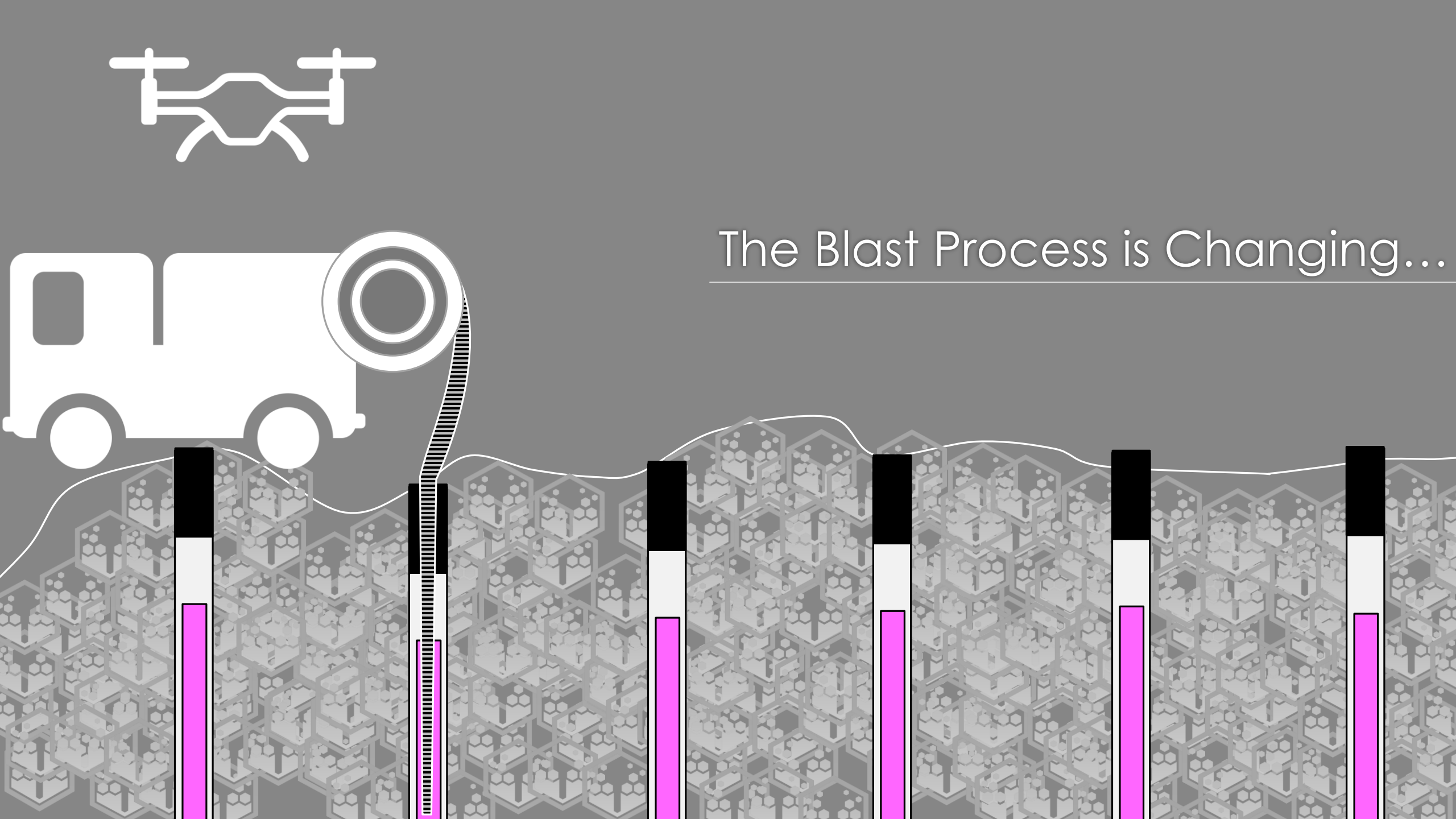
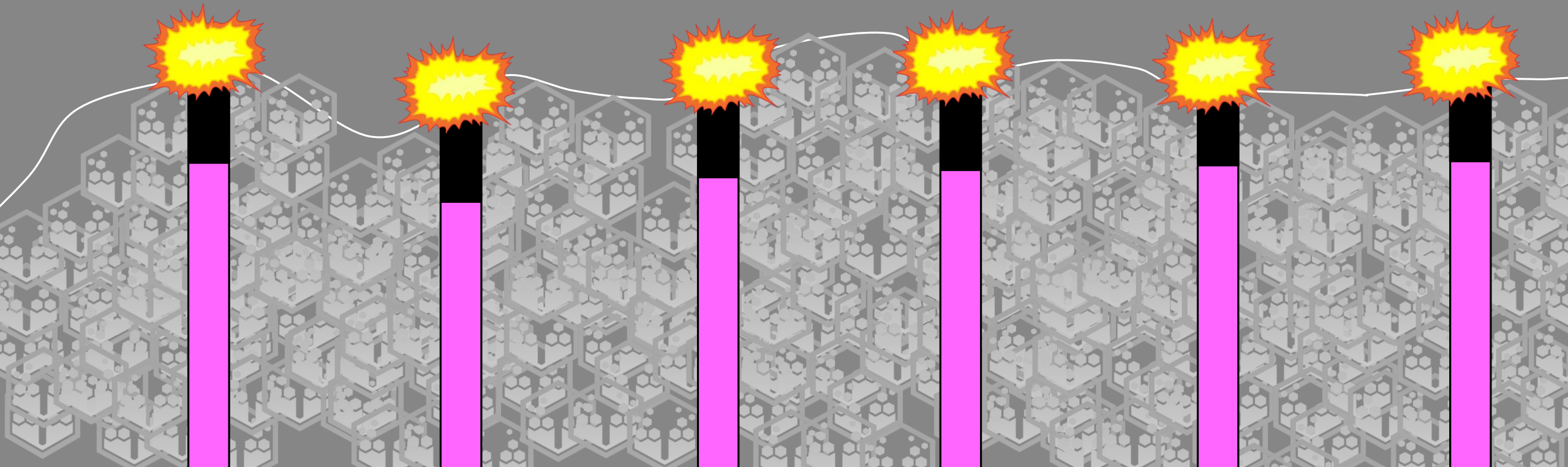
Vinicius Miranda – O-Pitblast
Francisco Leite – O-Pitblast
Thomas Palangio – Wipware
Raquel Sobral – O-Pitblast
Pedro Brito – O-Pitblast

Pattern Expansion – Fragmentation with Drones

The Blast Process is Changing…

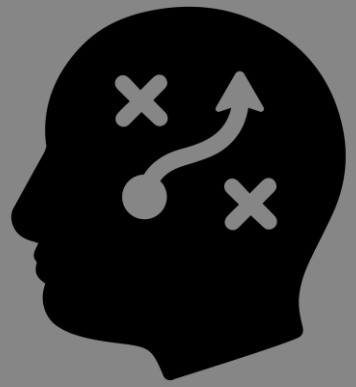


The Blast Process is Changing…



And also the way to control it!

What is pretended with a blast operation?

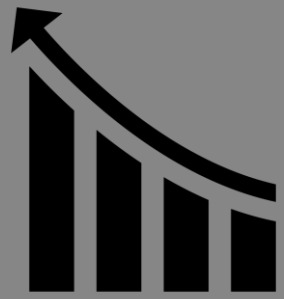


Eficiency

Precision

Quickness

Safety



Productivity

Drones

How Drones support operations's efficiency – Pattern Expansion?

What is a Drone?

UAV - Unmanned Aerial Vehicle:
- Non crewed Aerial vehicle

→ Military purposes → Civil Application
Mining Applications

Drones in Mining

survey procedures

mapping

misfires inspection

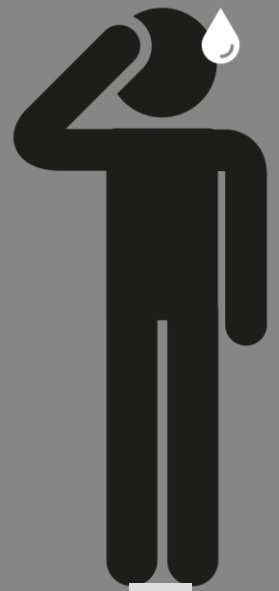
structures inspections

dilution control

machinery tracking

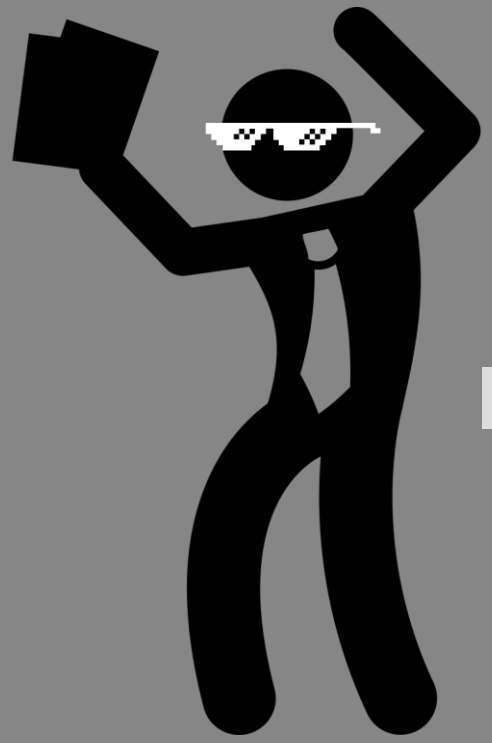
Muckpile mapping

- How to use a Drone to Control Fragmentation and save cost in Blasting?



No worries…

Is really easy!



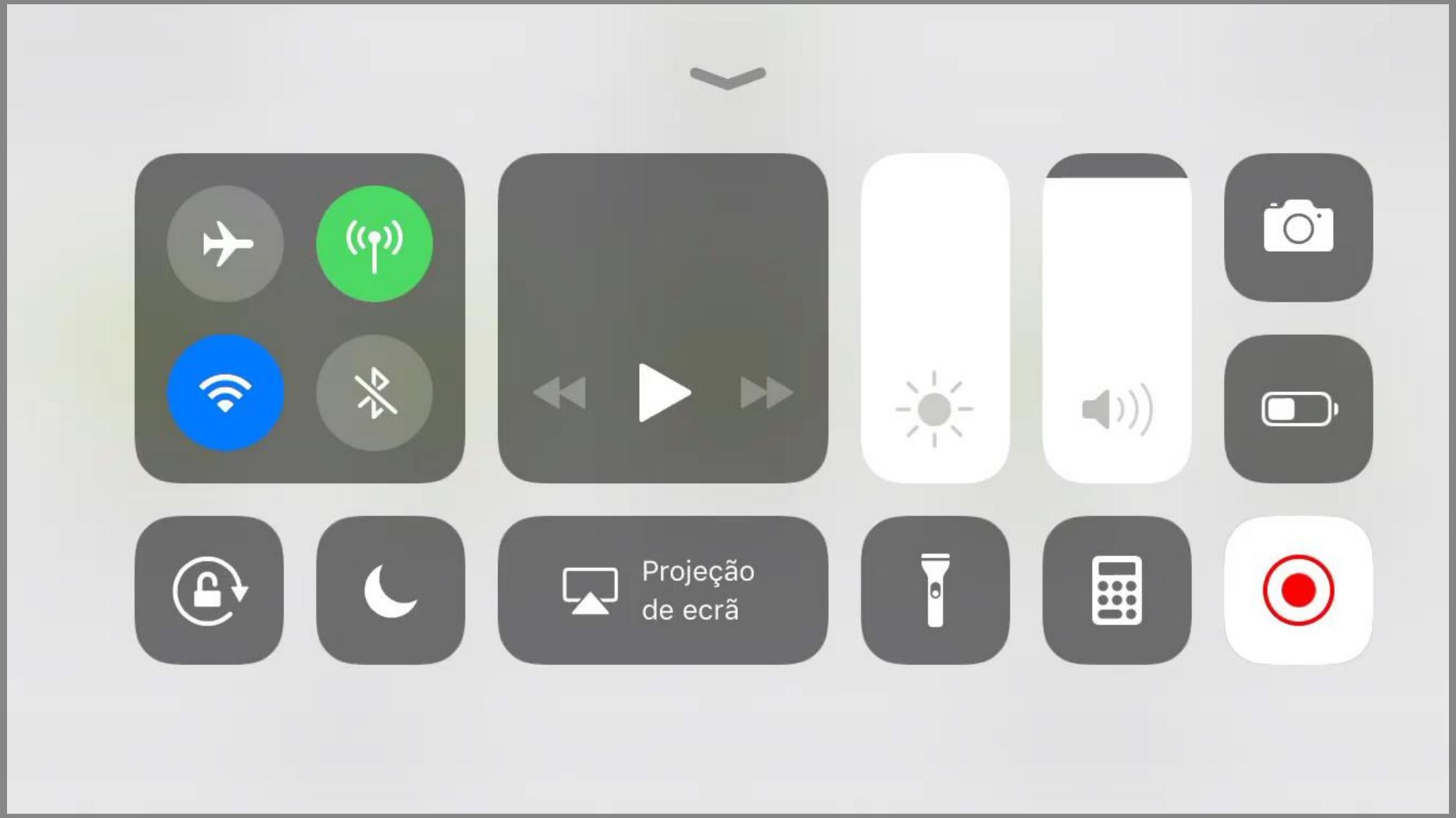
Drone Equipment

- Observe all drone safety and regulations in your area (**UAS Certification - FAA Part 107** or equivalent as necessary)
- Keep line of sight to your drone at all times
- Camera angle to 90° (perpendicular to the ground)
- Overlap to 80% (reduces optical distortion)
- Noon ±2 hours (minimizes long shadows)
- Flight altitude between 100-200ft (30-60m)
- 50-500 image samples (depends on area size)
- Use free mobile applications - pre-flight check

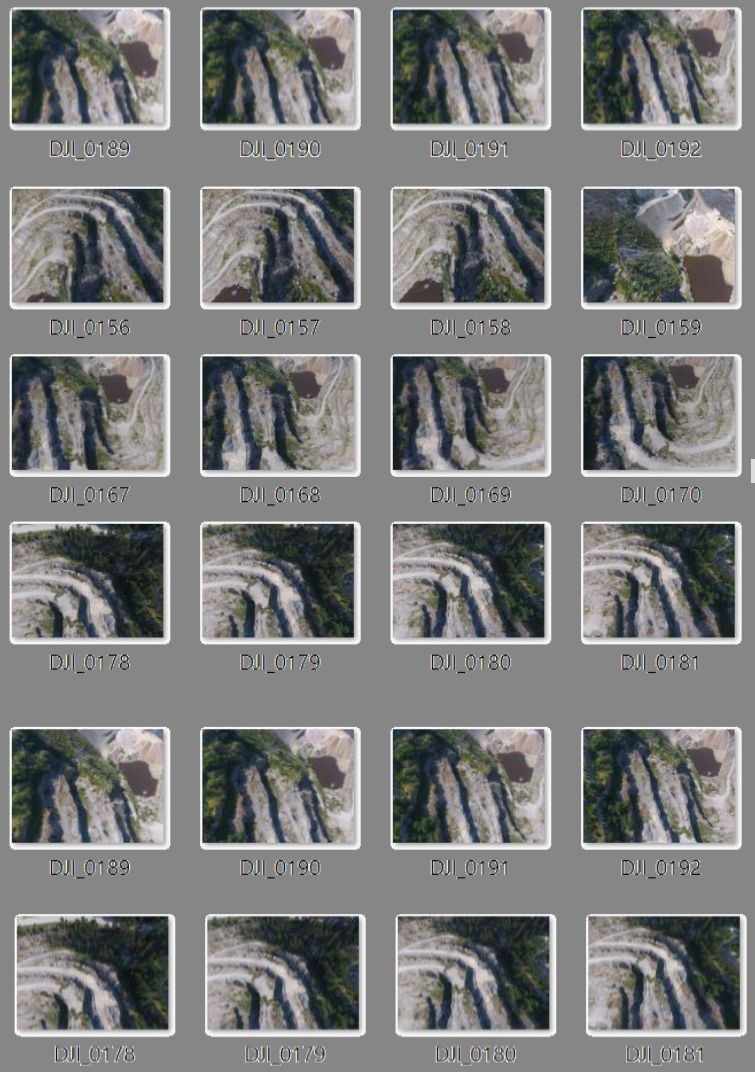
The Technology

WipWare

The Flight Plan



Data Treatment

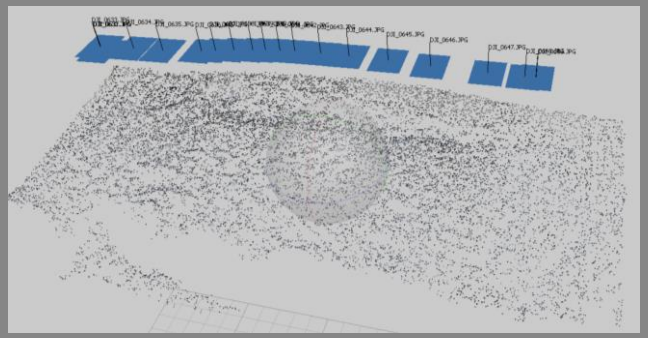


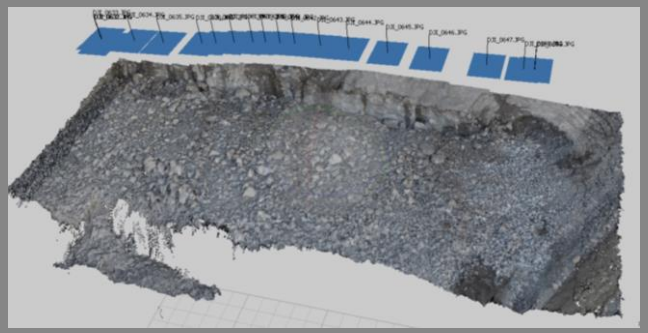
Align Drone Photos

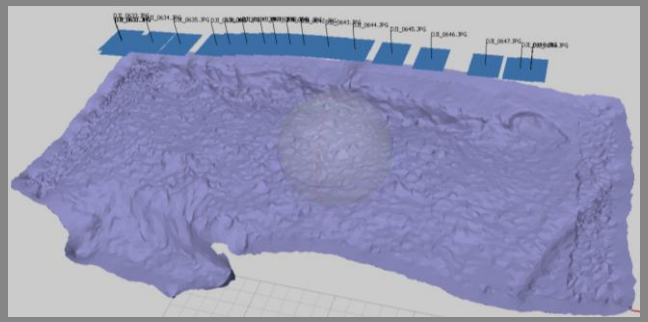
Build Dense model

Build Mesh

Orhtomosaic







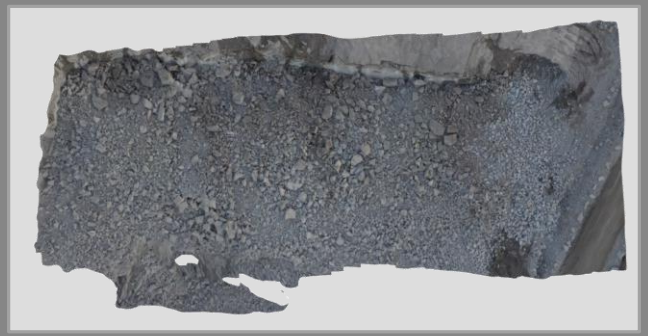


Photo Scan

3D Modeling and Mapping

Agisoft

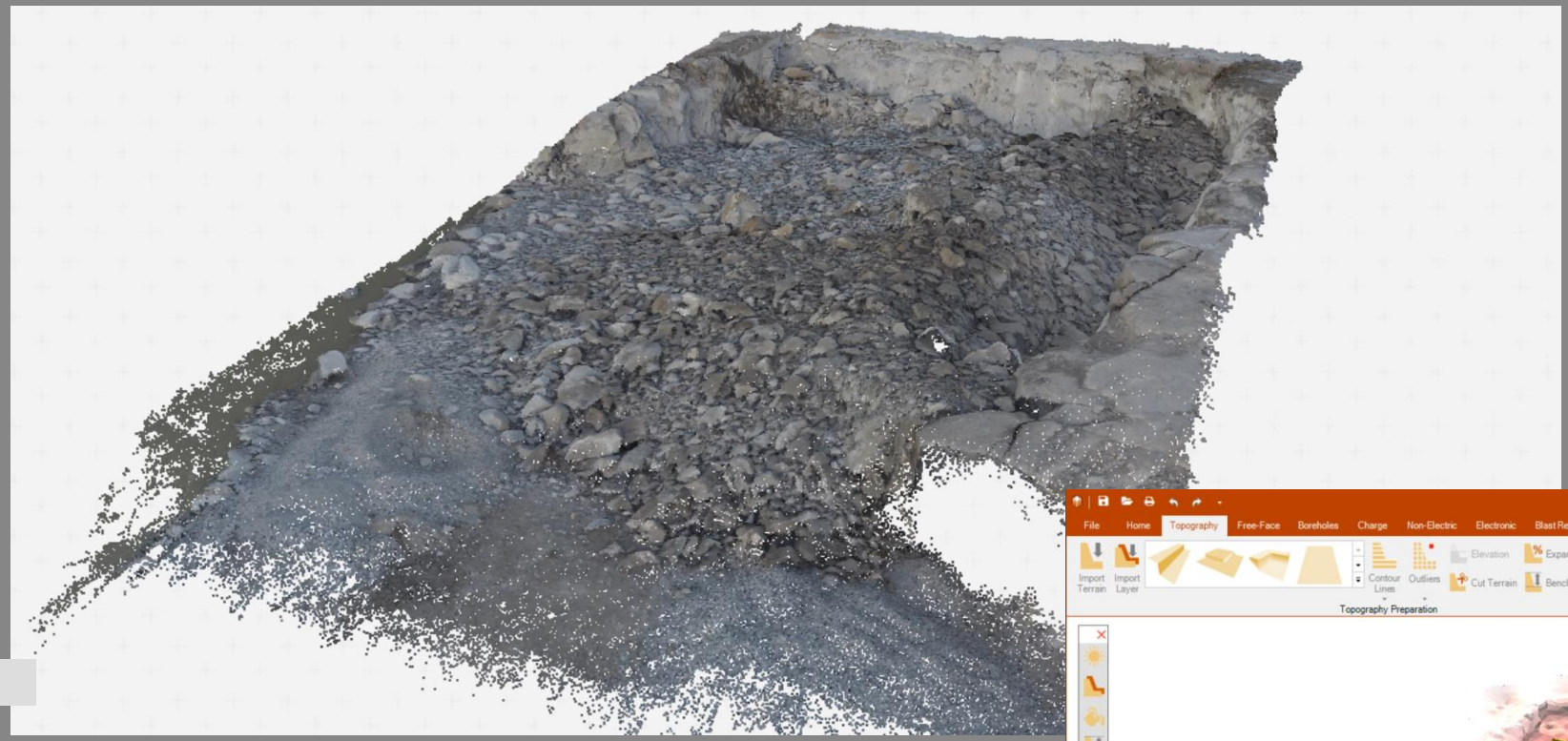
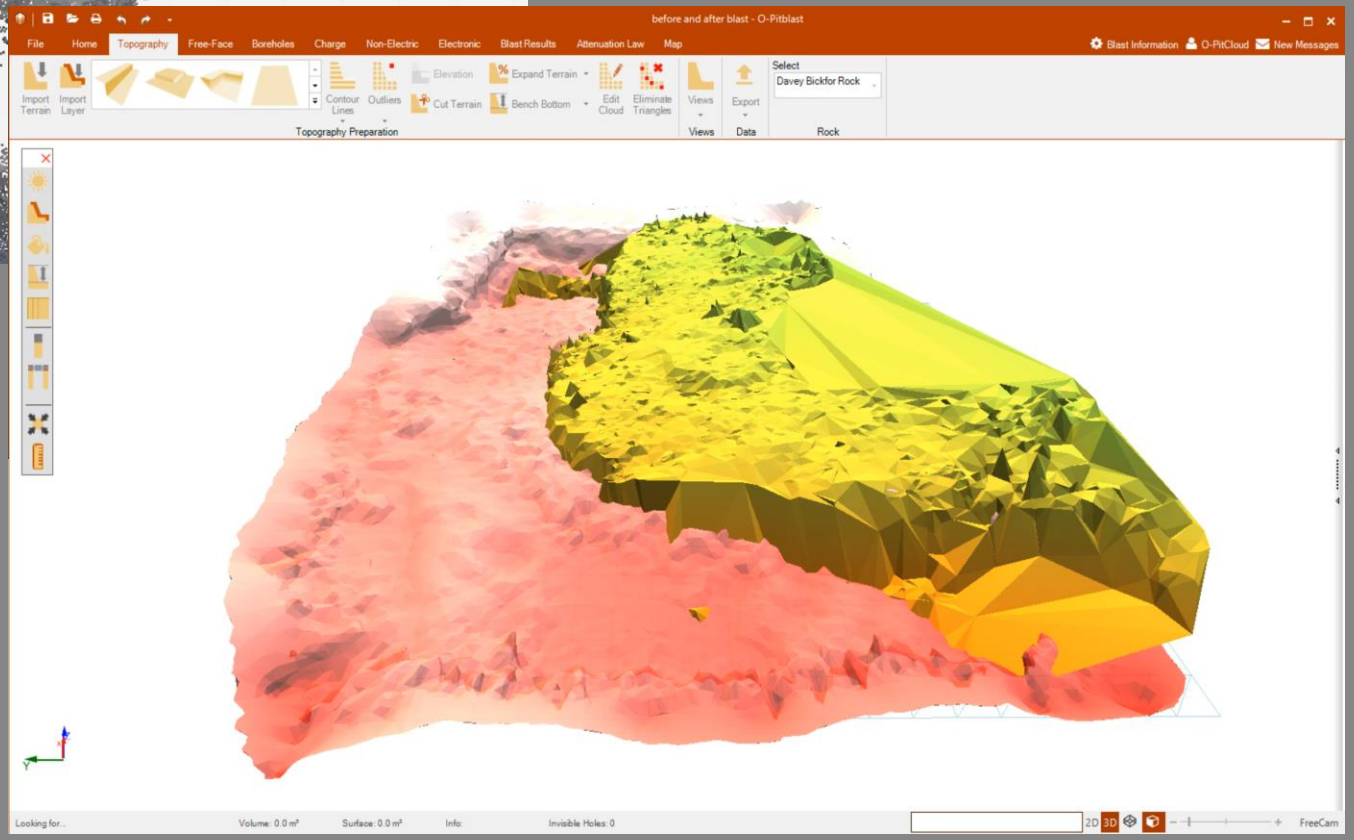


Photo Scan

3D Modeling and Mapping

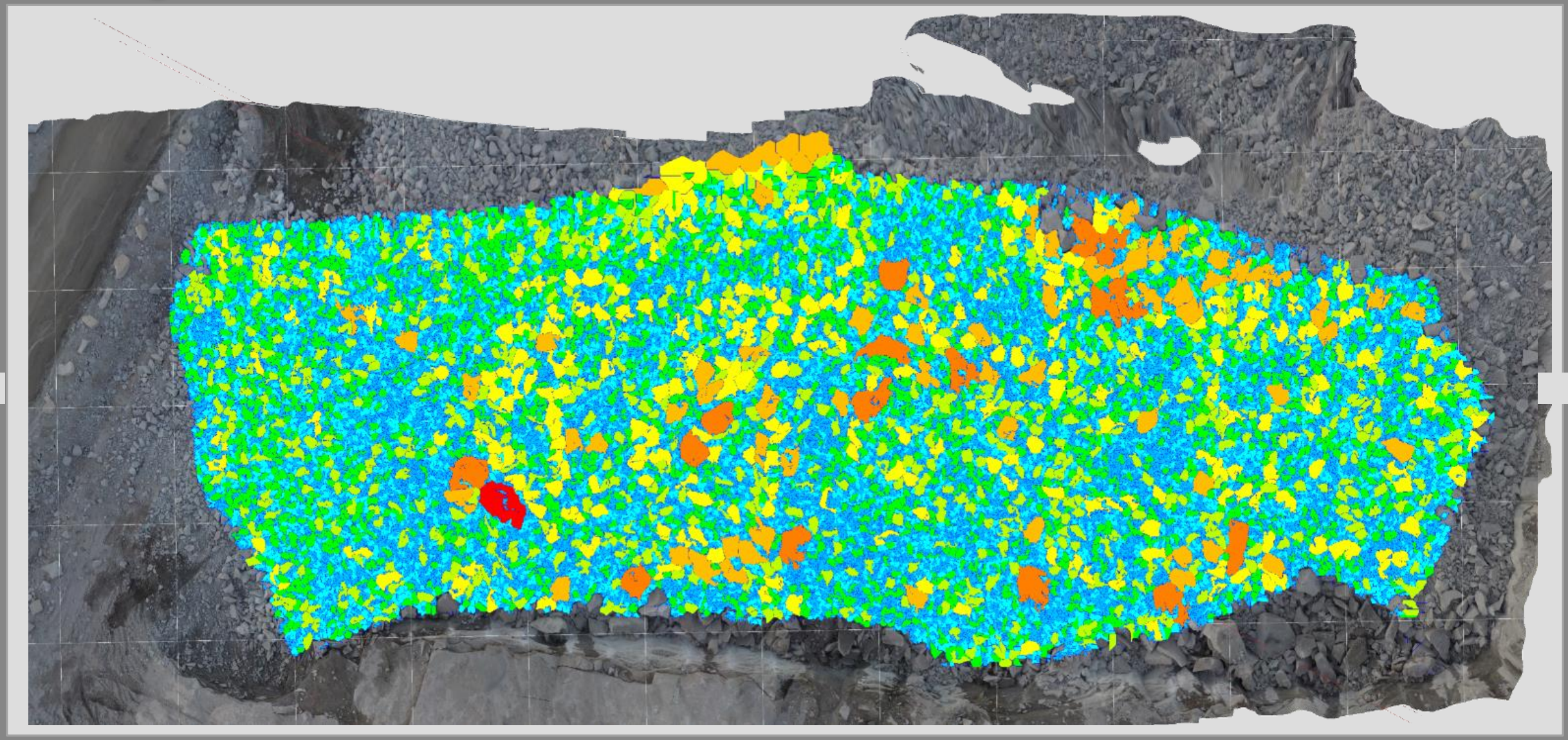
Agisoft

3D model



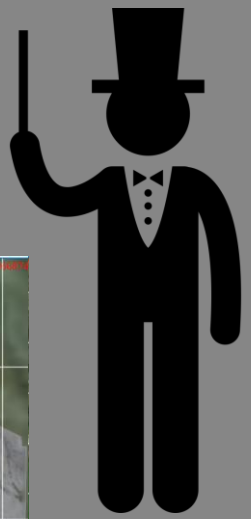
o-pitblast

Fragments Detection



Size Distribution

WipWare



o-pitblast

Fragmentation Report
UAV

WipWare

Site Name:	Explog	Date:	721/03/2018
Blast ID:	238	D&B Responsable:	Diego Ribas
		Frag. Analysis by:	Raquel Sobral

Fragmentation Curve

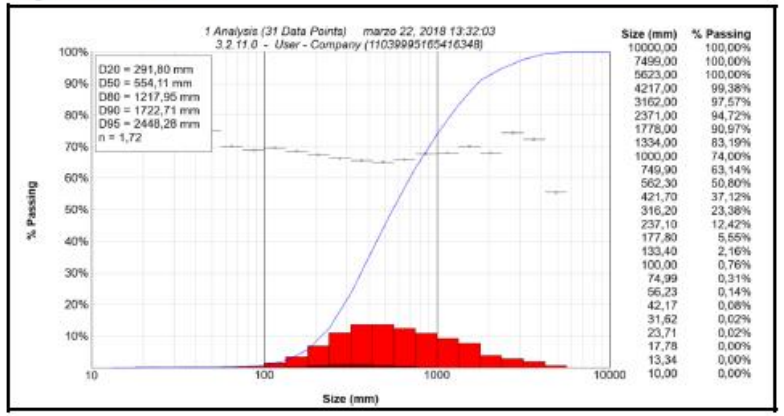
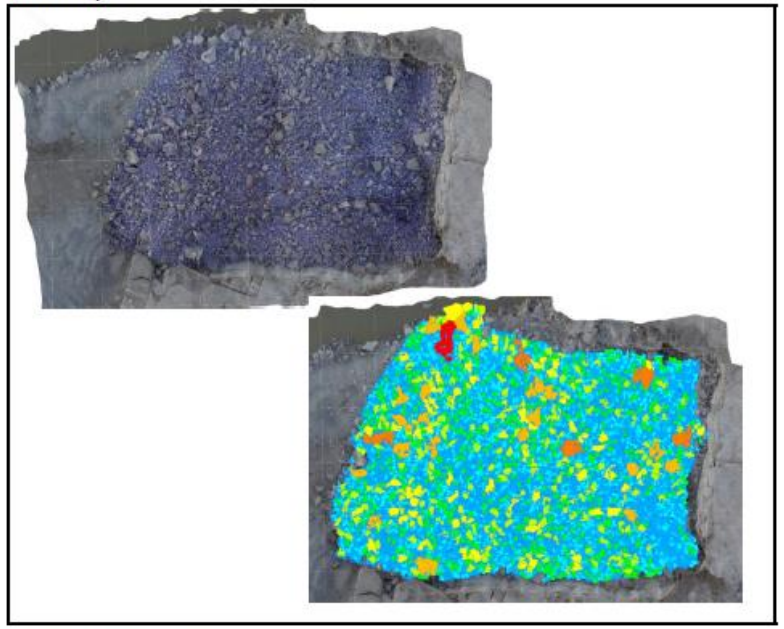


Photo Analysis



Rock Factor Calibration

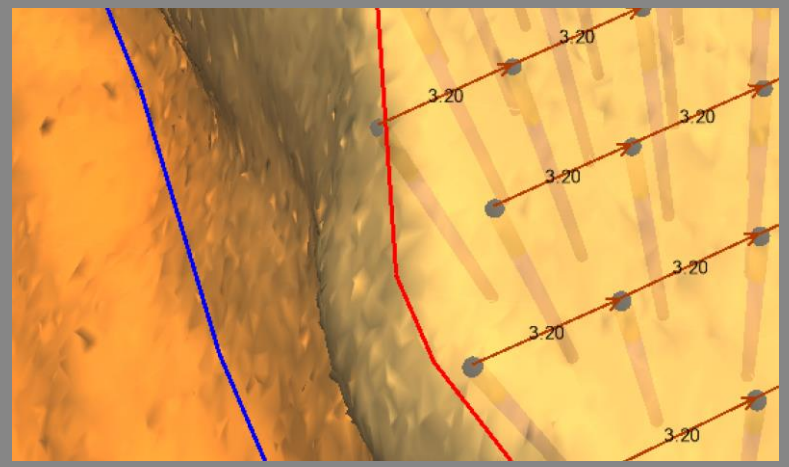
Optimization Accessment

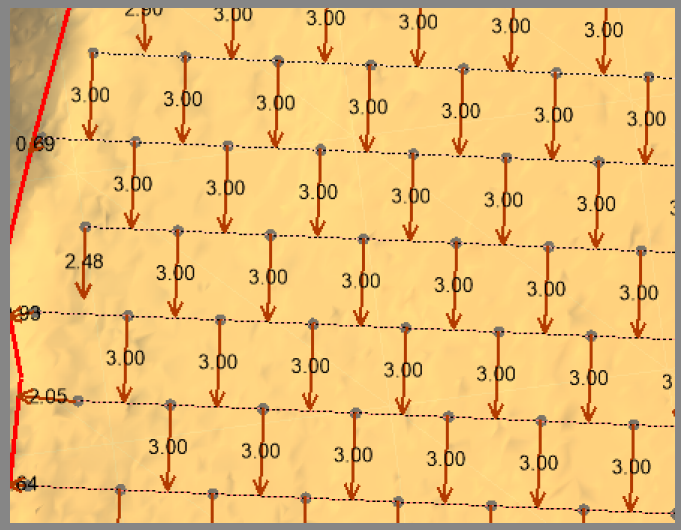
Pattern Expansion

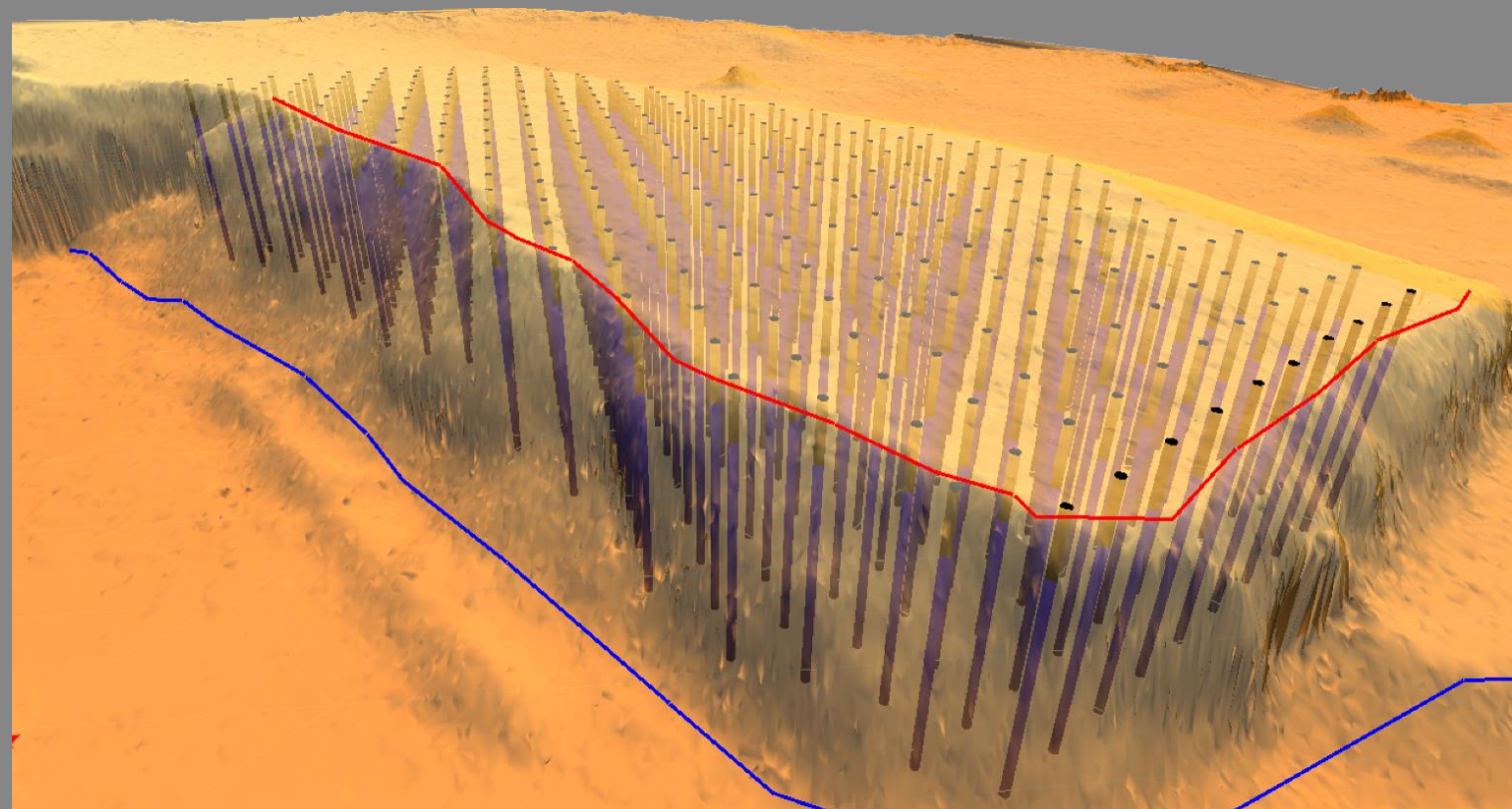
New Blast Design

Initial Blast Parameters

Parameter	Value
Burden	3,0 m
Spacing	3,5 m
Diameter	102,0 m
Stemming	2,8 mm
Subdrilling	1,2 m
Bench High	10 m
Powder Factor	0,77 kg/m3







Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion

Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion

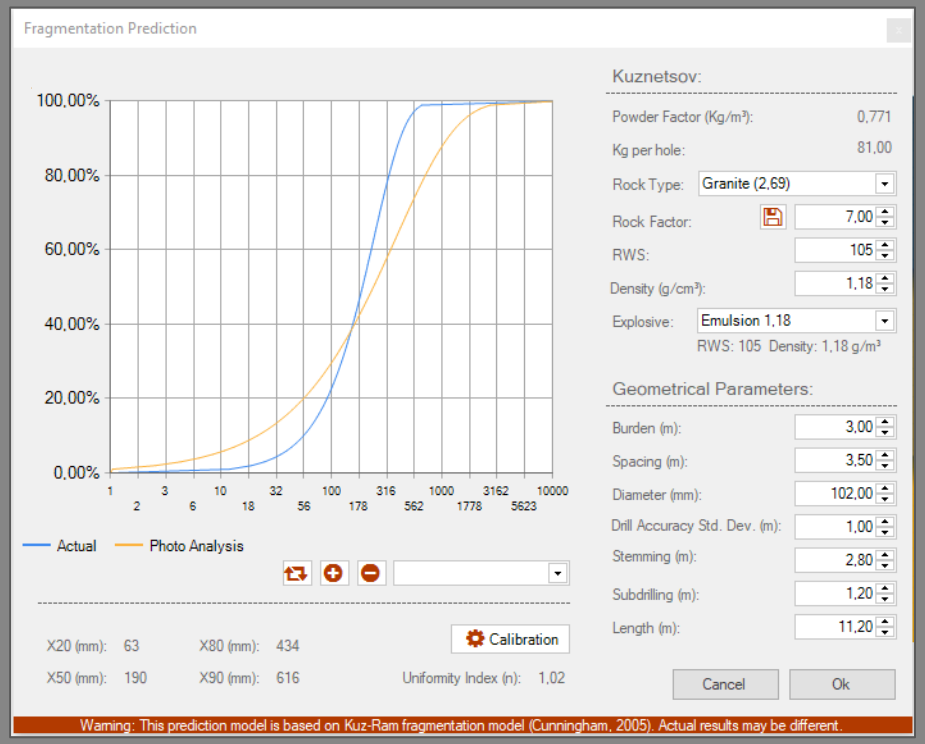
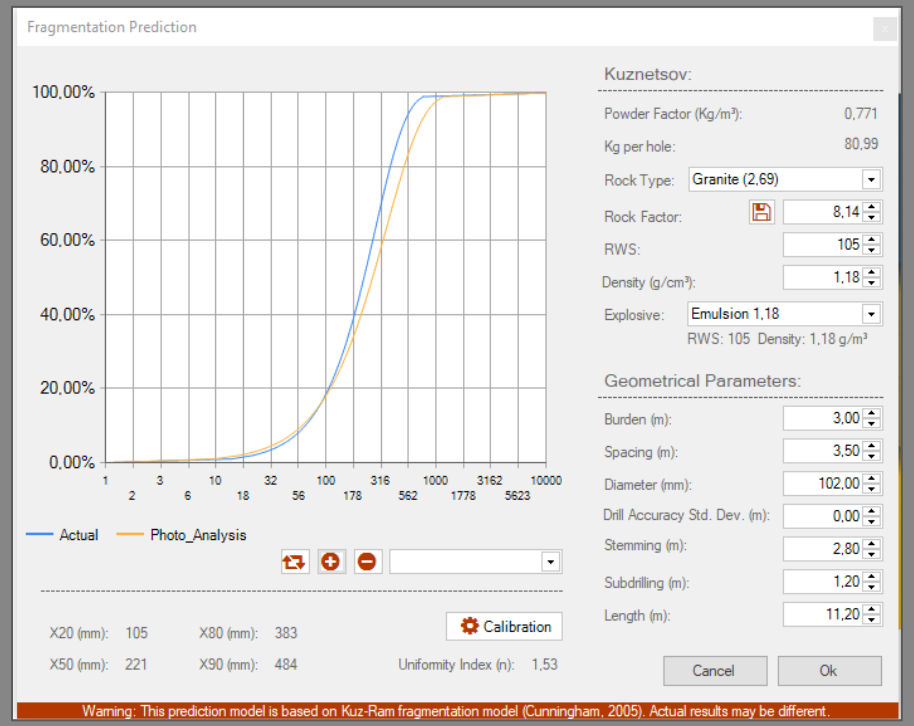


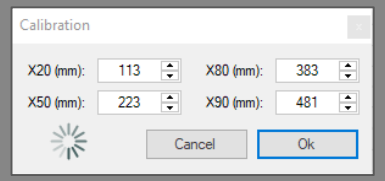
Photo analysis vs. Prediction

o-pitblast

Rock Factor adjustment – Prediction calibration



Fragmentation Calibration



WipWare

Rock Factor Calibration

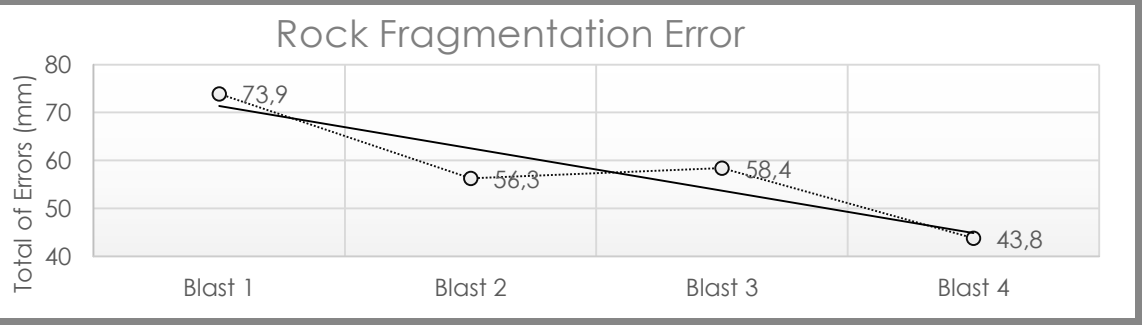
Optimization Accessment

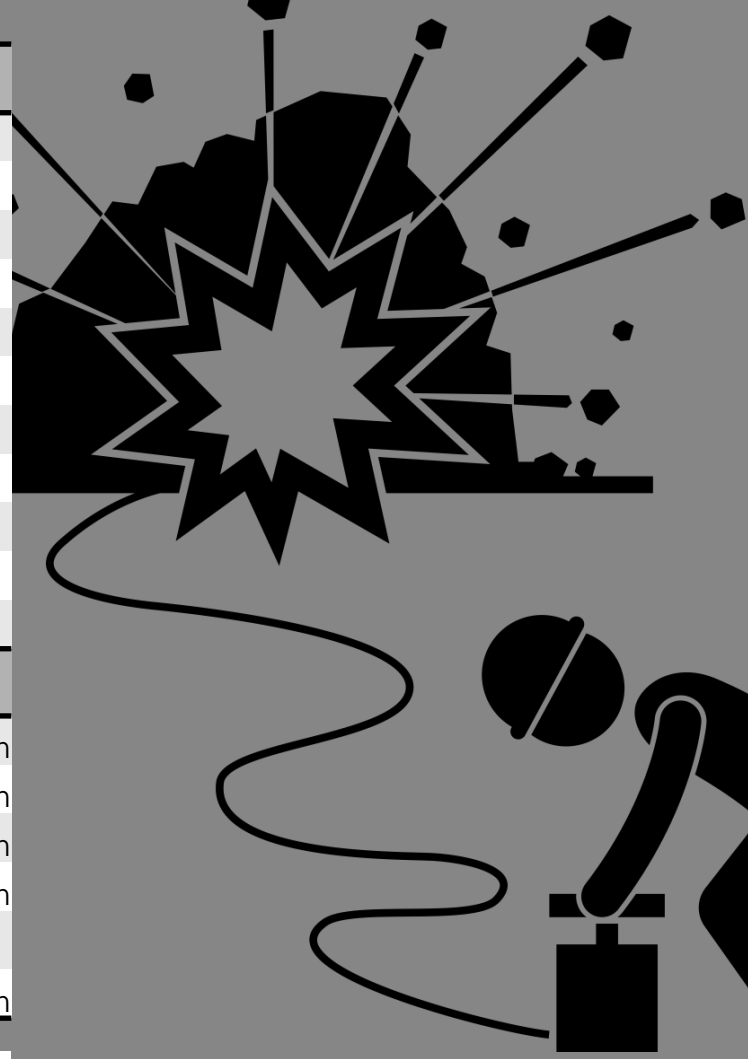
New Blast Design

Pattern Expansion

	Blast 1	Blast 2	Blast 3	Blast 4
(KR Adjusted) X20	91,0 m	97,0 m	102,0 m	106,0 m
(KR Adjusted) X50	190,0 m	204,0 m	213,0 m	224,0 m
(KR Adjusted) X80	330,0 m	353,0 m	369,0 m	390,0 m
(KR Adjusted) X90	416,0 m	446,0 m	466,0 m	493,0 m
(Photo-Analysis) X20	109,90 mm	114,00 mm	117,80 mm	115,30 mm
(Photo-Analysis) X50	209,60 mm	220,70 mm	225,80 mm	235,90 mm
(Photo-Analysis) X80	347,70 mm	364,50 mm	384,10 mm	399,50 mm
(Photo-Analysis) X90	433,70 mm	457,10 mm	480,70 mm	506,10 mm
Rock Factor Cal.	7	7,5	7,83	8,14

	Blast 1	Blast 2	Blast 3	Blast 4
Error X20	18,90 mm	17,00 mm	15,80 mm	9,30 mm
Error X50	19,60 mm	16,70 mm	12,80 mm	11,90 mm
Error X80	17,70 mm	11,50 mm	15,10 mm	9,50 mm
Error X90	17,70 mm	11,10 mm	14,70 mm	13,10 mm
Total Sum	73,90 mm	56,30 mm	58,40 mm	43,80 mm





Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion

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(KR Adjusted) X20	91,0 m	97,0 m	102,0 m	106,0 m
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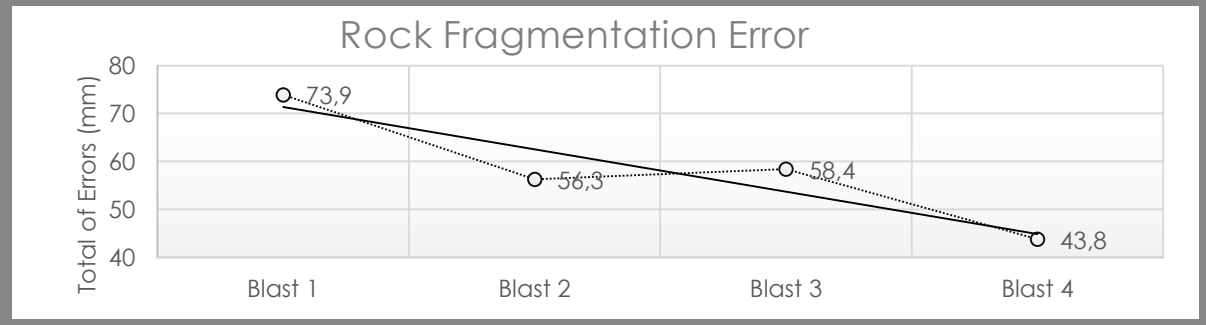

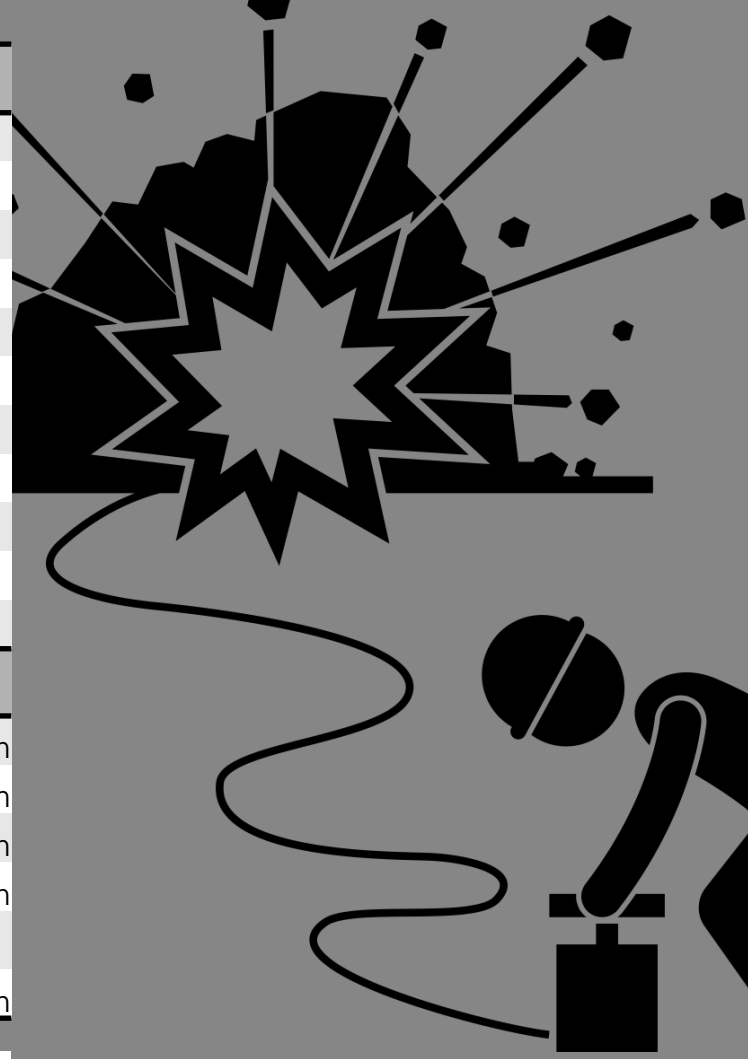

Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion

	Blast 1	Blast 2	Blast 3	Blast 4
(KR Adjusted) X20	91,0 m	97,0 m	102,0 m	106,0 m
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(KR Adjusted) X80	330,0 m	353,0 m	369,0 m	390,0 m
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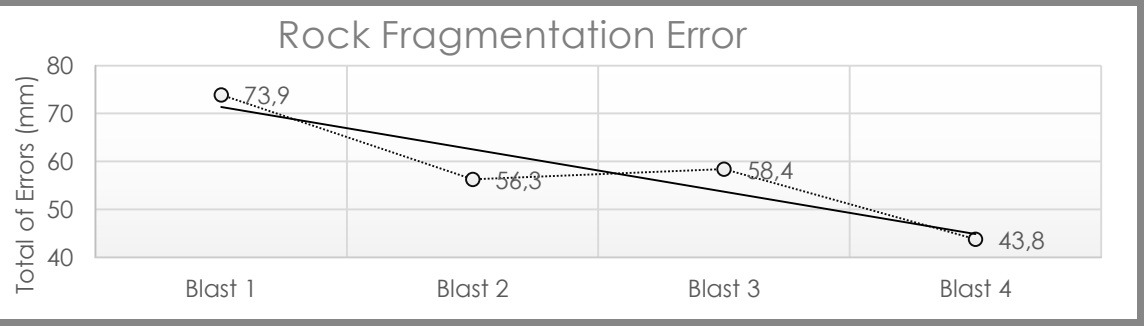

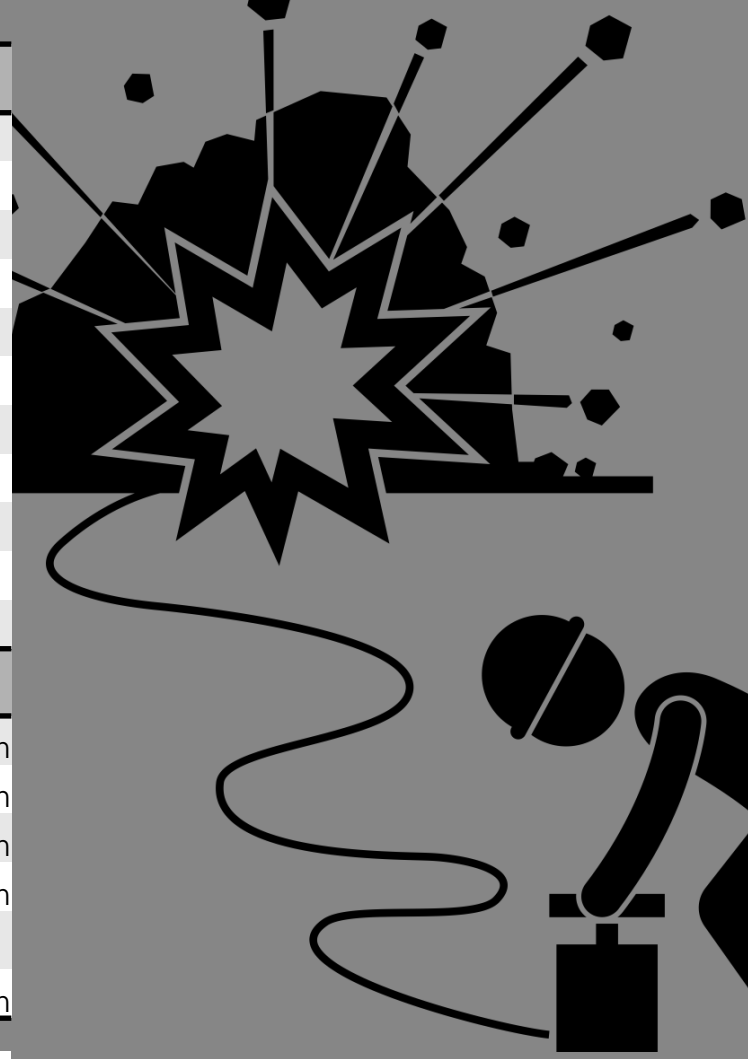

Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion

	Blast 1	Blast 2	Bla	Blast 4
(KR Adjusted) X20	91,0 m	97,0 m	102,0 m	106,0 m
(KR Adjusted) X50	190,0 m	204,0 m	213,0 m	224,0 m
(KR Adjusted) X80	330,0 m	353,0 m	369,0 m	390,0 m
(KR Adjusted) X90	416,0 m	446,0 m	466,0 m	493,0 m
(Photo-Analysis) X20	109,90 mm	114,00 mm	117,80 mm	115,30 mm
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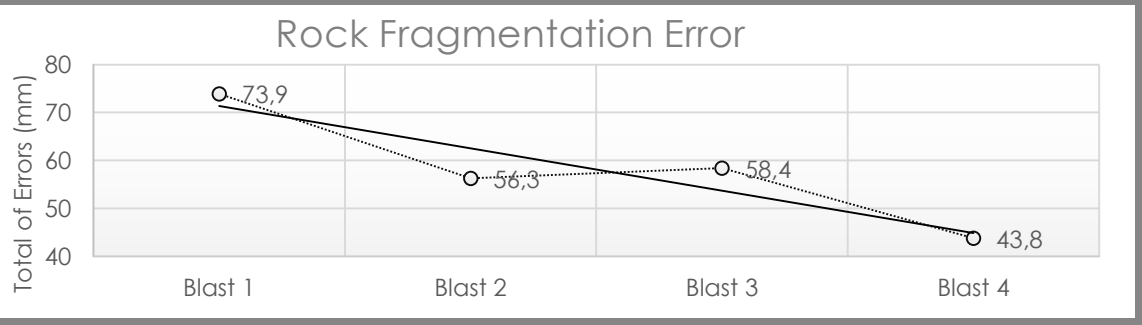
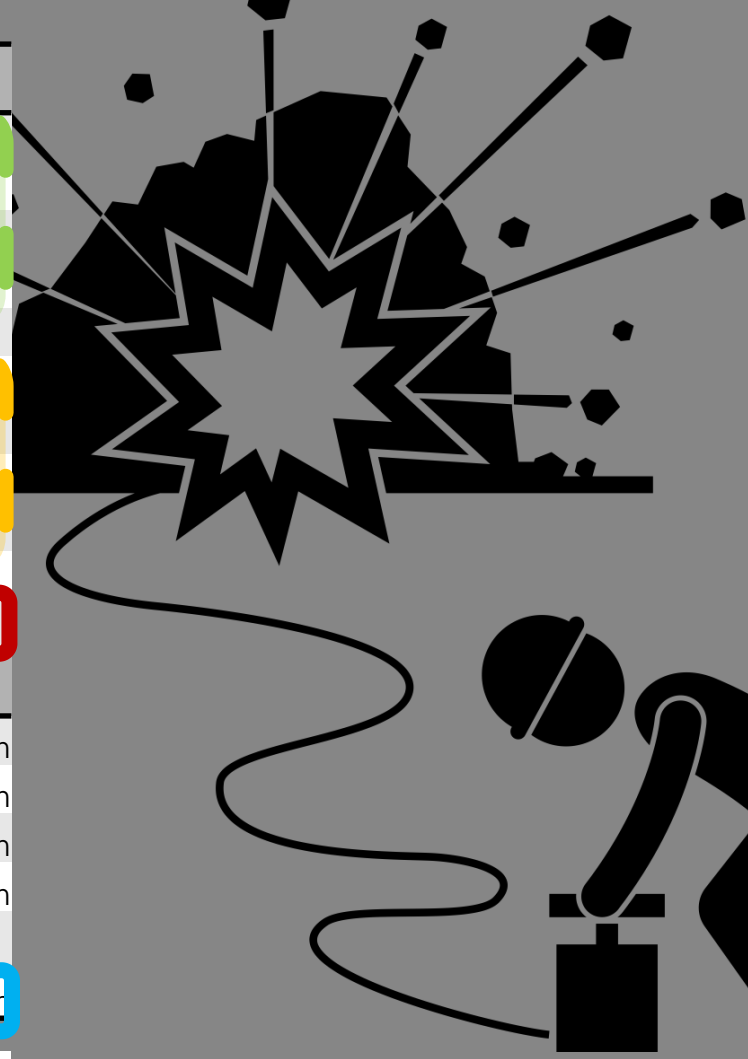
	Blast 1	Blast 2	Blast 3	Blast 4
Error X20	18,90 mm	17,00 mm	15,80 mm	9,30 mm
Error X50	19,60 mm	16,70 mm	12,80 mm	11,90 mm
Error X80	17,70 mm	11,50 mm	15,10 mm	9,50 mm
Error X90	17,70 mm	11,10 mm	1	13,10 mm
Total Sum	73,90 mm	56,30 mm	58,40 mm	43,80 mm



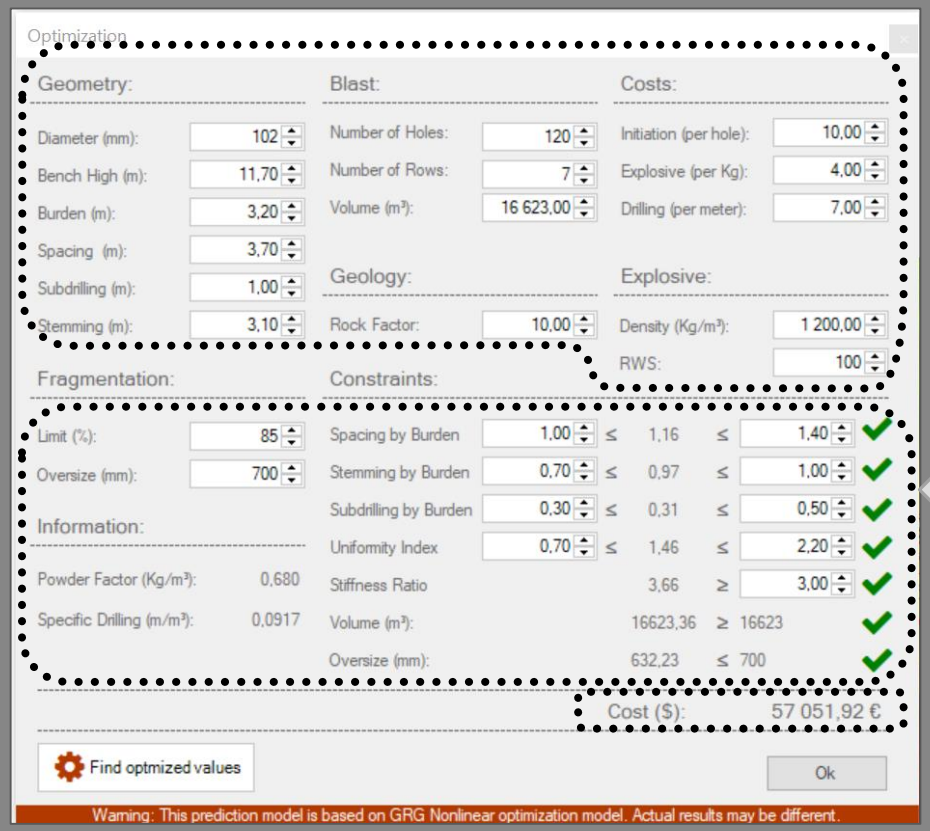


Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion



Decisions Variables

Restriction Variables

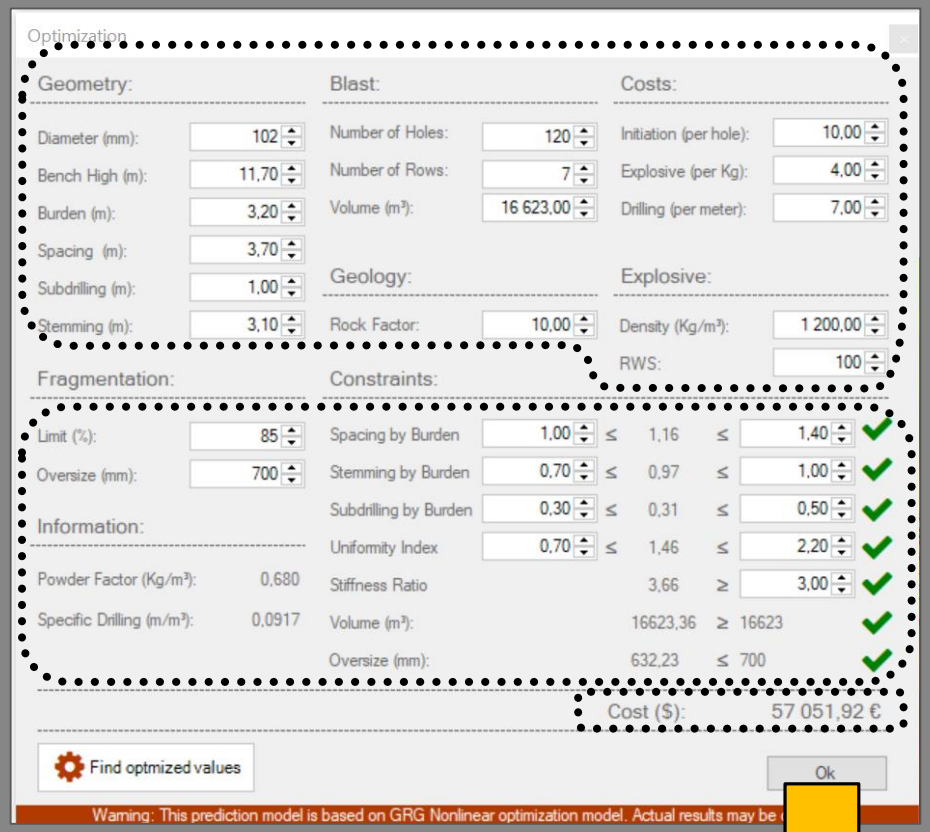
Objective Variable

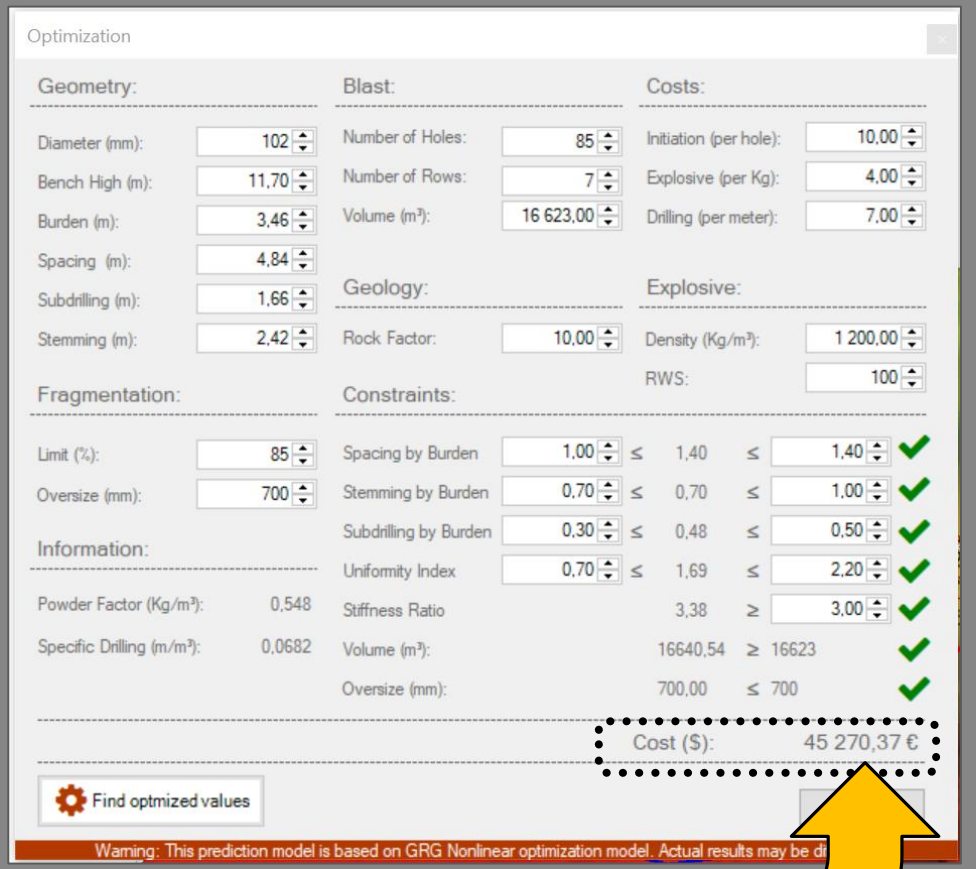
Rock Factor Calibration

Optimization Accessment

New Blast Design

Pattern Expansion





Rock Factor Calibration

Optimization Accessment

New Blast Design

o-pitblast

Pattern Expansion

WipWare

	Initial Parameters	Rock Factor Cal. STG 3
Diameter	102,0 mm	102,0 mm
Bench High	10,0 m	10,0 m
Burden	3,0 m	3,3 m
Spacing	3,5 m	4,0 m
Subdrilling	1,2 m	1,0 m
Stemming	2,8 m	3,3 m

	Initial Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Diameter	102,0 mm	102 mm	102 mm	102 mm	102 mm	102 mm
Bench High	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m
Burden	3,0 m	3,1 m	3,1 m	3,2 m	3,3 m	3,3 m
Spacing	3,5 m	3,6 m	3,7 m	3,8 m	3,9 m	4,0 m
Subdrilling	1,2 m	1,2 m	1,1 m	1,1 m	1,0 m	1,0 m
Stemming	2,8 m	2,9 m	3,0 m	3,1 m	3,2 m	3,3 m
(KR Adjusted) X20	105,0 mm	109,0 mm	113,0 mm	117,0 mm	121,0 mm	125,0 mm
(KR Adjusted) X50	221,0 mm	233,0 mm	245,0 mm	257,0 mm	270,0 mm	283,0 mm
(KR Adjusted) X80	383,0 mm	409,0 mm	433,0 mm	461,0 mm	488,0 mm	520,0 mm
(KR Adjusted) X90	484,0 mm	519,0 mm	552,0 mm	591,0 mm	629,0 mm	689,0 mm
(Photo-Analysis) X20	124,50 mm	134,70 m	151,80 mm	171,20 mm	223,90 mm	N/A
(Photo-Analysis) X50	240,10 mm	275,80 m	303,40 mm	327,10 mm	352,60 mm	N/A
(Photo-Analysis) X80	398,10 mm	449,90 m	480,30 mm	517,80 mm	543,10 mm	N/A
(Photo-Analysis) X90	501,50 mm	541,90 m	604,40 mm	653,80 mm	714,80 mm	N/A

Rock Factor Calibration

Optimization Accessment

New Blast Design

o-pitblast

Pattern Expansion

WipWare

	Initial Parameters	Rock Factor Cal. STG 3
Diameter	102,0 mm	102,0 mm
Bench High	10,0 m	10,0 m
Burden	3,0 m	3,3 m
Spacing	3,5 m	4,0 m
Subdrilling	1,2 m	1,0 m
Stemming	2,8 m	3,3 m

	Initial Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Diameter	102,0 mm	102 mm	102 mm	102 mm	102 mm	102 mm
Bench High	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m
Burden	3,0 m	3,1 m	3,1 m	3,2 m	3,3 m	3,3 m
Spacing	3,5 m	3,6 m	3,7 m	3,8 m	3,9 m	4,0 m
Subdrilling	1,2 m	1,2 m	1,1 m	1,1 m	1,0 m	1,0 m
Stemming	2,8 m	2,9 m	3,0 m	3,1 m	3,2 m	3,3 m
(KR Adjusted) X20	105,0 mm	109,0 mm	113,0 mm	117,0 mm	121,0 mm	125,0 mm
(KR Adjusted) X50	221,0 mm	233,0 mm	245,0 mm	257,0 mm	270,0 mm	283,0 mm
(KR Adjusted) X80	383,0 mm	409,0 mm	433,0 mm	461,0 mm	488,0 mm	520,0 mm
(KR Adjusted) X90	484,0 mm	519,0 mm	552,0 mm	591,0 mm	629,0 mm	689,0 mm
(Photo-Analysis) X20	124,50 mm	134,70 m	151,80 mm	171,20 mm	223,90 mm	N/A
(Photo-Analysis) X50	240,10 mm	275,80 m	303,40 mm	327,10 mm	352,60 mm	N/A
(Photo-Analysis) X80	398,10 mm	449,90 m	480,30 mm	517,80 mm	543,10 mm	N/A
(Photo-Analysis) X90	501,50 mm	541,90 m	604,40 mm	653,80 mm	714,80 mm	N/A

Rock Factor Calibration

Optimization Accessment

New Blast Design

o-pitblast

Pattern Expansion

WipWare

	Initial Parameters	Rock Factor Cal. STG 3
Diameter	102,0 mm	102,0 mm
Bench High	10,0 m	10,0 m
Burden	3,0 m	3,3 m
Spacing	3,5 m	4,0 m
Subdrilling	1,2 m	1,0 m
Stemming	2,8 m	3,3 m

	Initial Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Diameter	102,0 mm	102 mm	102 mm	102 mm	102 mm	102 mm
Bench High	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m
Burden	3,0 m	3,1 m	3,1 m	3,2 m	3,3 m	3,3 m
Spacing	3,5 m	3,6 m	3,7 m	3,8 m	3,9 m	4,0 m
Subdrilling	1,2 m	1,2 m	1,1 m	1,1 m	1,0 m	1,0 m
Stemming	2,8 m	2,9 m	3,0 m	3,1 m	3,2 m	3,3 m
(KR Adjusted) X20	105,0 mm	109,0 mm	113,0 mm	117,0 mm	121,0 mm	125,0 mm
(KR Adjusted) X50	221,0 mm	233,0 mm	245,0 mm	257,0 mm	270,0 mm	283,0 mm
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Diameter	102,0 mm	102 mm	102 mm	102 mm	102 mm	102 mm
Bench High	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m
Burden	3,0 m	3,1 m	3,1 m	3,2 m	3,3 m	3,3 m
Spacing	3,5 m	3,6 m	3,7 m	3,8 m	3,9 m	4,0 m
Subdrilling	1,2 m	1,2 m	1,1 m	1,1 m	1,0 m	1,0 m
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o-pitblast

Pattern Expansion

WipWare

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Bench High	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m
Burden	3,0 m	3,1 m	3,1 m	3,2 m	[illegible]	3,3 m
Spacing	3,5 m	3,6 m	3,7 m	3,8 m	3,9 m	4,0 m
Subdrilling	1,2 m	1,2 m	1,1 m	1,1 m	1,0 m	1,0 m
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Bench High	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m	10,0 m
Burden	3,0 m	3,1 m	3,1 m	3,2 m	3,3 m	3,3 m
Spacing	3,5 m	3,6 m	3,7 m	3,8 m	3,9 m	4,0 m
Subdrilling	1,2 m	1,2 m	1,1 m	1,1 m	1,0 m	1,0 m
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Some discussions

The use of technology

Safety and production

Samples gathering with drones

Opened a new horizon on the fragmentation analysis

Muckpile inspection

Reduce risks

Gas presence, twisted ankles and hand injuries.

Analysis Method Selection Matrix	Time *How much time does it take per study?*	Cost *How much does this analysis solution cost?*	Resources *How many people does it typically take?*	Data Quality *How representative is this analysis method?*	Blast Type
Image Analysis Service *You take the image samples using a digital camera then upload them to a web service for analysis*	**High** *1-3 Hrs/Images* *24-48 Hrs/Analysis*	**Very Low** *< $1k*	**Low** *1-2 Personnel*	**Good** *+60%*	**Surface & Underground**
In-House Image Analysis *You take the image samples using a digital camera or iPad/iPhone then analyze them using a specialized iOS app or Windows software*	**Medium** *1-3 Hrs/Images* *1-3 Hrs/Analysis*	**Low** *$1k - $6k*	**Medium** *2-3 Personnel*	**Good** *+60%*	**Surface & Underground**
In-House UAV Image Analysis *You take image samples using a UAV then analyze them with specialized iOS app or Windows software*	**Low** *1-2 Hrs/Images* *1 Hr/Analysis*	**Medium** *$2k - $10k*	**Low** *1-2 Personnel*	**Better** *+80%*	**Surface Only**
Automatic Analysis System *System automatically collects image samples in LHD or HD vehicles at the primary crusher, ore pass or draw point and analyzes them in realtime*	**Very Low** *0 Hrs/Study*	**High** *$45k - $90k*	**Very Low** *0 Personnel*	**Best** *+90%*	**Surface & Underground**

Fragmentation Primordial blast quality feedbacks.

Measurement needs to be

Fast, accurate, and constant

→ WipFrag software proved to be a very useful tool to calculate fragmentation

Mining cost optimization

Blast Continuous Improvement

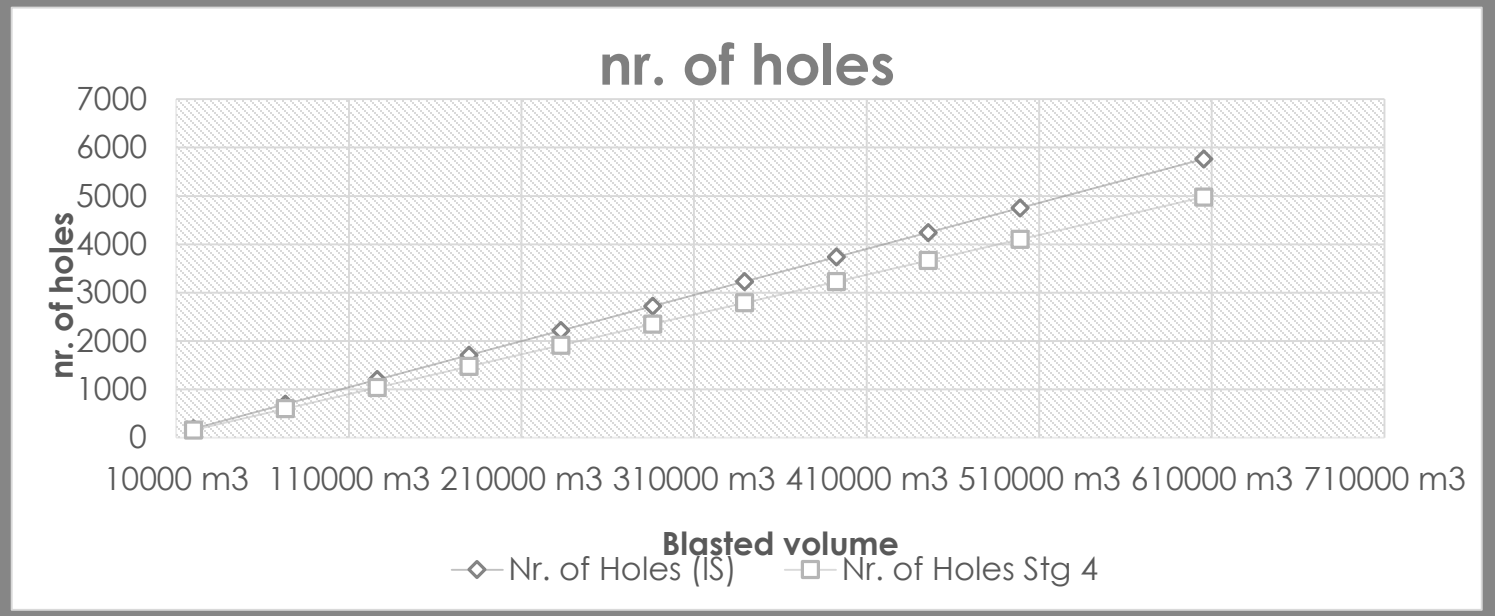
All the consequent stage of mineral processing

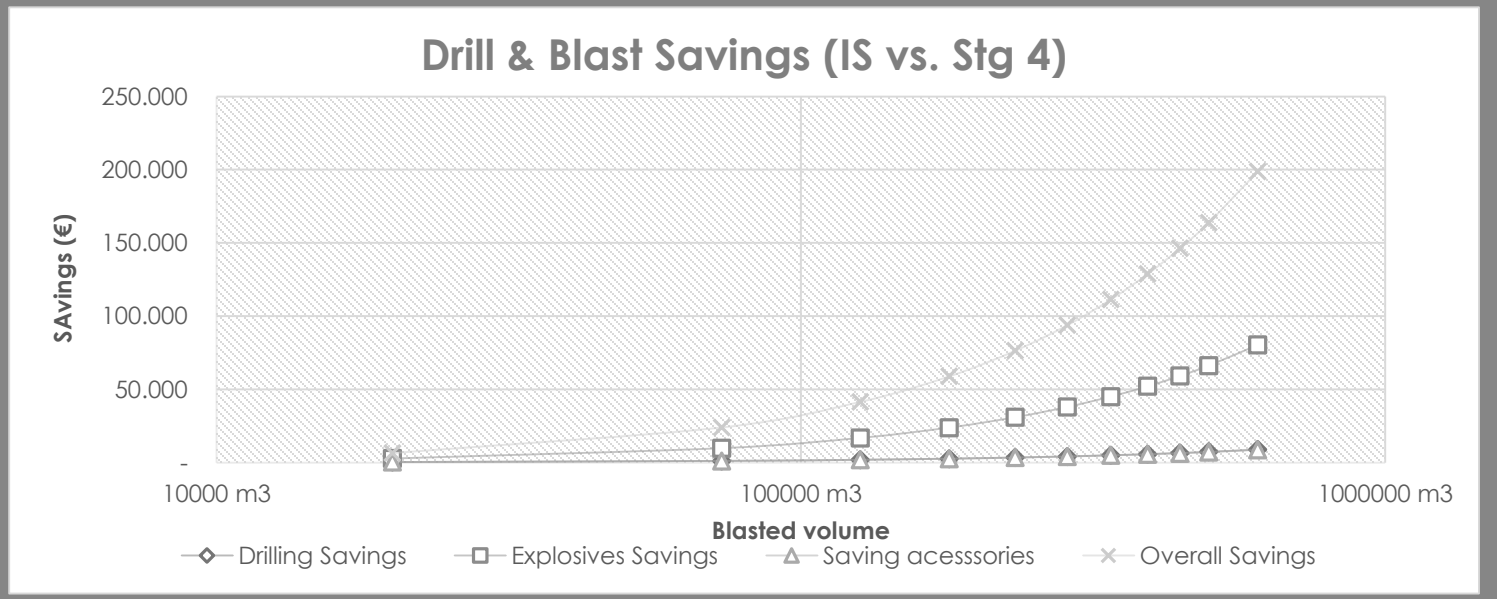
O-Pitblast's blast optimization algorithm

reduce 229.361,00 $ in 605.307,7 m^3/791712.58 yd^3 of rock

The optimization process, operation and field practices

Mathematical optimization





Control

Time

Precision

Versitile

Easy

Low Cost

Technology

Safe

Profit

Better use of Natural Resources

Vinicius Miranda – O-Pitblast
Francisco Leite – O-Pitblast
Thomas Palangio – Wipware
Raquel Sobral – O-Pitblast
Pedro Brito – O-Pitblast

Pattern Expansion – Fragmentation with Drones