# Proposal for a tool to help to verify the safety level of existing monocable aerial ropeways

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## 1. Introduction

Transport is essential for people to achieve their goals, to interact socially and to connect with essential services such as shopping, healthcare and education.

When it comes to public passenger transport, local authorities in all countries are faced with the challenge of developing efficient, safe and affordable means of travel for all, while drastically reducing the carbon footprint of transport.

Cable transport has the potential to meet all these needs. But it is a little-known means of transport, which can also impress, or even repel, a part of the population, at least for installations where vehicles are suspended in mid-air.

In this context, accidents on cableways clearly damage the reputation and development of this type of transport system.

Accidents on ropeways are also closely followed by the media, and a bad image can quickly be conveyed.

Countries with a long tradition of cableway installations generally have precise technical and safety rules designed to ensure the safety of passengers and operating personnel. These rules are drawn up in collaboration with professional partners (operators, manufacturers, supervisory authorities). They are regularly updated to take account of technical progress and feedback from accidents and incidents.

These rules generally cover the entire life cycle of a facility: design and construction, operating rules, maintenance and inspection rules.

Throughout the world, there are bodies of technical rules that are reputed to ensure a high level of safety, particularly for the people being transported (this is the case, for example, with Regulation 2016/424 adopted by the European Union and the accompanying standards).

However, there are also installations that do not comply with this high level of safety, having been built on the basis of different standards. There are also installations where fatigue and wear phenomena have not been properly measured.

In these various cases, the question arises as to whether additional measures should be taken on these cableway installations to improve their level of safety.

OITAF has therefore decided to draw up a recommendation dedicated to monocable aerial ropeways transporting persons, aimed in particular at their owners or operators, detailing an approach for carrying out an assessment of a cableway installation in order to check that it complies with a minimum safety standard or, where appropriate, to identify the measures (constructive or organisational) to be taken to complete and to improve safety and ensure its continued operation.

Although the drafting of this recommendation, entrusted to Commission I of OITAF, is not yet complete, it is sufficiently advanced to be presented briefly. This is the purpose of this article.

## 2. Diagnostic method

Before explaining the proposed method, it should be pointed out that the choice of when to carry out this diagnosis is left to the discretion of the owner or operator.

Clearly, the use of an underdeveloped referential, with manifestly significant discrepancies compared to a "high level of safety" referential, or the absence of significant maintenance or modernisation actions over a significant period of time since commissioning, should be seen as a warning signal that should trigger reflection on the future of the installation.

The diagnosis should be carried out by a specialist in the field of cableway installations. This specialist must have in-depth technical knowledge and/or sufficient practical experience. In practice, it may be necessary to involve several specialists (mechanical, electrical engineering, etc.).

The proposed approach comprises 4 main stages:

**First stage: History of the installation**

The first step is to reconstruct the installation's identity card and history, so that the specialist in charge of the diagnosis can clearly identify the specific features of the installation and its life.

This history will provide an opportunity to check elements such as the year of construction, the number of operating hours of the various sub-systems and the frequentation statistics (this gives an idea of the operating cycles experienced), the identity of the manufacturer and the design standards adopted at the beginning.

This stage should also enable a file to be compiled containing the main drawings, calculation notes, operation and maintenance instructions.

It is also necessary to recover information and traceability elements relating to the main maintenance actions already carried out (periodic inspections of grips, electromagnetic testing of the rope, non-destructive testing after dismantling, etc.), modifications made during the life of the installation and events experienced by the system and its components since the origine (incidents, accidents and near-accidents).

Finally, to complete the history, it is useful to check whether any safety information concerning this type of installation or the types of components has been distributed by the manufacturer(s) or other organisations.

This information will be useful for the other phases of the diagnosis, enabling the specialist in charge of the assessment to form an initial idea of the safety level of the installation, by identifying, for example, a particular sensitivity to certain factors, a traumatic past or a lack of maintenance.

**Second stage: Evaluation of the state of the installation's safety-related components**

It is necessary to assess the state of the components relevant to the safety of the installation. These are the elementary components or groups of components, sub-assemblies or complete assemblies integrated into the cableway installation for the purpose of ensuring safety, the failure of which presents a risk to the safety or health of passengers, operating staff or third parties (in this terminology, they may also be parts of the infrastructure).

These safety-related components of the installation may have been identified by a safety analysis carried out when the installation was designed. If such a study is not available, it will be up to the specialist to identify them. To do this, it will of course be possible to make a comparison with a generally similar installation that has a safety analysis.

If the installation is recent, at the very least a visual inspection of all the safety-related components should be carried out to identify any defects or damage (wear, corrosion, deformation, cracks, breaks, etc.).

For installations over 15 years old, it is necessary to carry out non-destructive testing of these safety-related components, particularly those subject to fatigue stress, generally after dismantling.
To help the specialist to draw up this programme of non-destructive tests, methodological elements are proposed in the recommendation.

This stage must be prepared and planned in accordance with the assessment of the various sub-assemblies of the installation presented in the next stage and the modification or replacement operations which may result.

Any faults identified must be dealt with appropriate measures, and repair procedures may need to be prepared by specialist design offices, identifying the levels of qualification required to carry out the repairs (e.g. for repair by welding). A new inspection is necessary after any repair.

It is of course necessary to ensure that the checks carried out and the repair operations are traceable.

**Third stage: Assessment of the functionality of safety-related sub-assemblies and components**

The recommendation foresees the break down of the considered cableway installation into several subsystems, either functional (e.g. operating/maintenance arrangements) or defining a coherent technical subset (e.g. vehicles or infrastructure).

For these various sub-systems, the recommendation provides an assessment grid for identifying the components or themes that must or can be the subject of improvement measures.

The measures defined in these grids are based on the experience of the countries represented on OITAF's Commission I, as these measures have generally been implemented on existing cableway installations to improve their level of safety.

For each of the topics identified, a question is asked to identify the desired safety objective, and operational measures are recommended to help achieve this objective.

Some examples taken from the diagnostic grids are given below:

| Sub-system | Component | Objective | Recommended measures |
|---|---|---|---|
| Drive and brakes | Drive sheave and its mounting | If the sheave is mounted on a rotating shaft or axle, have measures been taken to take account of the fatigue stresses resulting from this type of mounting? | It is necessary to :<br>1) Calculate the fatigue strength of the assembly.<br>2) Or install a catcher device for the sheave.<br>This device must be designed to maintain the position of the sheave as far as possible in the event of the shaft or axle breaking, so as to prevent the derailment of the rope. |

| Sub-system | Component | Objective | Recommended measures |
|---|---|---|---|
| Cable tensioning devices | Hydraulic tension | Are the permissible cable tension values monitored and guaranteed? | Provisions to be implemented for :<br>- Monitoring of the minimum tension threshold (pressure or tension monitoring), to guarantee adherence,<br>- monitoring of the high tension threshold (pressure or tension monitoring) or installation of a pressure limiter, to guarantee the safety coefficient of the rope. |
| Mechanical equipment in the stations | Cabin boarding area | Is the correct boarding of passengers in the cabins at the end of the boarding area monitored? | Gondola stations must be equipped with end-of-platform gates to detect a passenger trapped between the doors before the cabin leaves the station. |
| Mechanical equipment for line structures | Roller batteries | Are the consequences of a roller loss managed? | Anti-rotation stops must be fitted to the bogies of two rollers or the tilting of the bogie following the loss of a roller must be monitored. |
| Carriers | Chairs | Are the chairs fitted with safety-bar? | Installing safety-bars |

With regard to the "electrical control architecture" sub-ensemble, the approach is slightly different and the recommendation proposes a minimum list of safety functions that should be present in the electrical architecture of a unidirectional continuous motion single-cable aerial tramway.

The diagnosis not only looks at the design provisions, but also addresses operating and evacuation issues.
Feedback from experience shows that organisational problems and human factors relating to these issues are very often major contributory factors in accidents that do occur.
These issues are already covered by OITAF recommendations, and the diagnosis makes extensive reference to the best practices set out in these recommendations.

**Fourth stage: Drawing up an action plan based on the diagnosis**

On the basis of the previous stages, and on the basis of proposals from the specialist who carried out the diagnosis, the owner is in a position to define a programme of measures to improve the level of safety at his installation.

When several types of measures are possible to improve a particular situation, it is generally recommended that the measures in the order of priority shown below be given priority:
- constructive measures
- protective measures
- organisational measures.

It is necessary to check that the planned measures do not give rise to new risks (e.g. clearance limitation, unacceptable increase in stress, etc.).

The proposed tool does not provide for prioritisation of the measures, and the implementation plan must take account of the resources available and the need for consistency between the various actions.

It is recommended that the action plan be formalised in a single document and that the design and, implementation of the actions be documented and traced.

Appropriate checks must be carried out by the operator after each modification, in order to verify that they have been carried out properly and that the installation is operating correctly, periodical inspections also having to be performed (annually in particular).

## 3. Some limitations to the method

The study was limited to monocable aerial cableways. Although some measures may be relevant for other types of installation such as bicable aerial ropeways or funicular railways, the specific operating characteristics of these installations would require significant additions to the proposed minimum standards.

The focus is largely on functionality, with only certain components of interest relating to safety. On the other hand, the assessment of the dimensioning of the installation and its components is not considered in the proposed tool.

For these reasons, the guidelines proposed for the diagnosis cannot be considered as a complete safety referential for the design, construction, operation and maintenance of a cableway installation. It is limited to certain aspects and a limited number of functions that can be taken into account a priori in an existing installation, and which experience has shown to be important in preventing accidents.
Many other factors would need to be taken into account in order to approach the so-called "high level of safety" standards.

The recommended measures are formulated in general terms, without specifying the technical details of the design to be adopted. It is in fact considered that the design must respect the current state of the art (represented by the standards deemed to have a high level of safety), although it is accepted that adaptations may be necessary, particularly because of the interfaces to be ensured with the existing system.
One example of this is the rope catcher that the proposed tool identifies as being necessary for roller batteries. Application of state-of-the-art rules for the angle of recovery would guide the designer towards a fairly large width of rope catcher. If the transverse gauge initially available is quite small, a further reduction in the oscillation possibilities of vehicles on the inside of the line is undesirable and it is preferable to adapt these catch angle rules to define the geometry of the device.

Finally, this recommendation is limited to the risks incurred by passengers and does not consider the risks for operating or maintenance personnel. However, improving workplace safety requires an equally ambitious approach, involving a specific safety analysis based on the identification of the various operations to be carried out, their frequency and the associated risks, with a view to implementing relevant preventive measures covering the technical, human and organisational dimensions.

# 4. Conclusion

Ensuring the safety of cableway installations in operation is an immediate and essential responsibility for the owners and operators concerned.

Not all parts of the world where cableway installations are present have the fabric of technical rules or the presence of competent professionals that would normally help owners and operators to meet this responsibility.

OITAF is concerned about this situation and would like to propose a working method for checking the safety level of an existing cableway installation.

In the end, the working methodology proposed is fairly universal, since it could be compared to that of a doctor prescribing a check-up for his patient: medical file history, examinations to assess the state of health, prescription of medicines or operations, medical follow-up to check the effect of the care plan, etc.

The value of the proposed method and the accompanying documents lies in the fact that they draw on the practical and operational experience of several countries in maintaining the safety of large fleets of monocable aerial cableways.

The recommendation is not yet fully finalised, but it is well advanced and should be made available to the profession in the coming months.