HIGHWAYS AGENCY

Highway Agency Lighting Control System
Phase 1 Project Report

22nd December 2011

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This report has been prepared by the Highways Consultancy Group (HCG) and Highways Research Group (HRG). The HCG/HRG are a multi-disciplinary supply chain comprising over 20 diverse organisations, strategically designed to meet the technical consultancy and research needs of the Highways Agency. The Groups behave as a community, sharing knowledge and working in partnership with the HA.

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Issue and Revision Record

Rev	Date	Originator	Checker	Approver	Description
A	22 Dec 11	Shafiq Garda	Masud Hussain	John Turner	Initial Issue

Executive Summary

This Report should be considered alongside the following Task 421 Highway Agency Lighting Control System (HARLiCS) Phase 1 Documents:

- Evaluation Report,
- Future Enhancements Note, and the
- Outline Business Case.

The HARLiCS Phase 1 project was commissioned by the Highways Agency's Network Services Directorate in Dec 2010. Mott MacDonald as the consultant has developed and trialled the HARLiCS system and undertaken the necessary evaluation activities. This has led to the development of an Outline Business Case to inform the Highways Agency in its decision making for a future roll-out.

The HARLiCS system has achieved its technical objective of providing an open interface to the Central Management System (CMS) and having the ability to submit dynamic lighting level commands to control the lighting. In terms of reliability and availability the system has worked well with no major issues arising in performance.

The trial and evaluation of the system has provided opportunities for the system to be enhanced in the future so that it operates more efficiently and is more feature rich. These include software enhancements, integrating the system with wider traffic sources and introducing the flexibility of various dimming profiles.

The trial, on the M4 between junction 6 and 7, was only operated for 6 weeks which meant that there were certain limitations in the data obtained for evaluation. This is especially true for determining the impact HARLiCS has had on safety on the network. However, it can be stated at this stage that there was no degradation in safety during the period that the system was trialled. A robust safety case was developed that ensured that any lighting levels set were not compromising existing lighting standards and policy.

Analysis of the system from an operational and business perspective has yielded results showing benefits for energy and money savings.

Headline figures achieved are:

Headline benefits – implementation of a national HARLICS dimming system:

Scheme lit to ME2: 15.6%

Scheme lit to ME1: 26.4%

Headline benefits – implementation of a national HARLICS system incorporating MNSO:

Scheme lit to ME2: 54.1%

Scheme lit to ME1: 59.6%

Therefore, the system has demonstrated that it is a tool that takes another positive step towards intelligent lighting, building on the Midnight Switch-Off (MNSO) solution, and has the potential to contribute to the Highways Agency's future energy savings plan lending itself to be considered as an important intervention to deploy.

Following the appraisal process it is recommended that for Phase 2, Option 3 is adopted – HARLICS and MNSO National Roll-Out, as part of Area Energy Savings Plans. This is because this option offers the potential to save more money and achieve better returns on the overall investment. Option 3 also fits in with the Highways Agency's strategic needs related to economic and environmental factors. Key figures projected for Option 3 include:

- 2.6 % annual energy saving (5.66M kwh) for schemes lit to ME1; this will be reduced to a 2.3% annual saving (5.12M kwh) based on ME2;

- £480k annual cost saving for schemes lit to ME1 with an associated CO_2 saving of 2.997k tonnes and a return on investment in 7 years; this will be reduced to a £434k annual cost saving for schemes lit to ME2, with an associated CO_2 saving of 2.71k tonnes and a return on investment in 7.8 years.

If option 3 were to be implemented as part of a programme of renewals lamp and ballast costs could then be excluded and the return on investment would reduce to 4.2 and 4.8 years for respective ME1 and ME2 schemes.

In summary the HARLiCS system provides another significant step in improving the use of Highways Agency's assets in the most efficient and cost effective way and the recommendation is that commissioning of Phase 2 should be considered.

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1 Introduction

1.1 Background

The Highways Agency is committed to delivering their key business plan objective of delivering sustainable solutions and playing a significant role in reducing carbon dioxide (CO_2) emissions as part of national and international goals. This objective is in line with its obligation to reduce power usage by 25% by Jan 2015 as directed by the Greener Government Commitment. In line with delivering on this obligation and objective the Highways Agency has embarked on several trials related to lighting control on its network. The aim is to eventually roll-out technology that will enable the intelligent use of lighting assets on a 'needs' basis. The main pilot being undertaken is the Intelligent Motorway Lighting (IML) project which is concerned with evaluating the suitability of a Central Management System (CMS) for dimming only.

The Highways Agency is also undertaking a trial for a Midnight Switch-Off (MNSO) system which operates between 0000 and 0500hrs. This MNSO system is based on a timed blanket switch-off.

It has been recognised that dynamic traffic flow data from the network is required to enable the most suitable lighting levels to be set at any given time. A timed blanket light switch off has the potential for presenting high risk scenarios at certain locations. Also, a non-time only constrained approach, i.e. based on real-time traffic information, provides greater potential to reduce energy consumption. Therefore, an interface needs to be developed between the CMS system and the Motorway Incident Detection and Automatic Signalling System (MIDAS) to enable the provision of the required real-time traffic flow data to the CMS system.

This specific project known as the Highways Agency Road Lighting System (HARLiCS) will address this requirement and is a complete solution, providing the means to operate lighting levels on a needs basis.

1.2 Project Rationale

A key element of the above pilot will be the development and evaluation of the system described here in. A system has been proposed which aims to facilitate dimming on the basis of current traffic conditions whilst also providing a means to switch off and / or dim at predetermined times. A pilot was undertaken where the system was developed and its performance evaluated.

This pilot included the development of an interface between the proprietary CMS dimming equipment used for the pilot and the Motorway Incident Detection and Automatic Signalling System (MIDAS). Such an interface would enable vehicle flow rates and alerts from MIDAS to be used for controlling light output on the basis of real time traffic conditions; in addition to dimming at predetermined times on the basis of historical traffic profiles. In alignment with Highways Agency Lighting Strategy objectives the use of traffic data coupled with timed dimming and / or

switch off will enable the Highways Agency to safely “provide the right level of light, at the right place and at the right time”.

1.3 Lighting Standards and the Use of Traffic Data

The revised BS 5489-1:2003 lighting standard facilitates a reduction of lighting level in alignment with the Average Daily Throughput (ADT) of vehicles - traffic flow. Further to this, timed blanket switch off and / or the use of historical traffic profiles may not always be the most appropriate methods of reducing light output, for example at high risk locations where large variations in traffic flow may occur unexpectedly.

Theoretically, using real time traffic data to dynamically control lighting output, would improve the overall scope for installing dimming systems where MIDAS and lighting are co located, i.e. at most urban and strategic locations. This is because, theoretically, the safety argument for dimming is improved if the system is capable of reacting to changing traffic conditions and / or unplanned events.

The use of real time traffic data means the potential for reducing energy consumption for any particular scheme is greater than when using timed / profiled dimming or switch off, as the extent of dimming would not be constrained by time, or what has happened previously; it would only be constrained by what is happening now.

Using traffic data as one condition for lighting should ensure that the safest possible environment exists prior to making any change in light output. Ultimately, it can ensure a safe transition to the most desirable condition: that of safe switch off.

Recent advancements in lighting technology means that dimming control of the Highways Agency lighting asset is now a feasible proposition. By reducing light radiance, energy consumption, costs and greenhouse gas emissions could be cut by up to ⅓. In addition light pollution (glow in the night sky) can be substantially reduced. Depending upon the technology employed, it is also possible to increase lamp life and predict failures, hence extending the maintenance period and improving maintenance regimes.

1.4 Midnight Switch Off

The Highways Agency has developed a lighting control system known as Midnight Switch Off (MNSO). This system, with an RCC override, provides automated switch off capability at predetermined times, i.e. 0000 to 0500hrs. Further RCC Interfaces are not desirable and the same simple RCC GUI will need to be employed to provide an override for the HARLiCS system.

In addition it is thought that future widespread switch off would be best achieved through the use of a Highways Agency owned interface that can facilitate the use of any off the shelf Central Management System (CMS), the HARLiCS system should be able to perform this function.

1.5 Concept Proof

The Intelligent Motorway Lighting (IML) Phase2 on-site trial aims to take advantage of the revised British standard (BS 5489 and ILETR27) for road lighting. The standard permits lighting levels to be established on the basis of traffic flows. IML Phase I used an interface to MIDAS to prove the concept of using traffic flow data to control motorway lighting.

A robust operational interface between MIDAS and lighting would require the use of a CMS to control the lighting output, as proposed in the general IML trial. This interface would facilitate networked control of lighting using traffic data from multiple MIDAS links; whilst also providing a Midnight Switch-Off (MNSO) function which is the current Highways Agency lighting switch off system.

1.6 Further Development

Following proof of concept further work is required to pilot a modified CMS that can provide a complete solution with remote monitoring and control for dimming, including maintenance scheduling. CMS systems do not currently have the capability to use traffic data as described, and it would not be judicious for the Highways Agency to sponsor the development of bespoke proprietary interfaces from various manufacturers. In order for a CMS to dim on the basis of traffic flows, a robust operational interface to MIDAS will be required, with the CMS providing the necessary lighting interface for maintainers.

By developing a relatively simple open interface for CMS an open architecture is created allowing multiple suppliers, in an open market, to provide equipment to facilitate timed switch off, static and dynamic dimming. The appropriate interface will consist of an operational version of the concept prototype with additional timed dimming and switch off functionality. This development should facilitate networked control of lighting using nationwide MIDAS traffic data from MIDAS GOLD and ultimately the HATMS. It should provide lighting commands, derived from data collated from multiple MIDAS links, to any remote CMS system and its associated lighting scheme. An Engineers Graphical User Interface (GUI) will be necessary for configuration (including timed switch off), maintenance and evaluation purposes; an RCC GUI will be required for Control Centre for remote monitoring and control. These GUIs are distinct from the CMS interface being a specialist, proprietary scheduling and configuration tool used only by maintainers.

See Figure 1 below – proposed architecture for an overall HARLiCS system deployment.

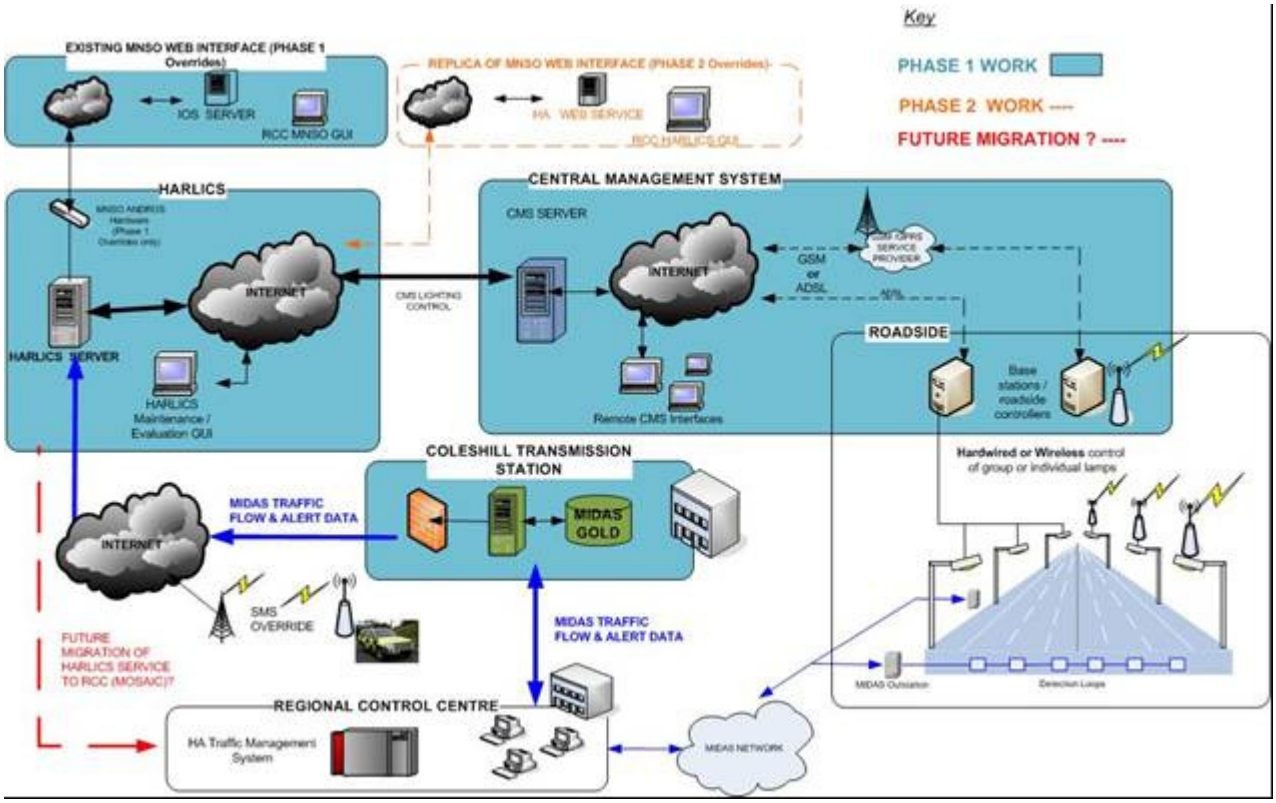

Figure 1 – Proposed Architecture

1.7 Phase 1 Objectives

The project is being undertaken in two phases. Phase 1 defines what is necessary for the introduction of a regional based system that will control a trial section of motorway lighting based on the traffic flowing through the section. This will include the necessary equipment procurement, software design and development and interface specifications, project studies and reports to deliver the HARLiCS trial and provide a basic system for Phase 2. Phase 2 defines what is necessary to extend the Phase 1 system to a national level, and allow for the procurement of "off the shelf" lighting control systems that will be compatible with the HARLiCS system.

The objectives for Phase 1 were therefore to:

- Draft a system requirements specification for the subsequent development of a HARLiCS system;
- Develop a system able to read a switched input from a MNSO Andros unit and command a CMS system to switch on or off accordingly;

- With proportional use of the IEC 61508 guidelines undertake a hazard analysis and risk assessment for the required system in order to deliver a safety argument, using the ALARP (As Low as Reasonably Practicable) principle, that will support the parent CMS Pilot Safety Case;
- Develop, test and integrate the approved system for operational use with MIDAS GOLD and pilot CMS systems;
- Undertake a system evaluation in accordance with an agreed evaluation plan and to
- Deliver an End Stage Report detailing all findings and providing recommendations for future enhancements as part of phase two.

A series of secondary objectives were defined as follows:

- Quantify the cost benefits of incorporating an operationally deployable HARLiCS interface into a CMS architecture;
- Using pilot figures for dimming on the basis of traffic flows calculate the potential reduction in emissions that could be achieved on a national basis;
- Identify any additional qualitative and operational benefits arising from the use of a HARLiCS interface within the CMS architecture, and to
- Support further deployment of MNSO systems.

1.8 Document Purpose

This End Stage Report includes pertinent details from across the Project and should be read alongside the other project deliverables. Naturally, detail from the Outline Business Case and Evaluation Report and other deliverables is summarised but not repeated here..

2 Technical Approach and Methodology

2.1 Technical Overview

Commercial off the shelf lighting control systems can dim and switch off road lighting at predetermined times and so can provide significant energy savings. However they do not take account of real time traffic conditions and are therefore limited in terms of when lighting energy can be reduced, relying instead on historical data to define safe times of operation. Many disparate CMS system are on the market, but none of these are designed so that they can communicate with the Highways Agency's bespoke traffic systems. Also, Highways Agency Lighting Policy is constantly evolving with changes taking place and implementing these would prove to be difficult with off-the-shelf CMS equipment which provides various levels of access and control, each with distinctly different human machine interfaces.

The HARLiCS system is a single point for lighting control developed to act as a 'supervisor' to any number of Web connected CMS systems. HARLiCS uses dynamic traffic flow data from the MIDAS network to enable the most suitable lighting levels to be set at any given time, with a greater potential to reduce energy consumption. By using traffic flow data lighting level reductions can be achieved that are not constrained by time and / or historical traffic flows. The lighting level is set in accordance with established Lighting Standards, based upon real-time traffic conditions, whilst being flexible enough to react to unplanned events by reinstating the lighting to maximum brightness.

For Phase 1 of this project, the HARLiCS system obtained traffic flow data from the MIDAS Gold Proxy system for a 3.3km length of the M4 between Junctions 6 and 7 which was selected as the trial section of the motorway. Traffic flow data was run through an algorithm engine from which appropriate lighting level commands were generated. These commands were then sent to the CMS system via an open interface and then implemented at the lighting asset on the network. The lighting commands were one of the following:

- Dynamic dimming based on traffic data.
- Operator override to default lighting.
- Timed dimming.
- Timed switch-off.

The system was designed to have the capability to receive overrides from RCC operators to put the lighting level back to a default level, e.g. full lighting, whenever required.

The Phase 1 architecture is shown in Figure 2 below.

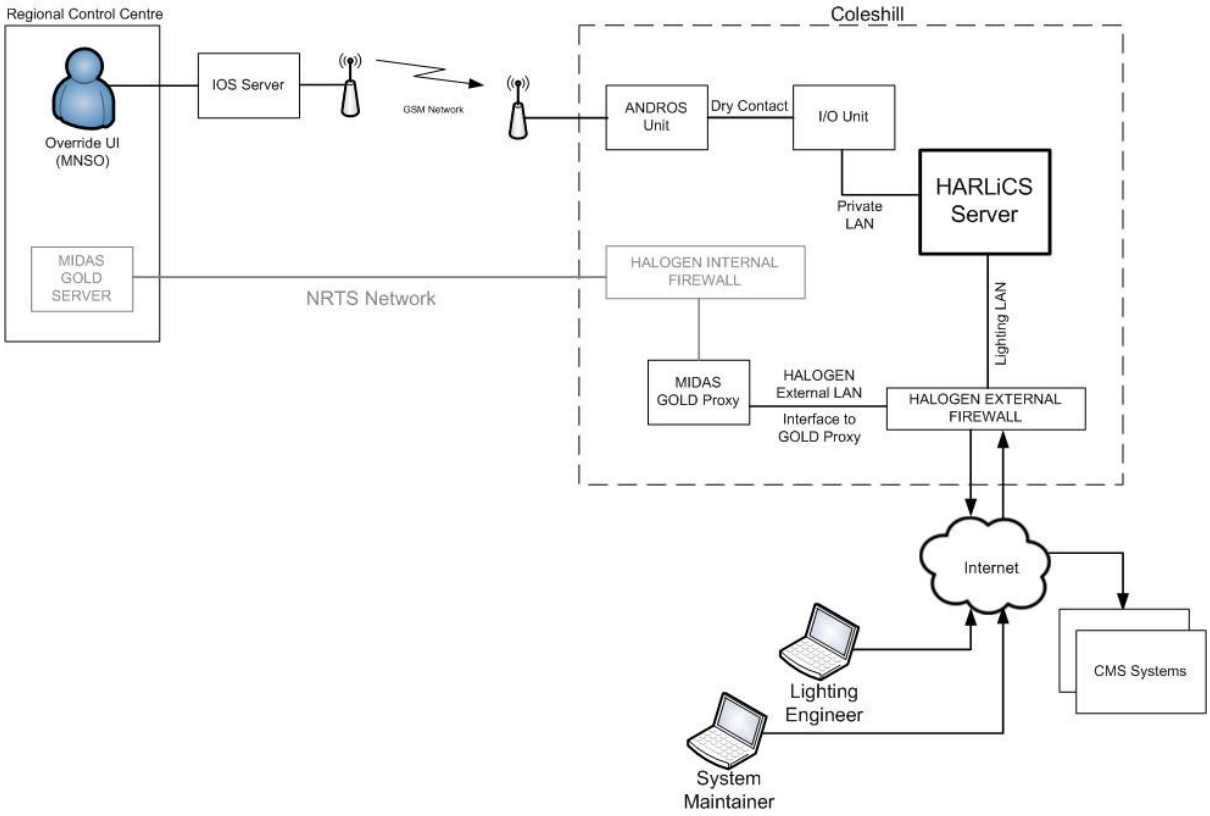

Figure 2 – HARLiCS Phase 1 System Architecture

2.2 Organisations and Resources Involved

The following organisations were involved in delivering the HARLiCS Phase 1 Pilot for the Highways Agency:

- Mott MacDonald was the lead consultant for the project and had responsibility for the undertaking the following:
    - Project Management;
    - Stakeholder Engagement/Management
    - System Development;
    - Safety Case Development, and
    - System Evaluation.

- The Highways Agency Intelligent Motorway Lighting (IML) Team, supported by Harvard Engineering were undertaking an existing pilot scheme for the CMS system. They were a key stakeholder and dependency for the project as the HARLiCS interface was to work directly with Harvard's CMS system which ultimately set the lighting levels based on the commands provided.

2.3 Project Approach

The approach to the task was through the following series of work packages (WPs) and activities:

Work Package 1.1 – Requirements Specification

The key objective of WP1.1 was to produce a Requirements Specification that contained the needs of the Highways Agency and other key stakeholders in relation to a HARLiCS interface to the CMS system. The requirements needed to consider the user and system level interfaces, determine factors that the algorithm needs to take into account for proposing lighting level commands to the CMS and define the location referencing scheme to be used. Key activities included:

- Stakeholder liaison including requirements workshop;
- Drafting of Requirements Specification;
- Formal requirements specification covering protocols for system level interfaces for both CMS and MIDAS systems, integrating MNSO system and description of algorithm engine, and
- Participation in Project Board Breakpoint meeting to obtain approval to proceed with design.

Work Package 1.2 – System Development

The key objective of WP1.2 was to design, test and deliver the HARLiCS system interface based on the requirements specification developed in WP1.1. The other objective was to perform a hazard analysis, risk assessment and safety impact of using the HARLiCS system in a controlled dimming environment. Key activities included:

- Development of simple hazard analysis to identify any safety requirements of the HARLiCS system;
- A risk assessment to determine safety integrity requirements for the identified hazards;
- Production of a high level system architecture document;
- Design of the HARLiCS system;
- Procurement of the system hardware, software and related communication equipment;
- Completion of Code of Connection to ensure an adequate level of security for the system;
- Development of reports that can provide statistics on the operation of the system, including all the dimming and switch off information. These reports will form a key part of the later evaluation phase, and the
- Production of support and maintenance documentation for the operational use of the HARLiCS server.

Work Package 1.3 – Installation and Evaluation of System

The key objective of WP1.3 was to ensure the smooth commissioning of the HARLiCS system, validate and evaluate the system design and identify the likely cost savings as a result of the developed system. Also, an outline business case was to be developed that identified key objectives for a safety case going forward. Key activities included:

- Engaging with Harvard as the CMS supplier to prepare for the installation of the HARLiCS system;
- Installation of the hardware at Coleshill, verifying basic operation and communication links;
- Installation both off the shelf and HARLICS specific software onto server platforms;
- Undertaking of Factory Acceptance Test (FAT) and Site Acceptance Test (SAT);
- Development of Evaluation Plan;
- Undertaking of evaluation according to the evaluation plan
- Development of supporting evidence for a safety case and the
- Development of an outline business case that will allow the Project Board to make a decision on whether the benefits to proceed to Phase 2 exist.

Work Package 1.4 – Operation and National Recommendations

The key objective of WP1.4 was to ensure the continued operation of the Phase 1 system throughout the trial period and apply any necessary minor software modifications to maintain system performance and availability. The second part of the work package was to develop a set of recommendations that included consideration for system enhancements, the potential benefits of a future system and potential costs and timescales for developing and implementing a Phase 2 system. Key activities included:

- Performing a defined set of support procedures during normal working hours to regularly check the health of the system and maintain an availability rate of >98% during normal operation (i.e. at night);
- Responding to automated condition notifications;
- Responding to identified software faults, and assess priorities in providing a solution to the issues. Faults may be reported from the trial CMS partner, MAC and others;
- Periodically assessing the system algorithm and outputs to help identify potential enhancements for future phases;
- Identifying system enhancements for inclusion in Phase 2; and
- Hosting a workshop with the IML team and the CMS supplier where key requirements for a future revised issue of the COI specification (for Phase 2) were to be discussed and outlined.

2.4 Task Deliverables

The following deliverables have been completed as part of this task:

- D.1 – Phase 1 Requirements Specification;
- D.2 – Safety Argument (including hazard analysis and risk assessment);
- D.3 – Phase 1 Functional HARLiCS System;
- D.4 – System Documentation;
- D.5 – Installation of server and associated equipment;
- D.6 – SAT documentation;
- D.7 – Phase 1 evaluation plan;
- D.8 – Phase 1 evaluation report;
- D.9 – Outline business case (including safety case);
- D.10 – COI Requirements Development (for Phase 2);
- D.11 – Recommendations for future enhancements;
- D.12 – Supporting information for Phase 2 PID, and
- D.13 – End Stage Report (this document).

2.5 Risks Identified

Risks were identified both prior to the project commencing and during the course of the task. The key risks are outlined below highlighting where focus for both the project sponsor and project manager lay to ensure that the project was delivered satisfactorily, and in line with the deliverables agreed at the outset of the project.

Risk	Consequence of Risk	Mitigation	Outcome
Dependency on being able to obtain "site data" that allows the association of Midas equipment to a particular lighting section.	Insufficient information to configure HARLiCS adequately	Held workshops and technical liaison with the trial CMS provider	Risk removed
Dependency on the Highways Agency and CMS supplier to define and provide the attributes of a lighting section in terms of class of road, relationship to adjacent	Insufficient information to configure HARLiCS adequately	Held workshops and technical liaison with the trial CMS provider	Risk removed

Risk	Consequence of Risk	Mitigation	Outcome
sections and parent lighting schemes.			
Lack of availability of historical MIDAS traffic profiles for the road section used in the HARLICS trial	Insufficient information to configure HARLiCS adequately	Hold workshops and technical liaison with the CMS supplier to agree the technical details of the COI, based on the requirements that emerge from HARLiCS.	Risk reduced
Lack of buy-in and cooperation from CMS suppliers to contribute to the development of requirements	Unworkable COI interface	Project team to engage early with suppliers to establish relationship and explain the importance of their contribution.	Risk removed
Lack of buy-in and cooperation from internal stakeholders to contribute to the development of requirements	System developed only partially meets wider requirements	Project Board to ensure that importance of project is understood by internal Highways Agency stakeholders and facilitate engagement with project team.	Risk removed
If CoCo isn't granted then can installation and running trial could be impacted.	HARLiCS trial cannot commence	Engagement with Highways Agency CoCO team for early approval of application.	Risk reduced
CMS pilot not designed and implemented on time to allow HARLiCS to be installed and piloted. No support resources available from CMS development team post implementation.	HARLiCS pilot not able to commence and trial as required	Work with CMS project team to align respective project programmes and ensure dates are mutually agreed going forward.	Risk removed
Availability of sufficient MIDAS sites at trial site impacting the evaluation and project success.	Insufficient MIDAS data information to generate lighting commands	Liaise with Highways Agency management and Area representative to request activation of required MIDAS sites. Potential use of 'emulated'	Risk reduced

Risk	Consequence of Risk	Mitigation	Outcome
		MIDAS data to replace non-activated MIDAS sites.	
Lighting levels may be overridden due to planned /unplanned maintenance or Traffic Management	Unexpected lighting levels set.	Liaise with the Streetworks Team for the area to ensure that they are aware of the project and Motts are to be contacted in the event of any change	Risk reduced

Table 1 - Risks Identified

2.5.1 Safety Case

A key activity undertaken during the task was developing a safety case for introducing HARLiCS as a control mechanism for dimming according to traffic flow. Needless to say that the Highways Agency place safety of the road users at the top of its priorities and so ensuring that the developed system doesn't compromise existing safety levels in any way was crucial.

The safety case didn't consider dimming through the use of a CMS which is a well established industry practice using off the shelf equipment. The safety objective of this work was to ensure that "HARLICS should maintain the safety integrity of the lighting system it controls, where any additional risk introduced by HARLICS is deemed broadly acceptable when compared to the current situation".

Using recognised tools and techniques the HARLiCS Project Team have established that HARLiCS meets the above safety objective. The Project Team applied core elements of IEC61508 (Functional Safety) to identify and analyse hazards. Several risks were identified in respect to the connection of HARLICS to the roadside CMS lighting system it controls which were within the tolerability or broadly acceptable region. Further work was carried out in consultation with Highways Agency and other stakeholders to develop key functional requirements to make any risks 'as low as reasonably practicable'. The subsequent design mitigated the identified risks where 5% of the risk was mitigated as tolerable with 95% being categorised as 'Acceptable'.

HARLICS includes multiple levels of data validation, fall back to historic lighting profiles and automatic and manual override facilities existed to ensure the roadside lighting was maintained at a level defined by the appropriate Lighting Standard (BS5489). The HARLICS trial itself included a level of additional protection through 'belt and braces' operational procedure that

enables the Managing Area Contractor (MAC) to reset the lighting system to full brightness through the CMS system and disable the link between HARLICS and the CMS if deemed appropriate. This was backed up by the override facility available to RCC operators which is identical to the existing Midnight Switch Off override.

In summary, the Project Team followed industry best practice and did all that was reasonably practical to ensure that the HARLICS interface does not affect the safety integrity of the lighting system it controls. The system architecture only facilitated dimming by 25% 'worst case' and would not allow lighting to be switched off or create poor uniformity.

2.5.2 Code of Connection (CoCo)

As the design of the HARLiCS system requires the use of the NRTS network, interfacing with external systems, i.e. CMS and the fact that it is new system implemented by the HA, a CoCo activity was required to be undertaken.

The CoCo documentation was developed by the Project Team in conjunction the Highways Agency's Traffic Technology Division (TTD). The design of the system demonstrated that the HARLiCS element of the overall lighting control system set-up was contained within the Highways Agency network and was installed at Coleshill which adheres to Highways Agency security requirements. Therefore, the existing architecture and configuration doesn't contain any areas that would breach network security requirements.

Due to the nature of the deployment of HARLiCS (i.e. pilot system) a provisional CoCo certification was granted that enabled the system to go live.

If any fundamental technical changes take place on the system or operational arrangements are revised, the CoCo will need to to be revisited and updated. An example of this is if the system is switched off and the redundant equipment is left at Coleshill for greater than three months, with no prospect of Phase 2 commencing and reusing it, then a formal Decommissioning Strategy will need to be developed and agreed by TTD. It is recommended by the consultant that if Phase 2 is not commenced by April 2012 then TTD are engaged to discuss and agree a strategy for a way forward reagrding the existing installation.

3 System Technical Performance during Trial

3.1 Introduction

This section summarises the observations of the HARLiCS system over the trial and higlights successes and any issues that arose. It also summarises recommendations for future enhancements to the system and particular consideration that needs to be given for decommissioning of the Phase 1 system and activities to undertake in Phase 2 for O&M requirements.

3.2 Successes

HARLiCS System

In general the system performed very well, and remained operational for the full duration of the trial.

The connection to the Midas Gold proxy was extremely reliable. This was assisted by the close network proximity of these two systems in Coleshill.

The decision to have HARLiCS use British Standard (BS) lighting classes for the basis of its calculations seems to have worked well. This allowed a direct translation of the ILE TR27 recommendations for traffic flow rates to lighting classes to be implemented. Any variation in the translation of lighting classes to luminance or power percentages is left to the CMS supplier, based on their knowledge of the lighting products and technologies used in their CMS systems. It is recommended that lighting commands continue to be defined in this way for future phases.

Reliability and Performance

The HARLiCS system was operating during the trial period with full auditing enabled, in order to enable the retrospective analysis of any situation that may have arisen. In addition, there was no archiving or pruning of the audit data – all data was kept available for online reporting. Given this situation, and the high volume of data collected, both the dynamic system operation and the extract of audit data still perform very well.

The responsiveness of the system was good, and there were no performance issues noted.

COI Operation

The COI specification and implementation is regarded as very successful, as it catered for all the situations encountered during the trial. It proved to be very reliable at providing a dependable

means of communicating with the CMS system. In addition, the trial CMS partner, Harvard Engineering, has been quite complimentary about how successful the use of the interface has been.

3.3 Issues

Communication with the trial CMS was mostly continuous. There were a small number of times where communication was interrupted, predominantly caused by a failure of the Domain Name resolution of the target CMS. The interruptions lasted at most for a period of 2 heartbeats, causing maximum outage times of less than 6 minutes. It has not been possible to determine where the root failure of the Domain Name System (DNS) occurred.

3.4 Future Enhancements

A note detailing the recommended enhancements is being submitted as part of the task deliverables and specific details can be found in the note. The key recommended enhancements are summarised below in order of priority.

Serial	Enhancement
1	Various software enhancements to improve algorithm and functionality of HARLiCS system.
2	Alternative mechanism for RCC overrides
3	Combining lighting profiles (timed dimming, switch-off and auto-switch off) to be activated at differing times of night.
4	Interface to CMS – batching lighting override commands
5	Review of algorithms to improve over time for dimming profiles and in line with specific lighting standards adopted by the Highways Agency
6	Flow based switch-off – go below the ME3 lighting class limit
7	Interface to other traffic data sources to improve quality of flow data
8	Simplified Engineers Terminal
9	Improved process and policy in place for support and management of system in Phase 2
10	Logging interface to HALOGEN to provide ability to supply operational and system level information to stakeholders.

3.5 System Decommissioning

In order to comply with the requirements of the Code of Connection, the system was switched off on 22 Nov 11.

However the hardware remains in place in anticipation of Phase 2 commencing by April 2012. If the system is left switched off and is expected to be redundant at Coleshill beyond April 2012, then a formal Decommissioning Strategy will need to be developed and agreed by TDD.

The following needs to be considered for the transition from Phase 1 to Phase 2:

1. The system has been switched off and left at Coleshill with the assumption that Phase 2 is going to be commissioned, (Anticipated approximately April 2012). Redundant equipment left at Coleshill for greater periods will have to be removed by the Highways Agency by following a formal decommissioning strategy that it will need to develop.

Furthermore the following has been carried out in line with the system switch off at the end of the trial for Phase 1:

2. MNSO interface to HARLiCS has been removed so overrides aren't possible any longer.

3. In the absence of HARLiCS, the CMS will operate in its default settings for setting lighting levels.

3.6 Handover to Maintenance

If HARLiCS Phase 2 is to be undertaken with permanent installations then a full MCH1349 will need to be undertaken as part of the work for Phase 2 and includes the following:

- As a Non-Standard scheme additional maintenance roles and responsibilities may be required, and their impact on existing, and
- Operational maintenance must be carefully reviewed.

It is therefore essential the Scheme Manager consults the Highways Agency Technology Service Manager as early as possible in the scheme process to agree maintenance arrangements to be applied (MCH1980, "Process for the Commissioning and Handover of Technology Schemes").

The Scheme Manager must comply with the following Operational & Maintenance requirements:

a) Notifications and Stakeholder Meetings.

b) Scheme Design and Installation Standards.
c) System Software and Site Data.
d) Training.
e) Maintenance Spares.
f) Commissioning.
g) Documentation.
h) Acceptance Testing.
i) TPMS Asset Inventory, Bar Coding and GPS Recording.
j) Specialist Test Equipment.
k) Warranty.
l) Intellectual Property Rights.
m) Health and Safety.
n) Information Security Requirements.

In addition to the above the MCH1529 “Code of Connection” will have to be undertaken in full as part of the Phase 2 work.

4 Evaluation

4.1 Introduction

The evaluation of the HARLiCS system undertaken was based on the HARLiCS Evaluation Plan and Methodology produced as part of the task deliverables.

The evaluation covered the trial operational period 05 Sep 11 – 16 Oct 11 and based on a 3.3km lit section of the M4 Junction 6 to 7 which has a normal lighting level of class ME2 at Sun Set (SS) using Iridium 250 Watt lamps and associated ballasts.

This particular section of the M4 has high flow rates that are not indicative of the entire network. Therefore, the potential savings identified from the trial are likely to be lower that those expected elsewhere on the network.

The savings achieved during the 6 weeks of the evaluation are shown below:

Energy saving per km per annum	14,006Kwh = 14.98%
CO_2 saving per km per annum	7.42 tonnes
CRC saving per km per annum	£89
Total cost saving per km per annum	**£1909 = 15.71%**

The results obtained during the trial have also been used to ratify the theoretical energy savings derived from historic MIDAS flow rates at a number of representative sites, over the course of a year.

This provides the Highways Agency with an accurate picture of the theoretical savings that could be achieved if HARLiCS was to be rolled out nationally. In summary they are:

1. HARLiCS only Scheme lit to ME2

Energy saving per km per annum	13,722Kwh = 14.94 %
CO_2 saving per km per annum	7.27 tonnes
CRC saving per km per annum	£87.24
Total cost saving per km per annum	**£1871 = 15.56%**

2. HARLiCS only Scheme lit to ME1

Energy saving per km per annum	23,421Kwh = 25.48 %
CO_2 saving per km per annum	12.41 tonnes
CRC saving per km per annum	£148.92
Total cost saving per km per annum	**£3193 = 26.4%**

3. Integrated HARLiCS and MNSO Scheme lit to ME2

Energy saving per km per annum (exc CRC)	48,654Kwh = 52.92 %
CO_2 saving per km per annum	25.79 tonnes
CRC saving per km per annum	£309.48
Total cost saving per km per annum	**£6634.5 = 54.11%**

4. Integrated HARLiCS and MNSO Scheme lit to ME1

Energy saving per km per annum (exc CRC)	53,763Kwh = 58.46 %
CO_2 saving per km per annum	28.49 tonnes
CRC saving per km per annum	£341.88
Total cost saving per km per annum	**£7331.07 = 59.62 %**

The operational integrity of the HARLiCS system during this period has also been evaluated and the results are detailed in the accompanying Evaluation Report.

It should be noted that during initial site surveys, the M4 J6 – J7 site proposed for the evaluation utilised lamps to provide a lighting class of ME1 at switch on, where the circuit wattage was in excess of 400W. However following the commencement of this project the lighting class of the scheme was changed to ME2, using Philips 250W Iridium lamps at switch on. This change meant that the potential for energy savings was substantially reduced.

The cost savings are derived from wattage values, lamp numbers and dimming coefficients for different parts of the scheme (main carriageway and slips). Evaluation was made on the 284 lamps within the trial section of network.

4.2 Project Objectives Evaluated

The "HARLiCS Evaluation Plan and Methodology" was designed to meet 7 main objectives:

Objective No.	Evaluation Objective
1	Evaluation of all key HARLiCS Functions (discussed in System Performance section): i. Lighting levels conform to BS5489 and ILE TR27 ii. Traffic flow – derived lighting levels iii. Real-time flow calculations iv. HIOCC alerts

Objective No.	Evaluation Objective
	v. Historic calculations vi. Reliability of HARLiCS system vii. System and manual overrides operate adequately viii. System operates appropriately in a distinct MNSO only mode ix. System operates in a distinct timed dimming only mode
2	Assess how HARLiCS could improve the MNSO safety case
3	Calculate energy and CO2 cost savings achieved by using HARLiCS
4	Define theoretical energy and CO2 savings for traffic controlled switch off periods
5	Evaluate additional qualitative and operational benefits by using the HARLiCS system
6	Provide evidence showing success's of the HARLiCS system against the task specification
7	Evaluate the operation and maintenance aspects of HARLiCS

4.3 Evaluation Summary

The Evaluation Report contains full details of the evaluation and conclusions. For the purpose of this report the headline findings for each objective is outlined below.

Objective No. (See above for objectives detail)	Evaluation Finding
1	i. Conformance to BS5489 and ILE TR27 established ii. Real-time data available at all times and deriving lighting profiles on historic data not required iii. Real-time flow calculations functioned correctly and no malfunctions reported iv. The number erroneous HIOCC alerts occurring brings into question of including HIOCC functionality in the HARLiCS system as a secondary

Objective No. (See above for objectives detail)	Evaluation Finding
	measure for checking abnormal traffic conditions v. Real-time flow rates in line with historic and defined thresholds. Future work should focus on analysing adjusting thresholds in line with safety criteria to obtain higher energy and cost savings. vi. 18 heartbeat failures experienced during trial, but none caused an issue as the availability of the HARLiCS/CMS system was 100% vii. No incidents occurred during trial so RCC overrides not necessary. Overriding at neighbouring MNSO sites did take place and the action was taken by operators to reinstate lighting levels at all local schemes. Analysis of logs demonstrates that HARLiCS was able to respond to outside overriding requests. viii. During the trial it was ascertained that the system had the ability to reinstate (via override) and switch-off lights as necessary. However, using HARLiCS for MNSO purposes requires further live operational testing. ix. Due to safety and operational reasons it was not possible to undertake a live test of the timed dimming interface. Results from FAT testing have been taken to confirm conformity.
2	Analysis to determine 'real' impact of HARLiCS on MNSO sites not possible to due to pre-configuration and project time constraints.
3	HARLiCS Trial Cost Savings INC CO2: 15.71% Optimisation of certain parameters in the HARLiCS software configuration enables up to 3.66% additional savings
4	Savings potential by deploying HARLiCS to control CMS is approximately 20%
5	Single point of control demonstrated Open standards design leading to competitive and innovative procurement routes In house control of system Capable of exploiting wide range of Highways Agency traffic data sources Capable of integration into wider Highways Agency control systems

Objective No. (See above for objectives detail)	Evaluation Finding
6	COI specification widely accepted by CMS suppliers Validation that real-time traffic data results in energy and CO2 savings better than those using a standalone CMS set to dim at predetermined times. RCC override of CMS possible due to HARLiCS Safety is not likely to be compromised due to robust functionality built into the system using best practice safety guidelines
7	Low level of monitoring and support resource likely to be required for small scale HARLiCS deployments. Handover to Maintenance and full CoCO and O&M documentation to be completed for 'live' implementation

5 Stakeholders and External Inputs

The nature of this project meant that numerous stakeholders had to be engaged and external inputs were required throughout the task. Stakeholder management was essential in this project to ensure the project deliverables met the needs of the Highways Agency and other interested parties. The successful outcome of this project to meet stakeholder's respective business goals and objectives was a driving factor in the task. Specific stakeholder engagement activities were identified at the outset and were embedded within each of the four work packages.

A key stakeholder exercise was the Requirements Definition workshop held at the start of WP 1.1. This activity was important as it gathered all the key stakeholders and enabled an open and detailed debate which resulted in an acceptable Requirements Specification which formed the basis of the HARLiCS design.

In summary the key stakeholders identified were:

- Highways Agency – HARLiCS Project Board;
- Central Management System (CMS) Task Team;
- CMS suppliers;
- Midnight Switch-Off (MNSO) Task Team;
- Intelligent Motorway Lighting (IML) Pilot Team;
- Trial Regional Control Centre (RCC);
- TechMAC – at trial region;
- Energy Solutions Programme;
- MIDAS Task Force;
- Highways Agency Traffic Technology Division;
- RCC Operations, and
- Enterprise Architecture (EA) Team.

Crucial external input was required from Harvard Engineering and Minos who provided the CMS and ANDROS (RCC override) equipment respectively. Both organisations were engaged early in the process to establish the dependencies and the projects requirements that they had to work to with the Mott MacDonald team. This was done via workshops, one-to-one meetings and ongoing discussions.

Harvard as well as a wide pool of CMS suppliers were engaged to ensure that the COI specification that was developed fit in with the technical approach and systems features they used for their CMS systems. This was important as a the ability to procure a HARLiCS capable CMS system from the open market is an important component of the Highways Agency's procurement strategy.

Ultimately the good relationship between the respective organisations has positively contributed to the successful delivery of the project of the system providing the confidence that a robust and open Phase 2 system is feasible.

6 Conclusions and Recommendations

6.1 System

There are numerous system related success measures that can be highlighted from the trial. These include:

- A detailed specification now exists that facilitates open market procurement allowing other suppliers to modify proprietary CMS and traffic data systems for Highways Agency off-the-shelf use. This will lead to best value and innovation solutions.

- The system generally performed reliably and in the desired manner throughout the trial period. The lighting level commands generated based on calculations from MIDAS data input conformed to the ILE TR27 recommendations.

  Recommendation 1 – continue to define lighting commands in line with ILE TR27, with the allowance available for the CMS supplier to apply any variances based on their lighting products and technologies.

- The developed interface can easily be migrated to support the use of CMS equipment from multiple manufacturers, as part of a future lighting system – workshop held with CMS manufacturers and the associated review of the design and specifications by the suppliers has confirmed that this success measure is met.

  Recommendation 2 – adopt COI interface as defined in COI specification.

- Other recommended system enhancements to consider for Phase 2 are:

Serial	Enhancement
1	Various software enhancements to improve algorithm and functionality of HARLiCS system.
2	Alternative mechanism for RCC overrides
3	Combining lighting profiles (timed dimming, switch-off and auto-switch off) to be activated at differing times of night.
4	Interface to CMS – batching lighting override commands
5	Review of algorithms to improve over time for dimming profiles and in line with specific lighting standards adopted by the Highways Agency

Serial	Enhancement
6	Flow based switch-off – go below the ME3 lighting class limit
7	Interface to other traffic data sources to improve quality of flow data
8	Simplified Engineers Terminal
9	Improved process and policy in place for support and management of system in Phase 2
10	Logging interface to HALOGEN to provide ability to supply operational and system level information to stakeholders.

6.2 Operational

There are numerous operational success measures that can be highlighted for the trial of the system at a quantitative and qualitative level. These include:

- In support of Highways Agency sustainability targets the design facilitates a pilot of the CMS system which is providing a demonstrable reduction in energy consumption of near 25% during periods of dimming, whilst also adhering to the requirements of BS 5489.

- The design validates that the use of real time traffic data results in energy and CO2 savings similar to or better than those achieved by using a standalone CMS unit set to dim at predetermined times.

Following the appraisal process it is recommended that for Phase 2, Option 3 is adopted – HARLICS and MNSO National Roll-Out, as part of Area Energy Savings Plans. This is because this option offers the potential to save more money and achieve better returns on the overall investment. Option 3 also fits in with the Highways Agency's strategic needs related to economic and environmental factors.

This option would support the Highways Agencys' objective to reduce energy consumption by 25% by 2015. The cost of delivering Option 3 will depend upon whether or not the proposed systems are implemented as part of a programme of renewals / planned energy saving work:

- The cost of implementation outside of any programme of renewals is estimated at £6,179,296.00 including roadside equipment costs and includes lamps and ballasts, with a return on investment between a 7 to 8 year period.
- The cost of implementation as part of any renewals work is estimated at £ 3,546,212.00 including roadside equipment costs and excluding lamps and ballasts, with a return on investment between a 4 to 5 year period.

In summary the business case has identified the following:

OPTION 2 (HARLICS delivered as part of an initial national roll out – early implementation)

- 1.8% annual energy saving (2.37M kwh) for schemes lit to ME1; this will be reduced to a 0.63% annual saving (1.38M kwh) based on ME2;

- £201K annual cost saving for schemes lit to ME1 with an associated CO_2 saving of 1.256k tonnes and a return on investment in 13.8 years; this will be reduced to a £117k annual cost saving for schemes lit to ME2, with an associated CO_2 saving of 751 tonnes and a return on investment in 19.4 years;

If option 2 were to be implemented as part of a programme of renewals lamp and ballast costs could then be excluded and the return on investment would reduce to 9 and 13.2 years for respective ME1 and ME2 schemes.

OPTION 3 (HARLICS & MNSO delivered as part of the energy savings programme)

- 2.6 % annual energy saving (5.66M kwh) for schemes lit to ME1; this will be reduced to a 2.3% annual saving (5.12M kwh) based on ME2;

- £480k annual cost saving for schemes lit to ME1 with an associated CO_2 saving of 2.997k tonnes and a return on investment in 7 years; this will be reduced to a £434k annual cost saving for schemes lit to ME2, with an associated CO_2 saving of 2.71k tonnes and a return on investment in 7.8 years.

If option 3 was to be implemented as part of a programme of renewals, lamp and ballast costs could then be excluded and the return on investment would reduce to 4.2 and 4.8 years for respective ME1 and ME2 schemes. This would take 9 – 12 months to complete based on the assumption that the roadside equipment and CMS were already operational.

> ***Recommendation 3*** – Proceed with Phase 2 and assess the feasibility of rolling out HARLiCS together with MNSO (Option 3 in Outline Business Case) to align with the Area team's Energy Savings Programme. This will deliver a 2.3 - 2.6% annual saving (5.12 - 5.66M kwh) on estimated HA annual energy consumption, consequently contributing positively towards the Highways Agency's energy savings plan.

- The HARLiCS system operates within an environment that has rigorous parameters set to ensure safety for users isn't compromised due to dynamic lighting changes. HARLICS includes multiple levels of data validation, fall back to historic lighting profiles and automatic and manual override facilities exist to ensure the roadside lighting is maintained at a level defined by the appropriate Lighting Standard (BS5489). This is

backed up by the override facility for RCC operators that is identical to the existing Midnight Switch Off override.

In summary, the Project Team followed industry best practice and did all that was reasonably practical to ensure that the HARLICS interface does not affect the safety integrity of the lighting system it controls. The system architecture only facilitated dimming by 25% 'worst case' and would not allow lighting to be switched off or create poor uniformity.

Recommendation 4 – Adopt existing safety case approach and review and refine as needs evolve in Phase 2 and beyond.

- Operations & Maintenance – In terms of the system being ready for 'Handover to Maintenance' as part of a fully operational deployment, relevant documentation needs to be put in place to meet the required criteria set out in MCH1349.

  Recommendation 5 – Commence Handover to Maintenance activities early in the Phase 2 project to ensure timely sign-off and readiness for live operation.

- Based on the scale of deployment of HARLiCS and the number of implementations that take place in Phase 2, the actual resourcing level and associated costs will need to be applied accordingly. As a guide it is felt that for a single HARLiCS implementation for a defined area would require resource of one engineer available for one day per week on average. The function carried out by the engineer would include:

- Following Maintenance Handover: Software maintenance support for a Non-Standard System Software requires a "Second / Third Line" software maintenance service that must be arranged through the MSP (Maintenance Service Provider (MAC / EMAC / TechMAC / NRTS etc)). This will normally require a sub-contract with the Software Supplier.

  Recommendation 6 – Consider resourcing requirements for operations and support of live system. Also, identify appropriate software supplier to provide software maintenance support and allocate sufficient budget.

- Code of Connection (TTD) – A Provisional CoCo had been granted by the Highways Agency's TTD for the trial period. If the existing system is not be reactivated and incorporated into a fully operational system by April 2012, then a decommissioning strategy will need to be developed and executed.

  A further and more detailed version of the CoCo will need to be developed in Phase 2 as the system will take on a'fully operational' nature.

Recommendation 7 – Commence Phase 2 by April 2012 so that the existing system doesn't have to be decommissioned from Coleshill.

Refine and update the existing CoCo to incorporate Phase 2 HARLiCS.

Finally, a Lessons Learnt Log has been developed as part of this project and is found in Appendix B of this document. There are several recommendations related to site selection, use of traffic data and integration of HARLiCS as an intervention for energy savings to consider for the future.

Appendix A Glossary

ADT	Average Daily Throughput
ALARP	As Low as Reasonably Possible
CMS	Central Management Systems
CoCo	Code of Connection
COI	CMS Open Interface
DNS	Domain Name System
FAT	Factory Acceptance Test
GUI	Graphical User Interface
HARLiCS	Highways Agency Road Lighting Control System
HIOCC	High Occupancy
HALOGEN	Highways Agency Logging Environment
HATMS	Highways Agency Traffic Management System
IML	Intelligent Motorway Lighting
MAC	Managing Agent Contractor
MNSO	Midnight Switch Off
MIDAS	Motorway Incident Detection and Automatic Signalling System
MIDAS Gold	Collection of MIDAS data for all Highways Agency regions
NRTS	National Roads Telecommunications Services
RCC	Regional Control Centre
SAT	Site Acceptance Test

Appendix B Lesson Learnt Log

Ref No.	Area of Project	Comments	Lesson Learnt	Benefit for the Future
1	Technical	CPMG expressed concerns about the operation of MNSO during periods of Hard shoulder running. To support the MNSO strategy for Managed motorways (MMs)HARLiCS will require ERA alert data / HS MIDAS / loop data to inform lighting decisions. This work should be included within any future phase as part of work to develop COTS detector i/ps	ERA / HS Flow / alert data input to HARLiCS could be An essential requirement for any future changes to HARLiCS	Improved safety case for dimming / MNSO on MMs. Potential to mitigate risks presented by key stakeholders opposed to MNSO / dimming
2	Technical	Site assessments and BCR calculations should include a check on how many MIDAS sites are available and how much it would cost to enable traffic counting on the crucial MIDAS sites	Availability of MIDAS data is restricted and limits the capability of the system. There are large cost implications to enable MIDAS sites for traffic counting	Better understanding of limitations / benefits prior to making an investment decision
3	Stakeholders	CMS billing solutions will require validation and early liaison should take place with the Highways Agency Energy Team and DNOs	CMSs may claim to have an EXEXLON approved CMS but this does not mean a billing solution exists	Monetary savings can be made
4	Technical	NTIS data should be considered in the future although links lengths may be longer and not representative; data is up to 15 minutes old;	NTIS Data has MIDAS content already and has been processed to reduce the number of alerts etc. HARLiCS could be replicating MIDAS data processing. It can be argued that NTIS data is a more readily available and effective solution	Re use of existing data could be possible and / or data may be available for some sites where previously it wasn't
5	Management	Careful site selection should include traffic analysis over an entire year	Each site should be carefully considered to ensure maximum benefits are derived. The BCR can drop dramatically where	Investment is made only at those sites that will provide the biggest return

Ref No.	Area of Project	Comments	Lesson Learnt	Benefit for the Future
			HARLiCS controls extremely busy sections of motorway i.e. flows and therefore light output remains higher for longer	
6	Stakeholders	Highways Agency National power usage may not be of relevance, National Grid should be consulted to confirm relevance criteria if HARLiCS is to be rolled out nationally; of particular interest is the period of switch off and how this and real time dimming could impact upon night time base loads. There may be some synergies. HARLiCS must be able to delay/advance timings for MNSO.	NG has a requirement to understand the existing and potential Megawatt implications of Highways Agency usage from a base load perspective.	Better understanding of the impact of energy reduction on the National Grid.
7	Management	The market place is changing and 400w ballast should become available over the next 18 months or so - the situation needs to be monitored and any CMS installed for control of 250watt schemes should be compatible with new 400w ballasts	No mature and proven 400Watt ECG exists which will impact upon the BCR	Highways Agency is able to keep track of developments ensuring that opportunities to make greater monetary / carbon savings are maximised
8	Stakeholders	The outputs of HARLiCS work should feed into the current lighting strategy and Area Energy Plans	It is likely (due to high CMS install costs) that a HARLiCS scheme will only prove cost effective if lamp changes, e.g. swap outs etc are paid for as part of ongoing renewals or change programmes that are due to occur anyway	HARLiCS remains a viable energy saving measure

Appendix C Decisions Log

Ref No.	Issue	Action / Decision	Decision Maker	Date of decision	Document Ref	Additional info
1	Hierarchy of HARLiCS operational control for Phase 1.	Phase 1 will only allow one of Timed Dimming, switch off or dynamic dimming.	Agreed at Highways Agency Stakeholder Workshop on 17/02/11	17/02/2011	N/A	
2	Method for determining onset of lighting commands from HARLiCS - is there a requirement to confirm photocell status in order to initiate lighting commands.	The photocell will be used for local control (local within CMS) and will not be passed to HARLiCS. A solar clock mechanism will be used to regulate the initiation of lighting commands.	Agreed at Highways Agency Stakeholder Workshop on 17/02/11	17/02/2011	N/A	
3	HARLiCS web service requirements.	HARLiCS will not need to respond immediately to status of CMS, therefore a "uni-directional" web service is required.	This was agreed either at the Phillips meeting, or the next Jason/Simon meeting after it.		N/A	
4	Confirmation of data source used to define granularity of lighting levels.	The granularity of lighting levels will be based on lighting classes as opposed to percentages or cd/ m2.	Jason Burrows	24/02/2011	Ref_Doc_001	
5	Decision on flow level data source to be used for Phase 1 of the project.	MIDAS data to be used for Phase 1 project	Jason Burrows	01/03/2011	Ref_Doc_002	
6	Decision on use of lighting standards to be used for the development of HARLiCS during Phase 1.	British Standards for Lighting will be used for Phase 1 of the project.	Gary Stockbridge	02/03/2011	Ref_Doc_003	
7	Overrides being sent to CMS during the day from HARLiCS due to tolerance levels issues. Causing lights to go on during the day and effecting lighting equipment.	Stop HARLiCS system until tolerance levels set at an acceptable level and then assess the impact. Meeting to be held with Harvard on 17th Aug to discuss ironing out any command and execution issues	Jason Burrows	11/08/2011	N/A	

Ref No.	Issue	Action / Decision	Decision Maker	Date of decision	Document Ref	Additional info
		on the CMS.				
8	Lighting commands sent to the CMS from HARLiCS during the day are being accepted with no photocell override for initiation of command	Programme the CMS system so that normal lighting commands aren't recognised during daylight hours.	Jason Burrows	11/08/2011	N/A	