THE VISUAL IMPACT ISSUE IN THE CIVIL ENGINEERING CURRICULUM

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EXTENDED ABSTRACT

In 2000, the EU released the "European Landscape Convention". In February of 2008 the EU Committee of Ministers issued a more comprehensive document developing the guidelines for the implementation of the European Landscape Convention. In terms of the civil engineering infrastructures design, this document consolidates the need to know how to assess the visual intrusion that such design is going to produce on the landscape. This task is integrated within the corresponding Environmental Impact Assessment.

When a civil engineering infrastructure is projected, its effect can be predicted and expressed as the result of having analysed two essential factors (landscape and population) and having combined two assessments (one subjective, the other objective). They tend to be called visual intrusion intensity (the former) and visual impact magnitude (the latter). It is common to assist the intensity assessment with computer-graphic simulators, and more or less sophisticated virtual reality, as well as to formulate the magnitude with numeric indicators, derived from a calculation process which does not differ too much from the ones used to study other elements of the project.

At the Civil Engineering School of Santander, the assessment of visual impact has been a matter of research since the year 2000, and it has been a post-graduate master level course since the year 2006. The purpose of this study is to describe the scientific, technical and technological scope of its content, outlining its most noteworthy educational elements and forms.

The study will also briefly refer the proprietary tools developed to evaluate visual impact, both in their numeric and in their graphic aspects.

KEYWORDS

VIA, Visual Impact Assessment, LIA, Landscape Impact Assessment, EIA, Environmental Impact Assessment, MOYSES® v4.0, CANTAVIA® v1.0.

1. INTRODUCTION.

A study on the environmental impact produced by a civil infrastructure construction should incorporate an assessment regarding the visual aspect. This assessment should prevent and take into account the effects of this projected construction on the landscape and on the population living (or travelling) more or less nearby. This can be carried out from several different approaches; the most common may be explored using acronyms that have quite a precise technical meaning. This is the case with VIA (Visual Impact Assessment), LIA (Landscape Impact Assessment), LC (Landscape Character), LVIA (VIA + LIA) and CLVIA (Cumulative Landscape and Visual Impact Assessment) [Hutton 1998], [SNH2002], [SNH2005], [SNH2009]. Below is a detailed summary of their general characteristics, mainly extracted from [Hutton 1998].

1.1. Visual assessment: Landscape and population.

The analysis of the visual effect that an infrastructure may cause on a landscape requires a previous categorisation of the landscape value on the site where the construction is undertaken, and also of the area of visual influence (so-called "view-shed"). This area may have a magnitude of tens of kilometres (in the case of wind farms) or much lesser distances (in the case of industrial development zones, for example). In any case, it is clear that to know this effect, there must be some previous sort of qualitative classification of the landscape. The most common is the so-called Landscape Units Map, which subdivides the territory into a mosaic of zones which are characterised by means of a qualitative-type visual quality index (from 0-very low to 5-very high or similar). The way these maps are obtained (which has more to do with geomorphological, biological, and patrimonial features) pertains to the field of activity called "landscape impact assessment" (LIA), the details of which are beyond the scope of the purpose outlined in this communication.

Having the landscape units map available, the analysis of the visual effect that an infrastructure may have on the population observing the construction, and the physical changes it produces on its site is what is known as the "visual impact assessment" (VIA).

1.2. Visual impact assessment: fundamental problems and objectives.

The visual impact assessment (that, by the way, may be negative or positive) involves always an answer to 4 main problems:

- The technological problem of how to properly visualize its effect just when construction has not yet been undertaken,
- The technical problem of how to reliably assess this effect,
- The administrative problem of how to adapt that assessment to the environmental planning in force,
- The social problem of how to convey that assessment to the population, a task that proves to be the most controversial and delicate of all.

The basic functions of a study on visual impact are ordered according to these fundamental objectives:

- The organisation of the spatial and temporal data necessary to carry it out, on a local and regional level,
- A clear identification of different types of impacts.

- The prediction itself of the impacts.
- The clear quantitative and qualitative expression of them.
- A clear and accessible communication of these impacts.

1.2. Studies on Landscape Integration in Spain.

Spain has signed the European Landscape Agreement and, as a result, environmental legislation obliges very diverse types of infrastructure projects to incorporate in the environmental impact study a chapter dedicated to landscape. Nonetheless, there is not a very wide-reaching specific legislation concerning the matter. Currently, only three regional administrations (Catalonia, Valencia and Galicia) have developed a landscape law, an essential instrument in order to be able to properly develop a visual impact assessment.

The region of Valencia has approved a Landscape Regulation [CV 2006] in 2006. This contribution is supported by this regulation, because it is the one that this team has dealt with the most often and in the most depth. Its regulatory development creates the concept of Landscape Integration Study (LIS) as the main technical vehicle of instrumentation for visual impact assessment. Its most essential characteristics are described below.

1.2.1. What is the purpose of a LIS? Objective and determinations.

The objective of a LIS is to predict and assess the magnitude and importance of the effects that new actions may produce on the landscape's character and in its perception, as well as how to determine strategies to avoid impacts, or to mitigate possible negative effects. This objective has two fundamental expressions:

a) The Landscape Integration Assessment of an action, which analyses and assesses the capacity or fragility of a landscape to adapt to the changes produced by the action without losing its value or landscape character.
b) The Visual Integration Assessment of an action, which analyses and assesses the changes in the composition of views toward a landscape as the result of the implementation of an action, the population's response to these changes and the effects on the visual quality of the existing landscape.

1.2.2. What does a LIS detect? Causes of Landscape intrusion.

An action or a infrastructure is not integrated into the landscape, and consequently produces a landscape and visual impact when one or several of the following circumstances occurs:

a) It does not fulfil the regional or national Landscape Integration Standards,
b) It blocks or generates an adverse effect on some Landscape Resource,
c) It creates blinding or illumination which affects visual resources,
d) It reduces the integrity in the perception of a cultural heritage element, or negatively affects its historical meaning,
e) It differs and contrasts significantly with the environment or the surroundings where it is located, and reduces the visual value of the landscape due to its extension, volume, composition, type, texture, colour, shape, etc.
f) It dominates, negatively changing the composition of the landscape or its elements perceived from a Relevant Observation Point.

1.2.3. What range does a LIS have? Territorial scope.

The range in distance of a visual intrusion has been a topic of reflection and controversy. For significant impacts (electrical line towers, wind power towers), the most used references are due to Bishop [Shang 2000], which establishes three different thresholds distance values, corresponding to the average distance where (i) the perception of a shape, (ii) its recognition or (iii) its possible visual intrusion is produced. It is this threshold of type (iii) that comes to play in our problem. Taking into account this distance threshold, a LIS will take into account, for each plan, project or action, the complete Landscape Unit or Units affected by the view-shed of the action, both in its construction and exploitation phases.
In this regard, the view-shed is understood as the part of the territory from where the action is visible, and seen spatially as a unit generally defined by terrain and distance. The view-shed may contain a part of a Landscape Unit, a complete Unit or several Landscape Units.

1.2.4. What does the Landscape Integration assess? Assessment criteria.

The assessment implies classification of the importance of impacts as a combination of the magnitude of the impact and sensitivity of the landscape. The potential of corrective measures must also be identified. In the assessment, the importance of landscape impact will be predicted before and after applying corrective measures.

2. ELEMENTS IN THE VISUAL IMPACT ASSESSMENT.

2.1. Visual Impact assessment Technologies and Techniques.

Although other assisting tools have been tested and reported, the ones most frequently used rely on GIS technology to assess resources by recreating hypothetical situations in the territory. It is recommended to know the description offered by [Turnbull 1987]. In general, there are three types of analysis to carry out: a local landscape analysis, a territorial analysis and an analysis from previously selected points of view:

- The local analysis of the landscape studies the visual impacts from very specific locations from where one's gaze is directed toward very concrete, specific zones.
- The territorial analysis (the most common technique) is carried out by calculating Zones of Visual Influence (ZVI). The ZVIs are the result of the sum of several view-sheds. The observer sets a number of vantage points, a view-shed is calculated for each one of them and the aggregation of these view-sheds makes up the ZVI, which is normally represented with a coloured map marking visibility intensity. See figure 1.
- The Viewpoint Analysis makes use of certain critical points of view previously selected, and from where the alteration in landscape may be perceived by a maximum of people and with very notable effects. A complete presentation of the method may be found in [Otero 2004].

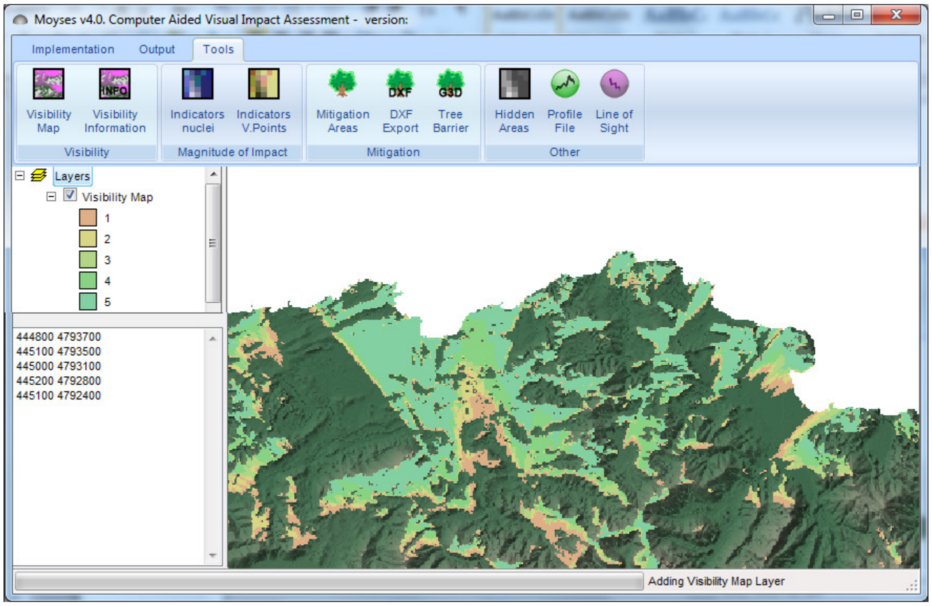
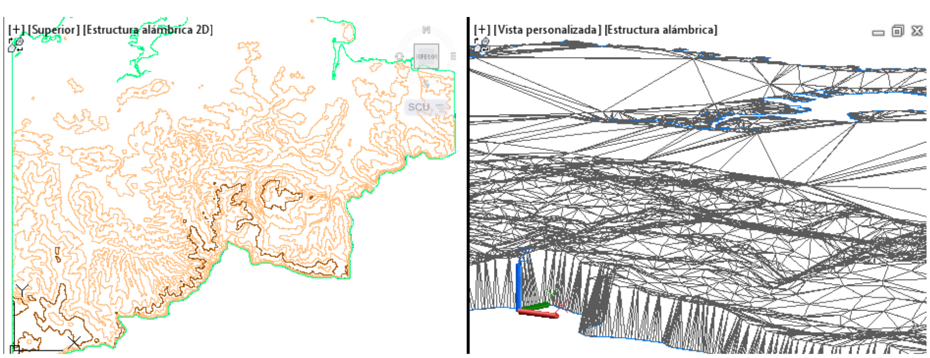


Figure 1: ZVI made by the aggregation of 5 view-sheds.

Along with the GIS techniques, simulated results based on graphic computation offer several techniques (see fig. 2):

- Wire-frame: the terrain is presented as a mesh (regular or not, with triangles where only their vertexes and sides are represented).
- Surface model: the terrain is also represented by triangular faces, in such a way that it is feasible to apply hidden lines and faces removal algorithms, or rendering operations.
- Combination of surface model with orthophotography: this is the most common technique nowadays. A model of the terrain is combined with aerial images of the ground, applied as texture. The result is very descriptive and may be explored in real time, flying or moving on the ground.
- Image processing: it merges real photographic images with other virtual ones (many times extracted from the previously described systems) to present the results hoped to be produced via manual manipulation. It is quite an artisan technique, and very controversial, but proves to be necessary in some of the assessment phases.



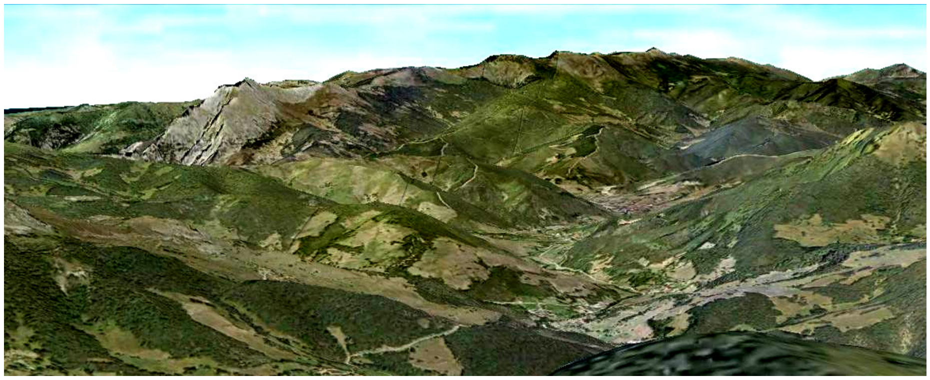


Figure 2: Simulated results based on graphic computation

2.2. Resumed work flow in a Landscape Integration Study.

The following sequence orders the typical work flow in an LIS:

- Identify the vantage points, the Landscape Resources visually affected and the scenic routes (roads with exceptional landscape value).
- Select viewpoints and visual itineraries of greatest public affluence which will include, in addition to others, the following: main communication roadways, population nuclei, principal recreational, tourist and massive affluence areas, and panoramic viewpoints.
- Obtain the view-shed for each viewpoint selected, marking short, medium and long distances from the observation point, determining the number of potential observers of the landscape being studied, but differentiating their proportion in relation to the following categories: residents, tourists and itinerants. Also the estimated duration of observation in the case of scenic routes or itineraries.
- The Observation Points will be classified as principal and secondary, according to the number of potential observers, the distance and duration of the view.

According to the level of importance, zones with maximum visibility, medium visibility, low visibility and those not visible or shadow zones will be obtained. Maximum visibility zones will be those perceptible from some principal observation point. Medium visibility zones will be those perceptible from more than half of the secondary observation points, and low visibility will be the ones visible from less than half of them.

3. THE CIVIL ENGINEERING SCHOOL COURSE.

3.1. Master’s Degree in Research in Civil Engineering.

Since the year 2007, training PhD students at the Civil Engineering school of Santander is undertaken with a PhD programme in Civil Engineering, which includes a preparatory phase (which essentially takes the form of a master of science degree in civil engineering, with 60 ECTS), followed by a doctorate phase, wherein the student prepares his/her doctorate thesis. Any qualified member at the Civil Engineering School of Santander may supervise doctorate students in this programme, which is a compulsory re-formulation of the one created in 2005 with the name Doctorate Programme in the “Development and application of Models in Civil Engineering”.

The subject of “Computer Graphics Applied to Visual Impact Modelling” (3 ECTS) is offered in the master level and has been in force since the year 2006. At the beginning, the weight of the purely graphic and descriptive component was greater, and this is why the name maintains the initial denomination of Computer Graphics. However, evolution and experience have shown that a large part of the knowledge summarised in the previous sections constitutes a matter to learn and work. The most relevant aspects of the syllabus and the individual project work proposed in this course are described below.

3.2. Computer Graphics Applied to Visual Impact Modelling Course.

The course has an eminently instrumental and practical character. In fact, of a total of the 3 ECTS, only 4 hours are dedicated to conventional theoretical sessions; 20 hours are developed in the laboratory, and 45 are personal work that, in reality, is carried out almost entirely in the course laboratories, since part of the necessary software can be exclusively used there. At the moment, this is possible because only 20 students by year undertake the master. The official documentation [MIIC 2011] of the subject presents these educational features:

- Specific competences
  - Knowing the technologies, tools and techniques in the field of Visual Impact produced by engineering infrastructures and constructions, especially related to civil engineering.
  - Being capable of identifying, measuring, stating, analysing, assessing, modelling, and scientifically and technically describing a Visual Impact problem within the scope of engineering.
- Results of learning in the course
  - The student will model, assess and express the visual impact of human actions, using computer graphic design tools.
- Course objective
  - To develop the methodological bases to begin the instrumental training of a researcher in the subject matter indicated in the title.
- Course programme: the topics and their distribution in classes of the diverse modalities are described next:

Table 1: Course programme

LESSON	THEORY	LAB	TUTORIAL	EVALUATION	GROUP WORK	INDIVIDUAL WORK
Computer Graphics (CG). Fundamentals. CG Standards.	1h.	0				
CAD Systems. The Advanced Program Interface (API) of a CAD system	1h.	2h.				
Civil Engineering CAD Systems. The API of a Civil Eng.CAD system		7h.				
GIS for VIA and LIA		2h.				
Tools of Virtual Reality for Civil Engineering	2h.	3h.				
VIA in Civil Engineering projects and works		6h.				
FINAL PROJECT			3h.	3h.	15h.	30h.
TOTAL	4h.	20h.	3h.	3h.	15h.	30h.

- Objectives and indicators of final course project: the detailed objectives as well as the elementary results to be achieved are shown in the table below. The final evaluation requires a brief presentation and defence.

Table 2: Objectives and indicators

OBJECTIVE	INDICATORS
Graphic data capture	a. Altimetry (mdt) b. Planimetry (nuclei, motorways, forests, viewpoints, landscape itineraries)
Computer-assisted civil engineering systems.	a. Alignments b. Profiles c. Cross sections d. Corridors
Preparations previous to visual impact assessment.	a. Assess population nuclei affected by the impact b. Classify them by distance (short, medium or long). c. Make a table of affected population. d. Assess motorway sections affected by the impact. e. Classify them by distance (short, medium or long).
Visual Impact Assessment	a. Practise defining a visual scope with sections radiation. b. Definition of a view-shed: spatial analysis
Simulation: Pre-processed.	a. Create mdt in tiff format with 5m pixel. b. Select adequate photos for covering. c. Shade the road zone in AutoCAD with MPOLYGON type entities d. Export the previous entities to shapefile e. Export population nuclei to shapefile. f. Export motorways to shapefile
Simulation. Project creation	a. Create the project. b. Load the terrain c. Load the photos (or part of them) d. Load the shapefiles e. Create vectorial layer groups. Import vectorial layers f. Load toponyms g. Create places category h. Incorporate places
Visibility results.	a. Create infos category b. Put various information about the roadway c. Create views d. From visible population nuclei to roadway info e. From first order visible roadway stretches to roadway info.
Semi-automatic generation of computer graphics	a. Capture computer graphics from the simulator b. Capture real photographs c. Filter elements and superimpose

4. THE TOOLS CREATED FOR LEARNING. (MOYSES® AND CANTAVIA®).

Supporting the Computer Graphics Applied to Visual Impact Modelling course, there is a research and development activity which was initiated 11 years ago. During this time the team teachers in charge of this subject have collaborated with the regional administration in the region of Cantabria, the construction company DRAGADOS, the Companies GENERCAN and E.ON-Renewable Energies, and with the national Ministry of Development. As a result of the work contracted or subsidised by these companies and entities, two internally developed applications are now available:

- MOYSES: Modeller and Simulator for the Evaluation of Visual Impact.
- CANTAVIA: Cantabrian Visual Impact Assessment.

The first of the applications supports the greater part of the specific GIS calculation process (indicators, ZVI, Viewpoints, View-sheds, etc.), while CANTAVIA is the 3D interactive simulator developed to incorporate any project in the Cantabria region territory

(Spain). Both elements could be the topic of specific communication to EUCEET. In any case, figures 3 and 4 give a first idea of their most noteworthy characteristics.

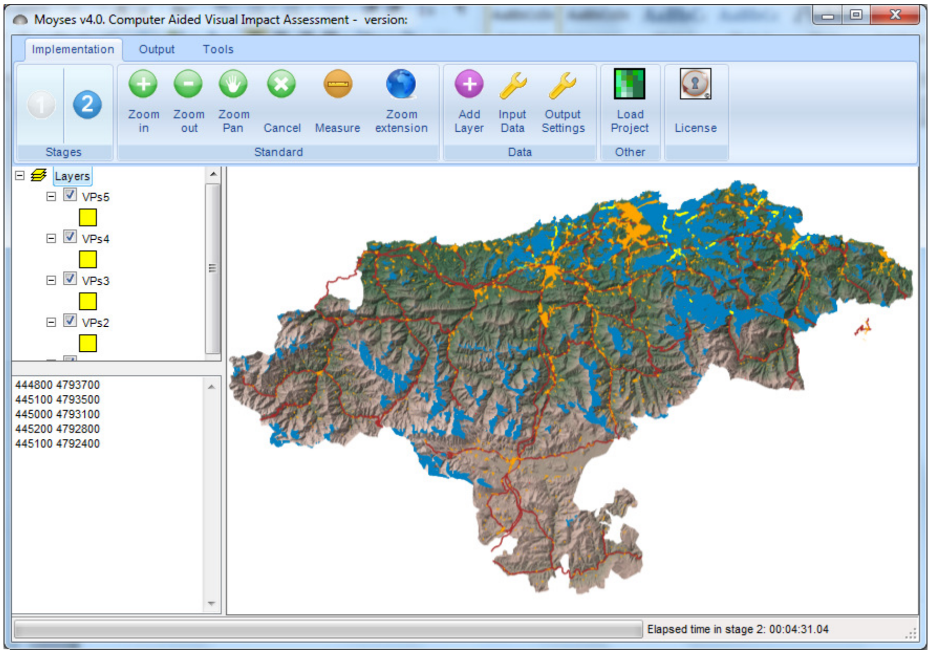


Figure 3: Application Moyses v4.0. On-screen, the result of calculating visual scopes.

Figure 4: general view of CANTAVIA

5. CONCLUSIONS.

Visual impact assessment, as an integral part of environmental impact assessment, is compulsory and requires professional training; this training can become a specific professional competency. In regards to civil project and construction, it again proves quite useful that the civil engineer (and no other specialists) is the appropriate professional to carry out (or to lead and supervise) the VIA study into a project-planning.

As has occurred on many occasions in the past, this implies reaction capacity on the educational sector's part to be able to offer this training in reasonable quality and opportunity conditions. The annual EUCEET 2011 conference is an appropriate occasion for the Civil Engineering School of Santander to present how they are carrying this out. In the document, an effort has been made to present the discipline from its foundation to its current development in a summarised format.

ACKNOWLEDGEMENTS.

MOYSES v1.0 (2001) was a partial result of the GETS Project EU, the TMR Program (1998-2000) [UE. FMRX-CT98-0162].
MOYSES v3.0 (2007) has been developed with funds from the "Plan Nacional de I+D+i" (National R&D Plan), Spain (Project 800018/A04, 2005-08).
MOYSES v4.0 (2011) is being funded by the contract ref: UC-24.2846.64001 with E.ON Renewable Energies CO
CANTAVIA v1.0. (2011) was partially funded by the contract ref: UC-24.2846.2846 with GENERCAN (Department of Industry of the Government of Cantabria).

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