

TRAF - NEW SOFTWARE FOR SKYLINES DESIGN FOR FOREST PURPOSES

I.C. DUȚĂ¹ Gh. IGNEA¹

Abstract: *The construction and exploitation of skylines used in forest operations represent a complex activity, because the involved tasks must consider some great mathematical knowledge, as well as optimization skills. This is one of the many reasons for which the skylines usage in Romanian forests encountered a regress in the last period. Also, empirical approaches in the skylines design process may lead to poor technical solutions with repercussions both on work safety as well as on the installation maintenance. Thus, the present paper presents both the usage and tasks which can be solved using the first version of the software product “TRAF”, a software solution to the above mentioned problems.*

Key words: *software, skyline, design, optimization.*

1. Introduction

Forest skylines are designed and constructed by considering the fact that they are not independent units, but more or less important links in the overall timber transport process.

The path choice must be considered the most important part in research and design studies, before the skyline setup because the current practice demonstrated that the economy in skylines construction is determined, to a great extent by their setup path.

Also, the design process constitutes an important part, due the fact that the overall maintenance activities are dependent on the design measures. A better maintenance of skyline ropes is usually achieved in uniform slope conditions, without slope breaks.

The design process for a skyline setup is a very complex one. Laborious studies and complex calculations are required to provide

sufficient decision making time, especially for scientific approaches. Eliminating the empirical approaches also provides a better setup and exploitation conditions for given cases.

Using the classic design approach, the studies and specific calculations can take days in order to achieve a suitable technical solution for given terrain conditions. Also, different machine types generate different calculus procedures or input variables. In order to avoid these complex design procedures, many companies adopt empirical design procedures, concretised in a shorter life expectancy for the yarder ropes, poor technological exploitation (Figure 1), as well as significant work safety issues.

All the above mentioned problems could be the result of an inadequate design, resulted from laborious calculations as well as an empirical approach of the design process.

¹ Dept. of Forest Engineering, Forest Management and Terrestrial Measurements, *Transilvania* University of Braşov.



Fig. 1. *Poor design practices resulting in technological problems*

Until now, there have not been present on the Romanian market software tools or products called to solve the design problems. This problem is more pregnant in the case of Romanian concept installations, being one of the main reasons of their disappearance from the forest practice.

2. TRAF - A Practical Solution for Forest Skylines Design

2.1. Software Design

“TRAF” from Romanian “Trasare Funiculare” is a software product designed for technical and design purposes in order to better select a setup solution for any type of skyline. It is written in Visual Basic for Applications, extending the Microsoft Office (Excel) capabilities by implementing a graphical results page in which both the terrain profile as well as the designed skyline are designed based on the input data introduced by designer.

This software product was developed by the paper authors in order to provide a scientific based tool for skylines design and setup, with application in production designs.

2.2. Necessary User Input Data and Design Results

Usually, the necessary terrain data for terrain profile realization is provided by using a wide range of data collectors. One

approach considers the data logging by using a declivity meter (for slopes), and a measuring tape (for distances). This topographic setup is simple and provides enough accuracy for design purposes. In case of tachometer usage, the slope is collected as vertical angles and the distance is measured usually by optical means. In order to respond to practical necessities, the presented software product covers both topographic procedures (Figure 2).

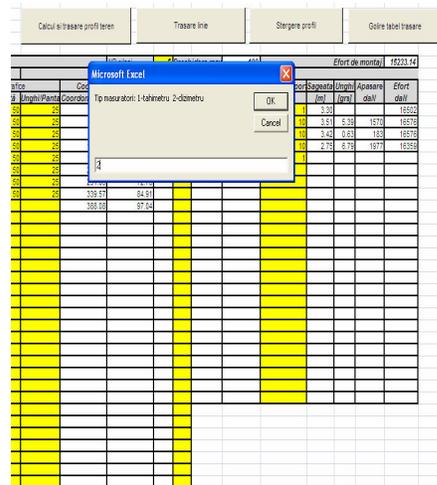


Fig. 2. *A message box for topographic procedure set up*

In order to realize the terrain profile (Figure 3), the user has to input terrain data and choose a topographic approach, by introducing the according input data in an input box, as shown in the example from Figure 2. After that, by pressing the dedicated command button (Calcul si trasare profil teren), the terrain profile is automatically generated by the program's algorithms, and another input box is displayed in order to select the proper installation (Figure 4). The user can choose between three options which include the Romanian concept machines as well as a predefining machine for which the program will ask for supplementary data.

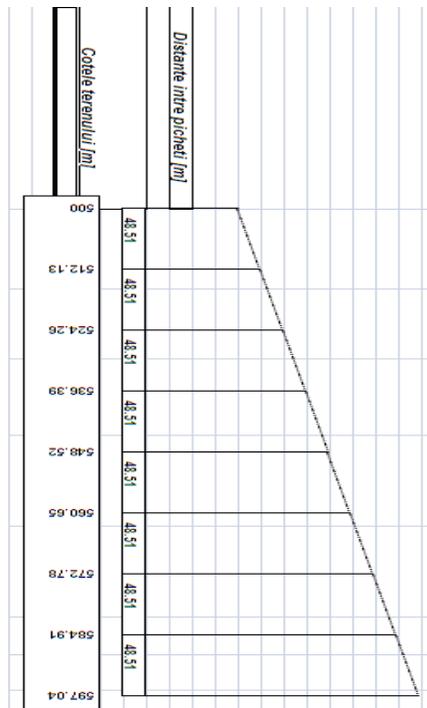


Fig. 3. Terrain profile generated by the program

In a first design stage, the design results will show only the terrain profile and related data such as distances between the points recorded by topographic means as well as the heights of the mentioned points.

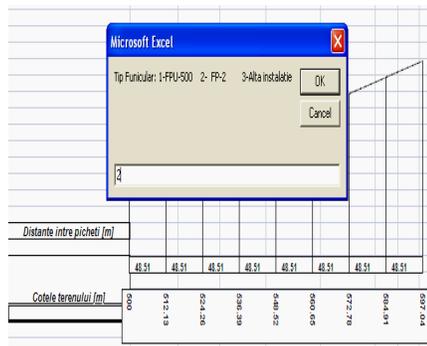


Fig. 4. Machine type selection

The machine (installation) type is selected by introducing in the proper input

box one of the following values: 1 - for Romanian skyline FPU 500, 2 - for Romanian skyline FP2 and 3 - for other machine type.

After the machine selection, several tasks must be carried out in order to obtain the final solution.

A first task comprises the number of spars. The design operator consults the terrain profile and establishes the best positions for spars location, as well as the necessary number of spars. After that, he introduces the number of spars in the designated cell. The next step consists of the horizontal distribution of spars. In order to carry out that task the designer has to consult the terrain profile and to introduce the spans between the designed numbers of spars.

The last task to be carried out in order to obtain the final design map consists of a provisory height establishment for the designed spars. Each spar has to be provided with a height in order to generate the skyline profile.

After these task realizations, the designer may proceed to acquire the final profile. In order to do so, he has to press the dedicated command button for skyline profile design. The specified command button is the second one and is named "Trasare line". By pressing this command button, the terrain profile will be updated by adding specific design elements (Figure 5) such as: skyline line (in red above the terrain line), distances between the spars, spar heights and the corresponding heights above the sea level, as well as deflections.

If the obtained solution is not a suitable one, the user may choose to input other data for spars: height, location etc. In order to carry out this task, he has to clear the profile area by pressing the command button "Ștergere profil" (the third one), and to reinitialize the procedures for terrain profile and the skyline profile by using the new data for the spars (Figure 6).

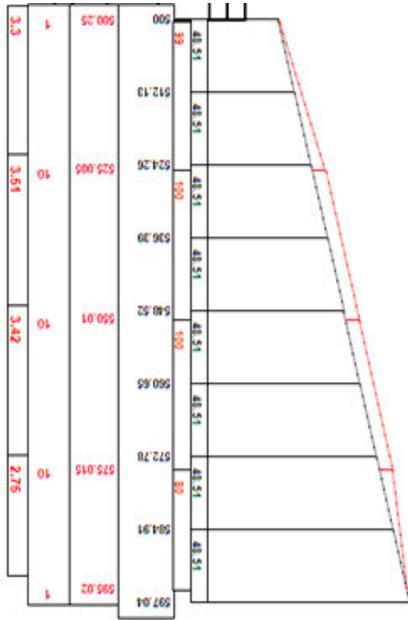


Fig. 5. Skyline profile and the design elements

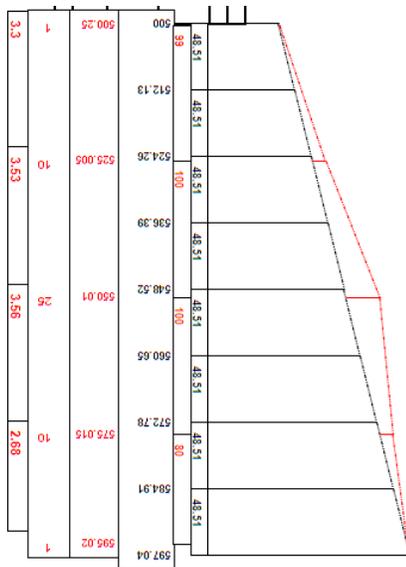


Fig. 6. A modified skyline profile

If the design operator needs to start a new project, he has to press both, the command button for profile erasing as well as command button for data table clearing.

In case of acquiring a suitable solution, the necessary design data are presented on the profile as well as in the data table, where supplementary data are presented.

2.3. An improved calculus algorithm

As presented above, the time consumption for design tasks in case of different skyline setups can be very long, especially for solving repetitive very complex equations. Also, the designer does not have in the classic approach the necessary tools for a rapid data reversion in order to reevaluate a certain design.

In this context, the implemented algorithms use the mentioned complex equations and realize the necessary iterations in a short time. Reconsidering a solution and reintroducing new data by analysing the older one is done in a few steps involving simple tasks.

Different setup solutions can be compared and saved properly in order to select the most suitable one. For this, the user has to save the host application under a different name, and to recalculate a new solution based on the data contained in the initial one.

2.4. Mathematical relations used in algorithm implementations

The design of a cable installation supposes the determination of skyline's deflection in each span in order to verify the assurance of free passing gauge for loads. The software uses relation (1) for deflection determination:

$$f = \frac{gl^2}{8T \cos^2 \theta} + \frac{Ql}{4T \cos \theta}, \quad (1)$$

where: f - represents deflection in a specific span; g - weight of cable length unit; T - cable effort; θ - cable's chord declivity; Q - load weight.

The effort of the cable varies in rapport with load position on the cable and it is calculated using the state equation of the skyline. The state equation of the skyline (Eq. 2) by considering a load positioned in the middle of the span. As seen in the mentioned equation, realization of the afferent calculations using traditional means is complex and takes a long time. By implementing a specific calculus algorithm acquiring the results, regardless the installation type and terrain characteristics can be achieved with only a few clicks. Also, the equation presented

below (Eq. 2) refers only to a single span, and the designer has to carry out several calculations by taking in consideration the number of spans for a specific setup.

In Eq. (2), T means the effort in which the concentrated load Q is located; T_0 - montage effort in the skyline; θ - average declivity of the skyline; g - cable mass on unit length; l_i - the length of span "i"; E - skyline elasticity modulus; A - metallic section of the cable; L_t - sum of all spans; Q - loaded carriage mass; a - horizontal distance between the spar (shoe) and carriage:

$$T^3 + T^2 \left(\frac{g^2 \sum l_i^3 E \cdot A}{24L_t T_0^2 \cos^3 \theta} - T_0 \right) - \frac{\frac{g^2 \sum l_i^3 E \cdot A}{24L_t} + \frac{E \cdot A}{2L_t} Q \cdot a(l-a) \left(\frac{g}{\cos \theta} + \frac{Q}{l} \right) \cos^2 \theta}{\cos^3 \theta} = 0. \quad (2)$$

Other important elements which are determined in order to design a cable installation refer to pressures and breaking angles of the skylines over the shoes. Cable pressure on the shoes is determined using relation (3):

$$A_i = 2T \sin \frac{\alpha_i}{2}, \quad (3)$$

where: T - cable effort; α_i - breaking angle of skyline over the shoe; A_i - cable pressure over shoe "i".

Cable pressure in certain cases has to be sufficient for cable stability over the shoe (minimum 2 kN), but, at the same time it has to be smaller than the maximum allowable values which result from a resistance condition of the shoe (which assure the carriage passing over the shoe in safety conditions - 14 kN).

Breaking angle is calculated using relation (4):

$$\alpha_i = \beta_{i-1} - \beta_i, \quad (4)$$

where: α_i - breaking angle of skyline over the shoe; β_i and β_{i-1} are the angles realized by cable's tangents and the horizontal in the uphill, respectively downhill spans of the spar "i".

3. Conclusions

The use of the new software product "TRAF" offers the premise for achieving high productivities in skyline design activities. According to the Romanian public forest sector necessities, the software product was designed by incorporating the most known skylines. The application can be extended by incorporating new skylines provided by different producers. In order to temporarily cover this inconvenience, the application offers an alternative solution by providing an interface for manual data input in case of a new skyline.

The application uses the specialist literature support for skylines design, being until now the most accurate application on the Romanian market in design tasks.

There are three major problems which can be solved by a large scale utilization of the software product: time saving (a process design takes no longer than ten minutes), accuracy (software product eliminates all the design errors, especially in case of complex equations solving), and optimization possibilities (by realizing multiple iterations for a specific skyline and given terrain conditions).

Also, a more updated program may be realized by incorporating-migrating the code from this application to a more complex one, which takes into consideration other relevant aspects, like cost estimation and successive installations in different felling areas. This resource will be developed in the near future.

Acknowledgements

Both, programme design and paper elaboration were supported by R.N.P. ROMSILVA, by funding the research grant no. 4111/2010 we would like to thank R.N.P. ROMSILVA, for financial and logistic support.

References

1. Ionaşcu, Gh., et al.: *Instalaţii cu cablu pentru transport de material şi lemn (Cable Installations for Materials and Timber Transportation)*. Bucureşti. Editura Ceres, 1982.
2. Ignea, Gh.: *Unghiul de frângere al cablului purtător pe suport, factor important ce condiţionează siguranţa în exploatare a funicularelor forestiere (Skyline Breaking Angle, an Important Factor which Influences Forest Cableways Operation Safety)*. In: *Revista Pădurilor* **1** (2005), p. 24-28.
3. Ignea, Gh., Borz, S.A., Ignea, M.: *Considerations Regarding the Constructive Parameters of the Forest Skyline Supports*. In: *Bulletin of the Transilvania University of Braşov*, Vol. 3 (52), Series II, 2010, p. 55-60.
4. Oprea, I., Borz, S.A.: *Organizarea şantierului de exploatare a lemnului (Timber Harvesting Site Set Up)*. Braşov. *Transilvania University Press*, 2007.