety requirement for operating these machines. A gas generator's deterioration mechanisms will therefore vary depending upon its use and operational environment. For example, a low running unit with multiple stops and starts will have a likely accelerated rate of deterioration than a unit which has been run for longer hours or has been in constant use. Gas generators are designed to be started and left to continuously run for long periods of time.
241. It is vital for the supply of gas to our customers that our gas generators remain available and resilient to the demands and changes on the NTS and investment in our Compressor Trains is essential to ensuring this availability is not compromised.

Inspections and Monitoring

242. The gas generator and power turbine assets are managed using a comprehensive monitoring, inspection and condition-based intervention programme. The assets are fitted with sensors to continually monitor all relevant characteristics such as vibration, temperature, performance etc. Gas generator assets that are used for more than 500 hours per year are also subject to annual internal visual inspections via a borescope, whilst assets that run less than 500 hours per year receive a borescope inspection every 2 years. The results of this monitoring are analysed every month and together with the results of the inspections and the run hours determine whether intervention is required.

Major Overhaul Regime

243. Operation of the NTS demands that the failure of gas generators in service is minimised. Gas generators should therefore be considered for replacement and/or overhaul before performance becomes compromised. In accordance with recommendations by the OEM, gas generators require major overhaul after a specified duty (operational run hours) has been reached. The effective run hours for each individual gas generator are determined using an internal calculation that takes account of damage factors attributed to number of starts, trips and the age of the asset. Typically, major overhauls are completed after 25,000 hours.

Managing Fleet Capacity

244. We manage the loss of operational fleet capacity in the event of a planned overhaul or 'Found on Inspection' (FOI) failure, by considering the following options:
- Availability of operational standby units
 - Use of fleet strategic spare gas generators
 - Proactively managing the operational life of the gas generator fleet

- Defer the overhaul, by strategically moving the gas generator to a low usage site
- Repair the gas generator
- Temporarily lease a gas generator from the market
- Purchase a new gas generator from the market
- Manage the increased risk through operational processes
- Accept risk of a reduction in standby capability (low utilisation sites)

RIIO-1 Business Plan

245. Our RIIO-1 investment programme was designed to maintain the reliability and availability of the gas generator units but recognised that there would be a reduced volume of works required on engines that would be replaced as part of the IED related investments. We did not plan to overhaul any of the 21 gas generators due for replacement during the RIIO-1 period, however we did plan minor refurbishment work to ensure units remain reliable until the replacement was to be installed and commissioned. Had we not been replacing these gas generators, we estimated that one unit a year would require overhaul.
246. In the business plan, the serviceability investments planned for gas generators over the RIIO-1 period included the re-life of:
- 6 to 8 Rolls Royce Avon units
 - 2 to 3 LM2500+ DLE units
 - 2 to 3 Solar DLE units
 - 3 to 4 SGT400 DLE units
247. Our plan assumed the midpoint number of re-life overhauls. We assumed that should we experience a need for an increased number of overhauls or repairs then we would substitute funding from another secondary asset group on a priority basis. These volume ranges reflect an operational utilisation uncertainty and do not include any further overhauls of the 21 engines that shall be phased out as they become either replaced or decommissioned to ensure our compliance with the IED.

RIIO-1 Delivery

Interventions

248. The interventions carried out on gas generators over RIIO-1 have been coordinated as part of the compressor and cab infrastructure campaign, prioritising compressor unit overhauls based on run hours and site criticality. Over the RIIO-1 period, we

overhauled 45 gas generators in total, 39 of these are in berth and the other 6 are retained as spares in storage.

Increased running hours due to demand

249. Our planned gas generator overhaul regime is predominantly driven by the amount of running hours an engine has completed since its previous major overhaul, in line with the intervals recommended by OEMs. An increase in running hours and/or increased stop/starts will therefore lead to more frequent overhauls of our gas generator assets.
250. During 2016/17 overall network running hours were twice that of the previous year; up until this point running hours remained relatively consistent throughout the early years of RIIO-1. This increase in running hours was driven by an increase in gas demand, notably requiring increased compression in Scotland and other northerly compressor stations as a result of higher levels of supply coming through the St. Fergus terminal. This was reflected in the following two years from late 2017, when we overhauled 11 gas generators across St Fergus, Aberdeen, Kirriemuir, Avonbridge, Nether Kellet, Bishop Auckland and Wooler; as a result of this increased duty on northern compressors.

Industrial Emissions Directive (IED)

251. There were 21 units impacted by Emissions Legislation which we advised in our RIIO-1 business plan would not be overhauled (expected to be replaced). During the period we overhauled 8 Gas Generators as they were placed under Limited Lifetime Derogation (LLD) or Emergency Use Derogation (EUD). Several Avon compressor units also required overhaul at St. Fergus to continue supporting entry flows.

Compressor and Cab Infrastructure Campaign Prioritisation

252. The gas generator SAC forms a significant part of our overall compressor train assets, many of which are critical to meeting our customers and consumers demands across the NTS. It is for this reason we prioritised investments in high value SACs such as gas generators; to ensure asset reliability is suitable for preventing any critical loss of compression.
253. During prioritisation of the Compressors and Cab Infrastructure Campaign for 2019-2021, the final principles for managing our gas generator assets were as follows:
- Continue Avon overhauls to maintain fleet units and spares, as they are the widest 'in use' type.
 - Adoption of a service exchange approach to reduce risk and drive better value for overhauls

- Gas generator unit rotation across sites to maximise run hours before requiring overhaul

254. We completed reduced scope overhauls to remedy some condition issues on units with a limited future need but were required in the shorter term.

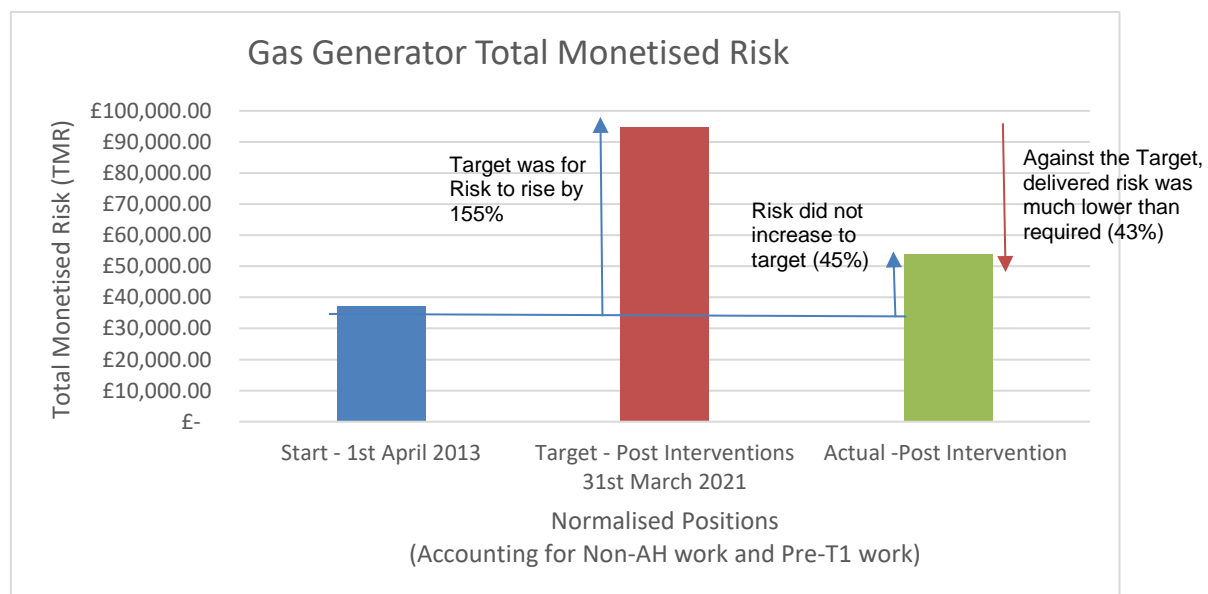
Efficiencies

255. Opportunities for increasing the efficiency of asset health works within the compressors campaign focused on the rolling programme of overhauls. Traditional approaches to overhauls were resulting in unanticipated faults being found on strip down. The units could not then be returned to service without rectification of the defect, at additional cost. A service exchange approach has been adopted for modern DLE gas turbine driven compressor machinery, whereby a fixed cost provides for gas generator or train replacement (depending on type) in the event of a loss of availability failure or when an overhaul is due. This approach allows for a fixed budgetary sum and drives out obsolescence by including updates to latest specification for machinery protection and efficiency, and via a quick turnaround.

Monetised Risk Position

256. The target established based upon the RIIO-1 BP was to allow risk to increase on gas generators by 155% across the 8-year regulatory period; we over delivered this target by 43%.

Figure 12 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

257. During RIIO-1 there was a small net reduction of gas generator assets which were predominantly driven by the decommissioning of several IED non-compliant units with extensive asset health issues, contrasted by the addition of two new units at Felindre, see tables below:

Table 20 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Refurbish	Removal	New Additions	Refurbish	Removal	New Additions
Entry Point	23	17	0	0	35	0	0
Compressor Station	23	5	0	0	4	0	0

Table 21 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	23	7	7	0	0	0
Compressor	23	57	54	2	5	-3

Variance against Plan

258. During RIIO-1 we experienced higher than normal demand levels, and at times increased levels of flow through St. Fergus terminal, therefore leading to increased running hours for our compressor fleet, predominantly in the north. This has required us to overhaul many gas generators earlier than expected, using OEM guidance to ensure our compressor fleet remained reliable against increased levels of demand.
259. In our RIIO-1 business plan we did not intend to overhaul any of the gas generators that were non-compliant with IED legislation, however, several of these units were placed under derogation and therefore not replaced as originally planned. This resulted in several of these units remaining operational and which were then overhauled with increased utilisation.

Conclusion and Learning

260. Over the RIIO-1 period we needed to overhaul more gas generators than we had originally planned, predominantly due to higher-than-expected levels of demand across the NTS and the retainment of several non-compliant IED units on derogation. We continue to use OEM guidance on overhaul frequencies for our gas generator fleet and use running hour forecasts to aid our overhaul planning.

vii. SAC 27 Metering

Executive Summary

261. The TMR on the network attributable to our fiscal metering assets is 0.05%. In RIIO-1 we have invested £11.5m in fiscal metering¹⁷ and over-delivered on this SAC monetised risk target by 21%, which is a result of delivering more targeted investment specific to site requirements, compared to our RIIO-1 business plan.

Table 22 Fiscal Metering Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013	Monetised Risk Target with Intervention Position (Normalised) 31st March 2021	Actual Monetised Risk – 31st March 2021
Entry Point	£132.24 7%	£75.16 3%	£653.86 31%
Exit Point	£1,318.69 69%	£331.46 13%	£183.45 9%
Compressor Station	£418.81 22%	£2,214.37 84%	£ 1,108.80 53%
Multijunction	£47.41 2%	£13.73 1%	£144.86 7%
Total	£1,917.16	£2,634.71	£ 2,090.96 21%

Introduction and investment drivers

262. The purpose of fiscal metering assets is for measurement of gas at legacy third party NTS supply points, such as power stations and large industrial users connected to the NTS.
263. There are several metering technologies in use across the NTS. This includes the most common method, the orifice plate meter, which measures gas flow based on differential pressure readings. Other types of metering equipment include ultrasonic meters as well as Turbine, Vortex, Coriolis, Annubar, Elbow, Venturi and V-cone meters. The primary meters are supported by secondary metering equipment such as flow computers, supervisory computers and data logging PLCs.

¹⁷ SAC includes station process metering which the control room use to monitor flow on Compressor Stations and Multi-junctions

RIIO-1 Business Plan

- 264. The RIIO-1 business plan made a modest investment associated with this SAC that had been based upon historical evidence of investment on these assets and any known defects at the time.
- 265. Fiscal metering formed part of our overall investments planned at our exit point primary assets, predominantly focussed on industrial offtakes and power stations. Investment were required for two key reasons - failing to maintain the safety and reliability of an exit point has an immediate impact on our customers' gas supply and failings in the metering or gas analysers systems will affect the accuracy of the customer's bill.
- 266. There had been several incidents and failures with the meters and old flow computers which formed the key justification for the RIIO-1 works. In addition, new calculations (ISO5167:2003) were required for the orifice plate metering systems, which the old flow computers could not compute. Hence replacement of old S500 machines with new flow computers, running up to date calculations had become necessary. Finally, there was a degree of uncertainty around flow rates at some exit points, especially low flow rates, which orifice plate metering systems were not designed to accommodate. Ultrasonic metering with a much greater 'turndown' would be able to accommodate a wider range of flows to the required level of accuracy.

RIIO-1 Delivery

Interventions

- 267. As per our RIIO-1 plan, investment has focused upon the replacement of obsolete flow computers and installation of ultrasonic meters as a replacement for orifice plate metering in key locations. A rolling programme of these asset health works was ongoing for most of the RIIO-1 period. Importantly, assets were prioritised for replacement based on customer requirements at exit points as well as the criticality of the site and the nature and severity of the obsolescence issue. This has resulted in different approaches for different sites, helping us to deliver more risk benefit.
- 268. The initial RIIO-1 interventions were orifice plate refurbishments, rather than replacement with ultrasonic technology. These refurbishments predominantly took place at sites where the long-term flow requirements of the customer e.g. power stations or industrial sites, were more uncertain. In these locations, rather than new technology, a refurbishment of the existing system with new flow computers was the most efficient option.
- 269. Where sites had a more defined future customer requirements, ultrasonic meters were installed, again with new flow computers. These metering systems can not only accommodate future flow ranges but have built in condition monitoring which improves the efficiency of maintenance and troubleshooting by the field force.

270. The third area of intervention has been the refurbishment of station process flow metering, typically turbine meters, at the compressor and multijunction primary assets.
271. The successful completion of this campaign of works cleared the backlog of metering asset health issues, as well as ensuring the long-term accuracy of balancing and metering system calculations across the network.

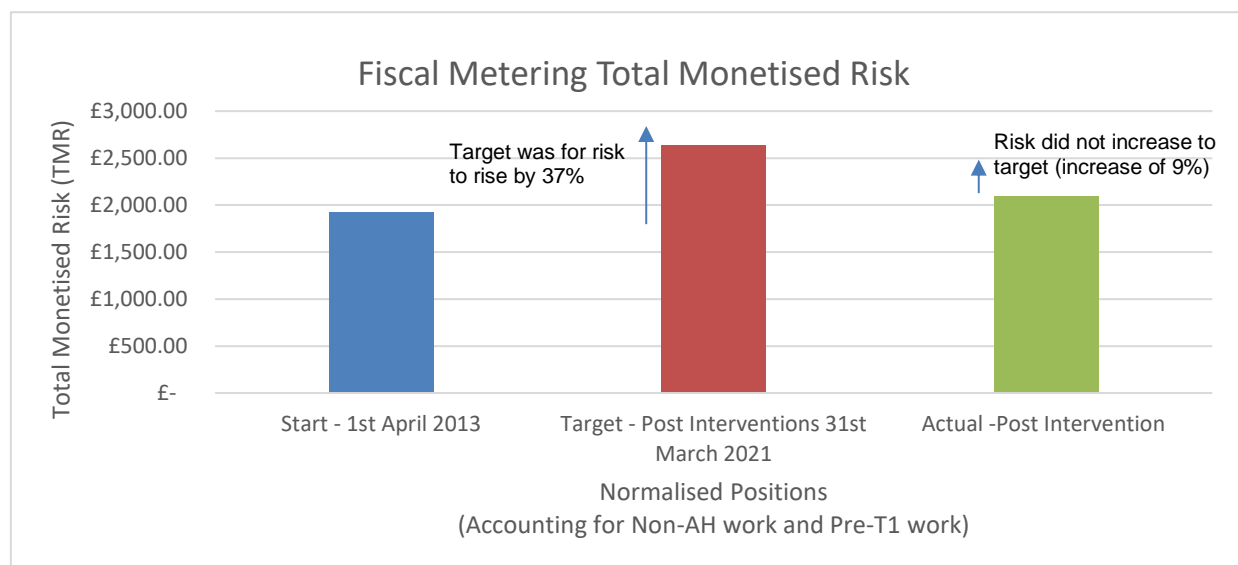
Efficiencies and innovation

272. Efficiencies have been delivered through taking a targeted approach and assessing the best systems for each site. Work under this SAC was bundled for delivery with the gas analyser work where required on the same sites. This was later encompassed in the Pre heat and Gas Quality, Metering and Telemetry (GQMT) campaign.

Monetised Risk Position

273. The target established based upon the RIIO-1 business plan was to allow risk to increase on fiscal metering by 37% across the 8-year regulatory period; we over-delivered this target by 21%.

Figure 13 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

274. In RIIO-1 there was a small net increase of metering assets; most interventions completed were replacements, as seen in the tables below:

Table 23 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	Additions	Replace	Removal	Additions
Entry Point	27	14	0	0	3	0	0
Exit Point	27	12	0	0	21	0	0
Compressor Station	27	10	0	0	5	0	0
Multijunction	27	11	0	0	3	0	0

Table 24 Total asset base changes (including non-Asset Health drivers)

Primary Asset Class	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	27	16	16	0	0	0
Exit Point	27	22	21	0	1	-1
Compressor Station	27	23	24	1	0	1
Multijunction	27	12	11	1	2	-1

Variance against Plan

275. Investment in metering assets has been broadly aligned with our RIIO-1 business plan, with a targeted approach, more monetised risk reduction has been delivered, compared to target.

Conclusion and Learning

276. We appropriately prioritised assets for replacement based on customer requirements at exit points, as well as the criticality of the site and the nature and severity of any obsolescence issues. Going forward into RIIO-2, work on several other exit points will continue whilst further flow computer investments are planned for station control metering.

viii. SAC 31 PIG Traps

Executive Summary

277. The TMR on the network attributable to our pig trap assets is 0.01%. In RIIO-1 we have invested £12.8m in Pipeline Inspection Gauge (PIG) traps and over delivered on this SAC monetised risk target by 2.5%.
278. Periodic PIG trap inspection, revalidation and remedial works has been planned and completed to ensure these assets remain compliant with the PSSR and remain fit for use. The timing of these investments can be estimated with a high degree of accuracy, however, the extent of remedial work required does vary. Additional condition driven interventions have also been required to enable In-line Inspections (ILI) to proceed; without these interventions we would not have been able to launch ILI equipment.
279. In RIIO-1 we have also removed some of our existing PIG traps, replacing them with connections to accommodate temporary, portable PIG trap installations. This asset health intervention effectively removes the hazard from site and has been considered on whole life cost grounds where the ongoing cost of refurbishment and repair is greater than the cost of removal.

Table 25 PIG Trap Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013	Monetised Risk Target with Intervention Position (Normalised) – 31st March 2021	Actual – 31st March 2021	Monetised Risk
Entry Point	£ 224.92 9%	£ 97.01 13%	£ 75.79	11%
Exit Point	£ 367.23 15%	£ 95.36 13%	£ 131.00	19%
Compressor Station	£ 343.00 14%	£ 129.82 18%	£ 161.97	23%
Pipeline	£ 414.63 17%	£ 73.43 10%	£ 37.93	5%
Multijunction	£ 1,054.31 44%	£ 329.37 45%	£ 300.49	42%
Total	£ 2,404.10	£ 724.99	£ 707.18	2.5%

Introduction and investment drivers

280. PIG traps facilitate safe management of our cross-country pipeline assets, providing the mechanism to launch and receive ILI tools, to clean the pipe of debris before collecting integrity data that enables us to make optimum investment decisions and ensure the continued safe usage of these pipeline assets.

281. The inspection of PIG traps are mandated in the PSSR, with the mandatory requirement for 6 yearly visual and 12 yearly major inspections¹⁸. The volume of each inspection type is based on the time since the last inspection for each individual PIG Trap and any defects identified require resolution and remediation within defined timescales. Where defects are identified during the PSSR inspections then the appropriate intervention will be undertaken to restore the asset to operation.
282. In addition to the legal requirements of PSSR, the assets deteriorate over time and with use, which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as PSR.
283. Being above ground, PIG trap coating is subject to deterioration and damage from plant and machinery; corrosion of the metal on all parts of the asset may then occur both externally and internally. The moving parts/components such as door hinges, seals and bleeder block suffer use-based wear and the pressurised elements of the asset can exhibit cracking due to fatigue.

RIIO-1 Business Plan

284. The volume of PIG trap inspection works was estimated with a high degree of accuracy given we must complete periodic inspections to ensure these assets remain compliant with the PSSR and remain fit for use.

RIIO-1 Delivery

Interventions

285. Volume delivery was broadly consistent with RIIO-1 business plan, with some additional interventions being required to enable an ILI run to proceed, where a PIG trap had experienced accelerated deterioration between inspection intervals.
286. The inability to hydro test PIG traps in situ prevents the determination of defects that are superficial only, subsequently we must remediate all defects identified prior to use. Where an ILI run is due and contractors are required to attend quickly, time pressures can potentially increase the cost of remedial works.
287. In the 2014/15 RRP narrative we advised that we would be considering options for PIG traps that were approaching the end of their useful life. This resulted in the subsequent removal of 9 PIG traps and the installation of permanent new bridle pipework and associated supports to enable the connection of portable PIG traps which would then facilitate the launch and retrieval of the intelligent PIG during ILI operation. This intervention was considered on whole life cost grounds when the

¹⁸ In addition to elements of the 6 yearly visual inspection, the coating is removed to enable a detailed examination of the pressure vessel body and its welds.

ongoing cost of refurbishment and repair was greater than the cost of removal. During RIIO-1 it became our preferred strategy to remove PIG traps where the diameter was less than 36" and when the site conditions, access etc, were suitable to accommodate a portable solution.

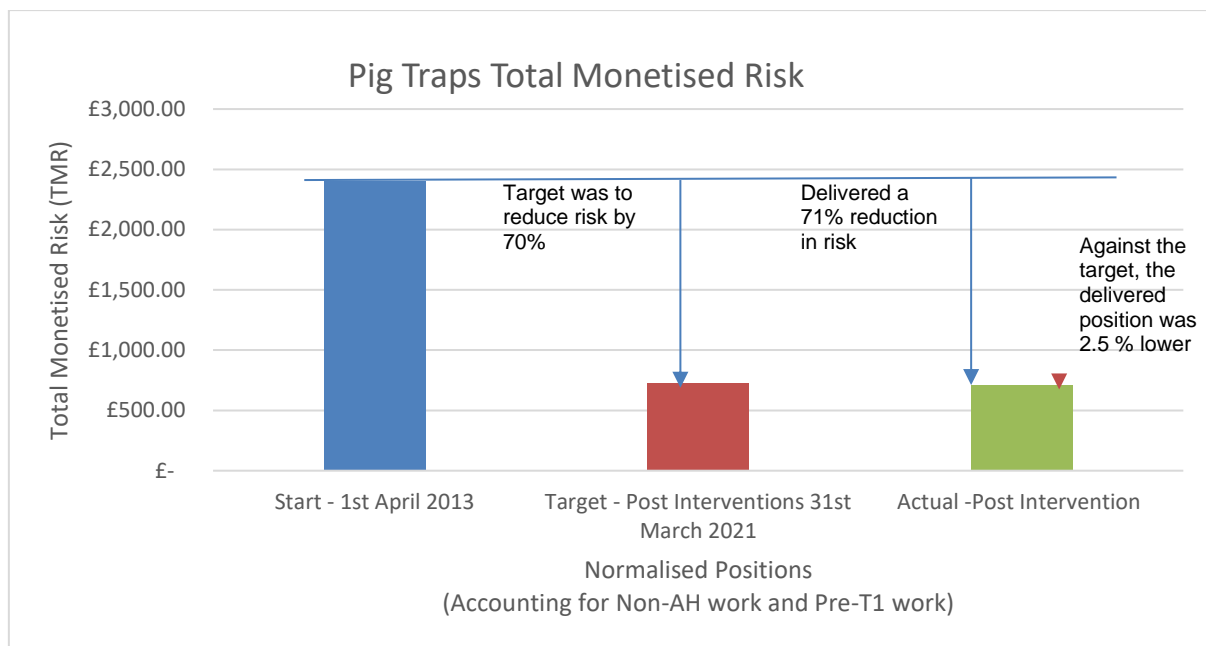
Efficiencies and innovation

288. Removal of a PIG trap removes the requirement for inspection and maintenance at periodic intervals in accordance with legislation; it also removes the potential hazard associated with PIG Trap doors, replacing them with a blank flange or contiguous pipework which provides a more secure point of containment.

Monetised Risk Position

289. The target established based upon the RIIO-1 BP was to reduce the TMR on PIG traps by 70% across the 8-year regulatory period; we have exceeded this target by 2.5%.

Figure 14 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

290. In RIIO-1 there was a small net reduction of PIG trap assets and the vast majority were removed and replaced with connections to accommodate temporary, portable PIG trap installations, tables below:

Table 26 Asset Health (only) intervention driven changes

Site	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	31	12	0	0	14	0	0
Exit Point	31	24	0	0	19	2	0
Compressor Station	31	20	0	0	17	0	0
Pipeline	31	28	0	0	28	5	0
Multijunction	31	67	0	0	69	2	0

Table 27 Total asset base changes (including non-Asset Health drivers)

Primary Asset Class	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	31	20	19	0	1	-1
Exit Point	31	31	30	1	2	-1
Compressor	31	30	33	3	0	3
Pipeline	31	33	28	0	5	-5
Multijunction	31	96	88	0	8	-8

Variance against Plan

291. Investment in PIG traps has been prioritised in RIIO-1 to ensure these assets remain compliant with the PSSR and to facilitate other essential works to ensure we can maintain the integrity and safety of the network.

Conclusion and Learning

292. We shall continue to periodically inspect PIG traps to ensure these assets remain compliant with PSSR and that they remain fit for use. Early inspection might be considered where ILIs are scheduled, so that any potential defects may be identified in sufficient time to arrange rectification in advance of ILI equipment launch.

ix. SAC 32 Above Ground Pipe and Coating

Executive Summary

293. The TMR on the network attributable to our above ground pipe and coating assets is 0.17%. In our RIIO-1 business plan we did not propose any capital investment allowance, however, invested £41.5m into our above ground pipework assets, due to physical asset condition and the need to maintain the safety and integrity of these assets at designated sites.
294. The rebasing exercise established monetised risk targets based upon replacement/refurbishment outputs in the form of rebased intervention volumes (129 interventions, i.e. sites). We delivered full site refurbishment interventions (Full site repaint) on above ground pipework assets at 77 sites and under delivered on this SAC's monetised risk target by 7%.

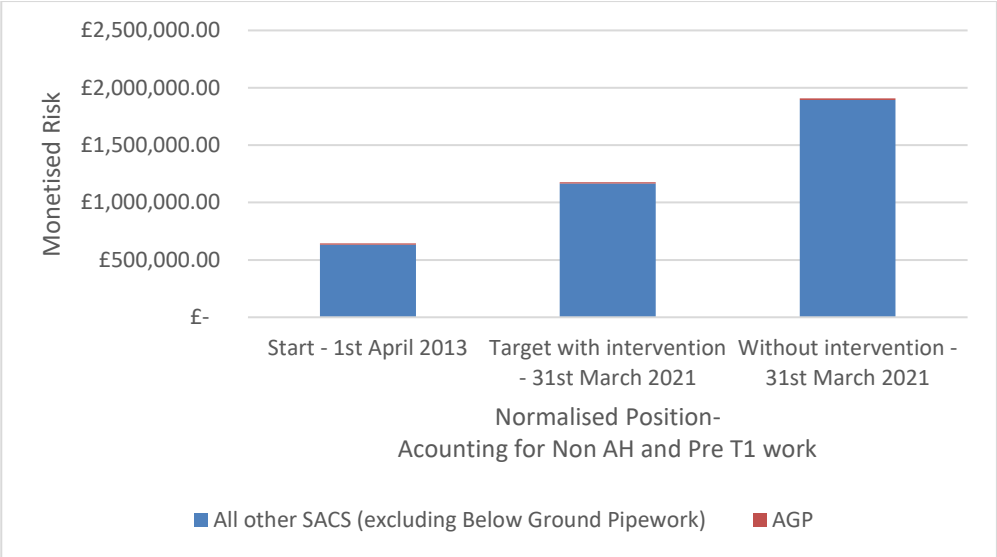
Table 28 Above Ground Pipework Monetised Risk Performance

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target (£) with Intervention Position (Normalised) – 31st March 2021		Actual Monetised Risk (£) – 31st March 2021	
Entry Point	£ 904.83	8%	£ 99.19	1%	£ 888.18	9%
Exit Point	£ 4,604.76	40%	£ 4,238.07	46%	£ 3,173.08	32%
Compressor Station	£ 250.40	2%	£ 107.48	1%	£ 182.59	2%
Pipeline	£ 1,658.58	15%	£ 597.32	7%	£ 1,452.85	15%
Multijunction	£ 3,999.62	35%	£ 4,113.07	45%	£ 4,103.44	42%
Total	£ 11,418.18		£ 9,155.13		£ 9,800.13	7%

295. No capital investment was proposed in RIIO-1 as risk has previously been managed via routine/non-routine painting of the above ground pipework assets. During the regulatory period and as reported within the RRP, it became increasingly apparent that the actual condition of our above ground pipe assets were considerably worse than modelled. We prioritised risk using plant status (high scoring risks typically being associated with assets that keep gas within the system to prevent a fire or explosion and ensure gas reaches consumers) and invested to mitigate the effects of corrosion on our above ground pipe at specific sites, however, this delivered only a very small monetised risk benefit. Remedial action focused on defects classed as category 6 under our T/SP/CM/4 inspection/assessment; we also sought opportunity to remove less severe corrosion defects at these same sites where this could be achieved cost effectively. Given the unit of measure for above ground site pipework is per site, where intervention was only on the priority defects at a site, this did not always allow us to claim an output.
296. Above ground pipework consists of a large number of assets, however, only contributes a small amount to the TMR on the network. Excluding for below ground

pipework which is the bulk of our risk, above ground pipework is less than 2% of the residual monetised risk at the start of the period, end of the period (with or without intervention) or our actuals.

Figure 15 Total Monetised Risk associated with Above Ground Pipework SAC (Note: excludes Below Ground Pipework)



Introduction and investment drivers

- 297. Above ground pipework is painted to prevent corrosion. Paint systems degrade over time (typical lifespan of 10-15 years); as the paint system degrades the pipework becomes exposed to atmosphere and we see the onset of corrosion. Corrosion growth rates are more severe where the site is located in areas subject to air borne salts or other contaminants, such as in coastal or industrial locations. Corrosion is more prevalent in key areas such as underneath pipe supports, at the transition from above to below ground (either at a pit wall or the wind/water line), in congested areas subject to stagnant air or on specific elements (such as flanges or small-bore pipework).
- 298. Throughout RIIO-1 we have sought to significantly increase our understanding of the condition and deterioration rates of our assets. We updated our corrosion management process, producing more detailed assessments of corrosion defects on our above ground installations, this data that was not available ahead of RIIO-1, however, showed widespread corrosion issues requiring resolution to ensure significant end of life asset risks do not materialise in the medium term.

Legislation/industry standards

- 299. These assets deteriorate over time and with use, which in turn leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as the PSSR and the PSR.
- 300. The industry accepted standard for the design construction, operation and maintenance and decommissioning management of above ground installations, including buried pipework in the UK is IGEM/TD/1. The corrosion of steel pipework either above or below ground is an unavoidable consequence of operation. The management of corrosion issues has improved with time and this is reflected in the evolving standard. Corrosion mechanisms are now better understood allowing the management of them to become more sophisticated. Coating/painting types and techniques have improved over time as the understanding of the materials and their long-term performance, safety and environmental impact is better understood. The remediation of pipework defects or “features” to industry standards (IGEM TD/1), supplemented by our policies and procedures is acknowledged by the Health and Safety Executive as an appropriate way of operating a safe above ground pipework asset and complying with required legislation.

Inspection Policy

- 301. T/SP/CM/4 inspections are undertaken and results recorded for seven individual asset types: general pipework, risers, flanges, pipe supports, pit wall transitions, cladding & valve vent and sealant lines; the condition of these assets are categorised 1-6. Any assets that are categorised 4-6 require further investigation/inspection to timescales outlined in CM/4.
- 302. Prior to the update of the CM/4 methodology in 2016 the results recorded from the inspections were for the worst category of defect identified for each of the seven asset types on a site. This provided the information required to further investigate and assess the site and determine the actual number of defects requiring remediation.
- 303. The update of the CM/4 methodology in 2016 changed the inspection and recording policy in order to undertake more effective and efficient management and planning of corrosion defects. From 2017 onwards, all CM/4 inspections recorded the volume of individual categories of grade 3, 4, 5 and 6 defects. Note that by 2024 all sites will have undergone a CM/4 inspection using the revised policy and individual counts of all significant defects for all seven asset types will be available.
- 304. Corrosion defects on above ground pipework are inspected and repaired in accordance with T/PM/P11 & T/PM/P/20. These specifications are well established within the gas industry for inspection of damage to pipelines and pipework. Following an inspection, assets in category 4, 5 or 6 are subject to further investigation and assessment which will include removal of paint followed by non-destructive testing, to assess the corrosion loss. A decision is then made against our defined policies to determine the intervention that is required, defects classified as superficial will be repaired by repainting, whilst those above the superficial limit

will require more extensive repair and may include; cut out and replace, recoat, composite wrap/epoxy shell.

305. The inspection regime, timing and defect categorisation is designed to ensure that a defect should not move more than one category between each inspection. This balances the effective monitoring of corrosion, the mitigation of risk of increasing corrosion and the costs of inspection.

RIIO-1 Business Plan

306. The RIIO-1 BP did not detail the requirement for capital investment in RIIO-1 as risk had previously been managed via routine/non-routine painting of the above ground pipework assets.

RIIO-1 Delivery

Network actual vs modelled condition

307. Throughout our RRP reporting, we have articulated that actual network condition is considered worse than the modelled view (RIIO-1 NOMs Methodology). We have therefore continued to target our asset health programme around key areas of risk identified through observed condition and issues. We have in effect “traded risk” across asset categories and prioritised high value asset categories such as Above Ground Pipework.

Painting (opex) insufficient to manage effects of corrosion

308. Our RIIO-1 business plan intended for routine and non-routine patch painting of our above ground assets to be managed via opex, however, this would not have allowed us to keep up with the rate of corrosion growth and subsequent deterioration observed on these assets. More extensive site wide capital painting programmes have therefore been necessary to refurbish sites where the effects of corrosion have been more severe to avoid isolation/unavailability of plant (isolation of defects being necessary to control any risk of loss of containment).

Resultant interventions

309. Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of the above ground pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore limit the availability or performance of the NTS as a whole.

Example site: St Fergus

310. We have been required to invest heavily at St Fergus Terminal, where accelerated corrosion has been prevalent and required urgent intervention. Due to its age, operating conditions and coastal location, the above ground pipework at St Fergus has experienced significant corrosion. To better understand the extent of the corrosion on the above ground assets at this site, in 2015 we conducted a full

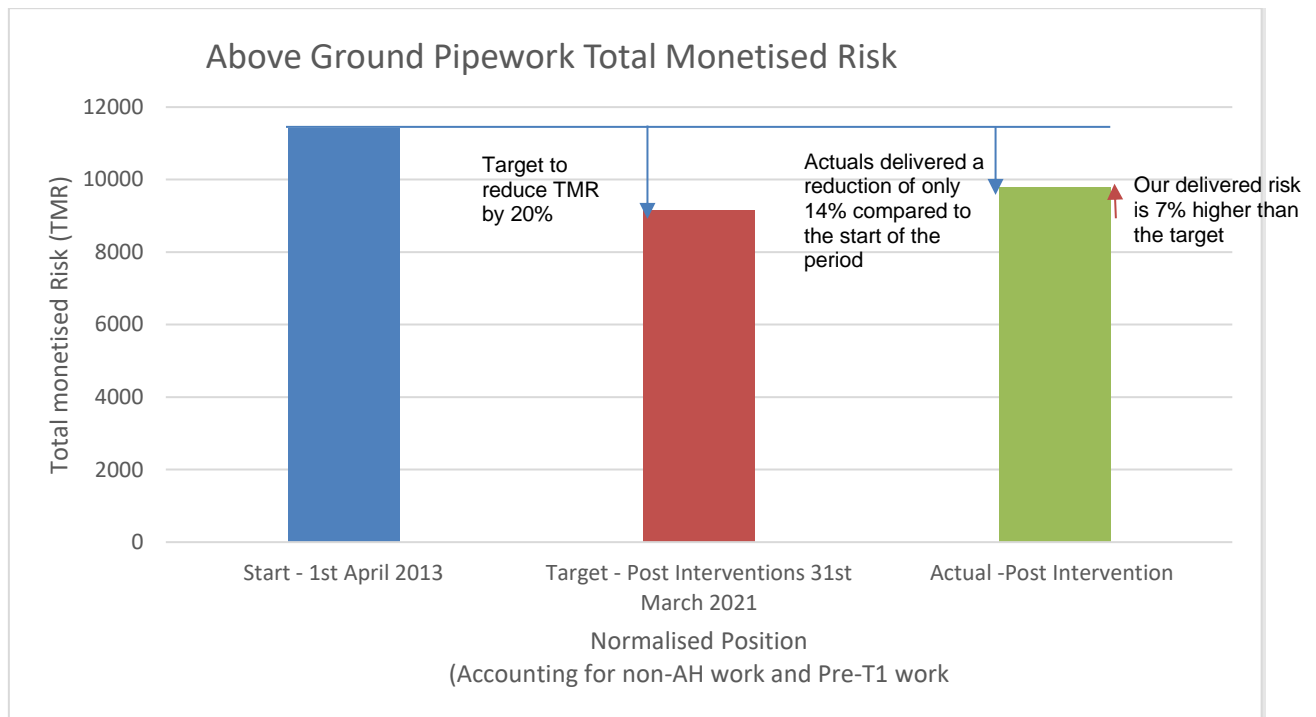
survey of all of the above ground pipework against T/SP/CM/4. The results of this indicated extensive corrosion across the site and the need to prioritise capital intervention in RIIO-1. We removed the majority of CM/4 Category 6 corrosion defects by the end of RIIO-1 and sought opportunity to remove less severe corrosion defects where this could be achieved cost-efficiently, these were tracked and managed via DORAM.

Efficiencies and innovation

- 311. Early asset campaign preparation activities included undertaking an initial cleansing of PSIs and wider works to assess the relative criticality of asset types. Note this was not limited to above ground pipework but rather all assets across the St Fergus Terminal. Given the volume of condition issues recorded, a site-wide campaign strategy was adopted as the best way to address its specific asset health issues, to mitigate having multiple projects with potentially overlapping timeframes present on site. The prioritised PSIs were reviewed in detail by SMEs then profiled on risk appetite to determine the detailed work programme for the remainder of RIIO-1 (2019-2021).
- 312. We have also conducted innovation projects to approve the use of composite repair wraps on above ground pipework; we have successfully installed these at the following sites: St Fergus, Brigg, Aberdeen and Aylesbury.

Monetised risk position

- 313. The target established based upon the RIIO-1 BP was to reduce the TMR on Above Ground Pipework by 20% across the 8-year regulatory period; we under delivered this target by 7%.

Figure 16 RIIO-1 Risk Performance against Start Position and Target**Asset base changes**

314. In RIIO-1 there was a small net reduction of above ground pipework assets, the volume changes are inclusive of non-asset health drivers.

Table 29 Asset Health (only) intervention driven changes

Site	SAC	RIIO-1 Business Plan			Actuals		
		Refurbish	Removal	New Additions	Refurbish	Removal	New Additions
Entry Point	32	0	6	0	3	0	0
Exit Point	32	66	0	0	20	2	0
Compressor Station	32	15	0	0	9	0	0
Pipeline	32	0	130	48	32	2	1
Multijunction	32	48	0	0	13	0	0

Table 30 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	32	18	16	0	2	-2
Exit Point	32	117	112	0	5	-5
Compressor	32	22	23	1	0	1
Pipeline	32	178	176	3	5	-2
Multijunction	32	82	80	0	2	-2

Variance against Plan

315. At several our above ground installations we have been required to complete intrusive capital interventions that were not planned within our RIIO-1 proposal, where the routine/non routine painting of our above ground pipework has not alleviated the aggressive corrosion growth we have observed.

Conclusion and Learning

316. Our capital investment in above ground pipework has been necessary to maintain the safety and integrity of these assets at designated sites. Our RIIO-1 business plan had intended to manage routine and non-routine patch painting via opex, however, this would not have allowed us to keep up with the rate of corrosion growth experienced on these assets. The learning taken to conduct more extensive site wide capital painting programmes where the effects of corrosion have been more severe has subsequently been adopted within our RIIO-2 business plan.

x. SAC 33 Below Ground Pipe and Coating

Executive Summary

318. The Total Monetised Risk (TMR) on the network attributable to our below ground pipe and coating assets is 75.83%. In RIIO-1 we have invested £77.7m in below ground pipe and coating, and over delivered on this SAC monetised risk target by 3%, which is a result of delivering an increased volume of work compared to our RIIO-1 Business Plan (BP).
319. We planned and completed PSSR inspections and interventions as required to maintain the safety and integrity of the network. The interventions completed were predominantly those prioritised by our risk-based scheduling method Intervals 2. These interventions delivered less benefit than those proposed within the RIIO-1 BP (as expressed in the rebasing exercise¹⁹), however, the increased volume of interventions delivered (2009 in total) allowed us to exceed the monetised risk target. The rebasing exercise established monetised risk targets based upon outputs in the form of rebased intervention volumes (1634).

Table 31 Below Ground Pipe and Coating Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 201		Monetised Risk Target (£) with Intervention Position (Normalised) – 31st March 2021		Actual Monetised Risk (£) – 31st March 2021				
Entry Point	£	4.20	0.00%	£	7.23	0%	£	9.77	0.00%
Exit Point	£	702.08	0.01%	£	752.40	0%	£	12,760.64	0.30%
Compressor Station	£	2.49	0.00%	£	5.42	0%	£	9.12	0.00%
Pipeline	£	4,698,217.99	99.98%	£	4,333,015.94	100%	£	4,178,259.90	99.63%
Multijunction	£	435.79	0.01%	£	2,889.49	0%	£	2,892.77	0.07%
Total	£	4,699,362.56		£	4,336,670.47		£	4,193,932.20	3.29%

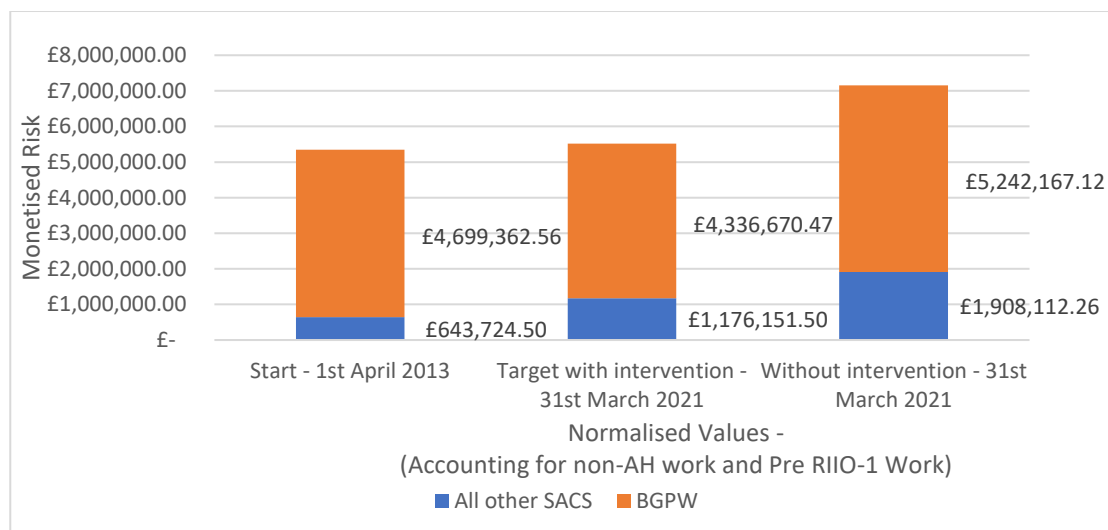
320. Below ground pipe and coating assets exist on all five PACs, with the 'pipelines' primary asset being more than 99% of the total below ground pipe and coating risk. Below ground pipe and coating within the pipelines PAC is therefore the focus of this SAC performance summary. The below ground pipe and coating assets at non-pipelines primary asset classes relate to below ground pipe and coating at AGIs, which is relatively insignificant compared to the NTS pipelines network.
321. The below ground pipe and coating SAC also carries a significant proportion (75.8%)²⁰ of the TMR on the network.

¹⁹ The RIIO-1 BP expressed volumes; in the rebasing exercise we assigned intervention volumes to assets alternatively from the middle of AH5 until all interventions were used.

²⁰ Based on 'actuals' dated 31st March 2021

322. At the start of the period, 1st April 2013, pipelines accounted for 88% of the networks TMR, with the bulk of the risk (99.6%) on the pipelines PAC attributable to the below ground pipe and coating SAC. The proportion of TMR associated with pipelines varies between the target, delivered/actual, and without intervention position, however, the pipelines PAC always carries the bulk of the total network risk, >75 %, with below ground pipe and coating carrying the bulk of the pipelines primary assets risk, >95%, in all scenarios.

Figure 17 Total Monetised Risk associated with Below Ground Pipe and Coating



Introduction and investment drivers

Pipeline inspection driven by Legislation

323. Our pipelines are designed and maintained to safely convey gas at a specified pressure and to meet legislative and safety requirements as set out within IGEM/TD/1 industry standard with regards to safety distances and other operating parameters. On a proximity weighted basis, it is our cross-country pipelines that pose the greatest potential safety hazard to the general public. The inspection of our pipelines as a pressure vessel are mandated in the PSSR and a regime of ILI allows us to understand the integrity of the pipeline and for any necessary remediation to be targeted.
324. Throughout RIIO-1 we have continued to ensure our transmission pipelines remain compliant with the PSSR and PSR, proactively managing known defects that have the potential to result in a loss of containment.

Intervals 2 determines inspection frequency

325. Our risk-based scheduling method 'Intervals 2' is used to demonstrate our compliance with PSSR and PSR and determines the interval to the next ILI for each pipeline, outputting a "next due" date for the inspection. The tool is mechanistic; its output provides us with a condition snapshot based upon the previous ILI data and CP maintenance data associated with a pipeline. Updates in pipeline feature data

and maintenance compliance may therefore cause forecasts to change, resulting in continual revisions to the ILI profile each year. This tool has been ratified by the HSE as “accepted practice”. The output of Intervals 2 is a modelled probability of failure which informs the required survey frequency. Intervals 2 does not directly consider the consequences of any pipeline failure resulting from failure to identify and rectify a defect. It is therefore possible that our legislative work does not target the highest monetised risk assets. This is an area for future discussions with competent persons and the HSE as the current process is mandated.

Threshold for integrity issues (Policy: T/PM/P/11) establishing need for intervention

- 326. Our internal policy T/PM/P/11 is used to determine the threshold for pipeline integrity issues and we always aim to remediate a pipeline defect before failure to ensure the network remains safe.
- 327. A severity profile for projected defects cannot be applied until ILI results have been interpreted by integrity engineers. Any feature/defect requiring excavation and repair has effectively reached or exceeded the limit of the superficial category detailed in T/PM/P/11 for a given pipeline. The specific limits for each pipeline will vary based upon the defect type and its operating stress.

RIIO-1 Business Plan

- 328. We advised that more than 60% of our NTS pipelines would exceed their original design life by the end of RIIO-1 and that an increased level of secondary asset investment would be required to ensure we are able to maintain the health and integrity of the pipeline system. Our forecast investment provided a marked step up to reflect an anticipated increase in the number of defects reported as pipe coating breaks down concurrent with pipeline age.
- 329. Our plan assumed the level of work would stabilise during the RIIO-1 period however there was a possibility that the number of interventions required may increase. We advised this would be managed via substitution of investment from other secondary asset classes to ensure high priority work is completed.

RIIO-1 Delivery

Resultant interventions

- 330. With our pipeline infrastructure carrying significant process safety risk and the resultant legislation that drives us to inspect and maintain the health of these assets, we have appropriately prioritised RIIO-1 investment on our below ground transmission pipelines. This has been in response to the identified risk of loss of integrity from the condition of our coating and cathodic protection systems; delivering considerably more ILI dig interventions than initially forecast in our plan to ensure our pipelines remain safe and operational.

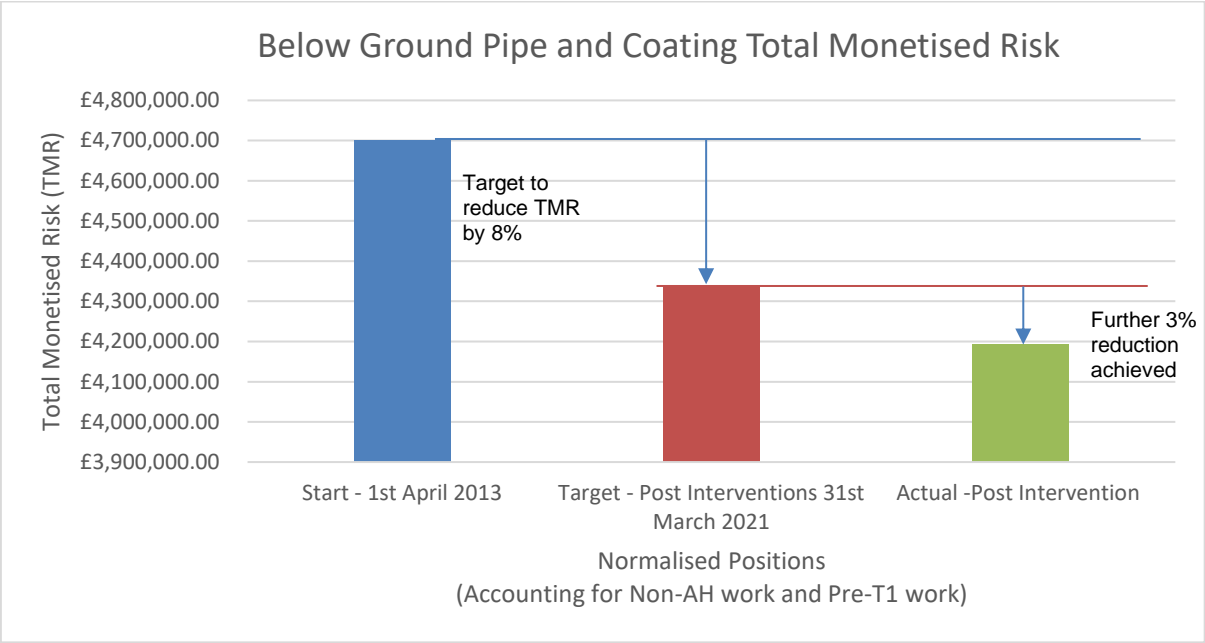
Efficiencies

331. In 2019/20 we moved from a one to two-year remediation process to allow for more efficient planning and delivery, the significant pipeline features investigated and remediated in this year had been identified from our 2017/18 ILI runs. This approach has allowed us to better plan across the entire NTS outage plan and consider how best to undertake other campaigns of work within the same outages required by the ILI digs.

Monetised risk position

332. The monetised risk target established based upon the RIIO-1 BP was to reduce the TMR on below ground pipe and coating by 8% across the 8-year regulatory period; we over delivered this target by 3%.

Figure 18 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

333. In RIIO-1 there was a 20km net reduction of pipeline assets and the vast majority was associated with the decommissioning of Feeder 1 (Easington to Paull); for site-based assets there has been a small reduction in the number of below ground pipe and coating related assets²¹.

²¹ The below ground pipe and coating NOMs associated with Feeder 9 were claimed as a refurbishment, hence do not appear in the additions/removals columns (Note: more Monetised Risk benefit would be gleaned from an asset removal and subsequent addition.

Table 32 Asset Health (only) intervention driven changes

Site	SAC	RIIO-1 Business Plan			Actuals		
		Refurbish	Removal	New Addition	Refurbish	Removal	New Addition
Entry Point	33	2	0	0	2	0	0
Exit Point	33	17	0	0	1	1	0
Compressor	33	9	0	0	1	0	0
Pipeline	33	1600	0	0	2003	24	4
Multijunction	33	7	0	0	2	0	0

Table 33 Total asset base changes (including non-Asset Health drivers)

Primary Asset Class	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	33	18	17	1	2	-1
Exit Point	33	117	116	1	2	-1
Compressor Station	33	22	23	1	0	1
Pipeline	33	7656	7636	5	25	-20
Multijunction	33	82	80	0	2	-2

Variance against plan

334. With our pipeline infrastructure carrying significant process safety risk and the resultant legislation that drives us to inspect and maintain the health of these assets, we have appropriately prioritised RIIO-1 investment on our below ground transmission pipelines.
335. For site based below ground pipe and coating (in the four non-pipelines PACs) we delivered less interventions than forecast, however, on the pipelines PAC we delivered an increased volume (~22%) compared to the RIIO-1 Business Plan²².

Conclusion and Learning

336. Our below ground pipe coating investment has focused on ensuring our transmission pipelines remain compliant with the PSR and PSSR, proactively managing known defects that have the potential to result in a loss of containment. Our cross-country pipelines pose the greatest potential safety hazard to the general public and carry 76% of the TMR on the network, the prioritisation of these assets has therefore been essential.

²² ²² The Below Ground Pipe and Coating unit of measure associated with the 4 site based PACs is per site, whereas for 'Pipelines' it is 1 asset per kilometre.

xi. SAC 34 Power Turbines

Executive Summary

337. The TMR on the network attributable to our power turbine assets is 3.23%. In RIIO-1 we invested £13.1m on power turbines, and over-delivered on our network risk target by 4%, which is a result of delivering overhauls as per the business plan that in turn have a high associated monetised risk value.
338. We have continued to inspect and manage our fleet of power turbines through an overhaul regime that follows OEM guidance and maintains desired levels of reliability and availability.

Table 34 Power Turbine Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention (Normalised) - 31st March 2021		Actual Monetised Risk – 31 st March 2021	
Entry Point	£ 5,221.78	13%	£ 22,662.66	13%	£ 24,264.00	14%
Compressor Station	£ 36,170.06	87%	£ 155,699.37	87%	£ 146,277.77	86%
	£ 41,391.85		£ 178,362.03		£ 170,541.77	4.4%

Introduction and investment drivers

339. Our gas driven compressor train consists of a gas generator, a power turbine and a gas compressor. The energy generated from the gas generator is used to propel the power turbine, driving the gas compressor which then increases the pressure and flow rate of the gas through the transmission pipeline. There are 61 operational power turbines on the network.
340. Due to the pattern of gas flows required by our customers and consumers becoming increasingly variable, the patterns of gas movement across the network have changed with increased, and much more complex demand on the compression fleet. This has increased the stress on compressor machinery due to greater frequency of start-stop cycles and more volatile running hour periods. Changes in usage, especially increasing start-stop cycles of the compressor train has resulted in the need to increase the number of power turbine overhauls. These interventions ensure that compression assets remain supported by the OEM and continue to operate at an acceptable level of availability.
341. Most of the investment associated with power turbines is derived from duty profiles (run hours and number of starts/stops); these are described in best practice integrity management policies based on OEM guidelines which we always aim to adhere to as a safety requirement for operating these machines.
342. It is vital for the supply of gas to our customers that our power turbines remain available and resilient to the demands and changes on the NTS and investment in our compressor trains is essential to ensuring this availability is not compromised.

Inspections and Monitoring

343. The condition information gathered from borescope inspections is used to determine the appropriate intervention period to overhaul the power turbine. A power turbine's deterioration mechanisms vary depending upon its use and operational environment. A low running unit with multiple stops and starts can deteriorate faster than a unit which has longer running hours or has been in constant use.
344. If power turbines are not inspected and maintained to the required standard, we run the risk of a potential loss of asset integrity due to its continued operation or its age-related degradation. The power turbine is high speed rotating machinery where integrity must be maintained to ensure that there is no catastrophic failure which could impact upon other assets such as the gas generator or compressor. The risk to the network is loss of single compressor machine capability. Depending on location of the compressor unit, gas flows and on the availability of a standby unit, exit or entry point capacity may be impacted. The outages required to manage the majority of overhauls typically take place during summer months when there is a reduced requirement for compression.

Major Overhaul Regime

345. In line with the OEM recommendations and gas industry standard practice, major sub-systems of the compressor train, including the power turbine, become life-expired after a specified number of 'life hours' have been consumed. Operating the machinery beyond their life hours significantly increases the risk of failure of the machinery and compressor train. The life hours consumed calculation considers the utilisation, age and operating regime of the asset. At the point where the asset is deemed to be life-expired, it is returned to the OEM for overhaul (or 're-life'). This activity effectively restores the full life of the asset for continued operation on the NTS.
346. Whilst power turbines are designed as part of a compressor train and are therefore matched with gas generators and compressors, there is some limited interchangeability that exists between sites and berths to help manage the requirement for overhauls. The approach to power turbine overhaul depends on the unit, with older power turbines overhauled 'in berth' and more modern integrated units being overhauled at the same time as the gas generator. Our power turbine asset base includes 'Dresser-Rand Vectra' power turbines which are unique in design and require particular attention within the broader power turbine overhaul investment strategy. Overhaul of this group of power turbines for example is managed by substitution, using a strategic spare Vectra power turbine to support the five power turbines installed at some of the high capacity compressor stations on the NTS (two units at Aberdeen, two units at Bishop Auckland and one at Carnforth).

Managing Fleet Capacity

347. We manage the loss of operational fleet capacity in the event of a planned overhaul or 'Found on Inspection' (FOI) failure, by considering the following options:

348. Availability of operational standby units

- Use of fleet strategic spare gas generators
- Proactively managing the operational life of the gas generator fleet
- Defer the overhaul, by strategically moving the gas generator to a low usage site
- Repair the gas generator
- Temporarily lease a gas generator from the market
- Purchase a new gas generator from the market
- Manage the increased risk through operational processes
- Accept risk of a reduction in standby capability (low utilisation sites)

RIIO-1 Business Plan

349. Our RIIO-1 investment programme was designed to maintain the reliability and availability of the power turbine units but recognised that there would be a reduced volume of works associated with those powered by gas generators identified for replacement as part of the IED related investments. This resulted in a reduction in the proposed number of power turbines to undergo a full overhaul, however, minor work was still required to ensure these assets remained reliable and available ahead of replacement works or their cessation to operate.

350. The serviceability investments planned for power turbines over RIIO-1 period includes the re-life of:

- 4 to 5 Rolls Royce RT48 power turbine units
- 7 to 8 EAS1 power turbine units
- 1 to 2 HSPT (Pignone) power turbine units
- 3 to 4 SGT400 power turbine units
- 1 Vectra 40G power turbine unit

351. These volume ranges reflected an operational utilisation uncertainty. There were no intended overhauls to the Siemens (GEC) ERB1s and Rolls Royce (Cooper) RT56s units in our plan, given these power turbines are RB211 (or Maxi Avon) driven and were therefore to be phased out as part of the IED investment programme.

RIIO-1 Delivery

Interventions

352. We overhauled 15 power turbines in RIIO-1 which have been coordinated as part of the compressor and cab infrastructure campaign, prioritising compressor unit overhauls based on run hours and site criticality. The majority of our power turbines were overhauled in the second half of RIIO-1, mainly due to increased usage of northern compressor units during higher levels of demand and flow through St. Fergus terminal. The location of power turbine overhauls reflects this, with 11 of the 15 overhauls taking place at the northerly compressor stations: Aberdeen, Avonbridge, Bishop Auckland, Kirriemuir, Wooler and St. Fergus.

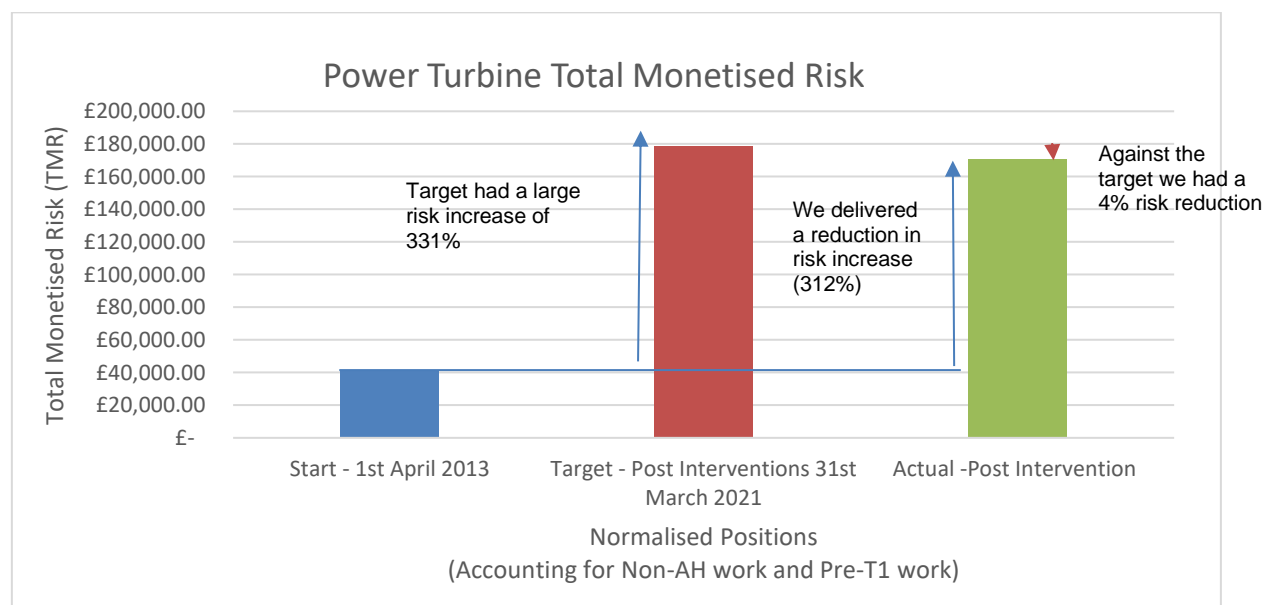
Efficiencies and innovation

353. Opportunities for increasing the efficiency of asset health works within the compressors campaign focused on the rolling programme of overhauls. Traditional approaches to overhauls were resulting in unanticipated faults being found on strip down. The units could not then be returned to service without rectification of the defect, at additional cost. A service exchange approach has been adopted for modern power turbines, whereby a fixed cost provides for gas turbine or train replacement (depending on type) in the event of a loss of availability failure or when an overhaul is due.

Monetised Risk Position

354. The target established based upon the RIIO-1 BP was to allow risk to increase on Power Turbines by 331% across the 8-year regulatory period; we over delivered this target by 4%.

Figure 19 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

355. During RIIO-1 there has been a small net reduction of Power Turbine assets which were predominantly driven by the decommissioning of IED non complaint units that were in poor condition to allow for prioritisation of spend, see tables below:

Table 35 Asset Health (only) intervention driven changes

Site	SAC	RIIO-1 Business Plan			Actuals		
		Refurbish	Removal	New Addition	Refurbish	Removal	New Addition
Entry Point	34	3	0	0	2	0	0
Compressor	34	11	0	0	13	0	0

Table 36 Total asset base changes (including non-Asset Health drivers)

Site	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	34	7	7	0	0	0
Compressor Station	34	57	54	2	5	-3

Variance against Plan

356. We delivered a volume of power turbine overhauls that was broadly in line with what we had originally anticipated at the start of RIIO-1. This volume of work was predominantly driven by the duty completed by each power turbine, overhauling in line with the frequency recommended by the OEMs.

Conclusion and Learning

357. We responded to an increased level of running hours for our power turbines, mainly associated with our northern compressor stations, completing major overhauls as required. This work has made sure our compressor fleet, of which power turbines are a major component, has remained at an acceptable level of reliability throughout RIIO-1. We continue to use OEM guidance on overhaul frequencies for our power turbines and use running hour forecasts to aid our overhaul planning going into RIIO-2.

xii. SAC 35 Preheaters

Executive Summary

358. The TMR on the network attributable to our preheater assets is 0.18%. In RIIO-1 we invested £15.5m in preheaters and under-delivered on our network risk target by 316%. This is a result of prioritising our compliance with PSSR and not always intervening on assets that deliver the most monetised risk reduction on the network. Changing customer requirements has also required us to focus investment on replacing existing preheat assets at industrial offtakes, to ensure they remain fit for purpose in supplying customers.
359. We have continued to maintain compliance with our PSSR obligations by inspecting and remediating preheater assets when necessary and meeting our connected customer requirements. Our asset health reprioritisation programme ensured that we were revalidating the need for replacement or refurbishment activities, by identifying customer connections, predominantly power stations, that had limited life expectancy.
360. The recent transition to NARMs has provided increased visibility of assets that are of high monetised risk value on the network; going forward this shall enable improved prioritisation of investment, intervening to reduce increased levels of risk going forward.

Table 37 Preheaters Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target (£) with Intervention Position (Normalised) - 31st March 2021		Actual Monetised Risk (£) - 31st March 2021	
Entry Point	£ 2,473.99	23%	£ 3,210.13	32%	£ 3,861.82	9%
Exit Point	£ 906.76	8%	£ 1,380.41	14%	£ 1,332.75	3%
Compressor	£ 7,202.66	67%	£ 5,207.43	52%	£ 35,812.93	87%
Multijunction	£ 238.30	2%	£ 141.70	1%	£ 373.52	1%
Total	£ 10,821.70		£ 9,939.67		£ 41,381.02	316%

Introduction and investment drivers

361. Preheater assets typically comprise boilers or water bath heaters, with heat exchange equipment and associated ancillary controls and monitoring. Pre-heat systems have a critical role in relation to gas quality and protection of NTS and customer assets from damage caused by gas temperature variations. Preheater assets exist on four of the five PACs, excluding pipelines. The 'compressor' primary asset carries most monetised risk associated with the preheater assets.
362. Natural gas within the NTS is pressurised in order to move the gas through the system; this pressure must be reduced at key locations such as customer offtakes. When depressurisation occurs, a process known as the Joule-Thompson effect

causes the gas to cool. If the gas is allowed to over-cool there is a risk of heavy hydrocarbon drop out and a reduction in gas quality or icing problems as any moisture present may condense and freeze.

- 363. There are two key drivers for gas pre-heating: to prevent the gas quality issues described and, in some cases, to meet customer contractual obligations. One of the primary performance requirements in customer contracts is gas temperature as this can be critical in protecting customer plant from damage caused by temperature variations.
- 364. Pre-heat system asset health works associated with customer offtakes and at key strategic locations within the NTS have been prioritised for RIIO-1, reflecting the critical role of this asset and the need for system reliability.
- 365. However, it is also recognised that there is a need to re-validate pre-heat requirements prior to making asset health investment decisions. This includes re-confirming the pre-heat flow and temperature requirements in order that equipment is appropriately sized for its current and future projected needs, which may have changed. Many of the legacy NTS offtakes with pre-heat systems are associated with power stations or other industrial plant that may be nearing the end of their projected lifespan. In such cases a fix-on-fail strategy may be more appropriate than full system replacement.
- 366. These assets deteriorate over time and with use, which leads to their inability to perform their required function which may result in them no longer complying with direct legislative requirements. Asset deterioration might include breakdown of coating, corrosion of both internal and external surfaces, fatigue.

PSSR Legislation

- 367. Heat Exchangers are captured under the PSSR and the aim of these regulations is to prevent serious injury from the hazards of stored energy. This is achieved through correct design, installation and maintenance, provision of information, operation within Safe Operating Limits (SOLs) and, where applicable, examination in accordance with a Written Scheme of Examination (WSOE) drawn up or approved by a competent person. Consequently, our WSOE contains minimum inspection and maintenance requirements that it must undertake to demonstrate compliance with PSSR. Compliance with PSSR has driven inspection and validation of the heat exchanger assets and the associated remediation of any defects found. However, waterbath heaters and modular boilers are not subject to PSSR.

RIIO-1 Business Plan

- 368. The majority of preheat systems were installed when sites were originally constructed and, at the time of writing our RIIO-1 business plan, were showing sign of deterioration through performance and reliability.

369. The forecast investment plan was to replace circa five small, eight medium and 16 large systems during the RIIO-1 period. In addition, there was also to be partial refurbishment of some preheaters to ensure they continue to provide adequate preheating requirements. The work was to be targeted at exit points where the condition and performance of the preheaters can no longer meet our customers' requirements and Compressor Stations where the gas generators were not being replaced as a result of the IED.

RIIO-1 Delivery

Interventions

Customer Contractual Obligations

370. During RIIO-1 we have been required to replace and refurbish several ageing pre-heat assets in order to ensure we have abided by the terms of our contract with customers. Overall, this has accounted for the majority of work we have needed to deliver. Due to the nature of legacy customer contracts for some NTS offtakes, we often provide the preheat and so have needed to respond to changes in customer requirements to continue effective preheating. One of the primary performance requirements in customer contracts is gas temperature, as this can be critical in protecting customer plant from damage caused by temperature variations.

PSSR Inspections and Revalidations

371. Heat exchanger pre-heat assets are captured by PSSR we have therefore continued to inspect these assets periodically to comply with the requirements of the legislation. These inspections enable us to continue to operate the asset, by confirming the integrity, and allowing the re-declaration of capabilities. Failure to complete these inspections and any associated repairs could result in prosecution by the HSE and the equipment affected would need to be isolated and depressurised until it could be inspected and revalidated. This could have a major impact on our ability to meet its capacity requirements and to maintain the reliability of the network.

Asset Health Reprioritisation

372. A number of pre-heat asset health projects were completed through the early years of RIIO-1, including replacement of obsolete systems at Didcot B, Keadby, Shellstar and Kings Lynn offtakes. As part of the reprioritisation work, a campaign approach was applied to drive efficiency. These included a small number of other customer offtake sites which also required replacement or remedial works.
373. The scoping of gas pre-heat system asset health works has two parts - identifying which works require prioritisation and which is the appropriate rectification strategy.
374. For legacy NTS offtakes, pre-heating systems are generally provided, operated and maintained by NGGT rather than by the customer themselves. Due to commercial confidentiality, the remaining life expectancy of the customer asset and

therefore also the gas offtake requirement is often unknown. For each asset health issue identified, there is a need to re-validate the pre-heating requirement from a commercial, process safety and gas quality perspective. Where customers are unable to assist with this process, this is based on the best available information and knowledge available.

375. The pre-heat asset health investment strategy applied was 'fix-on-fail' if the offtake has less than 5 years life expectancy and asset replacement if there is more than 5 years life expectancy.

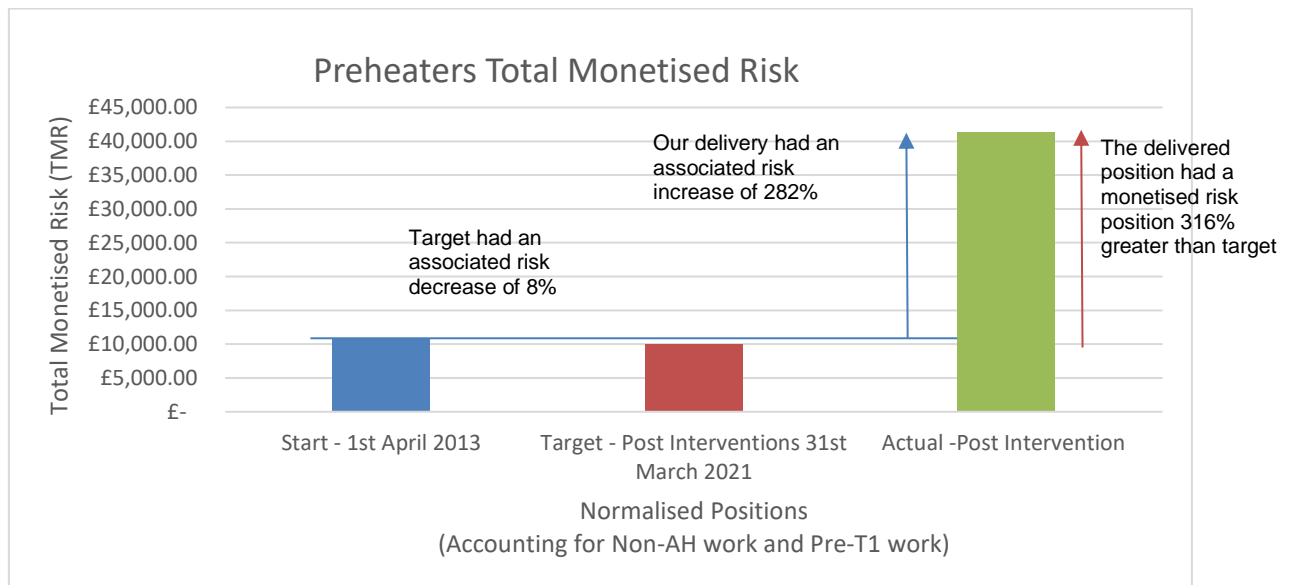
Efficiencies

376. All PSSR driven inspections during RIIO-1 have been sanctioned on a rolling basis within campaigns, typically covering the preheater, filters/scrubbers and pig trap SACs, in order to meet our major inspection obligations across the NTS.

Monetised Risk Position

377. The monetised risk target established based upon the RIIO-1 business plan was for the TMR on preheaters to reduce by 8% across the 8-year regulatory period; we under delivered this target by 316%.

Figure 20 RIIO-1 Risk Performance against Start Position and Target



Asset Base Changes

378. During RIIO-1 there has been a small net reduction of preheater SACs across the PACs; these changes are inclusive of non-asset health drivers.

Table 38 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Refurbish	Removal	New Additions	Refurbish	Removal	New Additions
Entry Point	35	2	0	0	1	0	0
Exit Point	35	12	0	0	11	0	0
Compressor Station	35	16	0	0	3	0	0
Multijunction	35	4	0	0	3	0	0

Table 39 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	35	4	3	0	1	-1
Exit Point	35	24	23	0	1	-1
Compressor Station	35	30	31	3	2	1
Multijunction	35	8	6	0	2	-2

Variance against Plan

379. Whilst we have delivered a small reduction in intervention planned volume, all interventions required to maintain legislative compliance have been delivered. During RIIO-1 we have been required to invest at more customer offtakes than originally anticipated, in order to meet our contractual obligations with changing customer requirements, whilst investing less at compressor stations than we originally expected.

Conclusion and Learning

380. Our preheaters investment has been primarily based upon legislative compliance, through delivery of the PSSR Campaign and targeting investment at our customer exit points where the existing preheat solution has no longer been suitable for meeting our contractual obligations. The visibility provided by NARMS going forward, shall help identify the asset interventions on the network that deliver increased monetised risk value on the network.

xiii. SAC 36 Station Controllers

Executive Summary

381. The TMR on the network attributable to our station process control assets is 0.18%. In RIIO-1 we have invested £11.7m in station process control systems and delivered volumes in accordance with our plan, however, under-delivered on this SAC monetised risk target by 70%.
382. Monetised risk values associated with system control assets are greater on entry points than compressor stations, however, our prioritisation of works has been obsolescence and condition driven, delivering more interventions on compressor stations resulting in a reduced monetised risk benefit being realised.

Table 40 Station Control Systems Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013	Monetised Risk Target with Intervention Position - 31st March 2021	Actual Monetised Risk – 31 st March 2021
Entry Point	£ 2,271.94 47%	£ 1,279.92 13%	£ 14,263.37 84%
Compressor Station	£ 2,532.66 53%	£ 8,660.62 87%	£ 2,640.97 16%
Total	£ 4,804.59	£ 9,940.53	£ 16,904.35 70%

Introduction and investment drivers

383. Station control systems control and monitor the overall station operation and manage flow and pressure through the site and in downstream pipes. They encompass unit control systems which control compressor operations (including monitoring, control and protection systems). For RIIO-1 performance detail on unit control systems, please refer to the specific report (SAC 37).
384. Investment in control systems is essential to maintain the safe control of our plant and to demonstrate that we remain compliant with the terms of our environmental permit, COMAH and the PSR. The main driver in RIIO-1 however, was to manage system obsolescence issues which has arisen for several reasons, including:
385. Asset life: The asset life of the various sub systems and components in a control system are varied. The average life of industrial control system (ICS) components exceeds 15 years, whilst the average supported life of a PC is 7 years for software (e.g. Windows operating system) and 3 years for hardware. These differences in lifecycle cause issues when upgrading the PC as invariably older ICS software will not be compatible or have the required drivers to operate on the new PC system, leading to equipment becoming obsolete.
386. System updates: Many OEMs continue to develop their products for improved functionality and to address cyber security concerns. Updates are either produced on a new version of the equipment, which means the original asset may become unsupported, or alternatively are produced as updated firmware which should be

updated on the device. These upgrades can be delayed due to the specific testing which must be undertaken to ensure compatibility to the interfacing equipment in each system and sub system.

- 387. Compatibility and availability of spares: As operational equipment firmware is upgraded the compatibility of spares should be considered as these may also need upgrading.
- 388. All equipment must also be compliant with corporate policies and standards in respect of cyber security. However, historically equipment has been retained in the installed state without updates to firmware, or operating system and without the necessary software patches or anti-virus software in place.

RIIO-1 Business Plan

- 389. The RIIO-1 business plan made a modest investment associated with this SAC that had been based upon the requirement to ensure we continue to demonstrate compliance with PSR and COMAH regulations, whilst actively progressing the increasing obsolescence challenges faced by our system controls.

Delivery in RIIO-1

Interventions

- 390. This work was delivered as part of the control systems campaign; where appropriate we bundled system control with other secondary asset systems, including unit control systems and anti-surge systems. Key challenges were to understand our asset data and manage obsolescence issues, with systems prioritised for action on overall site and unit criticality, whilst addressing any additional cyber security requirements.
- 391. We addressed urgent system replacements in RIIO-1 at locations where systems had failed and other options to repair faults had already been exhausted; these included:
- 392. The replacement of obsolete Texas Programmable Logic Computers (PLC) cards fitted at seven compressor stations. The PLC systems are the main part of the control system fitted to the station control and the unit controls systems. The new cards fit into the current infrastructure, without extensive modification to hardware or software. Replacing the cards reduce failures in communication systems and provision of spares will safeguard long term life of the control systems. There are beneficial reliability improvements with the replacement of the obsolete cards on the station system as this now ensures that a single processor fault will not cause a whole station outage.
- 393. At four compressor station we delivered an upgrade to existing PLC control systems which had become life expired and no longer supported by the manufacturers. The chosen replacement strategy was to migrate to Rockwell's

current Control Logix' PLC platform, a system already proven within NGGT and adopted across the industry.

394. Station control system replacements were also completed at Peterborough and Huntingdon.

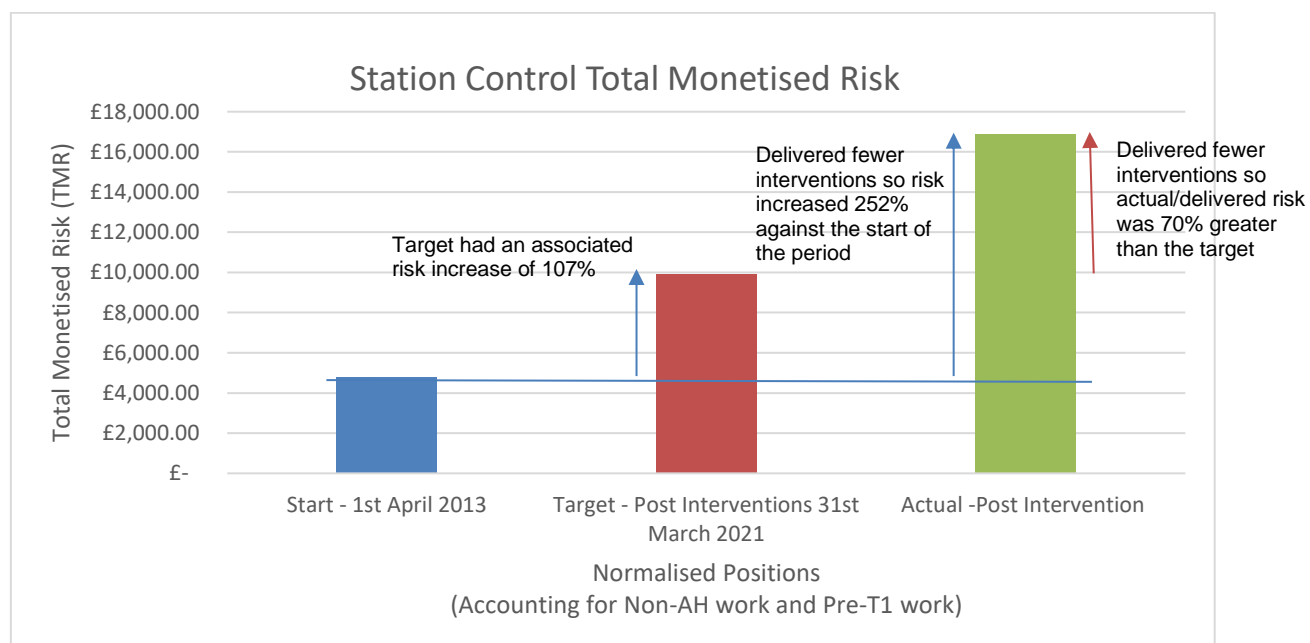
Efficiencies and innovation

395. The NIA project, Open SCADA was completed in 2019/20, which researched and developed a standardised SCADA solution, based on an open source platform to enable a common cyber security solution across the compressor fleet. This allowed us to perform independent SCADA system and control system updates and enables a common SCADA system strategy across the compressor fleet. The project developed and tested the new system for the VSD unit at Kirriemuir compressor station. The installation and commissioning were reduced to less than ten days compared to 3-6 months. We have started to undertake transitioning to business as usual planning towards the end of RIIO-1 ahead of planned installations in RIIO-2. We anticipate savings unit cost savings from the rollout of the open source system.

Monetised Risk Position

396. The target established based upon the RIIO-1 business plan was to allow risk to increase on station control systems by 252% across the 8-year regulatory period; we under-delivered this target by 70%.

Figure 21 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

397. In RIIO-1 there was one additional station process control system asset. All intervention changes are detailed in the below tables. The changes in asset base account for the commissioning of Felindre.

Table 41 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	Additions	Replace	Removal	Additions
Entry Point	36	3	0	0	1	0	0
Compressor Station	36	14	0	0	15	0	0

Table 42 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	36	4	4	0	0	0
Compressor Station	36	26	27	1	0	1

Variance against Plan

398. We have broadly delivered our volumes planned in our RIIO-1 business plan submission, however, given our prioritisation of works was obsolescence and condition driven, a greater proportion of the station control system interventions completed were on compressor stations, which delivered a lower monetised risk benefit compared to entry point interventions.
399. In RIIO-1 we adopted an approach based on obsolescence management, minimising significant capex replacements and extending asset lives as far as reasonably practicable, through the use of OEM spares, harvesting grey spares from asset replacement projects, and via asset refurbishment complimented by some asset replacements. We have introduced compensating controls such as new policies, procedures and the Transmission Test Laptop to interface with control systems, mitigating the key risk of malware. This approach minimised the risk of abortive works leading to stranded assets that risked being non-compliant with the pending Directive on Security of Network and Information Systems (the NIS Directive).
400. In 2016, the European Parliament set into policy the NIS Directive, which passed into UK law in 2018. This directive required Operators of Essential Services take appropriate and proportionate measures to ensure the integrity of the systems on which their essential services depend. In identifying these appropriate and proportionate measures, NGGT has, and continues to, evaluate the threat landscape, threat actor activity and NGGT's attack surface. By comparison, for RIIO-2 a different approach and increase in work is required to enable delivery of the Cyber Assessment Framework (CAF) profile expected of us under the NIS

Regulations. In RIIO-2 we are combining obsolescence (asset health driven) with Cyber resilience investments.

Conclusion and Learning

401. The delivery strategy evolved through RIIO-1, moving away from individual projects to campaigns of work which we shall continue to adopt in RIIO-2. In RIIO-2 we will deliver most of our station process control system investments via our Cyber security OT (Operations Technology) funding and learnings from our RIIO-1 campaign have been implemented into our delivery strategy for the RIIO-2 works. The additional visibility provided by the NARMs shall enable improved prioritisation of investment and enhanced network risk management.

xiv. SAC 37 Unit Controllers

Executive Summary

402. The TMR on the network attributable to our unit control system assets is 1.37%. In RIIO-1 we invested £28.0m in unit control systems and under-delivered the monetised risk target for this SAC by 38%, which is a result of delivering less interventions compared to our RIIO-1 business plan.
403. The work we have been required to deliver to comply with the NIS directive emerged between 2016 and 2018 and impacted upon our approach for investment in RIIO-1, hence we have delivered less full replacements as indicated in our business plan. We adopted an approach based on obsolescence management, minimising significant capital replacements and extending asset lives as far as reasonably practicable, utilising OEM and grey spares, minor asset refurbishments complimented by asset replacements only where condition issues deemed essential. This has allowed us to develop an efficient programme of works across RIIO-2 and RIIO-3 that aligns both the operational and cyber resilience requirements.

Table 43 Unit Control Systems Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention (Normalised) - 31st March 2021		Actual Monetised Risk – 31 st March 2021	
Entry Point	£ 2,579.44	9%	£ 10,310.56	14%	£ 3,472.00	3%
Compressor Station	£ 26,736.39	2%	£ 65,297.75	8%	£ 100,912.83	97%
Total	£ 29,315.84		£ 75,608.31		£ 104,384.83	38%

Introduction and investment drivers

404. Unit control systems control individual compressor operations, including monitoring, control and protection systems. They are important assets for maintaining the safe control of our plant and to demonstrate that we remain compliant with the terms of our environmental permits, COMAH and the PSR legislation. The main driver for the control system investments in RIIO-1 however, was to manage system obsolescence issues which has arisen for several reasons, including:
- Asset life: The asset life of the various sub systems and components in a control system are varied. The average life of industrial control system (ICS) components exceeds 15 years, whilst the average supported life of a PC is 7 years for software (e.g. Windows operating system) and 3 years for hardware. These differences in lifecycle cause issues when upgrading the PC as invariably older ICS software

will not be compatible or have the required drivers to operate on the new PC system, leading to equipment becoming obsolete.

- System updates: Many OEMs continue to develop their products for improved functionality and to address cyber security concerns. Updates are either produced on a new version of the equipment, which means the original asset may become unsupported, or alternatively are produced as updated firmware which should be updated on the device. These upgrades can be delayed due to the specific testing which must be undertaken to ensure compatibility to the interfacing equipment in each system and sub system.
- Compatibility and availability of spares: As operational equipment firmware is upgraded the compatibility of spares should be considered as these may also need upgrading.
- Unit control systems are critical for plant availability. As a result, we only intervene where absolutely necessary to avoid major outages. All equipment must also be compliant with our corporate policies and standards in respect of cyber security.

RIIO-1 Business Plan

405. In RIIO-1 we aimed to limit work on the control systems associated with units which were planned to be replaced under the IED project to emergency repair and refurbishment activities to ensure the units remain operational until they were replaced.
406. Prior to RIIO-1 we had been able to keep many of the existing control systems functioning by transferring equipment and spares between sites and replacing individual components which are otherwise obsolete. This became increasingly difficult to manage as the level of interchangeability between the systems is limited and many of the system designs are bespoke to the site and unit.

Delivery in RIIO-1

Interventions

407. This work was delivered as part of the control systems campaign; where appropriate we bundled system control with other secondary asset systems, including unit control systems and anti-surge systems. Key challenges for the control system investments were to understand our asset condition data and manage obsolescence issues, with systems prioritised for action on overall site and unit criticality, whilst addressing any additional cyber security requirements.
408. Monitoring degradation on unit control systems is difficult and once systems begin to fail, these need to be replaced or refurbished straight away. Our focus has therefore been to refurbish or replace equipment that has already failed on our critical sites and to address urgent system replacements at locations where systems failed and other options to repair faults had already been exhausted.

409. Additionally, we carried out replacement of CET4 overload devices at five compressor sites. The CET4 is an intelligent motor protection device providing overload and earth case fault detection, it also provides performance data to the compressor train unit control system. The devices on the network were over ten years old, obsolete and expensive to repair. Due to their high failure rate and the declining supply of serviceable spares this investment was carried out to reduce the risk of unit unavailability.

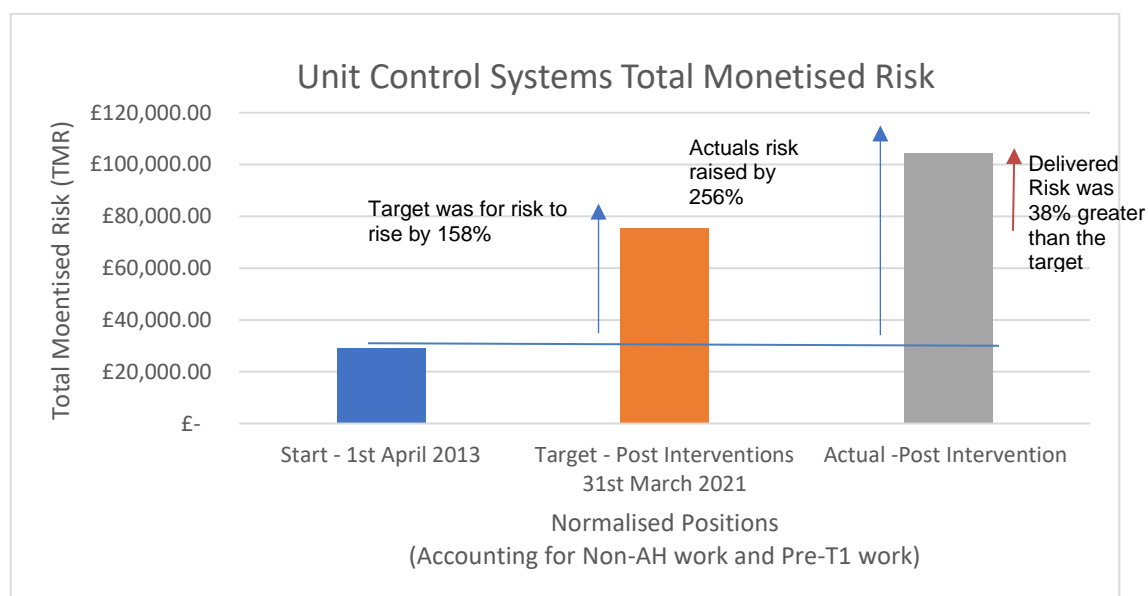
Efficiencies and innovation

410. Our delivery strategy evolved through RIIO-1, moving away from individual projects to campaigns of work. We have also used our improved understanding of the asset base to build our RIIO-2 plan to deliver the requirements of our Cyber Resilience plan, which has impacted our RIIO-1 delivery profile. We have established a continuous rolling programme of interventions undertaken on a site by site basis to help realise value through engineering, workforce and procurement efficiencies.
411. A number of factors have been considered when scheduling the sequence of sites within the programme of works, including overall site criticality, the nature and severity of known asset health issues, alignment with other works programmes and avoidance of common outages on adjacent stations.

Monetised Risk Position

412. The target established based upon the RIIO-1 business plan was to allow risk to increase on unit control systems of 158% across the 8-year regulatory period. We under-delivered against this target by 38%.

Figure 22 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

413. In RIIO-1 there was a small net increase in the unit control system assets, primarily driven by the commissioning of new compressor units in response to revised environmental legislation, see tables below:

Table 44 Asset Health (only) intervention driven changes

Site	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	Additions	Replace	Removal	Additions
Entry Point	37	5	0	0	5	0	0
Compressor Station	37	36	0	0	17	1	0

Table 45 Total asset base changes (including non-Asset Health drivers)

Primary Asset Class	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	37	7	9	2	0	2
Compressor Station	37	63	61	3	5	-2

Variance against Plan

414. In 2016 the European Parliament set into policy the NIS Directive, which passed into UK law in 2018. This directive required Operators of Essential Services take appropriate and proportionate measures to ensure the integrity of the systems on which their essential services depend. In identifying these appropriate and proportionate measures, NGGT has, and continues to, evaluate the threat landscape, threat actor activity and NGGT's attack surface.
415. The work we have been required to deliver to comply with the NIS directive emerged between 2016 and 2018 and impacted upon our approach for investment in RIIO-1, hence we have delivered less full replacements as indicated in our RIIO-1 business plan. We adopted an approach based on obsolescence management, minimising significant capex replacements and extending asset lives as far as reasonably practicable, through the use of OEM spares, harvesting grey spares from asset replacement projects, and via asset refurbishment complimented by some asset replacements. We have introduced compensating controls such as new policies, procedures and the Transmission Test Laptop to interface with control systems, mitigating the key risk of malware. This approach minimised the risk of abortive works leading to stranded assets that risked being non-compliant with the pending NIS Directive. By comparison, for RIIO-2 a different approach and increase in work shall be required to enable delivery of the Cyber Assessment Framework (CAF) profile expected of us under the NIS Regulations. In RIIO-2 we are therefore combining obsolescence (asset health driven) with Cyber resilience investments.

Conclusion and Learning

416. The delivery strategy evolved through RIIO-1, moving away from individual projects to campaigns of work which we shall continue to adopt in RIIO-2. In RIIO-2 we will deliver most of our unit control system investments via our Cyber security OT (Operations Technology) funding and learnings from our RIIO-1 campaign have been implemented into our delivery strategy for the RIIO-2 works to enable targeted, efficient and effective investments.

xv. SAC 43 Locally Actuated Valves

Executive Summary

417. The TMR on the network attributable to our Locally Actuated Valves (LAV) assets is 0.63%. In RIIO-1 we invested £48.3m in LAV, delivering interventions on 6 times the volume anticipated in our RIIO-1 business plan, however, under-delivering the monetised risk target for this SAC by 51%.
418. Our LAV investment has been primarily based upon outage availability, through delivery programmes such as the NARC. NARC was an efficient delivery programme that considered the condition of all assets on site; completing strategic interventions where delivery teams were mobilised, minimising the risk of returning to site to address future asset condition issues.
419. Interventions on LAVs have also been prioritised to enable effective isolations to facilitate other essential works, as a result we have not always intervened on those assets that deliver the most monetised risk reduction on the network.
420. The recent transition to NARMs however, has provided increased visibility of assets that are of high monetised risk value on the network; going forward this shall enable improved prioritisation of investment, intervening to focus on higher risk assets as a priority going forward.

Table 46 Locally Actuated Valves Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention Position (Normalised) - 31st March 2021		Actual Monetised Risk – 31 st March 2021	
Entry Point	£ 984.64	2%	£ 1,860.49	5%	£ 1,834.21	4%
Exit Point	£ 8,460.22	21%	£ 10,004.59	29%	£ 9,833.89	19%
Compressor Station	£ 958.87	2%	£ 2,868.84	8%	£ 2,767.10	5%
Pipeline	£ 23,319.38	57%	£ 10,409.65	30%	£ 28,750.06	55%
Multijunction	£ 7,355.96	18%	£ 9,485.40	27%	£ 9,152.41	17%
Total	£ 41,079.06		£ 34,628.96		£ 52,337.67	51%

Introduction and investment drivers

421. LAVs enable sites, pipelines or pipework sections to be isolated by means of local operation (80% of NTS valves) in order to carry out routine maintenance activities, repairs on the pipeline network or isolation in the case of an emergency.
422. These assets enable the execution of our operational and legal requirements under the PSR and GS(M)R, to provide:
- effective isolation of sections of the NTS to allow safe working.

- the ability to safely shutdown and isolate sections of the NTS in the event of an incident. Isolation or 'block valves' in feeders are typically located at intervals of between 15 and 40km to comply with the PSR and GS(M)R requirements to be able to vent down a section of pipework within 12 hours in the event of an incident.

423. Relevant deterioration mechanisms for LAVs are both time and use dependent. All LAVs will deteriorate in service due to wear and other damage to the internal sealing surfaces, including corrosion that affects the pressure containing parts of the valve.

424. Block valve sites installed on cross country pipelines each typically consist of a configuration of 6 LAVs. These sites limit gas loss in an emergency, facilitate maintenance, flow direction, repair, modification, testing and commissioning on the pipeline network. The enduring requirement for these block valve sites was reviewed throughout RIIO-1 to determine whether they were to be retained or decommissioned.

RIIO-1 Business Plan

425. The RIIO-1 business plan detailed that by 2020/21 more than 80% of block valves on the NTS would be beyond their original design life. The work required to refurbish or replace each being dependent upon its original design and asset condition. To maintain our emergency response capability whilst minimising the level of investment required to address these aged valves, we proposed to rationalise these assets, refurbishing and upgrading those strategically positioned valves to remote control, whilst taking the opportunity to remove those which were at close intervals.

426. The business plan for LAVs was based on the removal of circa 80 block valve sites that were deemed no longer required, reducing the number of LAVs which require refurbishment or replacement during the period, circa 240 valves based on an average of six valves at each block valve site. This would also reduce the number of LAVs requiring maintenance works, however given a large proportion of these assets would be over 40 years old by end of RIIO-1 (installed when the sites were first constructed), an increased volume of LAVs would require refurbishment or replacement due to their age and deterioration towards the end of the regulatory period. Whilst block valves were removed from the network during RIIO-1, these were in close proximity to another locally actuated valve. Therefore, the overall strategy was paused during RIIO-1, as our required ability to isolate in the event of an emergency are demonstrable as 'As Soon As Reasonably Practicable', which is justifiable under regulation 7.10 of the Pipeline Safety Regulations, where, removal of these assets could reduce this operational functionality.

427. Whilst our RIIO-1 business plan also detailed the required conversion of circa 80 LAVs to remote isolation, during the period, the landscape for this conversion changed given the increased threat associated with cyber-attack on our remotely operable assets, this subsequently drove a change in the business case.

RIIO-1 Delivery

Interventions

- 428. Investments have focused on maintaining the integrity of the NTS to ensure maximum reliability and efficiency for duty in support of NTS throughput. The objective has been to re-life, remove or replace, to avoid decreasing asset safety, and to increase efficiency and integrity.
- 429. Where possible, we have utilised specialist contractors to attempt repairing the valves (repacking and resealing) to ensure they continue to provide a reliable isolation as required. Where refurbishment is required however, the extent of the work has been dependent on the size and condition of the valve.
- 430. Where a valve cannot be refurbished either because the seals are irretrievable or the valve body is leaking, the valve has been cut out and replaced. This work is intrusive, costly and influenced by its strategic location on the network, the extent of the isolation required, the depth and the availability of outages.
- 431. At the start of RIIO-1, we launched a campaign 'Valves and Civils' to drive delivery efficiency through bundling of works; securing single extended outages to enable delivery whilst minimising disruption to network operation. This campaign of works comprised a batch of assets for which asset health work required accelerating. The campaign was later re-named NARC, and consisted of inspection, performance testing and repair activities of pipework and associated components, including valves and pipe supports at AGIs based on criticality and performance of corrosion prevention. This campaign ultimately focused on addressing the primary asset integrity risk of corrosion and the high criticality of asset failure. This campaign delivered the majority of our LAV interventions, block valve removals and replacements in RIIO-1.
- 432. In addition to NARC, we have also had to prioritise interventions where LAV functionality was not enabling effective isolations to facilitate other essential works e.g. validation of PIG trap integrity given the inability to depressurise the pig trap safely on isolation.

Efficiencies and innovation

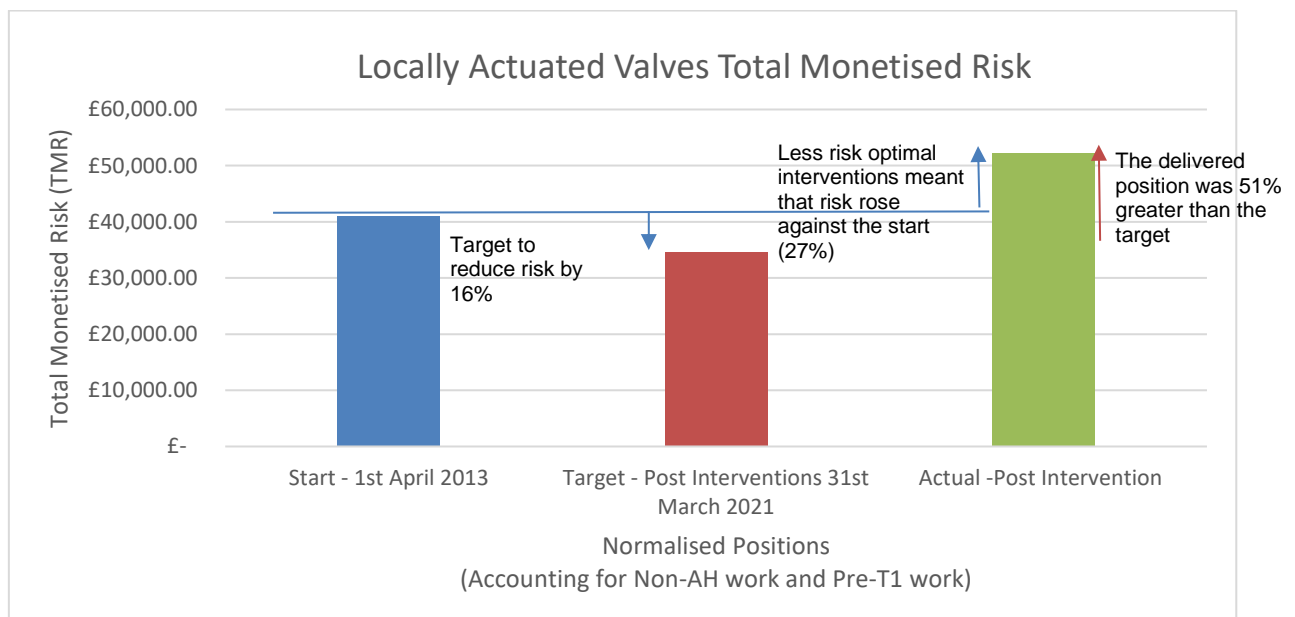
- 433. Several specific innovations have been developed during RIIO-1 and these will continue to be benefitted from through our RIIO-2 valve campaigns. We have reviewed our valve technical standards with a focus on efficiency within our Richmond programme which will lower costs for all future valve replacement. We also launched the "Refurb & Re-life" team within our Pipelines Maintenance Centre (PMC) department; this team enable the lowest cost interventions on valves and a range of other assets through expert knowledge, detailed surveys and a strong incentive to minimise costs to extend asset life that can be gained through in-house experts.

434. Towards the end of RIIO-1 we have been developing a ValveCare toolbox. This toolbox provides a method of assessing, cleaning and protecting the valve quadrant (an area of risk due to corrosion deposits build-up, causing the valve to become mis-aligned on its stops) accessing via the breather port at the top of the stem extension. This method avoids the need for expensive excavation and will continue to be considered as an intervention option being used by the Refurb & Re-life team in RIIO-2.
435. Block valve replacement has been based on a similar rationale to the “Valve Replacement or Removal” option. However, this option not only considers the volume of valve / actuator defects, but defects on other asset classes, such as civils, security, electrical etc. A campaign approach may therefore be employed to remove these risks and install a new block valve site that is fit for purpose i.e. safety by design. This approach has been used within the ongoing NARC works and allowed the business to embed some of the innovation best practices, such as the modular block valve design.
436. Where the block valve site is no longer required for isolation however, then a full pipeline specific risk assessment was carried out with relevant stakeholders to support that the valve does not provide any operational purpose. If this was the case, then the block valve site, its assets and associated risks were removed and piped through.

Monetised Risk Position

437. The monetised risk target established based upon the RIIO-1 business plan was to reduce the TMR on LAVs by 16% across the 8-year regulatory period; we under delivered this target by 51%.

Figure 23 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

438. In RIIO-1 there was a small net decrease of LAV assets and the vast majority was associated with the removal of block valve sites, and disconnection of connections in contrast addition of new compressor units for IED, see tables below:

Table 47 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	43	10	25	0	79	29	0
Exit Point	43	5	102	0	45	16	3
Compressor Station	43	24	0	0	111	0	0
Pipeline	43	0	492	0	114	56	0
Multijunction	43	22	0	0	59	5	4

Table 48 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	43	1533	1471	24	86	-62
Exit Point	43	1102	1083	14	33	-18
Compressor Station	43	2602	2692	154	64	90
Pipeline	43	1541	1474	7	74	-67
Multijunction	43	1368	1285	4	87	-83

Variance against Plan

439. Investment in LAVs has been prioritised in RIIO-1 to facilitate other essential works to ensure we can maintain the integrity and safety of the network. It has also been prioritised through the NARC delivery programme, completing strategic valve interventions to reduce the likelihood of returning to site to address future asset condition issues.

Conclusion and Learning

440. Our LAV investment has been primarily based upon outage availability, through delivery programmes such as the NARC. Whilst an efficient delivery programme in RIIO-1, the transition to NARMs has highlighted a required change in our delivery approach for RIIO-2, that will ensure we intervene on those assets of increased monetised risk value on the network. The visibility provided by the NARMs shall enable improved prioritisation of investment and enhanced network risk management.

xvi. SAC 45 Safety Valves

Executive Summary

442. The TMR on the network attributable to our safety valves assets is 2.36%. In RIIO-1 we invested £9.4m in safety valves (which shall be referred to as Remote Operable Valves (ROVs) throughout this report. We over-delivered on our network risk target by 6% for this SAC, which is a result of more targeted and risk beneficial work being delivered. Whilst we delivered 33% less interventions than expected, the interventions completed delivered a greater risk reduction/benefit as they were on higher risk assets.
443. Our ROV investment has been primarily based upon outage availability, through delivery programmes such as the NARC, as well as site specific remediation work to ensure that our primary assets continue to function as required. NARC was an efficient delivery programme that considered the condition of all assets on site; completing strategic interventions where delivery teams were mobilised, minimising the risk of returning to site to address future asset condition issues. Where the condition and performance of specific valves has been identified as sub-standard, we have also targeted by exception given the prohibitive costs associated with lone interventions.

Table 49 Remote Operable Valves Monetised Risk Performance Summary

Primary Asset	Monetised Risk Start Position - 1st April 2013		Monetised Risk Target with Intervention (Normalised) - 31st March 2021		Actual Monetised Risk - 31st March 2021	
Entry Point	£ 1,590.79	1%	£ 1,109.86	1%	£ 1,942.83	2%
Exit Point	£ 46,018.33	36%	£ 51,105.52	39%	£ 46,282.58	38%
Compressor Station	£ 13,744.32	11%	£ 6,960.14	5%	£ 8,432.34	7%
Pipeline	£ 420.12	0%	£ 464.26	0%	£ 462.52	0%
Multijunction	£ 64,998.51	51%	£ 70,864.58	54%	£ 65,516.01	53%
Totals	£ 126,772.07		£ 130,504.37		£ 122,636.29	6%

Introduction and investment drivers

444. Safety valves are remotely operable valves that allow the Gas Network Control Centre to isolate parts of the network quickly and efficiently, for planned or emergency isolation without the need to mobilise a workforce. These can be in small groups or just a single valve, depending on the local process environment, as such they appear on all PACs, generally with only a handful on each site where they are present.
445. ROVs differ from process valves, which are also remotely controlled but have local control by manned sites facilitating usage of process equipment. ROVs account for ~9% of the total number of valves on the NTS. These valve assets have a direct

impact on the site, downstream and network reliability, availability, maintainability and safety; should they fail to operate when required. The assets deteriorate over time and with use, leading to an inability to perform their required function, this can also result in them no longer being able to operate or seal correctly. The ability to isolate in the event of an emergency are demonstrable as 'As Soon As Reasonably Practical' (ASARP) which is justifiable under regulation 7.10 and assets failing to seal would fail the ASARP criteria.

RIIO-1 Business Plan

- 446. The RIIO-1 business plan detailed our intentions to rationalise circa 80 block valve sites from locally actuated valves to either ROVs where strategically required, i.e. where they were remote from a workforce that could be mobilised in the event of an emergency, or to be cut out completely where the interval between block valves was close. However, during the period, the landscape for these conversions changed given the increased threat associated with a cyber-attack on our remotely operable assets, this subsequently drove a change in the business case.
- 447. The RIIO-1 business plan detailed our intention to replace/re-life 106 of these valves and install new additional assets at our exit points to facilitate the safe and remote disconnection of customers.

RIIO-1 Delivery

Interventions

- 448. During RIIO-1 it became increasingly apparent that the actual condition of our assets were worse than forecast; requiring investment to focus on remediating defects on higher risk assets, ensuring our network remained safe and operational.
- 449. Where possible, we have utilised specialist contractors to attempt repairing the valves (repacking and resealing) to ensure they continue to provide a reliable isolation. Where a valve cannot be refurbished either because the seals are irretrievable or the valve body is leaking, however, the valve has been cut out and replaced. This work is intrusive, costly and influenced by its strategic location on the network, the extent of the isolation required and the availability of outages.
- 450. Overall, we have completed less refurbishments/replacements than expected in the business plan, however, the assets that were subject to intervention were of a higher risk and therefore delivered more benefit than the assets used to inform the target. In RIIO-1, we prioritised asset intervention based on condition; through the NARC and predecessor campaigns we then targeted sites in the exit, multijunction and pipelines PACs, where large volumes of mainly corrosion defects were present and there was a high criticality of failure, bundling with these programmes of work to achieve efficiencies.
- 451. Whilst NARC delivered a large proportion of the required interventions on ROV, additional targeted investments were completed to remediate known defects at

some of our more critical sites. The main drivers being to remediate a large number of defects in the most effective manner on high consequence assets.

452. For two sites, we upgraded the functionality of the block valve to be remotely operable, replacing one locally actuated valve in each case.

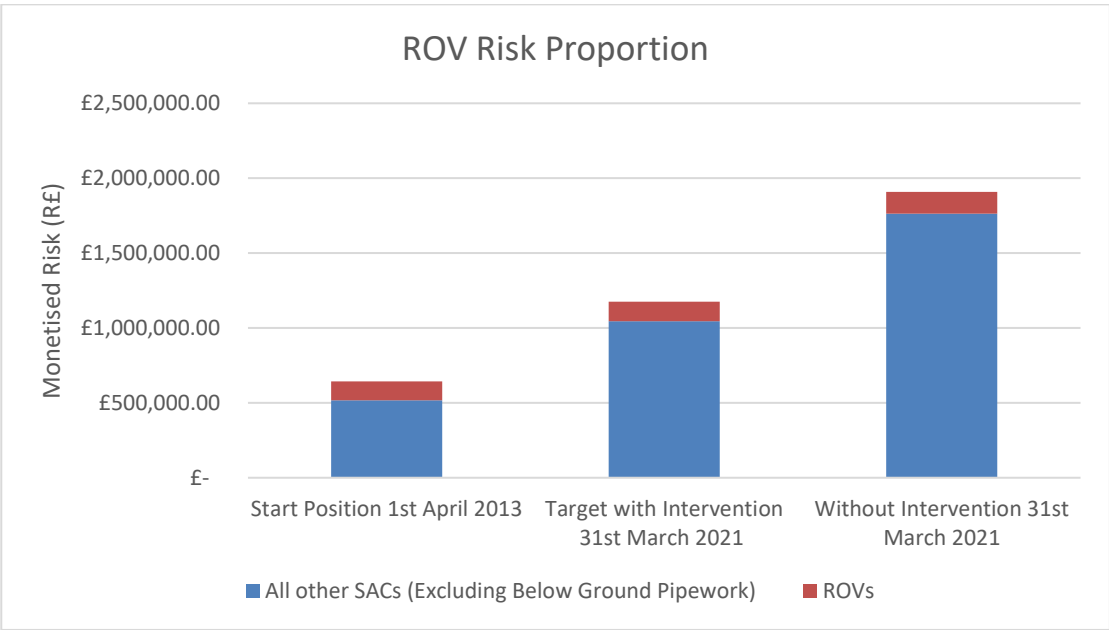
Efficiencies and innovation

453. Several specific innovations have been developed during RIIO-1 and these will continue to be of benefit through our RIIO-2 valve campaigns. We have reviewed our valve technical standards with a focus on efficiency within our Richmond programme which will lower costs for all future valve replacement. We also launched the “Refurb & Re-life” team within our Pipelines Maintenance Centre (PMC) department; this team enable the lowest cost interventions on valves and a range of other assets through expert knowledge, detailed surveys and a strong incentive to minimise costs to extend asset life that can be gained through in-house experts.
454. Towards the end of RIIO-1 we have been developing a ValveCare toolbox. This toolbox provides a method of assessing, cleaning and protecting the valve quadrant (an area of risk due to corrosion deposits build-up, causing the valve to become mis-aligned on its stops) accessing via the breather port at the top of the stem extension. This method avoids the need for expensive excavation and will continue to be considered as an intervention option being used by the Refurb & Re-life team in RIIO-2.
455. Alongside other SACs, we have gained unit cost and intervention efficiencies by bundling them into the campaigns such as NARC, rather than uniquely mobilising a workforce for delivering one intervention, the latter having only been done by exception where urgently required.

Monetised Risk Position

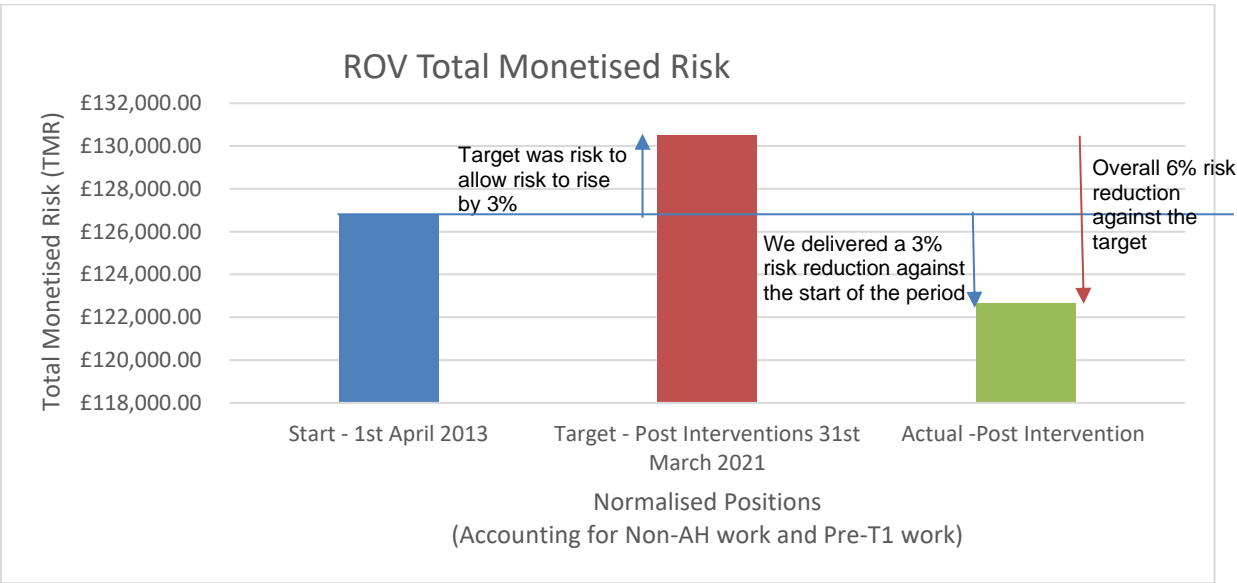
456. ROVs are the riskiest valve SAC and account for ~2% of our TMR target, rising to 10% (excluding for below ground pipework), as shown below.

Figure 24 Total Monetised Risk associated with ROVs



457. The monetised risk target established based upon the RIIO-1 BP was to allow the TMR on ROVs to increase by 3% across the 8-year regulatory period; we over delivered this target by 6%.

Figure 25 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

458. In RIIO-1 there was a small net decrease of ROV. Due to the increased cyber security threat, the expected large scale additions of ROVs were not delivered. Additions on compressor stations are associated with the commissioning of Felindre, changing its classification from a multi-junction to a compressor station. The other changes are due to the removal of Feeder 1 and commissioning or decommissioning of customer connections. See tables below:

Table 50 Asset Health (only) intervention driven changes

Primary Asset	SAC	Business Plan			Actuals		
		Replace	Removal	New Addition	Replace	Removal	New Addition
Entry Point	45	8	0	0	6	0	0
Exit Point	45	5	0	102	9	6	0
Compressor Station	45	29	0	0	25	2	0
Pipeline	45	2	0	48	4	0	2
Multijunction	45	62	0	0	26	0	1

Table 51 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	45	57	59	2	0	2
Exit Point	45	159	152	2	9	-7
Compressor Station	45	207	216	11	2	9
Pipeline	45	16	18	2	0	2
Multijunction	45	412	397	1	16	-15

Variance against Plan

459. While we have rationalised some block valves, we have replaced only a small number of these with ROVs, as the emerging cyber threat has required us to keep potential points of malicious third party interference to a minimum. The large volume of additions on exit points did not progress as expected in the business plan on this same basis.
460. Interventions were completed broadly in-line with the volumes expected in the business plan on most of the PACs, with the exception of Multi-junctions where ~50% of the volume expected has been delivered. Given the condition survey findings under the NARC campaign, we have targeted sites based on need. ROVs are not uniformly distributed throughout the network, as they appear on offtakes which are generally based near population centres and industrial regions, for this reason the NARC campaigns did not always intervene on ROVs in the same proportion as it did on other SACs, such as locally actuated valves which are present on every site.

Conclusion and Learning

461. We have effectively delivered for this SAC by bundling interventions with others to gain efficiency and by targeting higher risk sites as part of NARC and other campaigns. In RIIO-2, using the greater risk intelligence that NARMS provides, and using the campaign approach which has driven delivery efficiency in RIIO-1 we will intervene effectively on ROVs across the network which will deliver the right benefit for the consumer, whilst ensuring safe, reliable operation and maintenance of the network remotely.

xvii. SAC 46 Process Valves

Executive Summary

462. The TMR on the network attributable to our process valve assets is 0.34%. In RIIO-1 we invested £81.8m in process valves and over delivered on our monetised risk target for this SAC by 13%.
463. These assets have a direct impact on the site reliability, availability, maintainability and safety; should they fail to operate, they may impact the operation of a compressor station / entry point and in some cases would make the entry point site or compressor station / unit unavailable. Given the design of many process valves on the NTS do not lend themselves to refurbishment interventions, cut out and replacement has often been necessary. Complexities²³ associated with facilitating intervention on these critical assets without interruption to site / station availability has increased the cost associated with remedial works.
464. Increased volume delivery has contributed towards reducing 'Mean Time Between Failure' and increased compressor availability across the NTS, as without effective isolation provided by these assets, a unit/station would need to be on outage until remedial works has been completed.

Table 52 Remote Operable Valves Monetised Risk Performance Summary

Primary Asset	Monetised Risk Position - 1st April 2013	Start April	Monetised Risk Target with Intervention (Normalised) - 31st March 2021	Position	Actual Monetised Risk - 31st March 2021	
Entry Point	£ 4,013.84	82%	£ 16,153.60	85%	£ 14,940.66	91%
Compressor Station	£ 861.17	18%	£ 2,899.82	15%	£ 1,559.87	9%
Total	£ 4,875.01		£ 19,053.43		£ 16,500.53	13%

Introduction and investment drivers

465. Process valves enable isolation of a site or section of site pipework by the site, station or unit control system as part of normal site operations, transferring gas flow from one part of the plant or site to another. Associated with the ability to change flows around a process, they are located on Entry Points and Compressors Stations as close as possible to the equipment they isolate; accounting for ~9% of the total number of valves on the NTS. These valve assets have a direct impact on the site reliability, availability, maintainability and safety; should they fail to operate, they may impact the operation of an entry point or compressor station and in some cases would make the site or compressor station / unit unavailable.

²³ Including for example, poor ground conditions, depth of the valve, sub-surface congestion and extent of isolation required.

466. The assets deteriorate over time and with use, leading to an inability to perform their required function, this can also result in them no longer complying with direct legislative requirements.

RIIO-1 Business Plan

467. The RIIO-1 business plan made a modest investment associated with this SAC that had been based upon historical evidence of investment on these assets and any known defects at the time.

RIIO-1 Delivery

Interventions

468. Investments have focused on maintaining the integrity of the NTS to ensure maximum reliability and efficiency for duty in support of NTS throughput. The objective has been to re-life, remove or replace, to avoid decreasing asset safety and to increase reliability and availability.
469. Where possible, we have utilised specialist contractors to attempt repairing the valves (repacking and resealing) to ensure they continue to provide a reliable isolation as required. Where refurbishment is required however, the extent of the work has been dependent on the size and condition of the valve.
470. Where a valve cannot be refurbished either because the seals are irretrievable or the valve body is leaking, the valve has been cut out and replaced. This work is intrusive, costly and influenced by its strategic location on the network, the extent of the isolation required and the availability of outages.
471. A large proportion of the ball valves on the NTS are a 'fully welded' construction (i.e. Cameron, RMA) with a lower proportion as a '3-piece bolted body' construction, i.e. Cort CB-5 which has limited our ability to refurbish process valves for the following reasons:
472. A fully welded valve construction provides no method of entry to replace internal components and is welded into the pipework to minimise the risk of leakage. A destructive entry to the valve cannot be rectified for continued operational use; we have therefore performed 'enhanced maintenance' in the first instance, i.e. injection of sealant; where the process valve cannot be recovered, it must then be cut out and replaced.
473. A bolted body valve construction refurbishment requires the valve to be sent-off to be dismantled to replace the valve internals. This intervention requires an excavation and for the valve to be cut-out, therefore, it is cost prohibitive. Costs to cut out and attempt to refurbish a valve can be greater than a cost to cut-out and replace with a new valve. Enhanced maintenance has again been applied in the first instance; where we are unable to recover a valve, we have then excavated, cut out and replaced the asset.

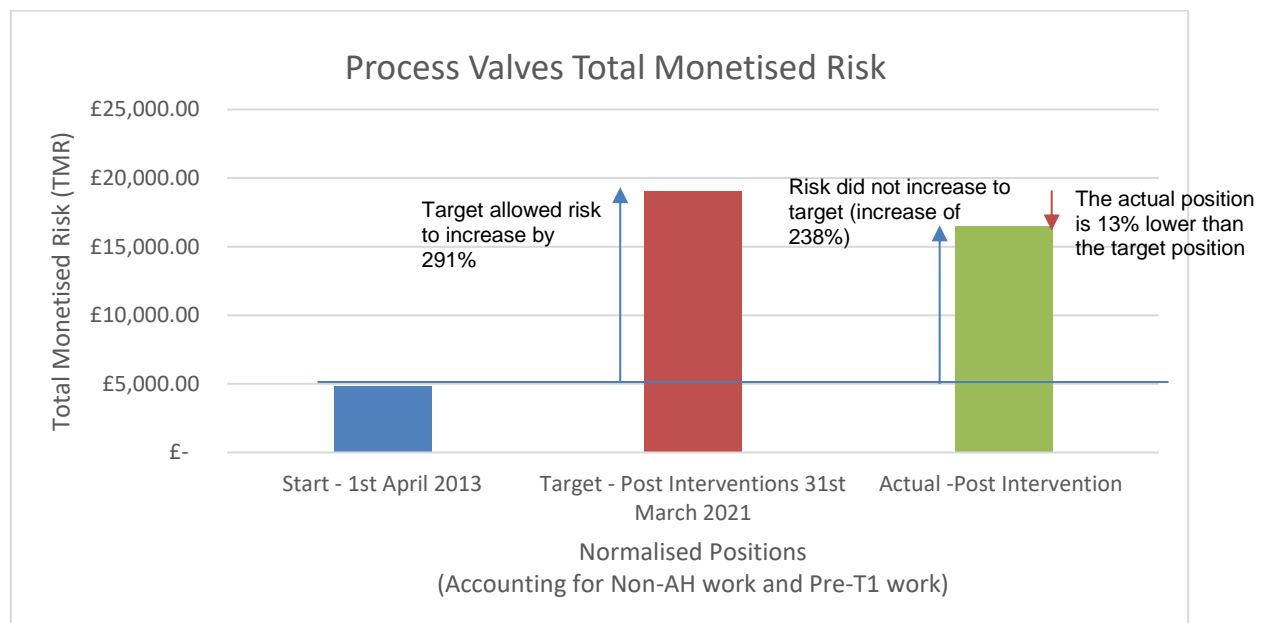
Efficiencies and innovation

474. Several specific innovations have been developed during RIIO-1 and these will continue to be benefitted from through our RIIO-2 programme of works. We have reviewed our valve technical standards with a focus on efficiency within our Richmond programme which will lower costs for all future valve replacement. We also launched the “Refurb & Re-life” team within our Pipelines Maintenance Centre (PMC) department; this team enable the lowest cost interventions on valves and a range of other assets through expert knowledge, detailed surveys and a strong incentive to minimise costs to extend asset life that can be gained though in house-experts.
475. Towards the end of RIIO-1 we have been developing a ‘ValveCare’ toolbox. This toolbox provides a method of assessing, cleaning and protecting the valve quadrant (an area of risk due to corrosion deposits build-up, causing the valve to become mis-aligned on its stops) accessing via the breather port at the top of the stem extension. This method avoids the need for expensive excavation and will continue to be considered as an intervention option being used by the Refurb & Re-life team in RIIO-2.

Monetised Risk Position

476. The target established based upon the RIIO-1 business plan was to allow risk to increase on process valves by 291% across the 8-year regulatory period; we over-delivered this target by 13%.

Figure 26 RIIO-1 Risk Performance against Start Position and Target



Asset base changes

477. In RIIO-1 there was a small net increase of process valve assets which were predominately driven by non-asset health related investments on compressor stations, generally to bring emissions legislation complaint compressor units online, see tables below:

Table 53 Asset Health (only) intervention driven changes

Primary Asset	SAC	RIIO-1 Business Plan			Actuals		
		Replace	Removal	New Additions	Replace	Removal	New Additions
Entry Point	46	53	0	0	79	0	3
Compressor Station	46	46	0	0	103	7	0

Table 54 Total asset base changes (including non-Asset Health drivers)

Primary Asset	SAC	2013	2021	Additions	Removals	Net Change
Entry Point	46	320	310	18	28	-10
Compressor Station	46	566	583	35	18	17

Variance against Plan

478. Investment in process valves has been prioritised in RIIO-1 to ensure we maintain the ability to change flows around a process, providing effective isolation of a site or section of site pipework. Given these valve assets have a direct impact on site reliability, availability, maintainability and safety, assets that fail to perform their function may impact the operation of an entry point or compressor station and in some cases would make the site or compressor unit unavailable.

Conclusion and Learning

479. Our process valve investment has rightly focused on maintaining the integrity of the NTS to ensure maximum reliability and efficiency for duty in support of NTS throughput. Given the direct impacts on site should these assets fail to operate, we have appropriately prioritised investment to ensure we maintain the ability to change flows around a process, providing effective isolation of a site or section of site pipework, which has also resulted in out-performance of our monetised risk target for this SAC.

IV. COST PROPOSAL

Executive Summary

480. This section covers NGGT's proposal on the methodology that should be used by Ofgem for calculating the costs associated with over- or under-delivery (here after referred to as 'associated costs'). This methodology also sets out how we propose to derive the financial data for a potential stage 5 submission. As required by the RIIO-1 NOMs Incentive Methodology: Appendix 6, chapter 8, our proposal details in the chapters below as follows:

- Methodology for deriving, or allocating, allowances by asset category
- Methodology for deriving, or allocating, expenditure incurred in delivering relevant asset interventions over the RIIO-1 period
- Methodology for identifying the specific delivery elements that have contributed to over-delivery or under-delivery
- Methodology for deriving the costs (or unspent allowances) related to the specific delivery elements identified through the methodology and how the effect of any deadband will be accounted for
- Worked examples

481. In summary, the NGGT proposal is that the associated costs must be calculated using a Unit Cost of Risk (UCR) approach on a network level which is supported by a more granular, but qualitative assessment of secondary asset classes.

482. In RIIO-1 we have had an absolute monetised risk target on a total network level across five PACs and 37 SACs. Our Asset Health allowances were agreed at the start of the RIIO-1 period, at a total level covering all Asset Health spend including 47 SACs, minor site capex and Feeder 9 planning costs. Whilst we understand that Ofgem require a methodology that evaluates performance at a relatively detailed level and wishes to understand the factors of change, it is not appropriate to retrospectively derive an allowance on SAC level in order to calculate a reward/penalty for NOMs incentive performance²⁴.

483. We propose as part of the stage 5 submission, should this be required, that data and narrative including expenditure per SAC over the RIIO-1 period is submitted and this information is used to establish areas of under-/over-delivery. Where possible, reference would be made regarding to deviations from our RIIO-1 plan in order to justify any under-/over-performance. Ofgem would undertake a qualitative assessment to establish any appropriate exclusions, or unjustified delivery of monetised risk as part of the stage 6 assessment.

²⁴ Ofgem clarified this position in an email dated 29 June 2021 following the Gas Regulation Group (GRG) NOMs letter dated 17 June 2021 on the RIIO-1 NOMs methodology update.

484. Following this quantitative assessment, we propose that the principles of the unit cost of (long term) monetised risk delivery (UCR) metric which was established through the proposed NARM Funding Adjustment and Penalty Mechanism for RIIO-2 should be used to determine any reward/penalty for RIIO-1. We propose submitting the necessary data for this calculation at network level alongside the qualitative information at SAC level, as illustrated in our example in section 4 below.
485. It is important to note that under the RIIO-2 NARM Funding Adjustment and Penalty Mechanism, reward/penalty is not calculated at intervention level, but at a sub-risk pot level²⁵. Whilst an intervention UCR is presented and used to understand different contributors to performance, this does not drive the reward/penalty calculation. We do not support retrospectively calculation allowances for a more granular analysis on the RIIO-1 performance compared to the agreed methodology for RIIO-2.
486. From our proposal Ofgem are able to scrutinise spend at an asset level alongside justification for how and what was delivered over the period and this should feed into the calculation of associated costs as described in our proposal below.
487. We have proposed an approach which we believe is fair and proportionate to our performance. We are happy to engage further on this topic, subject to the outcome of stages 1 and 2 and confirmation of the materiality threshold.

1. Methodology for RIIO-1 Asset Health Allowances

488. As part of the Ofgem assessment of our RIIO-1 business plan submission, Ofgem carried out a review of our expenditure on SACs in general and the linkage of replacement priorities and outputs and volumes we planned to deliver. Ofgem used the volumes and evidence provided for the specific secondary asset groups. As part of our submission we provided detailed reports on SACs where we were planning to spend greater than £10m (in 2009/10 prices).
489. Following this review, Ofgem determined that expenditure on specific secondary assets such as gas generators, gas analysers, locally actuated and remote isolation valves, power turbines and pre-heaters had been justified and the forecast expenditure was included in our Baseline allowances. However, they concluded that there was insufficient evidence to support the expenditure in some areas. Therefore, allowances were reduced in these areas²⁶. We also did not receive any additional funding for our proposed Bacton rationalisation programme. As part of our Baseline Asset Health allowance we received funding for Feeder 9 Planning²⁷.

²⁵ The sub-risk pot levels categories expected UCR benefits into High, Medium, and Low categories at which the allowance adjustments are calculated for RIIO-2 closeout.

²⁶ The reduction and forecast expenditure proposals are detailed in table 7.17 in the document RIIO-1: Initial Proposals for National Grid Electricity Transmission and National Grid Gas, Cost assessment and uncertainty Supporting Document, 27 July 2012.

²⁷ RIIO-1: Initial Proposals for National Grid Electricity Transmission and National Grid Gas, Cost assessment and uncertainty Supporting Document, 27 July 2012, paragraph 7.110.

490. Ofgem did not accept our suggestion that the reduced level of expenditure will impact our ability to meet our Network Replacement Output targets and Ofgem concluded that our Baseline allowance will allow the necessary works to achieve our NOMs target. No adjustments to our Network Replacement targets was made following the outcomes of the final proposals.
491. In Initial Proposals Ofgem summarised the proposed reductions to our SAC level spend in table 7.17. The reductions did not change for the published Final Proposals in December 2012, but we did receive one allowance (split across the eight years of RIIO-1) for Asset Health expenditure to deliver our Network Replacement Outputs. There were no specific allowances set per SAC or PAC. Ofgem concluded their costs for Asset Health expenditure to be £418m (in 2009/10 prices, excluding IQI and RPEs) across the eight years of RIIO-1.
492. Our allowances to deliver the Network Replacement Outputs are detailed in our RIIO-1 licence, Special Condition 7E and are summarised in the table below which include IQI²⁸.

Table 55 Asset Health Allowances in RIIO-1

Total Asset Health Allowances in £m	Total RIIO-1 2009/10 prices	Total RIIO-1 2020/21 prices
Allowances as per RIIO-1 licence, SpC 7E, table 3	440.8	600.8
Allowances incl. RPEs ²⁹	451.7	615.8

493. In RIIO-1 our network replacement outputs are an absolute monetised risk target on a total network level across five PACs and 37 SACs. Our Asset Health allowances were agreed at the start of the RIIO-1 period, at a total level covering all Asset Health spend including 47 SACs, minor site capex and Feeder 9 planning costs. This is a greater 'scope' than the direct delivery of our monetised risk across 37 SACs.
494. We have delivered our Asset Health programme in line with how these allowances were set. Following rebasing, allowances were not been split to account for the fact that only 37 out of 47 SACs deliver a monetised risk benefit. Rebasing was also very near the end of the eight-year period and so for the majority of this time there was not a different targeting approach taken for the 37 in-scope SACs than the out-

²⁸ IQI was applied following the final proposals and was agreed in final proposals paragraph 4.22, RIIO-1: Final Proposals for National Grid Electricity Transmission and National Grid Gas, 17 December 2012

²⁹ For RIIO-1 we received an allowance to account for the impact of Real Price Effects (RPEs), which was detailed in RIIO-1: Final Proposals for National Grid Electricity Transmission and National Grid Gas, Cost assessment and uncertainty Supporting Document, 17 December 2012, table 3.2.

of-scope 10 SACs. To enable our allowance reporting and support a methodology to calculate associated costs we proposed to split our Baseline Asset Health allowances into the following category using the information of our RIIO-1 business plan and table 7.17 of the Initial Proposals. We do not consider a further split of allowance is appropriate.

Table 56 Asset Health Allowances by Categories in RIIO-1

Asset Health Allowances split in £m incl. IQI and RPEs	Total RIIO-1 2009/10 prices	Total RIIO-1 2020/21 prices
37 SACs (lead assets)	342.6 ³⁰	466.9
10 SACs (non-lead assets)	75.4	102.9
Minor Site Capex³¹	27.2	37.0
Feeder 9 Planning	6.5	8.8
Total	451.7	615.8

495. We therefore propose to report the allowances for the 37 SACs as a total (phased across the eight years of RIIO-1) only on worksheet 4.1.1 as part of a potential stage 5 submission. The methodology we applied to derive the allowances per area of our Asset Health Baseline results in allowances that are consistent with RIIO-1 Final Proposals and related to the funded asset intervention volumes. We do not propose to provide any further split of the 37 SAC allowance for the purposes of a reward/ penalty mechanism as this was never set as part of the RIIO-1 Final Proposals.
496. We are also concerned that the requirement stipulated to derive or allocate allowances in this way is not consistent with the principles of the RIIO regulatory framework. Whilst we understand that Ofgem require a methodology that evaluates performance at a relatively detailed level and understand the factors of change, it is not appropriate to retrospectively derive an allowance on SAC level in order to calculate a reward/penalty for NOMs performance.
497. We note that under the RIIO-2 NARMs methodology, the reward/penalty mechanism is not calculated at intervention. Whilst an UCR per intervention is presented and used to understand different contributors to performance, this does not drive the reward/penalty calculation. The calculation uses the total allowance

³⁰ The allowances for the 37 lead SACs also include a proportion of “risk trading allowances”, which account for underspend across the 10 non-lead SACs (£31m in 2009/10 prices) and IQI allowances for Bacton of £6m in 2009/10 prices which was attributed to the 37 lead SAC allowances.

³¹ As reported in RRP as spend not assigned to specific SACs marked as GTO OTHER INC PWS.

for each 'sub-risk pot'. We cannot retrospectively undertake a more granular analysis on the RIIO-1 performance compared to the agreed methodology for RIIO-2.

2. Methodology for RIIO-1 Asset Health Expenditure

498. We report our expenditure against each of the 47 SACs in our regulatory reporting pack each year. This has been submitted for the full eight-year period in RRP 2020/21. The expenditure reported in fully aligned to the relevant interventions within each SAC. We would propose using this information for submission as part of any potential stage 5 submission.

3. Methodology for delivery elements contributing to over- or under-delivery

499. We propose the process to determine elements contributing to over- or under-delivery Ofgem will follow the process outlined in the NOMs Incentive Methodology (chapter 3).

(a) Qualitative assessment - NGGT

500. We propose that we would provide a narrative at the stage 5 submission including justification of our material over-/under-delivery, including both evidence at a network level and supporting explanation and justification of the principle changes that make up the over/under delivery at a secondary asset level. This supporting explanation would be provided at a SAC level, describing the work we have completed in RIIO-1, how this has been equally or more beneficial or less beneficial than the original plan and whether there are other factors that deliver benefits for consumers (current and future) that drive the differing delivery of NOMs. As part of our stage 1 and 2 submission we have already provided individual SAC reports to describe our performance in RIIO-1, we would build on this for a potential stage 5 submission.
501. For the narrative we would describe the monetised risk position delivered versus the outturn monetised risk position. This way we could demonstrate how we have delivered (over-/under-delivery) against our SAC monetised risk targets. In this narrative we will also describe potential consequential impacts that affect the opportunity to deliver the target performance. We would include in this narrative justification of the magnitude of expenditure, in total and relative to other asset categories. This would be similar to SAC reports in section III of this report, with more cost detail where possible.
502. The NOMs methodology for NGGT is relatively granular. There are 37 contributing categories and is somewhat different to other sectors where a 'project' level assessment would be applicable. We propose this qualitative assessment could focus on SACs where an under delivery is apparent or where expenditure contributes a significant proportion of the total, but we do not propose any further assessment below the SAC level.

503. NGGT's view is that there are no interactions with another incentive mechanism. Any interactions with load related mechanisms or non-Asset Health investments (asset additions or removals) are addressed through the Relevant Risk Changes in our stage 1 and 2 submission. Therefore, we are not considering this as part of our proposed methodology for associated costs.

Output of the stage: Narrative describing performance on a SAC level in relation to monetised risk targets only to aid Ofgem's determination of justified or unjustified over-/under-delivery.

(b) quantitative assessment - Ofgem

504. Using the proposed data and narrative, Ofgem could then determine whether we have provided adequate narrative which justifies that the delivery outcome was a better outcome for consumers than delivering the NOMs target or a lower levels of over/under-delivery. Ofgem can then determine how much of the material over/under-delivery is justified. The associated cost of over-delivery will then be calculated using the approach described in section 4.

Output of the stage: Level of over/- under-delivery that is deemed as justified in % and will feed into the calculation of associated costs described in section 4.

4. Methodology for calculating associated costs

505. As detailed in Ofgem's NOMs Incentive Methodology consultation published on the 7th May 2021, Ofgem considers three broad approaches possible to derive associated costs. These are:

- (1) a UCR approach such as applied in the Electricity Distribution sector worked example given in Appendix 2 to the 2018 NOMs Incentive Methodology*
- (2) a project-by-project approach or work programme-by-work programme approach*
- (3) a combination of both*

506. Ofgem's primary concern is the methodology deriving associated costs for under-delivery (i.e. unspent allowances) and ensuring that consumers do not pay for the under-delivery. As demonstrated in section I., II. and III. of our NOMs closeout performance report we have delivered our monetised risk target within 1% compared to our normalised licence target. Hence on a network level we have delivered our target. As detailed in the individual SAC reports in section III. we have over-delivered on our monetised risk position in some SACs and under-delivered in others. Across RIIO-1 we have overspent our allowances on Asset Health. Given NGGT's situation we believe our proposal to derive associated costs should be carried out on a network level. In the following sections we will set out our views of the three described methodologies proposed by Ofgem and which in our view is the appropriate methodology to use for NGGT.

(1) a unit cost of risk (UCR) approach

507. A unit cost of (long term) monetised risk delivery (UCR) metric was established through the proposed NARM Funding Adjustment and Penalty Mechanism for RIIO-2. It measures the financial spend required to deliver a R£ of long-term monetised risk benefit. deviation from this UCR at the end of RIIO-2 is used as a basis for calculation of rewards or penalties, subject to justification. The adjustment calculations following the determination of unjustified/justified over-/under-delivery are calculated (per sub-risk pot) on a network level, not on a SAC or more granular level of reporting established for RIIO-2 on a UID (intervention) level.
508. We propose an equivalent methodology for calculating rewards/penalties for RIIO-1 using a UCR approach. To derive our methodology for associated costs we have looked into using a UCR approach on a network level, on a PAC level and on a SAC level. The table below details the data requirements for each. Given NGGT's performance in RIIO-1 and availability of cost information, we think the UCR approach on a network level is the only viable approach and we detail the methodology below.

Table 57 Requirements Table

Requirements	PAC Level	SAC Level	Network Level
Granularity of costs	Not available	Available	Available
Granularity of allowances	Not available	Not available	Available
Granularity of monetised risk position	Available	Available	Available
Working assumptions through the period	Not available	Available	Available

UCR approach on a network level

509. In RIIO-1 we have an absolute monetised target on a total network level (across five PACs and 37 SACs), our Asset Health allowances have been agreed at a total level covering all Asset Health spend (not just the direct delivery of our monetised risk target as described above), an allowance on SAC level has never been set and should therefore not be used to derive UCR or to set associated costs of over-/under-delivery.
510. We therefore strongly recommend that any calculation of associated costs, especially a UCR approach, needs to be considered at a whole network level. This is because 1) our rebased target is set at network level and has been planned and delivered on a 'whole network basis' over the period 2) the mechanism is designed to encourage risk trading, therefore any "silo" approach to calculating costs of over- or under-delivery is not appropriate.

511. To calculate a UCR approach on a network level we propose to calculate this using a cumulative monetised risk delivered over the 8 years of RIIO-1 (assuming all interventions were delivered on 1 April 2013 and the benefit accumulates to 31 March 2021.). This metric is effectively the target cumulative monetised risk benefit to be delivered over RIIO-1. Our proposed calculation approach to determine a Baseline and Outturn UCR is detailed in the table below.

Table 58 Calculation of Outturn UCR and Baseline UCR

Metric	Unit/Term
A. Normalised licence target	R£
B. Actual delivered monetised risk position at the end of RIIO-1	R£
C. Network risk start position at the beginning of RIIO-1	R£
D. Without intervention position at the end of RIIO-1	R£
E. Target monetised risk reduction (cumulative monetised risk delivered over the 8 years of RIIO-1)	$R£ = (\frac{1}{2} \times \text{No. Of Years in RIIO-1}) \times [(D - C) - (A - C)]^{32}$
F. Actual monetised risk reduction (cumulative monetised risk delivered over the 8 years of RIIO-1)	$R£ = (\frac{1}{2} \times \text{No. Of Years in RIIO-1}) \times [(D - C) - (B - C)]$
G. Allowances for 37 SACs	£
H. Actual spend on 37 SACs	£
Baseline UCR	£/R£ = G/E
Outturn UCR	£/R£ = H/F

512. As prescribed by the NOMs Incentive Methodology the performance (over- or under-delivery) subject to reward/penalty calculations will be the deviation from the threshold level (deadband) rather than the deviation from the target level. Therefore, the Outturn UCR should be applied to the deviation amount from the deadband only.

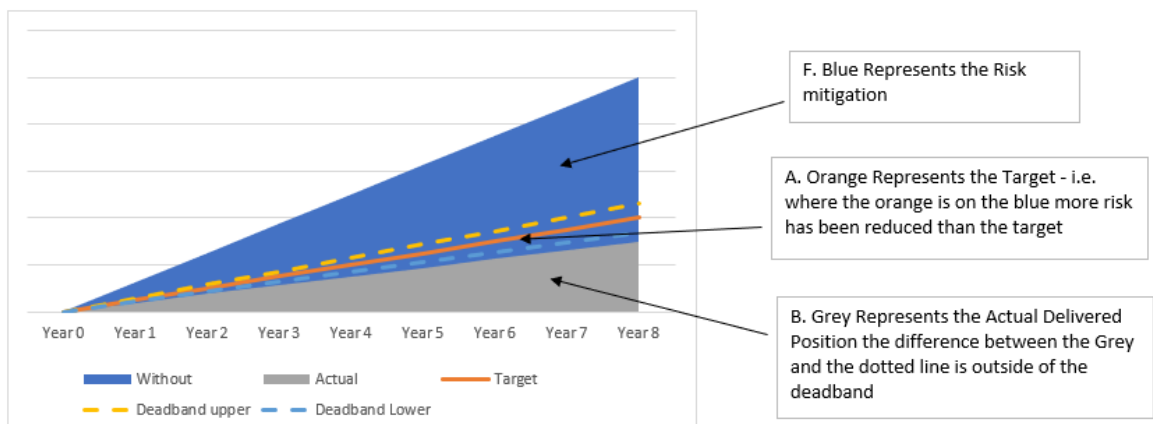
³² For simplicity we have approximated to a triangle (difference in target to start to target to without interventions multiplied by 8 (years) * 1/2 to give the area of a triangle).

513. To calculate allowance adjustments (associated costs), a target UCR is calculated using the Baseline UCR multiplied by our actual risk reduction. This gives us an allowance we would have had to mitigate the risk we have delivered and how much it would have expected to have cost. The table below shows the associated cost calculations in detail.

Table 59 Calculation of Associated Costs

Metric	Unit/Term
I. Allowance to achieve Actual using Baseline UCR	$\text{£} = F * \text{Baseline UCR}$
J. Allowance to achieve Actual using Outturn UCR	$\text{£} = F * \text{Outturn UCR}$
K. Value of monetised risk delivered outside the Deadband (+/- %)	<p><u>Over-delivery:</u> $R\text{£} = (\frac{1}{2} \times \text{No. Of Years in RIIO-1}) * [(A * (1 - \text{Deadband}) - C) - (B - C)]$</p> <p><u>Under-delivery:</u> $R\text{£} = (\frac{1}{2} \times \text{No. Of Years in RIIO-1}) * [(B - C) - (A * (1 + \text{Deadband}) - C)]$</p>
L. Justified/Justified Over-/Under-Delivery (stage 6 – Ofgem determination)	%
Associated Costs	$\text{£} = K * L * J$

514. The below graph visualises the calculations above and how we are proposing the UCR mechanism to work to determine associated costs with over- or under-delivery for NGGT.

Figure 27 Calculation of Associated Costs

515. It is to note that using monetised risk to calculate an UCR metric instead of long-term risk benefit, which is used for calculating the UCR values for NGGT as part of the RIIO-2 NARM Funding Adjustment and Penalty Mechanism, means that any deviation from the Baseline UCR would be more sensitive (or geared) to deviations in spend and/or monetised risk delivery.

(2) a project-by-project approach

516. We don't consider this suitable for the NGGT asset health works. Any major projects have typically been aligned to SACs (or combined complementary work on different SACs together in a campaign approach) which is already addressed through the proposal above.

(3) a combination of both

517. As above we don't consider this an appropriate approach for the NGGT work programme.

5. Worked Example

518. The treatment of over- and under-delivery is prescribed by NGGT's Special Licence condition 7.6, appendix 1 (see extract below). Following our licence principles the NOMs incentive revenue adjustment comprises three elements:

- (1) *The associated costs of the over-/ under-delivery – to be provided/excluded from RIIO-2 allowance;*
- (2) *The financing costs of the associated costs of the over-/ under-delivery – where one takes place there may be a related adjustment to compensate for the later/earlier timing of the allowances; and*
- (3) *A reward or penalty of 2.5% of the associated costs of the over-/ under-delivery.*

519. The following examples demonstrate how associated costs for over- /under-delivery could be valued for the purposes of the NOMs incentive methodology following our proposed methodology above. In this example, we have used R£ to denote monetised risk, avoiding confusion between monetised risk and the cost of over-/ under-delivery.

520. These examples are based on the following:

- Risk target (absolute target) of R£8.5m
- Deadband around the target +/- 5%
- Risk position at the start of RIIO-1 is R£9m
- Risk forecast at the end of RIIO-1 without intervention is R£20m
- Cumulative target monetised risk reduction = $(\frac{1}{2} \times \text{No. Of Years in RIIO-1}) \times [(\text{Without Intervention Position} - \text{Start RIIO-1 Position}) - (\text{Target Position} - \text{Start RIIO-1 Position})]$ is R£48m

Over-delivery example:

521. In the first example, the Licencee delivers an absolute monetised risk target of R£8m (a R£0.5m excess over the R£8.5m target, post normalisation), at a total cost of £450m. The amount spent is above the Asset Health allowances of £400m. Using a Unit Cost of Risk measure (UCR) introduces the following values:

- Cumulative actual monetised risk reduction $(\frac{1}{2} \times \text{No. Of Years in RIIO-1}) \times [(\text{Without Intervention Position} - \text{Start RIIO-1 Position}) - (\text{Actual Position} - \text{Start RIIO-1 Position})]$ is R£52m
- UCR Baseline = $\text{£100m} / \text{R£48m} = \text{£8 per R£}$
- UCR Outturn = $\text{£120m} / \text{R£52m} = \text{£9 per R£}$

522. This means the over-delivery of the absolute monetised risk target by R£1m represents a less efficient £9 per £risk point compared to the allowed £8 per £risk point. Following the cost submission and justification narrative submission at stage 5, Ofgem's assessment considers that £75k risk delivered above the deadband was 80% justified.

523. The amount which would be used to calculate the allowance adjustment for this example needs to account for the amount of over-delivery below the deadband of -5%. To do this we need to calculate the cumulative additional risk reduction achieved outside the deadband. This is calculated as $(\frac{1}{2} \times 8) \times [(8.5 \times (1 - 0.05) - 9) - (8 - 9)]$, which equates to R£0.3m. This will be rewarded with the outturn UCR of £9 per £risk point. Valuing R£0.3m extra points at the £9 per £risk point rate taking into account that only 80% of the over-delivery was justified means that the Licencee would be deemed to have merited a notional additional £2.1m in allowances at the start of the control period. This additional amount would be input to the Price Control Financial Model (PCFM), profiled across the RIIO-1 period in line with actual spend, to derive a revenue and Regulatory Asset Value adjustment that would apply to RIIO-2 allowances.

524. The Licencee would then also receive a 2.5% reward in respect of the associated cost of over-delivery and the financing costs for advancing the investment.

Under-delivery example:

525. In this example, the Licencee delivers an absolute monetised risk target of R£9m (a R£0.5m over the R£8.5m target), at a total cost of £450m. The amount spent is above the Asset Health allowances of £400m. Using a Unit Cost of Risk measure (UCR) introduces the following values:

- Cumulative actual monetised risk reduction ($\frac{1}{2} \times \text{No. Of Years in RIIO-1}$) \times [(Without Intervention Position – Start RIIO-1 Position) – (**Actual Position** – Start RIIO-1 Position)] is R£44m
- UCR Baseline = £100m/R£48m = £8 per R£
- UCR Outturn = £120m/R£52m = £10 per R£

526. This means the under-delivery of the absolute monetised risk target by R£0.5m represents a less efficient £10 per £risk point compared to the allowed £8 per R£risk point. Following the cost submission and justification narrative submission at stage 5, Ofgem's assessment considers that £75k risk delivered above the deadband was 80% justified.
527. The amount which would be used to calculate the allowance adjustment for this example needs to account for the amount of under-delivery above the deadband of +5%. To do this we need to calculate the cumulative additional risk reduction achieved outside the deadband. This is calculated as ($\frac{1}{2} \times \text{No. Of Years in RIIO-1}$) \times [(9 – 9) – (9 \times (1 + 0.05) – 9)], which equates to R£0.3m. This will be penalised with the outturn UCR of £10 per R£risk point. Valuing R£m extra points at the £10 per R£risk point rate taking into account that only 80% of the under-delivery was justified means that the Licencee would be deemed to have merited a notional removal of £2.5m in allowances at the start of the control period. This reduced amount would be input to the Price Control Financial Model (PCFM), profiled across the RIIO-1 period in line with actual spend, to derive a revenue and Regulatory Asset Value adjustment that would apply to RIIO-2 allowances.
528. The Licencee would then also receive a 2.5% penalty in respect of the associated cost of over-delivery and the financing costs for delaying the investment would be clawed back.

A note on cost data provenance

529. All actual expenditure data included has come from RRP table 4.2 Project Listing. The source is the area of the table describing the spend associated with Non load related – Baseline – Asset health, including the spend associated with all SACs, including those not part of the monetised risk target, and the spend not assigned to specific SACs marked as GTO OTHER INC PWS. This does not include the spend reported under the “Uncertainty Mechanism” associated with Feeder 9. The cost is reported in the 2020/21 price base, our original allowance was set in the 2009/10 price base. The allowance that is being compared to is from our RIIO-1 licence, Special Condition 7E, table 3. The allowance accounts for the Real Price Effects, as expressed in RIIO-1: Final Proposals for National Grid Electricity Transmission and National Grid Gas, Cost assessment and uncertainty Supporting Document, 17 December 2012, table 3.2. To convert from 2009/10 to 2020/21 multiple by 1.363, and from 2020/21 to 2009/10 multiple by 0.733. For the avoidance of doubt all costs, spend and allowances reported have been converted into 2020/21 prices. As per our licence and the guidance provided for this submission, NGGT's monetised risk values are in 2016/17 prices, for all positions and quoted values.