Vehicle Restraint Systems

Herbert Nyamakope (TII)

Eoin Doyle (Arup)

TII Standards Training 2017

Athlone	09th May 2017
Carrick on Shannon	11th May 2017
Cork	16th May 2017
Dublin	18th May 2017

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

VRS – Overview of Changes

VRS – Need for Change

- 2012/2013 – substantial inventory gathering of VRS on the national road network

- Myriad of issues identified

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

VRS – Need for Change

VRS – Need for Change

VRS – Need for Change

- Consultants were tasked with designing VRS for locations identified
- DN-REQ-03034 compliant VRS could only be designed for 30% of the locations
- Remaining 70% would require a risk based approach to design solutions for VRS in **constrained locations**

VRS – Need for Change

- Terminals and Transitions

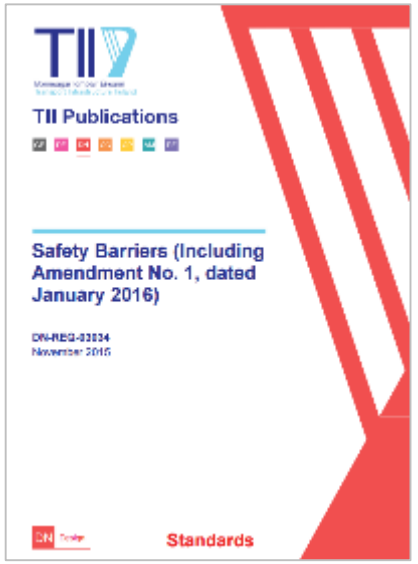
- Issues with historical terminals
- Issues with transitions to bridge parapets
- Not CE Marked products as no harmonised European standards
  - Assessment for compliance?

VRS – Need for Change

Existing standards

DN-REQ-03034 - VRS Design

- When, where, what safety barriers are required
- Hazards definitions
- Mitigation of hazards
- Risk assessments
- Terminals and Transitions



Does not fully address:

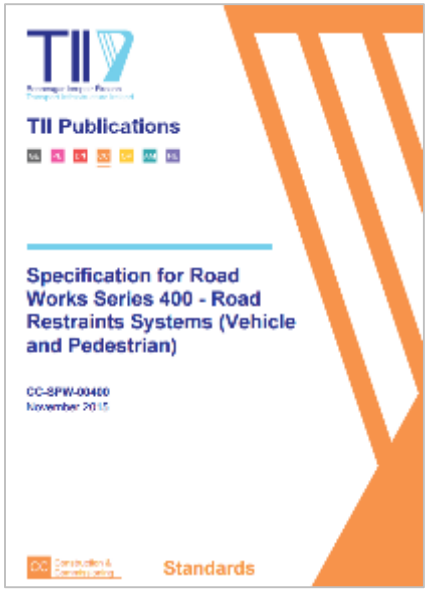
- Designs in constrained locations – e.g. no working width
- Connections to historical bridge parapets
- Other constraints associated with retrofitting to legacy roads

VRS – Need for Change

Existing standards

CC-SPW-00400

- Installation specification
- Written mainly for new installations on new road schemes
- Recent revisions to comply with CPR



Does not fully cover:

- Maintenance/repair issues
- Ground condition testing
- Compliance with manufacturers installation manual

VRS - Need for Change

Main problems:

- Inadequate designs
- Poor installations
- Limitations in standards
- Evident a lack of understanding of proper design and installation of VRS within industry

How do we address these challenges?!

Problem	Action	Status	Comment
Design	VRS Design Course	Ongoing	2 Day VRS Design Course developed - 270 Candidates certified to date
Design	VRS in Constrained Locations	Complete	DN-REQ-03079 Retrofitting VRS on Single Carriageways issued as Interim Technical Advice for industry feedback
Design	Update to Standard	In progress	DN-REQ-03034 currently being updated for publication in Q3 (Safety barriers & parapets)
Design	Terminal and Transitions	Complete	DN-REQ-03080 and 03081 outlining the assessment procedure for terminals and transitions issued, compliant lists being developed
Design	National VRS Consultant	In Progress	Assist LAs in designing, tendering and supervising annual repair /replacement programs
Construction	Update to Specification	In Progress	CC-SPW-00400 currently being updated for publication in September
Construction	Framework for Installers	In Progress	Tenders currently being reviewed – Strict conditions for qualification
Maintenance	Guidance for Repair and Maintenance	In Progress	Currently being finalised for review, publication date to be confirmed
Other	Promote establishment of an industry led VRS association	Complete	IBA established, engaging with TII re standards update and training

VRS – Retrofitting VRS to the Single Carriageway National Road Network

Eoin Doyle (Arup)

VRS Retrofit – DN-REQ-03079

- DN-REQ-03079 issued as Interim Technical Advice in February 2017
- Applicable where site conditions and constraints are such that design compliance with DN-REQ-03034 Safety Barriers is not achievable

VRS Retrofit – Design Process

Does not provide specific design solutions for particular constraints

- Provides a risk based approach to designing at constrained locations
- Provides designers with a defined process to inform their design decisions
- Provides for a consultation and approval procedure with TII
- Includes examples of possible solutions with advantages, disadvantages and limitations of each to assist the designer in developing a solution

Categories of Constraints

- VRS at Constrained Locations;
  - Lack of set back/working width;
  - Installations within the clear zone;
  - Accesses preventing full length of need;
  - Third party considerations;
  - Road junctions i.e. VRS continuing down the side road.

- VRS at structures;

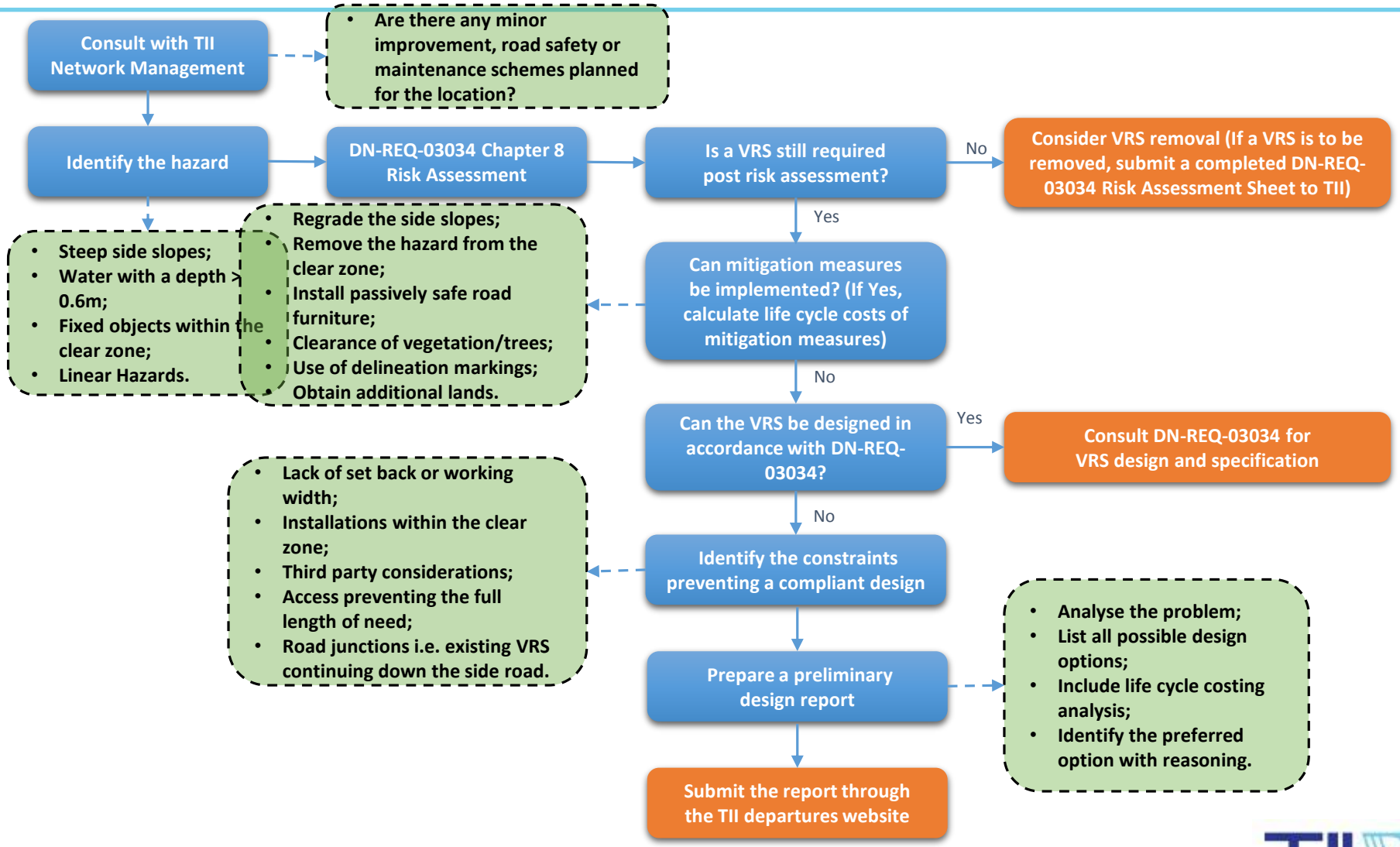
- VRS within urban settings.

Separate design process flowchart for each category

Overview of the Design Process

- Consult with TII to check if any improvement or refurbishment works are planned at the location
- Initial risk assessment to check if a VRS is actually required
- Assess if mitigation measures can be implemented to remove the need for a VRS
- Analyse the site specific constraints that may prohibit a compliant VRS design
- Develop suitable design options identifying the advantages and disadvantages of each.
- Identify the preferred option with appropriate reasoning, including consideration of whole life cycle costs, and
- Submit VRS PDR to TII for approval.

Category A – Constrained Locations



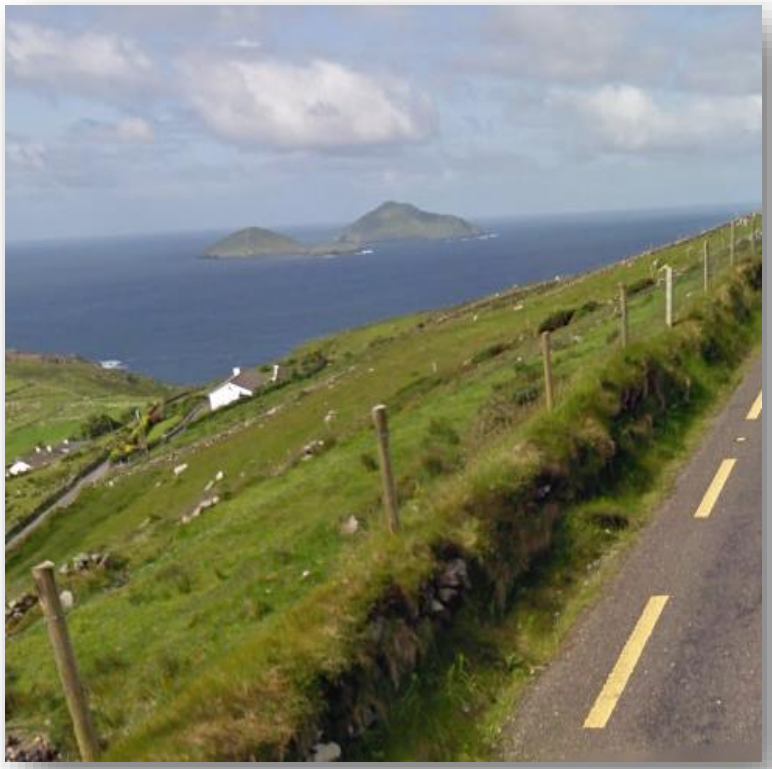
Constrained Location - Worked Example

Consult with TII Network Management

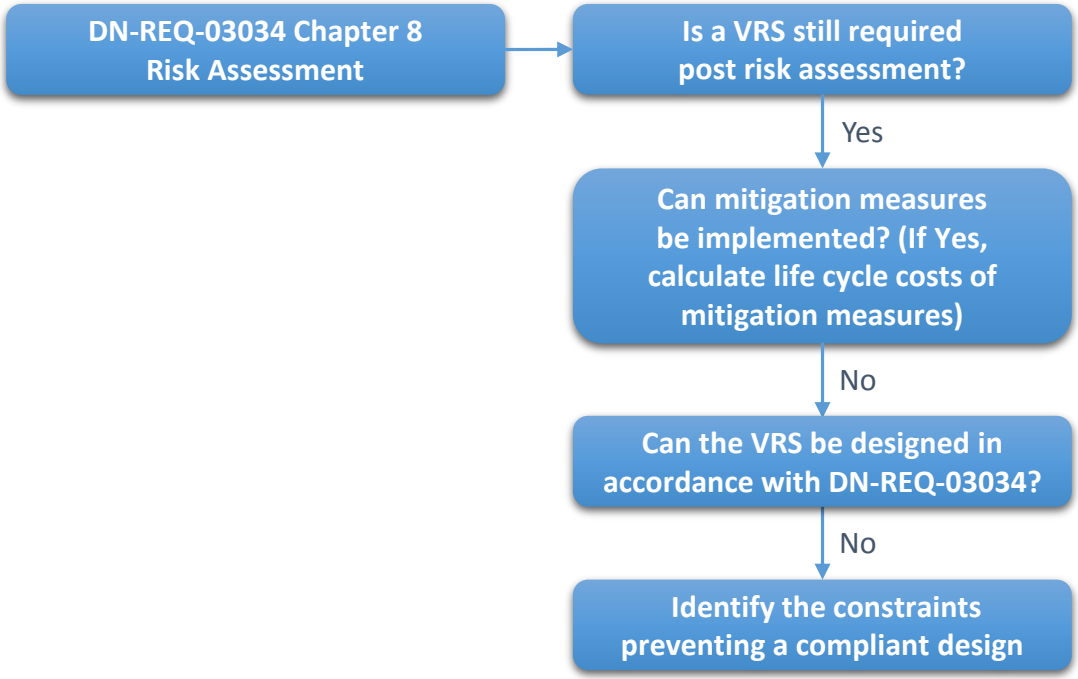
↓

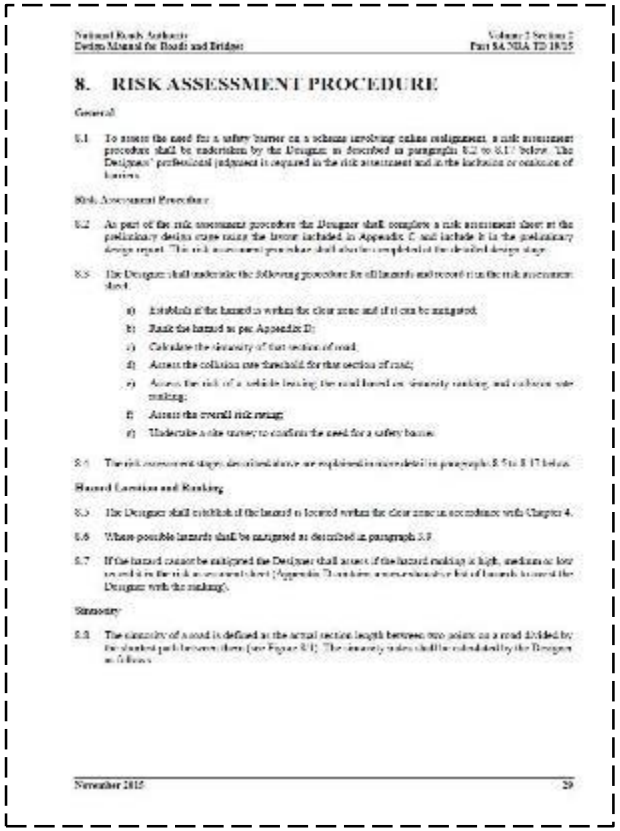
Identify the hazard

- Steep drop to the adjacent land.
- Stone wall within the clear zone.



Constrained Location - Worked Example





8. RISK ASSESSMENT PROCEDURE

- Lack of set back and working width requirements.

Constrained Location - Worked Example

Prepare a preliminary design report

- **Analyse the problem**;

- **List all possible design options**;
  - Install a high containment VRS;
  - Install concrete baseplates;
  - Install delineation;
  - Bespoke option.

Constrained Location - Worked Example

- **Identify the preferred option:**
  - Construct a dedicated pull in area;
  - Construct a reinforced masonry clad concrete wall;
  - Construct a high containment kerb;
  - Install edge delineation markers;
  - Renew road markings and install new signs.

- **Reasoning**:
  - Mitigation is not practical
  - It is an area of natural beauty which an aluminium VRS would detract from.

Submit the report through the TII departures website

Category B - Structures

- Exposed parapet ends are a hazard
- Parapets have no/unknown containment;
- No transition between the safety barrier and the parapet

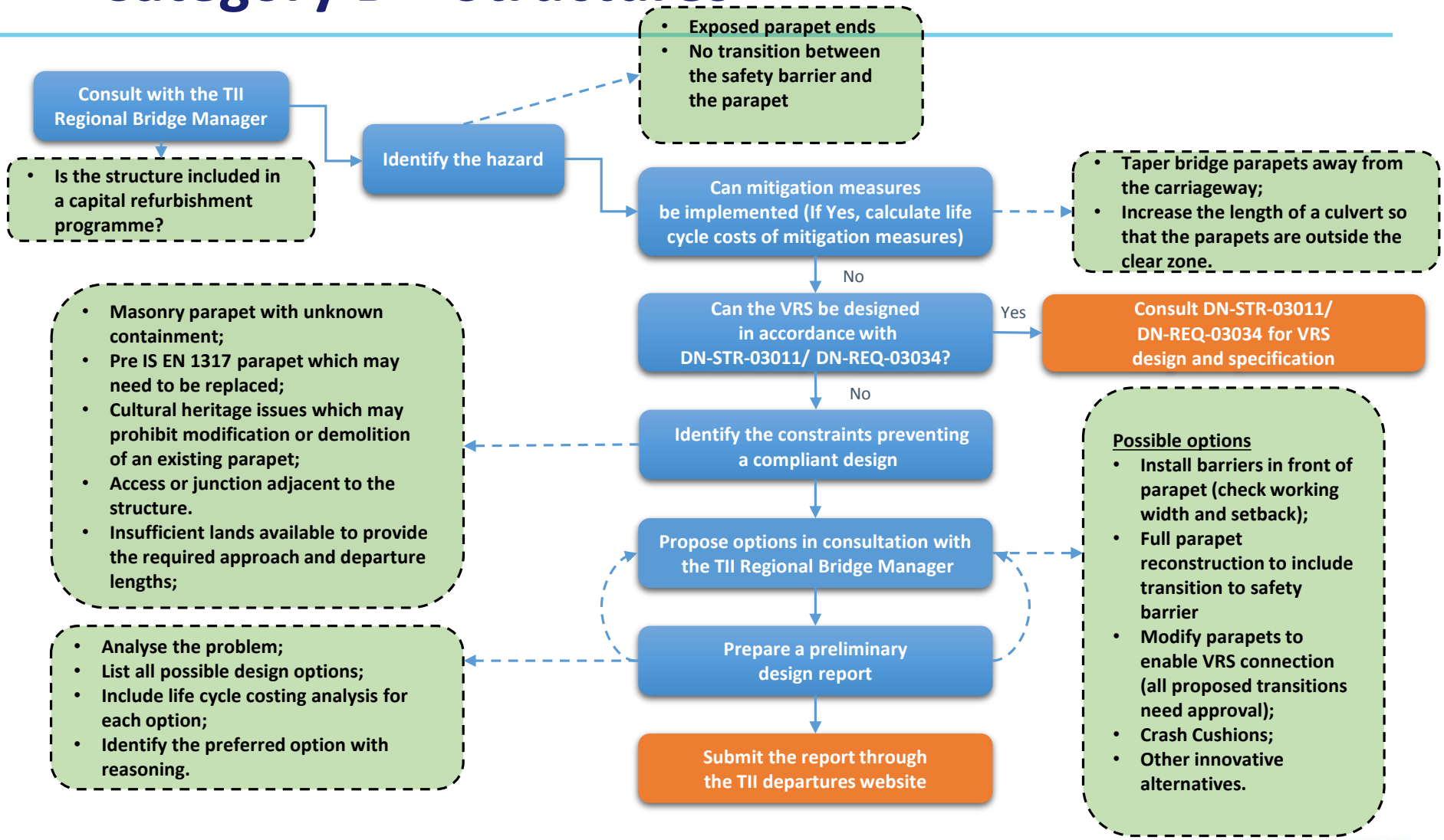
Rail Bridge Crossing - Constraints

- No transition included;
- An unapproved connection detail.

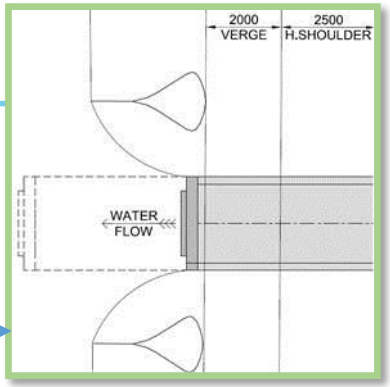
Culvert Crossings - Constraints

- No end terminal, no working width, length of need not catered for, height above the carriageway too low.

Category B – Structures



Category B – Structures



Consult with the TII Regional Bridge Manager

Identify the hazard

Can mitigation measures be implemented (If Yes, calculate life cycle costs of mitigation measures)

No

Can the VRS be designed in accordance with DN-STR-03011/ DN-REQ-03034?

Yes

Consult DN-STR-03011/ DN-REQ-03034 for VRS design and specification

No

Identify the constraints preventing a compliant design

Propose options in consultation with the TII Regional Bridge Manager

Prepare a preliminary design report

Submit the report through the TII departures website

Possible options

- Install barriers in front of parapet (check working width and setback);
- Full parapet reconstruction to include transition to safety barrier
- Modify parapets to enable VRS connection (all proposed transitions need approval);
- Crash Cushions;
- Other innovative alternatives.

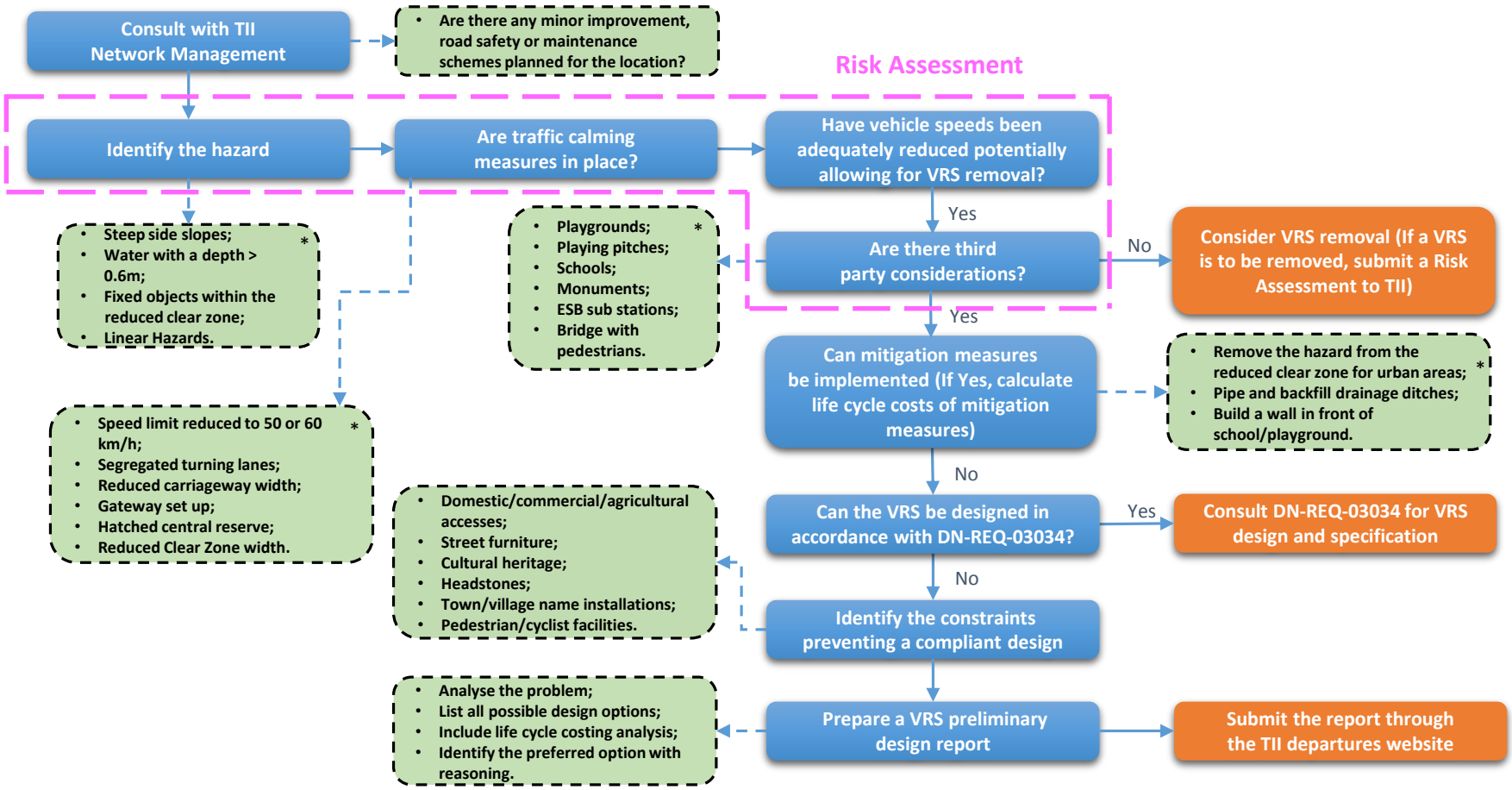
Category C - VRS within urban settings

VRS should not be provided in urban settings unless exceptional circumstances

- Category C flowchart provides a risk based decision making process primarily for use when considering the removal of legacy VRS:
  - in urban settings or speed limit zones;
  - locations where the speed limit may have been reduced subsequent to the installation of the VRS;
  - locations where traffic calming may have been reduced subsequent to the installation of the VRS.

VRS within urban settings

Category C – Urban Settings



* Non-exhaustive list.

VRS Preliminary Design Report

- Templates for VRS PDR for each category of constraint are provided as appendices including worked examples;
- Simple format with standard information in line with design process required;
- Life cycle cost analysis required (SAVERS);
- MS Word templates available http://tiipublications.ie/downloads/

Worked Example 1 – Category A, VRS at a constrained location

VRS ID / Location: N56DL-01 (N56DL_100066_S1_B4)			***VRS Preliminary Design Report Summary*** ***VRS at Constrained Location***
Description: A short section of existing untensioned corrugated VRS on timber posts with a ramped terminal upstream and full height fish tail terminal downstream. **Length:** 15m			

Consultation	**Outcome**
TII Network Management	Following consultation with AN Other on 11/08/2016 it has been established that there are no minor improvement, road safety or maintenance schemes planned for this location.
Identify the Hazard(s)	**Summary**
Steep embankment slope and water of likely depth >0.6m	Steep slope into deep water to the west.
Substantial fixed object extending above the	A low stone wall approximately 600m in length but with no piers.

VRS – Terminal and Transition Assessment Procedures

Eoin Doyle (Arup)

DN-REQ-03080 – Terminal Assessment Procedure

New Standard established to allow an assessment to be undertaken of the suitability of end terminals proposed for use with safety barriers on Irish national roads so as to develop a "Compliant Terminals List"

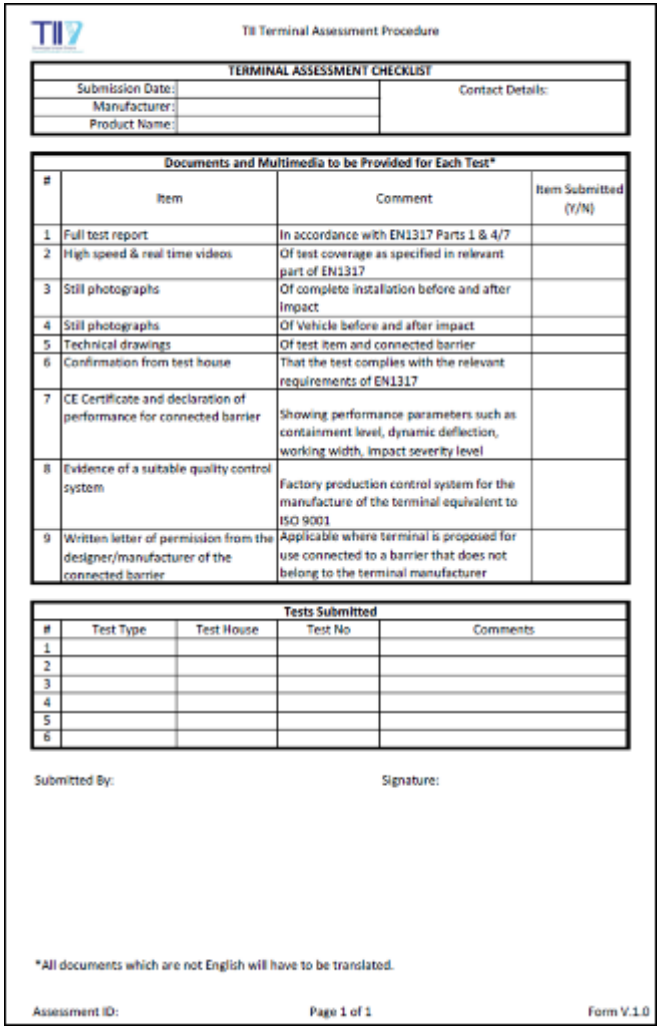
Need for the Standard

- Safety barrier end terminals not currently CE marked products – no Harmonised European Standard.
- DRAFT prEN 1317-7 is being developed for the testing and approval of terminal systems.
- TII have implemented the testing requirements of prEN 1317-7 in DN-REQ-03034 Safety Barriers.
- Standard will allow equivalent procedure to CE Marking based on Draft EN Standard.
- Some key items not clearly defined within prEN 1317-7 and are open to interpretation – clarified within standard.

DN-REQ-03080 – Terminal Assessment Procedure

Assessment Procedure

- ***Independent professional review*** of the test documentation provided by the supplier.
- ***Terminal Assessment Checklist*** of documentation to be provided included as appendix.
- ***Individual Terminal Test Assessment*** form used as a standard template of review and as a checklist for the minimum requirements of each individual impact test.
- ***Terminal Assessment Summary*** form will be used to summarise findings of the independent review for each impact test.
- Systems assessed as having undergone appropriate testing shall be added to the ***Compliant Terminal Systems list*** on the TII Publications website.



TII Terminal Assessment Procedure

TERMINAL ASSESSMENT CHECKLIST

Submission Date:		Contact Details:
Manufacturer:		
Product Name:		

Documents and Multimedia to be Provided for Each Test*

#	Item	Comment	Item Submitted (Y/N)
1	Full test report	In accordance with EN1317 Parts 1 & 4/7	
2	High speed & real time videos	Of test coverage as specified in relevant part of EN1317	
3	Still photographs	Of complete installation before and after impact	
4	Still photographs	Of Vehicle before and after impact	
5	Technical drawings	Of test item and connected barrier	
6	Confirmation from test house	That the test complies with the relevant requirements of EN1317	
7	CE Certificate and declaration of performance for connected barrier	Showing performance parameters such as containment level, dynamic deflection, working width, impact severity level	
8	Evidence of a suitable quality control system	Factory production control system for the manufacture of the terminal equivalent to ISO 9001	
9	Written letter of permission from the designer/manufacturer of the connected barrier	Applicable where terminal is proposed for use connected to a barrier that does not belong to the terminal manufacturer	

Tests Submitted

#	Test Type	Test House	Test No	Comments
1				
2				
3				
4				
5				
6				

Submitted By: Signature:

*All documents which are not English will have to be translated.

Assessment ID: Page 1 of 1 Form V.1.0

DN-REQ-03080 – Terminal Assessment Procedure

Items Clarified within Standard

Critical Impact Point

Test Approach 6 - prEN 1317:7 2014

- The aim of this test is to evaluate the danger of pocketing where there is a sudden change in stiffness between the connecting barrier and the terminal.
- PrEN 1317-7 does not provide specific parameters in relation to choosing the CIP.
- 2m to 5m is provided as guidance within standard based on experience and prEN 1317:7 2012.
- If outside range requires computational simulations to verify point chosen is most critical point to assess potential pocketing.

Figure 4.1: Example of test approach 6 with impact point too far away from the end of terminal

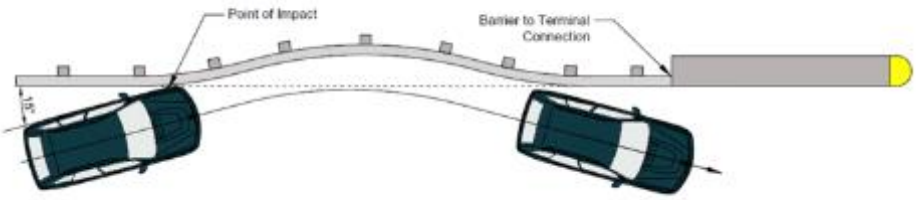
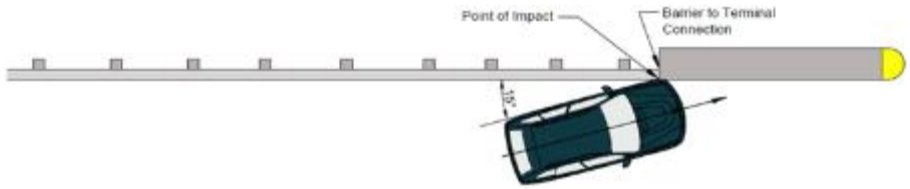


Figure 4.2: Example of approach number 6 test with impact point too close to the end of terminal



DN-REQ-03080 – Terminal Assessment Procedure

Items Clarified within Standard

Connecting to safety barriers systems other than that which the terminal was originally tested with

- Required to notify TII - may or may not require further submission depending on characteristics of connecting barrier

Where connected directly to different barrier:

- the cross section and material of the proposed barrier compared to the barrier used for the ITT
- the difference in dynamic deflection between the barrier system used for the ITT and the proposed system; and
- an assessment of a simulated crash test using the proposed barrier if deemed necessary.

Where terminal is provided with the transition piece it was tested with:

- connection to adjacent barrier is subject to transition requirements of ENV 1317:4.

DN-REQ-03081 – Transition Assessment Procedure

New Standard established to allow an assessment to be undertaken of the suitability of transitions between VRS of different performance or cross section proposed for use on Irish national roads so as to develop a "Compliant Transitions List"

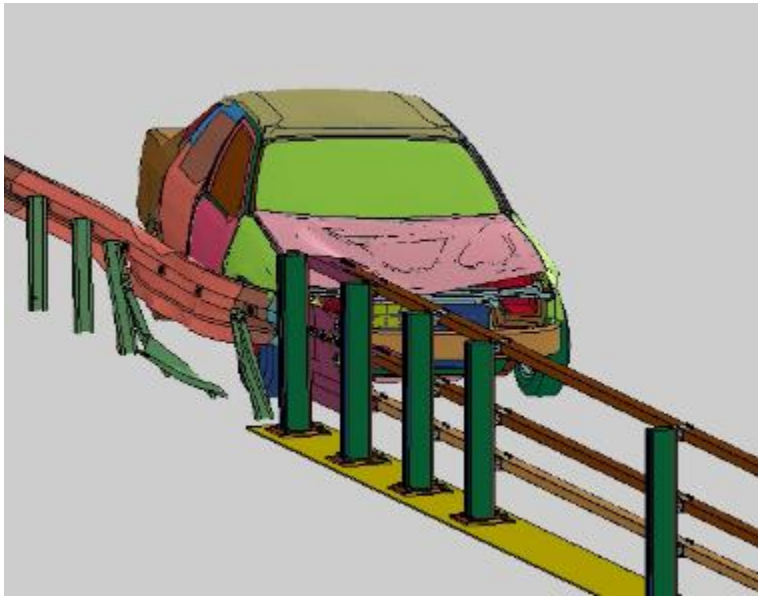
Need for the Standard

- Transitions not currently CE marked products – no Harmonised European Standard.
- Standard will allow equivalent procedure to CE Marking based on Draft EN Standard through an independent assessment of test results.
- Some key items in relation to the testing of transitions are clarified within standard.

DN-REQ-03081 – Transition Assessment Procedure

Assessments

- Full Scale Physical Impact Tests
- Simulated Crash Tests



DN-REQ-03081 – Transition Assessment Procedure

Assessment Procedure

- Individual Transition Physical Test Assessment Form used to assess each individual physical impact test.
- The virtual tests will be assessed and a Virtual Test Assessment Report will be prepared to summarise the findings of the assessment.
- Transitions deemed suitable following assessment under this Standard will be added to a Compliant Transitions list on the TII Publications website

DN-REQ-03080 – Transition Assessment Procedure

Items Clarified within Standard

- The point shall be taken as the point of intersection of a straight line parallel to the vehicle centreline, at the maximum width of the vehicle.

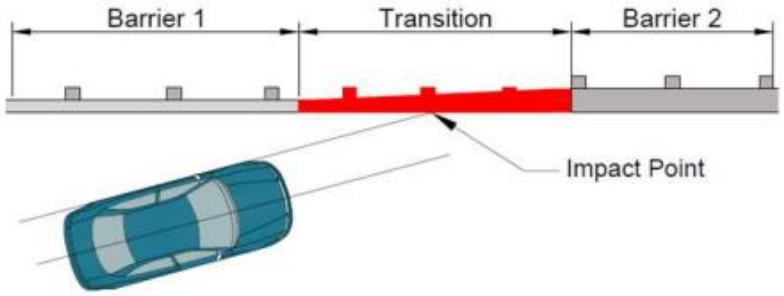


Figure 4.1 – Impact Point

- Light Vehicle Test (TB11) to evaluate the impact severity of the transition.

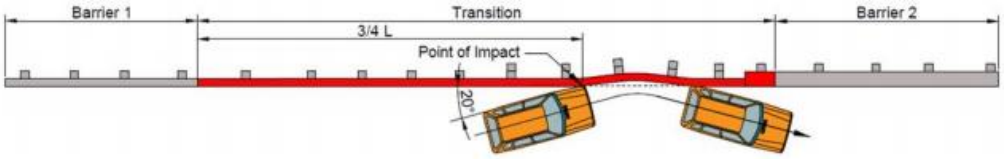


Figure 4.2 – Example of a TB11 test on a longer transition, where 3/4L Impact point is too far away from the stiffer barrier to show highest severity

- Containment Test (TB32 or higher) to evaluate the containment level of the transition and to identify any potential for pocketing

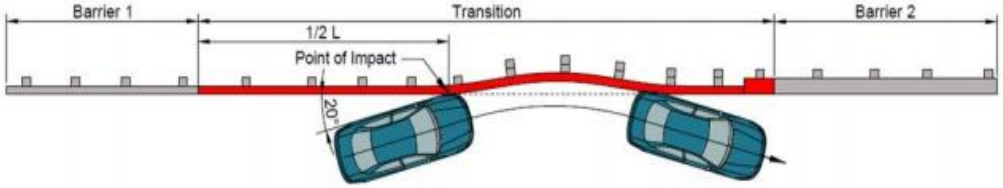


Figure 4.4 – Example of a TB32 test on a long transition, where half way impact point is too far away from the stiffer barrier to show potential pocketing

Questions & Answers

Thank you