« Roads otherwise to induce calm driving » Understanding driving behaviours to design roads in a different way.

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Abstract

The RACA (Roads otherwise to induce calm driving) concept is a proactive approach to reduce road casualties and to give the utmost priority to road users' safety. This concept consists on working on the road and its environment to impact user's behaviour. Initiated in 2006 with the aim to reduce speeds and comply with speed limits, the RACA idea has grown beyond its original scope. This paper describes the different stages of the process. The proposed approach is based on the following considerations: a proper knowledge of driver behaviour and acceptability of the rules, relevance of road types and appropriate use of design guidelines, approaches through landscaping and legibility and last, evaluation and capitalisation of experimental results. The approach is also developed with a logic of sharing experiences, sharing knowledge and consideration of the multiple actors and uses of the road.

Keywords: road safety; design roads; method; driver behaviour; experiences.

Résumé

Le concept de "Route Autrement pour une Conduite Apaisée" s'inscrit dans une démarche volontariste pour lutter contre l'insécurité routière et faire de la sécurité des usagers un objectif majeur. Ce concept consiste à agir sur l'infrastructure elle-même et son environnement pour influer sur le comportement du conducteur. Initié en 2006, avec comme principal objectif la réduction de la vitesse et le respect des limitations de vitesse par les usagers, le concept RACA va aujourd'hui bien au-delà de cette notion. Cet article décrit les différentes étapes de la démarche. Cette dernière s'appuie sur les réflexions suivantes : la connaissance du comportement des conducteurs et l'acceptabilité des règles, la pertinence de la typologie routière et du bon usage des règles de conception, les démarches paysage et lisibilité, et l'évaluation et la capitalisation des résultats d'expérimentations. La démarche est par ailleurs élaborée dans une logique de mutualisation des expériences, des connaissances et de la prise en compte des différents corps de métier de la route.

Mots-clé: sécurité routière ; conception routière ; méthodologie ; comportement des conducteurs ; expérimentations.

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1. Introduction

The concept of "Roads otherwise to induce calm driving", presented at the 24th World Road Congress in Mexico in 2011, is a proactive approach to reduce road casualties and to give the utmost priority to road users' safety. This concept consists on working on the road and its environment to impact user's behaviour.

Initiated in 2006 with the aim to reduce speeds and comply with speed limits, the RACA idea has grown beyond its original scope. The global behaviour of users, rather than just in terms of speed, has now been placed at the heart of this concept, in particular by drawing on the human sciences. Today, speed is no longer the only factor that can be leveraged in order to induce the right behaviour on the road. Indeed, it is demonstrated that the reduce of speeds has a direct and non-linear effect on the reduce of the risk of accidents (a reduction of 1% of the speed, resulting in a reduction of 4% of fatalities) (Nilsson, 2004), and now the research needs to go further by taking into consideration other aspects of users' behaviour.

The opening of the RACA concept is based on this will and results of the multidisciplinary RACA working group, which has a multi-criteria approach, and take into account human factors in the design of the infrastructure. The goals of this initiative are to act on the infrastructure so as to incite users to naturally adopt behaviours adapted to each situation, to develop a technical approach in order to build roads differently, to raise awareness amongst all those who may exercise an influence on the subject and to embrace the notion of sustainable development.

Therefore, it is important at this point to describe the RACA initiative in its entirety, since its beginnings in 2006 to the present day. It is also important to recall the origin of the initiative and the steps it has taken along the way, in order to understand how it has developed and where it is currently heading.

2. Roads otherwise to induce calm driving (RACA)

The concept of the "Calm Road" emerged in the mid-2000s and an initiative was gradually launched from 2006 onwards. The goal of this initiative was to combat danger on the roads, mainly by reducing speeds, but also by designing roads so that the speed limits actually make sense to users.

2.1. The origin of the RACA initiative

In 2006, the French General Highways Directorate introduced the idea of building roads that encourage road users to slow down, without making them less comfortable. The conference held on 9 March 2006, " *La route autrement : concevoir des routes incitant à une conduite apaisée*" ("Road otherwise : to build roads to encourage calm driving"), focussed on one particular aspect of road safety: the link between speed and the infrastructure (width of the carriageway and the surrounding landscape). Then, it was raised the need to further understand the mechanisms of this interaction to determine if it was possible to design roads that induce slower speed or compliance with the speed limit and so to get drivers to a calmer driving.

This conference was the genesis of the RICA initiative (*Route Incitant à une Conduite Apaisée* : a road encouraging calm driving), which considered only speed as the criterion defining drivers' behaviour, and has since become the RACA initiative.

As a consequence, a working group was set up, with the aim of following-up the Conference by defining lines of thought, of course focused on the links between behaviour and the infrastructure/environment, and a revision of the design rules.

2.1.1. The general principles of the RACA concept and initiative

Following the creation of the working group, the RACA concept was further developed and elaborated, to the extent that it could be implemented and become operational. The principles of the RACA concept are rooted in the wish to design readable infrastructures, so that users "naturally" remain within the speed limit. In order to achieve this initial goal of reduced speeds, it is necessary to understand the human mechanisms.

2.1.2. The transcription of the conference's goals

The RACA initiative has progressed since the conference in 2006. The first step consisted of transcribing the input exposed at the conference in a series of tables: the guidelines, questions, knowledge already acquired or to be consolidated, etc. The purpose of this learning exercise was to make operators more aware of the "Calm Road" and to incorporate the concept into their projects. Two matrices were compiled on the basis of a number of questions classified by theme. One, called the "Project matrix", addressed road projects in all stages of development, from new roads to renovations, while the "Knowledge matrix" listed all the available knowledge of these questions, in order to gauge the level of command of the knowledge, decide whether it needed to be strengthened or if the distribution of the knowledge needed to be improved.

The need for a review of French and foreign research related to RACA emerged before the operational implementation of the initiative. Findings amongst foreign research included the concept of Self Explaining Roads (SER), introduced in The Netherlands at the start of the 1990s at the TNO (Theeuwes & Godthelp, 1992), which aims to design roads that are self-explanatory and encourage adapted or expected driving behaviour. In France, the *Sétra*'s "Landscape and Readability" approach is used to roll out this initiative in cooperation with the operators. Steps will then be taken to set up a method to assess behaviours after the recommended layout has been completed, so that the initial results of the impact of the road layout on the behaviour and perception of users can be highlighted (e.g., Sétra 2006a, 2006b).

2.2. The implementation of the RACA initiative

2.2.1. The application of RACA concept

Once all the knowledge on the interaction between infrastructure and users had been compiled, the RACA initiative started its own experiments based on the goals of the concept. The project to build an airport at *Notre-Dame des Landes* near Nantes was the first to incorporate the concept of the "Calm Road" into the design of access roads in 2008. This project aims to implement a technical design that incorporates the landscape and the infrastructure by considering the crossways profile, roundabouts and their approaches, equipment and vegetation. The layout selected to meet the RACA goals (lower speeds when approaching the roundabouts on the airport's access roads) will be assessed in experiments on a driving simulator as part of the *Ifsttar*'s I2V "operation of research", which is investigating the impact of visual information on drivers' behaviour.

2.2.2. Promotion of the RACA initiative

The RACA initiative is being promoted and published mainly through publications intended to bring the initiative to the attention of all, but especially to highway operators. The first documents produced by the initiative consist of concrete proposals in the form of feedback sheets, which can contribute to the improvement of highway regulations and doctrine. The purpose of these documents, published by the *Sétra* and produced by *CETE Normandie-Centre* (see Figure 1 and 2), is to form a body of feedback and to meet three goals:

- to consolidate and share knowledge on the link between the infrastructure in its environment and the behaviour of users
- to keep a record of the assessment of sites before and after their renovation
- to incorporate the results in user-friendly tools and methods

Fig. 1. RACA Feedback Sheets.

Fig. 2. Illustrations of assessed layouts: "2+1", roundabout with median range, "peanut" crossroad (CETE NC, 2010).

Layouts are qualified according to a pre-defined approach (see Figure 3 the structure of a RACA feedback sheet):

- a site visit to identify the indicators required to measure the effective performance of the layout in achieving its goals
- the definition of an assessment procedure according to the data to be collected
- an analysis of data on injury and material accidents and on the drivers' behavior before and after the construction of the new layout

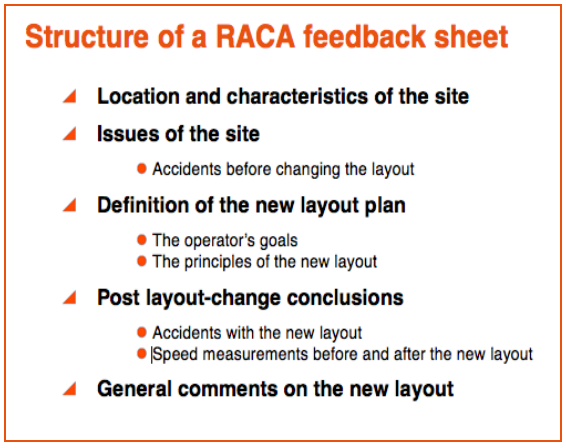

Fig. 3. Structure of a RACA feedback sheet (CETE NC, 2009).

Several feedback sheets have already been published (see Figure 1):

- 2+1 lanes: an example in the Manche department (Sétra, 2009)
- A safer junction layout for calmer driving (Sétra, 2009)
- The “peanut” roundabout: a new type of junction (Sétra, 2010)

These fact sheets are available on the *Sétra* website (*http://www.setra.developpement-durable.gouv.fr/Fiches-d-experiences.html*).

In order to better formulate the methods of the RACA concept, the working group wanted the collection of RACA feedback sheets to be supplemented by two new types of document, the “method sheet” and the “research sheet”, containing both feedback from the field and the results of research. The purpose of the “method sheets” is to document the methodological approaches to road projects, while the “research sheets” contain the results of research from an operational perspective and promote the new tools. One research sheet has been written and is currently in the process of being published (The benefits of using driving simulators in the assessment of road layouts: example of narrower lane width by laying down multi-functional strips, Sétra, In press).

Other documents can also be used to promote the RACA concept, such as the "information memos" (*Note d'Information*) published by the *Sétra* (Sétra, 2008). These "information memos" are intended to quickly deliver information on a given subject. They review current knowledge, studies, discussions, experiments or techniques at the time of their publication. In this way, they will constitute a body of documents that may be of use to highway specialists. But their relevance and content must always be gauged according to any regulatory or technical changes that have occurred since their publication. The proven benefits of certain innovative layouts can sometimes result in changes in the regulations. One example was the analysis of roundabout with median range (Article R110-2 of the French Highway Code, amended by the decree n°2010-1390, 12 November, 2010, authorising the installation of roundabout with median range in urban environments).

The diagram in Figure 4 shows how the RACA concept has evolved since the conference in 2006.

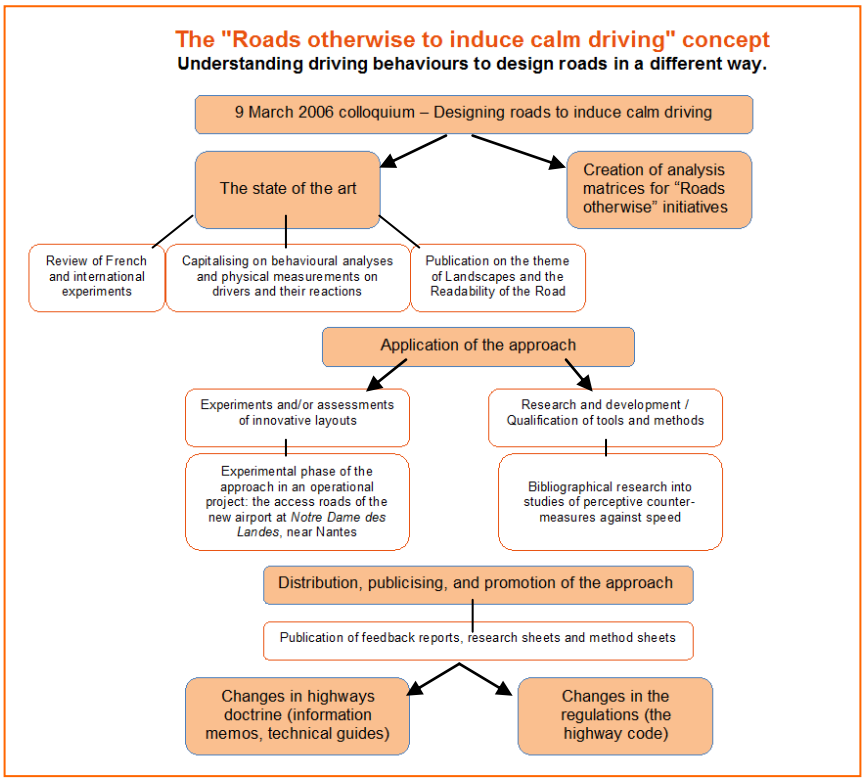

Fig. 4. RACA concept: description and development since the 2006 conference (CETE NC, 2011).

The development of the RACA initiative can be seen in particular through the changes in the needs for publications, since the promotion of the initiative no longer consists merely of feedback on experiments, but now also demands information on new methodological approaches and new tools derived from the research.

3. The development of the initiative: from current observations towards a RACA method

3.1. Current observations

The RACA initiative has prompted several studies contributing to the application of the concept, such as the access roads project at *Notre-Dame des Landes* airport. But other research and other projects have also contributed to enriching knowledge of the "Calm Road", among others the SURE programme (*Sécurité des Usagers sur les Routes Existantes*, Safety Ranking and Management of the Road Network in Operation), and the concept can also develop by taking account of the results of research in France and elsewhere.

The working group that was set up after the conference, has now merged with the *Ifsttar*'s Self-Explaining Road working group, which looked into human factors and their incorporation in the design of the infrastructure. This group's goal is to produce a document reviewing the concept in terms of:

- existing operational initiatives. The initiatives that are already implemented in road projects include the CSPR (*Contrôle de Sécurité des Projets Routiers*, Road Projects Safety Control), which mainly aims to integrate road safety in every phase of the project (preliminary studies, pre-project, project). The ISRI programme (*Inspection de Sécurité Routière des Itinéraires*, Safety Inspections) is another safety initiative implemented in the life cycle of road infrastructure, just like the SURE initiative (*Sécurité des Usagers sur les Routes Existantes*, Safety Ranking and Management of the Road Network in Operation). The former aims to identify any shortcomings in the infrastructure that could produce situations in which an accident could occur, independently of any known accident studies and the behaviour of the users. The latter includes an analysis of reports on corporal accidents in an effort to determine the typical scenarios, factors contributing to accidents, the location of the problems and, finally, to understand the influence of the road infrastructure on accidents.
- initiatives contributing to the development of the RACA concept. As well as the existing initiatives, projects and research in France and abroad also provide input for the development of the RACA concept. In France, the *Ifsttar* contributes through its "operation of research" (SERRES: operational solution for safe and environmentally-friendly roads, Ifsttar, 2011, and I2V: The impact of visual information on driving behaviour, Charbonnier & Dumont, 2012). The *Sétra* contributes through its research into speed (adaptation of speeds, 70 kph zones, and an innovative project: safer roads, accident-free roads). Research projects, such as S_VRAI (Saving lives by analysing the feedback from incidents, Ledoux, 2011) and RoadSense (Prevention of Involuntary Lane Departures Based on Road Audio Tactile Warning, Anelli et al., 2012) also make a contribution. Outside France, the SER concept has spawned some concrete projects (SPACE: Speed Adaptation Control by Self-Explaining Road, Sjögren et al., 2012, or ERASER: Evaluations to Realise a common Approach to Self-explaining European Roads, Eenink, 2012) which provide useful and interesting input for the RACA concept. These ongoing activities will provide input that is essential to the consolidation of the RACA concept and will allow it to grow at the interface between research and operational studies.

All of the knowledge gathered in the course of these activities helps to develop the RACA concept and allows it to grow, in particular by looking into a broader approach that will allow the RACA concept to be integrated in every phase of road projects, so that, ultimately, it will become possible to design RACA roads.

3.2. Presentation of the RACA method

The idea of developing a RACA method, based on the discussions of the working group, emerged naturally in order to take the RACA initiative further and to make sure that the "Calm Road" concept is incorporated in road projects (new roads, renovations, existing roads).

3.2.1. The RACA method: Goals and challenges

The proposed RACA method must be linked to the existing initiatives (CSPR, SURE, ISRI, etc.), in as much as the indicators used in these other programmes could include the RACA road indicators, so that the projects meet the criteria of a RACA road layout. One of the planned developments consists of progressing from the concept to

the method, while integrating the initiatives that are already in place, for new projects, on-the-spot projects (*Aménagement Sur Place*: *ASP*) or for the existing network. First and foremost, the RACA indicators could be used to assess the road in terms of RACA goals, and in particular its impact on user behaviour. The *CETE Normandie-Centre* initiated this application of the concept in terms of indicators that can be used to assess any road project from the perspective of the "Calm Road" (F. Rosey & O.Moisan, unpublished). These indicators would obviously take account of speed, but not only of speed, as the results of the RACA-related research have already hinted. They could then be used to describe a RACA road and perform RACA assessments of any road project (layouts, routes or projects). In concrete terms, this analysis could be made using matrices, as is currently the case in the SURE and CSPR programmes, so that these operational initiatives can be integrated as efficiently as possible. The goal consists of making sure that an indicator reflects all the requirements of the trades involved in the road project and of defining the project phase in which they intervene. To this end, and in order to subsequently assess any road project, it is necessary to define the precise objectives of a RACA road beforehand. Ultimately, the goal consists of allowing the various stakeholders to collaborate right from the outset, in order to design a project that is consistent with all of the trades that may be involved.
In this case, this approach will help to identify the parameters that can be adjusted in order to improve the road from the perspective of the RACA concept, whether the project is still in progress or already exists.
Moreover, the aim of the initiative would be to incorporate a "user" variable, in order to check that a RACA road remains a RACA road (i.e., it still meets the criteria of a RACA road), irrespective of the users and the manner in which they use the road.

The question of the assessment of the RACA method consists of finding the right tools to assess or design a RACA road. The assessments of road projects will contribute to the assessment of the method itself. It is important to identify the tools that already exist for this purpose, and the tools that need to be developed.
3D viewers of road projects and driving simulators already exist. Driving simulators have already been used to assess road layouts, for example at crest vertical curve (Auberlet et al., 2010) or narrower lane width by laying down a multi-functional strip (Rosey et al., 2009), and to analyse the approaches to the roundabouts on the access roads at the *Notre-Dame des Landes* airport, in order to view the infrastructure and its environment and measure their impact on drivers.

This RACA method would incorporate the concept of the "Calm Road" in the existing operational approaches, in order to assess the various project phases from the perspective of the RACA indicators. These indicators still need to be consolidated, but this perspective would offer the means of concretely applying the "Calm Road" concept, in its extended form that goes beyond mere speed reductions, to road projects.

3.2.2. Building on and sharing feedback
Contrary to other countries, the feedback from the initiatives and experiments in France is not always accessible to all, because is not part of a national process yet. This situation does not encourage, for example, each French department to share experiences on new layouts which could contribute to the RACA concept. Therefore, a serious effort must be made to improve communications on the RACA experiments and their results, both today and in the future. The RACA method is an opportunity to insist on the need for systematic feedback in order to subsequently improve the assessment of the initiative. Ideally, it should be possible to promote and publicise the experiments that have opened the way for this innovative initiative, to share this knowledge and, consequently, to develop and improve the approach.

The project to capitalise on feedback should focus essentially on the project owners (the State, the regional or local authorities) in order to make them aware of this procedure, once a new layout project has been completed. Sharing this information, on, for example, the characteristics of the road layout and its users, would help to enrich everyone's knowledge and to avoid reinventing the wheel every time a new road layout project is planned. The interactive nature of the feedback cycle would also pitch the method against field studies, in order to make sure that the method remains close to the operational reality by integrating results from the field. This method of operation would enable the methods in place to be assessed more easily. It could also be strengthened by a process to assess layouts and to capitalise on data in order to make sure that the feedback is systematically taken into consideration.

4. Conclusion

Further to the "*La route autrement : concevoir des routes incitant à une conduite apaisée*" ("Road otherwise : to build roads to encourage calm driving") conference, organised in 2006 by the French General Highways Directorate, and after having compiled a comprehensive bibliography, in particular of research conducted abroad into subjects related to "Calm Driving" (behaviour, design, landscaping, etc.), the formal launch of the RACA initiative provided a means of reviewing current levels of knowledge in order to draw up specific reference documents.

The RACA concept has been applied to several projects, and in particular to the access roads of *Notre-Dame des Landes* airport, near Nantes. Moreover, the assessment of new road layouts from the perspective of speed reduction fits in closely with this course of action. The quest for innovative solutions proposed by highway operators, experiments and the assessment of new objects for highways have resulted in the creation of feedback sheets, method sheets and research sheets designed to build on and distribute knowledge.

The complete RACA initiative that has been deployed and the consideration of RACA-related research in France and elsewhere have caused the concept, which focussed only on speed reduction at its inception in 2006, to evolve. The RACA concept now takes account of users' behaviour in its entirety, rather than simply looking at the impact of infrastructure on speed. In this respect, the RACA initiative is also tending to become broader. The long-term goal of the initiative is to reach a point at which all the RACA criteria of a road are taken into consideration throughout the road project. These criteria remain to be defined, as do the objectives of the RACA roads to which they refer. Once they have been defined, work can start on integrating the criteria and indicators of RACA roads, for example through the operational programmes that already exist, such as SURE and ISRI. This appears to be an interesting route forwards for the future of the RACA initiative.

References

Anelli, P., Pardo, F., & Violette, E. (2012). Roadsense, Prévention des sorties involontaires de voie par alerte routière audio tactile. ATEXPO, Congrès International ATEC-ITS, 1er février 2012, Versailles, France. http://roadsense2013.eu/

Article R.110-2 1er du code de la route. Repéré à http://www.legifrance.gouv.fr/affichCode.do?idArticle=LEGIARTI000006841273&idSectionTA=LEGISCTA000006143847&cidTexte=LEGITEXT000006074228&dateTexte=20100429

Auberlet J.M., Pacaux M.P., Anceaux F., Plainchault P., & Rosey F. (2010). The impact of perceptual treatments on lateral control: A study using fixed-base and motion-base driving simulators. *Accident Analysis and Prevention, 42*, 166-173.

Charbonnier, P., & Dumont, E. (2012). I2V- Impact des informations visuelles sur les comportements de conduite. Séminaire Impact des informations visuelles sur les comportements de conduite, 19 juin, 2012, Paris, France. http://actions-incitatives.ifsttar.fr/fileadmin/uploads/recherches/seminaires/i2v/i2v_120619_0_Charbonnier.pdf

Eenink, R. (2012). ERASER - Evaluations to realise a common approach to self-explaining European roads. Final conference on the ERA-NET ROAD program Safety at the Heart of Road Design, 13 january 2012, Stockholm Arlanda, Sweden.

Ifsttar. (2011). Présentation de l'opération de recherche SERRES. http://actions-incitatives.ifsttar.fr/fileadmin/uploads/recherches/seminaires/2011-serres/serres-operation.pdf

Ledoux, V. (2011). Présentation du projet SVRAI, partenariat pour une démarche innovante de réduction du risque routier. Réunion annuelle 2011 de la COTITA plénière et conférences sur les risques, jeudi 17 novembre, Aix-en-Provence, France. http://www.cotita.fr/IMG/pdf/2011-11-17_SVRAI.pdf

Nilsson, G. (2004) Traffic safety dimensions and the power model to describe the effect of speed on safety. Bulletin 221, Lund Institute of Technology, Lund.

Rosey F., Auberlet J.M., Moisan O., & Dupré G. (2009). Impact of narrower lane width comparison between fixed-base simulator and real data. *Transportation Research Record, 2138*, 112-119.

Rosey F., Moisan O., (unpublished). Development of indicators that can be used to assess any road project from the perspective of the "Calm Road": this study will be part of the report currently being drafted by the RACA working group. This paper is expected to be issued in 2014.

Sétra. (2006a). Paysage et lisibilité de la route. Éléments de réflexion pour une démarche associant la sécurité routière et le paysage. Service d'Études sur les Transports, les Routes et leurs Aménagements, Bagneux, France.

Sétra. (2006b). Recueil d'expériences - Paysage et lisibilité - Approche « paysage et sécurité routière ». Service d'Études sur les Transports, les Routes et leurs Aménagements, Bagneux, France.

Sétra. (2008). Insertion d'une infrastructure routière – Concilier terrassements et enjeux paysagers – Note d'information n°84. Service d'Études sur les Transports, les Routes et leurs Aménagements, Bagneux, France.

Sétra. (2009). 2+1 lanes: an example in the Manche department – Experiment sheet. Service d'Études sur les Transports, les Routes et leurs Aménagements, Bagneux, France.

Sétra. (2009). A safer junction layout for calmer driving – Experiment sheet. Service d'Études sur les Transports, les Routes et leurs Aménagements, Bagneux, France.

Sétra. (2010). The "peanut" roundabout: a new type of junction – Experiment sheet. Service d'Études sur les Transports, les Routes et leurs Aménagements, Bagneux, France.

Sétra. (In Press). Intérêt de l'utilisation des simulateurs de conduite dans l'évaluation des aménagements routiers – cas de la rédaction de la largeur de voie au profit de bandes multifonctionnelle – Service d'Études sur les Transports, les Routes et leurs Aménagements, Sourdun, France.

Sjögren, L., Anund, A., Charman,S., Ahern, A., Pumberger,A., Cocu,X., Van Geem, C., Grayson, G., & Helman, S. (2012). Speed Adaption Control by Self-Explaining Roads - Final report. Deliverable Nr 6, March 2012, SPACE - Speed Adaption Control by Self Explaining Roads.