AEGIS

PROJECT TITLE:	CLASS 37 LPG FUEL CELLS
DOCUMENT TITLE:	ASSURANCE STRATEGY
DOCUMENT NUMBER:	AES/300139/R01
ISSUE:	3

THE POSITIVE CHOICE

Author

Document ID	AES/300139/R01
Issue	3
Signature Date	10/08/2023
Signatory Name	Elizabeth Jackson
Job Title	Head of Rolling Stock Assurance
Company	AEGIS Engineering Systems Limited

Reviewer

Document ID	AES/300139/R01
Issue	3
Signature Date	14/08/2023
Signatory Name	James Johnson
Job Title	Engineering Director
Company	AEGIS Engineering Systems Limited

Approver

Document ID	AES/300139/R01
Issue	3
Signature Date	14/08/2023
Signatory Name	James Johnson
Job Title	Engineering Director
Company	AEGIS Engineering Systems Limited

AMENDMENT RECORD

ISSUE	DATE	AMENDMENT
1	28/07/2023	First Issue
2	07/08/2023	Budget appendix added
3	10/08/2023	Updates in reponse to client comments

CONTENTS

1 INTRODUCTION

1.1 Background to the project

G-Volution are seeking to deliver proof of concept for the installation of a Bio-LPG fuel cell on a Class 37 locomotive. The project will be staged:

- The first stage will be a 1kW, 160kg unit
- The second stage will be a 80kW, 583kg unit

Both stages will include the fuel tank, fuel cell and integration into the locomotive auxiliary circuits. All components will be contained within the bodyshell.

The intention is for the introduction of an independent auxilliary supply for the vehicle, using a new bio fuel.

1.2 Scope

This Approvals Strategy considers all changes that will be made to the vehicles under this project including:

- The fitment of the new equipment
- The movement of any existing equipment to facilitate the new equipment
- The interfacing of the new equipment with the existing equipment
- Cab updates for any new indications

Placing into Service is excluded and is to be addressed by the Operator.

1.3 Purpose / Objectives

The purpose of this document is to record the plan for delivering safety to the modification of the Class 37 locomotive with risks reduced so far as is reasonably practical in accordance with the CSM-RA [Ref 3].

1.4 Document Contents

This Approvals Strategy has been developed at a very early stage of the project. As a result some information is not yet known.

Blue text has been used as a placeholder for information which will be expanded on as the project progresses.

Black text provides the current information at time of publication.

Green text used for quotes.

2 PROJECT DESCRIPTION

The project is currently at concept stage, and no further details are available.

As the project progresses it will develop a System Definition to capture greater detail of the project and equipment description. The System Definition is considered to be the 'Master' description, the information provided here is for high-level context only.

ACTION 1 - Prepare a System Definition to provide a detailed scope and definition for the project.

Technical equipment diagram and description

The key elements of the system include:

- Solid Oxide Fuel Cell
- LPG Storage
- LPG Gas Train
- Control system
- Batteries

Operational Concept

Trial phasing and location

Trial criteria

Maintenance

Testing

Phasing

2.1 Project Plan

2.1.1 Timeline

Please refer to the master project management programme for the project timeline [Ref 1]. It has not been reproduced here to avoid divergent versions.

At the time of writing, the project is due into service in xxx.

2.1.2 Role and Responsibilities

The role and responsibilities of the organisations (Actors) involved in this project are:

Table 1: Roles and Responsibilities

Organisation	Responsibility / Role
G-Volution	Modification designer and vehicle integrator (Including management of related sub-contractors) Proposer
Colas	Operator Maintainer
Installer	x
Colas	Owner
Office of Road and Rail	Regulator / Safety Authority
x	Hazard Record Manager Safety Engineering Support
x	Standards Verification Body
Network Rail	Infrastructure Manager

All parties in this list are competent and responsible for contributing to the CSM-RA process appropriate to their role. This may include contribution to the hazard identification process through to addressing or accepting safety requirements.

ACTION 2 - Define the stakeholders and their roles and responsibilities with regard to Approvals Activities.

3 APPROVALS CONTEXT / ASSURANCE FRAMEWORK

In this section the assurance requirements will be outlined at a high level followed by the strategy necessary for addressing them in subsequent sections.

3.1 ROGS

The Operator will need to implement its engineering change process in line with its SMS. Details are not captured in this Strategy.

3.2 CSM-RA

A CSM-RA will need to be applied to the project. A Significance Decision will need to be made and documented. The application of CSM-RA will depend on the outcome of the significance decision.

If it is not significant, risk assessment is still required and the CSM-RA process is recommended as this is known and familiar to all stakeholders in the industry. Independent review is not required.

If it is significant, the regulations must be applied in full, including independent review by an Assessment Body.

ACTION 3 - Complete the CSM-RA Significance Decision

For the purpose of writing this strategy it has been assumed that the change will be significant (due to the novelty of the fuel type).

3.3 Network Rail – Product Acceptance & Design for Reliability

Not applicable to this project.

3.4 Compatibility

The project will establish compatibility between the modified locomotive and the network on which it will run.

The project will apply "RIS-8270-RST Issue 1.1 Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure". Areas of particular note for this vehicle will include:

- **Gauging** this is expected to be unchanged, however, ride and dynamics will need to be checked due to the change in weight
- **EMC** compatibility with lineside systems due to changes in electrical profile

All other compatibility interfaces are to be checked.

The compatibility assessment will be documented.

Once more details are available, it will be possible to establish if consultation and notification will be needed or not. The modification may be sufficiently minor (with regard to compatibility) that further consultation and notification to affected parties

will not be necessary. However, for the purposes of this concept approvals strategy, it should be assumed that consultation will be needed.

3.5 Interoperability

The UK Railway Interoperability Regulations – RIR 2011 (as amended) requires that:

"Requirement for authorisation

4.(1) No person is to put into use any structural subsystem unless—

(a) the Safety Authority has given an authorisation under these Regulations for the placing in service of that subsystem;

(b) the Competent Authority has decided under regulation 13 that for the upgrading or renewal of the subsystem, an authorisation is not required for the subsystem to be put into use;….

"renewal" means any major substitution work on a subsystem or part subsystem which does not change the overall performance of the subsystem; and cognate words shall be construed accordingly;

"upgrading" means any major modification work on a subsystem or part of a subsystem which improves the overall performance of the subsystem; and cognate words shall be construed accordingly;

In this context sub-system means 'rolling stock'.

It is the view of the project that the proposed modifications do not lead to 'major' performance changes at the subsystem level. The rolling stock, traction, braking and speed profiles will be unchanged by this modification. Although an additional power supply is being installed this does not trigger the criteria. Therefore RIR does not apply to this project, Authorisation is not required.

3.6 Standards Compliance

As the modification does not require re-authorisation in accordance with RIR, then the verification process set out in RIS-2700-RST Issue 2, 'Rail Industry Standard for Verification of Conformity of Engineering Change to Rail Vehicles' ([Ref 2]) needs to be applied. In this standard, the appropriate level of verification is defined by the proposer of the change, in this case G-Volution, in accordance with their SMS requirements for Engineering Changes.

AEGIS has completed an assessment of the modification and have determined that 3rd party attestation will be required, to support its engineering change pack and change process.

The independent third party assessment will need to be undertaken by a competent Certification / Approved Body.

The standards to be complied with by the project have been captured in Appendix A. This may be added to or adjusted following the hazard identification process. Please refer to the hazard record for the master standards list (this plan may not be updated).

The output of this process will be a Design Conformance attestation statement and for additional assurance the design can be verified by a Build Conformance attestation statement to support testing and service entry.

4 RISK ASSESSMENT AND MANAGEMENT

This section captures the process the project will follow with regard to the application of CSM-RA. This is in the context of oversight and management by a competent assurance specialist – the Hazard Record Manager.

4.1 Competence

Appropriately competent staff will be used to manage the Hazard Record and apply the CSM-RA process.

4.2 Risk Assessment Scope – System Definition

The project will document the project details in a System Definition – as required by CSM-RA. This will form the scope of the hazard identification and risk assessment work.

The System Definition will be sufficient to support the hazard identification process. Detailed records of the final design and build are expected to be recorded in the project Technical File. Please also refer to section 4.7 for a note on interfaces. The level of detail to be recorded in the system definition regarding interfaces will be at a high level suitable for the use of the system definition to guide the hazard identification process.

If the design changes significantly the System Definition will be updated as necessary.

4.3 Hazard ID

The project will undertake hazard identification activities as necessary to identify all reasonably foreseeable hazards. This is likely to involve at least one full hazard identification workshop, which will be facilitated by an experienced Chair.

The work may be supplemented by desktop review, supplemental studies on specialist topics or additional workshops. The scope of these will be established as the project progresses by the Hazard Record Manager.

The output of the hazard identification process will be a hazard list capturing all the identified hazards. This forms the basis of the hazard record.

4.4 Hazard Record

A hazard record will be created and maintained for the duration of the project. Its contents and process for update will be overseen by the Hazard Record Manager, with updates as necessary to support the project development and phasing. This will include collating information/input from the project stakeholders.

During the 'active' phase of the project the hazard record will be managed on behalf of the proposer by the Hazard Record Manager. At the end of the 'active' phase it will be handed over to the Proposer / Operator for ongoing upkeep and management for the life of the asset.

For this project the active phase is up to handover for Service Stage.

4.5 Risk assessment

All identified hazards will be risk assessed including:

- Application of a risk matrix to categorise risk acceptability
- Identification of measures to manage and reduce the risk

The Hazard Record Manager will lead the application of risk ranking activity to ensure a consistent approach for all entries.

All project stakeholders (assigned entries) will be involved in the process of agreeing risk ranking, identification and implementation of mitigations.

4.5.1 Matrix

The risk matrix used for this project will be recorded in the hazard record. Addressing each hazard individually is considered an appropriate approach to provide an overall acceptable risk for this project.

The matrix includes a 'broadly acceptable' band, and as the limit to apply this band has been set very low, this can be used at an individual hazard level without further consideration of the total risk from broadly acceptable hazards.

For new electronic systems which could lead to a catastrophic or critical accident, a safety requirement will be raised to address the explicit risk estimation requirement for design targets / failure rates.

The risk matrix will be applied to establish the worst-case credible outcome, not necessarily the worst case imaginable. This is to support the project with identification of the most important risks so they can be prioritised.

4.5.2 ALARP / SFAIRP

With the combination of the CSM-RA and Health and Safety at Work Act in the UK the terms ALARP and SFAIRP are considered interchangeable.

The project will establish that all the identified risks have been managed to be tolerable and ALARP. This will be established by:

1. Application of the risk matrix criteria, pre- and post- mitigation
2. Engineering judgement whilst selecting the safety requirements
3. Options selection (documented safety measures) for issues which are less clear cut

The pre-risk ranking for many hazards on a railway project can lead to 'intolerable' risk, yet the mitigations are clear and straight forward, such as the application of a code of practice. Therefore the pre-risk ranking is often of little practical benefit to enable a project to focus its efforts on the most important risks.

The Hazard Record Manager will review each entry, with the project team, and apply judgement to determine which require further investigation, identification of options and options selection. This review will be captured in the ALARP review column in the

hazard record (Y or N). As a result most entries will have safety requirements recorded – sufficient to establish that the risk will be tolerable and ALARP. It is anticipated that only a few entries may have multiple safety measures (options) documented in addition (in advance) of the safety requirements selection.

This approach is considered to be in line with CSM-RA Annex 1, 2.2.2 "To focus the risk assessment efforts upon the most important risks".

4.5.3 Mitigations / Safety Requirements

For each identified hazard, safety requirements will be established to mitigate the risk. As noted in section 4.5.2 safety measures may also be documented for some entries. This will be by exception – proportionate to the level of risk and novelty.

The CSM-RA risk acceptance principles- code of practice, reference system or explicit risk estimation will be identified and recorded for each requirement. If a reference system argument is used, details of the appropriateness/applicability of the reference system will be captured in the hazard record.

Each safety requirement and, therefore, hazard will be closed appropriately for the phase of the project. Appropriate evidence will be recorded in the project library; this may include reference to drawings, reports, photographs, certificates or declarations, again proportionate to the level of risk and novelty.

Assumptions identified during the work will be captured in the hazard record. As the project progresses, they will be reviewed to confirm that they are factually correct for this project, or added to the limitation or application condition list as appropriate. This will be an iterative process, with periodic reviews during the project. Should a material change arise as a result, the hazard identification will be revisited.

4.6 Hazard Ownership and Transfer of Hazards

It is expected that the Modification Designer will remain the owner of all hazards identified until completion of the project and handover of the full hazard record to the operator.

Should any hazards arise which are not the responsibility of the project and need to be handed over, this will be addressed by correspondence with the identified new owner.

Individual safety requirements will be allocated to other project stakeholders as 'owner', they are the responsible party for addressing that requirement. Closure will be addressed by appropriate evidence.

For parties with duty holder / legal responsibilities, such as the Operator, the Hazard Record Manager will confirm understanding with the duty holder and may not request further evidence of closure, as this would be their legal responsibility and covered by industry regulation. For example an Operational Requirements Specification may be drafted to capture the necessary safety requirements relating to operation; a letter/email declaration that the list has been received and accepted would be taken as sufficient for closure, rather than evidence against each individual entry.

4.7 Interfaces

Issues on a project of this nature will generally occur at the interfaces, it is therefore essential that they are effectively managed. They would generally arise from the 'unknown-unknowns', as a result detailed documentation of interfaces will not be documented in this plan or the system definition. Interfaces will be managed as part of the design integration process.

Interfaces on this project will be managed by communication and collaboration between the parties. With regard to safety the primary means is via the hazard identification process.

The key stakeholders will participate together in a combined hazard identification process to foster discussion and exploration of the 'edges', boundaries and interfaces. Which will, in turn, be addressed by safety requirements.

4.8 Safety Report

At key points in the process the Hazard Record Manager will arrange for a safety report(s) to be written, documenting the process followed, any issues arising and points that are likely to be of note to the operator or other stakeholders likely to read it.

The project includes 2 stages which require formal reports, static testing at a depot or similar location, and service entry. The safety case reports will build on the previous report, rather than reporting from first principles.

4.9 Independent Oversight

The CSM-RA significance decision needs to be made. It has been assumed that it will be significant and therefore an Assessment Body (AsBo) will need to be appointed.

ACTION 3 - Complete the CSM-RA Significance Decision

4.10 Output of the CSM-RA process

The output of the CSM-RA process will include:

- Approvals Strategy (this document)
- System Definition
- Significance Decision
- Hazard Record including:
  - Hazard list
  - Safety Requirements Specification
  - Risk assessment
- Safety Report(s)
- Proposer's Declaration
- Safety Assessment Report – produced by the AsBo

5 STAKEHOLDER AGREEMENT WITH THIS PLAN

This Plan will be shared with the affected project stakeholders, namely the owner and operator, and possibly Network Rail, for their agreement. This need not be explicitly documented, however, should any issues arise, the Plan will be updated to achieve consensus.

6 CONCLUSIONS

At this stage of development there are a number of unknowns which require further development. These include:

ACTION 1 - Prepare a System Definition to provide a detailed scope and definition for the project.

ACTION 2 - Define the stakeholders and their roles and responsibilities with regard to Approvals Activities.

ACTION 3 - Complete the CSM-RA Significance Decision

However, a general process has been outlined in this Approvals Strategy, and when followed the project will effectively and efficiently manage the safety risks arising from the project. The process will also deliver the requirements of CSM-RA.

An approximate budget to deliver the activities noted in this Approvals Strategy is provided in Appendix B.

7 REFERENCES

[Ref 1] Project Programme (live document) to be written

[Ref 2] RIS-2700-RST Issue 2 Rail Industry Standard for Verification of Conformity of Engineering Change to Rail Vehicles

[Ref 3] Commission Implementing Regulation (EU) 402/2013 on the common safety method for risk evaluation and assessment, as amended by the Rail Safety (Amendment etc.) (EU Exit) Regulations 2019 [S.I. 2019/837] (as amended by the Railways (Safety, Access, Management and Interoperability) (Miscellaneous Amendments and Transitional Provision) (EU Exit) Regulations 2019 [S.I. 2019/1310])

8 ABBREVIATIONS

Term	Description
ALARP	As Low As Reasonably Practicable
AsBo	Assessment Body
CSM-RA	Common Safety Method For Risk Evaluation And Assessment 402/2013 (as amended)
EMC	Electromagnetic Compatibility
LPG	Liquid petrolium gas
ORR	Office of Road and Rail
RIR	The Railways (Interoperability) Regulations 2011 (as ammended)
RIS	Rail Industry Standard
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) (as ammended)
RSSB	Rail Safety and Standards Board
SFAIRP	So Far As Is Reasonably Practicable
SMS	Safety Management System

APPENDIX A STANDARDS LIST

The table below shows the list of proposed standards to be subject to conformance verification in accordance with RIS-2700-RST.

This may be added to or adjusted following the hazard identification process. Please refer to the hazard record for the master standards list (this plan may not be updated).

Standard	Issue	Title
BS EN 45545-7	2013	Railway applications. Fire protection on railway vehicles. Fire safety requirements for flammable liquid and flammable gas installations
BS EN 50121-3-2	2016+A1: 2019	Railway applications - Electromagnetic compatibility Part 3-2: Rolling stock - Apparatus
BS EN 50153	2014+A1: 2017	Railway applications. Rolling stock. Protective provisions relating to electrical hazards
BS EN 50343	2014+A1:2017	Railway applications - Rolling stock - Rules for installation of cabling
EN 45545-2	2020	Railway applications — Fire protection on railway vehicles Part 2: Requirements for fire behaviour of materials and components
GE/RT8006	3	Assessment of Compatibility of Rail Vehicle Weights and Underline Bridges
GE/RT8073	4.1	Requirements for the Application of Standard Vehicle Gauges
GM/RT 2142	4.1	Resistance of Railway Vehicles to Roll-Over in Gales
GM/RT 2161	2	Requirements for Driving Cabs of Railway Vehicles
GM/RT2045	4	Braking Principles for Rail Vehicles
GM/RT2100	6.2	Requirements for Rail Vehicle Structures
GM/RT2130	5.1	Vehicle Fire, Safety and Evacuation
GM/RT2141	4.1	Permissible Track Forces and Resistance to Derailment and Roll-Over of Railway Vehicles
GMRT2173	4	Requirements for the Size of Vehicles and Position of Equipment
RIS-2004-RST	1	Rail Vehicle Maintenance
RIS-2780-RST	1.1	Rail Vehicle Structures Sections 2.1 & 2.2.
RIS-8270-RST	1.1	Assessment of Route Compatibility of Vehicles and Infrastructure
RIS-8273-RST	1	Assessment of Compatibility of Rolling Stock and Infrastructure - Gauging and Stepping Distances

Standard	Issue	Title
UKLPG COP 11	Jun 2001+ A1 2003	Autogas fuel systems for light and heavy duty vehicles (Note that this is not an approved code of practice, and may not be sufficient, on its own, to demonstrate legal compliance.)
UKLPG COP 22	Aug2011+ A1 2012	Design, Installation and Testing of LPG Piping Systems (August 2011) (Note that this is not an approved code of practice, and may not be sufficient, on its own, to demonstrate legal compliance.)
Legislation		Legislation – applicability will be subject to the final design details, and could include: Pressure Systems Safety Regulations 2000. Pressure Equipment Regulations 1999 Pressure Equipment (Safety) Regulations 2016 The Simple Pressure Vessels (Safety) Regulations 2016

APPENDIX B BUDGET

The following table provides an approximate budget for the work packages described in this strategy.

Price element	Budget	Notes
CSM-RA	£60,000	Does not include assessment of any fire alarm/suppression system and assumes no safety critical software.
ASBO	£28,000	Significant change
Compatibility	£15,000	Assuming fuel cell is EN 50121-3-2 compliant
Design Assurance (Standards Compliance)	£40,000	Based on assessment of evidence provided by G-volution to support clause by clause statements for the standards identified. We will provide guidance on the evidence required.
RIS2700 Certification	£32,000	Based on the standards identified
Total	£175,000	

Please note that these are approximate budgets only based on the information received, the assumptions stated in this draft approvals strategy and engineering judgement for the open points. This does not form a proposal for acceptance.