Operational benefits when running Longwall Automated Face Alignment & Horizon Control Systems

Longwall USA
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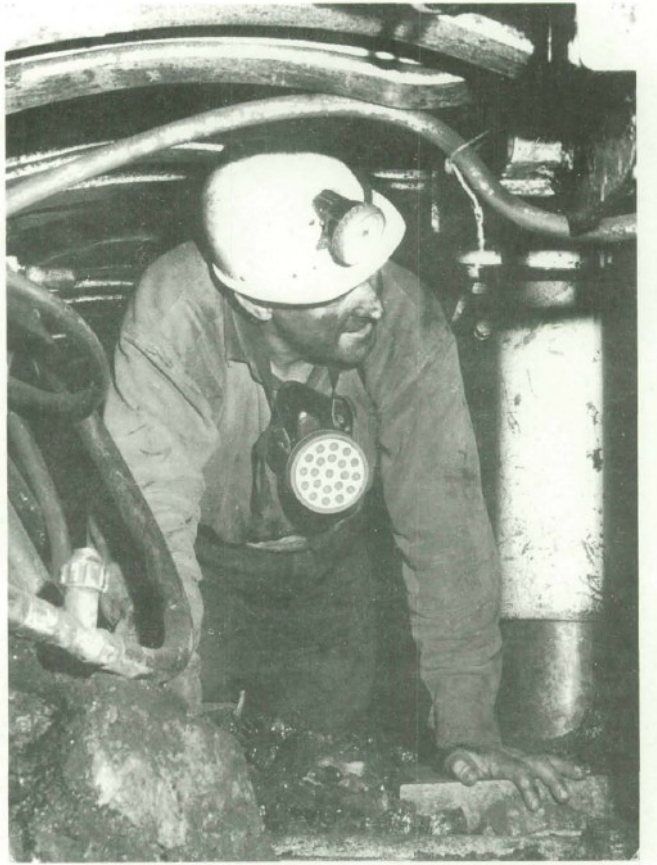
Jeff Ley
Willem Fourie

Why develop automated features



Regulations

- Dust & Noise Exposure, H_2S

Risk Mitigation

- High Pressure Fluid Injection
- Struck By & Crushing Injuries
- Slips, trips and falls

Operational Considerations

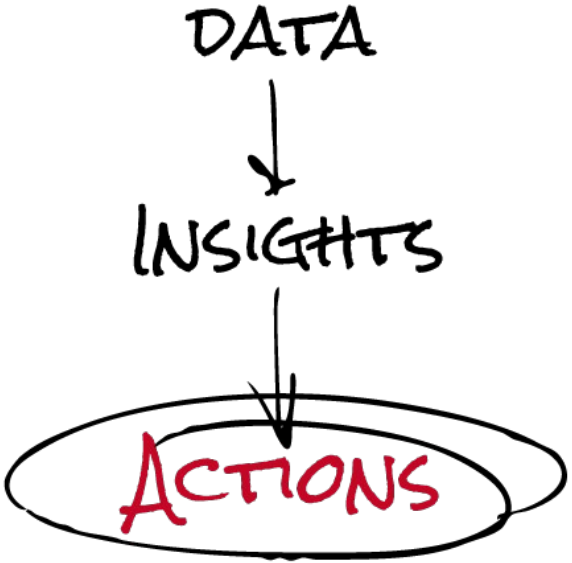
- Consistency, Speed, setting pressure, web
- Seam Height

Challenges of mining

Two of the biggest challenges that mines face today are managing the cutting horizon and face alignment.

Horizon control – control the cutting horizon of the shearer to maintain in-seam position, reduce waste and remove operators from the dust

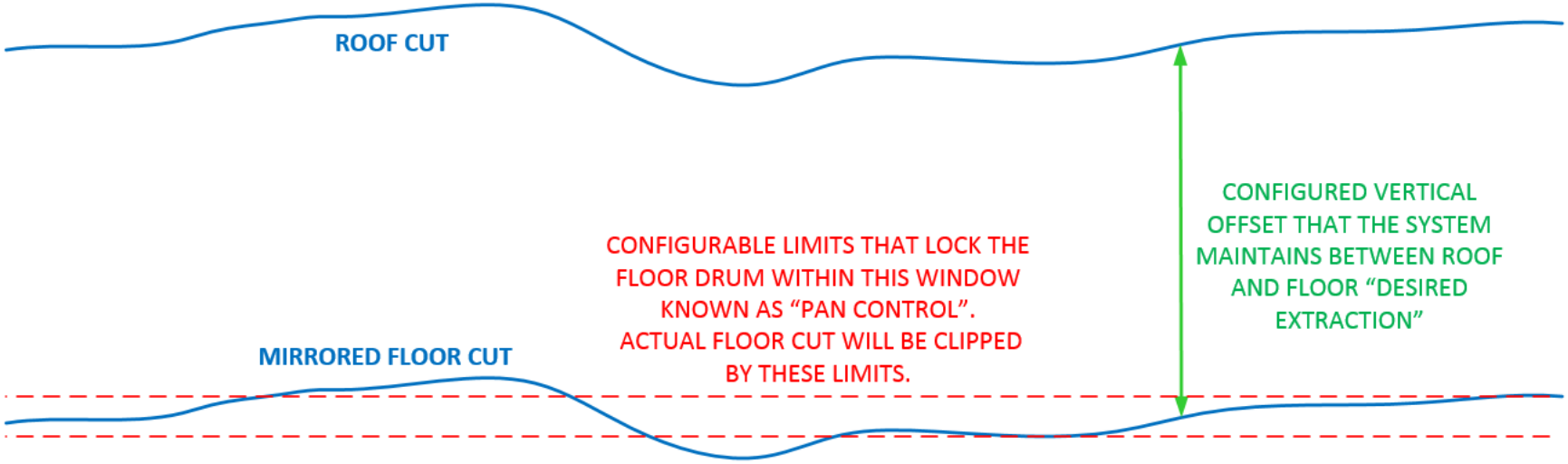
Face alignment – managing AFC straightness for better strata control, less equipment wear and maximizing equipment utilization



Horizon Control

Existing Shearer Automation Methods

- Today, most OEMs utilize an automation method that positions the floor drum in a manner where it mirrors the shape of the roof (as cut by the operator), at a predefined offset away from this roof line.
- KMC refers to this mode as “FX1” & “FX2”. Other manufacturers may refer to this as “Extract to Previous” or “Extract to Current”.

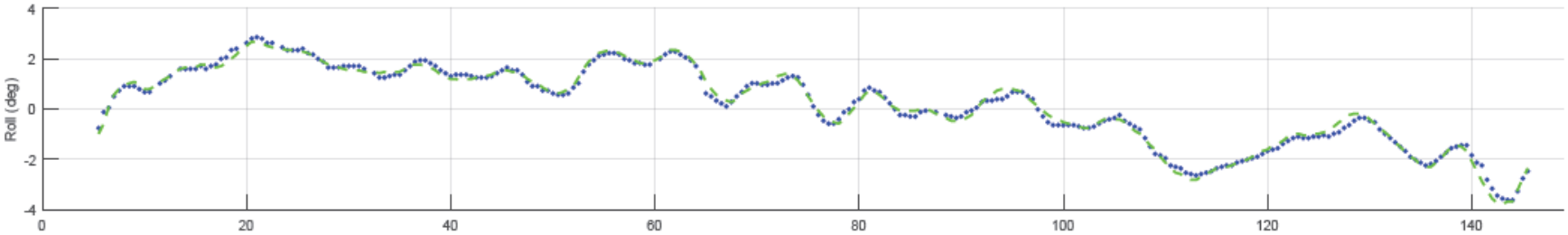


Existing Shearer Automation Method

Issues with existing FX1/FX2 methods:

- Every movement of the roof drum effects the position of the floor drum
- Known to cause “roll oscillations” along the face. As the shearer hauls across the pans, bumps in the floor can create bumps in the roof due system lag (sensor response & filtering, hydraulic response time, etc..) The bumps in the roof now get reflected back into the floor. This problem compounds each pass unless the operator intervenes. Pan Control limits the effect of this problem but is a major contributor to inaccuracies.

Example: roll oscillations



Pitch Steering

Goal

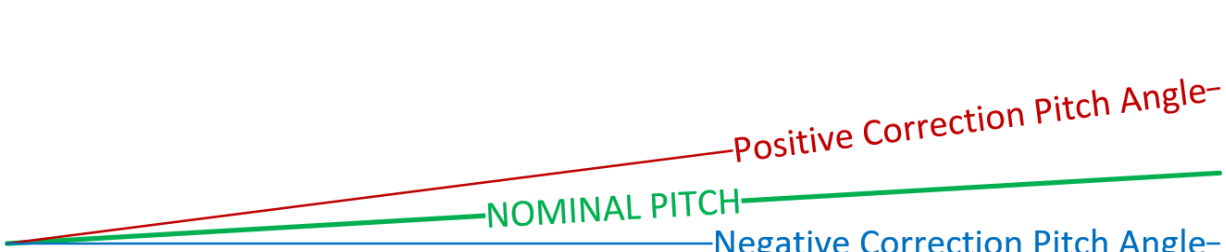
- Create a smooth floor for longwall equipment to operate from

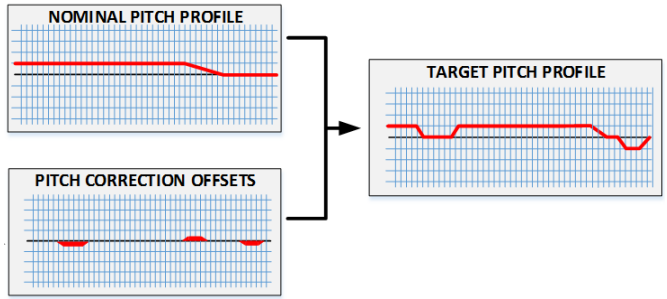
Methods used

- Manage the floor as a surface, rather than a mirror of the roof cut
- Utilize available information about the seam being mined (gate road surveys, elevation profiles).
- Allow the longwall equipment to move with the seam, but in controlled, incremental steps.

Pitch Steering – General Description

- Floor drum Automation mode that is designed to achieve specific pan angles after the panline is pushed
- Configuration of the system starts with the creation of a "**Nominal Pitch Profile**"
  - Reflects the Nominal Angle of the seam being mined
- The system will **maintain the pans at the Nominal Pitch angle unless an elevation change is required**
- Elevation changes are achieved by adding a **positive or negative pitch correction offset to the Nominal** pitch target for that section of the face.
  - Results in a very **predictable and controlled elevation change**.



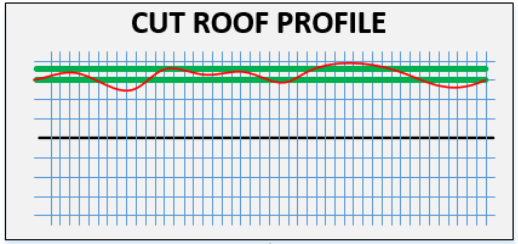


What determines if an elevation change is required?

There are 2 options for generating Pitch Corrections in the floor:

Option 1: Based on how the roof is cut

- When the Roof is cut higher or lower than a configurable tolerance window.
- This tolerance window allows the system to focus on maintaining the pans at the Nominal Pitch angle unless the seam changes enough to require an elevation change.



Option 2: Manual Entry of Pitch Corrections into the PRS mimics

- Floor Cut is completely decoupled from the Roof.
- Roof is cut at a pre-defined height off the pan on each pass.
- The operator evaluates the face after the pans have pushed to determine if a floor correction is required
- If required, the operator selects the magnitude of the correction, the horizontal range that the correction will be applied, and the number of passes to maintain the correction.
- The system then cuts the correction on subsequent passes until fully consumed.

Additional Features

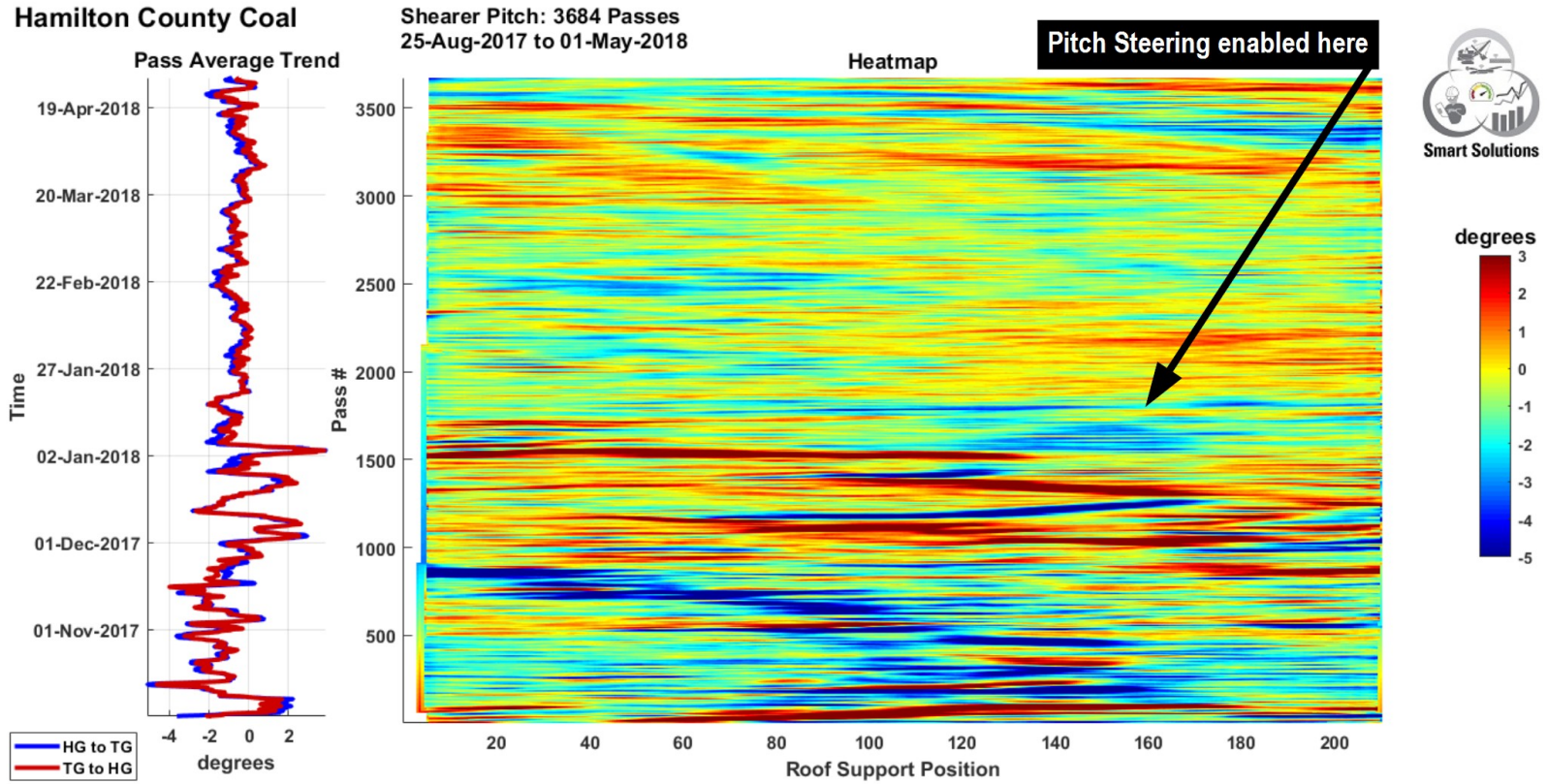
Smoothing Ramps

- Added to each of the corrections to create smooth transitions from pan to pan, preventing drastic changes in pitch or roll angle.

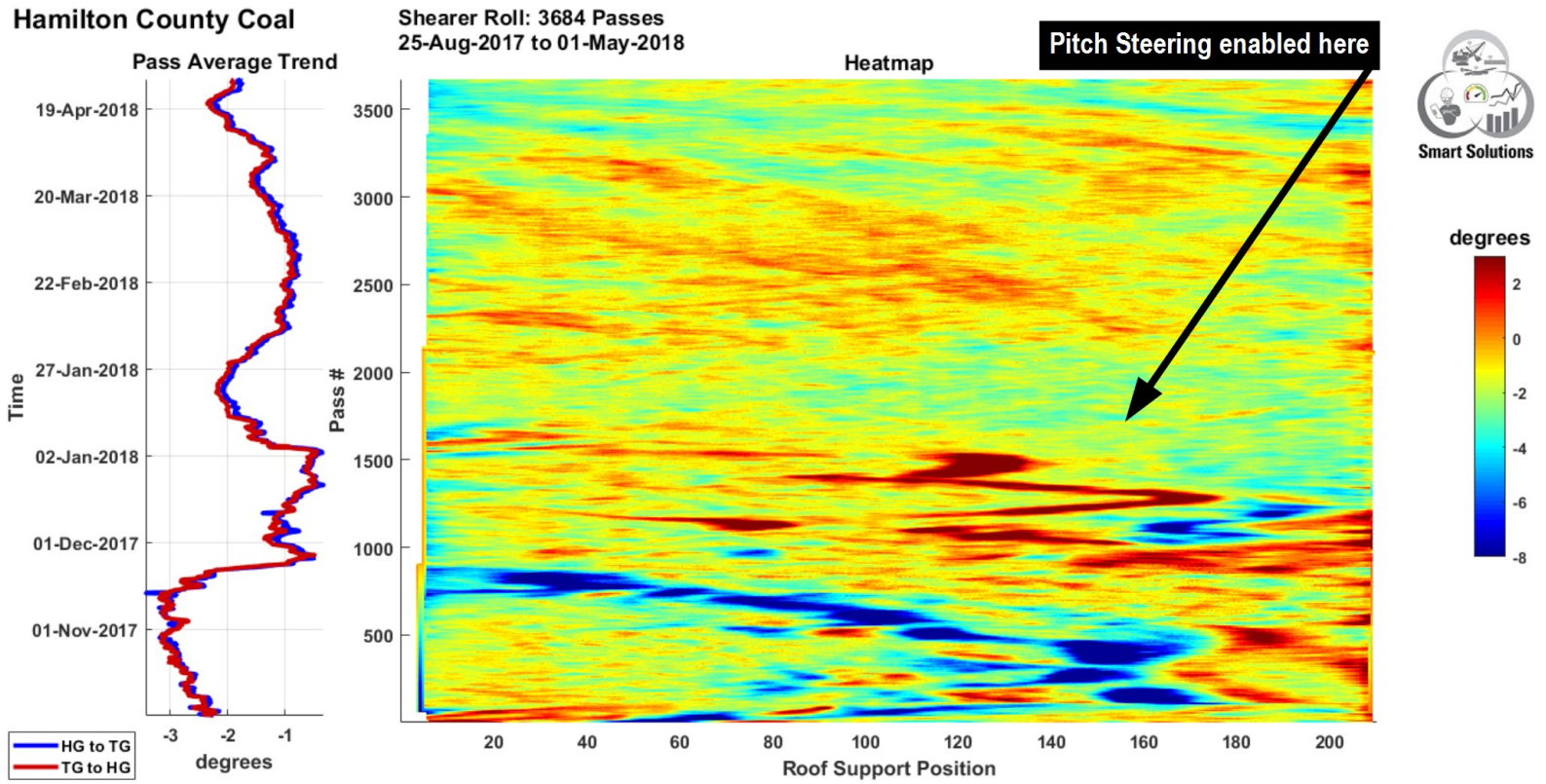
Adaptive Nominal Pitch Profile

- Optional feature that automatically updates the Nominal Pitch profile at each 0.25m increment along the face, based on the rolling average of the target pitches over a configurable number of previous passes
- Allows the system to learn and adapt to a changing seam angle, minimizing the corrections that would have to be made by the operator as the seam changes.

Field Data – Shearer Pitch Angle



Field Data – Shearer Roll Angle



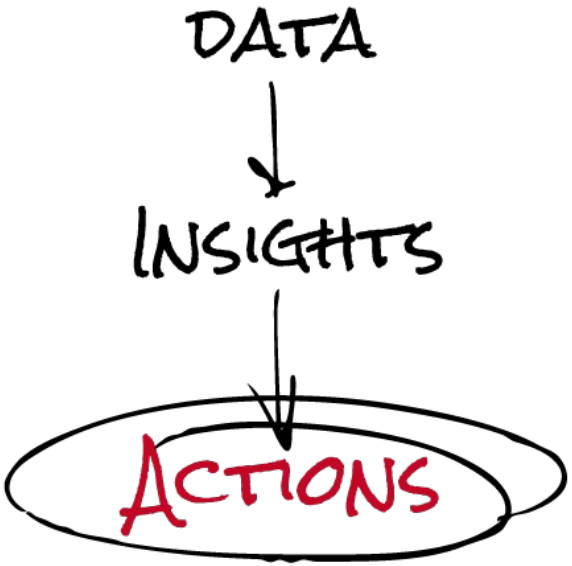
Pitch Steering Benefits

- Creates a smooth floor, without detrimental roll oscillations
- Reducuction of AFC articulation which leads to less mechanical wear on pan joints, chain and flight bars.
- Reduces AFC power usage
- Smooth floor provides better alignment of roof supports for greater strata control
- Controlled and predictable elevation changes prevent abrupt changes in pan angle from pass to pass, drastically reducing the possibility of shearer to roof support collision hazards and dog bone breakage
- Provides the option to position the operator further away from the cutting area for the majority of the mining sequence

Automated Face Alignment

Continued mine challenges – face alignment

- Need to manually straighten the face
  - Making unnecessary wedge / fly cuts
  - Additional gate-end cut outs
- Unplanned repairs & maintenance
  - Chain and dog-bone breakages still occur
  - Sprocket and pan-line wear are high
- Operational costs are increasing
  - Longwall retreat taking longer than planned
  - Labor costs keep increasing
- Under utilized data systems
  - Ability to measure face alignment for every pass
  - PRS advance push can be controlled through the control system



Face alignment control

The primary functions of the landmark face alignment system are:

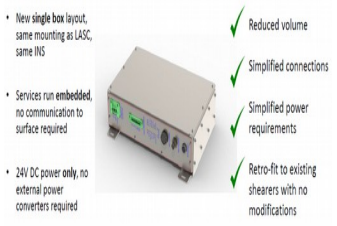
- to measure the straightness of the longwall face and
- provide corrections values for the PRS control system during advancing or pushing of the AFC

How is this achieved

- Face straightness is determined using an INS (Inertial Navigation System), mounted on the shearer
- The system provides RPCs (Required Position Correction) to the PRS control system to be utilized in performing automated face alignment
- Corrections can be applied on the AFC advance or push and available for all automation modes (Bi-Di, Uni-Di or Kaiser Cut) as well as manual operation

LASC 2 – Hardware (Mounted within shearer)

- **CPU Unit**
  Runs all LASC services, communicates with the shearer and Roof Support System.



- **Inertial Navigation Sensor (INS)**
  Highly Accurate Sensor which measures shearer position in 3 dimensional space to determine the profile of the face.

- **Haulage Encoder**
  Coupled to the shearer's haulage gear train to determine speed and direction

Supported Cutting sequences

The automated face alignment system supports the following shearer cutting sequences:

- Bi-Di
- Kaiser Cut Variable Web
- Uni-Di (Snake on Tail)

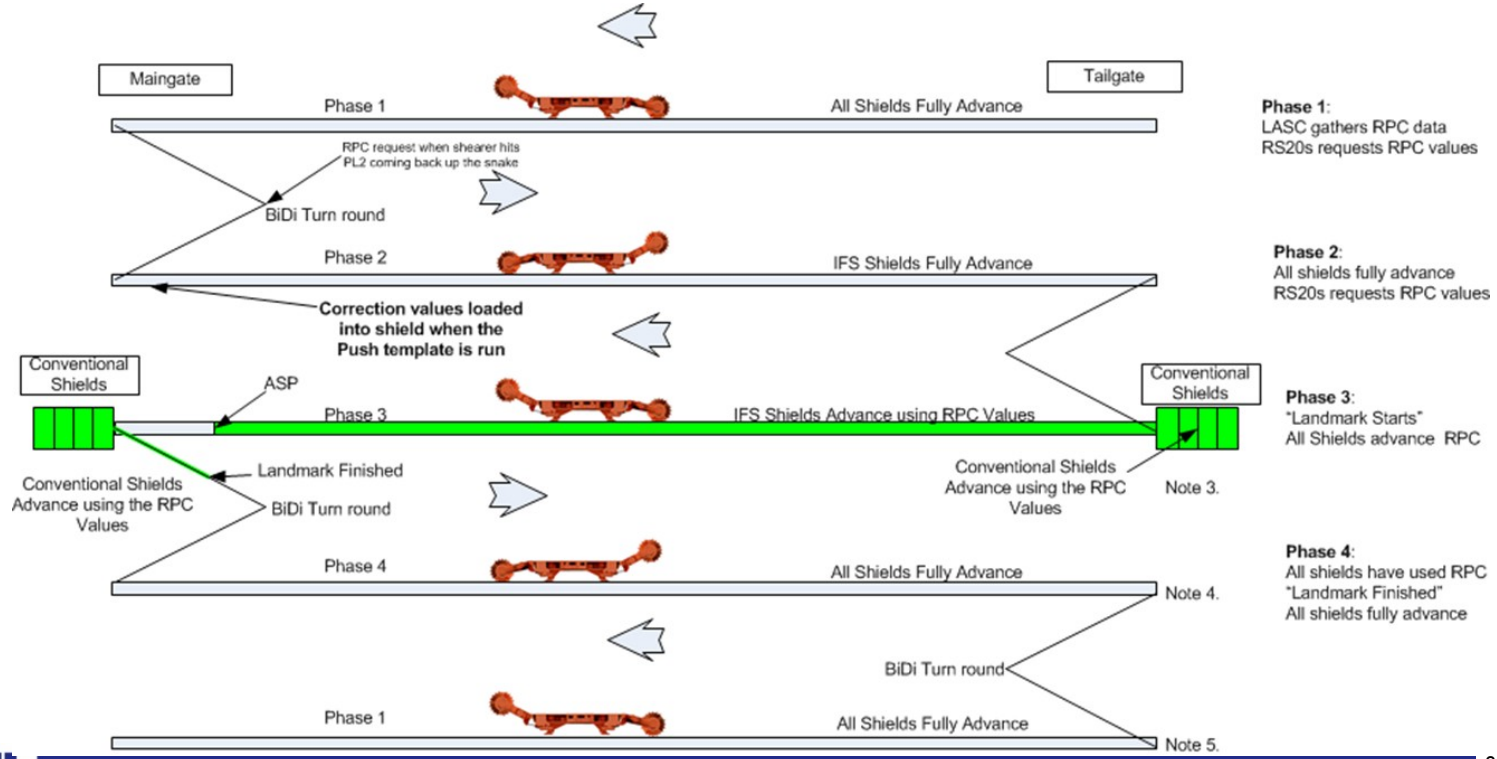
Whilst using face alignment in conjunction with PRS automation this provides more consistent production. The PRS control system also accommodates manual intervention by the operators during poor roof conditions.

If manual electronic control is required the PRS system will electronically halt when its advance target is achieved. The operator is prompted that the target has been achieved, if the operator needs to continue passed its advance target they can override the target and fully advance the PRS.

Roof supports that have faulty ram position transducer will be auto dragged to there required position by neighbouring shields.

Automated face alignment using Bi-Di

The following sequence assumes conventional advance is OFF at the Headgate and ON at the Tailgate and data retrieval is selected to take place at the Headgate.

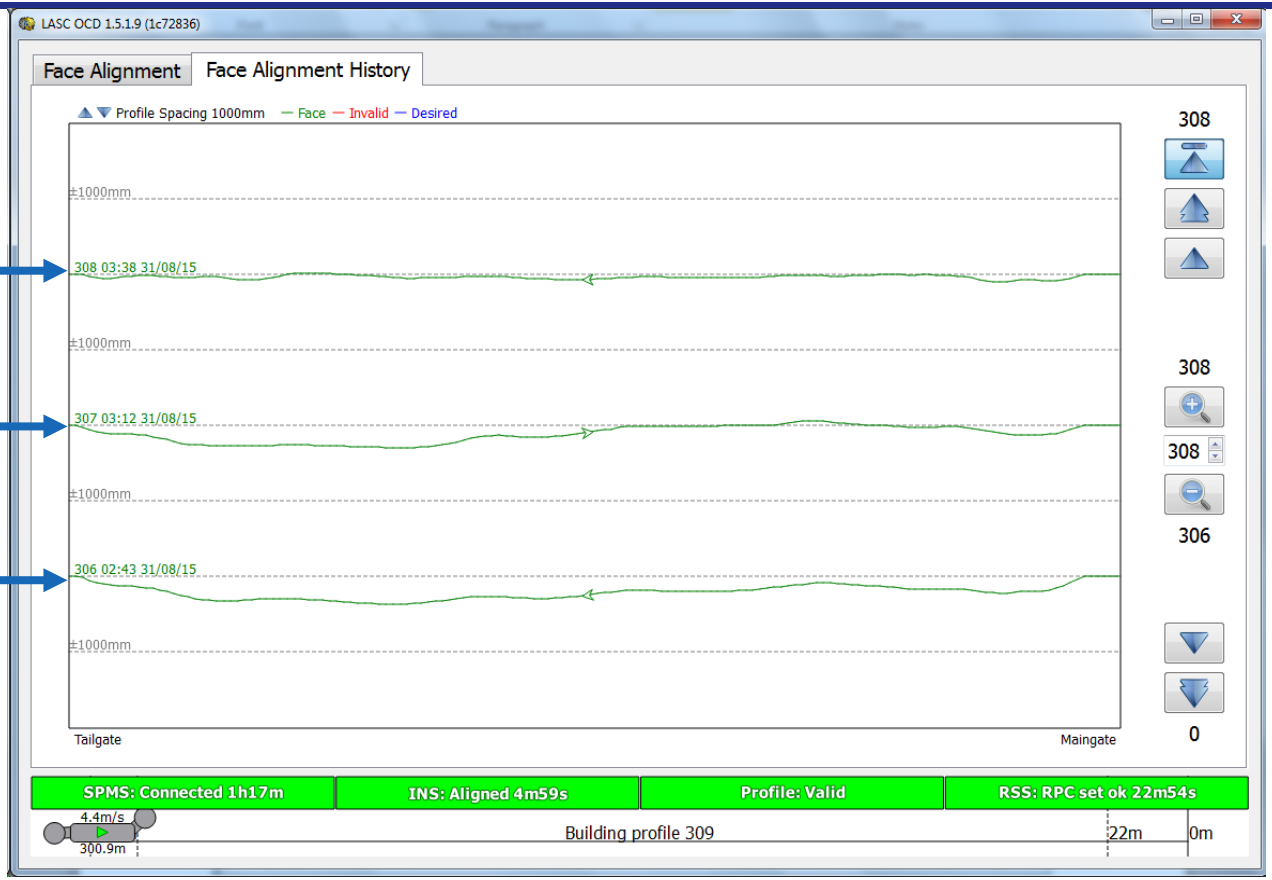


Face alignment trends

All shields fully advance

IFS shields advance

Prior to RPC's applied



Face alignment

By using face alignment during automation and making small corrections the system can achieve a straightness of approximately 4-inches (~100mm) across the face

Case Study - Hamilton County Coal

Automated face alignment activated after ~700 passes

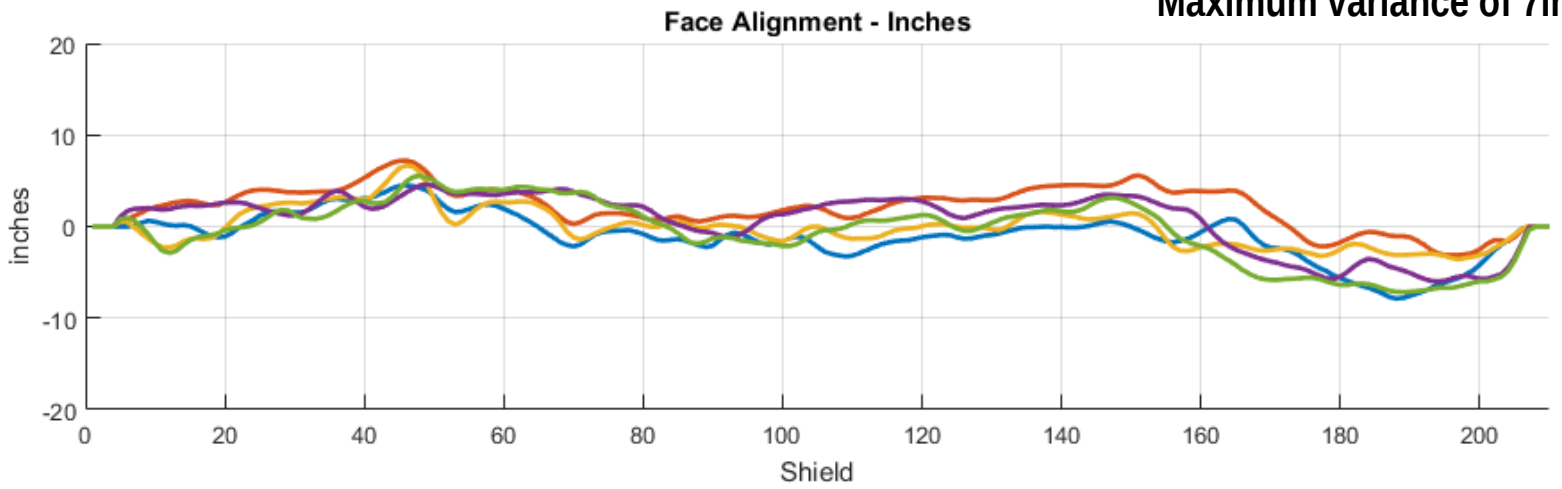
- Single panel comparison helps simplify some variables i.e. roof conditions, equipment differences, etc.

Three key performance indicators evaluated

Note: straightness measured

1. Improvement in face alignment
2. Reduction in wedge cuts & gate end lag cuts
3. Reduction in abnormal cutting time

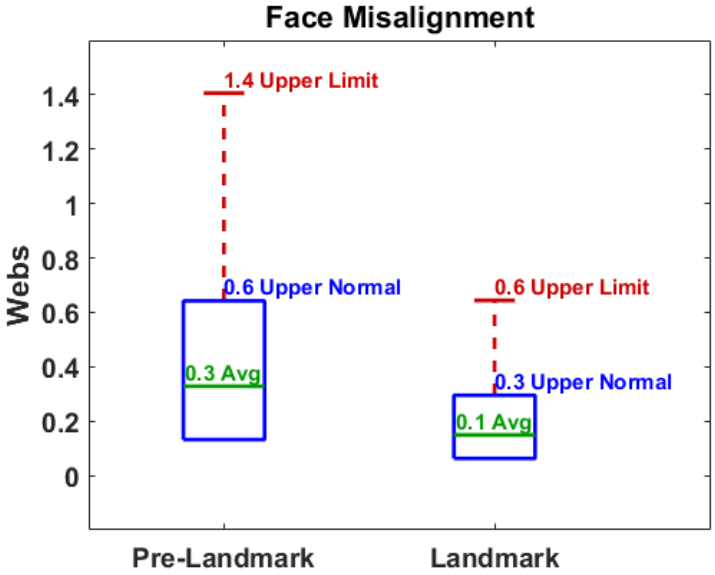
Maximum variance of 7inches



Case study - face alignment improvements

Face alignment data was recorded at every shield for every pass pre- and post-face alignment activation
More than 680,000 measurements evaluated for the case study

Face alignment improvement



32% improvement in face alignment

Benefits to operation

Saved ~ 3,100 cutting minutes

Resulted in a faster longwall retreat of **10days**

- Reduced labor cost
- Reduced equipment wear
- Improved chain management
- Improved productivity
- Reduced fly cuts

The benefits of automated face alignment & horizon control

When using automated face alignment through the control system to automatically keep the conveyor straight it provides the following safety and production benefits:

- **Removal** of **operators** from **harms way** and dusty areas previously required to perform ‘string line’ cuts to correct the conveyor
- **Reducing** the number of **bends** in the face means a reduction in AFC power requirements
- **Reduced wear** on mechanical components
- Running automated face alignment achieves **consistent cutting rates** as there is reduced need for fly-cuts
- Reduced **operator interaction**, the corrections are performed as a background task during production
- Panel retreats are done to budget and within required mine planning and **schedule**

Thank You