RocPro3D

3D assessment of rockfall hazard

Professional 3D stochastic trajectometric simulation software for land-use planning studies, mitigation works design, operational safety issues in the extractive industry

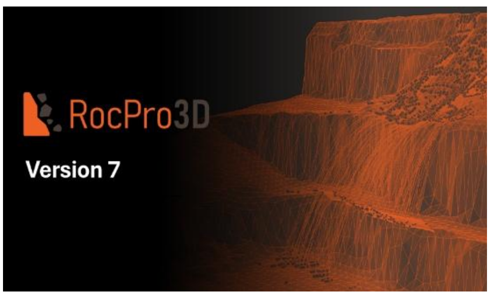
Answers to your rockfall problems thanks to exhaustive 3D simulations

Accurate and fast calculations, allowing simulations to be carried out at very low propagation probabilities (10^{-4} to 10^{-6})

Intuitive and friendly user-interface

Integrated tools for rapid analysis of trajectometric calculations, allowing to dimension protective structures, to create hazard maps compatible with the CADANAV or MEZAP methodologies, and to compare and improve quickly your simulations with respect to field observations

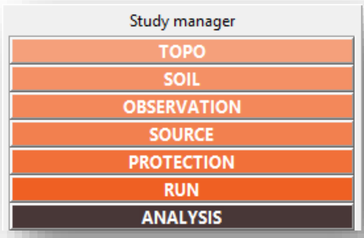
Advanced protection reliability analysis using the RockStop software module



Quick to get started with, intuitive to use

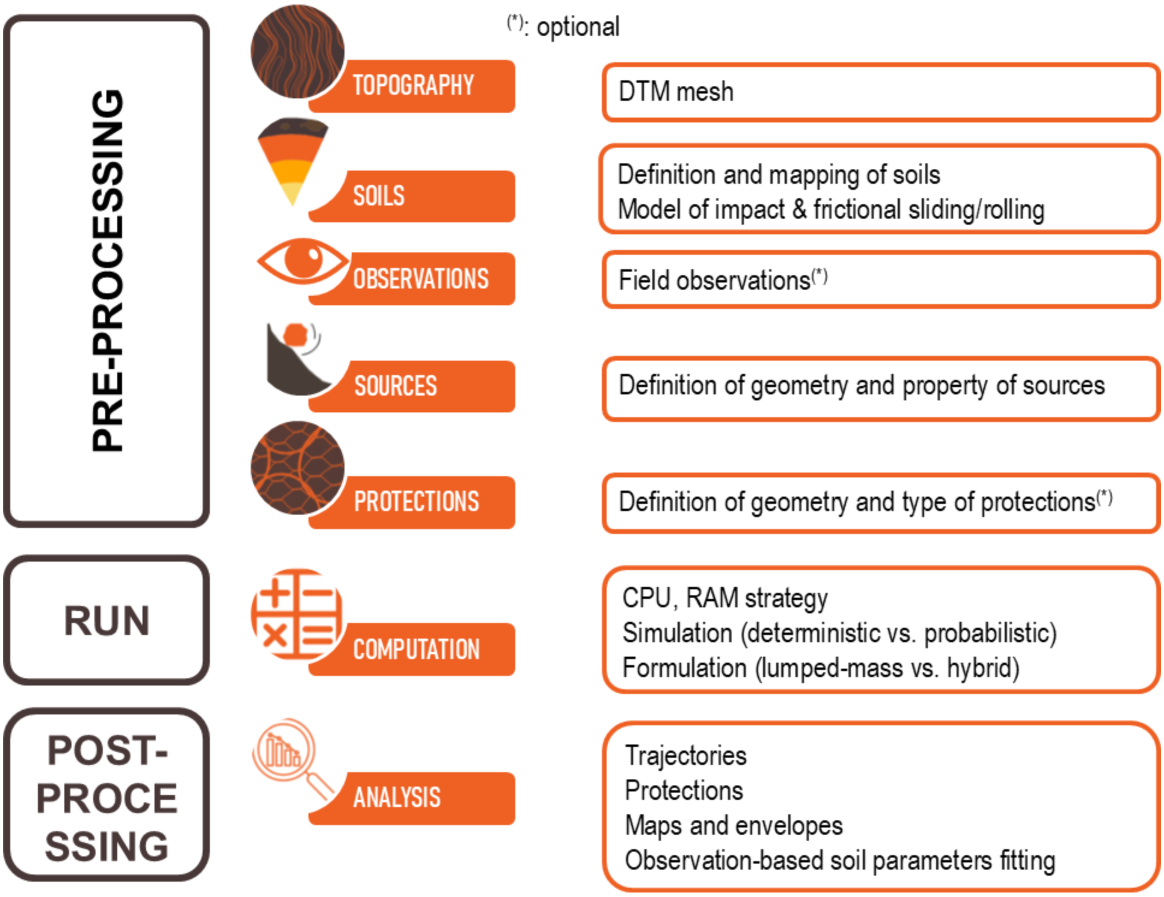
Full integration via the study manager

Pre-processing, calculation and post-processing tools



Simplified model setup, with step-by-step guidance

Integrated and optimized pre-processing (DTM, creation and assignment of soils, import observed blocks, creation/import of sources and protections), allowing you to focus on analysing the results



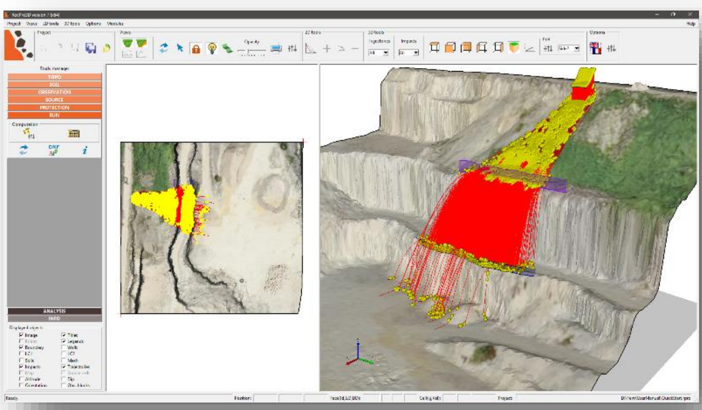
Steps for implementing the simulations

Rapid visualization and analysis of results, facilitated by interactive and scalable views

2D and 3D views, with results at each impact (XYZ coordinates, height, soil, time, velocities before and after impact, energies)

Vertical profile view (energies, velocities, height, time) for each trajectory or in the protections plane

Statistical analysis (histograms, indicators, tables) on trajectories, protections, envelopes



User interface

Physical models

Formulation

Hybrid (lumped-mass with finite size block and rotation), for free-fall, impacts and frictional rolling

Impacts

Dissipation via restitution coefficients (R_N, R_T), R_N being constant or velocity dependent $R_N(V_N)$

Effects related to block rotation considered

Frictional rolling

Dynamic frictional (Coulomb) rolling model, numerically integrated with geometric accuracy control

Transitions

Geometrical conditions to allow switching between free-fall and translation kinematics and vice versa

Stochastic approach

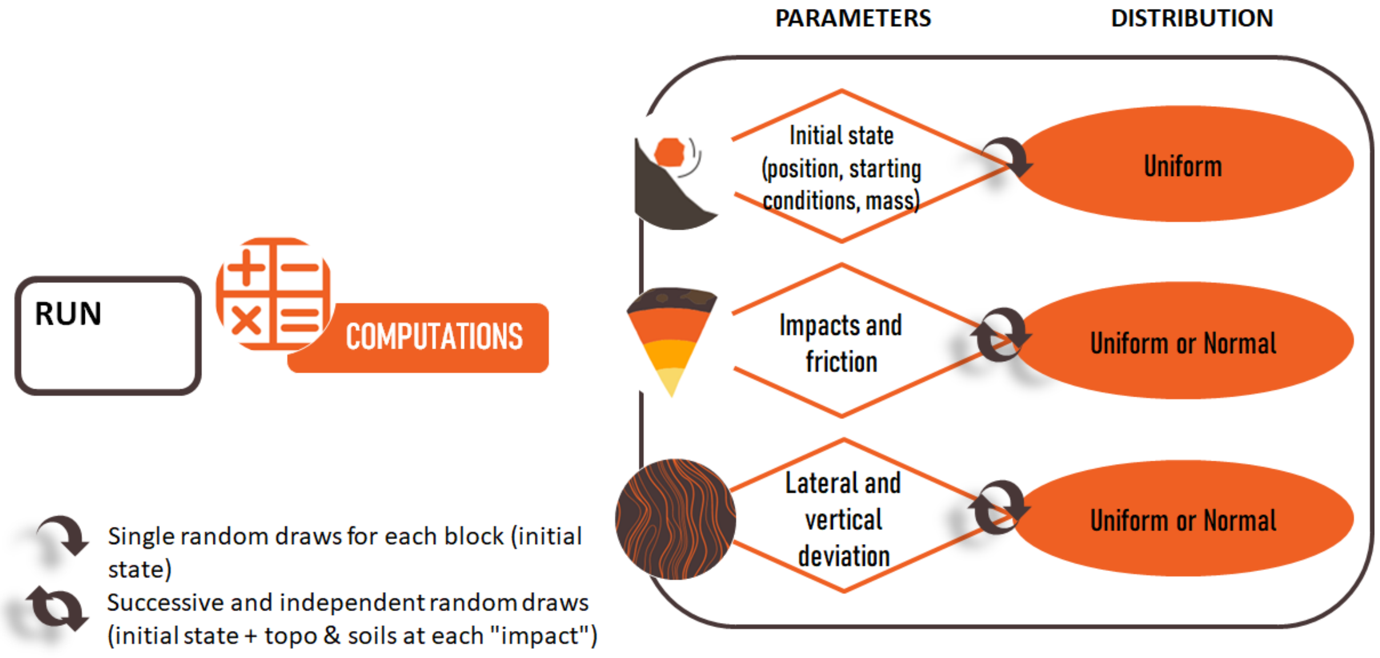
Computation modes

Deterministic mode

Probabilistic mode (Monte-Carlo type stochastic) with choice of variables (Gaussian or equiprobable) for the properties:

- Soils (restitution and friction coefficients, lateral deviation, rebound flattening)
- Blocks (initial starting condition, initial position, mass, rebound perturbation)

Different RAM management strategies for the simulations, adapted to the purpose of each study (e.g. design of mitigation structures or hazard assessment)



Principle of the probabilistic approach used in RocPro3D

Topography

Creation of DTM

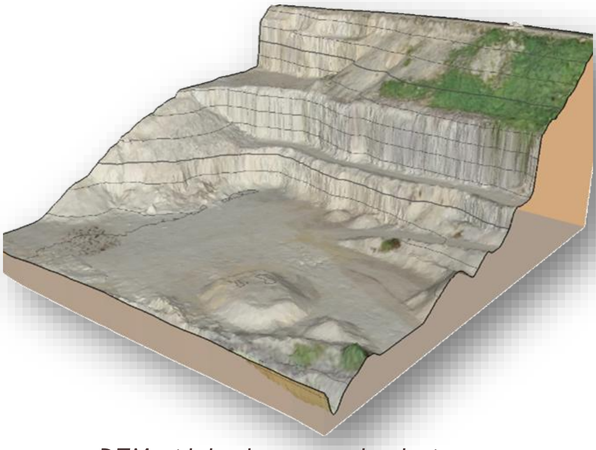
From 2D profiles, imported DTMs (DEM, regular or irregular triangular meshes) or topographic maps

DTM realism

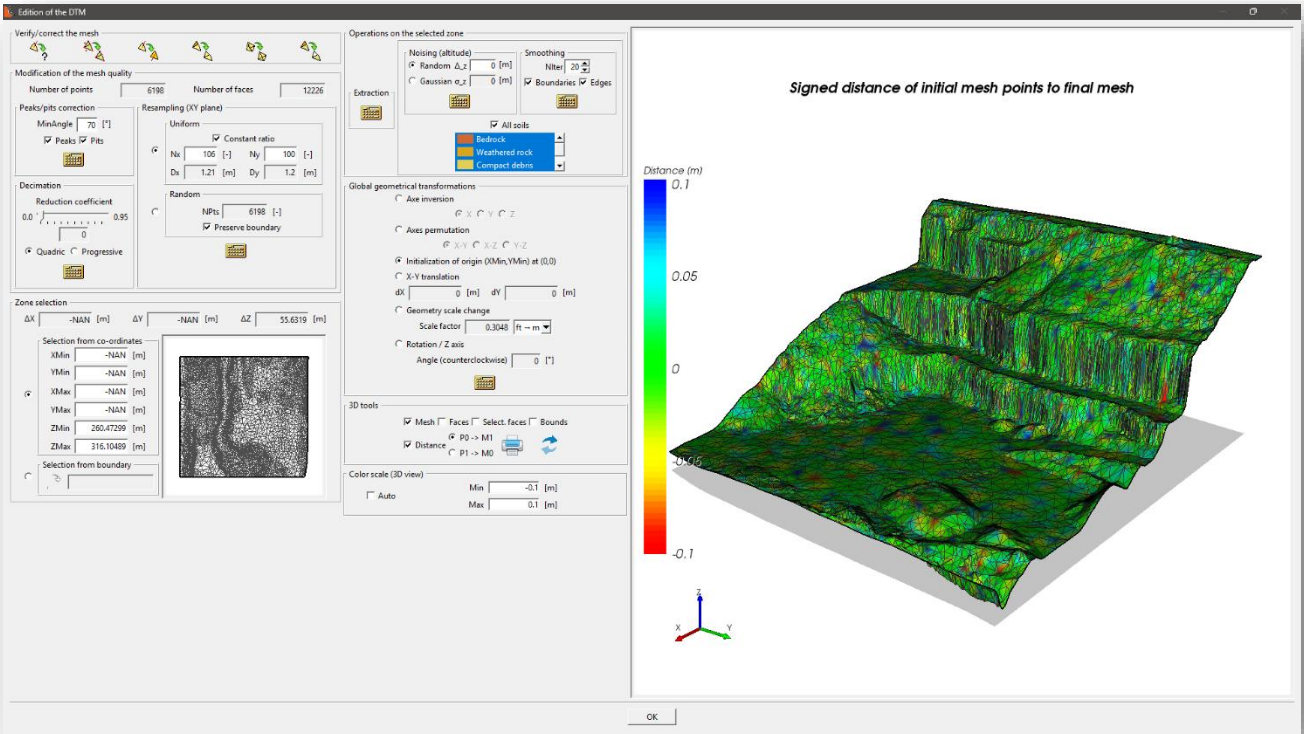
Overlay of topographic contour lines and image mapping

DTM edition

Non-conforming mesh detection/correction, decimation, resampling, zones extraction, noising, smoothing, geometric transformations



DTM with level curves and ortho-image



DTM edition: distance map (Hausdorff) between initial mesh and resampled mesh

Soils

Soils and physical parameters

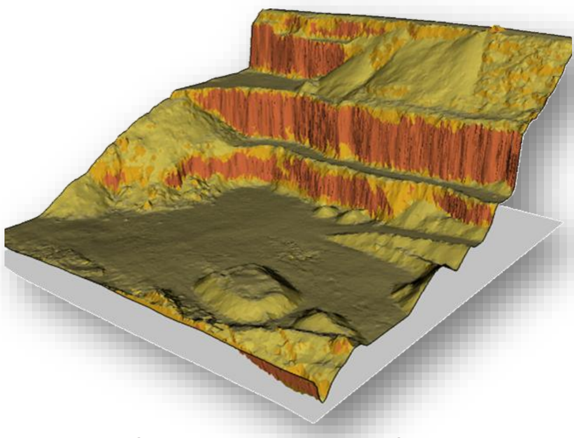
Predefined or user defined

Dissipative model $R_N(V_N)$

Specific to each soil

Quick assignment of soils to the DTM

By faces, by zones or by filters (XY coordinates, elevation, dip, orientation)

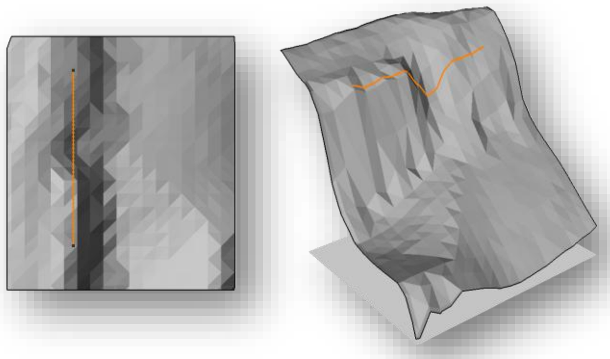


Soils assigned by multiple filters

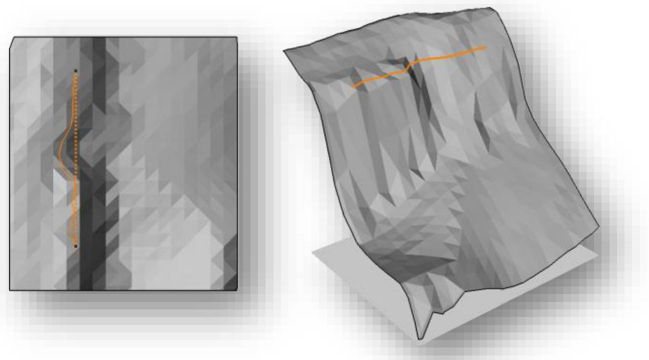
Sources of starting blocks

Easy positioning by projecting (horizontally or vertically) the source baseline onto the **DTM**
Possible **import** from **shapefiles** or **points files**
Linear or **surface geometry**
Number of blocks per source or **global block density** for all sources. **Selection of:**

- **Initial conditions:** initial fall, initial velocity or mixed
- **Block properties**: size, density, shape



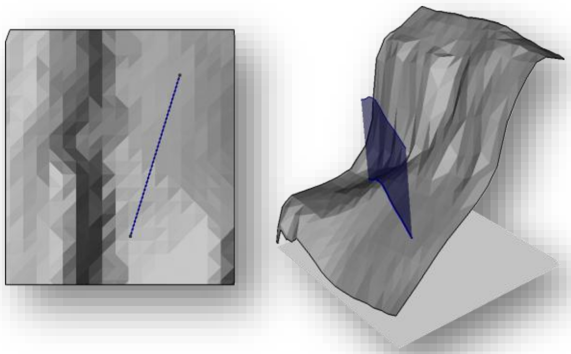
Vertical projection (baseline) on DTM



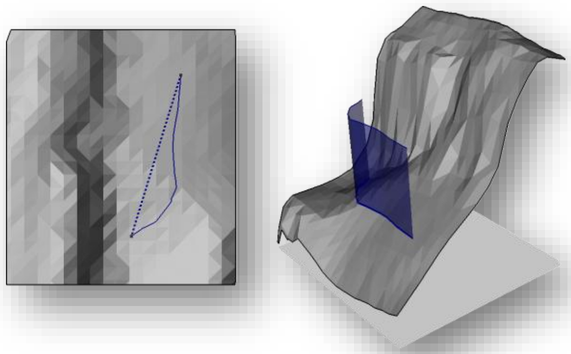
Horizontal projection (baseline) on DTM

Protection structures

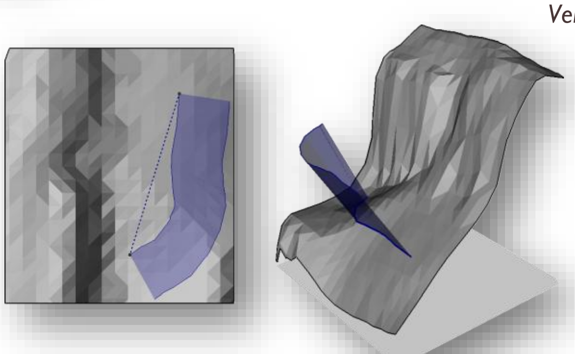
Easy positioning by projecting (horizontally or vertically) the protection baseline onto the **DTM**
Possible **import** from **shapefiles** or **points files**
Real (nets, merlons) **or fictitious** (data collectors) **protection**, with an inclination **vertical, normal** to the DTM, or **angular** to the vertical)



Vertical projection (baseline) on the DTM
Vertical protection



Oblique projection (baseline) on the DTM
Vertical protection



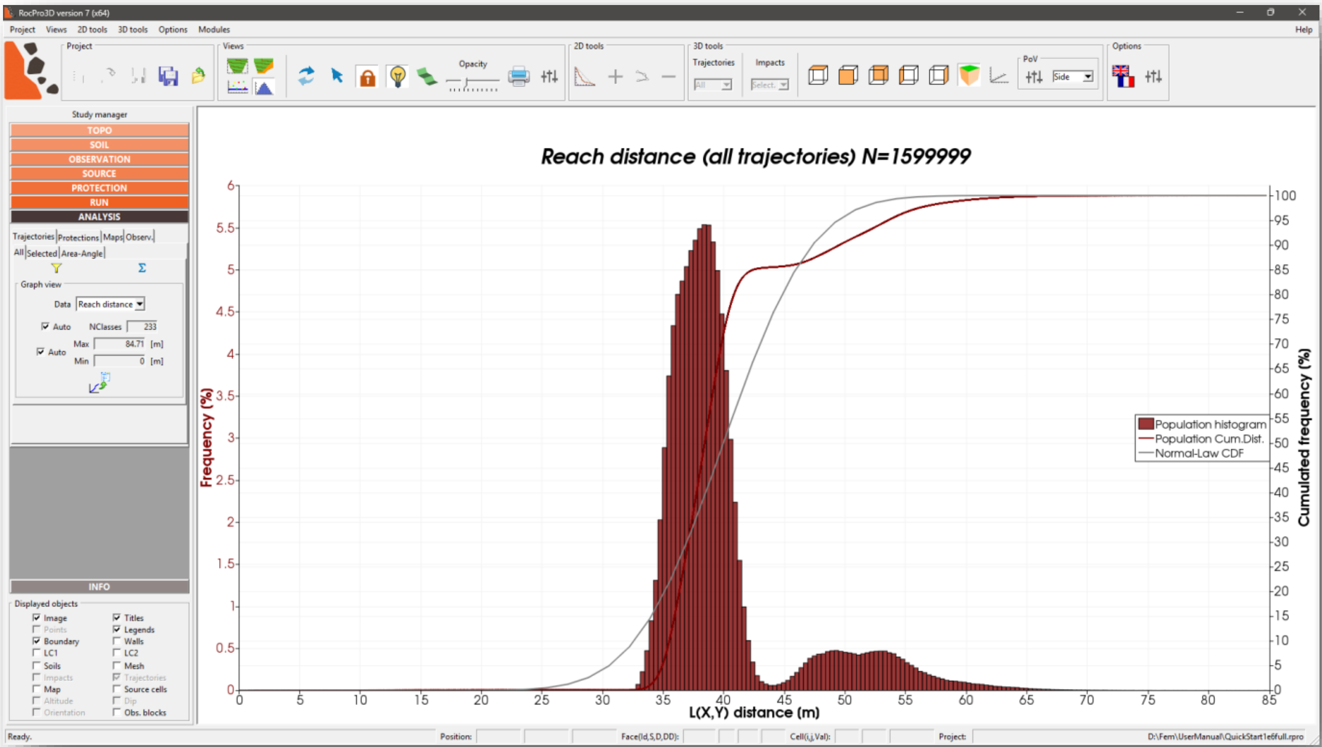
Oblique projection (baseline) on the DTM
Protection at 30° inclination / vertical

Trajectories: from global to local scale

Global analysis of all the trajectories

Visualization of block trajectories and impacts in 2D and 3D views

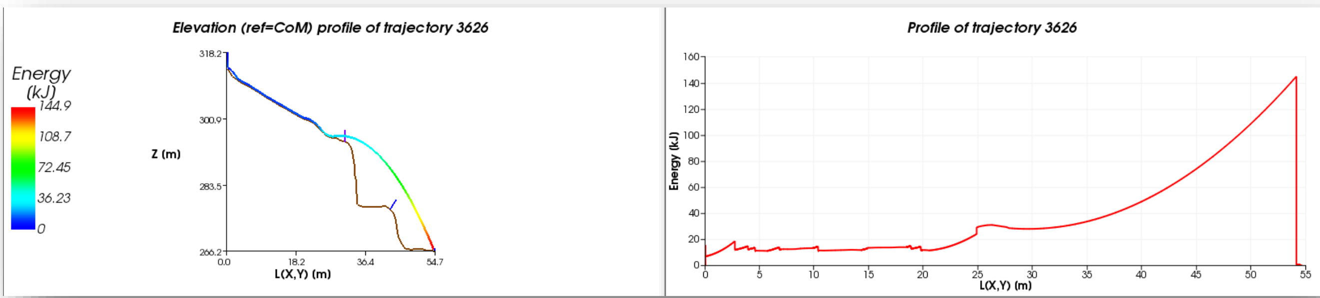
Analysis of the **distribution of reached distance** and **travel times** for **all blocks**, with possible filtering by **block source**



Histogram of the blocks reached distance [simulation with $1.6 \cdot 10^6$ blocks]

Detailed analysis of individual trajectories

Evolution of energies, velocities, heights, and time on the elevation profile of the trajectory or along the selected trajectory



Example of energy analysis for a trajectory: elevation profile (left) and profile (right)

Possibility to export all calculated results for trajectories as ASCII or DXF files

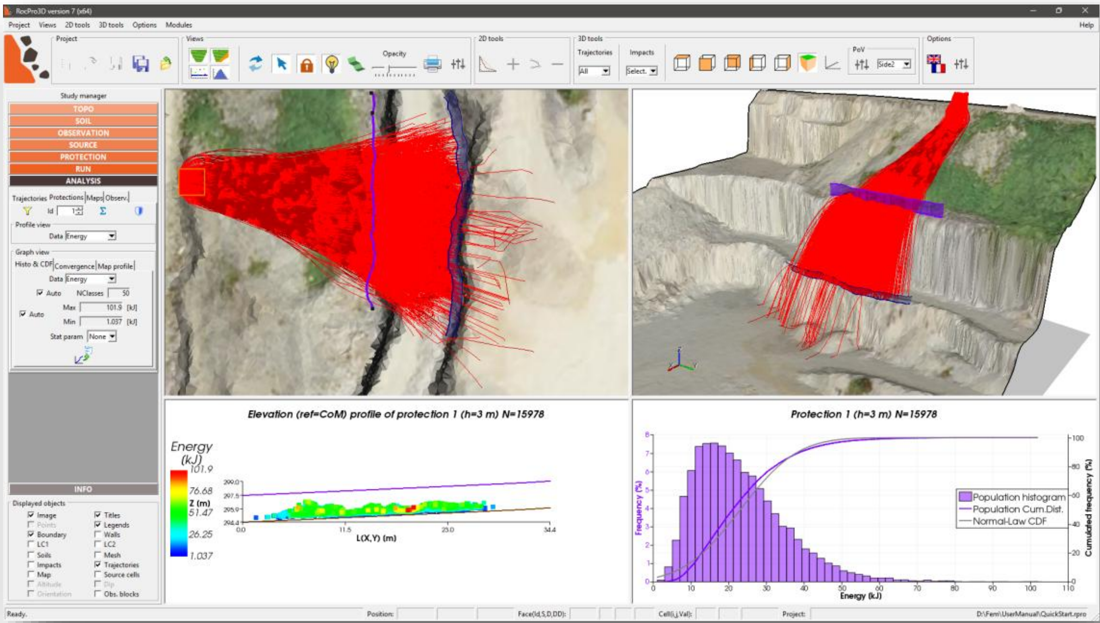
Protections structures: elements for dimensioning

Visual analysis of the trajectories in the plane of protections

For all blocks intersecting the (poly)plane of a protection, visualization of the analysed result (travel time, energy, velocity, impact height) according to the elevation profile of the protection

Statistical analysis of the trajectories in the plane of protections

Statistics (mean, max, confidence limits, quantiles, Kolmogorov-Smirnov hypothesis test), **cumulative frequency curves** and **statistical convergence indicator** for all blocks intersecting a protection (poly)plane (travel time, energy, velocity, height)



Example of analysis on protection: elevation profile (left) and associated statistics (right) – [simulation with 10^4 blocks]

Possibility of refining the analysis by applying filters on the block sources, on the protection part and on the type of impact

Synthesis of the analysis as summary tables for the different types of impacts

Protection statistics

Protection Id 0 (full length: 0-34.44 m)
Fictitious: height=3 m, capacity=0 kJ
Properties of blocks reaching or passing over the protection :
Mass[kg] : Min=299.4, Max=1197.6
Volume[m³] : Min=0.11976, Max=0.47904
1/1 sources taken into account, Ids:
1

Tables 1-3

All the blocks (N=15978 ; 100%)

	Min	Max	Mean	StDev	CL-99	CL-95	CL-90	CL-68	Q-99	Q-95	Q-90	Q-80	Q-50	KS-d	KS-p
Energy [kJ]	1.037	101.8	23.09	11.87	53.65	46.34	42.6	34.89	59.63	45.26	38.96	32.15	21.04	0.07	0
Energy(T) [kJ]	0.795	74.4	17.25	8.867	40.1	34.63	31.84	26.07	44.2	33.78	29.27	24.12	15.69	0.071	0
Energy(R) [kJ]	0.242	27.42	5.832	3.067	13.73	11.84	10.88	8.882	15.6	11.65	9.864	8.049	5.271	0.075	0
Velocity(T) [m/s]	2.045	12.37	6.688	1.229	9.852	9.096	8.708	7.909	9.8	8.74	8.232	7.657	6.67	0.016	0
Velocity(R) [m/s]	4.031	33.53	15.28	3.538	24.39	22.21	21.1	18.8	25.39	21.77	19.96	18.09	14.85	0.049	0
Height P [m]	0.306	1.987	0.592	0.191	1.084	0.966	0.906	0.782	1.174	0.955	0.859	0.723	0.541	0.105	0
Height Z [m]	0.306	1.987	0.592	0.191	1.084	0.966	0.906	0.782	1.174	0.955	0.859	0.723	0.541	0.105	0
Time [s]	4.714	9.613	6.37	0.688	8.141	7.718	7.501	7.054	8.165	7.608	7.324	6.986	6.254	0.072	0

Possibility to modify the geometry and position of fictitious protections in post-processing, allowing to refine the geometry of protection structures

Maps and envelopes: tools for dimensioning and for hazards assessment

Analysis grid

Definition of raster grids for maps and envelopes (cells dimensions independent of the mesh)

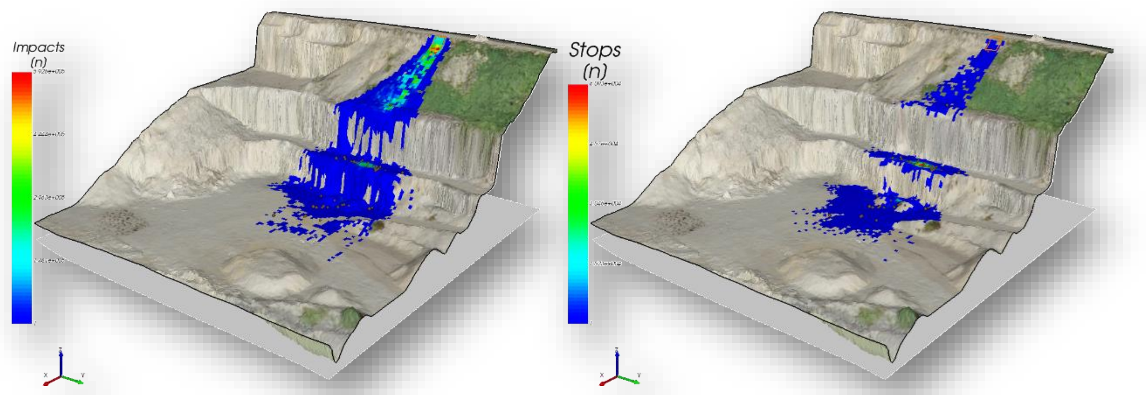
Maps and envelopes

Maps are the spatial representation of the analysed result as fields. To refine the analysis for certain fields, specific maps, **envelopes**, make it possible to select the statistical indicator considered relevant.

A total of 11 maps and 3 envelopes are available to pre-dimension protections or to assess hazards

Generic maps	Protections dimensioning	Hazards assessment
Map of impacts	Envelope of energy	Map of energy classes
Map of stop points	Envelope of velocity	Maps of P(propagation) and its classes
Map of minimum travel time	Envelope of passing height	Maps of P(reach) and its classes
Map of NumTraj		Maps of energy and travel line min angles

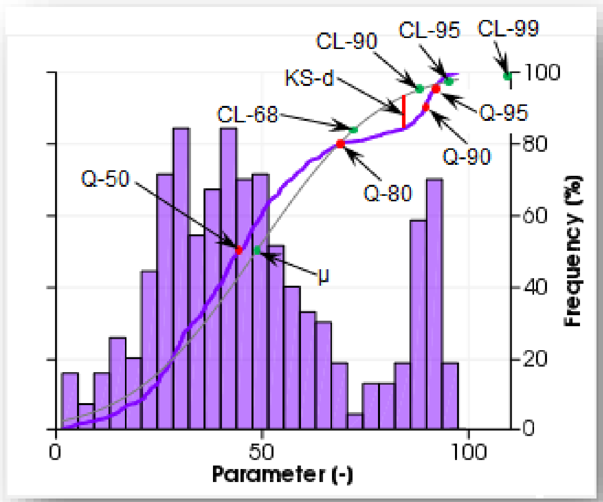
Generic maps



Example of impacts map (left) and stop points (right) – [simulated with $1.6 \cdot 10^7$ blocks]

Statistical indicators of envelopes

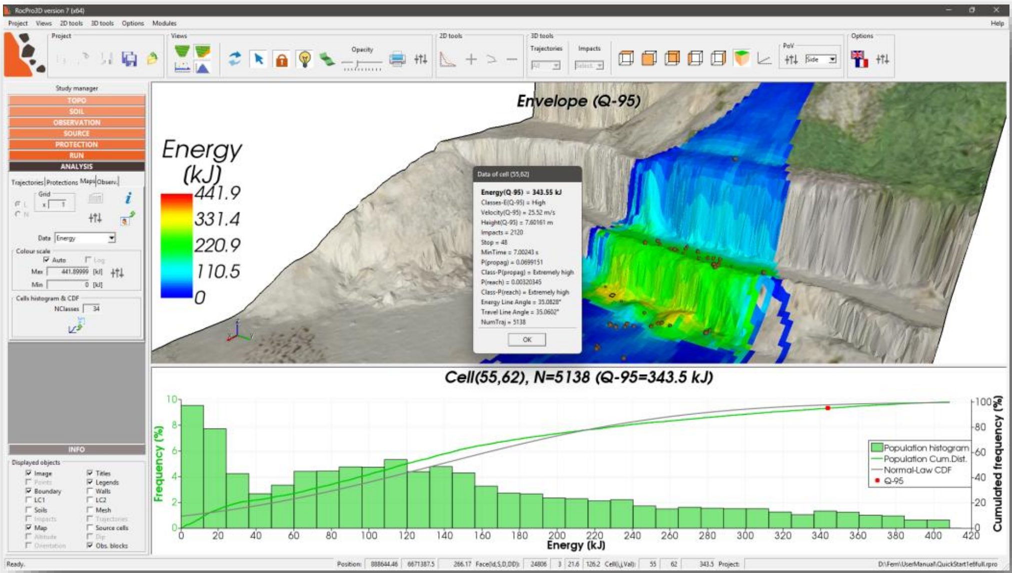
Various statistical parameters (min, max, mean, quantiles, confidence limits, normality test) are available to select the relevant envelopes for analysis



The different statistical indicators available for the envelopes

Statistical analysis of the envelopes at the level of the grid cells

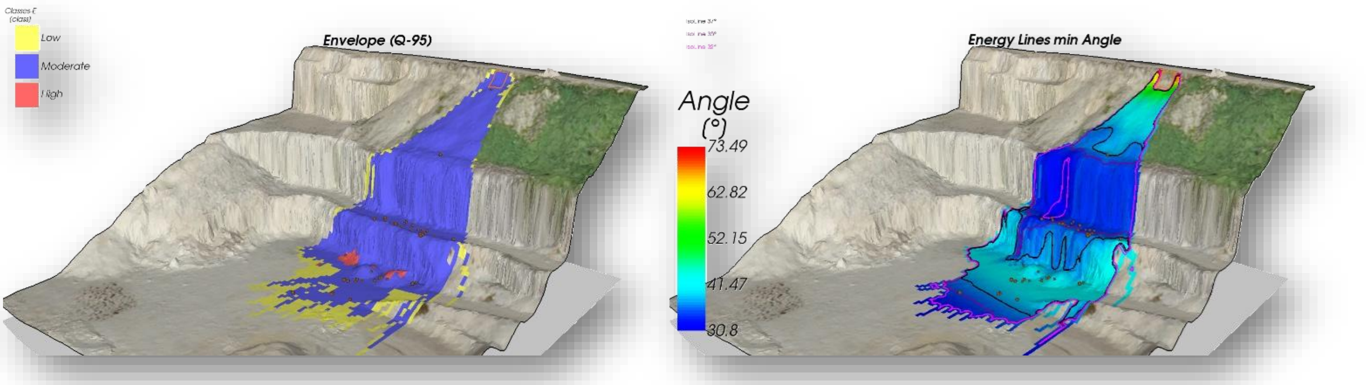
In some cases, statistical analysis (mean, standard deviation, median, histogram and cumulative frequency curves) of the population of each cell may be required to verify the relevance of certain high statistical values observed locally (in particular for grid cells exhibiting small-size population)



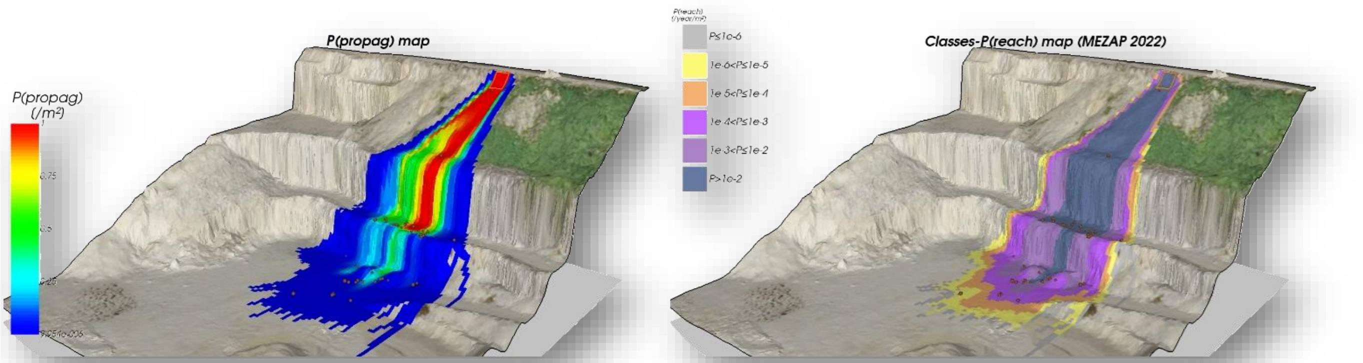
Example of statistical analysis at the scale of an envelope cell – [simulation with $1.6\cdot10^6$ blocks]

Hazard assessment

Various maps allow to evaluate different hazards according to the CADANAV (2013) or MEZAP (2022) methodologies



Example of energy classes envelope according to CADANAV (2013) (left)
and energy line min angle map (right) – [simulation with $1.6\cdot10^6$ blocks]

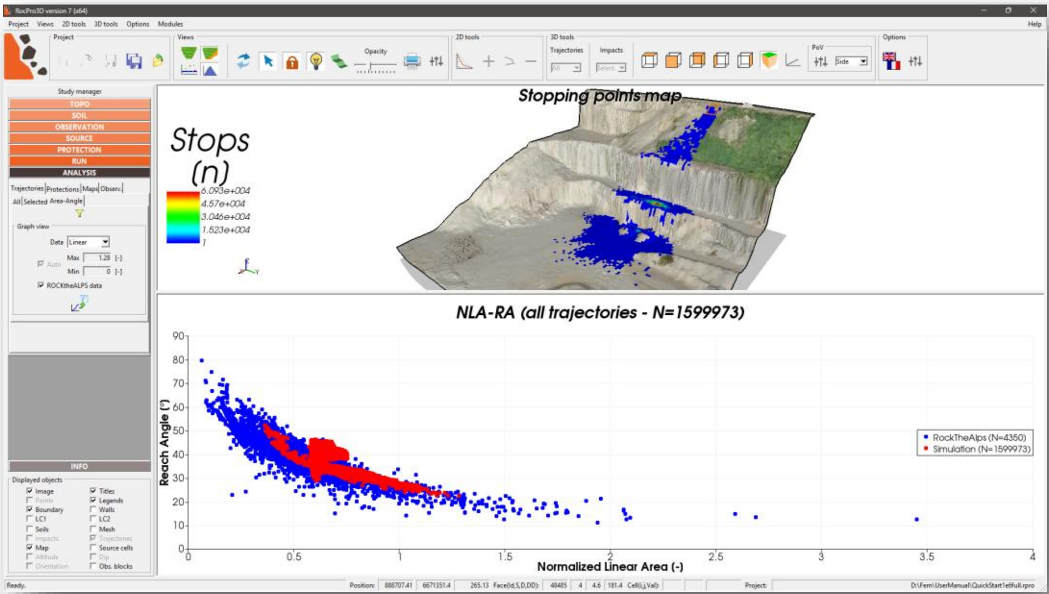


Example of P(propagation) map (left)
and classes of P(reach) maps according to MEZAP (2022) (right) – [simulation with $1.6\cdot10^6$ blocks]

Useful tools to quickly compare and improve simulations with field data

Compare simulated reached distances with an international field database

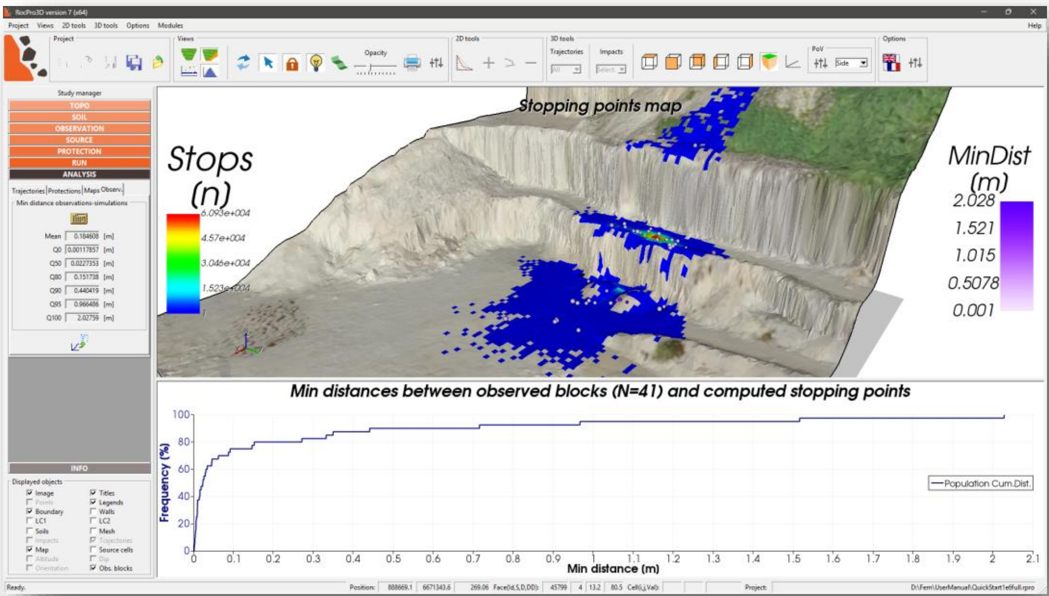
Simulation results are reported in an ELANA type chart, together with the RockTheAlps database. This allows a quick visual inspection and assessment that your results fit the general database trend.



Simulations results and RockTheAlps database reported in an ELANA chart (bottom)

Enhance simulation fitting using field observations

The observed position of blocks in the field can be used to compute the min distance between populations of observed versus simulated blocks. This provides an objective error estimate, that can be used as a metrics to run optimization fitting of soil parameters.



Min distance computed between each field observed blocks and simulated stopping positions: 3D representation of observed points with their MinDist value (top) – MinDist statistical cumulative distribution (bottom)

Advanced protection reliability analysis using the RockStop software

RockStop is an advanced computational tool developed to support the reliability-based design and assessment of rockfall net fences. With a reliability-based approach (EN 1990:2023 Annex C), RockStop explicitly quantifies the probability of failure of rockfall barriers, accounting for the natural variabilities of rock mass, velocity, and trajectory height.

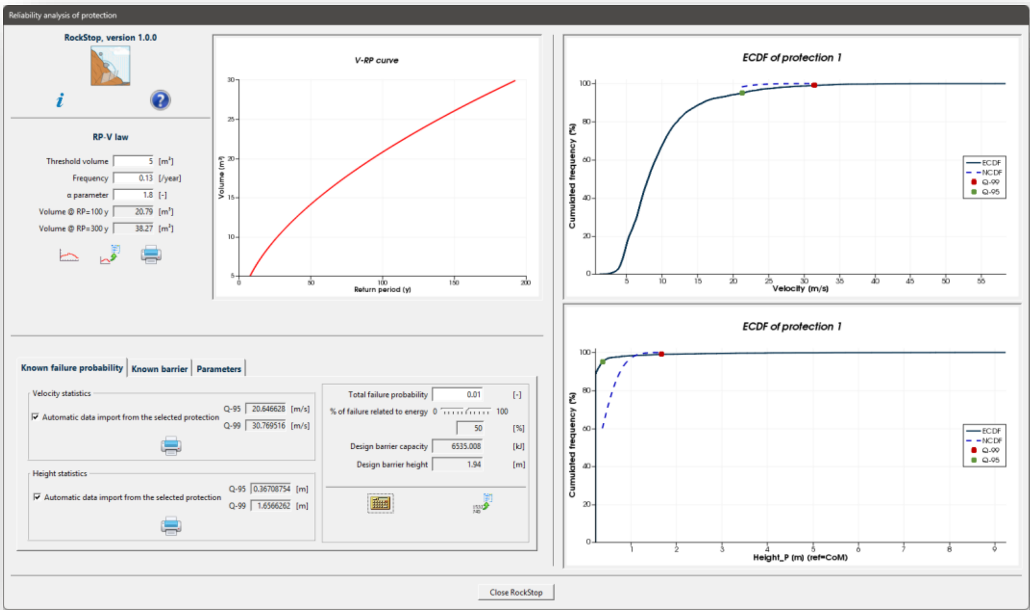
The software integrates site-specific data (block size distributions and event frequency) with trajectory analysis outputs, enabling a comprehensive and probabilistic evaluation of barrier performance.

Two complementary applications are available:

- design of barriers (kinetic energy absorption capacity and height) for a target failure probability;
- assessment of the failure probability of an existing barrier.

The approach explicitly considers the exceedance of barrier performance in terms of both energy absorption capacity and interception height, providing a physically consistent description of failure mechanisms. By capturing these mechanisms, RockStop enables a rigorous estimation of failure probability within a residual risk quantification framework, supporting informed decision-making in hazard mitigation.

RockStop is integrated seamlessly within RocPro3D, facilitating its use in professional engineering practice. Overall, RockStop enables site-specific and performance-based design, contributing to safer and more efficient rockfall risk management.



User interface of the embedded RockStop module

The RockStop software is developed at and owned by Politecnico di Torino (De Biagi & Marchelli, 2025)

Politecnico di Torino

Need a trial or a software demo?
Contact us!

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www.rocpro3d.com

Required configuration

- 64 bits Windows OS
- High performance multi-core CPU (Intel Core iX, ultraX, AMD Ryzen)
- 32 Gb RAM (64 Gb recommended)
- Minimal disk space: 1 Tb
- Dedicated 3D graphic card
- Optimal graphic resolution: 1920x1080 pixels