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Developing a road safety review tool to identify design standard and safety deficits on high risk road sections

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Abstract

The ESReT (European Safety Review Tool) project has developed a tool to support the review of road sections that have been identified as ‘high risk’ according to network screening processes. The tool provides a methodology to practitioners for the collection and analysis of road attribute data using low cost, non-specialist equipment. The overall result is a consistent and repeatable approach to the investigation and assessment of high risk road sections.

There are two main parts of the assessment performed by the tool. The first part is a comparison of road attributes against design standards; the optional second part is a comparison of road attributes against ‘safety rules’. The road design standard check allows road authorities to compare the attributes of existing heritage roads with current design standards. This allows road authorities to identify where, and in what way, modern design rules are not met. Various design standard attributes are included in the tool including: median width, lane width, shoulder type and width, verge width, curve radius, crests and sags, stopping sight distance and intersection type. The optional ‘safety’ check allows the road authority to see where key safety rules are violated. This means aspects of the road that may contribute to high severity crashes are identified along with aspects of the road that may lack credibility to the road user. Attributes relating to safety include median type, clear zones (median and roadside), intersection type and frequency, stopping sight distance, adjacent land use, presence of pedestrian and cycle facilities etc.

The ESReT system allows road attribute information to be visualised and reviewed by the road authority, and presents the results of the road design standard and safety checks by showing deficits both in tabular form and on interactive maps. The ESReT system does not aim to provide a definite design solution to the road authority, rather it provides experienced practitioners with standardised information about the road along with suggestions so that they can develop the best solutions based on their experience and local knowledge.

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1. Introduction

The European Directive 2008/96/EC on Road Infrastructure Safety Management requires road authorities to undertake road safety impact assessments, road safety audits, identification of high accident concentration sections and safety inspections on the trans-European road network.

The Directive states that high priority road sections that have a high concentration of injury collisions should be evaluated by expert teams through site visits. Through the CEDR Transnational Road Research Programme Call 2013, a consortium of EU technical and research organisations were commissioned to develop an automated technique capable of being run on a mobile device to support road authorities in undertaking this evaluation on site in a repeatable and systematic way.

This paper provides an overview of the project and the resulting tool as developed to date.

2. Objectives

The project had a number of core objectives that needed to be fulfilled:

1. The development of automated techniques for capturing road inventory data using inexpensive, portable devices
2. The development of a data collection protocol that would support the consistent collection of information about the road section during site visits
3. The development of a tool to compare road attribute data with current road design standards and identify sub-standard elements that are considered to be deficits
4. The development of a tool to compare road attribute data to specified ‘safety rules’ to identify unsafe elements (deficits) as an option
5. Provide an analysis programme that will present the characteristics of the existing route in a standardised manner using spatial and cartographic presentation where possible
6. Provide an analysis programme which will include a logic system for the triggering of appropriate treatments based on identified design standard/safety deficits to provide a simple way of capturing the results of any collision data analyses
7. Enable the tool to support the practitioner through presentation of the deficits identified, information on potential treatments for consideration and prioritization of the deficits based on crash typology.

The resulting application is ready for practical application in the field. It can be applied to a variety of road types including rural single carriageway roads, rural dual carriageway roads and motorways. In addition to these road types, the tool is also applicable where a road passes through small settlements (villages etc.) within an overall rural context. It is not suitable for use in large urban conurbations.

3. Development of the tool

The approach that has been taken in the development of the tool reflects international best practice and draws on principles from the Safe System and Sustainable Safety approaches to road safety. Key principles concern the survivability of crashes when they occur and the need for a consistent approach to be taken across the network.

The work has built upon previous research undertaken through the CEDR programme EuRSI project which was charged with examining how Mobile Mapping Systems (MMS) could be utilised to help collate road network information for Road Safety Inspection. Some of the outputs of EuRSI contributed to the development of Ubipix (http://app.ubipix.com/) which is an online geospatial media cloud based platform.

This platform enables road infrastructure information including video, geometry and roadside objects to be captured using free smartphone apps, low-cost third-party GPS camera or survey grade MMS to be uploaded, processed, stored, analysed and visualised through a secure web-based browser. Ubipix has been designed and constructed around open source tools including PostgreSQL database and OpenLayers dynamic web libraries. Interoperability is based around best industry practice including open standards such as W3C and OGC. The platform supports complete work-flows for mapping and managing road networks including data ingestion, discovery, fusion, analysis, visualisation and dissemination.

This platform was made available to this project through an Application Programming Interface (API) which enabled a customised 'white-label' instance to be designed, constructed and tested. This API already has all of the elementary functions including data import, transformation, spatial analytics, map display and graph profiling tools. These components have been customised and extended for this particular project.

The tool identifies solutions that are safe, credible and practical. In that regard, a series of algorithms have been developed around the design standards and safety rules.

3.1. Design Standards

The requirement was for the development of a system that categorises design standards in a consistent manner, whilst allowing each road authority to adequately summarise the detail of their design standards, in order that the tool can be used by any road authority even where there are significant differences in standards.

The team has therefore developed a method of 'describing' European design standards in a common manner for the full list of parameters identified. The 'allowable' values for each parameter for different types of roads with different speed limits were captured in this methodology. Design standards were obtained and used for this task as follows:

- Ireland – National Roads Authority, Design Manual for Road and Bridges
- UK – Highways England, Design Manual for Road and Bridges
- Germany – FGSV.de Reader
- Netherlands – CROW.nl Online Knowledge Modules

Lookup tables that express the permitted values for each of the attributes of interest at different speeds were derived for all road types across all of the countries; these lookup tables are editable to add or adjust standards.

Deficits are detected by simply comparing what the road attribute is to what it 'should' be according to the relevant design standards. If there is a difference (i.e. if the attribute does not fall within the allowed range of values), then a deficit will be triggered.

3.2. Safety Rules

The safety algorithms form one of the key components of the tool. They allow data on road attributes collected in the field to be compared with 'ideal' values based on safety principles.

The aim of the safety algorithms is to underpin the flagging of safety deficits on high risk sections to experienced practitioners. Therefore the tool does not need to provide a measure of absolute level of risk, nor provide an overall 'safety rating' of a route. Rather, the aim is to provide the safety practitioner with information to assist them with the development of a treatment programme.

The values in the table were based on safe system rules as described by Wramborg (2005) and expert judgment where there was no alternative information.

Suitability of various features at different speeds is considered to be the most appropriate way to create the tool since the relationship between speed, transfer of kinetic energy in a crash and injury outcome is considered to be very clear. This builds on the work undertaken in the project ERASER (Aarts et al., 2011).

The tool is designed so that the practitioner can identify deficits against posted speed limit or against actual driven speeds. The tool allows the practitioner to enter in details of any speed surveys that have been done previously on the road (in particular values for 85th percentile speed or V90).

3.3. Application

The algorithms use a series of collected attributes and conditions to identify the severity of safety concerns for a given location. These are based upon:

- Raw attributes
- Calculated attributes
- Safety switches
- Mitigations and
- Information

The raw attributes are the items that are collected from the video surveys, either through automatic image processing of the video or through manual tagging by the practitioner.

The calculated attributes are items that are used in the safety ideal values part of the tool and are calculated based on the raw attributes. For example:

$$\text{Curvature coefficient} = \frac{\text{Rate of change of horizontal alignment,}}{\text{Length}} \tag{1}$$

which are both raw attributes collected automatically during the video survey

Some of the safety ideal values are not relevant for all conditions; for example, if the pedestrian flow is low then there is no need to alert the practitioner if there is a lack of pedestrian facilities. Pedestrian and pedal cyclist deficits are switched off as default. Additionally the switch concerning land use overrides the number of pedestrians and pedal cyclists, and vehicle parking so that if the adjacent land use is recorded as commercial or residential and there is no vehicle parking but the pedestrian or cycle flow is low, then the pedestrian and pedal cycle deficits are switched on.

The mitigation conditions identify any existing mitigation measures that are already present that the engineer needs to be aware of during the review.

The information attributes are items that engineers should be aware for a route when using the tool. These are items which are important but are either not intrinsic to the tool (for example, presence of roadworks) or do not vary with speed (for example, road condition). In most cases the default value for the item is ‘sufficient’ but the item will be flagged when the value is entered as ‘poor’. These do not provide input to the algorithms; they are for information only.

The tool therefore helps the engineer to assess the high risk sites, by presenting the nature of any deficits and their severity; the characteristics of the road that are contributing to the deficits; associated crash types; and treatments that are likely to have an impact on the deficit identified.

4. Using the Tool

The web technology platform which underpins the tool is cloud-based on a secure cluster and has been customised to provide a number of key functions:

- Allow users to register at different levels of access

- Allow users to review, edit and add new design standards
- Enable data collected by multiple sources - smartphone apps, third party devices and existing survey data to be imported, structured and stored
- Allow users to review uploaded data through video imagery, mapping and graphical displays and to manual tag additional attributes and features, both continuous and static
- Facilitate comparison of survey data with design standard and safe systems rules in order to detect, highlight and display deficits
- Provide information on possible treatment options for identified deficits and filter deficits by associated crash type

4.1. Login and Dashboard

The first step is for users to log into the system using agreed names and password. Permissions depend on the user type, from standard access allowing the user to create and review projects to being able to modify national design standards in the system.

Once logged in the user is presented with the Dashboard, which is the homepage of the ESReT platform. This allows the user to see their groups and selected projects, and also links to create new groups or projects and manage and create design standards.

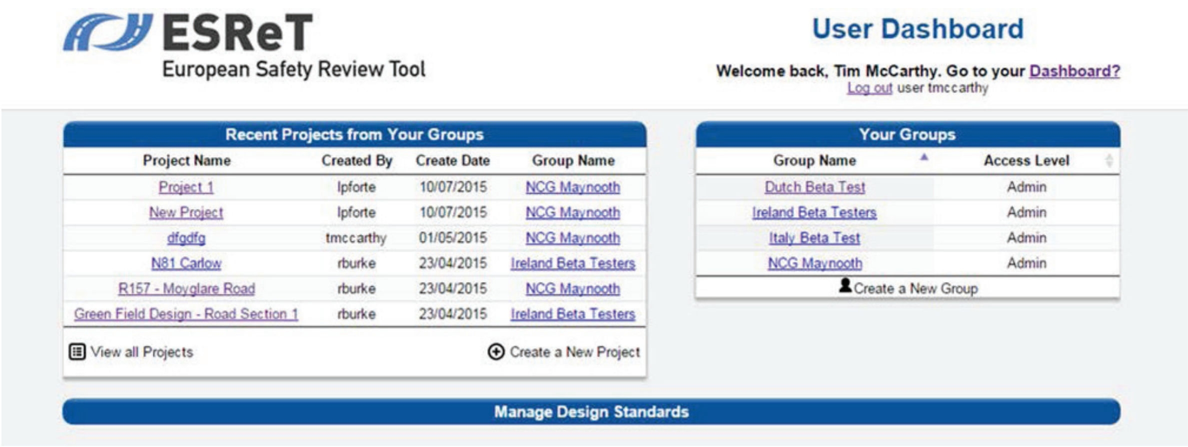

Fig. 1. User dashboard.

4.2. Manage and create design standards

The user can access existing design standards by selecting one of the available countries – currently Ireland, United Kingdom, Germany and the Netherlands. All design standards in the system for that country are listed, along with the road class identification, cross section, description and minimum / maximum design speed. Selecting a design standard shows the detail for that country’s relevant road features, such as road width, alignment, speed, sight distance etc. with the respective values for this particular design standard. Depending on access level, the user can edit these values and also create new design standards for a country.

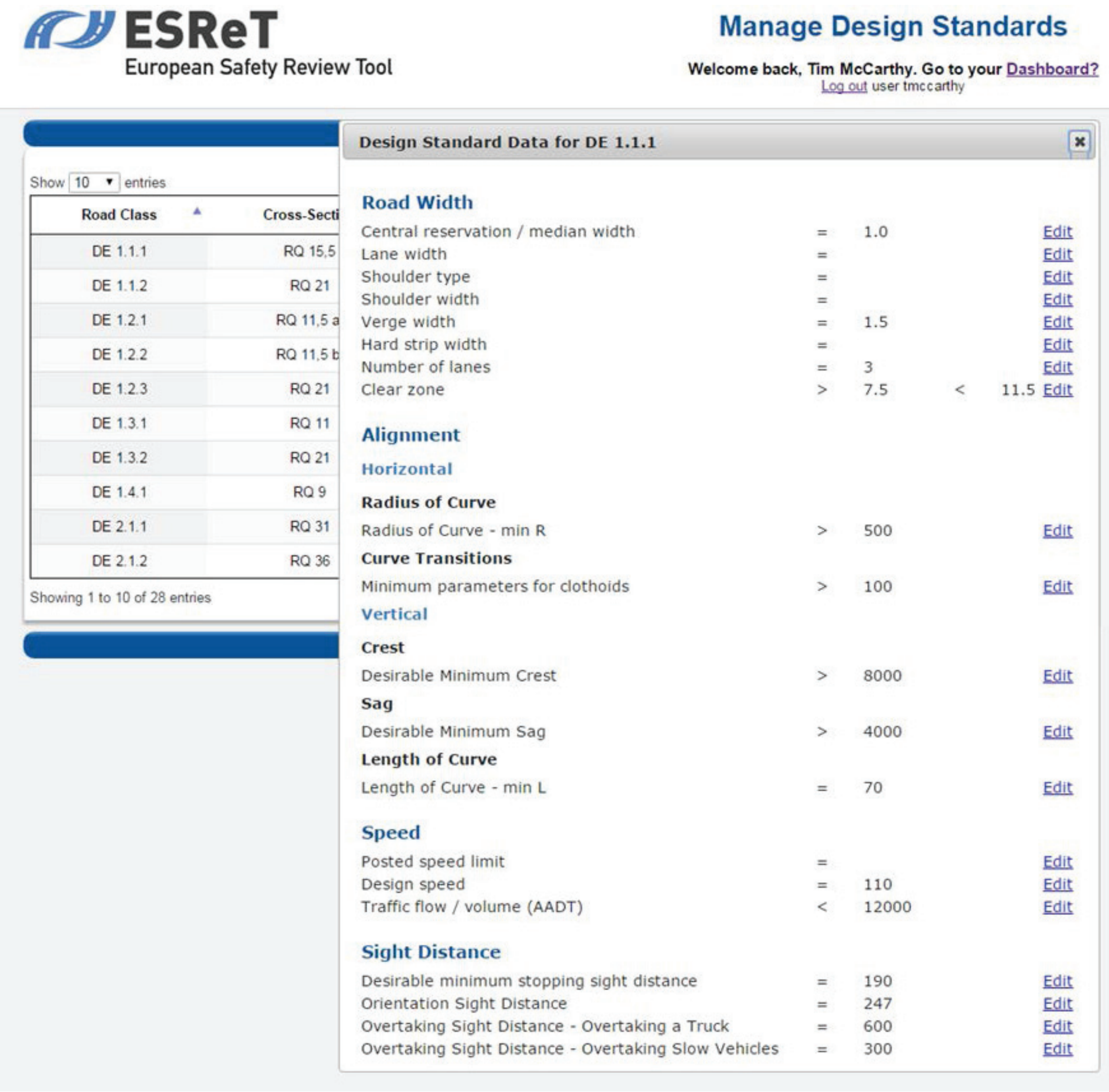

Fig. 2. Managing design standards.

4.3. New projects and data upload

The first step of creating a new project is to provide a brief description and associated country and design standard. (This does not preclude analysis against other design standards once created.) The next step is to define the ‘area of interest’ to define the approximate extent of the road section in question – this allows the system to extract the relevant sections of survey data. Survey data files and Ubipix tracks recorded from the mobile application can then be uploaded and added to the project.

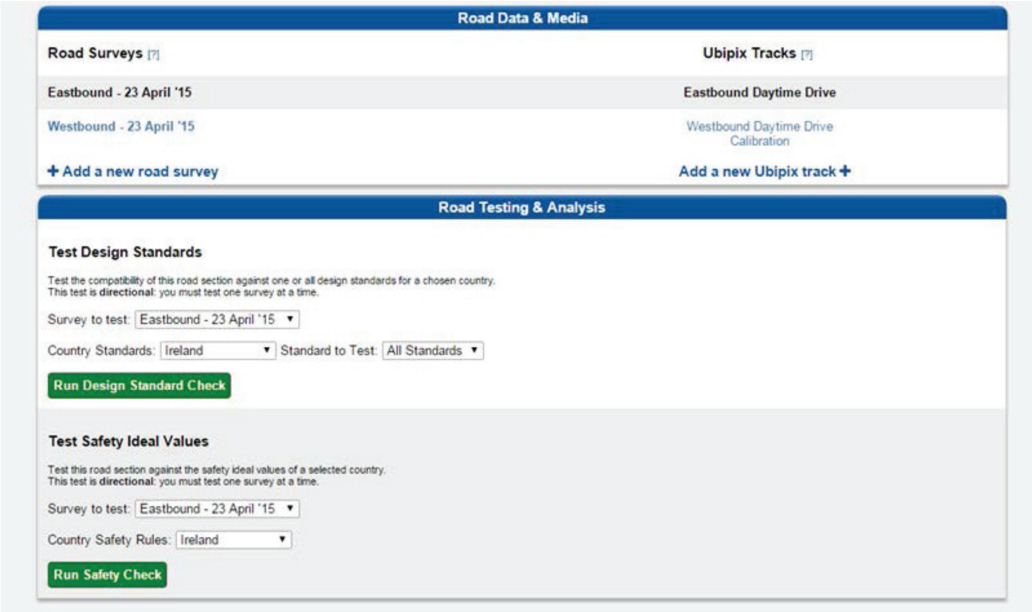

Fig. 3. Uploading files.

4.4. Project display and review

The main display consists of four elements - Ubipix video feed, mapping, graphical display and working tools. The journey can be explored simultaneously through the video, map and the displayed graph – all three features are linked and indicate the same location along the journey. Any location within the journey can be accessed through any of these features.

The user can select which road features are displayed on the graph; options are design speed, speed limit, lane width, hard shoulder, horizontal curvature, vertical curvature, horizontal sight distance, vertical sight distance, left side verge, right side verge.

Five tools allow the user to work with these data:

- Manual tagging of continuous road features: This allows the user to tag features such as hard shoulder, roadside slopes, safety barriers etc.
- Manual tagging of static road features: This allows the user to tag features such as crossings, intersections, trees etc.
- Map overlay: This allows the user to change the mapping base layer and add overlays. The options for overlays are: road features, project area of interest, video recording track and video recording 'point-of-view'.
- Download data: This allows the user to download the currently-viewed survey to a csv file.
- In-screen measurement: This allows the user to measure distances using the video display

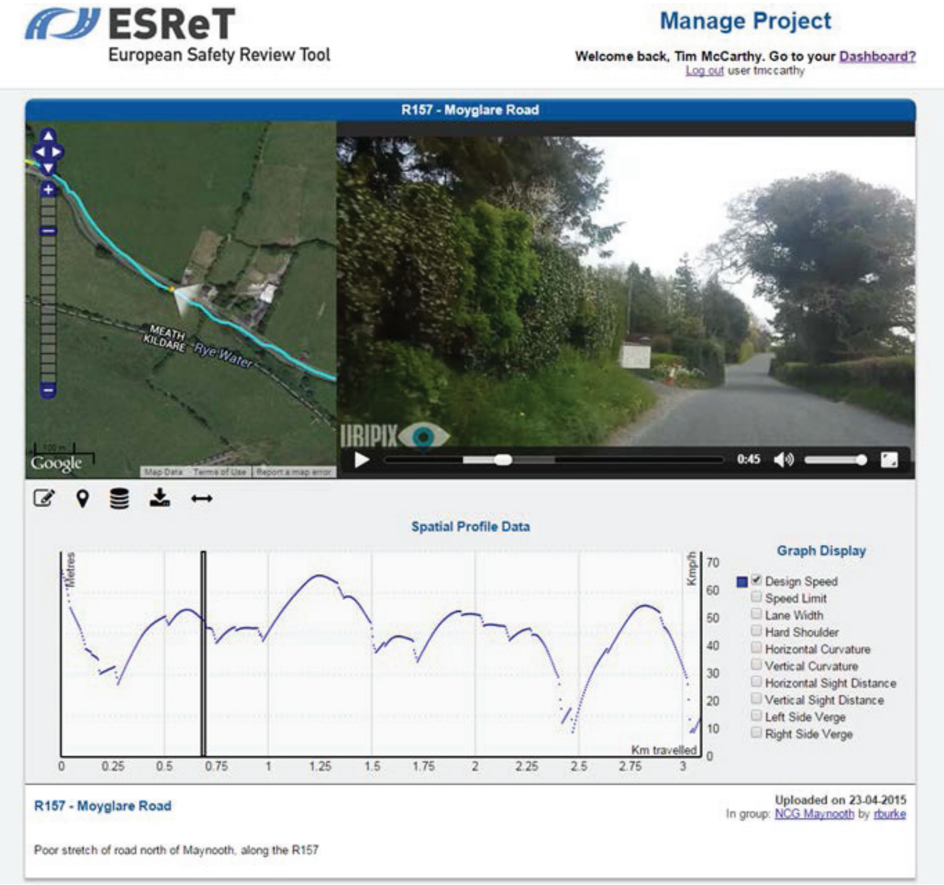

Fig. 4. Main review screen.

4.5. Testing and analysis

The main functionality of the tool is the ability to test the road section against one (or all) design standards or against the safety ideal values for a chosen country. For the design standard check the results are displayed in table form, indicating which rules have been broken and giving details of the deficit, including highlighting the location of the deficit on the map.

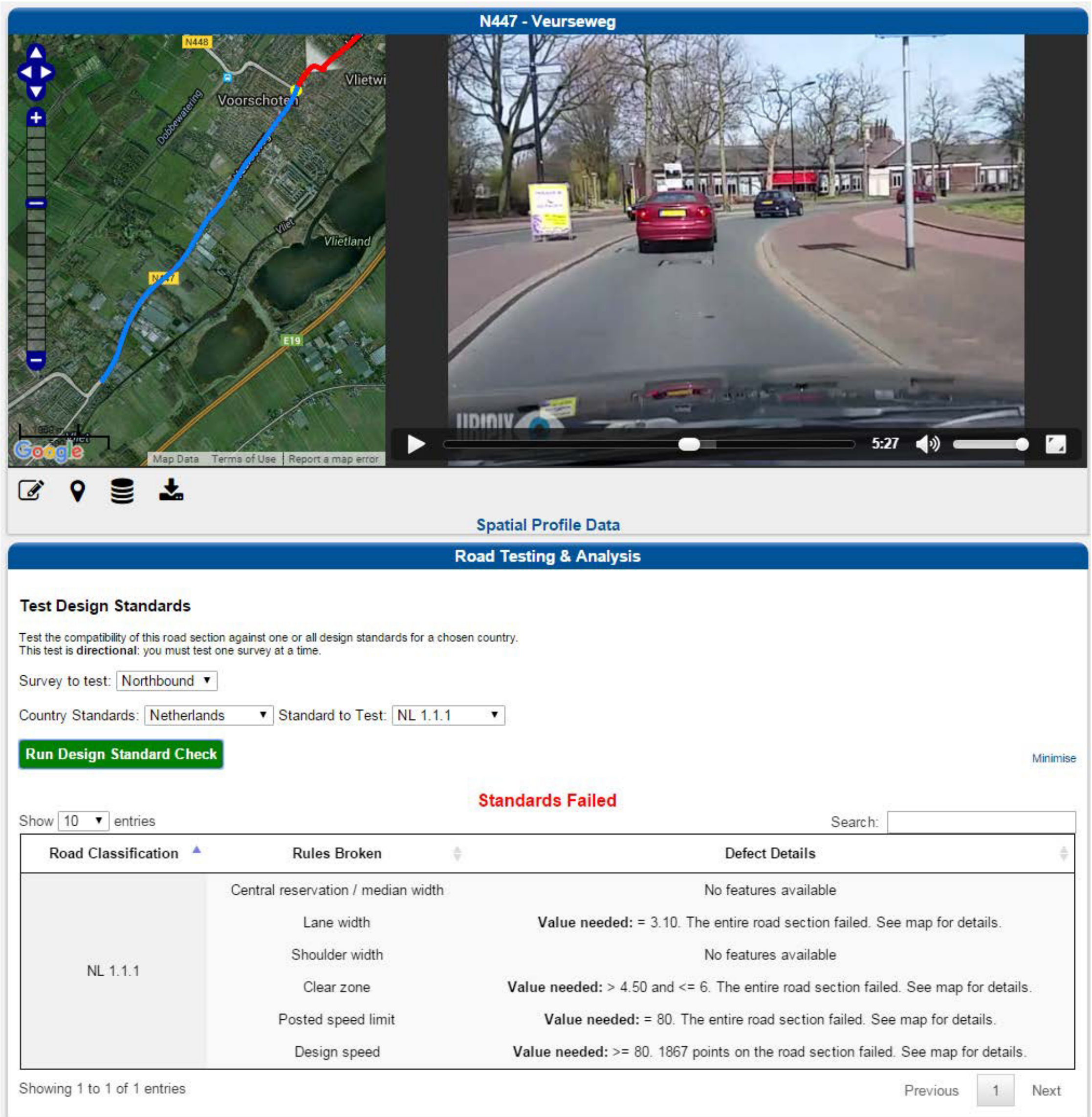

Fig. 5. Example of design standard check results.

For the safety check, the results are displayed in table form indicating which safety values have been passed / failed with respect to various speeds at 10 km/h intervals.

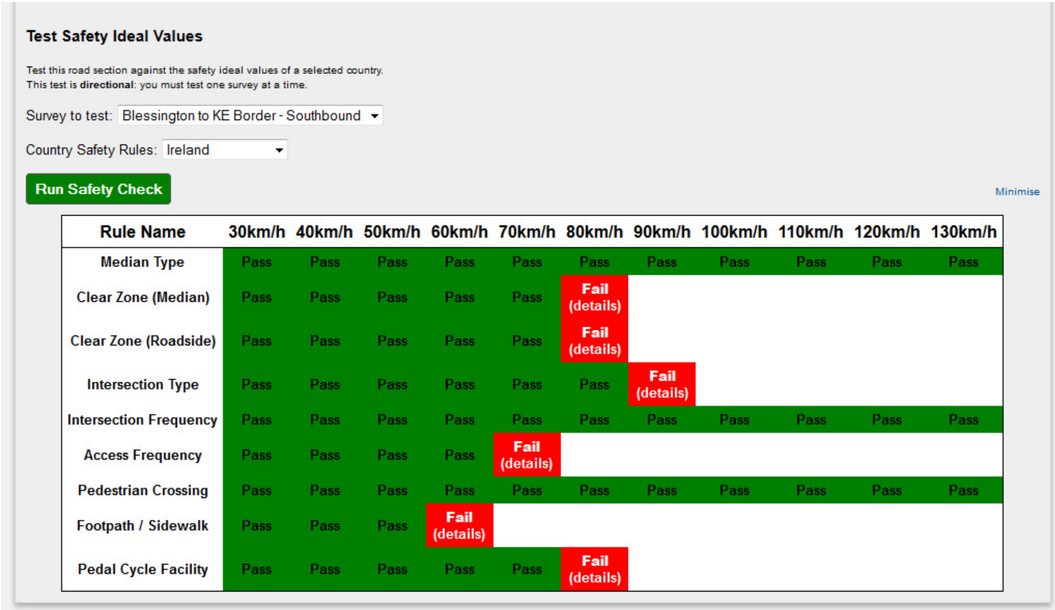

Fig. 6. Example of safety check results.

The user can click on a deficit result to display relevant information on potential treatment option associated with that particular deficit. It is important to note that these are options rather than recommendations as the system is intended for use by expert practitioners; practitioner will need to consider what is appropriate for the individual situation using their local knowledge of the road section and circumstances.

An option is provided to allow the user to filter deficits associated with a certain crash type. This allows a user, who has previously identified a high-risk road section with a high incidence of a particular crash type, to filter the results to identify the deficits that may be the cause and therefore to identify the possible treatments that may reduce the risk of that crash type.

5. Conclusions

The ESReT project has developed a tool to support the review of road sections that have been identified as ‘high risk’ according to network screening processes. The tool provides a methodology to practitioners for the collection and analysis of road attribute data using low cost, non-specialist equipment. The tool provides a comparison of road attributes against design standards and against ‘safety rules’ to identify deficits and information on potential treatments. The ESReT system does not aim to provide a definite design solution to the road authority, rather it provides experienced practitioners with standardised information about the road along with suggestions so that they can develop the best solutions based on their experience and local knowledge.

At the time of preparing this paper, the tool is still in the final stages of development. All the attributes and algorithms have been finalised, together with the video capture interfaces. An initial trial of the system is in process and the findings being analysed.

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