MOTORWAY ASSET MANAGEMENT AND FOLLOW-UP POLICIES

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ABSTRACT

In order to maintain its structural assets in good working condition and best allocate maintenance funds, ASF has established a formal set of asset management and follow-up policies. These policies enumerate the different obligations: the motorway specifications which delineate a number of more or less clearly defined requirements, the standards and the legislation binding upon motorway managers. Where there is no legislation, internal policy has been formulated and implemented to manage certain structures where failure could affect client safety, cause environmental harm or generate serious economic consequences.

Accordingly, policies covering the pavement, the engineering and hydraulic structures, sewage and water protection systems, superstructures, vertical and horizontal signs, and other, have been established.

Then, the paper describes in detail road follow-up and management and tools and systems used by the motorway manager.

1 INTRODUCTION TO THE SOUTHERN FRANCE MOTORWAY FIRM (*AUTOROUTES DU SUD DE LA FRANCE ASF*)

The firm Autoroutes du Sud de la France (ASF) is part of the VINCI group. ASF is a motorway management company and operates the longest French toll motorway network. Founded in 1957, ASF has grown with time and today operates 2,600 kilometres of motorway.

The company's infrastructure assets presently account for 61 million square meters of roads, 3800 engineering structures, 5200 hydraulic works, and 1500 vertical signs.

Given these significant assets, ASF has established methodologies for optimised financial and technical management.

Fig. 1 - Map of the ASF network

2 CONTEXT

Given the scope of the ASF network, the operators' different priorities, the types and intensity of traffic, geographical constraints and variable climates, ASF has established uniform management and follow-up policies in the effort to maintain good working order while optimising maintenance costs and minimising customer disturbance.

ASF policies enumerate the various obligations for which the motorway manager is responsible:

- The motorway specifications and the organisational plan (a contract stating the motorway manager's objectives and obligations with respect to the licensor, for a 5-year period). These set several obligations: application of the technical instruction for monitoring the engineering works on motorway sections commissioned since 1995, maintenance of the structures in good working order …
- The statutory texts binding upon the grantees. The decrees issued by the water police, and the subsequent prefecture decrees ….
- The internal rules established to manage certain structures where failure could jeopardise client safety, cause harm to the environment, or have significant economic consequences.

In addition, analysis of jurisprudence and judgements issued in cases involving infrastructure has led to policy considerations of further provisions.

3 GENERAL ORGANISATION

The policies established in the domain of infrastructure and roads have been broken down into 4 essential phases: inventory, monitoring, notation and works scheduling. Each of these phases is based on systems and methodologies of varying sophistication. The architectural principle retained uses known models such as described hereafter:

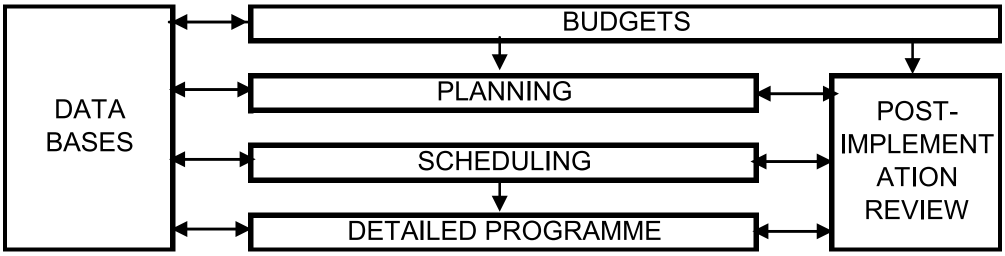


Fig. 2 – Road management principle (OECD model)

The inventory of objects making up the assets is contained in the information systems (IS). Depending on the object's technicality, the information system can be specific. This is the case for roads and engineering structures which use two bases, entitled Argusbase and GOA. Information on the other objects is supplied in an Oracle data base. All this data can be examined on the specific systems and on a GIS (SIGAL: *Système d'Information Géographique des Autoroutes de Liaison* Geographic Information System for Rural Motorways) which sums up the information.

4 TRACKING POLICIES

Tracking policies involve seven high-stakes domains (security, financial …) which cover the bulk of the motorway infrastructure assets. The policies add to the indicators and elements to follow, and indicate the information systems to be filled out (whether dedicated or general) and the models for calculating the notation to rank structure condition.

4.1 Sewage structures

Policy entails two directions. First, semestrial inspection by ASF agents. The purpose of this inspection operation is to start the routine maintenance to be performed and to inspect certain elements such as valves and blanking devices. In addition, detailed inspections are launched every five years by outside suppliers who check structural behaviour and the surroundings of the structure.

4.2 Engineering structures

The contract between ASF and the licensor states application of the 1979 circular, revised in December 1995, relative to surveillance and maintenance of engineering structures. Accordingly, routine monitoring of the engineering structures was set up, at frequencies of 1, 3, 6 or 9 years. Annual and tri-annual monitoring is generally performed by ASF personnel trained for this purpose. The other surveillance, in most cases, is assigned to outside engineering consultants. Hydraulic structures with openings greater than 2 m are also covered by this surveillance requirement. Specific surveillance measures have been set up for tunnels.

4.3 Pylons and masts

Policy principle for pylons and masts entails regular surveillance of pylon condition, with performance of maintenance work if required. These works are monitored regularly throughout their lifetime, with annual inspection performed yearly by ASF agents and formal in-depth five-year inspections performed by outside suppliers. Each time a new antenna is installed, and after each storm or outstanding climatic event, a detailed inspection takes place.

4.4 Horizontal signs

Recommended surveillance of horizontal signs primarily involves the retro-reflected luminance coefficient which is scheduled as a function of the product lifetime, every one or 2 years. The signs are inspected using a ECODYN high speed apparatus.

4.5 Vertical signs

Vertical sign structures (arms, portal frames, high masts) are routinely tracked every five years. This inspection controls bolt tightening, visual quality of the welds and corrosion in the case of steel structures. These inspections result in allocation of a grade, and are followed up by annual inspection at ground level, by ASF personnel. Specific inspections are added after events or circumstances which could affect structural condition (storms, floods, earthquake …).

4.6 Fencing

Fencing is inspected annually along the entire perimeter, to ensure that fencing is complete and unbroken. Any defective points are inventoried on a data base then scheduled for repair. In addition, daily surveillance of animal impact is noted in a logbook and each occurrence launches fencing inspection in the area of occurrence.

4.7 Pavement

Routine inspection takes place every three years using high-speed systems: SIRANO held by SCETAUROUTE, AMAC® held by Vectra and commissioned in 2006, and SCRIM held by VECTRA. Evenness, roughness, transverse profile (ruts), distress and transversal friction coefficient are all measured.

Pavement policy and monitoring are described in greater detail in the following chapters.

Table 1 – Summary of inspection frequency

	Periodic inspection	Specific inspection

Pavement	3 years	Zero point after construction or reinforcement
Sewage structures	5 years	Inspection after weather event (flood …)
Engineering structures	3 years	Zero point after construction or modification
Pylons and masts	5 years	Inspection after weather event (storm …)
Horizontal signs	1 or 2 years	Adapted as a function of guarantees
Vertical signs	5 years	Inspection after weather event (storm …)
Fencing	1 year	Inspection if animal carcasses found

5 PAVEMENT MONITORING POLICY

5.1 Inventory

ASF network pavement assets are recorded in a data base called ArgusBase, which describes the following:

- Geometrical characteristics of the motorways,
- Pavement layers (construction and maintenance), changes in homogenous pavement structures over time,
- Data from the testing devices.

The data base is client/server organised. It can thus be accessed by different users from regional management or centralised management, and be used to perform different queries. Data is processed in the form of diagrams, statistics or graphic displays. The base is connected to a geographical information system (GIS) which covers the entire network and is accessible on the Intranet.

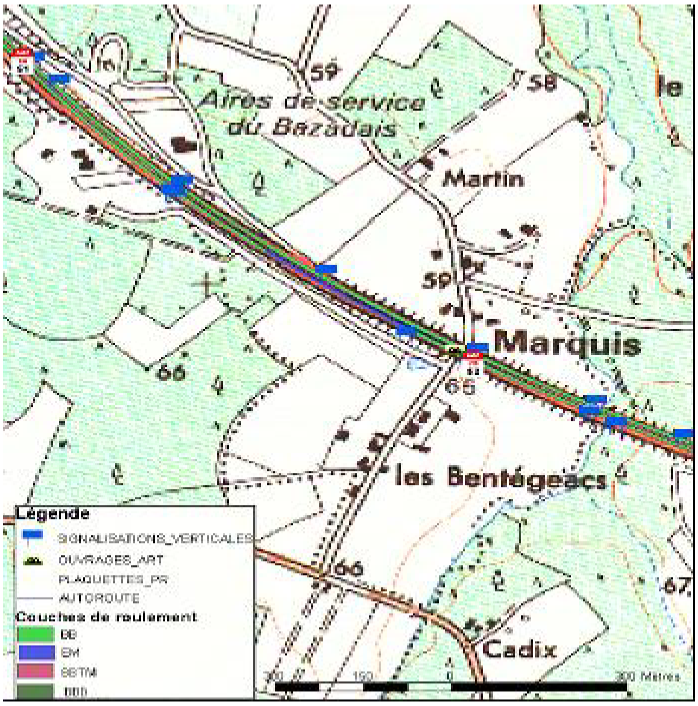


Fig. 3 – Data visualisation using the GIS

5.2 Monitoring policy

ASF has set up a pavement monitoring policy which relies on periodic and routine investigation. This investigation can be extended with specific investigations which take into account observations made on a given section.

Routine investigation focuses on the following surface characteristics:

- Longitudinal evenness (wave band note - NBO) and transversal (ruts - ORN and water stage - HE),
- Grip (transversal friction coefficient - CFT),
- Macro-texture (sand patch test calculated - HS_c),
- Distress (identification and quantification of distress – FL, FT …).

Two high-speed multi-function systems are used to survey these indicators. In some cases, single-function systems are used, however, their use is limited so as to reduce disturbance to the client and obtain consistent reference directions.
For grip and macro-texture surveying, the SCRIM/RUGOLASER system is used. For the other characteristics (longitudinal and transversal evenness, distress), the AMAC® system is used (AMAC = *appareil multifonction d'auscultation des chaussées* – multi-function pavement investigation system). .

Investigation frequency is displayed in the table below:

	Transversal friction coefficient	Macro-texture	Longitudinal evenness	Rutting	Distress
System	SCRIM	SCRIM	AMAC®	AMAC®	AMAC®
Frequency	6 months – 3, 6, 9 ...years	6 months – 3, 6, 9 ...years	3, 6, 9 ... years	3, 6, 9 ... years	3, 6, 9 ... years

Table 4 – Routine monitoring frequency

Routine investigations are then completed by specific investigations, with tighter frequencies to monitor a particular characteristic, and structural investigations such as deflexion and tread radius.

5.3 Index and service level calculations

5.3.1 *Investigation results*

The results from investigations conducted with aforementioned systems are presented in the form of measurements with 20-m increments. All of these measurements are integrated in the ArgusBase management system. They can be accessed and visualised in the form of diagrams.
Investigation results are also used to calculate the representative index for pavement service level. To develop these indices, ASF pursued the early thinking on these indices, started in 2004 by the French motorway firms. This led to establishment of three types of indices: unit index, specific index and global index. ArgusIndex, a specific model of the management system, is used to calculate these indices.

5.3.2 *Unit indices*

Each measurement produced by a pavement investigation machine is assigned a grade corresponding to a service level, A for good down to E for poor, thus obtaining a unit index. Thresholds between the different levels are set based on ASF experience and the service level sought per type of motorway.

Example of a rutting unit index:

	5	8	10	15	
Rutting	A	B	C	D	E

It is thus possible to visualise, for a given section, or for the entire ASF network, the distribution of unit indices based on each level of quality, and their changes over time.

5.3.3 *Specific and global indices*

Specific indices are obtained by combining two unit indices. For example, in combining the macro-texture and the micro-texture, one obtains a specific index which represents grip.

Global indices are obtained more than two unit indices. A representative global index for surface characteristics was developed by combining the transversal friction coefficient, the macro-texture, rutting and longitudinal evenness.

Indices are combined together using matrices similar to the one shown below. Matrices can be symmetrical or asymmetrical, depending if one indicator is given more significance than another.

Specific index		Index 1				
		A	B	C	D	E
Index 2	A	A	B	B	C	C
	B	B	B	C	C	D
	C	B	C	C	D	D
	D	C	C	D	D	E
	E	C	D	D	E	E

Fig. 5 - Example of calculating a specific index

5.4 Calculating a global grade

Each of the indices defined above can be used to calculate a grade which represents a section, a motorway or an entire network.

Calculation of the grade is based on assigning a value to each service level. For example, if one seeks a grade out of 20, the A service level is given the grade of 20, B level is 15 and so on down to 0 for level E. Each service level is also weighted. The formulas used by ASF undervalue the A, for there is no point in excellence, and overvalues the E, a level which is theoretically seldom reached.

	A	B	C	D	E
Grade	v1	v2	v3	V4	V5
%	p1	p2	p3	P4	p5
Coefficient	c1	c2	c3	c4	c5

$$\text{Global grade} = \frac{\sum_{i=1 \text{ to } 5} vi.pi.ci}{\sum_{i=1 \text{ to } 5} pi.ci}$$

Fig. 6 - Example of global grade calculation

5.5 Processing results

The results obtained from the grades and the service level index calculations can be used for several objectives.

5.5.1 *Comparing motorways and monitoring change in service level time*

An initial analysis of the indices is done for each motorway. Distribution of each of the indices is analysed for all the motorways, which enables identification of the motorways with the lowest levels. These motorways are then subjected to more detailed analysis of all the surface characteristics, and shall be given priority for maintenance work.

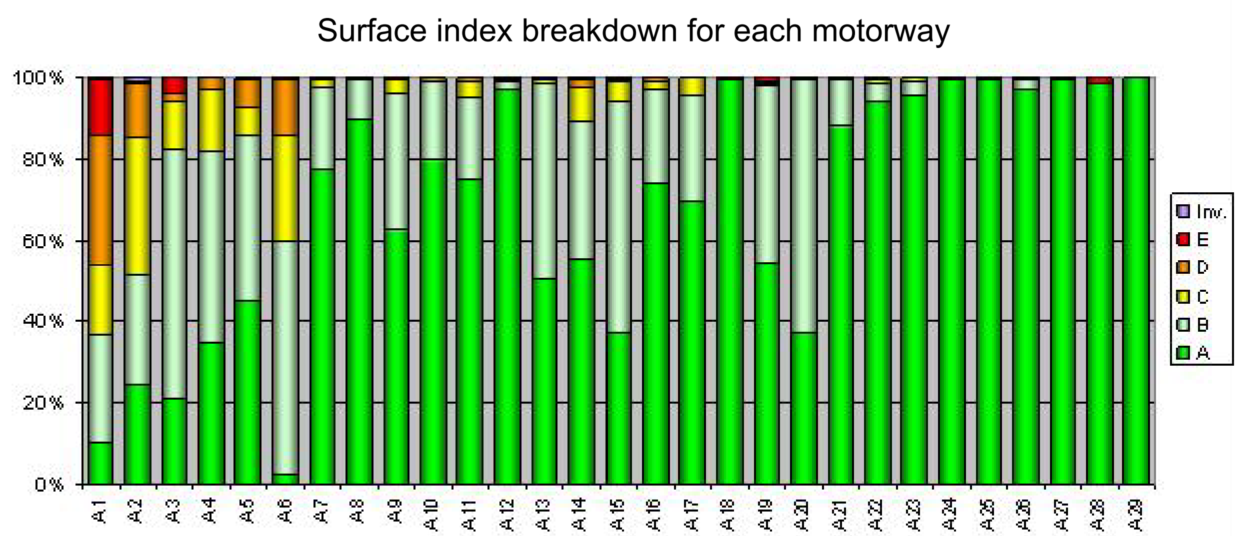


Fig. 7 – Breakdown of the surface index on each motorway

Changes over time in the service level are then analysed for each motorway. In the event of a drop in the service level, it can be seen if such changes are rapid or not, and best schedule maintenance work. This also can be used to verify if performance of maintenance work leads to improvements in the level of service.

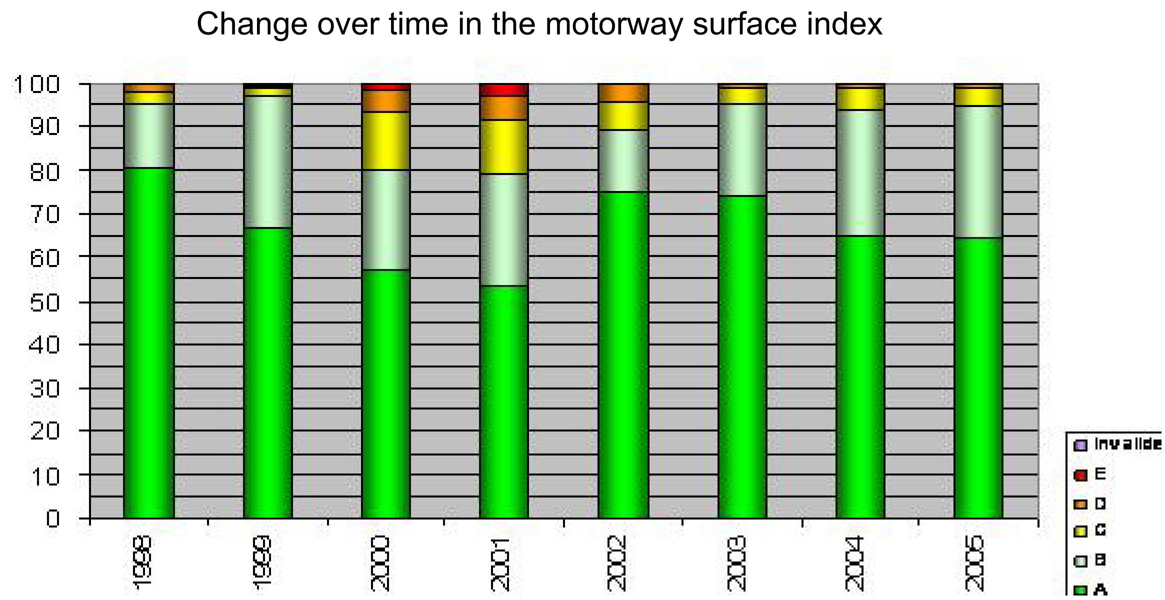
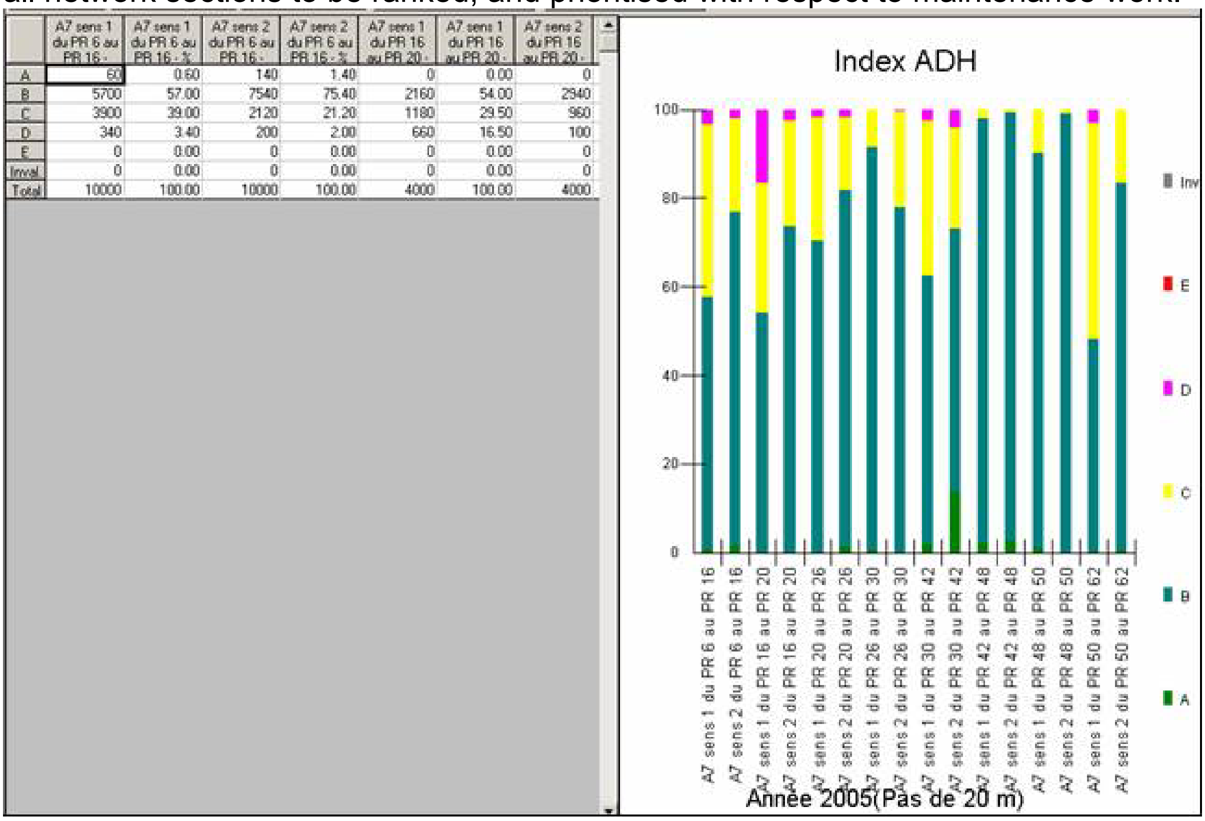


Fig. 8 – Change in motorway surface index over time

5.5.2 *Ranking sections*

Indices are also calculated for each homogenous section of wearing course. This enables all network sections to be ranked, and prioritised with respect to maintenance work.



	A7 sens 1 du PR 6 au PR 16 -	A7 sens 1 du PR 6 au PR 16 - %	A7 sens 2 du PR 6 au PR 16 -	A7 sens 2 du PR 6 au PR 16 - %	A7 sens 1 du PR 16 au PR 20 -	A7 sens 1 du PR 16 au PR 20 -	A7 sens 2 du PR 16 au PR 20 -
A	60	0.60	140	1.40	0	0.00	0
B	5700	57.00	7540	75.40	2160	54.00	2940
C	3900	39.00	2120	21.20	1180	29.50	960
D	340	3.40	200	2.00	660	16.50	100
E	0	0.00	0	0.00	0	0.00	0
Inval	0	0.00	0	0.00	0	0.00	0
Total	10000	100.00	10000	100.00	4000	100.00	4000

Fig. 9- Indices for homogenous sections

Later, in combining this ranking with the various constraints (budget, personal, concomitant construction sites …) selection is made of the sections requiring work.

The global grade is primarily used at the network level. By comparing change in the grade with change in the maintenance budget, the impact of maintenance work on service level can be verified.

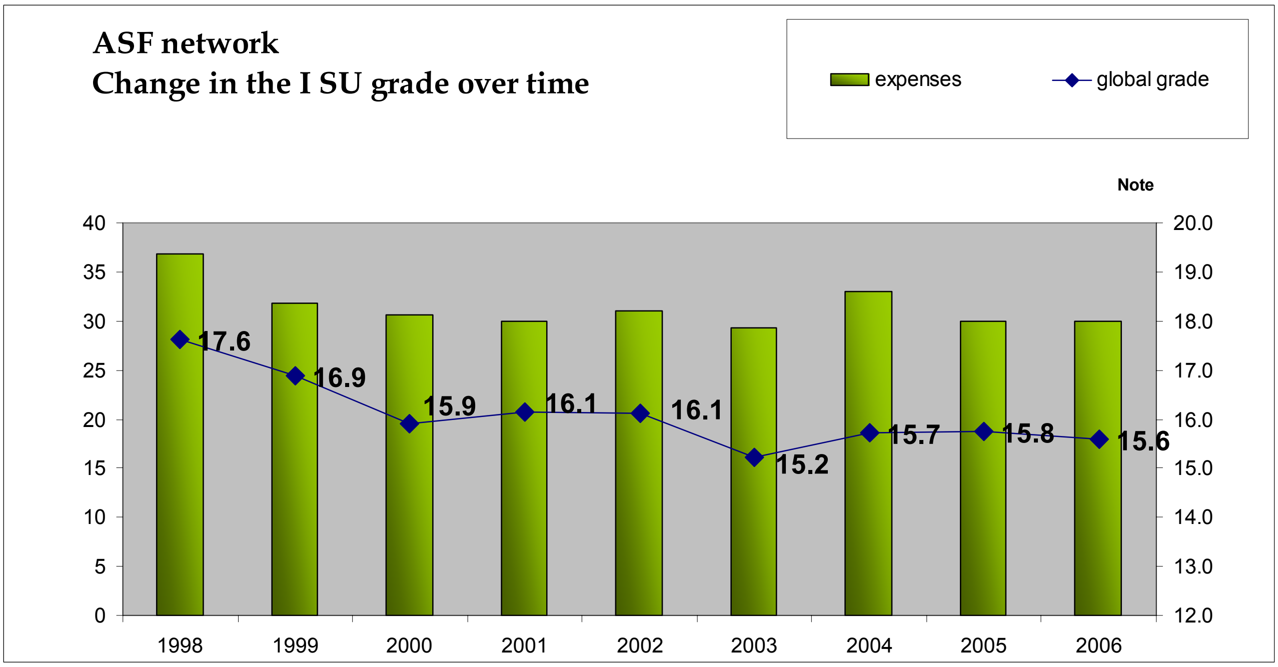


Fig. 10 – Change in the ISU grade

6. CONCLUSIONS

These systems have been implemented for several years within the context of monitoring policies, and since the early 1990's for pavement monitoring and management. Their application has enabled ASF to better manage its assets and optimise maintenance work and budget, while continuing to preserve good service levels, improve the quality of its assets and reduce the legal and technical risks for its motorway managers.

These systems, now mature, have been widened to apply to other assets, and other fields, where needs have been identified, enabling ASF to optimise its management in the face of new constraints (regulations, traffic) and new techniques and technologies which continue to arrive on the market.

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