Dimensions+

Session C-1426

Utilizing Production Measurement Systems For Large Scale Earthmoving Operations

Alan Sharp

Trimble

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Session Abstract

In the process of coordinating large earthwork operations information is invaluable to ensure projects are completed on time and on budget. This SlideShare covers how a system was implemented on a large coal mining operation in South Africa.

Using a browser-based platform, the mining operation was able to leverage Trimble technology for the tracking of cut/fill operations, haul road construction, and earthwork transportation operations. Given that this information is communicated in real time, managers can generate reports for any given operation.

It covers the challenges presented throughout the implementation and lessons learned. Additionally how this technology is currently being utilised and some potential use-cases for the industry at large.

Overview

Primary Earthworks Operations

- Mineral excavation operations

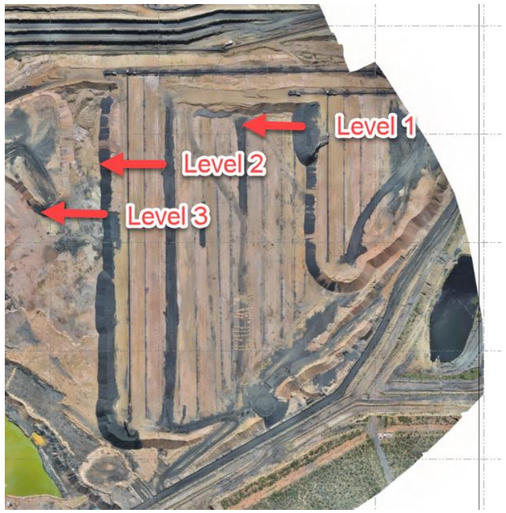
Secondary Earthworks Operations

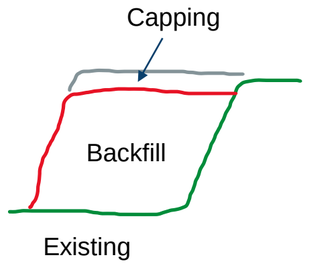
- Backfill
  - Backfill
  - Capping
- Haul road construction and maintenance
- General earthworks operations

Focus of this project

Secondary Earthworks Operations Example

- Mine waste generated from Coal cleaning process
- One strip ~2.5m m3 of backfill
- One strip takes ~3 months to complete
- Three backfill zones operational at 3 levels concurrently
- Backfill progresses to West





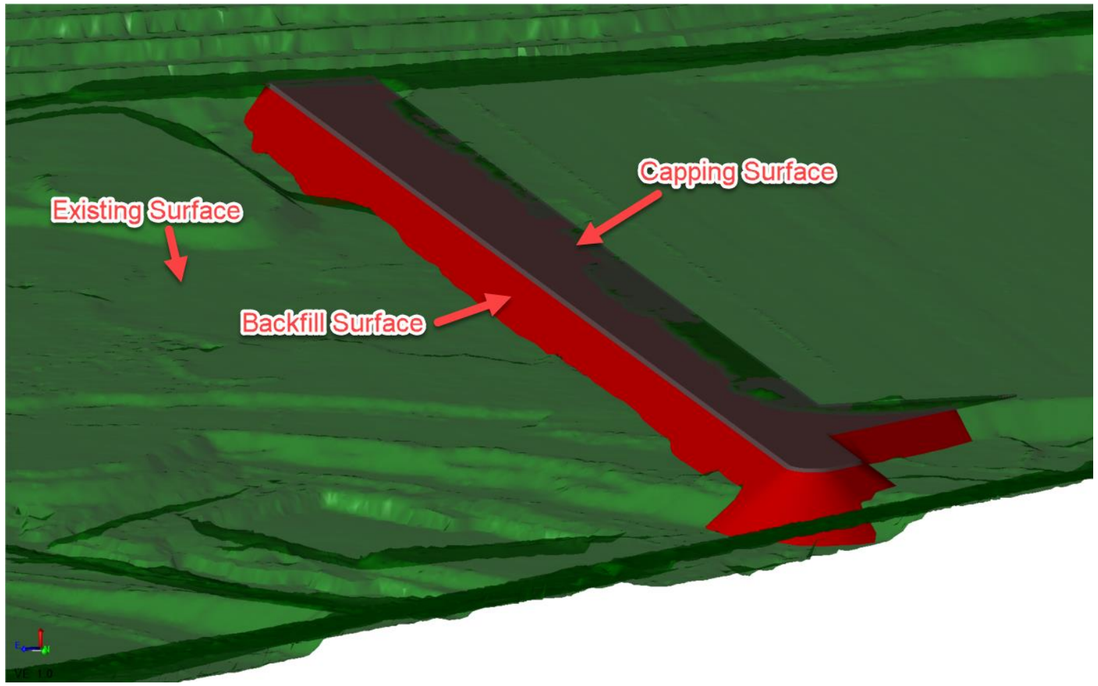
Backfill & Capping Example Overview

Secondary Earthworks Operations

- Earthmoving fleet of dozers and graders
- Equipped with Trimble GCS900 systems

- Survey department uses Trimble Business Center alongside Vulcan and other software

- Survey department flies the site weekly with drones to map current state / work in progress updates

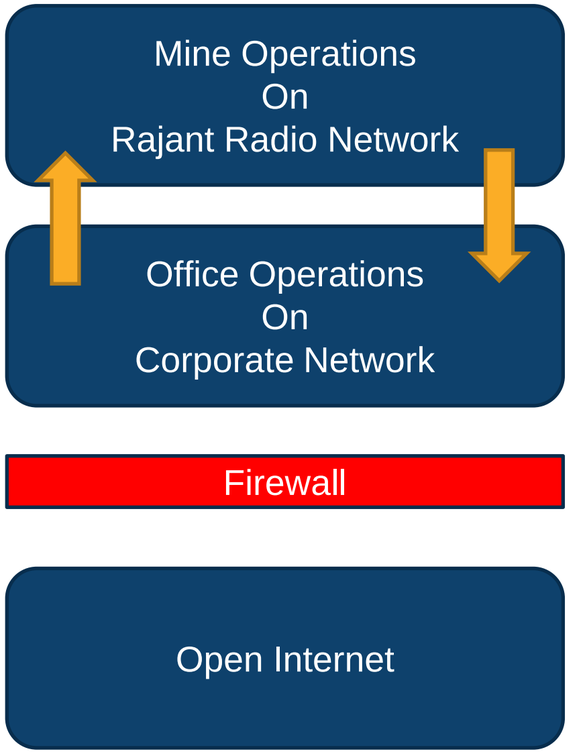


Mine Project Requirements

The mine wanted a system to monitor their secondary earthmoving fleet operations that could

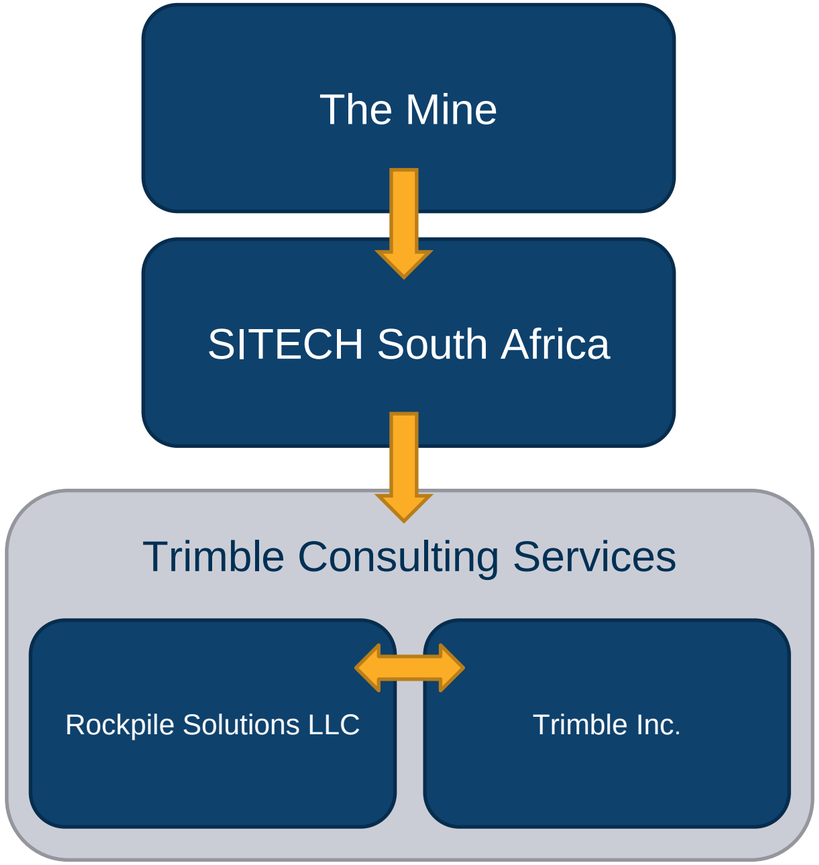
- Show the position / working state of their secondary equipment fleet
- Use GCS900 machine productivity data to supplement their weekly surveys to provide daily shift volumes and progress analysis
- Provide Production, Productivity and Quality metrics

The mine does not allow any production data on the open internet. The solution had to provide a closed network operation using their Mesh Radio network on site and corporate network at the mine only



Development / Project Process

- The Mine worked with SITECH South Africa initially on the request
- SITECH South Africa came to Rockpile Solutions with the initial request
- Rockpile Solutions worked with the Mine to scope the requirement details
- Because the requirements needed Trimble approval / involvement
  - Rockpile Solutions worked with Trimble Consulting Services
  - Gained approval to utilise / access Trimble Technologies to provide solution
- Project was quoted / estimated based on statement / scope of work
- Project was approved – work commenced in Q4 2021 / delivered and commissioned in Q3 2022



Project Components / Functions

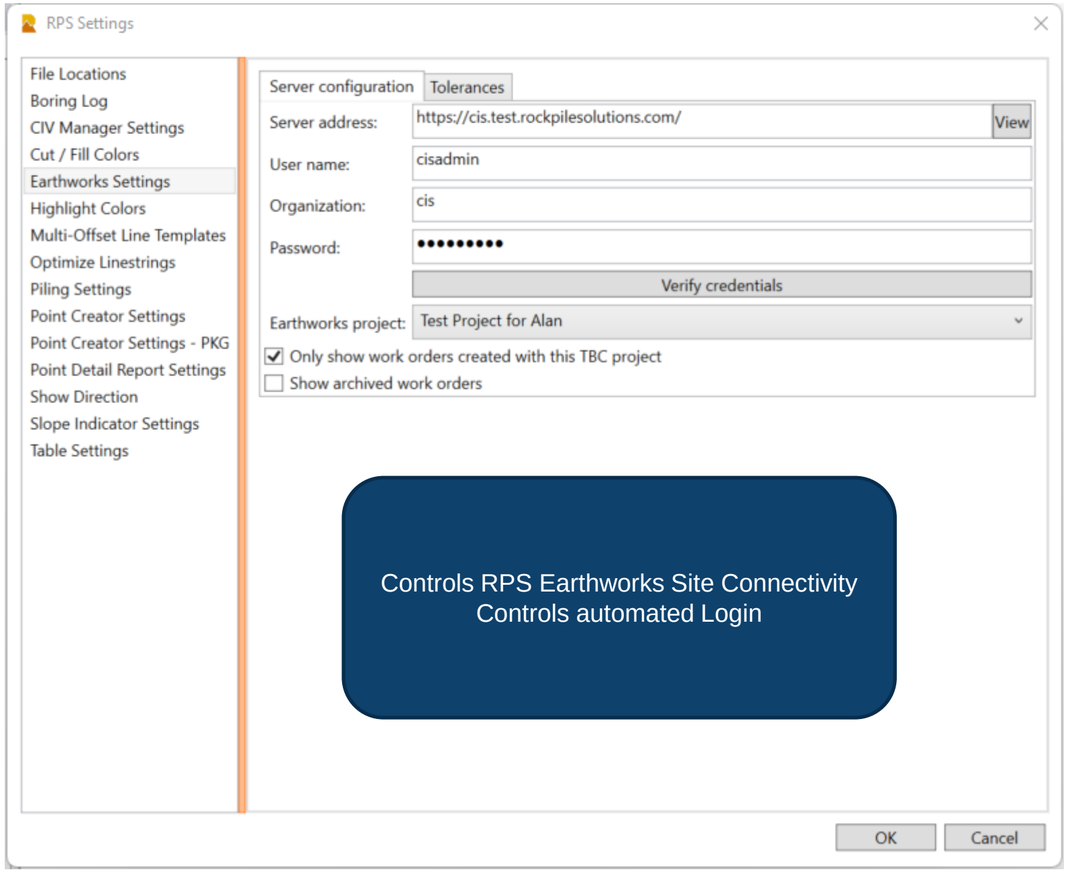
Trimble Business Center

- Provide a direct link to RPS Earthworks
- Create a settings file to control
- Create a “Work Order” and “Data Manager” for RPS Earthworks
- Provide a bi-directional data link to RPS Earthworks using APIs from Earthworks

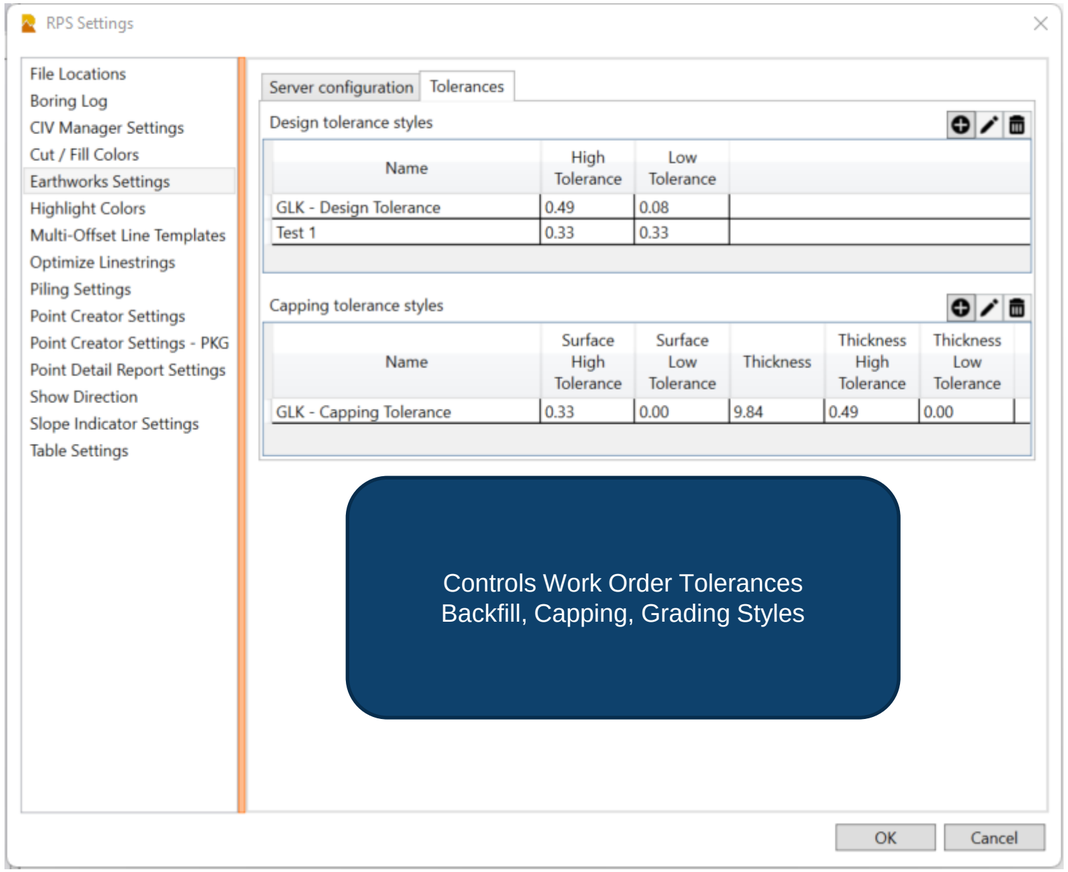
RPS Earthworks

- Create the RPS Earthworks System
  - Map layers
    - Image tiles
    - Linework overlays
    - Work Order overlays
    - Survey surface overlays
- Incorporate Trimble “Raptor” Production Server and other Trimble Web Services
- Create Work Order Manager
- Create Work Order Results Analysis

TBC - RPS Earthworks Settings

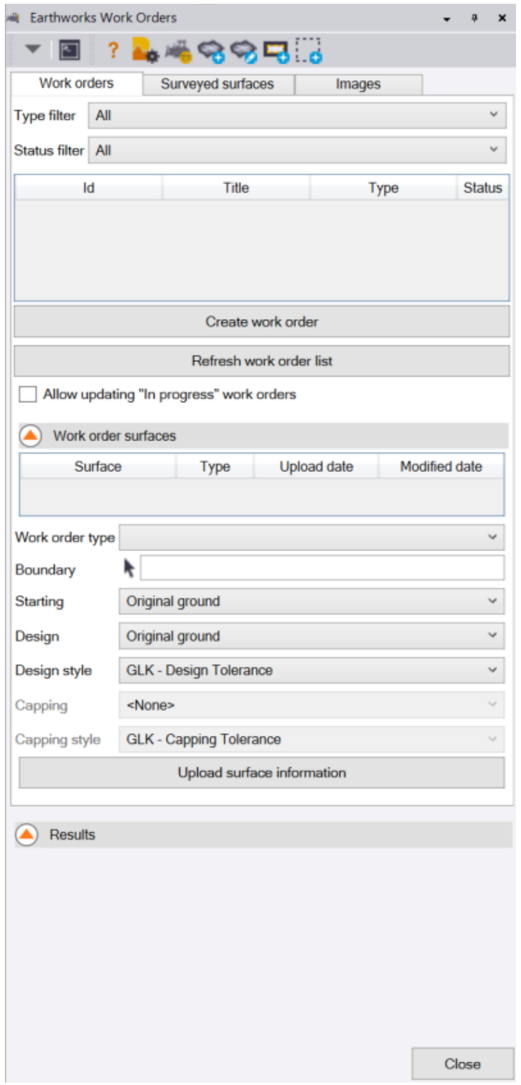


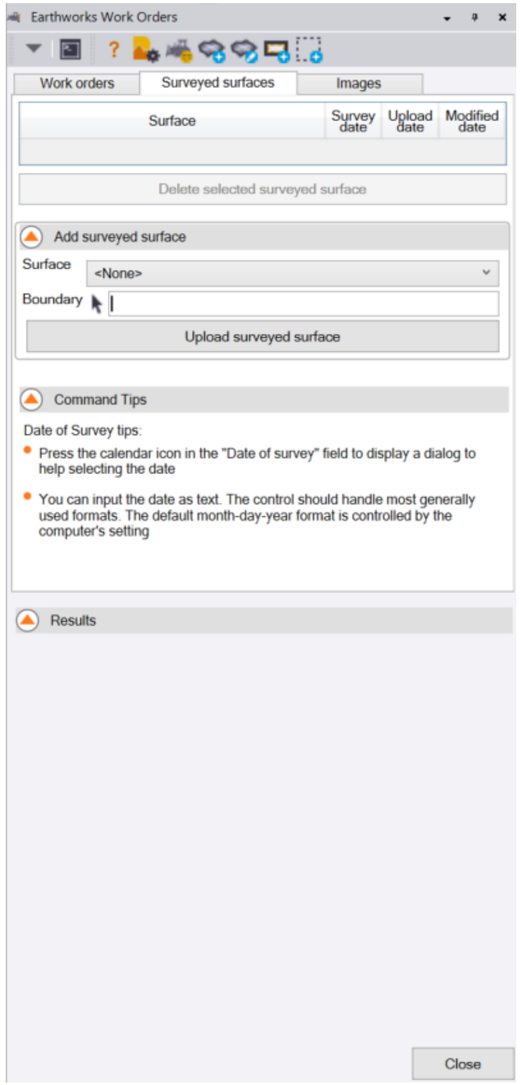
Controls RPS Earthworks Site Connectivity
Controls automated Login

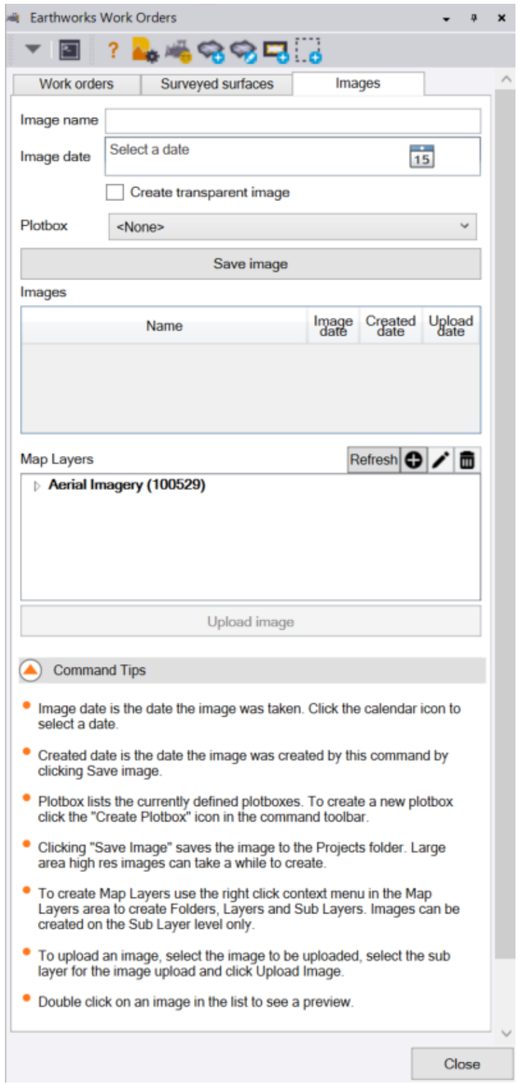


Controls Work Order Tolerances
Backfill, Capping, Grading Styles

TBC - Earthworks Work Orders







Work Orders Creation

Creates WO
Loads Surfaces and Boundaries
Sets Tolerances

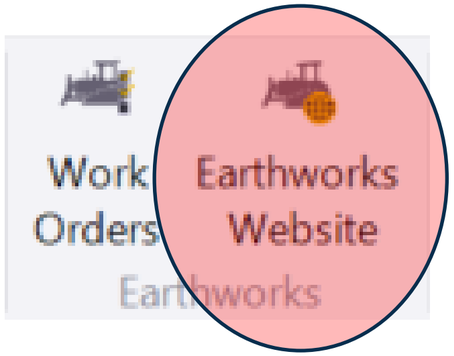
Surveyed Surfaces

Loads Survey Surfaces with Date / Time
Assigns surface boundary to limit

Images

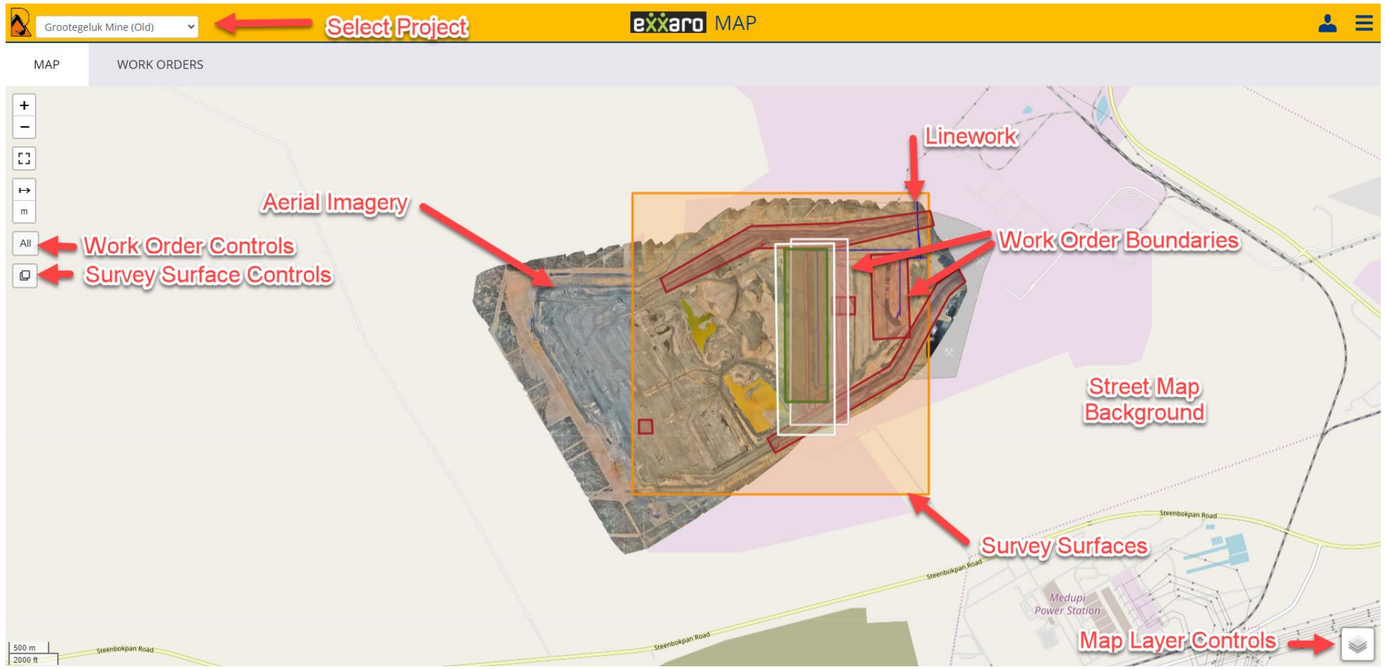
Creates high resolution images
Uploads images to map layers

TBC – Earthworks Website



RPS Earthworks - Map Layers

- **Aerial Imagery – updated weekly**
  - Source Data - High Resolution ECW
- **Linework – key mine features**
  - Source Data – CAD Linework / GIS Lines
- **Work Order Boundary Lines**
  - Source Data – TBC Boundary Lines
- **Survey Surface limits**
  - Source Data – TBC Survey Surfaces



Production / Productivity

- **Production**
  - Defined as work completed
  - In this case unit of production = earthworks volume m^3

- **Productivity / Production Rate**
  - Defined as the rate of production output i.e. equals production completed / time elapsed
  - In this case unit of productivity is m^3/hour or m^3/shift

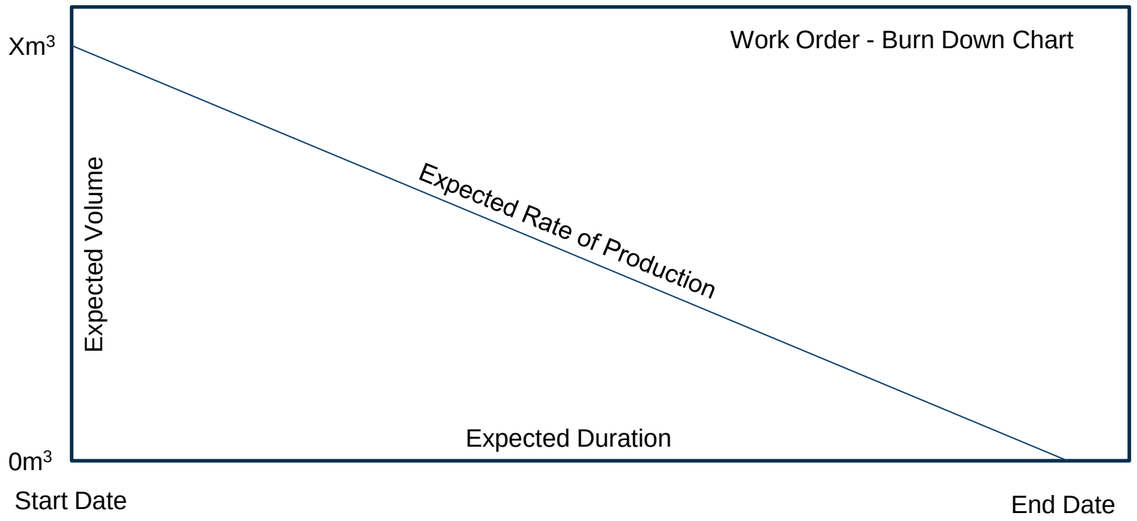
Note Production and Productivity will vary by task

A task and task type are needed (Work Order and Work Order Type)

Work Orders

- **Work Orders define**
  - The type of task / work order (Backfill, Cut/Fill, Grading)
  - The starting point surface, design surface and in backfill operations the capping surface
  - The quantity of work (volume between starting surface and target surface in Cut/Fill)
  - The planned and actual start date
  - The planned days to work (i.e. 5 days or 7 days)
  - The planned shift pattern (i.e. 2x 12 hour shifts)
  - The planned production rate per shift per crew
  - The number of crews assigned per shift to the task
  - Days expected to be lost due to holidays, operational breaks, bad weather
  - Days required for completion and approvals process

- **Work Orders**
  - Compute the expected duration of the task and an expected end date for the task
  - This becomes the basis for production and productivity monitoring

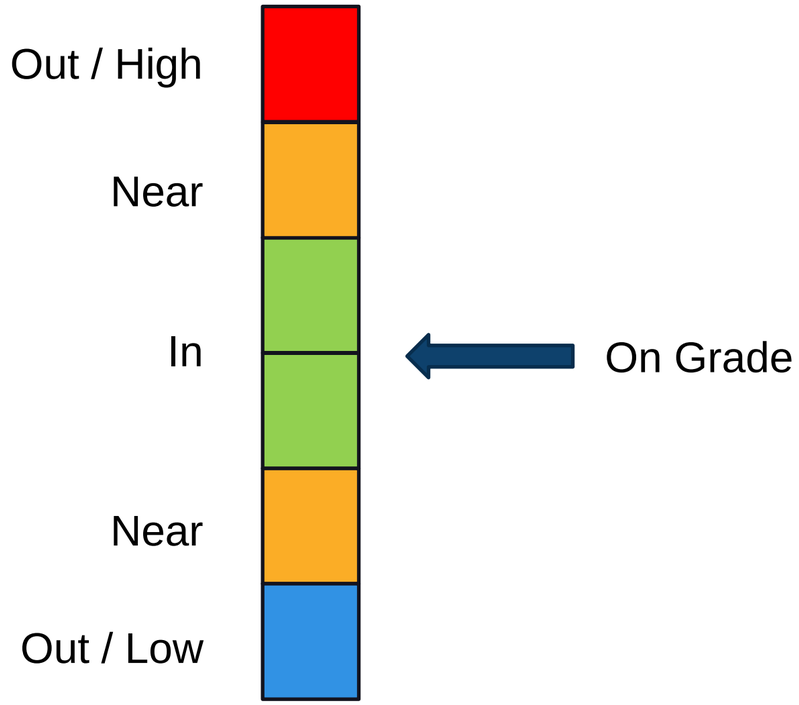


Quality / Work Order Completion

- **When is a Work Order completed?**
  - Work orders have a target surface that when created, the work order is completed (from a production standpoint)
- **How do we know when the target surface has been created?**
  - A target surface has been created when 100% of the target surface is at the desired elevation and there is no remaining cut or fill to be carried out
- **Does the target surface have to be accurate to 1mm to pass this test?**
  - No – there is a tolerance that we work to - a +/- value above and below the design that is acceptable
  - For backfill capping surfaces they also have to meet a minimum thickness of capping material

In / Near and Out of Tolerance (High / Low)

- **Earthworks Surface Tolerances**
  - Define what is “In Tolerance”
    - In tolerance can be High or Low
  - Define what is “Near to Tolerance”
    - Near to tolerance can be High or Low
  - Define what is “Out of Tolerance”
    - Out of tolerance can be High or Low



Target Volume

Placed Fill: 4,538,863.5 m³ Cut: 219,492.6 m³ Import: 4,319,370.9 m³ Export: 0 m³

High Tolerance: 0.1 m Low Tolerance: 0.1 m

Capping Surface

Capping Thickness: 0 m

High Tolerance (Capping Surface): 0 m

Low Tolerance (Capping Surface): 0 m

Thickness High Tolerance (Capping Surface):

Thickness Low Tolerance (Capping Surface):

Fill volume: 0 m³

Inspection & Approval Time Required

Please enter the number of anticipated days/hours required to complete inspections and approvals: 3 days

Extend Scheduled Workdays

Number of workdays unable to work (holidays, weather, etc.): 0 days

Approval

Approve/Accept Pending Approval

Cancel/Suspend Active

Additional Infromation

Notes | Work Order History

Add Note

Alan Sharp - 2022-03-19 07:26

Work Order hit delays because of bad weather today - bad weather expected to last 2-3 days - schedule will be imp[acted by 3 days as a result

List View

Scheduled Start: 2021-10-01 21:21

Actual Start: 2021-10-08 06:00

Scheduled End: 2022-04-13 21:21

Actual End:

Schedule Working Days vs Calendar Days

Working Days

Cut + Fill working days	12
Days to complete inspection	3
Work days per week	7

Calendar Days

Cut + Fill days	348.7
Cut + Fill + Inspection days	351.7

Quality

Surface 85.6%

Cut out of tolerance	0%
Fill out of tolerance	14.4%

Work Schedule

Scheduled Work Order Duration:

Estimated Work Days to Complete Work Order: 12 days*

* Estimated days to complete work order is not based on calendar days, but days of actual work.

Projected Work Days: 7 days/week

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
☑	☑	☑	☑	☑	☑	☑

Production Rate Estimate

	Cut Production Rate Volume moved per hour		Fill Production Rate Volume moved per hour		
☑ First shift crew	800	m³	800	m³	Crew starts at 18:00
☑ Second shift crew	800	m³	800	m³	Crew starts at 06:00
Total volume moved per hour:	800	m³	800	m³	

Dashboard View

Grootegeluk Mine (Old)

exxaro WORK ORDERS

MAP | WORK ORDERS

EW-0000084 BF - 860 - 16 - I | Charts and Reports

Work Order: EW-0000084

Reference ID: BF - 860 - 16 - I

Title: Backfill - 860 - Move 16 - I

Description: Backfill - 860 - Move 16 - I

Type: Backfill with Capping

Note: Only Fill will be reported.
Any Cut will be reported in capping work order.

☐ Suspend, archive and hide?

Created By: CIS Admin
Date Created: 2022-03-13 21:19
Last Modified: 2022-09-06 14:01

Starting Surface: WIP Surface - Nov 3rd 2021
Target Surface: 860 - Move16 - DS

Estimated End:
2022-09-18
As of 2022-09-06 14:01

☑ Limit WO results to machine Design Name tag data omitting any Survey Surfaces

In Design | Scheduled | In Progress | Needs Approval | Complete

Behind Schedule

	EW-0000201	BF00001	2022-07-03	2022-11-09	2022-12-15	Behind Schedule	4,724,581	613,131	4,111,450	13	87

Work Order Header

Grootegeluk Mine (Old)

exxaro WORK ORDERS

MAP | WORK ORDERS

Work Order Type: All | Status: In Progress | View: Dashboard | Include Archived

Dashboard

Create a Work Order | Search

Burndown Chart	ID	Reference ID	Date Started	Planned End	Expected End	Schedule	Target Volume (m³)	Volume Completed (m³)	Volume Remaining (m³)	Complete (%)	Remaining (%)
	EW-0000151	CF - 010 - AS	2022-04-01	2022-04-10	2022-09-08	Behind Schedule	57,141	57,934	0	101.4	0
	EW-0000131	Test CF 2	2022-03-12	2022-04-24	2022-09-09	Behind Schedule	524,408	530,257	0	101.1	0
	EW-0000150	HR1 - CF - 001	2022-02-01	2022-05-27	2022-09-09	Behind Schedule	2,589,788	2,604,806	0	100.6	0
	EW-0000078	BF - 86 - 16	2021-10-10	2022-04-13	2022-09-10	Behind Schedule	4,758,356	6,540,562	0	137.5	0
	EW-0000084	BF - 860 - 16 - I	2021-10-08	2022-04-13	2022-09-18	Behind Schedule	4,758,356	5,777,030	0	121.4	0
	EW-0000201	BF00001	2022-07-03	2022-11-09	2022-12-15	Behind Schedule	4,724,581	613,131	4,111,450	13	87

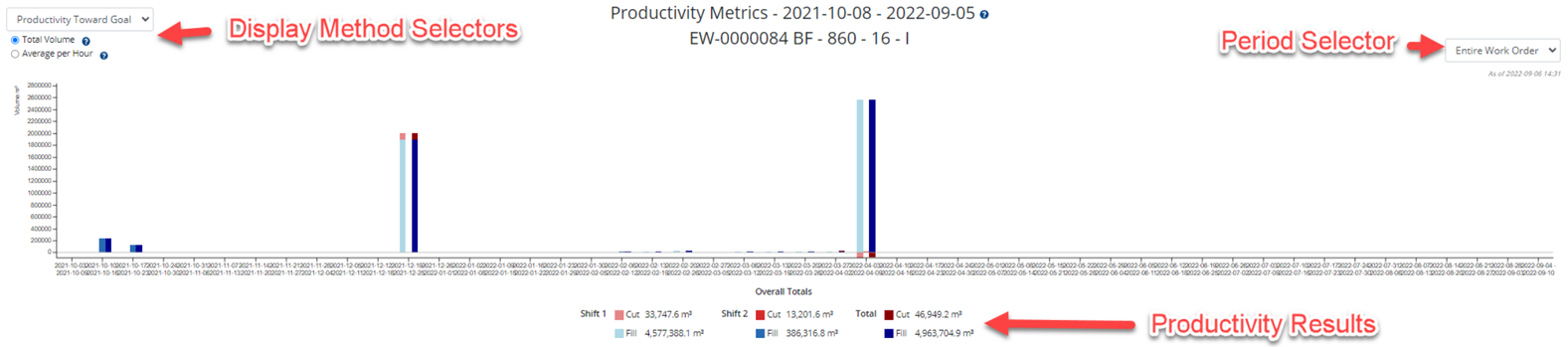
Work Order Schedule

Work Order Charts & Reports

Burndown Chart

Work Order Charts & Reports

Surface Elevation Map



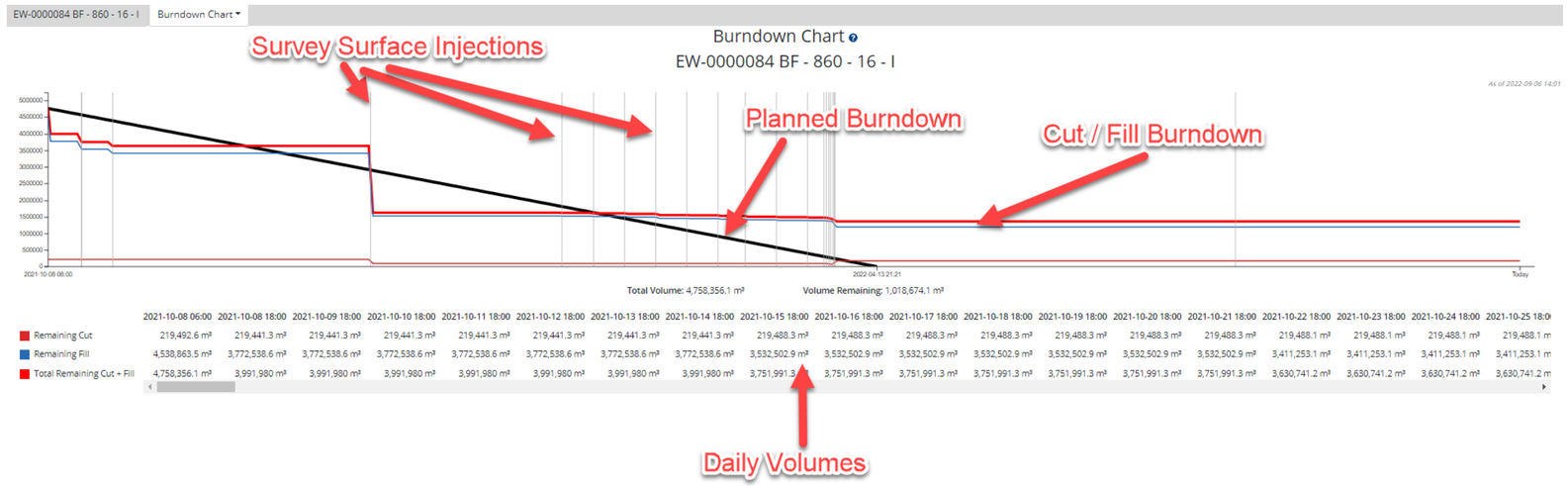
Work Order Charts & Reports

Cut / Fill Map

Work Order Charts & Reports

Productivity Metrics

Work Order Charts & Reports



Quality Metrics

Problems / Issues Solved

- Performance / Speed
  - Graphics performance with large Hi-Res imagery
  - Graphics generation of e.g. Map overlays for Cut Fill, Quality, Elevation
  - Volumetric computations and methods to generate the numbers required
  - Parallel development of backfill and capping quantities
- South Azimuth Coordinate Systems
- Simplicity of use / automation of results

Project Status

- **Current Status**
  - Documentation and Testing Completed
  - Training & Rollout with the Planning and Survey departments
  - Initial data from machines being captured and processed to supplement survey data
  - Refinement of some tools and processes

- **System Refinements Completed**
  - TBC Point Cloud Processor to decimate point clouds from surveys intelligently
  - Image generation at High – Medium – Low resolutions
  - Geo-reference scan data to South Azimuth integration with Point Cloud Processor

Documentation – Written & Video Content

MYROCKPILE COMMUNITY

RPS Earthworks System ▸ RPS Earthworks - Earthworks Documentation ▸ Latest Top Edit + New Topic

Topic	Replies	Views	Activity
About the RPS - Earthworks Module The RPS Earthworks Module provides a work process management system for earthmoving operations including Large scale Cut to Fill Earthworks operations Grading and Trimming operations Backfill and Capping operations Th… read more	0	75	Apr 2
RPS Earthworks - Work Order Productivity Chart	0	112	Apr 5
RPS Earthworks - Cut Fill Map	0	112	Mar 26
RPS Earthworks - Work Order Burndown Chart	0	81	Mar 26
RPS Earthworks - Work Order Surface Elevation Map	0	84	Mar 26
RPS Earthworks - Settings	0	150	Mar 25
RPS Earthworks - Map Screen	0	92	Mar 25
RPS Earthworks - Work Orders	0	110	Mar 25
RPS Earthworks - Work Order Quality Map	0	65	Mar 25
RPS Earthworks - Map Layer Controls	0	98	Mar 21
RPS Earthworks - Earthworks Permissions	0	88	Mar 21
RPS Earthworks - Members - Devices and Groups	0	100	Mar 17
RPS Earthworks - Project Manager Engineer and Work Supervisor Roles	0	115	Mar 17

TBC - Creating and Managing Work Orders For RPS Earthworks

RPS Earthworks System ▸ RPS Earthworks - TBC Documentation

Note: All surfaces that re uploaded to the RPS Earthworks system are cropped automatically to the work order boundary prior to upload. The original surfaces are not affected by the cropping process.

Results:

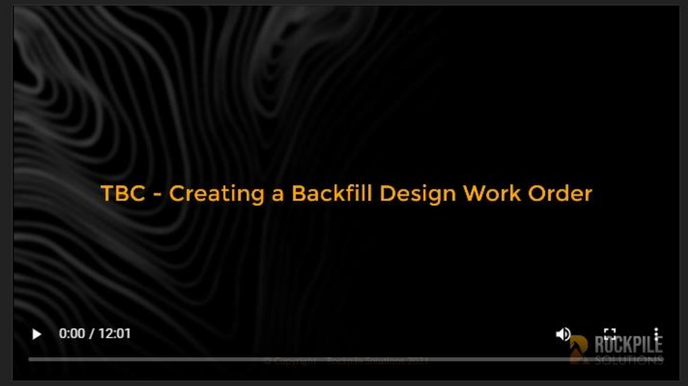
As the surfaces and boundary data are uploaded to the RPS Earthworks system the progress and success / failure of the upload is captured in the Results area.

Command Tips:

The command tips provide hints to you as a user on how to use the command where tips are useful. The tips are supplemented by pressing the F1 key to access this help document and video.

Video Demonstration:

The following video shows you how to use the Images tab of the Earthworks Work Order command



Command Header toolbar:

Lessons Learned / Summary

- There are many things that go into a complete solution
- There are many people / parties that contribute to a solution like this
  1. The Mine
  2. SITECH SA
  3. Trimble
  4. Rockpile Solutions
- Requirements change / evolve as work is completed – flexibility is required
- Getting the desired results / reports takes time and the “correct” approach