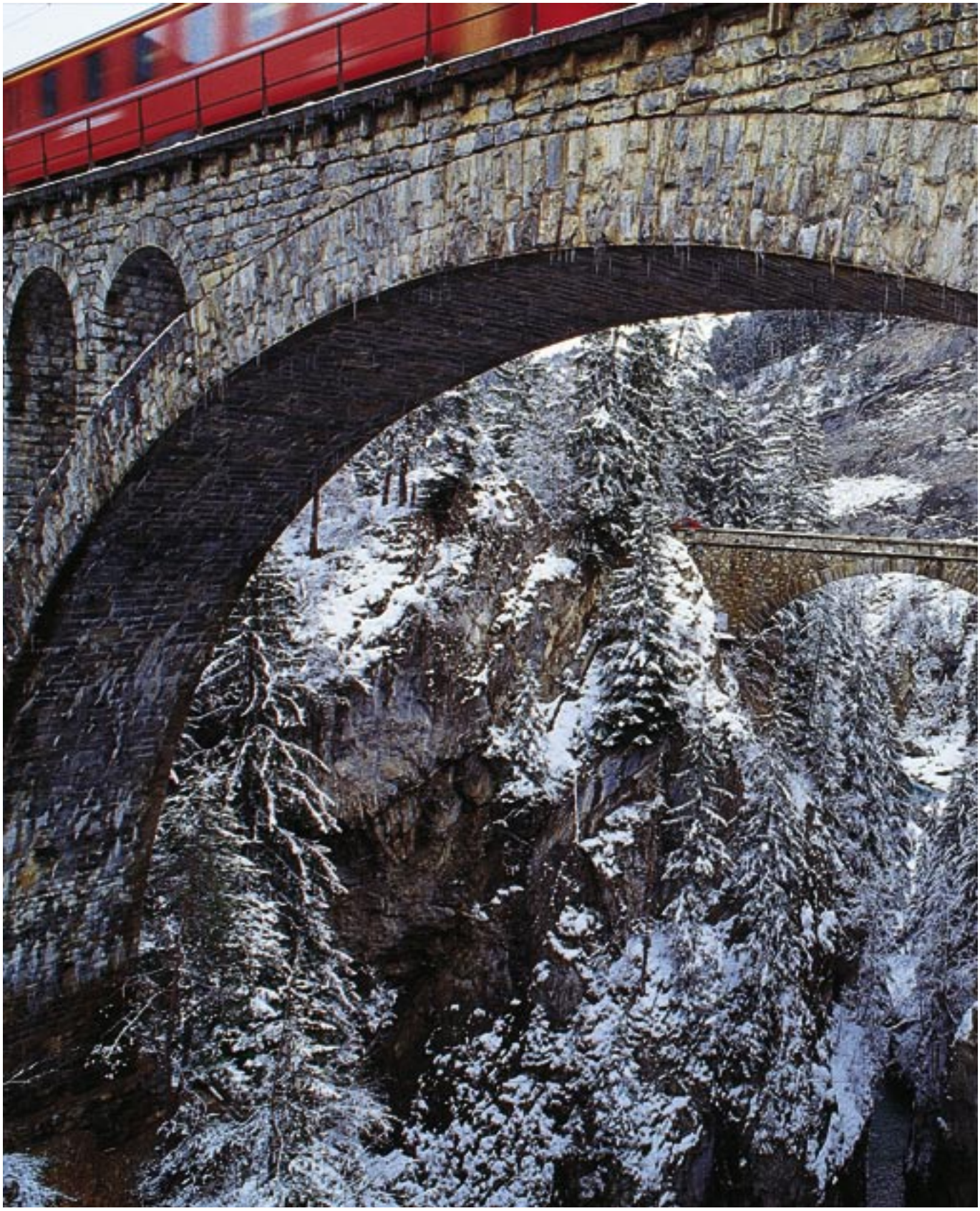
4. State of Conservation and factors affecting the Property



Albula line > Solis Viaduct with the old road bridge in the background.
R. Pedetti

4.a Present state of conservation

4.a.1 Railway

The Rhaetian Railway is having a number of detailed inventories of its structures carried out which will cover the entire railway network. The bridge and tunnel inventories has already been completed (appended to the candidature documentation ["Annex" File] in electronic form); surveys of the protective structures, retaining walls, trackways and electrical installations have all been commissioned. A programme of inspection and assessment of the protective galleries is at the planning stage, whilst inspections of the stations are due to start in the near future. The aim of these systematic investigations is to assess the safety, the remaining useful life and the condition of the structures, and to ensure their conservation. The preliminary condition assessment, which is a purely visual inspection of the structures, is designed to identify the type and extent of any serious defects and damage which may be present. Determination of the causes of the damage follows in a second step; this cannot be made, in part without the aid of more detailed surveys. The results will provide the basis for identification of the rehabilitation measures required and for updating the existing, long-term investment plan (Business Plan).

Bridges

A systematic inspection of the bridges along the whole of the Rhaetian Railway network was carried out for the first time during 2003 and 2004. Here, the term 'bridges' referred to structures with a span of more than 2 m. Structures with shorter spans were defined as 'crossings' and were not included in the bridge inspection programme. The following table summarises the type and number of bridge structures on the Albula/Bernina section. There are altogether 196 bridges with a total length of 5,441 m.

Bridges within the railway perimeter

Section	Number of bridges	
Albula section (Thusis – St. Moritz)	**Total**	**135**
	Masonry viaducts	114
	Concrete bridges	18
	Steel bridges	2
	Other types of construction	1
Upper Engadin (Samedan – Pontresina)	**Total**	**9**
	Masonry viaducts	2
	Concrete bridges	4
	Steel bridges	3
	Other types of construction	0
Bernina section (St. Moritz – Thusis)	**Total**	**55**
	Masonry viaducts	23
	Concrete bridges	10
	Steel bridges	21
	Other types of construction	1

The maintenance period for modern concrete load-bearing structures in road construction is around 25 years. This figure is based on the engineering lifetime of bridge elements such as their sealing and surfacing. The lifetime of the supporting structure itself is around 75 to 100 years. The normal maintenance period for railway bridges is between 30 and 40 years.
The condition of the supporting structures has been subdivided into the following 5 classes.

Characteristics of the condition classes

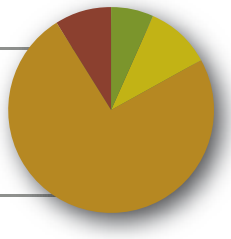
Condition class	Colour code	Measures
1 good		No measures required during the current maintenance period
2 acceptable		The bridge could (but need not) be maintained during the current maintenance period.
3 defective		Maintenance must be carried out during the current maintenance period. The time at which this is done can be freely selected.
4 poor		Rapid rehabilitation or strengthening is required over the next few years. If additional safety precautions are taken then the intervention can be postponed and/or any increase in the extent of the damage can be restricted so that the rehabilitation or strengthening will only be required sometime during the current maintenance period.
5 alarming		Immediate measures are needed to ensure the safety of the structure.

Condition of the bridges on the section between Thusis and St. Moritz (Albula line)

The following chart shows the breakdown of the bridges on the Albula line into the five different condition classes.

Evaluation of the bridges on the Albula line

Condition class	Bridges
good	9
acceptable	14
defective	100
poor	12
alarming	0



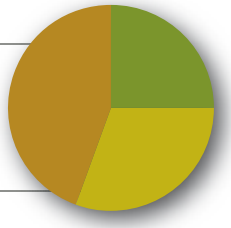
The very large number of bridges in condition class 3 stands out. All but 6 of these are jointed quarrystone viaducts dating from the time the line was constructed. The type of damage is largely the same in each case. All these structures lack bridge sealing to prevent ingress of water into the supporting structure. Without sealing, the joints in the load-bearing masonry become soaked; in winter, frost action then causes the joints to crumble. Track sealing will have to be built into all of these bridges and the joint mortar will have to be replaced. A sealed masonry viaduct with newly mortared joints can remain in service for another 50 to 70 years.
The 14 structures in condition class 4 are also quarrystone viaducts. 13 of these have been maintained as they were originally; in the remaining structure the central opening has been replaced by a concrete frame. These structures show signs of major defects and serious damage. Corrective maintenance work will have to be carried out on them during the next 10 or so years.

Condition of the bridges on the section between St. Moritz and Tirano (Bernina line)

There are a number of different types of bridge structure on the Bernina line, including masonry, concrete and steel bridges. 35 of the total of 55 structures are still standing as they were originally built, and date back to the years between 1907 and 1909. The following chart shows the breakdown of the bridges on the Bernina line into the five condition classes.

Evaluation of the bridges on the Bernina line

Condition class	Bridges
good	14
acceptable	17
defective	23
poor	1
alarming	0



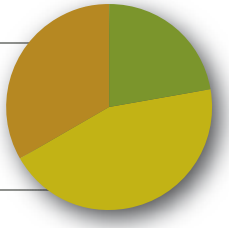
About half the bridges on the stretch between St.Moritz and Tirano fall into condition class 3; consequently mid-term, the need for rehabilitation work is higher here. Further, there is also one structure in poor condition requiring prompt rehabilitation measures.

Condition of the bridges on the section between Samedan and Pontresina

The bridges in the Upper Engadin are not all in the same condition. 5 of the total of 9 bridges date from 1907, whilst the remaining bridges are more recent. The following chart shows the breakdown of the bridges on this section into the five condition classes:

Evaluation of bridges in the Upper Engadin (Samedan – Pontresina)

Condition class	Bridges
good	2
acceptable	4
defective	3
poor	0
alarming	0



Only three of the bridges between Samedan and Pontresina fall into condition class 3, consequently a certain amount of corrective maintenance work will be required over the medium term here as well.

Main causes of damage

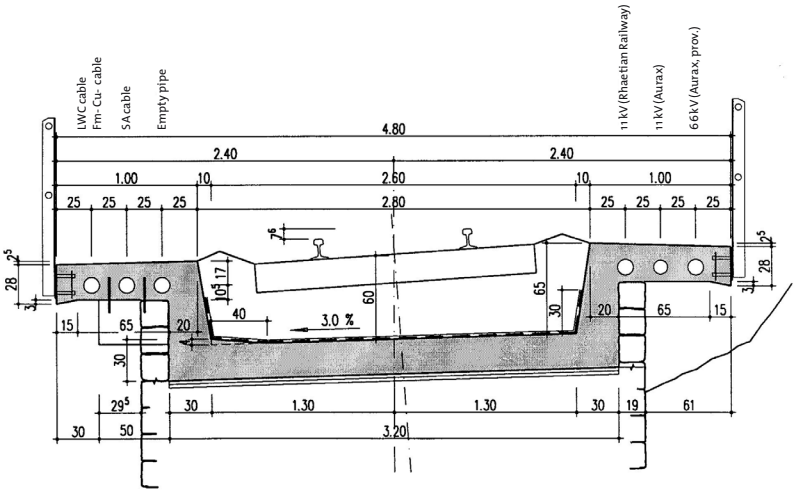
The damage and defects are largely due to the following three causes (cf. 4.b.i and 4.b.ii):

- major damage in the masonry joints resulting from the ingress of water and the effect of frost
- structural deformation resulting from ground movements
- heavy loading of the trackway, insufficient depth of ballast

Programme of works

The 15 bridges on the Albula/Bernina lines which fall into the condition class 4 range will be rehabilitated within the next 10 or so years. The following table summarises these structures.

Rhaetian Railway > Laying the concrete ballast trough on the Val Lumpegna Viaduct in the Surselva, 2005.
Rhaetian Railway



Rhaetian Railway > Standard cross section of the Val Lumpegna ballast trough.
Rhaetian Railway

Bridges in condition class 4 on the Albula/Bernina lines

Name of bridge	km	Length [m]	Causes of damage	Planned rehabilitation
Albula line				
Bändertobel Viaduct	46.991	57.40	ground movements	
Lochtobel Viaduct	47.824	121.70	trackway, masonry joints	2007
Lehnen Viaduct	51.905	72.30	ground movements	
Lehnen Viaduct	52.279	29.00	ground movements	
Lehnen Viaduct	59.270	34.10	masonry joints	
Underpass for a path	61.606	20.30	masonry joints	
Landwasser viaduct	63.070	100.00	trackway, masonry joints	2009
Val Nava Viaduct	64.954	44.50	ground movements	
Ava Lungia, farm track underpass	71.533	15.40	masonry joints	
Underpass Lower Saliaz path	73.645	13.20	masonry joints	
Underpass Old Saliaz path	74.001	13.20	masonry joints	
Blais Leda underpass for a path	78.418	13.60	masonry joints	
Albula Viaduct III	82.560	139.90	masonry joints	2008
Lehnen Viaduct	102.400	37.35	masonry joints	2007
Bernina line				
Poschiavino Bridge Rasica	59.181	23.20	bearing safety	2007

In the medium term – that is, over the next 40 years – the 126 bridges in condition class 3 will also have to be rehabilitated. Most of these are masonry viaducts dating from the time the line was built. Here, comprehensive bridge rehabilitation is the only economically sensible form of renovation. As mentioned already, the basis for the long-term preservation of these bridges is the installation of trackway sealing. This measure will be carried out together with repair of the masonry joints and renewal of the trackway (replacement of the ballast and the rails).

The pilot project for the rehabilitation of the quarrystone viaducts was completed in 2005 with the 'Rehabilitation of the Val Lumpegna' on the stretch Reichenau – Disentis. Installation of the ballast trough which seals the bridge was carried out with the support of the cantonal office for the preservation of monuments and with other external experts. The objective was to ensure the preservation of the original character of the bridge. Work on the rehabilitation of the Val Susauna Viaduct on the Lower Engadin section started in 2006. The construction approach developed for these first two bridge rehabilitation projects is to be further improved with the help of the specialists and the construction companies involved. The aim here is to define a standard construction approach for the maintenance of quarrystone viaducts.

Other Objects

Since 2005, the tunnels on the entire Rhaetian Railway network have been the subject of a systematic inspection programme; the evaluation results were presented in October 2006. A detailed assessment of the condition of the retaining walls should be available at the beginning of 2007. It is incumbent on the Rhaetian Railway, as the owner of the works, to maintain the protective structures, which were built with financial support from the federation and the canton, in good condition and to inspect them at regular intervals. The Rhaetian Railway has now started in part to meet the above obligations and in part in the course of its conservation programme to carry out structural inspections of all its avalanche baffles, rockfall barriers, stream correction measures

and slope stabilisation works (mudflow barriers). One reason for this is the obligation to maintain and inspect these works (already referred to); another is to provide information for use in developing the Railway's maintenance planning programme. Work is presently underway on the inventory of these objects in the Lower Engadin (Bever – Scuol); this work will serve as a pilot project for other areas. The condition survey of the protective structures covers the entire network and is likely to be completed within the next two to three years. A programme of maintenance for the protective structures will then be developed in coordination with the cantonal office for forestry; the programme is likely to extend over several years. So far no detailed condition assessment of the galleries has been carried out, although one is planned to begin in the near future. The track superstructure along the Albula line is presently the subject of a systematic renewal programme, under this programme work on renewal of the trackway of the Bernina line started a few years ago.

The following passages, based on the information currently available, describe the condition of the various types of structure on the Albula and Bernina sections.

Tunnels

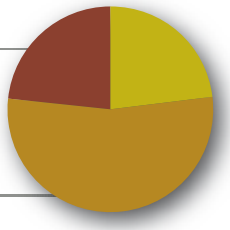
Condition

There are altogether 50 tunnels on the Albula/Bernina line, with a total length of 18,421 m. The key feature is the Albula tunnel which, with a length of 5,865 m, is more than 30 % of the line's total tunnel length.

The following chart shows the breakdown of the tunnels on the section between Thusis and Tirano into the various condition classes.

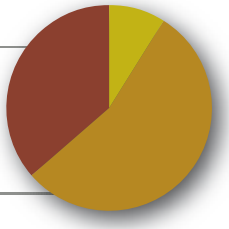
Evaluation of the tunnels on the Albula line (Thusis – St. Moritz)

Condition class	Tunnels
good	0
acceptable	9
defective	21
poor	9
alarming	0



Evaluation of the tunnels on the Bernina line (St. Moritz – Tirano)

Condition class	Tunnels
good	0
acceptable	1
defective	6
poor	4
alarming	0



More than three-quarters of all the tunnels fall within condition class 3 and 4 (assuming the ranking of the Albula Tunnel as class 4). Considerable corrective maintenance work on these tunnels is essential over the short to medium term to guarantee operation.

Types of damage and their causes

The main types of damage to the tunnels are:

> crumbling of the joint mortar and bulging of the masonry
> deformation of the structures

The damage to joints and masonry is caused by the ingress of water and the effect of frost, the deformation of the structures is the result of differential ground movements. Other damage is due to the design, whereby the vaults of the tun-

nels are mostly lined with quarrystone masonry but without any strengthening provided for the sole. The tunnel profiles are usually horseshoe-shaped – a form which in structural terms is quite unfavourable. In most cases no measures were taken to seal the vaults or to drain off the mountain water.

Programme of works

The programme of works will largely be based on the results of the main inspection. A comprehensive rehabilitation is planned for the 100-year old structure of the Albula tunnel, giving it an additional lifetime of 70 more years. The rehabilitation work will include all aspects of current railway engineering technology, such as track superstructure, track substructure, catenary system and cable installations; it will also include implementation of the safety requirements in the existing railway tunnel. The Swiss Federal Office for Transport (BAV) is currently preparing a guideline on a classification system and safety requirements for existing railway tunnels.
A number of other improvement measures are also to be considered for inclusion in the next larger-scale rehabilitation projects. In general, the clear cross-sectional area of the tunnels is roughly 18 m^2 to 20 m^2, however, in many places the actual dimensions are less than the theoretical railway loading gauge.

Condition of the protective structures

Protective galleries

The galleries along the Albula and Bernina lines are all avalanche and/or snow protection galleries. Those on the Albula line are massive stone-built structures with masonry vaults which were built when the line itself was constructed. The galleries on the Bernina line have very light steel structures and a roofing of timber planks or corrugated iron sheets. These galleries were designed to resist much smaller falls than would be designed for today, when more stringent safety specifications are applied. This is particularly true for the light structures on the Bernina line.
Between 1983 and 1985, the Maliera gallery between Bergün/Bravuogn and Preda was replaced by a new and longer protective gallery. This has a framework structure on one side with steel supports set in concrete on the valley side. Some of the galleries on the Bernina line have been rehabilitated, but only minor additional strengthening was incorporated at that time.
The maintenance condition of the protective galleries is likely to be the same as for the tunnels. On the Albula line it is probable that damage will be found in the masonry joints; much more serious damage is likely to be found in the lighter galleries on the Bernina line which have not yet been renovated.

Other protective structures

The Albula/Bernina section is protected at several points by avalanche baffles, rockfall barriers, stream containment and slope stabilisation measures (mudflow protection). Many of these protective structures – mostly avalanche baffles – date from the time when the line was built. In recent years many of the structures between Filisur and Bever along the Albula section which protect the line from rockfalls and avalanches have been renewed. In some cases the structures have been extended or additional new structures built to meet the potential level of risk which exists today. The work was carried out in close cooperation with the cantonal Forestry Office. The focus of the work on the Albula line includes Sils i.D./Schin Gorge, Filisur – Bergün/Bravuogn (Surmin rockfall

barrier), Muot (avalanche baffle with approximately 500 protective structures) and the Val Bever, where in 2005 a mudslide barrier was built near Spinas to protect the south portal of the Albula tunnel, and where the Alpetta avalanche baffle is currently being renewed and extended.
The focus of the work on the Bernina section is on the upper part of the line. The inventory of the avalanche baffle on the Pila slope between Alp Grüm and Cavaglia has already been completed. The baffle consists of some 450 protective structures. A first stage of the rehabilitation work is due to begin in 2007. The Poschiavo rockfall barrier (built in 2005) and a number of other rockfall shelter walls along the Miralago – Brusio – Campocologno (the Li Geri protective embankment) – Tirano section are additional structures exposed to a high level of risk and must be monitored carefully.
The steadily increasing concern for safety and the continuing climatic change will soon lead to the need for the construction of additional protective barriers, primarily as protection against rockfall and landslides. The measures which might be used here include massive reinforced concrete protective galleries or the use of flexible protective catch nets. The selection of one or other type of barrier will depend on local conditions.

Condition of the retaining walls

During the construction of the railway a distinction was made between proper retaining walls which provide support to the trackway on the valley side and revetment walls along the sections of the line on a mountain slope and which protect the slope on the mountain side of the trackway from erosion. The retaining walls on the Albula section consist of either vertical or inclined (1:5) gravity walls in mortar-jointed masonry. The retaining walls on the Bernina section were built as dry stone walls with an inclination of 1:3 or as mortar-cemented walls with an inclination of 1:5. The revetment walls on the Bernina section are of a similar type of construction; these walls are either dry stone with an inclination of 1:3 or mortar-cemented with an inclination of 1:5.
Today, retaining walls and revetment walls are almost always built in concrete. In the nominated area, new concrete retaining walls of this type, to a design based on the existing structures, with an advance wall are already being built.
Retaining walls are often overburdened by water running down from the mountain side and building up behind the wall. This results in bulges forming in the masonry and could entail the risk of partial collapse. Frequently, damage to the masonry joints is also caused by the ingress of water and the effect of frost (see the description of the condition of bridges). Masonry joints can be further damaged or even destroyed by plant growth.
Massive retaining walls are relatively insensitive structures. Localised damage to this type of wall does not entail a direct threat to the structure as a whole. Extensive plant growth and gaps in the masonry where individual stones or bricks have dropped out can, however, give the structure an unkempt appearance and in the long term lead to a loss of structural safety. Over the next few years, partly due to the age of the structures, a substantially increased volume of maintenance work will be needed for retaining and revetment walls. The work should result in these supporting structures remaining in good working condition for a long time to come.

Condition of the trackway

Trackway on the Albula section

By the end of 2007 all of the section between Thusis and Tiefencastel will have been largely renewed, as will 85 % of the section between Tiefencastel and Filisur. Over the next 10 to 15 years large sections of the track between Filisur and Preda and between Spinas and Bever will become due for renewal. Special cases are presented by the section between Tiefencastel and Surava in the area of the "Brienzerrutsch" (an instable slope near Brienz) and by the Albula tunnel. Here, the broad Brienzerrutsch pushes the terrain (and consequently also the trackway) southward towards the Albula by up to 10 cm each year. One of the results of this is that annual inspections and corrective measures have to be carried out in order to maintain the safety of railway operations. In the Albula tunnel there is a conflict between the aims of providing adequate track bedding/track height and maintaining sufficient clear vertical profile. In parallel to the renewal of the track superstructure, work will also be carried out on the trackway shoulder and track drainage, maintaining, extending or improving them to bring them up to modern standards and requirements. Where necessary renewal of the cable conduit blocks will be included in the projects.

Trackway on the Bernina section

Work on the systematic renewal of the superstructure installations on the Bernina line only began a few years ago. There is a considerable backlog to deal with here. The priority work, which involves renewing the track on the section to meet latest standards, will take at least another 8 to 10 years to complete. For a number of operational reasons it was decided to carry out the work on the station facilities (length of passing tracks, safety facilities and so forth) early in the overall programme. For this reason, the facilities will soon have been brought up to a good standard throughout to cope with today's traffic volumes. The Bernina line is located at quite a high altitude, it has many gradients, a difficult geometrical alignment with many tight bends and much of it runs through difficult terrain. Maintenance and renewal work to this line therefore present much greater logistical and constructional challenges than do the other sections in the Rhaetian Railway's main network. Here, engineers planning work on the higher reaches of the line have to deal with the additional problems of frost and the short construction season.

Electrotechnical installations

An initial systematic inspection of the Rhaetian Railway's electrotechnical installations was carried out in 2004. This preliminary condition assessment is presently being updated. The work covers the following main sub-systems:

> safety facilities (such as points and derailers, barriers, blinker systems, signals, track switching systems, axle counters, train protection) and
> low voltage, power and telecommunications facilities (LT facilities) – such as track lighting, points heating, potential equalisation, earthings, lightning protection, internal facilities installations (light, heating, ventilation, air-conditioning, electricity supply, telephone and telecommunications installations, data transfer facilities, data communication, train radio and marshalling radio, automatic ticket machines, ticket cancelling machines, parking meters, customer information systems, loudspeaker systems, fire detection systems, rectifier equipment,

Rhaetian Railway > Renewing the catenary installations.
P. Donatsch / Rhaetian Railway

coach preheating systems, static frequency converters, substations, switch gear and network control stations).

There are 27 locations on the Albula section with electrotechnical plant and systems. 15 % of the LT facilities and 45 % of the safety installations on the Albula line are in good condition. The condition of a further 85 % of the LT facilities and 50 % of the safety installations have been classed as acceptable; the general condition of these installations is good, although individual parts and components have defects; operational safety, however, is assured in every case. The only installation which is in poor condition is the 54-year old safety installation in St. Moritz; this will have to be replaced within the near future. There are 37 locations on the Bernina section with electrotechnical plant and systems. Here, 16 % of the LT facilities and 36% of the safety installations are in good condition. On 78 % of the LT facilities and 55 % of the safety installations individual parts and components have minor defects, these do not, however, present any risk to operational safety. 3 % of the LT facilities and 9 % of the safety installations are in poor condition: increased investment is needed here to assure operational safety. The facilities classed as defective will have to be replaced in the near future. The only facility in condition class 'poor' is the Charnadüra tunnel portal LT facility in St. Moritz (on the Pontresina side). However, if special measures are taken, operational safety can also be assured for this facility.

Catenary systems

Large sections of the catenary systems on the Albula line are in good condition. Those sections which have not been rehabilitated are due to be renewed, with work planned to be carried out in stages over the next few years. For some years now, work has been ongoing on a systematic renewal of the catenary systems on the Bernina section, where the continuing growth in train services has meant that the power supply capacity had to be increased. The rectifier equipment was modernised at the time the catenary system was renewed. The renewal work is being carried out in stages, with sections of about 1.5 to 2 km being dealt with each year.

Buildings

The station buildings are generally in a relatively good condition, with no immediate need for renovation work. Most of the buildings contain technical installations related to the railway, which has meant that the buildings have been maintained regularly. When restoration work is carried out, care is taken to ensure that as much as possible of the original features are preserved and, where necessary, even recreated. Some of the original auxiliary buildings have lost their nominal function. Only the most essential maintenance work was carried out on these buildings to ensure that the appearance of the buildings is preserved.

Albula line > A Rhaetian Railway train at Tiefencastel. In the background, to the right, the village of Stierva.
T. Keller / Rhaetian Railway

4.a.2 Cultural landscape

Graubünden (Switzerland)

The condition of a cultural landscape depends on its economic exploitation; if this is abandoned then the cultural landscape changes significantly as the natural processes take over. In the long term, economic exploitation can only be assured if it provides the people involved with an adequate means of existence.
General changes in society entail changes in the demands placed on the living space and so to the demands placed on the cultural landscape; the changes also affect the way in which the cultural landscape is exploited. As with all living cultural landscapes, those in the Albula/Bernina area are subject to dynamic change, which is in turn a reflection of cultural development. Some of the activities which affect the area and so the cultural landscape have more widespread effects. Most of these are recorded in the Cantonal Structure Plan (cf. 5.b) where they are assessed, giving due consideration to the interests affected. The Structure Plan is subject to continuing elaboration and updating and thus provides a basis which can be used to guide the development of the cultural landscape and to facilitate realisation. The Management Plan does not include financial flows which affect a wide area (e.g. acreage contributions to the farming industry) or the level of compensation for services provided by farmers in the public interest. These concerns are defined by law; however, taking them into consideration involves mutual coordination and agreement.

Waterways – Realignment of the River Flaz

The most striking change in the cultural landscape of the Albula/Bernina region in recent times was caused by the realignment of the river Flaz, in the Upper Engadin. The Flaz has its catchment area in the Bernina region. Until recently the river ran parallel to the railway from Punt Muragl to Samedan, where it flowed into the River Inn. The change in the course of the river was made with the idea that the built-up areas of Samedan, located on the floor of the valley, would then be protected from high water levels. These areas used to lie in the major high-water flood zone (100-year flood level). Today, the river runs from Punt Muragl along the foot of the slope of Muotta Muragl towards Gravatscha, where it joins the Inn. At the time the Flaz was relocated, work was also carried out to renaturalise the River Inn between Samedan and Gravatscha. The relocation of the river was designed to meet ecological and environmental demands, earning the scheme a number of prizes as a project of outstanding quality.

Agriculture and forestry

The whole of the cultural landscape of the Albula/Bernina region is well managed with respect to agriculture and forestry. Melioration measures, such as those carried out in recent years, provide the structural conditions which allow the cultural landscape to be managed with the means available today (mechanisation and modernisation) and in a way that ensures its continuing preservation. Such land improvement works are still in progress in some areas of the Val Poschiavo.
Over the last 20 to 30 years agricultural operations

Samedan > The River Inn has been 'renaturalised' between Samedan and Gravatscha.
Tiefbauamt Graubünden, Chur

Samedan > The Flazbach now flows naturally into the Inn at Gravatscha.
Tiefbauamt Graubünden, Chur

Samedan > Renaturalisation of the river has created natural habitats.
Tiefbauamt Graubünden, Chur

Samedan > Historic view of the village; with the lazy meanders of the Inn.
Rhätisches Museum, Chur

have been relocated out of the villages because of problems with the emissions caused (noise, air, dust and so on). This has occurred along the whole section of the railway line. In relocations of this type the new location for the agricultural operations is selected with due attention being paid to the various interests involved (integration into the landscape, ecological aspects, operational processes, protection against natural hazards, future extensions, and so on). As a consequence of the development of the laws and standards relating to animal husbandry, the production of foodstuffs, and so forth, which are applicable to the whole of Switzerland, the farm buildings too have changed. The new animal quarters are much larger than their predecessors and therefore stand out more in the landscape. The aim is to integrate any changes to buildings and structures related to the agricultural use of the land into the landscape carefully. In doing so attention is given to preserving (and even renewing) special features of the cultural landscape such as dry stone walls, hedges and narrow paths. These modifications are carried out in accordance with the existing legal and planning conditions and with due consideration given to land tenure regulations and to what can be reasonably expected of the farmers.

Access ways have recently been constructed in the forests; these make economic exploitation of the forests possible even in areas with steep slopes. In recent years, there has been a 'renaissance' of objects constructed with wood from the region's forests (e.g. a timber bridge in Tiefencastel, a forestry centre in Bergün/Bravuogn). Local timber is also used for energy recovery (e.g. for wood chip heating systems).

In future the primary focus will be on the regular maintenance and preservation of the infrastructure provided for the management of the local agriculture and forestry.

Settlements

Settlements are constantly changing, although to different degrees; outwards, through expansion of the area covered by the settlements, internally, through construction on vacant plots of land in the heart of the villages, through continuing renewal or through measures aimed at increasing density. The villages and hamlets in the Albula valley, as in the Val Poschiavo, are developing less markedly than those in the Upper Engadin – a difference which is largely determined by the unequal weighting of spatial policy in these regions. In 2005/2006, a survey of the building zones was conducted with a view to better comprehension of the quantitative changes taking place in the villages. A geographic information system (GIS) was used to collect details of the building zones, aggregate them and compare them, using standard criteria, with the official survey of built-up area coverage. This work now forms the basis for a reporting exercise that is carried out and presented to the federation and parliament at periodic intervals. In turn, the obligatory reporting exercise ensures that the surveys are carried out at regular intervals.

In striving for high quality settlement development, one decisive factor is the way that historic buildings are treated in those parts of the settlements/villages most worthy of protection. An overview is available which indicates how the local authorities deal with the historic centres of their settlements/villages in their building laws; the overview shows whether the measures implemented are in keeping with the specified legal and structure planning principles. This overview was last updated in 2006 and will be updated at specified intervals in future; it forms part of the reporting process referred to earlier. It is established that the planning conditions have been created in all the local authority areas within the

nominated World Heritage Site, to allow meticulous treatment of the village nuclei worthy of protection. But it is not only the external appearance of the villages or the façades of the buildings which are being protected and preserved. The valuable fabric of the interior of the buildings and the typology of the buildings is also being preserved. Civil works on historic monuments, significant in terms of the history of art and culture, are carried out after conferring with specialists from the cantonal office for the preservation of monuments; the specialists also accompany the entire work process in detail. In special cases this technical department can arrange for financial contributions from the canton and even from the federation.
Every building application received for construction outside the building zone is recorded, dated and coded and the site concerned georeferenced. This database provides an opportunity to obtain an understanding of the quantitative changes taking place in the cultural landscape.

Infrastructure (roads, transport facilities for tourists, the production and transport of electricity)

Various types of infrastructure characterise the cultural landscape of the Albula/Bernina region. The road network will remain in its present form long term; there are no plans for the construction of any new, continuous, longer-distance transport axes. Existing roads are regularly maintained, renewed and brought in line with today's requirements. These works include measures taken to protect against natural hazards; examples include the rehabilitation of the road through the Schin gorge (land slips) or the road across the Bergünerstein (rock falls). Larger-scale renewal work and new franchising work is due to be carried out for a number of transport facilities for tourists. These do not involve new access links but rather the renewal and improvement of existing facilities which are coming to the end of their working life. These facilities were built during the tourism boom of the 1960s and 1970s. In some cases the renewal work has already been completed.
Other infrastructure features in the Albula/Bernina area include the numerous hydropower stations and the overhead lines needed to transport electricity. The power stations have always been the source of power for the operation of the railway and are frequently the subject of new concessions. The overhead line has been renewed in recent years (the Bernina axis). In terms of the use of hydropower, the project to increase the storage height of the Lago Bianco is worthy of mention (cf. 4.b.ii).

Quarries and gravel pits

Quarries and gravel pits are also elements which are important for the preservation of the cultural landscape today. The supply of gravel, sand and stone for the next 20 years is largely assured. The relevant sites are included in the Cantonal Structure Plan (cf. 5.b). Along the Albula and the Bernina lines, culturally-relevant changes to three of these sites can be expected short to medium-term; the remaining sites will continue to shape the cultural landscape as long as they are in use. The quarry near Sils i.D. is a source of hard stone that is used as track ballast. The operation of this quarry – hidden in the scenery – will be closed down over the next few years, as any further extension of it would lead to the destruction of valuable elements of the cultural landscape (the ruins of the Campi fort – a cultural monument of national significance and an element of the core zone). Studies have shown that stone of appropriate quality is available in the Farrirola area, near the railway line between Filisur and

Bergün/Bravuogn. This is a location were material was quarried and processed in earlier years. The preliminary work (incl. modification of the Structure Plan) on the realisation of a new quarry is almost complete. However, the facilities in the area of the Cambrena delta (Bernina axis, Lago Bianco) will be closed down and not replaced should the planned increase in the storage height of the Lago Bianco be realised

Tirano (Italy)

The agricultural economy

Agricultural businesses like the cooperative dairies and the fruit and vegetable consortia provide economic activity throughout the region through the production of goods and the sale of services. There are others which might be better defined as "micro-businesses" since they are owned and run by the members of one family in most cases. The agricultural sector is historically important in mountain areas. Indeed, in spite of the difficulties imposed by the nature of the mountain terrain, which is difficult to access and not conducive to intensive exploitation, agriculture has always played an important part in the culture and economic structure of the villages in the area. In recent years, however, there has been a gradual decline in the sector. There are currently 189 agricultural businesses in Tirano, 175 of which operate on an area of less than 5 hectares. These figures are a significant reduction on those for 2000, when there were 476 farms. Furthermore, there has been a reduction in the area given over to vineyards in the town and its surroundings. As a result, some areas have been changed into fields and pastures and have not been replanted, therefore requiring less work. There are several livestock-breeding farms, mainly rearing cows and pigs, but also sheep, goats and horses, as well as poultry and bees.

Infrastructure

The area has an extensive network of roads, but this presents several problems. Geographical factors and the effects of national and international decisions over the years have meant that the area, and the Valtellina or Veltlin as a whole, continues to play a marginal role in the overall scheme of transport infrastructure and, therefore, in the movement of people and goods through the Alps. There is one main road, the Strada Statale 38 dello Stelvio, which runs along the floor of the valley and is joined by a series of secondary roads connecting the various villages. This creates heavy traffic and has a negative effect on access to the area. In comparison with other parts of Italy, the Valtellina region has a high density of commercial vehicles due to the poor coverage provided by, and the limited use made of, the railway network – which only goes as far as Tirano and is only a single track – and the resulting dependence of commercial traffic on road transport. In addition to the local bus services, there are two different railways in the area, the Milan – Lecco – Tirano railway and the Chur – Bernina – Tirano railway (both on only one track), and they meet in Tirano. To reach other communities from there, one has to use the local buses, operated by STPS (Società di Trasporti Pubblici di Sondrio).
Other service infrastructures include transmission facilities (TV, radio, radio relay and telephone), power lines and hydroelectric stations, which make Valtellina a high production area of hydroelectric and biomass energy. There is also a wood biomass plant in Tirano, which was

built in 2000 for the production of thermal energy. It has been enlarged since then and can now produce about 7,500 MWh of electricity per annum. It supplies a network of 300 users, spread over an area of nearly 20 kilometres, as well as sports and leisure facilities.

Settlements

The municipality of Tirano encompasses several frazioni (localities) – Baruffini, Cologna, Madonna di Tirano and Roncaiola – which have seen an increase in the number of houses used as main residences, second homes or holiday accommodation.

Bernina line > The railtrack is exposed to the elements, particularly in winter.
P. Donatsch

4.b Factors affecting the property

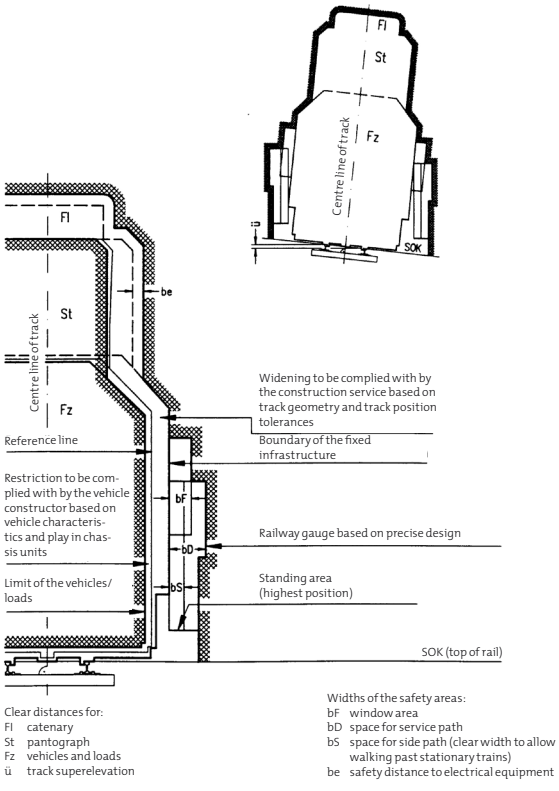
As a service provider, the railway is subject to constant change. The development of tourist offers, changes in commuter and leisure transport and the continuing adaptation of rolling stock to user needs attest to socio-dynamic influential factors. Even the cultural landscapes traversed by the railway are in a process of constant change although their historic and traditional use is still recognisable in the landscape and settlement pattern. Furthermore, state agricultural and energy policy, the endeavours with regard to nature and heritage protection, and the efforts to manage spatial planning are reflected in the cultural landscape. The forces of nature affect people, the environment and the railway infrastructure. Both at company level in the Rhaetian Railway, as well as at authority levels, the monitoring, assessment and use of suitable protective measures with respect to the risk of natural dangers is legally and financially assured. Methods and procedures are subject to appropriate regulations. Climate change, which has become increasingly more apparent over the past ten years, is a further influencing factor. In the Albula/Bernina region, as in all other Alpine regions, the consequent increase in extreme meteorological occurrences and the thawing of the permafrost affect all areas of life as well as development perspectives.

4.b.i Development Pressures

Railway

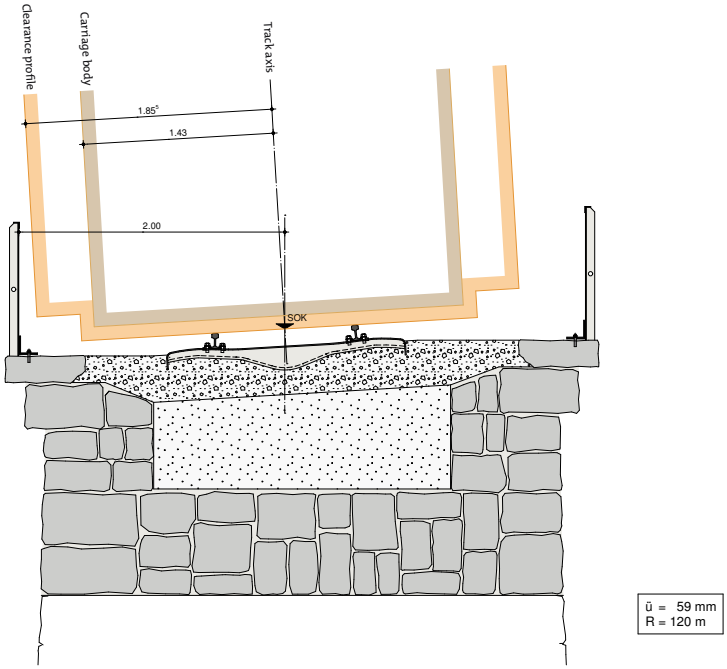
The constant modernisation of rolling stock corresponding to state-of-the art technology and the changing needs of rail passengers has an influence on the railway infrastructure. Thus, the increase in travelling speed requires adaptation of track banking (ü) and the longer carriages necessitate adaptation of curve radii (e); vehicle width directly affects the radius of the reference curve and the clearance gauge.

The following diagram shows the realisation of the clearance profile according to the provisions of the railway decree:



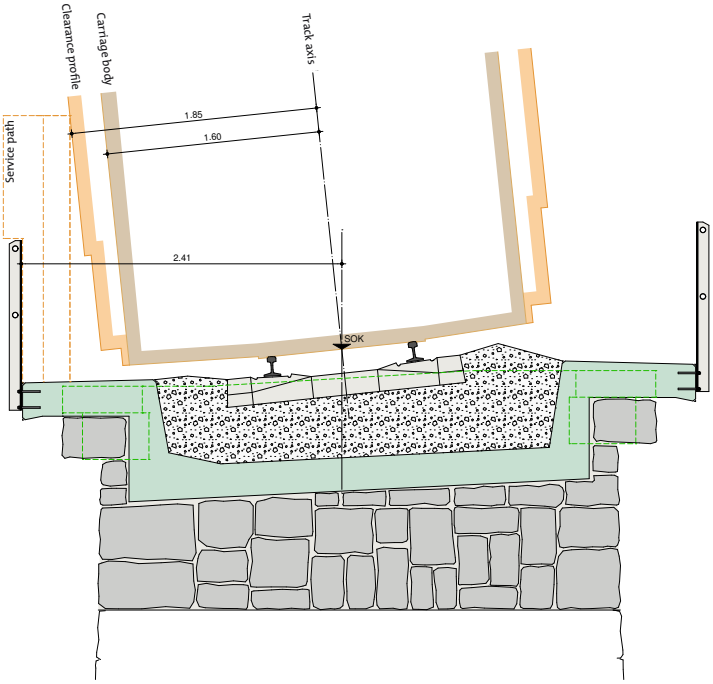
The clearance profile was defined as follows when the railway was built:
(ü=track banking; e=curve radii)

$b_{min} = 1.775 + e + 2.0 \times ü$
(without service path)



Today the clearance profile is calculated as follows:

$b_{min} = 1.85 + e + 2.0 \times ü$ (without service path)
$b_{soll} = 2.05 + e + 2.0 \times ü$ (with service path)



At the time the railway was built, trains ran at 30 km/h; the longest carriages were 14.30 m long and 2.70 m wide; on bridges, the minimum distance between the carriage body and the railings was 60 cm on either side. On straight line sections, there was therefore a minimum width of 3.90 m between the railings. This width was increased to 4.0 m on the Albula line for snow blower operation. In curves, the modified position of the vehicles, both horizontally and vertically, was taken into consideration according to the legally established standards. If, the same safety standard is to be reached as at the time the railway was built with today's rolling stock and speed, the minimum width between the railings for bridges in the arc radius (R = 100 – 130 m) has to be increased to 4.52 m. This corresponds to a widening of around 25 cm on both sides (curve radius +10 cm, track banking +7 cm, rolling stock width +5 cm).

Increased speed also leads to a greater load on the single-track system. The original ballast depth of 35 cm is only just sufficient for today's needs. When renewing the track, the sleepers and rails, as well as the old ballast, will be completely replaced and the ballast depth increased.

Today, in contrast to early days, the safety of railway personnel has also become a primary focus. Crossing the rails is classed as dangerous if the sighting time is less than 6 seconds. Assuming about the same sighting time for the Landwasser Viaduct, a railway worker caught off guard by a train approaching at 45 km/h must be at least 75 m from the entrance of the Landwasser Tunnel in order to still be able to make his way to safety. If he is closer to the tunnel entrance, his safety can no longer be guaranteed. In contrast to the tunnels there are no niches on the bridges, which is why a service path (safety zone for employees) must be created if the construction work exceeds a certain length. Taking a service path of 40 cm into account, the target width between the rails according to the above explanations is 4.92 m (4.52 m + 40 cm). In the interest of a compromise between conservation of a historic monument and technical safety demands, the Rhaetian Railway is fundamentally aiming at a minimum bridge widening to only 4.80 m in curves. Furthermore, the service path need not extend over the whole length of the bridge, but can be reduced in places. Increased safety requirements make constant adaptation of the installation inevitable. In order to guarantee the safety of passengers, structural measures in the Albula Tunnel will have to be addressed in the near future. Amongst other things, the Federal Department of Transport will shortly issue new guidelines for the classification and safety requirements for existing railway tunnels.

Cultural Landscape

Graubünden (Switzerland)

Spatial development

On the basis of demographic development, settlement structure and key economic data, four regional types can, in principle, be distinguished in the Alpine area, each with different development tendencies. However, these dovetail in some places and, by their interaction, have a significant influence on landscape development:

> *Central regions* with densely urbanised centres and periurban agglomerations. As well as tourism and other services, industry and

Diavolezza mountain station > In the background, to the left, Piz Bernina and the Biancograt.
C. Sonderegger> / Graubünden Ferien

Bergün/Bravuogn > Haymaking mountain style.
R. Pedetti / Graubünden Ferien

business are also often considerably developed in these areas.

- *Periurban regions* with high proportions of commuters to agglomerations within, or frequently outside, the Alpine centres. This regional type is characterised by population growth with, at the same time, a lack of independent economic dynamism.
- *Rural areas* with a dispersed settlement structure and, as before, strongly marked by agriculture. Business and tourism play only a marginal role. This type shows a more or less balanced population trend.
- *Depleting regions* with marked decreases in population and a very high proportion of agriculture.

The Thusis-Domleschg region, with the once important service centre of Thusis on the north-south route, can be characterised as a periurban region. Under the influence of the economically powerful Chur-Rhine Valley agglomeration, it shows population growth but is losing economic dynamism because the orientation to the magnet of Chur appears increasingly determinant.

The Albula valley is an agricultural region, fighting against the phenomena of ageing and migration, and economically subject to the influence of the neighbouring tourist centres of Lenzerheide, Savognin and Davos.

The Upper Engadin is a focus region experiencing steady population growth. Here, tourism is the principle economic sector and the most important influential factor with regard to spatial planning. The Rhaetian Railway had an influence on the development of tourism and, in the early days, even played a leading role in promoting it. The Bernina Pass countryside has been formed both by the development of tourism in the Upper Engadin and by the infrastructure of the Rhaetian Railway. It owes its attractiveness to the Bernina Group and the Biancograt, always a magnet for climbers.

In the rural area of Val Poschiavo, the population and regional economic structure has, to a large extent, remained stable thanks, amongst other factors, to innovative industrial and tourism projects as well as to the economic advantages arising from the proximity to the Italian Veltlin and to the Upper Engadin.

In general, nature and cultural landscapes are increasingly coming under pressure from changed usage demands. In the Alps, natural living areas are endangered by increasing traffic, over-development and the 'correction' of rivers and lakes. As a result, biodiversity is steadily diminishing in the Alpine region, as it is elsewhere. Nevertheless, the Alps are the largest remaining 'natural' region in central Europe. Thirty thousand animal and thirteen thousand plant species bear witness to a great natural variety. Nature reserves are a successful tool for maintaining the Alpine biodiversity. In the Albula/Bernina region too, numerous nature reserves of the most differing categories have been established. The Upper Engadin lakeland and the Bernina massif are listed in the federal Inventory of Landscapes and Natural Monuments of National Importance (cf. 5.b and 5.c). Amongst other things, Swiss spatial planning law lays down legally binding provisions, and various planning tools, at cantonal and local levels, for all spatial development trends. In principle, spatial planning focuses on sustainable development. In particular, economical management of the limited surface resources has priority (cf. 5.b).

Agriculture

By and large, the farming sector still plays a major role in the Alps, particularly in the northern regions, where a structure-conserving agricultural policy, as well as specific regional and sector policies, ensure that agriculture remains viable. Low-yield mountain farming is coming increasingly under pressure against the background of global liberalisation. The organic production of local specialities and marketing them in collaboration with the tourist sector, offers one possibility for the future. In the Albula/Bernina region, there are various successful agricultural initiatives in this direction, such as, for instance, the "ansaina" product label in the Albula valley. Swiss agricultural policy supports this development. Instead of the price and product subventions practised until the 1990s, today, surface-related direct payments are made to agricultural enterprises which, for their part, are linked to ecological strictures. This helps to compensate for the disadvantages of farming in mountain regions. The consequent assurance of care and conservation of the cultural landscape has positive effects not only on biodiversity, but also on tourism. In Graubünden, over half of the agricultural enterprises already operate according to the guidelines of the "Bio Suisse" (organic) label, which is recognised throughout Switzerland. As well as the incentive created by the agricultural policy, market demand is also responsible for the high number of enterprises that have switched to organic production.

Hunting and fishing

In Switzerland, hunting and fishing are legally regulated at federal and cantonal levels. Both are important for the preservation of species, the careful management of natural resources and the sustainable ecological development of the fauna in general. In particular, regulation of the animal populations requires human intervention, since the damage to mountain forests, for example by foraging, would be excessive if there were no control. The regular hunting season in Graubünden, is restricted to three weeks in September. But special hunting regulations are applied in the event of very large populations, small animals or particular species, such as the Alpine ibex. Along the Albula / Bernina route, designated federal hunting-ban areas (no hunting allowed) and various game reserves are also factors influencing the World Heritage perimeter.

Closed seasons have also been established for fishing. The stretches of water and the periods when fishing is permitted are clearly defined. The cantonal office for hunting and fishing constantly monitors and regulates fish populations.

Forestry

Forests fulfil diverse functions. Mountain forests, in particular, offer indispensable protection for settlements and traffic and, as ecologically sensitive nature areas, require particular care and active management. The ecological stability of mountain forests is adversely affected by various factors. These include, for instance, ungulate foraging which prevents natural forest rejuvenation and renewal, the ingress of atmospheric pollutants (ozone, nitrogen), natural disasters, which are occurring more and more frequently as a consequence of global warming, and the growing demands of leisure and sporting activities.

As well as the protection and leisure functions mentioned, forests also have a supply function; the work-intensive management of the mountain forests is carried out by the local forestry services. Today, the cultivation of timber is not very profitable and is consequently dependent on public funds. Graubünden and regional players are working to position wood more favourably on the marketplace as an ecological and renewable raw material.

Quarrying

Stone or gravel is quarried at various locations in the Albula/Bernina region, for example by Sils i.D. at the entrance to the Schin Gorge and in the Flazbach river bed between Pontresina and the Morteratsch station. Quarrying is extremely important both for the regional economy and for the supply of hard rock beyond the region. This is used, for instance, in the construction of protective structures against natural dangers (barriers, weirs etc.) and also for the Rhaetian Railway, where it is used, amongst other things, as track ballast. When the resources at a location have been exhausted, restitution or re-greening is carried out, taking ecological and scenic aspects into account. In the interest of regional autonomy and guaranteeing supply beyond the region, a few new quarries will be opened up in the future.

The use of hydroelectric power

The relationship between constructing a railway and the use of hydroelectric power on the Bernina has already been dealt with in chapter 2.b.7. The use of hydroelectric power clearly marks the Albula/Bernina cultural landscape, be it through the installations for producing electricity or technical constructions, such as high-tension cables and catchment reservoirs. The use of hydroelectric power in mountainous regions is of great importance both from energy technology as well as ecological and economic considerations and, because of increasing energy requirements, it will continue to be so in the future. In view of the generally anticipated shortage of power and efforts to use less constant sources of energy such as wind or photovoltaic solar power, high-efficiency pump-fed power stations are extremely important to balance supply and demand. Consequently, the present hydroelectric power stations will be modernised and upgraded. This will also have an influence on, and modify, the cultural landscape in the future. The Graubünden cantonal authorities approved the water-rights franchise for the hydroelectric works in the upper Poschiavo valley by a resolution of 15th August 2006. This ensured that the current Rätia Energie AG complex can be operated for a further 80 years. Approval of the franchise also gives Rätia Energie AG the option to extend the power station. For example, there are plans to raise the water level of the Lago Bianco reservoir to increase its storage capacity. This would entail realigning the existing dam walls and increasing their height by about 17 m. Realisation of this project would result in an insignificant shift in the layout of the railway track, which runs immediately alongside the lake. A working group led by the well-known architect Aurelio Galfetti, in collaboration with representatives of the Federal Commission for the Protection of Nature and Cultural Heritage, the Rhaetian

Railway and Rätia Energie AG, has drawn up a design for the dam wall and for the layout of the railway line at the location concerned taking care to ensure that the historic railway route along Lago Bianco retains its character. In addition, compensation measures with regard to both nature and landscape (protection and utilisation planning) were agreed during the concession procedure for the higher water level project.

Traffic infrastructures (roads, tourist transport facilities, electricity production and distribution)

Besides the railway infrastructure, the other infrastructures in the Albula/Bernina cultural landscape are affected by social change, inasmuch as the constantly increasing demands with regard to speed, capacity, safety, efficiency, aesthetics, comfort, etc. also have repercussions. No major road network measures are foreseen today beyond routine upkeep. At local level, the aim is to construct bypasses in locations where protection of the population, cramped conditions in old village nuclei and road capacities necessitate them. In the next few years, relevant measures are only due on the Bernina axis, namely ring roads to bypass Poschiavo and Le Prese, as well as San Carlo and Campocologno. In connection with Poschiavo and Le Prese, tunnel solutions are also under discussion. With regard to tourist transport facilities, the general renovation requirement was mentioned (cf. 4.a.2). Thus, for instance, renewal of the Darlux cableway facilities in Bergün/Bravuogn, which run above the loops of the Rhaetian Railway, will soon be realised. This example demonstrates the previously mentioned conjunction of various factors. In view of its attractiveness for tourism, renewal of this cableway is extremely important for Bergün/Bravuogn. Should it not be realised, jobs in the tourism sector would undoubtedly be lost. In the winter season, it is precisely these employment opportunities that make it possible for people in the farming sector to earn additional income and thus secure their livelihood. If this were to cease, there would be consequences with regard to the continuation of farming and consequently for the cultural landscape of the region as a whole. Renovations of cableways and ski lifts in the Upper Engadin are also scheduled to begin soon.

Tirano (Italy)

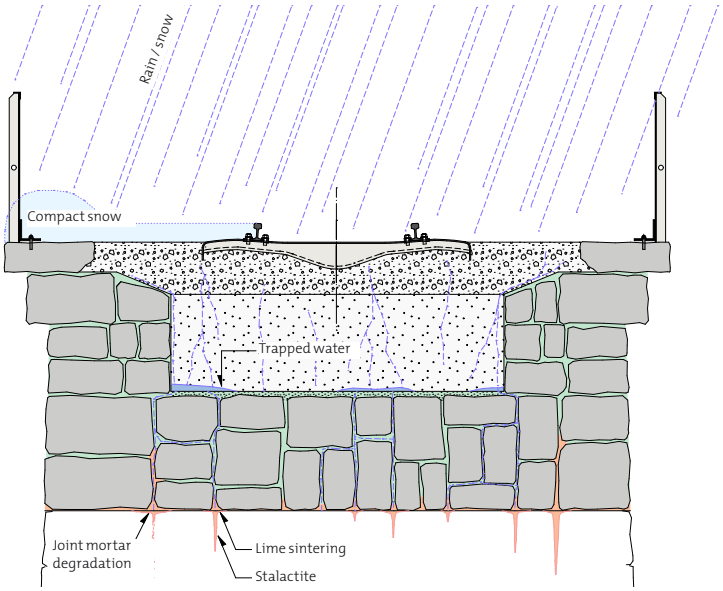
While the province occupies a privileged position in terms of natural beauty, the same cannot be said in economic terms: there is no overall predominance of one sector over another and this puts a limit on development. The majority of companies are family-owned and managed or collective businesses like cooperative syndicates, while companies of more substantial size are concentrated in the lower valley. In the last few decades, there has been a shift from the agricultural sector to the tertiary sector and service industries. Historically, the agricultural sector has been important in mountain, particularly alpine, areas. In recent years, however, people have gradually abandoned the sector because it did not generate enough income. Also, the structure of society had changed and, with the improvement in educational standards, the young preferred to seek employment in the service sector or leave the valley altogether to work in the big cities. The number of agricultural businesses is much lower now than it was in 2000: in fact,

there are only 189 farms in Tirano today, 175 of which operate on an area of less than 5 hectares. In addition, there has been a reduction in the area used for growing vines, a reduction that can be seen in every community belonging to what is known as the Tirano Mountain Community (Comunità Montana Valtellina di Tirano) and that is most evident in Teglio and Tirano, the two communities which had the largest area of vineyards. Villa di Tirano is the sole municipality in which the cultivation of vines, linked to the production of DOC (Denominazione di Origine Controllata) and DOCG (Denominazione di Origine Controllata e Garantita) wines, has shown signs of recovery in recent years. The secondary sector in Tirano comprises: 82 businesses in the field of manufacturing, 54 in construction, 209 in commerce, and 39 in transport, making a total of 384. Industry and handicrafts in the area are two closely-related sectors which, while representing a significant proportion of local production and employment, do not put it into the categories of "intensively industrialised" or "pronounced craft industry presence". Natural resources in the province are scarce, limited to a few quarried products (granite and serpentine stone, located in Val Malenco, Val Masino and the area of Novate Mezzola), forest assets (despite the size of the forests, these assets do not constitute a particularly valuable source of income), and various sources of mineral water (Bormio and Val Masino). There is also intensive exploitation of water resources for hydroelectric purposes in Valtellina, but the energy produced is used elsewhere. The region has transport infrastructure problems which have dragged on for decades. While the infrastructure has been used more and more, the province has seen no corresponding modernisation of the road network, resulting in traffic problems at peak tourist periods. The Bernina railway, which connects the famous resort of St. Moritz with Valposchiavo and terminates in Tirano, is essential for tourism in the area. In the case of broadcasting installations and electricity power lines, accelerated technological development has brought an increase in infrastructure supplying electrical power and in transmission facilities for radio, television and telephone. There is also a wood biomass plant in Tirano, which was built in 2000 for the production of thermal energy. It has been enlarged since then and now produces some 7,500 MWh of electricity per annum.

4.b.ii Environmental Pressures

The average temperature in the northern hemisphere has increased by around 1°C in the past century entailing a 10 to 20 cm rise in sea level; worldwide, approximately 10 % of the ice and snow mantle has melted since 1970. The principle cause of global warming is the constantly increasing amount of fossil fuel being burned and the release of the associated greenhouse gas CO2 into the atmosphere. Various climate models have simulated the effects climate change will have on the Alpine economy and habitat. Extreme weather situations (e.g. storms, excessive precipitation) will occur more frequently, the snow line will recede making numerous winter sport areas unprofitable, the vegetation line will rise, glaciers will melt, the permafrost will thaw making high-altitude slopes unstable and increasing the danger of mudslides and

Pontresina > Two protective embankments have been built above the village; the thawing of the permafrost made this measure necessary.
E. Süsskind



Damage mechanism of water ingress - frost damage

- **Ballast**
- **Filling material**
- **Mortar coating**
- **Joint mortar**
- **Degraded joint mortar**

Rhaetian Railway

rockfalls. A research project in Pontresina examined the permafrost problem on the Schafberg. Consequently, as the first municipality in the Alpine region to react to global warming and thawing of the permafrost, Pontresina built two protective barriers above the village. Within the Albula/Bernina perimeter, glacier shrinkage can be particularly well documented using the example of the Morteratsch glacier at the foot of Piz Bernina. When the railway was constructed, the glacier tongue reached to within a few meters of the track. In the meantime, however, it has receded by almost 2 km into the Morteratsch Valley. The loss of volume has accelerated since the 1990s. On average, the glacier's rate of retreat is 17–20 m per annum. Environmental influences not only affect the cultural landscape as such, they also have an influence on the bridge constructions of the Albula/Bernina railway line. Thus, rain and melt-water seep down in places where the ballast trough is not watertight and the drainage no longer functions correctly, into earth-filled structures, where it collects along the side walls and at the low points between two neighbouring vaults, forcing its way into the masonry joints. Temperature fluctuations and frost subsequently lead to sintering out of the chalk into the soffit and decomposition of the joint mortar (cf. 4.a.1).

Temperature fluctuations are also responsible for changes in the length of straight masonry bridges. The crown rises in winter but dips in summer. In the case of curved viaducts, changes in length can be compensated by displacement towards the outside of the curve (summer) or towards the inside of the curve (winter). Terrain shifts also have a similar effect on bridges, but deformations to supporting structures are much greater than those caused by fluctuations in temperature. Buckling is more frequent in the longitudinal direction whereas tilting or torsion is more likely to occur laterally. These deformations are also inevitably linked to serious cracking in the masonry. Terrain shifts mostly occur to one side of a bridge element entailing asymmetric stress in the construction.

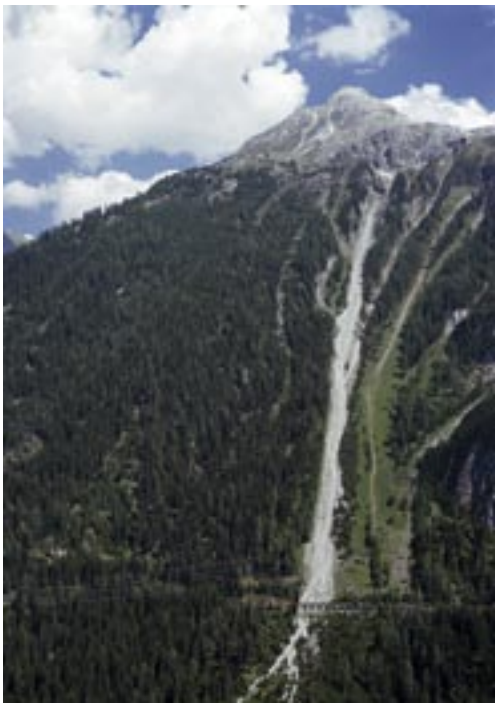
4.b.iii Natural disasters and risk preparedness

Natural dangers, such as terrain shifts, avalanches or mudslides threaten settlements, people and the traffic infrastructure. This is particularly pronounced in mountainous regions in view of the topographical conditions. That these natural hazards are increasingly escalating into real disasters is not only a consequence of accentuated weather extremes as a result of global warming, but is also connected with the expansion of residential areas and new infrastructures. The elaboration of measures to protect against natural dangers is regulated by law. In Switzerland the bases are set out in hydraulic engineering and forestry legislation. The cantons have to produce danger-risk maps, and the construction of technical protective measures is subsidised. Since 2002, a land register of natural dangers has been introduced throughout Switzerland. In the Albula/Bernina region the data serves as a basis for drawing up and verifying danger-risk maps, zone plans and expert opinions. The zones in the populated area of the cultural landscape are plotted according to this data, determining whether homes and sta-

Muot avalanche baffle > Photograph 1905.
Rhaetian Railway

Muot avalanche baffle > Photograph 1938.
Rhaetian Railway

Muot avalanche baffle > Photograph 1957.
Rhaetian Railway



Muot avalanche baffle > Photograph 2006.
M. Weidmann

bling for animals or installations for public use may be constructed; whether reinforced constructions are necessary or whether building is prohibited. Further, valuable information for projecting protective measures is obtained from the comprehensive damage review after violent storms.

Various forms of natural hazards can be seen along the Albula/Bernina railway line. The stretch of line through the Schin gorge has always been unstable, since the underlying lamellar Graubünden slate is prone to landslides and rockfalls. In the Albula valley, a broad unstable slope between Tiefencastel and Surava influences the operations of the Rhaetian Railway. The effects of this deep-seated, progressive landslip is spectacularly visible in Brienz/Brinzauls with its leaning church tower. Between Filisur and Bergün/Bravuogn, above all problems with rockfall incidents occur. This danger is countered, amongst other measures, by installing rockfall catch netting. The Bergün/Bravuogn-Preda stretch of track is exposed to the risk of avalanches. The avalanche baffles on the Muot slopes are particularly impressive. They were erected already 100 years ago when the railway was built and are maintained by the railway's own specialists. The section of track in Val Bever is exposed to various avalanche courses, which explains why the track was laid on a dam in the middle of the valley. Mudslides are also a constant cause of concern for the Rhaetian Railway engineers in Val Bever. For this reason, a large protective dam was constructed at the south portal of the Albula Tunnel.

The landscape, railway infrastructure and the settlements between Samedan and Pontresina in the Upper Engadin were frequently affected by serious flooding. The Flaz river, in particular, which has its catchment area in the Bernina region, caused significant damage on several occasions. A major correction project, diverting the Flaz via the south easterly side of the valley, has largely eliminated this danger (cf. 4.a.2). The stretch of track from Pontresina via the Bernina Pass to Cavaglia is exposed primarily to dangers from avalanches, rockfalls and snowdrifts. Immediately after Morteratsch station, enormous boulders alongside the railway line bear witness to earlier rockfalls. In the Arlas section, the dynamics of these natural dangers are visible; the alignment of the track had to be modified here to ensure safety. The snowdrift baffles are a striking feature on the Bernina Pass and the Poschiavo stretch. Here again, the alignment has already been modified and adapted to present conditions.

The stretch in Val Poschiavo is exposed to potential risk at various points from landslides, avalanches, rockfalls, mudslides and flooding. In 1987, the whole valley and railway infrastructure was affected by serious flooding. The Rhaetian Railway, together with the federal government and the canton reacted to this event with enormous investments in protective measures. The Rhaetian Railway employs its own specialists who, in collaboration with experts from federal and cantonal offices, constantly monitor, assess and, if necessary, implement suitable protection measures. The necessary resources for this are 80 % covered by cantonal and federal subsidies (these contributions may vary according to the measures required and the degree of danger).

Where there are trees bordering the railway

Val Tasna Viaduct > In August 2005, the old bridge collapsed in a great storm before the new parallel structure was finished. The new bridge was not damaged by the storm.
Rhaetian Railway

Bernina line > The lower Cavagliasco Bridge. The original stonework bridge had to be replaced by an army emergency bridge in 2002 due to earth movements.
Rhaetian Railway

track damage must be reckoned with, particularly during storms, along the entire Albula/Bernina line. This kind of risk can be minimised by continuous monitoring and tree thinning.

4.b.iv Visitor/tourism pressures

In Graubünden, tourism is the principle economic activity, generating around a third of all revenue. The demand is generally dependent on the time of year, winter being the highly frequented peak season. In the Albula/Bernina region, tourism plays a prominent role, particularly in the Upper Engadin; the hotel and self-catering industries here account for over 3 million overnight stays per year. The attractiveness of the area for tourists has clearly been enhanced by the construction of the Albula and Bernina railways. Its excellent international reputation is the outcome of active planning over many decades. Naturally, tourism brings more traffic, entailing an above-average increase in the amount of motorised private transport. This in turn necessitates an extensive infrastructure and detracts from the quality of living, due to air and noise pollution. The Rhaetian Railway, as the main public transport carrier, has an extremely important role to play in alleviating these effects.

In connection with tourism, the construction of second homes should also be mentioned. There was a boom in second homes in the wake of social and socio-economic change in the 1960/70s. In the Upper Engadin today they account for around 60 % of the overall dwellings in Graubünden, corresponding approximately to the proportion in other well-known tourist destinations. Overall in Graubünden, the percentage of second homes has been kept steady over the past two decades by strict spatial planning measures. In the Upper Engadin, between 1980 and 2000, it increased by a mere 1 percentage point. The cantonal spatial development planning office is determined to continue keep this development under control.

Complementary to the concentration on tourism, as can be seen in the Upper Engadin, numerous small tourism initiatives, oriented to regional economies, have been created in the past few years. These are based on an intact natural and cultural landscape, and on cooperation. Thanks to rising demand, a dynamic regional economy can be counted on in this tourist segment, which is so closely linked with nature and culture. In the Albula/Bernina region this primarily involves the two more rural areas of the Albula valley and Val Poschiavo. Here, the offer for visitors is centred on natural and cultural values. The landscape, as the capital stock of tourism, is protected, well looked after and used very carefully. In the Albula valley, the first regional nature park in Switzerland, the "Parc Ela", was opened in June 2006. Besides the Albula valley, it also includes large parts of Oberhalbstein (Julier axis).

In general, tourism can be counted as one of the strongest influential factors in the nominated asset. Tourism has a positive effect, offering the regional population a source of income and promoting the economy; above all the question of whether the Albula/Bernina region would be "overstressed" if admitted as a UNESCO World Heritage Site is of prime importance in assessing the possibility of negative consequences.

In this respect it is interesting to note that the number of overnight stays (tourism indicator) in Graubünden has decreased since the beginning of the 1990s. Fundamentally, the capacity of the

Rhaetian Railway is largely limited by the single-track layout and the rolling stock, and is only occasionally used to capacity during the peak tourist season. With regard to the appearance of the villages and landscape, the legal and planning measures curb any possibility of exceeding the "capacity limit" in tourism. In future, the focus will be on maintaining the position in the important and highly competitive tourism sector. This will also require modification of the services and facilities offered to tourists. Where these changes involve buildings and installations they will be realised with all due respect for the various interests involved (cf. 5.b and 5.c).

4.b.v Number of inhabitants within the property and the buffer zone

Population data

Population in the core zone:
7,715 persons
Population in the buffer zone
(near and distant area):
59,805 persons

Full time job equivalents

Workplaces in the core zone:
4,384 jobs
Workplaces in the buffer zone
(near and distant area):
8,460 jobs