



## Background

The Very Light Rail Regional Programme (VLRPP) consists of 3 discrete projects, which were put forward to WMCA and DfT in an overarching Strategic Outline Business Case, as requested by DfT, as follows:

- Coventry Very Light Rail (CVLR) scheme promoted by Coventry City Council (CCC) (£40.5m)
- Dudley Very Light Rail National Innovation Centre (VLRNIC) promoted by the Black Country Innovative Manufacturing Organisation (BCIMO) and Dudley Council (£12m allocation with £1.2m released through SOBC)
- Mass Transit Options Appraisal study which is to include an assessment of urban VLR promoted by Transport for West Midlands (TfWM) (£5m allocation with £600k released through SOBC)

The three projects complement each other as follows:

- CVLR is the pilot scheme, with Coventry leading the development of the VLR product (CVLR Vehicle and CVLR Track) and facilitating the construction of the first in-highway section of CVLR track as the final demonstration of the proof of concept for the system.
- VLRNIC is supporting the CVLR R&D (Research & Development) programme by providing test facilities for the system before the installation in a live highway.
- TfWM are in the early stages of exploring the use of CVLR technology (as well as other mass transit options) for corridors in the West Midlands

## Recommendation for Independent Review Panel

During the assessment of the Strategic Outline Business Case for CVLR and VLRNIC, the Department for Transport (DfT) recommended that they should be considered as Research and Development (R&D) projects, rather than standard capital infrastructure projects. DfT advised that, given the R&D nature of the projects and the value of the projects, an Independent Review Panel (IRP) be established to bolster assurance.

## Integrating an IRP into SAF for CVLR and VLRNIC

As DfT advised that the projects should be treated as R&D, in practical terms, this meant that instead of following the standard Green Book 5 case model approach for CVLR and VLRNIC, they should be treated as a stage gated development process with specific target milestones which must be met to allow progression and release the various agreed tranches of funding.

The DfT have now agreed mechanisms for handling the approvals of CVLR and VLRNIC with stages, which

include the requirement for an IRP to assess work undertaken between each stage to determine whether the projects are commercially and technically sound and to then make recommendations to decision makers on whether to proceed. The CVLR Stage Gates agreed with DfT are contained in Appendix 1.

In order to ensure that an IRP could be reasonably aligned with and integrated into the existing governance arrangements a proposal has been developed by WMCA Programme Assurance and Appraisal, TfWM Programme Development teams and CRSTS Programme Team:

- Individual business cases will still follow the WMCA's SAF process
- Stage Gate reviews will be conducted by an internal TfWM panel prior to submitting a report with a recommendation to WMCA decision makers.
- For CVLR there are Stage Gate within the SOBC phase that require IRP involvement. The first is prior to the release of funding for the construction of the City Centre Demonstrator. The second is post construction and prior to release of funding for Outline Business Case compilation.
- For VLRNIC the IRP will review the commercial business plan and FBC prior to submission to SAF.

## Further Information

There is currently a cabinet report being produced by the Programme Director for VLR for review and consideration of the CCC cabinet updating them on the changes to the CVLR project including the governance changes detailed above. Coventry City Council submitted a CVLR change request capturing this approach and setting out the various stage gates and the finances associated with each. This was approved by WMCA's DSO on 22<sup>nd</sup> April.

## Summary

This report is to brief senior offices on the intended governance structure for the CVLR and VLRNIC projects and explain how they integrate with WMCA's SAF process. The report also confirms the projects will continue to be aligned with WMCA SAF. WMCA is the Accountable Body for delivery of CRSTS 1 programme. The IRP can make recommendations to the project team which can be shared with WMCA officers. However, decision making on business case approvals will continue to be considered by the appropriate level of WMCA Governance.

Appended:

Appendix 1 – CVLR Stage Gates

Appendix 2 – SAF/ IRP Process explained in 3 diagrams:

Diagram 1 – how the IRP will integrate with SAF

Diagram 2 - how the CVLR stage gates will be reviewed by the CVLR IRP and WMCA as the project goes through each business case Stage Gate

Diagram 3 – how VLRNIC FBC will be reviewed by the DMBC IRP and WMCA prior to FBC funding release.

# CVLR Stage Gates (WMCA /DfT Version)

8<sup>th</sup> May 2024

**Evidence highlighted in red will be subject to Independent Panel Review**

Stage Gate Description and outcome	Documentation required to release funding and when documentation can be submitted	Outputs from phase once Funding released	Evidence of output Pass/ fail	Requirement from WMCA, DfT and / or Independent Review Panel at end of Stage Gate	Funding Required and Status
<p><b>1a CVLR</b> Vehicle and Track Testing, Route Design and stage 1 preliminary traffic management works implemented.</p> <p>Outcome: Performance tested vehicle with an appropriate safety case and gap analysis that demonstrates the vehicle can be adapted for City Centre Operation</p> <p>Performance tested track with no visual cracking and CCC Director for Highways sign off for next stage</p> <p>A viable route with sufficient evidence (from surveys and utilities) that</p>	<p>WMCA SOBC submitted by CCC/TfWM DfT SOBC submitted by CCC/TfWM DfT Proforma completed by CCC/TfWM DfT Below the Line Paper to Investment Portfolio Decision Committee (IPDC)</p> <p><b>Above documentation has been submitted</b></p>	<ol style="list-style-type: none"> <li>1. Installation of 3 Track Test Sites (WMG, Whitley Depot and Dudley Loop)</li> <li>2. Evidence from vehicle and track testing, including gap analysis for the vehicle and latest safety case assessment</li> <li>3. Design and partial implementation of the City Centre Traffic Management Plan</li> <li>4. Design for City Demonstrator Route from Rail Station to Former Ikea Building (800m)</li> <li>5. Concept design for CVLR route 1 from Rail Station to University Hospital</li> <li>6. Baseline accident data on the City Demo route across all modes.</li> <li>7. Baseline air quality exhaust and non-exhaust emissions data of the City Demo route.</li> <li>8. Evidence illustrating Coventry's understanding of the regulatory regime to implement the CVLR City Demo route</li> <li>9. Evidence of potential market for CVLR</li> <li>10. Baseline data indicating local travel attitudes to public transport</li> </ol>	<p>Evidence for WMCA:</p> <ol style="list-style-type: none"> <li>1. Photos</li> <li>2. Report on FATS/ SATS evidence for vehicle testing and gap analysis evidenced by the Hazard records. Case for safety consultants engaged working towards City Demonstrator compliance. HV system &amp; battery commissioned by competent persons. Evidence from Whitley Test Track that the track is performing as expected under loadings (see Appendix 1)</li> <li>3. Design drawings and photos</li> <li>4. Design drawings</li> <li>5. Design drawings</li> <li>6. Baseline data report</li> <li>7. Baseline data report</li> <li>8. Planning Process Report</li> <li>9. WMG Report/ Soft Market testing report and Spreadsheet detailing interested parties</li> <li>10. Baseline data report</li> </ol> <p>Evidence for DfT: Assurance from WMCA that the evidence of outputs in Stage Gate 1a has been fully assessed to meet their requirements and recommendation from the SRO to progress to the next stage gate as set out in the report summarising findings from review of evidence.</p>	<p>WMCA assurance team required to assess evidence of outputs in Stage Gate 1a and recommend or otherwise progression to next stage gate to DfT via a report summarising findings from review of evidence. Report to be submitted alongside a Consideration Paper and an updated VLRRP DfT Innovation Proforma</p> <p>DfT to submit Consideration Paper to IPDC to propose the process, stage gates and governance arrangements for the VLRRP programme.</p>	<p><b>£8.9m (original value)</b></p> <p>£6.4m released on 18.4.23</p> <p>£2.5m released at IPDC on 3<sup>rd</sup> July 2023</p> <p>Change Control approved by WMCA DSO on 22<sup>nd</sup> April 2024 for final cost for Stage Gate 1 of <b>£7.9m</b></p>

enables CCC Director for Highways sign off for next stage			<p>Updated proforma (signed off by WMCA) with a CA report that summarises:</p> <ol style="list-style-type: none"> <li>11. Key learnings (and where learnings have been published) and risks from deliverables in Stage 1a (including CCTMP)</li> <li>12. High Level Risk Register and Mitigations</li> <li>13. Latest Case for Safety for Vehicle and Track and recommendations for Stage 2a</li> <li>14. Independently verified cost estimate for City Demonstrator Construction that confirms City Demonstrator can be delivered within funding envelope.</li> <li>15. Report outlining work to be undertaken in phase 2a to develop Commercialisation Strategy</li> </ol>		
<p><b>2a. CVLR</b> Continued Vehicle and Track Testing, City Centre Demo pre-construction preparation, procurement of long lead items and completion of preliminary traffic management works.</p>	<p>Report documenting outputs from CVLR Stage 1a which contains evidence of outputs from Stage 1a as appendices.</p>	<p>Items in red to be reviewed by IRP</p> <ol style="list-style-type: none"> <li>1. Priced schedule for construction of City Demo Route</li> <li>2. Track performance data from Whitley (from embedded telemetry)</li> <li>3. Noise and vibration data from Vehicle Testing on Dudley Test Track (from embedded telemetry)</li> <li>4. Programme outlining works to provide a Gen 1.5 vehicle that is</li> </ol>	<p>Evidence for WMCA (items in red to be reviewed by IRP)</p> <ol style="list-style-type: none"> <li>1. Priced schedule with market evaluation for City Demo construction demonstrating it can be delivered within cost estimate for Stage 3a</li> <li>2. Whitley and Dudley Data as detailed in Appendix 1</li> <li>3. Dudley Data as detailed in Appendix 1</li> <li>4. Draft Case for Safety in place for City Centre vehicle operation. Vehicle delivery</li> </ol>	<p>IRP to examine technical evidence, assess the Case for Safety, cost forecasts, programme and risk, before Stage Gate 3a is authorised. In order to meet the stage gate requirement, the IRP will determine if specific technical parameters (Set by CVLR Delivery Team – appendix 1) have been</p>	<p><b>£6.1m (Original value)</b></p> <p>Approved – IPDC 11<sup>th</sup> Dec</p> <p>WMCA DSO approved Change Control 22<sup>nd</sup> April 2024 to reprofile Stage Gate 2 to</p>

<p>Outcome: Track ready to be installed on a fully designed route and a vehicle ready to be operated on the route once installed, within the cost envelope agreed for stage 3.</p>	<p><b>Documentation can be submitted in +3 months<sup>1</sup></b></p> <p><b>VLRRP DfT Proforma – to be updated and submitted</b></p>	<p>fit for City Demo operation<sup>2</sup> supported by ICP</p> <ol style="list-style-type: none"> <li>5. A plan for the development of a Safety Management System (for City Demonstrator) and initial Road Safety Audits completed, with integration of Safety Requirements into the Case for Safety.</li> <li>6. Operator appointment strategy and scope of works defined with provisional costing supported by external organisation providing operational support.</li> <li>7. Evidence of engagement discussions and agreements in principle with utilities (C3's &amp; where provided C4s) in respect of required changes being deliverable within £2m/km average allowance</li> <li>8. Council approvals in place to authorise City Demo construction</li> <li>9. Implementation of the City Centre Traffic Management Plan that are not integrated with the CCD construction.</li> <li>10. Long lead items (slab and rail) procurement strategy with evidence of viability and cost from market</li> <li>11. WMCA approval to proceed</li> </ol>	<p>strategy and programme for engineering works.</p> <ol style="list-style-type: none"> <li>5. Draft integrated case for Safety for system implementation</li> <li>6. Operator scope of works incl. concept of operations document &amp; outline cost estimate to operate CCD</li> <li>7. Utility status updates, C3's, C4s Engineering counter arguments to challenge diversionary activity and alternative mitigation proposals.</li> <li>8. Highways, planning and Council consents</li> <li>9. Photos</li> <li>10. Evidence of industry support for the viability of procurement and price</li> <li>11. WMCA report</li> </ol> <p>Additional evidence for DfT: Assurance from WMCA and the IRP that the evidence of outputs in Stage Gate 2a has been fully assessed to meet their requirements and recommendation from the SRO to progress to the next stage gate as set out in the report summarising findings from the review of evidence.</p>	<p>met, the Case for Safety is robust and confirm the programme is on target to meet its objectives, within the CRSTS allocated funding envelope.</p> <p>IRP specialists to set out recommendations in a report. WMCA to submit summary report and recommendations to DfT</p> <p>DfT governance (Roads Investment Committee) to determine whether allocated Stage Gate 3a funding to be released. Date tbc – anticipated Sept. 24</p>	<p>deliver outputs listed at a cost of <b>£8.3m (incl. contingency of £1.5m)</b></p>
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<sup>1</sup> Indication of time it will take to submit documentation once process / stage gates have been agreed

<sup>2</sup> Gen 1 vehicle was designed to be tested in an offline environment. The vehicle requires modifications to ensure it is fit for purpose for the City Demo operation under manual driver operation. This vehicle will be known as Gen 1.5.

			<p>Updated proforma (signed off by WMCA) with a CA report that summarises:</p> <ul style="list-style-type: none"> <li>• Independent assurance report from WMCA appointed panel</li> <li>• Key learnings (and where learnings have been published) and risks from deliverables in Stage 2a (including CCTMP)</li> <li>• High Level Risk Register including Mitigations.</li> <li>• Outline steps to finalise Draft Cases for Safety for Vehicle and integrated system for operation in Stage 3a</li> <li>• Priced schedule following procurement of City Centre Demo construction partner (demonstrating City Demonstrator can be built within cost envelope for 3a) and long lead items can be procured to support programme. Outline Cost estimate for Operations and Maintenance of City Centre Demo for 12 months.</li> <li>• Draft commercialisation strategy and outline of steps to be taken in phase 3a to finalise commercial strategy.</li> </ul>		
<p><b>3a.CVLR</b> City Centre Demo construction and commissioning, including attitudinal research. Costs</p>	<p>Report documenting outputs from Stage 2 which contains evidence of outputs from Stage 2 as appendices.</p>	<ol style="list-style-type: none"> <li>1. Evidence that construction and utilities costs were within budget</li> <li>2. Initial testing and trialling evidence from commissioning of constructed system. evidence of accident data from City Demo</li> </ol>	<p>Evidence for WMCA:</p> <ol style="list-style-type: none"> <li>1. Construction cost evidence (invoices) and cost forecast illustrating how construction costs in future could be reduced (economies of scale)</li> </ol>	<p>IRP to examine technical evidence, assess the Case for Safety, cost forecasts, programme and risk, before Stage Gate 3a is authorised. In order</p>	<p><b>£11.4m (original value)</b></p> <p>Funding requirement increased to</p>

<p>validation for next stages.</p> <p>Outcome: An operational City Centre Demonstrator of CVLR technology, with costs and time to construct data available, to showcase the benefits of urban VLR mass transit to interested parties.</p> <p>The City Demonstrator will enable the commercialisation strategy to be implemented.</p>	<p><b>Documentation can be submitted in +15 months</b></p> <p><b>VLRRP DfT Proforma – to be updated and submitted</b></p>	<p>route compared with the baseline across all modes.</p> <ol style="list-style-type: none"> <li>3. Evidence of air quality exhaust and non-exhaust emissions from City Demo route. Data captured and compared with baseline data.</li> <li>4. Evidence of engaging with the public during demonstrator construction and commissioning to understand their views on vehicle appearance and installation process.</li> <li>5. Initial indication whether CVLR would encourage model shift from cars</li> <li>6. Update of a report comparing CVLR with guided mass transit systems i.e. Light Rail and BRT.</li> <li>7. City Centre Segregated cycleway</li> <li>8. Central Six Link Rd (aka Western Link Rd)</li> <li>9. City Centre Demonstrator Insurance</li> <li>10. Operations and Maintenance contract</li> <li>11. Evidence of achieving necessary consents to construct and operate City Centre Demonstrator</li> </ol>	<ol style="list-style-type: none"> <li>2. Data from City Demo construction and commissioning (quantitative assessment criteria TBC)</li> <li>3. Report</li> <li>4. Report</li> <li>5. Survey data/ Report</li> <li>6. Report</li> <li>7. Photos and usage data</li> <li>8. Photos and usage data</li> <li>9. Insurance document</li> <li>10. O&amp;M Contract</li> <li>11. Report detailing Consents required and achieved</li> </ol> <p>Additional evidence for DfT: Assurance from WMCA and the IRP that the evidence of outputs in Stage Gate 3a has been fully assessed to meet their requirements and recommendation from the SRO to progress to the next stage gate as set out in the report summarising findings from review of evidence.</p> <p>Updated proforma (signed off by WMCA) with a CA report summarising the following:</p> <ul style="list-style-type: none"> <li>• Independent assurance report from WMCA appointed panel</li> <li>• Key learnings (and where learnings have been published) and risks from deliverables in Stage 3a</li> <li>• High Level Risk Register including Mitigations</li> </ul>	<p>to meet the stage gate requirement, the IRP will determine if specific technical parameters (Set by CVLR Delivery Team – appendix 1) have been met, the Case for Safety is robust and confirm the programme is on target to meet its objectives, within the CRSTS allocated funding envelope.</p> <p>IRP specialists to set out recommendations in a report. WMCA to submit summary report and recommendations to DfT.</p> <p>DfT governance to determine whether allocated Stage Gate 4 funding to be released.</p>	<p><b>£16.5m (incl. contingency of £1.8m)</b> approved via WMCA DSO Change Control on 22<sup>nd</sup> April 24</p> <p>Subject to DfT's RIC Approval (Date tbc)</p>
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			<ul style="list-style-type: none"> <li>• Operational Case for Safety for Vehicle and Track and integrated system</li> <li>• Final costs of City Demo construction</li> <li>• Forecast costs for a First Route construction in Coventry</li> <li>• Commercialisation Strategy</li> </ul> <ol style="list-style-type: none"> <li>6. Data from City Demo operation (quantitative assessment criteria tbc)</li> <li>7. Report</li> <li>8. Report</li> <li>9. Survey data</li> <li>10. Report</li> <li>11. Updated Strategic Case</li> </ol>		
<p><b>4. VLRRP</b> Business case development for Line 1 commercial service. CVLR Vehicle and Track design for manufacture, investor exploitation and technology roadmap to commercialisation</p>	<p>Report documenting combined outputs from all stage gates above which contains evidence of outputs as appendices.</p> <p><b>Documentation can be submitted in +24 months</b></p> <p><b>VLRRP DfT Proforma – to be updated and submitted</b></p>	<ol style="list-style-type: none"> <li>1. Production of OBC for the Line 1 route (subject to outcome from CVLR Route 1, City Centre Demonstrator and TfWM Mass Transit optioneering work), comparing different modes (including LRT and BRT), using real data from a live environment about CVLR. The objective of this report would be to satisfy the DfT that CVLR, along with other modes, can go forward to assessment in the OBC for the Line 1 route.</li> <li>2. Gen 2 Design strategy for Manufacture of CVLR Vehicle</li> <li>3. Design and Manufacture process documented for CVLR Track</li> </ol>	<ol style="list-style-type: none"> <li>1. OBC</li> <li>2. CVLR Vehicle future design strategy</li> <li>3. CVLR Track Design and Manufacture process report</li> <li>4. O&amp;M Strategy</li> <li>5. Report detailing further R&amp;D requirements</li> <li>6. CVLR CCD Testing data</li> <li>7. Accident data</li> <li>8. Air quality data</li> <li>9. Survey data</li> <li>10. Survey data</li> <li>11. Updated Staregic case for CVLR</li> </ol>		<p><b>£8.5m</b></p> <p>Yet to be approved</p>

		<ol style="list-style-type: none"> <li>4. Operation and Maintenance Strategy for Route 1</li> <li>5. Further R&amp;D work packages defined following City Demo trials</li> <li>6. Evidence from testing and trialling the elements in a live environment.</li> <li>7. Evidence of accident data from City Demo route compared with the baseline across all modes.</li> <li>8. Evidence of air quality exhaust and non-exhaust emissions from City Demo route. Data captured and compared with baseline data.</li> <li>9. Evidence of engaging with the public during demonstrator trials to understand their views on ride quality and vehicle appearance.</li> <li>10. Evidence indicating whether CVLR would encourage modal shift from cars</li> <li>11. Update of Strategic Case for CVLR innovation to account for any changes as a result of the innovation (led by BCIMO VLRNIC and TfWM Track R&amp;D) and any external changes, e.g. new legislation.</li> </ol>			
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**Date Metrics from Track Test Sites:**

**Objective:** The CVLR trackform is reliable and safe – that it technically meets the appropriate safety standards, that it has less impact upon road condition than conventional Light Rail track, and is resilient to loading by road traffic.

WHITLEY Test Track (Stage Gate 1a and 2a) – Quantitative Assessment Criteria:

Sub-system	Details	Quantitative assessment
<p><b>CVLR Slab</b> primary structural element of the CVLR-track system</p>	<p>Comparison of the measured real-world strains imposed by road going vehicles vs FE-modelled and max. permissible strains for UHPC as per standards.</p>	<p>FE Model: Maximum modelled strain under HGV loading was 85.7 <math>\mu\epsilon</math>. Target value for strain measured at TP1 (corrected for thermal loading) to be within +/- 100% of FE modelled values.</p> <p>Measured strains to be &lt; 150 <math>\mu\epsilon</math> (conservative minimum target maximum elastic tensile strain recommended in UHPC standards.)</p>
<p><b>Foundation layer</b> Existing ground at -30cm and buried utilities</p>	<p>Demonstration of significant reduction of pressure load transmission from slab to supporting foundation layer to demonstrate that loading onto any buried utilities will always be less than existing loading.</p>	<p>Pressure load outside of CVLR slab &gt; Pressure load under CVLR slab</p> <p>Pressure under CVLR slab &lt; 30 kPa</p>
<p><b>CVLR track system</b> Foundation, Slab, Rails &amp; Fastening system, pavement</p>	<p>Relative movement between slabs and between slabs and underlying foundation</p>	<p>Movement between slabs and between slab and foundation &lt; 0.5 mm</p>

Dudley Test Track (Stage Gate 2a) - Quantitative Assessment Criteria

Sub-system	Details	Quantitative assessment
<p><b>CVLR Slab</b> primary structural element of the CVLR-track system</p>	<p>Comparison of the measured real-world strains imposed by the CVLR vehicle vs FE-modelled and max. permissible strains for UHPC as per standards.</p>	<p>FE Model: Maximum modelled strain under HGV loading was 52 <math>\mu\epsilon</math>. Target value for strain measured at TP1 (corrected for thermal loading) to be within +/- 60% of FE modelled values.</p> <p>Measured strains to be &lt; 150 <math>\mu\epsilon</math> (conservative minimum target maximum elastic tensile strain recommended in UHPC standards.)</p>
<p><b>Fastening System</b> Mechanical fixing system securing the rail to the Slab.</p>	<p>Replication of the lab-based certification "Repeated load test – BS EN 13146-4:20"</p>	<p>The measured deflection (lateral-slippage) of the rail fastening blocker to be limited to 0.2mm</p>
<p><b>CVLR track system</b> Foundation, Slab, Rails &amp; Fastening system, pavement</p>	<p>Relative movement between slabs and between slabs and underlying foundation</p>	<p>Movement between slabs and between slab and foundation &lt; 0.5 mm</p>
	<p>Vibration transmission</p>	<p>Benchmark study between CVLR track system and standard embedded sleeper urban tram track system. Vibration transmission through the CVLR system to be &lt; 120% of vibration transmission through the standard embedded sleeper urban tram track system.</p>

## **Date Metrics from Vehicle Testing:**

**Objective:** The VLR vehicle is reliable, safe and that it technically meets the vehicle specifications for operation in a live environment.

This will be based on the ORR Guidance for Safety Verification of Tramways and the overarching requirements as detailed within the Railways and Other Guided Transport Regulations (ROGS).

## **CVLR Vehicle Demonstrator – Quantitative Assessment Criteria**

The success criteria for the CVLR vehicle program, for milestone end of Q1 2024, relate to 4 fundamental pathways of the vehicle development program which are currently primary focus.

These pathways relate to:

### **1. Foundation braking system**

Generation 1 of CVLR is defined as being the vehicle as delivered to Coventry City Council in June 2022, in a FAT (factory acceptance tested) and SAT (site acceptance tested) condition by the original OEM.

Testing over recent months has shown that whilst braking performance is generally good and broadly meeting the design intent, the reliability of the proof-of-concept braking system has been generally low, with concerns raised by CCC engineering team in regard to the assurance possibility, for use as city demonstrator, a condition known as Gen 1.5. Said concerns are echoed by the safety consultants and ICP.

#### **Metrics**

- a. A report will be issued relating to the performance, reliability and safety assurance position of the innovative triple system brake by wire system as fitted to the Generation 1 vehicle, with observations, lessons learned and suggested improvements for next stage development, as part of the roadmap to autonomous braking systems, with a view to adopting automotive braking best practise and standards.
- b. The vehicle foundation braking system will be modified in 3 phases, to provide a robust and reliable braking system, providing braking for extended testing, validation and vehicle demonstrations, ultimately leading to a city demonstration capable brake system.

For stagegate 2a, the Phase 1 brake upgrade will be implemented

- i. Design implementation and validation of air over hydraulic foundation brakes, park brake & security brake, with 4 channel redundancy
- ii. Design implementation and validation of power supply redundancy for the electromagnetic track brakes
- iii. Design, implementation and validation of advanced WSP (wheel slip protection) algorithms, to maximise regenerative braking and hence efficiency, whilst providing fastest controlled stop and wheel flat protection.
- iv. Preliminary design, i of safety assured security brake/parking brake. The output metrics of the above works, will be:

Engineering Design information relating to the modification program, e.g, drawings, calculations, Bill of Materials

Brake performance testing, with report outputs measuring:

Vehicle brake performance baseline in respect of the vehicle brake performance to its original design specification

Vehicle brake performance comparison in respect of the requirements as defined in TPG and its referred standards, namely En 13452 part 1.

Report and recommendations of any further works required to achieve City Demonstrator brake performance requirements, or derogation obtained from ICP.

## 2. Vehicle General Safety, running and reliability

Following brake phase 1 upgrade, commence reliability and operability testing – target 500km by Q1 milestone

Metric will be:

Bogie individual wheel load analysis and weigh distribution

Software and driver interface updates to reliable running state, full fitness to run, including formal 1<sup>st</sup> software release

Prepare report on running logs, capturing salient observations – reliability, errors and issues, relevant fixes, wheel wear data capture, battery usage and energy consumption

Engineering change

Records of essential engineering changes to the Gen 1.0 vehicle to satisfy ICP and Safety Body requirements for CVLR operation as GEN1.0

## 3. Upgrade of CVLR Gen1.0 to Gen 1,5, for use as city demonstrator.

The vehicle engineering and test team are key resource in supporting and delivering the vehicle and its respective reporting and governance to the identified Safety Requirements, as defined by System Safety Metrics – vehicle centric.

The metrics for this element are covered by the Safety Case statements.

## 4. Vehicle impact – Wheel and Rail interface

The vehicle project design intent was to have very low wheel and rail wear, and also low noise and vibration, particularly in tight radii alignments.

The metric to be determined at the Q1 milestone, will be to have a target of total 250 passes around the 15m test loop.

Starting with a fresh set of wheels, the wear will be regularly monitored and recorded.

Results will be captured and offered for review by industry experts for future validation against the vehicle dynamic engineering data provided by the OEM engineering teams, and for characterisation of a full life costing software model for rail / wheel interface

### **Data Metrics for System Safety (Infrastructure and Vehicle Integration):**

**Objective:** The primary metric for both the Infrastructure and Vehicle 'Safety Case' will be the number of hazards, their status and the associated Safety Requirements (mitigations).

For the culmination of the **Detailed Design Phase**, 'success' will be the identification of all foreseeable hazards (as bound by the System Definition (i.e. scope of the engineering change)), whereby each hazard has:

- One or more Safety Requirement(s) (mitigation(s)) identified, with a clear definition of the expected evidence to close the hazard (i.e. design drawing, factory acceptance testing, calculation etc);
- Each Safety Requirement clearly denoted as being generated from 'Codes of Practice' (i.e. existing standards, regulations relevant to the Infrastructure / Vehicle) or 'Explicit Risk Estimation' (i.e. for innovations or approaches from different sectors, details of the calculation / modelling that has justified the engineering option);
- The correct status designation of '**mitigation identified / managed**' applied to each hazard, and confirmation with the Independent Competent Person (ICP) that the Safety Requirements are suitable.

For the culmination of the **Construction Phase**, before Placing into Service, 'success' will be the **closure** of all hazards, comprising the evidence based realisation of all associated Safety Requirements, and confirmed via the presentation of the Safety Case to the ICP. Broadly the metrics will be the same as for the Detailed Design Phase, but with the following additions:

- All Safety Requirements will be shown as '**closed**', with objective evidence provided against each. For those that are not fully closed a time bound plan will be developed and presented to the ICP as part of the Safety Case;
- Therefore, all Hazards related to these Safety Requirements will be shown as '**closed**', or similarly if still open, a time bound plan provided for each, and the residual impact of this assessed (i.e. hazards that are tolerable pre-mitigation may be deemed acceptable by the ICP, as long as there are sensible controls in place, before the hazard can be fully 'closed');
- Success Metrics proposed as follows, with the following numbers reflective of the current status (i.e. during Detailed Design Phase but before completion (Final Gen 1.5 Vehicle for City Demonstrator):

<b>Hazards - Status</b>					
Total	Open	Managed	Closed	Transferred	Cancelled
204	194	2	5	0	3

<b>Hazards and Safety requirements</b>				
Total	Hazards with SR	ICP reviewed	Hazards without SR	Hazards with SR TBC
204	170		21	13

<b>Safety Requirements - Acceptance Principles</b>				
Total	Codes of Practice	Explicit Risk Estimation	Reference Systems	N/A or TBC
178	83			95

<b>Safety Requirements - Status</b>			
Total	Open	Evidence Provided	Closed
178	178		



**Generic CVLR Data Metrics:**

Develop a rapid transit solution which can (benchmarks to be determined):

Objective 1: Cost 50% less than equivalent Light Rail systems to develop “half the cost”

Objective 2: Reduce development timeframes compared to equivalent Light Rail systems by 50% “deliver twice as quickly”

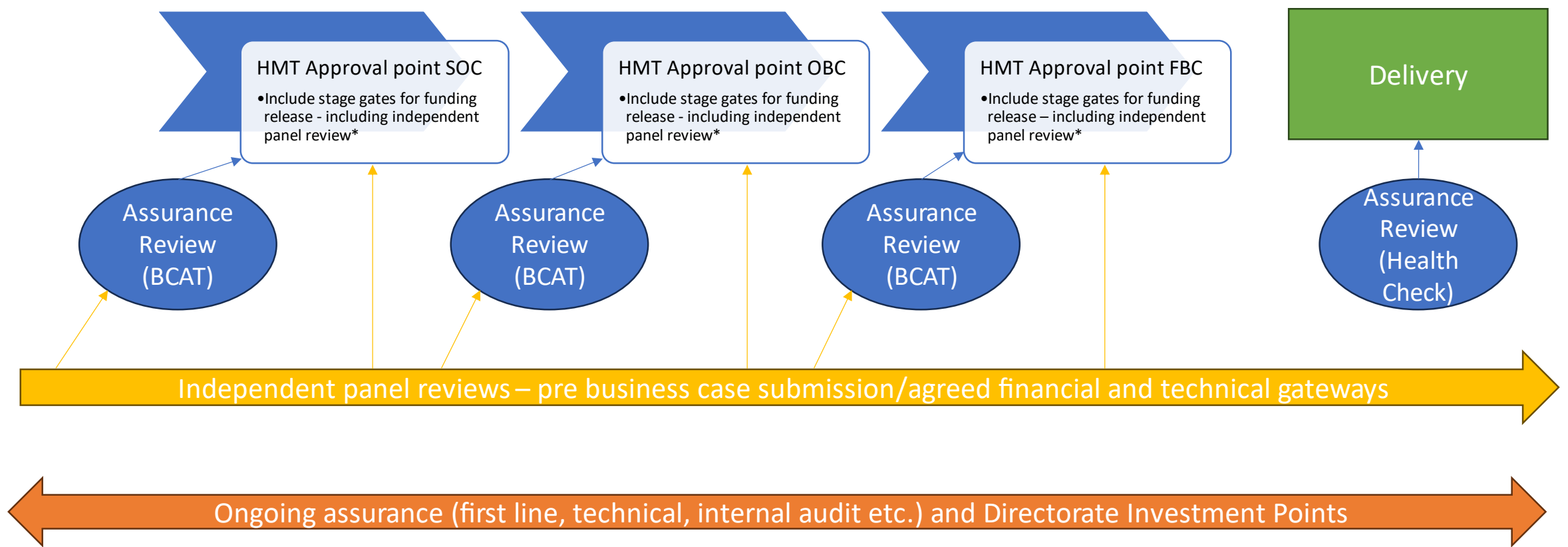
Objective 3: Reduce delivery costs by 50% compared to an equivalent Light Rail system “half the cost”

Objective 4: Reduce delivery timescales by 50% compared to an equivalent Light Rail system “deliver twice as quickly”

Objective 5: Reduce projected operating costs by 33% compared to a Light Rail system “two-thirds of the cost to operate”

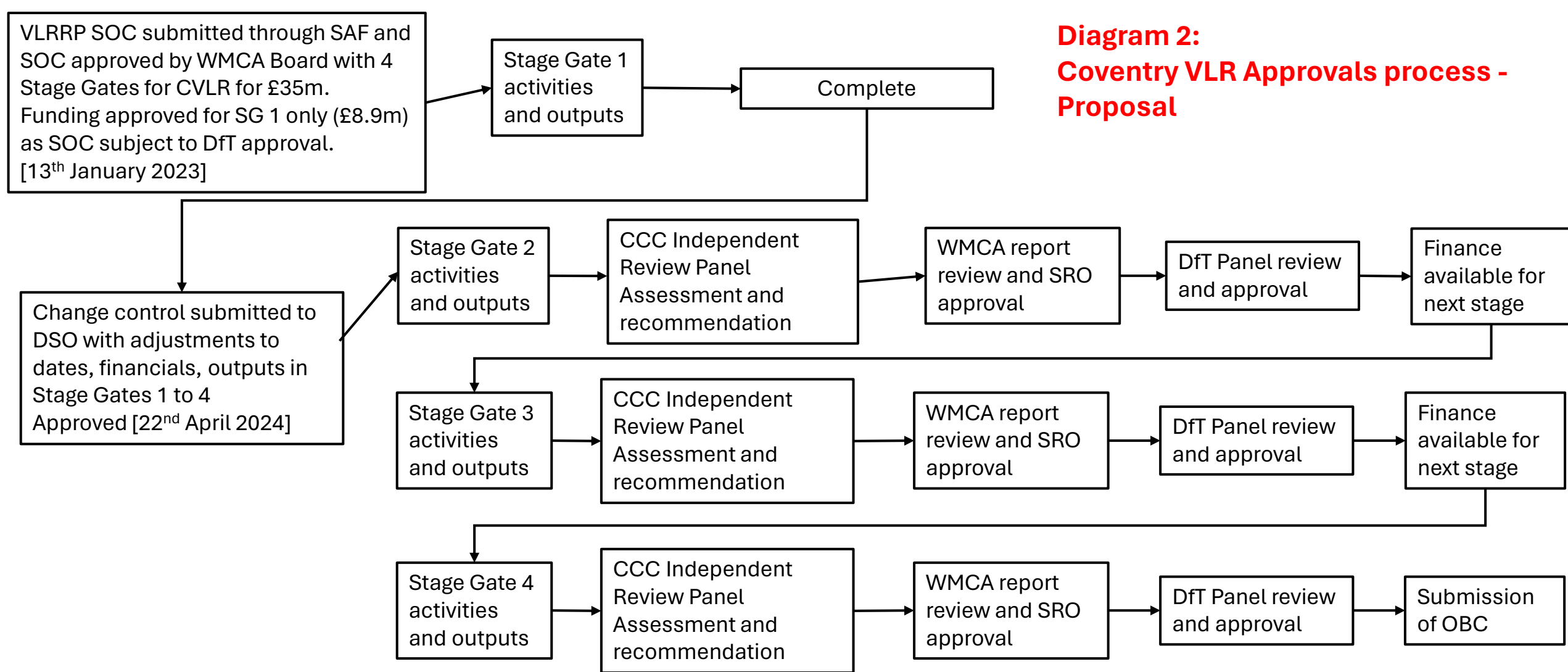
**Diagram 1:**  
**How the IRP will integrate with SAF**

# Workflow for Assurance with independent panel



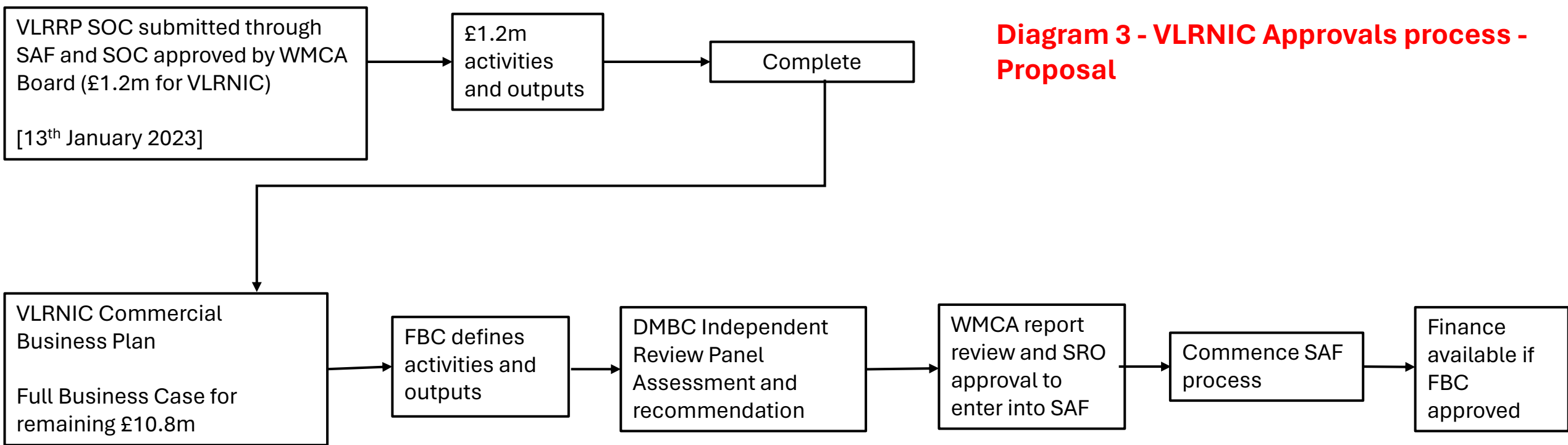
\*See additional appendices for stage gate review detail

**Diagram 2:  
Coventry VLR Approvals process -  
Proposal**



- VLRRP = Very Light Rail Regional Programme
- SOC= Strategic Outline Case
- SAF = Single Assurance Framework
- DfT Panel = Roads Investment Committee

### Diagram 3 - VLRNIC Approvals process - Proposal



\*Subject to identified and available funding