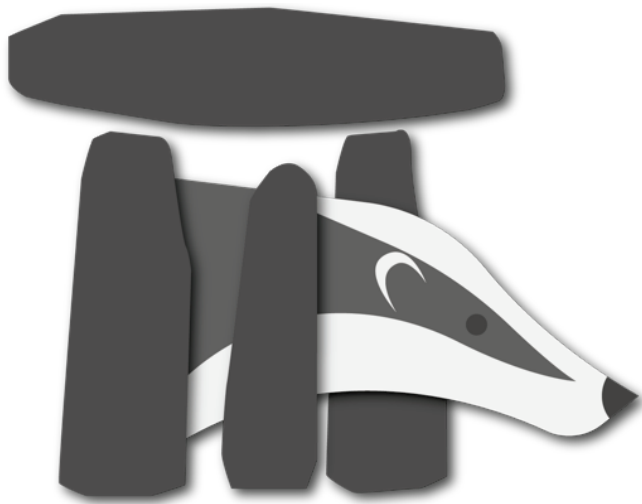




QS 6C
Testing, Commissioning and
Handover Plan



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1.0 Introduction

The Badger team recognise that the correct Testing, Commissioning and Handover of M&E and Technology installations have a significant impact on the safe and reliable operation of the tunnel. Our experience from previous road tunnels demonstrates that if the appropriate resources, time and importance is given to these functions, the Stonehenge Tunnel can be a project which we can all be proud of. Lessons learnt from other projects show that when program allowance is insufficient or inadequate importance is given to these functions, the rectification of snags can take significant time.

Our proposal below for the Testing, Commissioning and Handover Plan is to follow the requirements set out in the ITPD and includes additional items based on our experience.

2.1 General

2.1 We will follow the requirements of the Manual of Contract Documents for Highway Works (MCDHW) 7000 series in particular Clauses 7301 (Testing and Inspection Prior to Delivery) and 7302 (Testing Inspection and Commissioning at Site). For the technology systems we will follow MCH1980 'Technology Management and Maintenance Manual' and GG182 'Handover into Operation and Maintenance'. We will follow the guidance set out in BS ISO/IEC/IEEE 24748 part 4 'Systems and Software Engineering, Life Cycle Management. Systems Engineering Planning'. At each stage, the requirements of the project will be verified in accordance with systems engineering principals. The approach will be generally in accordance with the principals outlined in BS EN 61508 'Functional Safety of Electrical / Electronic / Programmable Electronic Safety Related Systems' parts 3 and 6 and will employ the industry standard Vee model to verify that the project requirements have been completed.

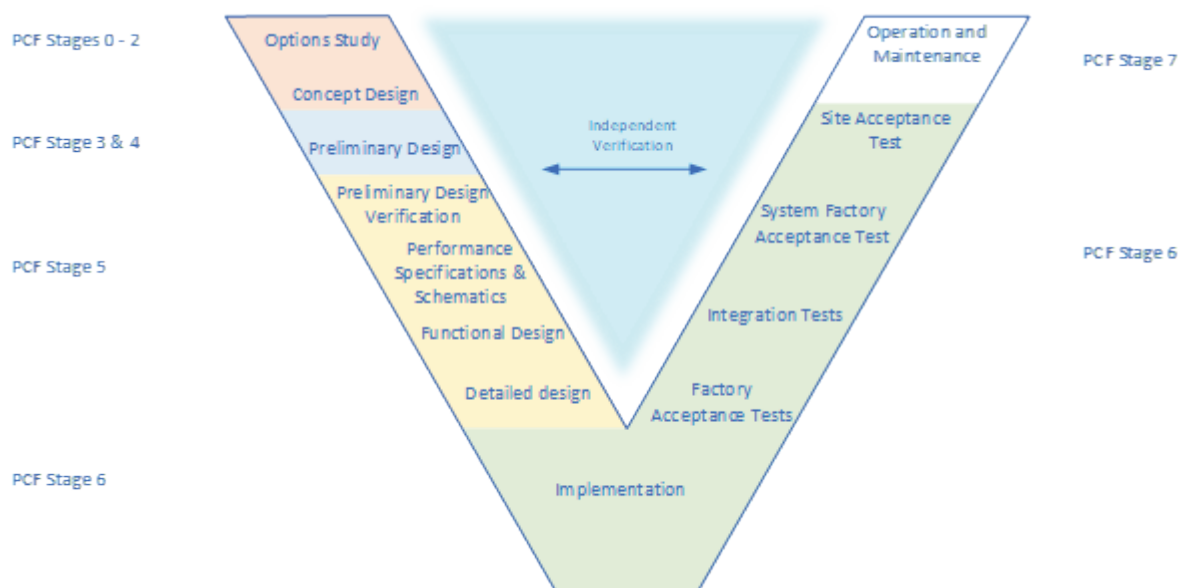


Figure 2-1 Vee model with mapping to the Highways England Project Control Framework

2.1.1 Three months prior to the start of testing and commissioning, Badger will appoint a dedicated commissioning engineer to oversee all the Testing, Commissioning and Handover of the M&E and Technology installations. They will be responsible for co-ordinating all the various subcontractors and third parties to ensure the process runs smoothly and is fully documented. They will be responsible for isolations and energisations of systems and ensure



that the activities are carried out in a safe manner. They will be the single point of contact for Highways England and their specialist suppliers and their attendance at site.

2.1.2 Inspection, testing and commissioning of the M&E Systems and Technology Equipment will be undertaken to demonstrate compliance with the requirements of the project scope. All proposed products will be submitted with the appropriate technical construction file as required by MCH1600 (Product Acceptance Process) for HE approval. Badger will manage this process in a timely manner and will ensure packages are complete and accurate prior to submission. Badger will ensure that all equipment will be subject to verification of compliance with TR1100 (Product Acceptance Process) by testing or certification.

2.1.3 Inspection and test plans, and commissioning plans will be prepared to demonstrate how the works will be inspected, tested and commissioned.

2.1.4 A structured and systematic approach to inspection, testing and commissioning will be undertaken with plans developed for:

- ▮ testing and inspection prior to delivery;
- ▮ testing, inspection and commissioning of individual components and systems;
- ▮ demonstrating system performance and
- ▮ integration testing of multiple systems, Stonehenge Tunnel and the complete works.

2.1.5 Inspection, testing and commissioning activities will be undertaken in stages to enable progressive assurance of the works to be undertaken. At any time software changes are made, software configuration control will be implemented and roll back plans developed.

2.1.6 Faults identified during testing and commissioning will be rectified with re-testing and commissioning of the replacement part(s) or whole system, if required.

2.2 Inspection and Testing

2.2.1 Inspection and test plans will be prepared for:

- ▮ system build testing;
- ▮ post assembly testing;
- ▮ pre-factory acceptance tests (pre-FAT);
- ▮ factory acceptance tests (FAT);
- ▮ factory integration testing for all the sub-systems;
- ▮ site acceptance tests (SAT);
- ▮ site integration testing and
- ▮ site end to end testing.

2.2.2 Inspection and test plans will:

- ▮ identify the mandatory tests and inspections required by the relevant standards;
- ▮ demonstrate compliance with the requirements of the scope;
- ▮ permit verification of assumptions made during the design;
- ▮ identify where a nominated third party is to carry out an inspection / test;
- ▮ identify where inspections or tests are to be witnessed;
- ▮ identify hold points;
- ▮ define the scope and acceptance criteria of the inspection and test;
- ▮ identify any testing accreditation and calibration requirements;
- ▮ define the actions for dealing with nonconformities and corrections;
- ▮ define the release / rejection procedures and
- ▮ contain the template / proforma for recording the results of the inspection and test cases.



2.2.3 The Supervisor, Client and relevant Others will be consulted to determine their requirements for inspection and testing, including witnessing of tests and hold points.

2.2.4 A schedule and programme for inspecting and testing the works will be prepared.

2.2.5 Inspection and testing will be undertaken in accordance with the inspection and testing plans, schedule and programme.

2.2.6 The Project Manager and Supervisor will be notified a minimum ten (10) Working Days prior to any test or inspection taking place.

2.3 Technology Commissioning Plan

2.3.1 A Technology Commissioning Plan will be prepared which includes the following:

- ▮ commissioning programme and timescales;
- ▮ summary of the commissioning standards;
- ▮ key deliverables;
- ▮ key roles and commissioning responsibilities (RACI);
- ▮ summary of relevant Others;
- ▮ descriptions of the pre-commissioning and commissioning activities and stages;
- ▮ interdependencies between the commissioning of individual M&E Systems and items of Technology Equipment;
- ▮ operational confidence, regime and integration testing;
- ▮ the Consent to Implement (CTI) process for Technology Equipment;
- ▮ the handover process for M&E Systems and Technology Equipment to the Client and operational and maintenance implications and
- ▮ any other M&E Systems and Technology Equipment testing and commissioning requirements for demonstrating compliance with the Scope.

2.3.2 The Technology Commissioning Plan will include the Supervisor's, Client's, manufacturer's and relevant Others requirements for commissioning of M&E Systems and Technology Equipment.

2.3.3 Elements of the Technology Commissioning Plan that relate to Technology Equipment will be prepared in accordance with the testing and commissioning philosophy and requirements of:

- ▮ MCH 1980 'Process for Commissioning and Handover of Technology Schemes' and
- ▮ GG 182 'Major Scheme Enabling Handover into Operations and Maintenance'.

2.3.4 The handover process for M&E Systems and Technology Equipment to the Client will demonstrate that:

- ▮ formal, robust governance is in place to control the transition into operation and maintenance of the assets;
- ▮ all key activities and associated approvals are defined and agreed prior to any element becoming operational;
- ▮ the works complies with the requirements of the Scope and
- ▮ the works can be handed over into operation and maintenance.

2.3.5 For Technology Equipment handover, the Consent to Implement (CTI) process will be implemented in accordance with the requirements of GG 182.



2.3.6 Testing and commissioning will not be undertaken until the Technology Commissioning Plan has been accepted by the Project Manager.

2.4 Testing and Commissioning

General

2.4.1 Throughout testing and commissioning, measures will be implemented so that no danger is posed to other ongoing site activities or to others within the vicinity of the testing or commissioning activity.

2.4.2 During local and remote testing and commissioning, Road Users will not be subjected to dangerous, misleading or inappropriate conditions / instructions.

2.4.3 Signage will be deployed to inform Road Users:

- ▮ that testing and commissioning is being undertaken and
- ▮ of the status (functionality) of the item undergoing testing and commissioning.

2.4.4 Where M&E Systems and Technology Equipment are provided for the use of Others, tests may be witnessed by the relevant Others.

2.4.5 The completion of all FAT and SAT stages will be witnessed. This should include the Cat 3 checker to enable them to sign off the Check Certificate.

2.4.6 The following remotely undertaken tests will be attended:

- ▮ all FAT at the Client's 3rd party provider and manufacturers' premises and
- ▮ all SAT at the Client's south west ROC.

2.4.7 Where testing and commissioning activities require remote operation of Stonehenge Tunnel M&E Systems and Technology Equipment, testing and commissioning will be coordinated with the Client through the Project Manager.

2.4.8 A staged approach to testing and commissioning of M&E Systems and Technology Equipment will be undertaken as outlined in Table 2-1 (Site Acceptance Tests (SAT)).

2.4.9 The Client's Software Maintenance Contractor's (SMC) will not commence FAT of the Site Data until the Project Manager has been notified by the Client's Site Data Action Group (SDAG) that the commencement of FAT is authorised.

2.4.10 SAT of M&E Systems and Technology Equipment will be completed in accordance with the manufacturer's requirements to:

- ▮ confirm functionality;
- ▮ check, address and configure Software; and
- ▮ verify information contained in the configuration plug.

2.4.11 Where testing and commissioning activities involve an interface with NRTS, testing and commissioning will be coordinated with the Client's TSP.

2.4.12 Testing and commissioning of the average speed enforcement system to obtain Home Office Type Approval (HOTA) will be undertaken and coordinated (as required).

2.4.13 Technical Vulnerability and Patch Management Plan will be developed for the TCMS, the provisioned Services, and connected Modules and Devices which includes:



- ▮ the methods to guarantee the integrity and compatibility of the systems with patches before their deployment;
- ▮ a schedule against which automated vulnerability scans are to be run on the system;
- ▮ an approach and associated capability to remediate newly reported zero-day vulnerabilities;
- ▮ procedures and schedule for patching the system after commissioning;
- ▮ procedures and schedule for security testing at every stage of FAT & SAT.

Testing and Commissioning – SAT 1 (Construction)

2.4.14 Prior to the commencement of SAT 1, M&E Systems and Technology Equipment required to undergo SAT 1 will:

- ▮ have the supporting infrastructure completed;
- ▮ be installed in its final configuration, using the permanent fixing systems;
- ▮ be powered by the permanent power supplies;
- ▮ have passed all FAT and have passed all installation inspections.

Table 2-1 Site Acceptance Tests (SAT)

SAT & Expected Duration	Stage	Activity (Testing and Commissioning)	
		M&E Systems	Technology Equipment
SAT 1 12 Weeks	Construction (Device functionality tests)	Local commissioning of Devices, including individual groups of Devices. Factory and on-site testing of Devices.	Local commissioning, including individual groups of technology Devices. Factory and on-site testing of Devices. (NRTS installation and circuit provisioning ongoing in parallel at this stage).
SAT 2 8 Weeks	Asset Readiness (System performance tests)	Demonstration of individual system performance using local or manual control of the system.	Single or groups of Devices from the line communications controller (LCC) (or equivalent). NRTS longitudinal cable network and circuits. System site integration.
SAT 3 19 Weeks	Operational Regime Testing (Integration testing)	Demonstration of integrated M&E Systems and Technology Equipment “end to end” testing of the whole system and tunnel asset: • Using the TCMS from the TSB; • Using the TCMS from the Client’s ROCs; • Testing the integration of the National TCMS and • Complete testing of all the TCMS Services. On-site integrating testing including: • In station and associated site data; • Complete NRTS circuits; • Modules / Devices • Outstations and controllers; and • Resolution of all operational critical issues.	



Testing and Commissioning – SAT 2 (Asset Readiness)

2.4.15 Prior to the commencement of SAT 2 for any individual M&E System or single or groups of Technology Equipment Devices, the following activities will have been completed:

- ▮ all SAT 1 activities for the system or device to be tested, including any supporting system or device;
- ▮ installation and commissioning of any local and longitudinal communications network between individual system components;
- ▮ confirmation that the NRTS transmission infrastructure has passed testing and is functional;
- ▮ Confirmation that MCH 1514 'Code of Connection' has been accepted and
- ▮ Results from cyber security testing in line with BS ISO/IEC 27001 'Information Security Management Systems' have been completed.

Testing and Commissioning – SAT 3 (Operational Regime Testing)

2.4.16 The following Technology Equipment commissioning prerequisites will be complied with before commissioning of Technology Equipment is undertaken:

- ▮ SAT 1 and SAT 2 have been completed;
- ▮ the TCMS has had all vulnerabilities mitigated in accordance with the Remedial Action Plan;
- ▮ testing of NRTS transmission infrastructure has been completed by the Client's TPS and confirmed as functional;
- ▮ the NRTS circuits to the Modules and Devices have been activated;
- ▮ the required SDLs have been installed and the implementation has been confirmed as successful;
- ▮ all required changes, including new operator interface desks and control terminals have been completed in the Client's South West SWROC and
- ▮ the Client's SWROC has reached operational readiness.

2.4.17 Technology Equipment commissioning will not commence until the Project Manager has notified the Contractor that the Technology Equipment commissioning prerequisites have been complied with.

2.4.18 Operational regime testing of Stonehenge Tunnel will include the following scenarios:

- ▮ tunnel operation and contra-flow (signalling, queue protection and AID) to demonstrate the functionality of individual systems;
- ▮ normal tunnel operation with queue protection applied;
- ▮ closure of an individual lane;
- ▮ closure of a bore and the application of contraflow operation;
- ▮ closure of the tunnel and implementation of the diversionary route;
- ▮ operation during failure or isolation of individual components, power supplies and systems demonstrating degraded modes and identification of alerts to Minimum Operating Requirements and
- ▮ a full "black start" test in which the tunnel will be started from a condition of having no electrical supply, tunnel fully operational and all external supplies are removed, this proves resilience of tunnel systems to maintain safe operation for 2 hours and then controlled closure.



2.4.19 For each Stonehenge Tunnel operational regime testing scenario, the following will be demonstrated:

- ▮ that the tunnel asset can be placed into any operational mode from the operator interface of the TCMS at the TSB;
- ▮ that the tunnel cannot be placed into an unsafe operational mode;
- ▮ that individual M&E Systems, components or Technology Equipment can be taken out of operational use without impacting the tunnel;
- ▮ that automatic control of any M&E System or Technology Equipment can be overridden by manual intervention at the user interface of the TCMS at the TSB;
- ▮ that manual operation of M&E Systems and Technology Equipment (where required) is available;
- ▮ that the operational status and condition of all M&E Systems, components and Technology Equipment can be viewed from the operator interface of the TCMS at the TSB;
- ▮ that there is a reported change of status on the operator interface of the TCMS at the TSB when the tunnel operating mode is altered and when Device or Module is taken out of service;
- ▮ that alarms are displayed on the operator interface of the TCMS at the TSB;
- ▮ that alarms are raised that match the Minimum Operating Requirements;
- ▮ that systems can be reset remotely from the operator interface of the TCMS at the TSB; and
- ▮ that the same functionality of the TCMS at the TSB is available using the TCMS located in the Client's ROCs.

2.5 Acceptance into Operation and Maintenance

2.5.1 The requirements contained in MCH 1349 'Technology Maintenance Instruction Operational and Maintenance Requirements for Technology Systems and Equipment' and MCH 1399 'NMCS Maintenance Instruction Notification of a Change in Equipment Quantities for Maintenance' will be complied with prior to Completion of section 3.

2.5.2 Prior to Completion of section 3, materials, training and handover to permit the Client to assume independent operational control of the works will be provided and coordinated.

2.5.3 Materials and training on the operational control of the works will be in accordance with MCDHW Clause 7015, (Training) be provided to personnel from:

- ▮ the Client;
- ▮ the Client's representatives;
- ▮ those maintaining the M&E Systems and Technology Equipment;
- ▮ Emergency Services and
- ▮ the Client's TSP.

2.5.4 The following materials will be provided:

- ▮ user, reference and training manuals;
- ▮ original equipment manufacturer (OEM) user manuals;
- ▮ maintenance manuals, as-built drawings, spares, software, special tools;
- ▮ Health and Safety File and
- ▮ any additional documentation required to permit the Client to assume operational control of the works.



2.5.5 The following operational and training manuals for each component of the M&E Systems and Technology Equipment as well as an integrated manual will be provided with procedures covering:

- ▮ normal operating procedures and agreed mitigation to be applied when the MOR is breached or approaching a level where the MOR would be breached;
- ▮ response to emergency situations and alarms;
- ▮ incident detection system alarms;
- ▮ Plant alarms and failures and
- ▮ maintenance and renewal.

2.5.6 The following will be determined from consultation with the Client and relevant Others:

- ▮ the familiarisation requirements and
- ▮ the nominated personnel required to undertake training.

2.5.7 Training will be tailored for the following groups:

- ▮ management, supervisors and operators;
- ▮ installation, testing and commissioning personnel;
- ▮ maintenance personnel;
- ▮ Emergency Services personnel and
- ▮ other Stakeholder personnel.

2.5.8 Safe and effective training will be provided to cover procedures and safe implementation of the following activities:

- ▮ normal operation;
- ▮ maintenance;
- ▮ routine inspection;
- ▮ fault diagnosis and assessment and
- ▮ emergency operation.

2.5.9 Training will be provided:

- ▮ utilising a mixture of classroom and site-based components;
- ▮ at locations reflecting the nature of the training being delivered;
- ▮ which is convenient and accessible for those being trained and
- ▮ to maximise 'hands on' experience, which is identical, as far as is reasonably practicable, to that of the installed system.

2.5.10 Prior to, and throughout, the commissioning works, training will be provided to personnel and operators.

2.5.11 A training programme will be prepared for the works which identifies the:

- ▮ elements of the M&E Systems and Technology Equipment that require training;
- ▮ proposed contents of the training;
- ▮ stage of the commission the training is to be undertaken;
- ▮ list of nominated personnel to attend training;
- ▮ intended purpose and outcomes of the training; and
- ▮ time periods required and proposed location for the training.

2.5.12 Prior to Completion of section 3, accompanied orientation site visits will be arranged and provided for personnel who are to be responsible for the operation, maintenance and incident response to:



- ▮ become familiarised with the works;
- ▮ be shown the access arrangements and
- ▮ understand the safe maintenance and operation of the works.

2.5.13 Prior to Completion of section 3, a live emergency exercise will be planned and undertaken in conjunction with the Emergency Services and relevant Others to confirm all emergency systems and Plant can be operated according to the defined emergency operation procedures.

2.5.14 Prior to Completion of section 3, Badger propose to have a proving period all the systems are operational and where stakeholders are invited to visit the finished tunnel, be demonstrated the various systems. There will be the opportunity during this time to hold some public events such as charity runs through the tunnel should Highways England wish to.

3.0 Maintenance Period Requirements

3.1 A minimum of 6 months prior to the Maintenance Completion Date, Badger will hand over all materials relating to the handover of the Maintenance Services, including:

- ▮ GG182 'Major schemes - Enabling handover into operation and maintenance' and MCH1980 'Process for commissioning and handover of technology schemes'
- ▮ all handover PCF products;
- ▮ user, reference and training manuals;
- ▮ original equipment manufacturer user manuals;
- ▮ maintenance manuals;
- ▮ the minimum retained spares list;
- ▮ the handover of spares; and
- ▮ any additional materials required to permit the Client to assume complete control of the works.

3.2 Prior to the Maintenance Completion Date, Badger will provide accompanied orientation site visits for nominated personnel from the Client or other stakeholders to:

- ▮ become familiarised with the works;
- ▮ be shown the access and maintenance arrangements; and
- ▮ understand the safe maintenance of the *works*.

3.3 Badger will provide safe, effective and quality training to cover the procedures and safe implementation related to:

- ▮ normal operation;
- ▮ maintenance activities applicable to each Asset Category or Asset;
- ▮ routine inspection; and
- ▮ fault diagnosis and assessment.

4.0 Responsible, Accountable, Consulted and Informed Matrix

An outline Responsible, Accountable, Consulted and Informed (RACI) matrix is shown below.



Organisation		Construction Joint Venture	Design Joint Venture	M&E main Contractor	M&E subsystem Contractors	TCMS Contractor	National TCMS contractor	Highways England
Activity	Sub System	Informed	Informed	Accountable	Responsible	Consulted		
	FATS							
Integration	Tests	Accountable	Informed	Responsible	Consulted	Consulted		
	Pre-SAT	Informed	Consulted	Responsible	Consulted	Consulted		
System	FAT	Accountable	Consulted	Responsible	Consulted	Consulted		
	In tunnel integration	Accountable		Responsible	Responsible			
System	Pre SAT	Accountable	Consulted	Responsible	Responsible	Consulted	Consulted	
	SAT	Accountable	Consulted	Responsible	Responsible	Consulted	Consulted	Consulted
System	Commissioning	Accountable	Consulted	Responsible	Responsible	Consulted	Consulted	Consulted
	Hand-over	Accountable	Consulted	Responsible	Responsible	Consulted	Consulted	Consulted
Permit to use			Accountable				Consulted	Responsible

4.0 Key Risks

The key risks to the testing, commissioning and handover of the tunnel are listed below:

- ⚠ Program (Badger risk) - Any delay to the civil works or M&E fitout will reduce the time for testing and commissioning. Our mitigation is that Badger will ensure that a robust, well planned and coordinated civils & M&E program is controlled and maintained;
- ⚠ NRTS (3rd party risk) – This will be the first tunnel that NRTS have equipped. They may find unforeseen issues that delay integration. Our mitigation is that Badger will work closely with NRTS at every stage to assist them in their delivery;
- ⚠ ROC (3rd party risk) – This tunnel will be the first for the SWROC to operate. Staff training will be carried out however staff will take some time to be familiar with the systems. Our mitigation is that Badger will ensure that high quality training will be provided in good time, trainers on hand during initial opening along with the opportunity for operators to visit site to appreciate the tunnel systems;
- ⚠ National TCMS (3rd party risk) – Integration with the national TCMS, interface specifications will need to be agreed and tested. Our mitigation is that Badger will work closely with the national TCMS provider at every stage to assist them in their delivery;
- ⚠ Fire Service acceptance of undercroft (3rd party risk). Our mitigation is that Badger will work closely with the Fire Service to get agreement well before commissioning;
- ⚠ Utilities (3rd party risk) – Delays to utility provision could cause delays to testing. Our mitigation is that Badger will work closely with the utility providers at every stage to assist them in their delivery;
- ⚠ Speed enforcement (3rd party risk) – Approval of variable mandatory speed limit with average speed cameras could be delayed due to being first in the UK. Our mitigation is that Badger will work closely with speed enforcement provider and ensure adequate testing time is in the program;
- ⚠ Availability of Authorised Persons to switch HV at the appropriate time (Badger risk). Our mitigation is that Badger will ensure that program and resources are fully understood ahead of time.