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## **THE ADJUSTMENT OF ROAD ASSETS WITH RESPECT ON THE ENVIRONMENT**

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## **ABSTRACT**

Italy has an extensive infrastructure system which, both due to degradation over the years and to failure to meet the newer safety standards, inevitably require periodic adjustment and recovery works. This is a challenge for local government and planners, as they will be increasingly required not to design new infrastructures but to plan adjustment and/or renovation of existing ones: an undoubtedly more complex task. In the case of roads, recovery and adjustment can be seen from different points of view including safety measures, but also various environmental, social and urban planning factors. In the first place it is clear that most of the roads are based on outdated design criteria unsuitable for today's use, so adjustment of the horizontal and vertical alignment of the road is necessary. However, this is not sufficient and a step back is needed to remember the reason why roads were created: they have made communication between peoples possible. Ancient Romans make a shining example: consular roads, like Appia and Cassia, allowed communications with the whole empire and are still routes of fundamental importance for our national road system.

Adjustment works should therefore allow recovery of this function in order to promote and distribute the economic and social development to the decentralized and isolated regions. Moreover, local context should be examined during preliminary design in order to analyze the delicate hydrological balance and the whole ecosystem and plan maintenance and/or recovery works accordingly. The purpose of this paper can be summarized in the following considerations: the adjustment of a road cannot exist without reconsideration of its strategic function, together with the respect of the environmental context it is inserted in.

**Keywords:** adjustment, function, environmental Introduction

## **INTRODUCTION**

Italy has implemented an extensive infrastructural system which needs adjustment, recovery, and maintenance works for various reasons, such as the need to comply with new safety standards or its inadequacy to new uses.

The adjustment of existing road system can be a strategic issue for the socioeconomic development of the country, since it is going to be a increasingly important subject for study, research and design. For instance, the historical centers of Italian cities, the suburbs and the streets, together with railway lines to be partly reused as light rail system, can be adapted to new uses on different territorial levels. As for the streets, the adjustment can be seen as providing support to the highway and to the structural network, at national, interregional and regional levels, to improve safety conditions, particularly poor in suburban ordinary streets, and to ensure better accessibility to those regional areas, especially piedmont and internal ones, in conditions of marginality, from which populations continues to migrate towards urban areas, better equipped and served by more efficient transport facilities. AA.VV.(1996)

The Committee appointed to set new standards for the adjustment of existing roads suspended its activities when a draft of "Rules for adjustment of existing roads" was issued. The preface to this document states that the existing road network is significantly extensive and has the most varied physical characteristics, defined by reference to different criteria and design standards which, in some cases, no longer fit with the current ways of use. Commissione per la predisposizione di nuove norme per gli interventi di adeguamento delle strade esistenti (2006) The immediate consequence is the substantial inadequacy of the existing road network in terms of infrastructure provision, with consequential impact on service quality and safety. Annunziata et al.(2010) The document also highlights that adjustment actions have been put in place over time in the absence of specific regulations: this has introduced elements of inconsistency in the composition of the road space along the various routes, and particularly in secondary roads which show more interactions with the local context, either natural or artificial.

## **THE MANAGEMENT OF ROAD SYSTEM**

A global road network is usually made of various roads, managed by different authorities, interconnecting with each other and, possibly, with different networks, and therefore requiring territorial management at a higher level than that of their individual owner.

The global road system is typically intended as composed of roads, i.e. the infrastructures directly required to enable movement of vehicles, including functional appurtenances managed by the same owner.

This concept is thought to limit the assessment and the consequent work set-up which, therefore, needs be reconsidered: it is necessary for the different managing authorities to work together in order to define the needs of the infrastructures under their responsibility, considering them as part of a more complex system which serves a given area seen in its unity, although subject to the decisions of different authorities. The direction of this coordinated management can only be entrusted to regional government; this allows planning of actions and allocation of financial resources to be based on a concerted preventive assessment of needs and therefore on the identification of the required measures.

The prevailing purpose of infrastructure network management, within a highly structured system of decision support, is to maintain it appropriate for the functions assigned to each of its components within a given life: when an infrastructure does not meet all or part of the requirements, a functional adjustment is necessary to amend abnormal situations. Functional adjustment works, in particular, will be necessary as a result of an unexpected variation in the required functions of the road, which causes a reduction of the useful life and/or its inadequacy to meet the new requirements generated by the varied conditions of use. Thus, new design and planning choices are required since infrastructures need qualitative and/or quantitative adjustment. Planning functional adjustment for existing infrastructures is often more difficult than designing new ones; in fact they were meant to meet different design criteria and are often characterized by a marked heterogeneity of compositional elements, since they were usually designed and built when no design standards techniques were available. Considering this, when planning functional adjustment actions it is not possible to refer to the same criteria used in designing a new infrastructure, which are based on a set of prescriptive rules for each of its composing elements: new regulations are therefore necessary. It is recommended that, in the absence of specific regulatory guidance, rules for new roads are to be referred to, allowing greater flexibility on application of the relevant prescriptive criteria in order to provide context-sensitive design. *Ispettorato generale per la circolazione e la sicurezza stradale (2001)*

Our proposal is to consider road system management as including design, maintenance and adjustment, aimed at maintaining/improving the service provided by a infrastructure network. In this perspective, management of a key or first level route of regional interest should be based on a study considering all the network components which are fundamental, for instance, in order to support the same functionality as primary routes. Geometric and design characteristics of the main route and its ordinary suburban road sidings, as well as location and choice of the type of intersections need to be defined.

For both main routes and sidings the approach to be followed in planning of adjustment actions is “preventive,” enabling network management to ensure operation even under adverse weather or traffic conditions, and/or during maintenance works, albeit with service level reduction, always in stable flow conditions. Attention needs to be drawn on the importance of the ordinary road systems which should be recovered in their function of raising/ensuring operation of higher territorial level routes, in order to implement the highway network service to the territory they belong to.

## **THE SERVICE OF THE ROAD TO ITS TERRITORY**

The objective of road management is providing a service for a time period called useful life, but this concept should refer to several intrinsic characteristics of the road infrastructure. In fact, attention is generally drawn on degradation of the physical elements of the superstructure and its artworks, but vision should be broadened introducing another parameter related to the design flow. The loss of stable flow conditions indeed causes the decay of the ordinary operation of the infrastructure and therefore makes it necessary to intervene in order to ensure the continuation of the useful life in view of the varied vehicular design flow conditions and/or of its composition.

Moreover, whether the road is considered as part of a network and/or a local context, or if social, urban and ecological factors are taken into account, it is clear that, in evaluating the condition of road degradation, according to different needs, the following should be considered:

- local context;
- road system.

As already mentioned, the deterioration of a road and/or of a road network implies that they are no longer able to perform the function assigned at a given level of service, because, for example:

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- demand for transportation has changed due to variations on territorial organization or on regional transportation system;
- environmental, social and/or economic conditions of the context have changed;

and therefore the geometric and design characteristics assigned to the different road network segments will prove inadequate to meet the expected new features of the current vehicle flow. Annunziata et al.(2004)

This comprehensive approach to network management can result in the need for functional recovery, as well as assigning functions requiring adjustment and/or partial design to sections of the existing road network. According to this approach, it is fundamental to study the delicate hydrological balance and the whole ecosystem of the territory so that they are respected and restored, if needed. It is also necessary to respect the principle of correctly harmonizing the infrastructure in the local context from the visual point of view. It would also be important to make good use of naturalistic engineering works, where possible, using other consultants such as geologists and botanists. Preliminary design, in particular, should indicate the various critical issues of the area, the different actions needed, the characteristics of the road system, particularly its artworks and its horizontal-vertical alignment, as well as the priority order in the design and implementation of the infrastructural works on the different “functional lots” of the road network. Priority of actions aimed at healing the critical environmental issues of the area could depend on the infrastructural works design; or the need/desire to solve an infrastructural problem, in line with a pattern of territorial organization, could drive action on physical-naturalistic environment to solve its critical issues. This results in the route design highlighting both the critical environmental issues and the need to solve them: the overall project, meeting the criteria of sustainability, will lead to designing the road as part of its context, with its characteristics and criticality, adopting a cultural choice to find reasons and ways to increase the positive benefits arising from the road design.

The Environmental Impact Study, therefore, should not only limit the alterations of the existing natural balance, but restore it during planning and execution of the actions. Annunziata et al.(2007)

Special mention is to be given to civil defense plans which should be taken into account when planning requalification actions. These may consider suburban routes as having a synergistic function to the main routes, in order to ensure crossing of and/or accessibility to a given area. Among the elements for assessment of action priority, planners should consider whether it is convenient to identify which roads are to be adjusted and adapted to the needs of “civil defense”, on which traffic flow could be diverted, albeit with lower service levels, when mobility is penalized by the critical conditions occurring in the area and/or on its main routes.

These roads, often mistakenly referred to as alternative, should be designed together with the adjustment of the main route, and the interconnections of the different routes should be similarly designed to facilitate the use and management of the road system.

## **FUNCTIONAL RECONDITIONING OF A ROAD NETWORK**

The above mentioned issues imply that functional reconditioning should start from the attribution of specific functions to individual road elements. This requires that a classification method for existing roads is defined, based on comprehensive or sector design, with infrastructure specifications and other planning tools. The obvious goal of classification is to standardize the characteristics of the different types of road infrastructure. This will result in a validity check of the functional hierarchy of roads, identified by the planning tools. Framework and planning projects of the network considered, if any, should therefore be examined, identifying assigned and performed functions as medium to long term goals of the existing roads in that network (main, primary, secondary, local functions).

In view of the fact that road network design is part of reconditioning/reorganization of the context the network belongs to, it is appropriate that the environmental impact study begins, in the drafting of the Transportation Plan, with a Strategic Environmental Assessment (SEA). This document is provided for by Directive 2001/42/EC of the European Parliament and Council on the assessment of plans and programs related to the environment, and it represents a new way to use environmental impact assessment tools to decide territorial transformation. In Italy, SEA has been transposed by D.L. 16/01/2008, no. 4 “Additional provisions amending and integrating D.L. 03/04/2006, no. 152, establishing environmental regulations.” It implies that the evaluation phase is performed during the preparation of plan or program and before its adoption or submission of the expropriation proceedings.

SEA aims to ensure that human activities are compatible with the conditions for sustainable development, and therefore in compliance with the regenerative capacity of ecosystems and resources, the preservation of biodiversity and equitable distribution of benefits related to economic activities. In this context:

- environmental assessment of plans and programs which can have a significant impact on the environment aims to guarantee a high level of environmental protection and contribute to the integration of environmental considerations into the preparation, adoption and approval of such plans and programs, ensuring that they are consistent and contribute to conditions for sustainable development;
- environmental assessment of projects is aimed at protecting human health, at contributing to quality of life by means of better environment conditions, at ensuring maintenance of the human species, and at maintaining the reproductive capacity of the ecosystem as a basic resource for life.

SEA is a process which includes conducting a subjection check, drawing up an environmental report, carrying out consultations, assessing plans, programs, and the results of consultations, expressing a justified opinion, information on the decision and monitoring. Considering plans and programs which can have significant impacts on the environment and cultural heritage, assessments are made for each plan and program related to the evaluation and management of air and environment quality, or to farming, forestry, fisheries, energy, industry, transport, waste and water management, telecommunications, tourism, town and country planning or territorial organization, defining the framework for approval, authorization, location or, in any case, carrying out of projects listed, for example, in Italy's D.L. 16/01/2008, n. 4.

Performance objectives are therefore specified in the definition of the functional class the infrastructure will fit in after adjustment actions, and these objectives need to be congruent with those specific of the requested functional class.

The following can therefore be considered among the goals of functional reconditioning of a road network:

- contributing to a territorial reorganization aimed at balancing the overall system of settlements and services;
- the adjustment of road networks in order to meet civil protection requirements, so that connections to and across a given area are guaranteed;
- enhancing the road network connectivity features within a transportation system;
- improving territorial accessibility;
- enhancing traffic safety conditions and improving service levels.

The "target goal" of sustainable environmental quality of the actions is to be added, since it needs to be addressed to from the beginning of the planning phase in the preliminary design.

Moreover, greater attention is to be given to the fact that road systems are used to manage the location of activities on an area. An infrastructure transport system aimed not only at speeding up the connections between suburbs and centers, but also at laying the foundations for a different organization of a given area, achieving goals of territorial balance, can be considered even more convenient than all the other design alternatives.

## **ADJUSTMENT ACTIONS**

In particular, adjustment actions obtained by creating new works needed to improve functional performance of the road network are not only meant to achieve the above mentioned objectives, but also to improve performance of the road network in terms of:

- quality of service;
- fail-safe infrastructure;
- environmental quality,

within the constraints of existing conditions and particular situations. Annunziata (20011)

Performance objectives are in fact defined in the planning process of the road network which the infrastructure belongs to, in which the infrastructure functional class, expected after the adjustment actions is defined; performance goals of the infrastructure should be congruent with those of that specific functional class.

The definition of performance objectives, related to the quality of traffic, consists in making choices regarding, in particular, the following parameters:

- quality of service of the road as a result of the adjustment works;
- annual rate of accepted operational situations during which the quality of service is lower than expected.

Defining safety performance objectives implies making decisions about the limit value of the number of accidents per traffic and length unit, referred only to accidents involving deaths or injuries and based on the present characteristics of the road considered. In the absence of reliable average accident rates and appropriate critical levels to refer to in

fixing limit values, an objective of reducing accident rates by at least 15% of the average value estimated on the road under study could be set. In this regard, it is believed that timing indicated by D.L. 15/03/2011, No. 35 “Implementation of Directive 2008/96/EC on road infrastructure safety management” should be appropriately anticipated. Road Safety Impact Assessment (RSIA), containing an analysis of the impact that a new road and of a substantial modification of the existing network, also resulting from adjustment actions which involve changes to the route, can have on the safety level of a road network, needs to be drawn up for roads belonging to the network of national interest, as well as those managed by the autonomous regions and provinces. Often these suburban ordinary roads – inadequate in their design and geometric characteristics, and with at-grade intersections which are often not properly located and designed – are the scene of serious accidents even if their traffic volumes are significantly lower than those affecting highways and the networks of national interest.

In order to define these parameters, in most cases, values specified for the new roads in a functional class similar to that expected for the infrastructure after adjustment actions should be referred to.

The definition of performance objectives related to the environment quality is basically about the choice of the limits of:

- noise input levels into the surrounding environment;
- concentration of pollutants in the air, given the direct relationship between concentration of pollutants and traffic flow;
- concentration of pollutants discharged into soil and waters.

Designing of adjustment actions on a network as a whole, and the adoption of appropriate measures for the network management will be aimed at maintaining the flows on the segments within the limits of their environmental capacity. In defining design objectives of adjustment actions, an objective framework of priorities should take the following into account:

- the role assigned to each route in the context of the network and its efficiency, in terms of the service provided, of operational reliability and environmental criticality;
- the type of necessary adjustment actions, in order to evaluate programs as a whole, and manage organic actions allowing significant economies of scale within homogeneous performance standards;
- the dynamics of processes under way, on which the laws of functional obsolescence depend, to identify the action timeframe and ensure the containment of costs by mean of renovation of the existing infrastructure.

Moreover, when defining the objectives, it would be appropriate to propose a consideration on the territory and its forms of organization, particularly with regard to “minor urban systems.” An urban system is defined as a complex of communities and centers interacting with each other. Gravitation phenomena are common, mostly directed towards strong polarities which mark the centers of the system. There is a difference between strong and weak urban systems, which can be identified based on several factors, such as the number and quality of services, traffic patterns, and production dynamics.

When considering these contexts, territorial balancing should be the objective, by means of maintenance of resident population, which is valuable economic and environmental resource of the area, and creating a system of punctual collective use services, made of service centers of different sizes linked together and to the settlements they serve. Reconditioning of a road network should not simply remove the critical issues related to the traffic flow, but it should be aimed at consolidating the system of service centers, especially in areas where such systems are vulnerable and at risk. This road network seems to be identified as consisting mainly of suburban ordinary roads. Attention should therefore be drawn on the importance of this type of network, which needs to be recovered in its function of raising/ensuring operation of higher territorial level routes.

In order to better explain what stated above regarding the definition of priority criteria, it seems possible to argue that regulations, which articulate the design in three subsequent levels of technical elaboration, should be rethought in the sense that restricting the management of a road to its mere structure seems to be limited. If management of an infrastructure network – including planning, design, maintenance and adjustment – is an important part of a restructuring/reorganization project in a given territory, in order to improve accessibility, as well as to give roads fail-safe features, it should be extended from the single road to those network elements providing interconnection with other roads which complete the routes serving the area they belong to. Priority choices need to involve those elements of the existing road network which are to be reconditioned, and thus adjusted, so as to comply to the assigned function in the reorganization of the transport system serving a given territory.

Therefore, it seems appropriate that preliminary design is derived from a feasibility study which considers the road as part of a network together with its connections to the territory, as important as the road itself in order to remove the conditions of poor accessibility. The feasibility study should first identify the geometric and design characteristics of the main route and of the interconnecting ones as well as locate and select the intersection types. The primary network is to be seen as a whole, albeit with different hierarchical positions, functions and in different types of road.

All alternative hypotheses identified, seen as consisting of a main route, connecting junctions with other routes, and of the synergistic stretches of road serving a given area, should be compared by evaluating the different objectives of each of them and their degree of realization. Different priorities of main and secondary routes should be estimated within the network to which they belong in their synergistic relationship to the territory they serve.

Therefore, in conclusion, it appears that recovery, adjustment and enhancement works should be referred preliminarily to the local context and the service network, so as to ensure infrastructure conditions aimed at the recovery of territories currently penalized and thus marginal.

## CONCLUSIONS

The management of an existing road system should correspond to a precise classification of the road network, based on design planning of reorganization of territory and of transportation. The assignment of functions, and therefore of geometric and design characteristics, needs to be the outcome of a check carried out by means of an evaluation which also takes the social function of the road into account, so as to ensure adequate connections with all parts of the Country, fostering a more homogeneous distribution of services on the territory.

If the design is an important part of a renovation/reorganization project of a given area in order to improve accessibility as well as to give the road fail-safe features, it is advisable to extend design to consider the relationship with those network elements providing interconnection with other roads, thus enhancing the functions assigned to the route.

This means, in other words, that the route is to be designed taking into account the junctions interconnecting with other routes of the same hierarchical level and of next higher or lower levels. If the ultimate goal of road design consists in finding the best compromise solution for functional, economic and environmental needs, the infrastructure should meet, its goal should be always maintaining the service provided by the road even in case of adversity or critical conditions.

During the planning and design phases, it is necessary to carry out a strategic environmental assessment as this would be the only way to ensure a high level of environmental protection and promote sustainable development. SEA has, in fact, the primary aim of highlighting the compatibility of objectives and operational strategies of a design or program with that area, based on the levels of sensitivity and vulnerability which were previously identified.

Actions of overall functional reconditioning of the existing road network need also to be defined by environmental impact studies. This report examines and determine the measures needed to mitigate and offset the effects on the environment and public health of the actions planned, and to redevelop and improve the environmental quality of the local context. The environmental systems are thus described highlighting any existing critical issue; then areas, components, environmental factors and the relationships between them will be analyzed from the perspective of the specific case.

The environmental framework assesses multiple uses of environmental resources, priorities in those uses, and further potential uses caused by the project proposed, as well as existing quality levels for each environmental component affected and any degradation phenomena under way.

Reference regulations for environmental impact studies and for environmental assessment procedure set out the categories of infrastructures subjected to that procedure. However, a road infrastructure, regardless of the type to which it belongs, is always a new/renovated element placed in an environment characterized by its own natural balance. It is therefore up to the sensitivity of the managing authority, of the local government, and of the designers with their technical capabilities ensuring management of road systems in accordance with criteria of compatibility and environmental sustainability.

Priority needs to be given to those elements of the existing road network to be renovated, and thus adjusted, in order to comply to a new function assigned in the reorganization of the transportation system, preferentially removing unsafe conditions and improving service levels. Therefore, in conclusion, degradation, and recovery, adjustment and

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enhancement actions, should be preliminary referred to the local context and to its road system, so that working on a route and the connecting junctions becomes an opportunity for healing environmental critical situations of that area.

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