THE GOALS OF ROAD SYSTEM MANAGEMENT

Authors:
Annunziata F.
Full Professor - University of Cagliari - annunz@unica.it
Maltinti F.
Researcher - University of Cagliari - maltinti@unica.it

ISBN 978-88-902409-0-4

ABSTRACT

The design of a transport infrastructure is the result of an interdisciplinary cooperation among different cultures, which treat topics that have reference to the wide theme of relationships between road and surrounding area. The road design is an important part of the restructuring/reorganization plan of a given territory, to improve its accessibility in a logic of territorial balance. The goal aims to preserve the environmental and economical resource given by the settled population as well as to give the same security network characteristics. Therefore, it is appropriate to design and to maintain a particular corridor with attention to those network elements that provide an interconnection with the routes making part of the same hierarchical level or the level immediately lower/higher.

The concept of "environmental impact assessment" means to analyse pre-emptively the problem concerning the total relationship of a road intervention with the crossed area, to estimate the risks linked to the road construction and to consider the constrains, given by the condition/goals that have to be achieved to create a specific organizational territory scheme. Hence, the physical and naturalistic constraints, also dependent on the maintenance of the existing environmental balances, should be considered in the allocation of certain functions in the route in question. The design level allows to have indications on the different criticalities of the crossed area, interventions, characteristics of the road, in particular those concerning its work of art, the same plano-altimetric diagram and again, in the same order of priority, on the design and implementation of different "functional lots in the roads".

The need/wish to solve an infrastructure problem will lead to the necessity of working on the physical and natural environment with the goal to remedy criticalities. Therefore, it appears that the design and the adjustment of the route highlight the environmental criticalities and the resulted need to solve them.

Keywords: SIIV, Rome, conference, guidelines for authors.

INTRODUCTION

It should be immediately stated that road system management is part of the general management of the transport system: the government of a country or region needs to meet the demand for mobility of people and goods, taking into account all transport modes. A possible definition of road system was proposed at the AIPCR (World Road Association Italy) XXVI Road National Congress: "It is the system consisting of the road, the infrastructure needed to allow vehicles to travel, made up of roadways, shoulders, aggregate base courses, road signs and markings, guardrails, artwork, water drains, etc. These include the infrastructure functional appurtenances under the responsibility of the road owner: embankments, fences, walls, sidewalks, parking and service areas, and expropriated areas close to the road, though not directly used for the implementation of the road project.", Annunziata et al. (2010). This definition tends to include all elements already available to the road owner, used or usable for road management, and it excludes the surrounding areas which require further expropriation in order to be used.

The above definition of road system appears to limit the consideration of the global road network, since the latter generally consists of several roads, operated by different owners, interconnecting with each other and possibly also with networks of different kind, and thus require a territorial management, at a higher level than the owner's competence. This concept and the resulting work setting should therefore be reconsidered with the different operators organizing their own activities keeping in mind that theirs is part of a more complex infrastructure system. Single actions will need to be seen in their interconnections with and their impact on the infrastructures managed by other organizations: the system is to serve the territory as a whole, although several organizations are responsible for decisions. The regional government will necessarily have to coordinate all the activities; this allows planning of actions and allocation of financial resources to be based on an agreed-upon verification of needs leading to the identification of necessary actions.

The concept of management also needs to be defined. A definition was proposed by AIPCR: "The management of infrastructure assets involves the application of economic principles and methods of good technical practice in a highly structured decision support system, aiming at the best allocation and use of resources." Annunziata et al. (2010).

The above definition should include design, construction, operation, maintenance and adjustment, as subsequent stages, to guarantee the useful life of the infrastructure set in the design initial phase. Immediately after the

infrastructure construction, a series of activities requiring for operation, maintenance and possible adjustment are indeed to be implemented; however, a maintenance plan for the infrastructure as a whole and in its parts needs to be set at the design stage.

In general, operating and maintenance activities are aimed at achieving two different objectives:

- operation relates more directly to the service that the infrastructure provides to users and, therefore, it includes activities aimed at ensuring traffic functionality and safety, meant to minimize the total cost users bear;
- maintenance relates more directly to preservation of the asset value of the infrastructure.

Maintenance plan defines the timing of actions to be performed on the elements of the infrastructure, in order to achieve certain goals with fewer resources or to attain the best possible result using set resources. These objectives differ depending on the subjects and the issues involved. In particular, for road *users* and *society*, maintenance is to ensure that the functional status of the infrastructure do not fall below a minimum acceptable level, defined with regard to the other functional parameters having a direct influence on the effects produced by traffic. Particular attention should be paid to those defects affecting road safety and requiring immediate action; for the *Government*, the infrastructure should be protected from any type of excessive deterioration in order to guarantee an appropriate road system; to ensure protection of the *environment*, works should be performed in accordance with the requirements of eco-compatibility.

It follows that it can be stated that the prevailing purpose of the management of infrastructural assets is to keep them appropriate to the functions assigned to each of their components within a given useful life.

When an infrastructure fails to meet all or part of the requirements, particularly those related to structural aspects, such as traffic quality and safety, it is necessary to adjust it so as to restore situations which are functionally abnormal: according to the situation, actions will involve single elements or the infrastructure as a whole. Functional adjustment actions are sometimes necessary as a result of an unforeseen change of the functions of the road leading to a reduction in useful life and/or to an inadequateness to meet the new requirements arising from the varied traffic conditions. Planning a functional adjustment action is more complex than designing a new infrastructure, since it must take into account the existing situation which is characterized by a significant lack of homogeneity of the infrastructure component elements, usually designed and built in far-off times. Suburban road systems were often designed and built in periods in which technical design standards were not available. This means that, when planning functional adjustment actions, designers cannot refer to the same criteria used in designing a new infrastructure, which are based on a set of prescriptive recommendations for the individual elements composing it.

This aspect is increasingly being highlighted, so that it is necessary to set new regulations in order to control adjustment actions on existing roads provided within the tools for planning and designing of the public roads owners. Lacking specific prescriptive regulations, it is recommended to refer to the rules set for new constructions, allowing application of the prescribed criteria with greater flexibility and so ensuring context-sensitive design AA.VV. (1996).

THE ROAD MANAGEMENT IN ITS SERVICE TO TERRITORY

When it comes to the need to adjust a road in order to remove its conditions of deterioration, the following issues are usually considered and analyzed:

- base and pavement, in their functional (roughness, regularity, noise level) and structural features (structural strength of the foundation layers and of the earth foundation);
- surface and subsurface drainage works, and in particular the possible alteration of the grading curve, the deterioration of permeability, obstruction/disruption of drainage canals;
- major (subsidence, etc.) and minor (loss of functionality) artworks;
- subsidence of the bed or of the foundation soil, faults in optimization of water regime in the area, etc.;
- subsidence of the road internal structure: unsuitable soil, inadequate building techniques, inadequate embankments slopes, etc.;
- central and lateral restraint systems, which may need to be replaced as non-compliant or inadequate, since the characteristics of the traffic have changed or simply because they are damaged, etc.;
- inadequacy of intersections, in terms of location, design, sight distance, etc.;
- lack of safety conditions.

In terms of importance, the base and the artworks are assigned by far the greatest share among the various components of a road, so that road maintenance activities are often identified with those related to these two components both in terms of costs and results. However, appropriate performance indicators are also to be indentified and used for parameters relating to the other road components.

The proposed key of interpretation is to consider the road system management as including the activities of planning, maintenance and adjustment aimed at maintaining/improving the service provided by an infrastructure network; this should also include elements added over time for greater functionality purpose arising, for example, from changes in the local context where the infrastructure is located.

In this perspective, the management of a key route, should be based on a study that also takes into account all the network components which are fundamental, for example, to support the same functionality as the primary route. Geometric and design features of the main and link roads, the location of intersections and the type choice will be identified. Afterwards, the various adjustment actions needed for the design development will be prioritized.

Both for main and connecting routes, a “preventive” approach should be followed in planning the adjustment works; an approach which allows network management to ensure operations even under adverse weather and/or traffic conditions or due to maintenance work, albeit with reduced levels of service but always under conditions of stable flow.

THE DETERIORATION OF ROADS AS PART OF LOCAL SYSTEMS

A road can be said to be fail-safe when it has the following elements:

- the geometric features of the section correspond to the design hourly flow and are commensurate with the design speed, ensuring stable flow conditions till the end its useful life;
- horizontal and vertical radii of curvature, longitudinal and transverse gradients are compatible and appropriate to the design speed;
- sight distance on each element of the layout is commensurate with the design speed and helps to determine adequate levels of service;
- crossings and accesses are regulated and visible at an adequately safety distance;
- pavement are characterized by coefficients of friction and regularity conditions ensuring conditions of stable motion, even in the most frequently critical environmental conditions;
- lateral ditches are not deep with deep-set section;
- the gradient of the excavation slopes and of embankments are consistent with the soil geotechnical features;
- roadways are bordered and separated by appropriate spaces and/or devices which allow the arrest of vehicle deviation;
- fixed obstacles are adequately separated from the vehicular flow.

The concept of useful life is generally bound to conditions of the base and the artworks, but it should more properly be referred to the infrastructure as a whole. It could, for example, be referred to its normal operation, in the absence of structural deterioration of artworks, and in particular to the service provided by the road. Certainly, speed and flow are functions of the conditions of base and pavement, so the useful life may be connected to the failure of stable flow conditions. Consequently, if the purpose of road management is to ensure its service for a number of years, with reference to the design flow, action will be needed to guarantee the continuation of useful life despite the changing of environmental conditions: changing the extent and/or the composition of design flow.

If we only take the road infrastructure into account, it will be considered not fail-safe when it is damaged, meaning deterioration, subsiding, and/or functional deficiency of the road, with particular reference to its physical elements. Removing these conditions may require, for example:

- correction of sight distance in curves;
- including transition curves, without changing the horizontal road alignment;
- correction of the inadequate radii of curvature;
- reduction of excessive length of straight stretches, causing incorrect driving behaviors, inconsistent with the standards adopted in the design;
- introducing all the features which help creating an fail-safe road.

When taking into account the road as part of a local network and/or context, instead, or referring to social, urban and ecological factors, evaluating the condition of road deterioration according to the different needs, the following should clearly be considered:

- local context;
- road network and routes.

As mentioned above, the deterioration of a road and/or road network means that it is no longer able to fulfill the role assigned at a given level of service, because, for example:

- the demand for transport has changed due to a different local organization or changes in the transport system;
- the environmental, social and/or economic conditions of the context have changed;

and thus the geometric and design features assigned to different parts of the road network prove inadequate to meet the expected new features of vehicular flow. Conversely, it could occur that deterioration of the network causes a damage to the involved socio-economic area or an unacceptable environmental impact. Therefore, planning of adjustment actions should take into account the indications of planning tools and they should be performed in compliance with the environmental values of the context.

This global approach to road system management could result in a need for functional renovation, or that the elements of the existing road network are assigned functions involving adjustment and/or partial design of some sections. In this case, and with reference to the environmental aspects, the following should be provided:

- SEA (Strategic Environmental Assessment) when considering a global road layout, to ensure that it is environmentally sustainable;
- an environmental impact study when planning the adjustment of a single road section.

In the preliminary design definition of a road layout, in order to prevent deterioration, particular attention should be paid to the nature of soil. Land suitable for productive activities should be avoided as well as soil unsuitable for the possible creation of embankments. Moreover, a solution is environmentally sustainable if full length compensation of soil can be obtained within a certain average distance of transport. This is true provided that non-renewable soil resources used as construction materials. If “secondary raw materials” (scraps of industrial products, materials resulting from demolition, etc.), available or resulting from treatment plants, can be used, this design approach may change. The design of a road may include sections both where it is more convenient to use natural soils and where it is more convenient to use secondary raw materials. Annunziata et al (2004)

In evaluating layout alternatives, the reclamation of land now occupied by dumps of materials considered unusable and/or the revival of productive activities connected to the quarrying industry could be added to the benefits. From the considerations above it is clear that, despite the regulatory framework concerning the proper environmental placement of road system infrastructures is extensive and well structured, the rules for environmental feasibility studies need to be reviewed. They should in fact refer more specifically to the need of both limiting the use of non-renewable soil resources and of land suitable for productive activities, as landfills, and encouraging environmental reclamation activities using waste as construction materials. There is still no expressed and firm will to award, where possible, the opportunity of choosing waste, secondary raw materials, or use of natural materials and non-renewable resources.

Finally, with regard to planning tools which should be taken into account when planning adjustment actions, civil defense plans deserves special attention. They should contain a classification of suburban routes with a function of “supporting” the main routes in order to ensure crossing of and/or accessing to a given region. In this perspective, civil defense plans should also contain a hypothesis of readjustment of the road network serving a given area, resulting from the evaluation of the unreliability of the individual road, and thus of the deterioration of ability to perform its function on certain occasions.

This goal of road system adjustment can be defined innovative in some way. Among factors to be taken into account prior to actions, is the convenience of identifying, within the road network serving a given region, the roads that may be appropriate to meet the needs of civil defense, on which, albeit with lower levels of service, traffic hit by the critical conditions occurring in the region and/or on the main routes could be diverted.

Some areas, for instance, are considered critical because of their hydrogeological instability and/or because they are exposed to recurrent adverse weather conditions. It is not possible to exclude a priori that these areas are crossed by highway infrastructures on which traffic must be ensured even in particularly adverse weather conditions. Therefore,

planning of “support routes” should be carefully considered, meaning routes in areas less exposed to critical weather conditions, on which some of the traffic flows can be diverted in order to alleviate traffic conditions on the main corridor.

Other actions to be considered when defining “support routes” are slope stabilization, base and artworks consolidation, adjustment of cross-sections, slight route variants. They should be designed concomitantly with the dimensioning of the main corridor. Similarly, interconnections between the different routes should be designed in order to facilitate use and management of the primary road system of which they are part. Annunziata et al (2007)

With reference to the poor conditions of a road as part of a network and/or a road system, the inadequacy of the intersections is particularly prominent. In this regard, both questions and hints arise which can be a useful basis for subsequent project phases:

- Adjustment of road layout to improve traffic safety should first consider, in the preliminary and final design, the resolution of the nodes;
- In the preliminary design of the road network, which includes the road layout, solutions of the nodes may be consequently localized and their features defined. These solutions, given the usual critical condition of a road network nodes, should be seen as a constraint in the subsequent design of the plano-altimetric alignment of the element of the road network;
- In the final design, the study of the planimetric and altimetric alignment could start from the design of intersections, so as to constrain the plano-altimetric choices primarily to ensure the visibility of the areas of intersection: In particular, the choice of design features of planimetric and altimetric curves as well as the longitudinal layout definition should be appropriate to ensure the aforesaid conditions of visibility.

In defining and planning actions required in a given route, the following general criteria will be considered:

- analysis of the action in relation to existing policy tools and their assessment on consistency and on the type of relation;
- analysis of the action within the context of the road network of which it is part;
- framework of actions in a route perspective;
- assessment of how the action is to achieve a uniform solution and, in case of inconsistency situations, functional definition of the transition sections;
- evaluation of actions in order to avoid environmental impacts which would make actions no longer acceptable.

OBJECTIVES OF FUNCTIONAL RENOVATION

According to the approach above, the first step of functional renovation is to assign specific functions to each road element: therefore a methodology for classification of existing roads needs to be defined, and it requires general or sector planning with infrastructure specifications and other planning tools. With a correct view to fostering of existing environmental resources, evaluating the role and function of road within the network (local, regional or national).

Standardizing the characteristics of different types of road infrastructure is the main goal of classification. It means a validity checking of the functional hierarchy of roads, identified by means of suitable planning tools. In absence of these tools, the classification procedure first requires a provisional identification of the function of each infrastructure. For this purpose, tools for traffic organization (suburban and urban roads traffic plans), if any, should be taken into account. Annunziata et al (2004)

Programs and planning framework of the network in question (National Transport Plan, Regional Transport Plan, Municipal Town Planning or other planning tools), if any, should be analyzed and the main functions performed or to be assigned, as a goal, to existing roads in that network (primary, main, secondary, local function) need to be identified. It should also be noted that these kinds of plans are to streamline the existing road network, with adjustment and/or improvement actions, with a perspective of urban development in the medium/ long term. The aims of their purpose is therefore different form that of Urban Traffic Plans or Suburban Road Traffic Plans which, especially through actions of immediate effects, are meant to reduce the most frequent critical conditions of traffic.

In other words, the functional classification of roads – whose validity will be the same as that of the transport planning tools from which it derives – should be the basis for traffic planning, highlighting features and improper uses of road infrastructures, allowing to identify the main factors causing lack of safety, and directing the planning of

adjustment activities. Performance goals are thus set down within the definition of the functional class the infrastructure will belong to after the adjustment actions and thus their objectives must be congruent with that specific functional class.

Therefore, the following are the goals of a road network functional renovation: Annunziata et al (2007)

- achievement of traffic safety conditions and improvement of levels of service;
- improvement of access conditions to the area;
- giving the road network connectivity features within the transport system to which it belongs;
- contributing to the territorial redefinition aimed at balancing the system of settlements and services;
- adjustment of road networks in their civil defense purposes, so that access to and/or crossing of a given region are always guaranteed.

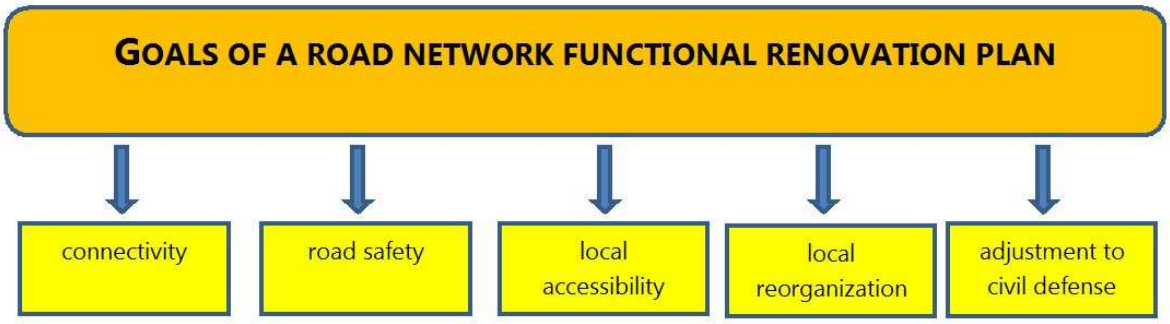

Figure 1 - Goals of a road network functional renovation plan

The "condition-goal" of environmental sustainability of the actions can be added to the aforesaid objectives.

As mentioned, the functional renovation of road networks can be aimed at creating an integrated and intermodal system, in which each component plays a role corresponding to its technical and economic characteristics and is complementary to the others. A process of functional renovation of the road sections constituting the network is therefore to be enhanced, since the definition of that integrated system should be achieved by pursuing the goal of streamlining the available resources, paying maximum attention to using and reusing of the existing ones.

Moreover, increasing attention should be paid to the fact that the road system is to be used to control the location of activities in the area. Increasing connectivity of transport networks is a fundamental condition to support the creation of a more reticular local structure and a better development. A transport system which is no more aimed only at speeding up the connections between "outskirts" and "centers", but also meant to lay the foundations for a different organization of an area with a perspective of territorial rebalancing: such a system can be considered of higher convenience among all the various design alternatives. Annunziata et al (2010)

THE DIFFERENT PHASES OF FUNCTIONAL RENOVATION

Functional renovation of a road and/or a network can be achieved through actions of:

- routine maintenance;
- extraordinary maintenance;
- adjustment.

Routine maintenance is defined as the set of activities and actions necessary to ensure the maintenance of the functional features of the road system aimed at keeping conditions of traffic safety, according to the original design and regulations in force at the time of design.

Therefore, for instance, the following can be considered actions of routine maintenance:

security and supervision of road system;

- verification and control of functional characteristics of the elements of the road system;
- renovation of roads, which can be partial (pothole patching, etc.) or complete (replacement of worn pavement with the same characteristics as the original one);
- repair of guardrails damaged by accidents;

- repainting of road markings and repair or replacement road signs;
- maintenance of the green areas and buffer areas;
- management and maintenance of installations (lighting, ventilation in tunnels, etc.)
- cleaning and maintenance of all the side elements of the road (cobbled shoulders, embankments, drainage networks);
- maintenance and replacement of joints and support devices of bridges and viaducts;
- restoration of damaged concrete walls and artworks;
- etc.

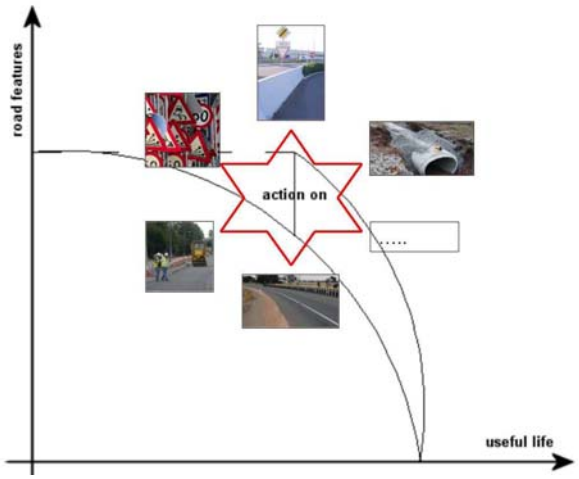

Fig: 2 Routine maintenance actions

Extraordinary maintenance includes those activities, needed to ensure road system functionality, involving changes in functional and geometric features and in the road type and category, in order to achieve, by means of a functional or regulatory adjustment, an improvement of the system in respect to the original design. These activities result in an improvement in safety conditions and outflow, with the same expected useful life.

The need for such activities may arise from:

- adjustment of the road as for its assigned function;
- new legislation on road safety;
- opportunities for using new techniques and methods for improving traffic safety;
- etc.

The extraordinary maintenance works can be divided into:

- localized functional adjustment**:**

- resurfacing with pavement with better features than original (e.g. permeable paving);
- partial or total reconstruction of the existing base with superior features and/or new building techniques (e.g. recycling in site) to meet changed traffic characteristics which impair the original structure;
- adjustment of the drainage network, including any existing treatment plants, according to changed hydrogeological needs, and in any case within the limits of the property;
- restoration and recovery also of structural parts of existing artworks;
- sight distance correction in curves;
- inclusion of transition curves, without changing alignment;
- etc.

- adjustment to regulations**:**

- replacement of guardrails with new barriers as provided for by regulations in force;
- new installation of road signs/markings made on the basis of a new road sign plan;
- widening of the roadway within the limits of the owner’s property in order to reach the size as for new technical standards;

- etc.

The impact of different maintenance policies depends on the ability of owners to know their road systems and to develop suitable surveys to determine action strategies in order to prevent the deterioration and decay of the functional features (preventive maintenance) rather than facing the emergency of recovery actions (corrective maintenance).

Hence, in order to improve traffic safety conditions on an existing road, and/or to adapt an existing road network to civil defense purposes, at least routine maintenance works should be carried out. Actions should comply with the regulations in force at the time of maintenance planning.

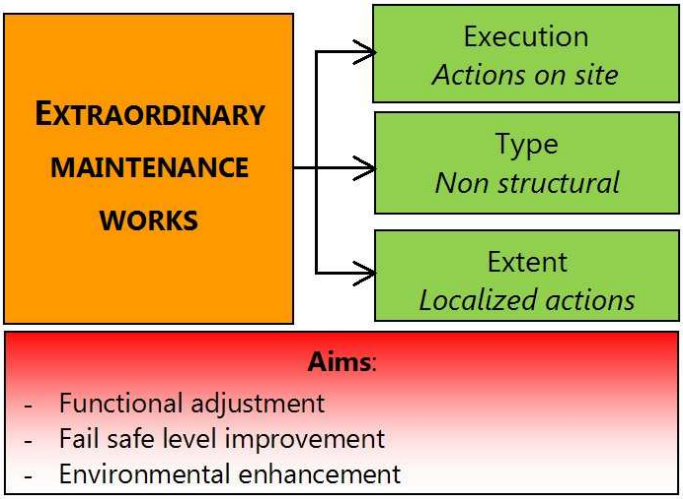

Figure 3 - Extraordinary maintenance works

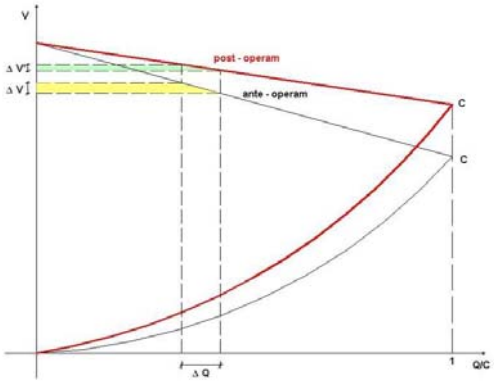

Figure 4 The flowchart resulting from extraordinary maintenance activities, Annunziata et al. (2007)

ADJUSTMENT ACTIONS

International references: the U.S. example

The forthcoming drawing up and adoption of regulations on adjustment of existing roads is a peculiarity of our country. The need to enact such regulations arises from both the difficulty of applying the Ministerial Decree dated 5/11/2001 to existing roads and from the consequences resulting from lack of homogeneity which characterize our road network. This national peculiarity is directly reflected in the difficulty of translating the word “adeguamento” (i.e. adjustment) or finding the corresponding word in foreign languages Ispettorato generale per la circolazione e la sicurezza stradale (2001), Commissione per la predisposizione di nuove norme per gli interventi di adeguamento delle strade esistenti (2006).

In the U.S., as an example, “highway improvement projects” are aimed at the improvement of the characteristics of a road. Some of these projects are to be drawn up in accordance with provisions of Federal regulations, others do not follow this procedure. The projects can be divided into different categories, in which case there are plans for new

construction or reconstruction (where the action aims at the construction of a road, the relocation of an existing road according to a new alignment, the widening of a section or to substantial changes for safety improvement). Moreover, projects classified as 3R (Resurfacing, Restoration, Rehabilitation) include those whose primary objective is that of both preserving and extending the level of service of a road and to increase its safety.

3R projects category includes reconstruction works on pavements, slight widening of lanes and shoulders, improvement of traffic safety by means of localized actions or works on the intersections, small changes in longitudinal gradients and radii of plano-altimetric curvature, repair of artwork and removal of obstacles to visibility. As far as it was intended, 3R projects seem to fall into the category of extraordinary maintenance works.

The last category of improvement works finally include maintenance, which consist of all actions needed to preserve the road in good condition. They include removing debris from the roadway, cleaning of water drains, removal of snow, etc. These actions may be somehow equivalent to operating activities, or to routine maintenance.

The goals of adjustment actions

On the other hand, adjustment actions, obtained by construction and/or completion of new works and/or elementary networks, mainly have the following goals:

- resolving critical and/or localized situations, in order to obtain an improvement of traffic, corresponding to the changed size and composition of the vehicular flow and of local accessibility;
- achieving an integrated and intermodal system, ensuring connections between different modes of transport;
- contributing to definition of different country and town planning.

The goals, which are among those previously mentioned, refer to better performance in terms of:

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

within the constraints or preexisting local circumstances. Annunziata et al (2006)

Performance goals are in fact defined during the process of designing the road network to which the infrastructure belongs. The functional class of the infrastructure expected after the adjustment works should be defined in the design phase, and its performance goals are to be congruent with that specific functional class. Performance goals, should obviously be defined taking into account the choice of time horizon of the action, which will influence all estimates about evolution of demand for transport.

The definition of performance goals, related to the quality of traffic, includes the making of some decisions on, inter alia, the following parameters:

- quality of service offered by road after adjustment works;
- verified annual frequency of operational situations in which the quality of service is lower than expected.

These parameters in most cases are to be defined referring to the specified values for new roads of the class similar to that expected for the infrastructure after adjustment works.

The definition of performance goals relating to road safety includes choices about limit values of the number of accidents per traffic and length unit, referred only to accidents involving dead or injured people, based on the current accident rates of the road in question. Lacking reliable average accident rates and appropriate critical levels as point of reference to identify the limit values, the objective of reducing accident rates of at least 15% of the average estimated value on the road under study.

The definition of performance goals related to the quality of the environment basically is about choosing the limits of:

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

Planning adjustment works to the network as a whole and adopting appropriate measures for the network operation will be aimed at maintaining flows in road links within the limits of their environmental capacity.

As considered above, priority actions may involve, at least, routine and extraordinary maintenance, in order to keep and improve road safety, to get higher levels of service, and to ensure that an existing road network guarantees communications in order to comply with civil defense purposes. In this respect, priority among different road sections will depend on the criteria above. Prioritization of actions in relation to the completion and/or new construction of individual road sections and/or primary network also depends on those criteria, especially when pursuing goals of territorial reorganization and/or of building an integrated and intermodal system, implementing interconnections and functional complementarity between different modes/transport infrastructures.

At this point of discussion, it seems appropriate enriching the definition of objectives with a reflection on the region and its forms of organization, especially with regard to the "small urban systems." An urban system is defined by a set of communities and centers interacting with each other, characterized by a series of relations located in space and time. Gravitational phenomena are common, mainly toward strong polarities, and they mark the system centers. Assuming these systems can be identified based on various factors, including the number and quality of services, production and demographic dynamics, as well as the mobility phenomena, a substantial difference between strong and weak (or minor) urban systems would be evident. The latter can be defined according to more specific factors, such as the presence of a strong depopulation and aging of the population, lack of job opportunities, decline and loss of quality in public services.

When operating within these contexts, goals can and should become their territorial redistribution, maintaining the resident population, a valuable environmental and economic resource of the region, and creating a system of punctual community services, made by service centers of various sizes connected to each other and with the settlements they serve. Therefore, the adjustment of a road network should not just simply remove the critical issues from the traffic routes, but it could help consolidate the system of service centers, more so in areas where such systems are vulnerable and at risk.

This road network seems to be identified as consisting mainly of suburban roads. Attention should therefore be paid to the importance of this type of roads to be recovered in their function to raise/support functionality of the corridors of higher regional level. Adjustment is to be designed from a "preventive" perspective so that the road networks can be managed ensuring continuous operation, albeit with a reduction in the levels of service (but always with stable flow) in the presence of adverse weather or traffic conditions and/or in case of maintenance works.

For a better explanation of what was stated above, regarding the definition of priority criteria, it seems possible to assert that regulations, which provide for three subsequent design levels of technical examination, should be rethought since it appears a limit to merely confine the road management to the road centerline. If the management of an infrastructure network, including planning, design, maintenance and adjustment, is an important part of a restructuring/reorganization program of a given region, in order to achieve improvement of accessibility as well as fail-safety of roads, management should be extended from the single route to those network elements which provide interconnection with other roads completing the road system serving the region in question.

Therefore, it seems appropriate for the preliminary design to ensue from a feasibility study considering the road network of which the corridor is part: its connections to the region are as fundamental as the main corridor in order to remove conditions of poor accessibility. The feasibility study should primarily identify the geometric and design features of main and connecting roads, then locate and select the type of intersections. The primary network is to be considered as unique, albeit distinguishing hierarchical positions, functions and therefore different types of road. Gatti et al (2008)

All the identified alternative hypotheses, consisting of a main corridor, connection with other roads, and the "supporting" links serving a given area, should be compared, considering, for each of them, the different goals and their achievement degree. Within a network defined as such, different priorities of the main and secondary roads need to be assessed.

In synthesis, the concept of deterioration and therefore of restoration, adjustment and enhancement actions need to be first related to the local context and to the service road network, so that infrastructural conditions ensure regeneration of areas currently penalized, and thus marginal.

Types of adjustment action

Functional adjustment works can involve, totally or partially, all the elements of the infrastructure. They can be either:

- general, if they are continuously extended on the stretch of road subject to adjustment;
- localized, if they are limited only to a section of a road or to an intersection.

The main adjustment strategies can be defined as:

- Functional improvement - actions needed to adapt the infrastructure to an increased transport demand and to changed traffic features. They are thus actions making changes to geometric and design features of road elements, so as first to obtain an improvement of the level of service and a change in the functional classification of road;
- Improvement of the fail-safety level of the infrastructure - actions needed to reduce frequency and severity of accidents. In addition to those already mentioned, there are actions involving other compositional elements of the infrastructure, aimed at obtaining solutions for specific critical situations and a change in the conditions of road use;
- Environmental restoration - actions needed to improve the environmental quality in areas crossed by the infrastructure. These include actions aimed at reducing noise pollution, improving air quality, protecting soil and water.

In that case, functional renovation actions of infrastructural systems may include the adjustment of existing geometric and design features of existing routes, also with significant variations of the road layout. With regard to artworks, actions are to be included in extraordinary maintenance, unless it is necessary to adapt the structure to changed stress conditions.

A special case is the transformation of an existing road, so that it can fully meet the changed needs of transport demand, and therefore:

- structural adjustment of artworks;
- adoption of a different type and category of road.

These actions, although aimed at adjustment to new regulations, significantly and/or radically change functional and safety features of the road. Therefore considering them as new construction seems more appropriate.

Each adjustment strategy is implemented by means of a series of actions, which my fall into two types:

- Structural actions, if they physically involve the infrastructure, leading to a change in the design features of the centerline, the composition of the cross-section and intersections;
- Management actions, affecting the use the infrastructure, by defining specific criteria for management and control of mobility, change of equipment, facilities serving traffic, and road side elements, and by means of appropriate security plans for emergency management.

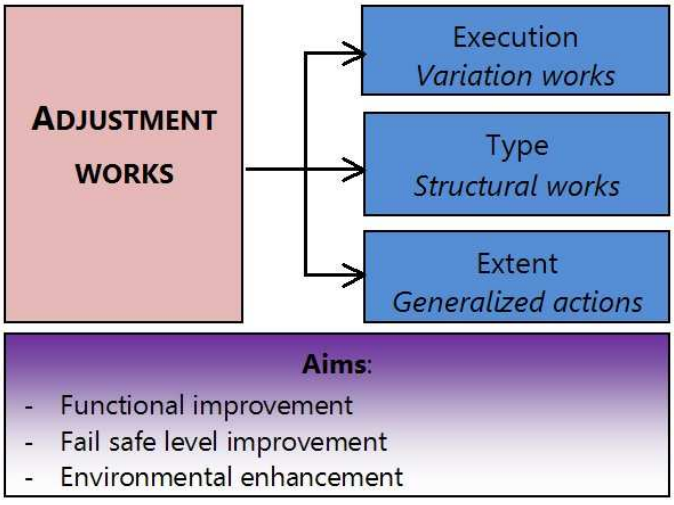

Figure 5 - Adjustment actions

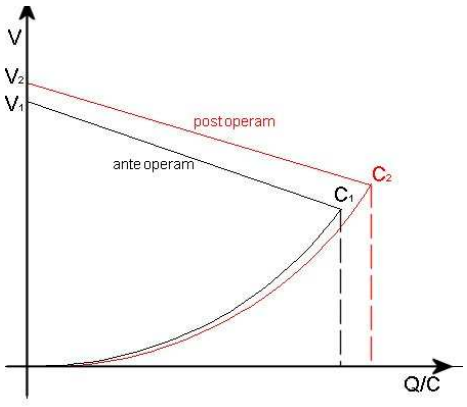

Figure 6 - Flowchart for adjustment actions

Planning of functional adjustment actions follows the same procedure as new road construction, and is divided into three different planning levels: preliminary, final and detailed design.

In the preliminary design phase some design alternatives will be identified, each including a balanced set of structural and management actions which can together contribute to the implementation of adjustment strategies adopted at planning stage.

Structural works modify geometric and design features of the road elements and help implement the functional improvement strategy of the infrastructure. Such actions tend to give the existing road network geometric and functional standards set for new construction roads.

In the preliminary design stage, the best planning alternative is identified considering performance goals to be achieved, including improvement of safety and environmental quality. The project alternative selection will consist of a series of structural activities, which may be localized or generalized and may involve the following aspects:

- Reorganization of the right-of-way, by changing the composition of section (insertion of additional lanes, service roads, bike paths, walkways, driveways, etc.), or of the cross-sectional dimension of its component elements (lane, outer edges, or side sizes), or introducing functional furniture (traffic calming devices) that modify the geometry of centerline and/or the section, as well as other actions involving the road structure, belonging to an overall coordinated and aimed at achieving certain performance goals in terms of traffic, safety and environmental quality. This type of actions, which may involve minor changes to the existing layout (correction of some elements of plano-altimetric alignment), but that is achieved mainly on the existing area of the road, is called adjustment in site;
- Change of plano-altimetric alignment of centerline and cross-section of the infrastructure to adapt it to future transport demand and make it consistent with the principles of readability, comprehensibility and responsiveness to users' expectations which are the basis of modern road planning. This type of action involves a real variant to the existing layout;
- Adjustment of intersections connected to the road section to the features of its functional class by means of hierarchization and reorganization of some or all permitted maneuvers and of their reserved spaces, with reference to all the categories of traffic allowed.

When planning adjustment works, especially involving a variation of the existing layout, existing regulatory requirements for new construction roads should be considered, integrating them, where necessary, with appropriate flexibility criteria.

Managing adjustment actions involve a change in the way of using an existing infrastructure, in order to make it congruent with its physical features, possibly improved partially by means of structural works, as well as with the natural environment crossed by the infrastructure, and with the of user types allowed to use it.

CONCLUSIONS

Conclusions can be summarized in the following considerations.

Managing an existing road system should be consistent with precise road network classification, according to a strategy of reorganization and design of the local transport system. The assignment of functions, and thus the geometric and design features should be the result of an audit carried out by a strategic environmental assessment.

SEA has the goal both of ensuring a high level of environmental protection when planning transformations in the area and of contributing to the integration of environmental considerations into the draft and adoption of plans and programs to foster sustainable development. Therefore, SEA is a simulation and a prevision of what would happen to the environment involved, once all the transformation actions are implemented. It has, in fact, the primary aim to highlight the compatibility of the goals and operational strategies of a plan or program with the objectives and standards of maintenance and enhancement of environmental quality of the overall area involved in the planning and programming action, in respect to the levels of sensitivity and vulnerability previously identified.

The actions of global functional adjustment of an existing road network cannot forgo environmental impact studies. Regulations applicable to the environmental impact studies as well as to the environmental assessment procedure set out the categories of works to be submitted to that procedure.

The following are also subject to assessment of compatibility:

actions on existing works, not belonging to the admitted categories, if the resulting work falls in those categories;

actions on existing works, in the categories in question, if the resulting work has characteristics which differ from the original one, with the exception of renovations and of additional third lane if required by the need for traffic safety and the maintenance of levels of service.

The second case occurs when separated carriageway roads are adjusted in order to significantly increase the levels of service, in view of an increased transport demand, requiring a change of geometric features, a higher design speed, and thus a variation of the layout design features, or the construction of new interchanges that could significantly change the traffic system connected to the main infrastructure.

Besides the provisions of regulations, a road infrastructure, regardless of its type, is always a new element placed in an environment with its own natural balance. So is up to the sensibility of the owner, of the local governments and of designers with their own technical skills to deal with the management of road systems according to criteria of environmental compatibility and sustainability, even when most of it does not fall into a category for which regulations require an environmental impact assessment.

REFERENCES

AA.VV. (1996). Problematiche costruttive e manutentorie delle infrastrutture viarie. Collana di Ingegneria delle Infrastrutture Viarie – Studi e Ricerche (Responsabile scientifico: prof. ing. Carlo Benedetto – *Curatore: dott. ing. Maria Rosaria De Blasiis) – Supplemento n° 2.I.P.S. (International Publisher Service), Roma.*

Ispettorato generale per la circolazione e la sicurezza stradale (2001*) Decreto del Ministero delle Infrastrutture e dei Trasporti - Norme funzionali e geometriche per la costruzione delle strade*

Annunziata F., Coni M., Maltinti F., Pinna F., Portas S. (2004) Progettazione stradale integrata. *Zanichelli editore Bologna*.

Commissione per la predisposizione di nuove norme per gli interventi di adeguamento delle strade esistenti (2006) Bozza Norme per gli interventi di adeguamento delle strade esistenti

Porru R.– Maltinti F.– Annunziata F. (2006) Norme funzionali e geometriche per la costruzione delle strade.
Parte I de "La normativa delle progettazione stradale. *CUEC EDITRICE, strumenti didattici n° 15.*

D. Melis, F. Maltinti, E. Cecere, F. Annunziata (2006), Norme per gli interventi di adeguamento delle strade esistenti: alcune riflessioni. Parte II del "La normativa della progettazione stradale." *CUEC EDITRICE, strumenti didattici n° 15.*

Annunziata F., Cecere E., Coni M., Maltinti F., Pinna F., Portas S. (2007) Progettazione stradale. Dalla ricerca al disegno delle strade" *Dario Flaccovio Editore S.r.l., Palermo*.

Gatti G., Polidori C., Cavuoti E. (2008) Manuale di sicurezza per le strade secondarie: dai risultati della ricerca europea una guida pratica per gli interventi di sicurezza stradale per le strade regionali, provinciali e locali, *Mario Adda Editore Bari.*

Annunziata F. Bianchini B., Caraffa T., Maltinti F., Montanino G., Trevisone V., Zoppoli P.(2010) Sistemi di gestione del patrimonio stradale." Parte 1 del Quaderno CT D.1 "Metodologie e criteri per la gestione del patrimonio stradale." - Quadriennio 2008/11. Tema Strategico TC D "Qualità delle infrastrutture stradali" – Comitato Tecnico D.1

Gestione del patrimonio stradale". Associazione Mondiale della Strada – AIPCR – Comitato Nazionale Italiano - XXVI Convegno Nazionale Stradale AIPCR (Roma, 27-30 ottobre 2010) – pagg. 9-33

http://www.cnsservizi.it/media/3440/segnaletica-stradale.jpg (1st april 2012)

http://www.sicemspa.net/prefabbricati/barriera.jpg (1st april 2012)

http://www.maccaferri.com/media/corporate_08/article_images/solutions/pavimentazioni_sottofondi_01.jpg (1st april 2012)

http://www.milfordtownship.org/2009/rds/images/oldplainseliptical.jpg (1st april 2012)

http://www.dpti.sa.gov.au/__data/assets/image/0017/46061/wire_rope.jpg (1st april 2012)