Improving the Simplified Ventilation Model for Mine Expansion Planning at Kiruna Mine

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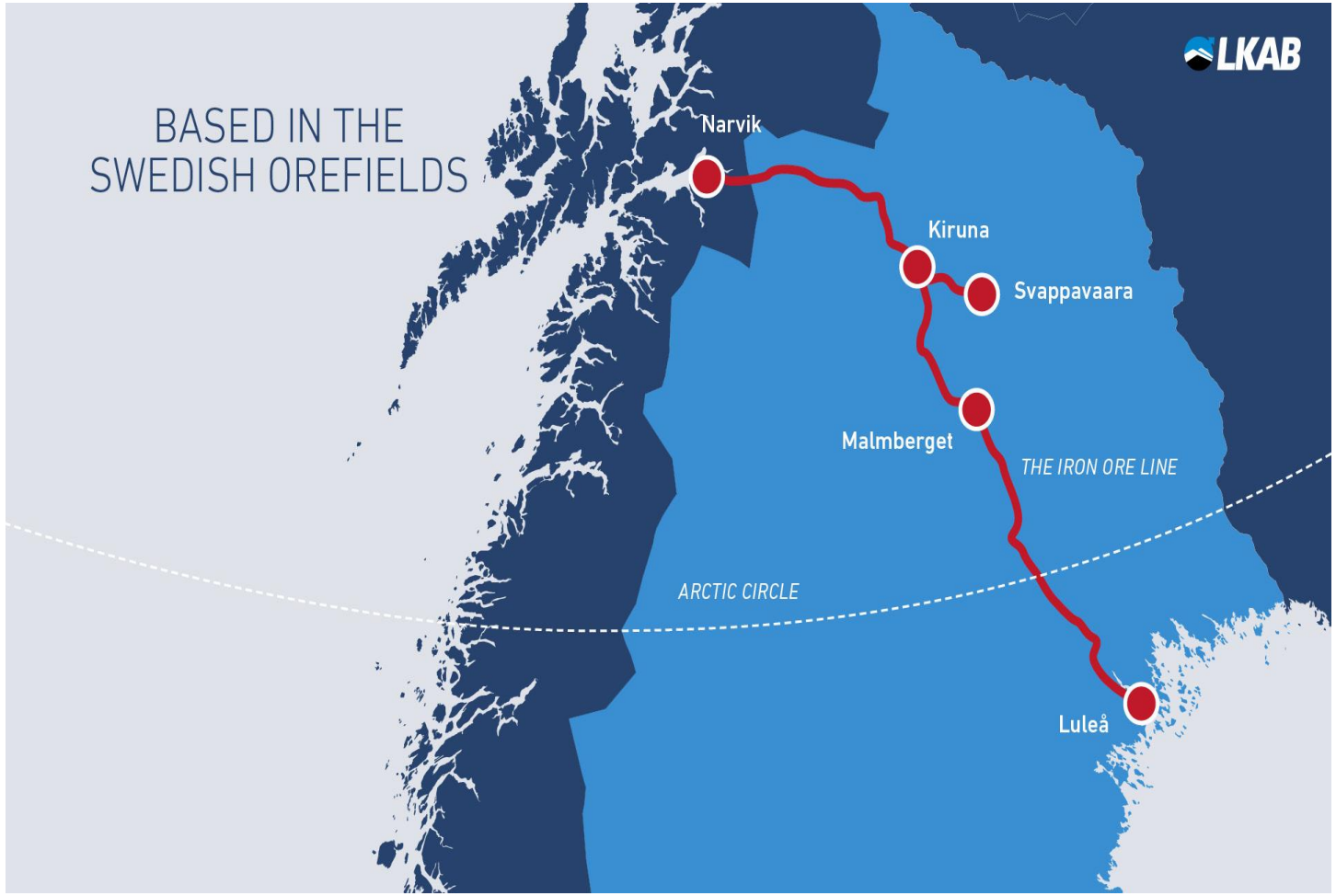
Agenda

- Introduction
- Previous and current work
- Progress and procedure examples
- Current results
- Next steps
- Summary

Introduction

LKAB

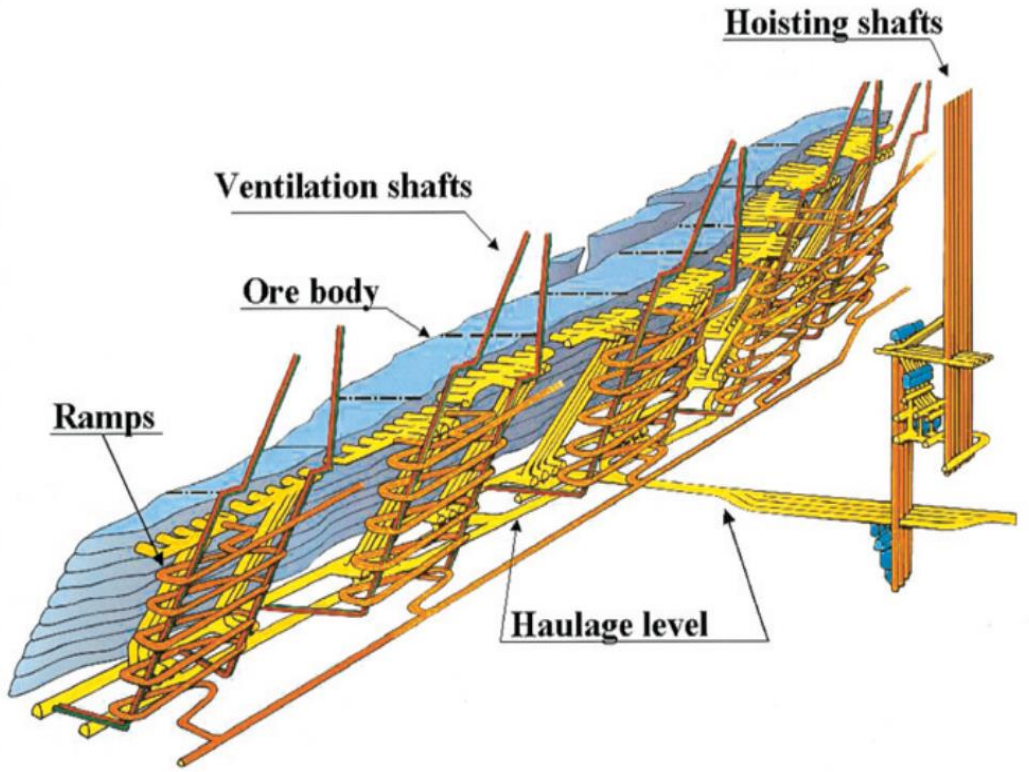
- Swedish state-owned company, established in 1890
- Major European producer of iron ore products
- Three different mines above the arctic circle (Kiruna, Malmberget, Svappavaara)
- Undergoing ambitious transformation towards
  - Critical minerals
  - Carbon-free sponge iron
  - A new world standard for mining operations



Introduction – Kiruna Mine

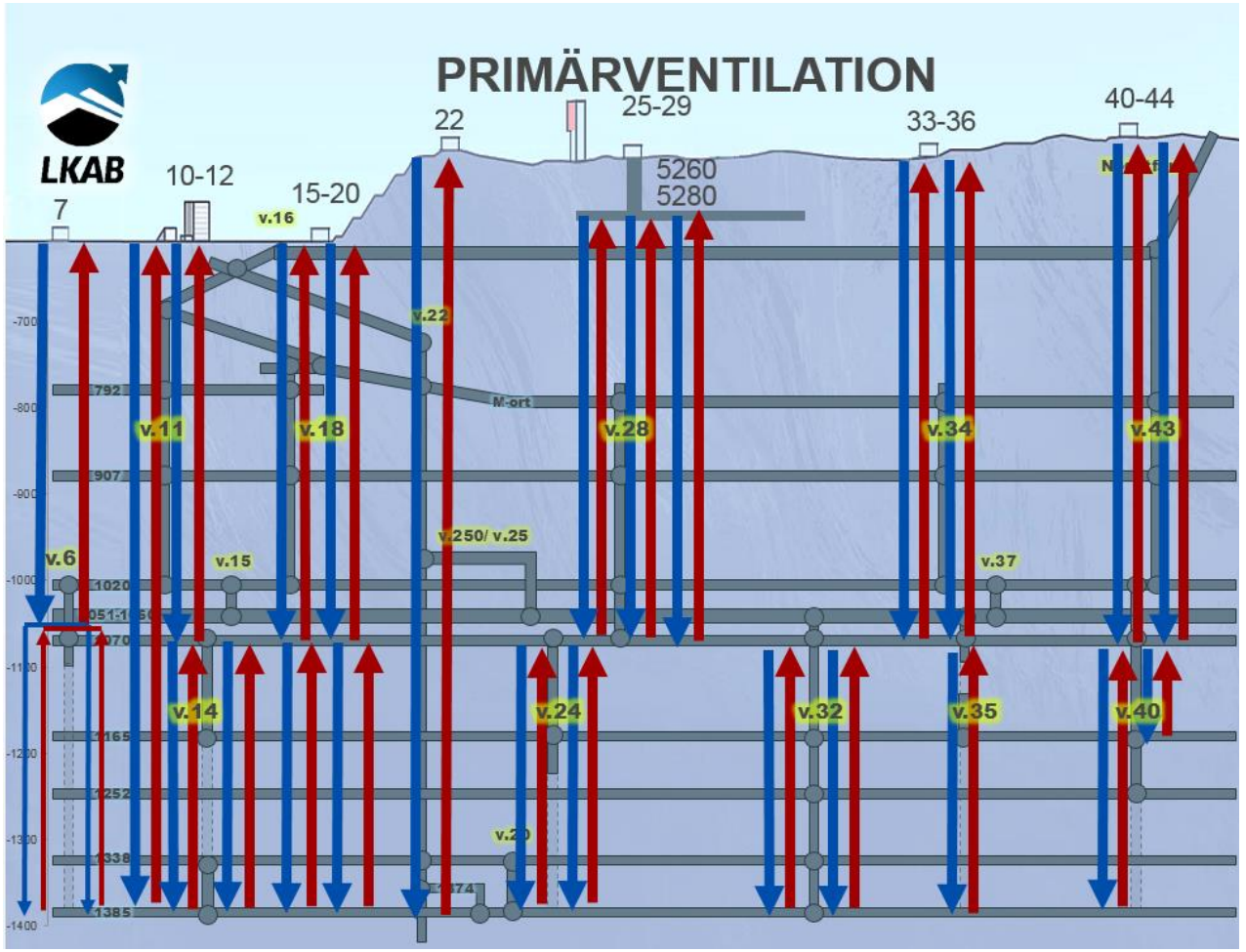
- Kiruna Mine is the world's largest underground iron ore mine
- Sublevel caving method
- Orebody length 4-5 km with width of up to 120 m
- Current production below level 1000 m with main haulage level at the depth of 1365 m
- Production roughly 28 Mtpa

Kiruna Mine system.



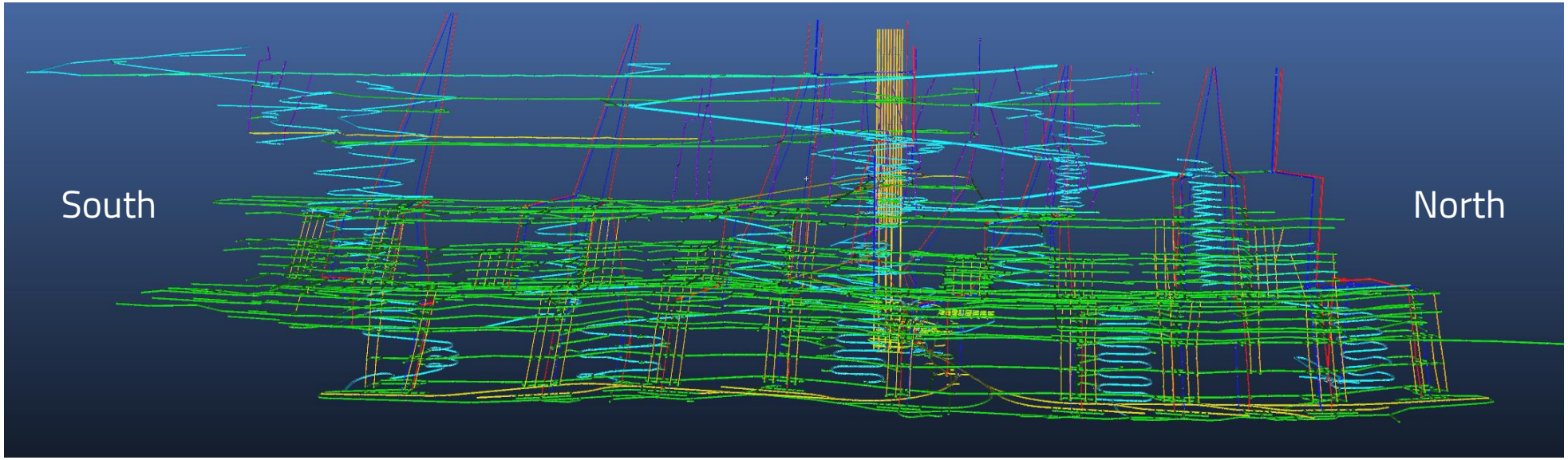
Introduction – Primary ventilation system

- Push-pull system
- Majority of the main fans located on the surface
- Total installed ventilation capacity around 2500 m^3/s
  - Most stations have capacity of 150 m^3/s, which is used to supply fresh air to one mining block
  - The largest station has capacity of 450 m^3/s to supply two blocks
- About 15 % of the supplied airflow is used to supply permanent infrastructure while most of the fresh air is distributed to production areas



Simplified ventilation model building – Previous work

- Creating a model to study airflow requirements for the Kiruna mine expansion towards greater depth and optimizing the current ventilation system
- A simplified model was used to do the first ventilation model calibration



Simplified ventilation model building – Previous work

Input	Include (+)	Exclude (-)
▪ Old mine maps from Microstation + Deswik files (for completion of the upper levels) ▪ Deswik files ▪ Existing Ventsim model for Block 4 and Block 8 ▪ Existing Ventsim model for the hoist area	▪ In-use ventilation shafts, production shafts and ore passes, ramps, footwall drifts, transportation and medial levels ▪ Main fans and ventilation walls ▪ Known orifices and regulators in ventilation walls	▪ Production drifts ▪ Auxiliary fans and ducts ▪ Old ventilation shafts ▪ Konsuln test mine ▪ Level, block, airway separation ▪ Upper levels area (levels, ramps) ▪ Old connections between hoist area and main mine

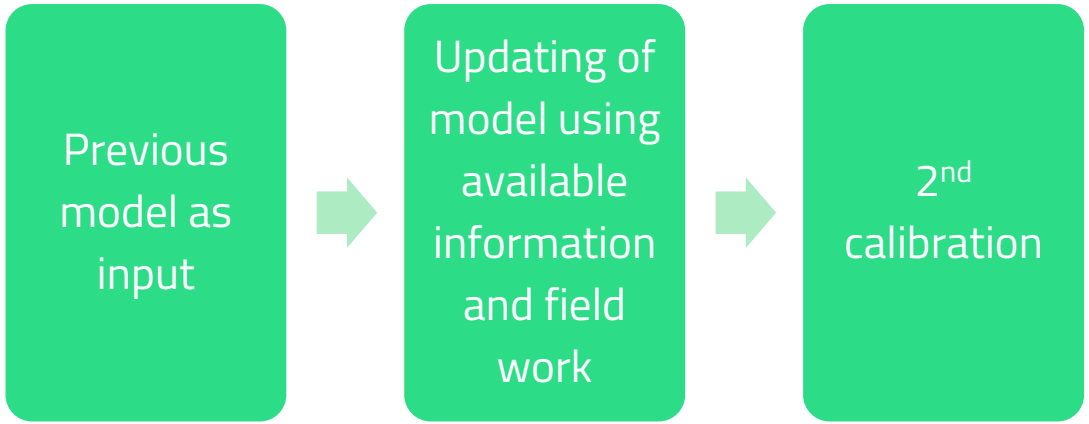
Simplified ventilation model building – Previous work

Outcome

- Airflow in primary ventilation infrastructure was found to correlate to a decent extent (within +/- 10%)
- Leakage into cave levels and from old ventilation shafts, causing erroneous airflow and discrepancies between measured values
- Missing connections between the hoist area and the main mine affected the airflow distribution in the model (e.g., too high airflows in the few connections)

New objective

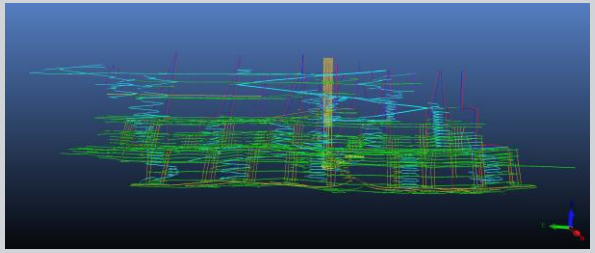
- Necessity of more detailed model to improve the accuracy of the results and to assist in near-future planning



Updated ventilation model building

Input

- Previous model
- Deswik files
- Actual old level references
- Updated main ventilation routes
- Actual airway profile sizes



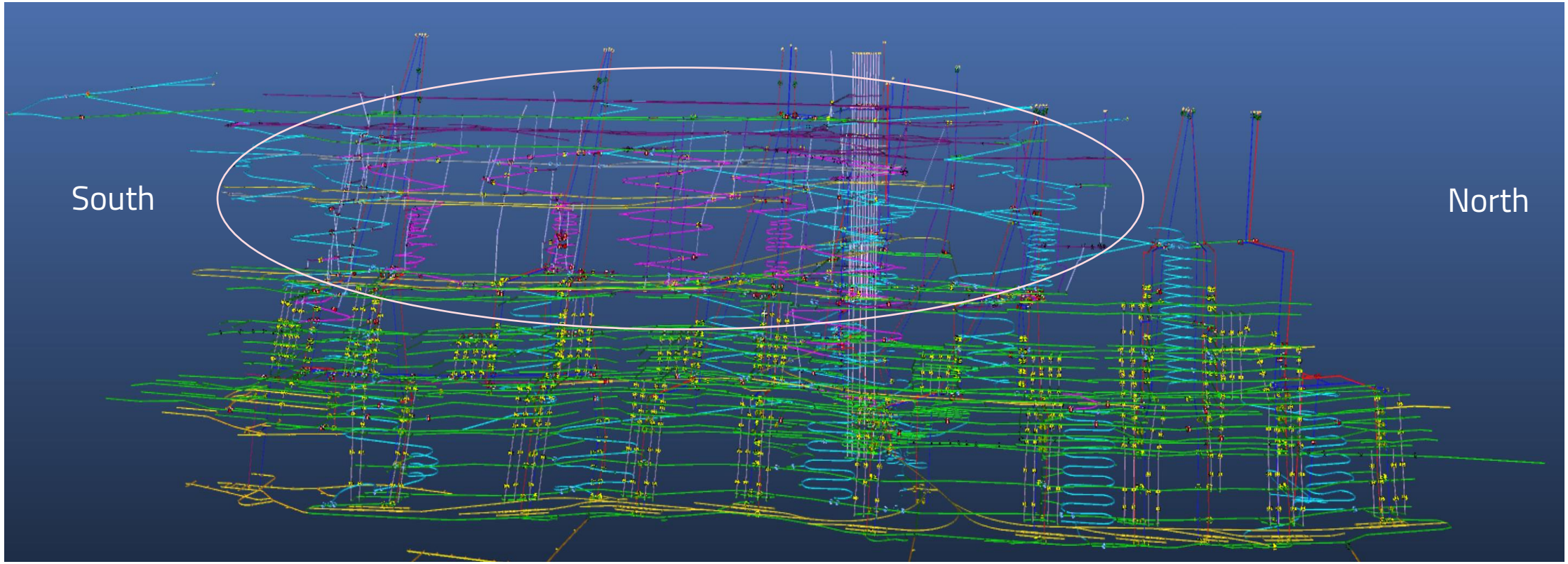
Include (+)

- All existing airways from the previous model
- Additional airways (ramps, levels, and other previously excluded connections)
- Old shafts
- Actual regulators (walls, doors, known orifices)
- Upper-level areas
- Old connections between the hoist area and the main mine

Exclude (-)

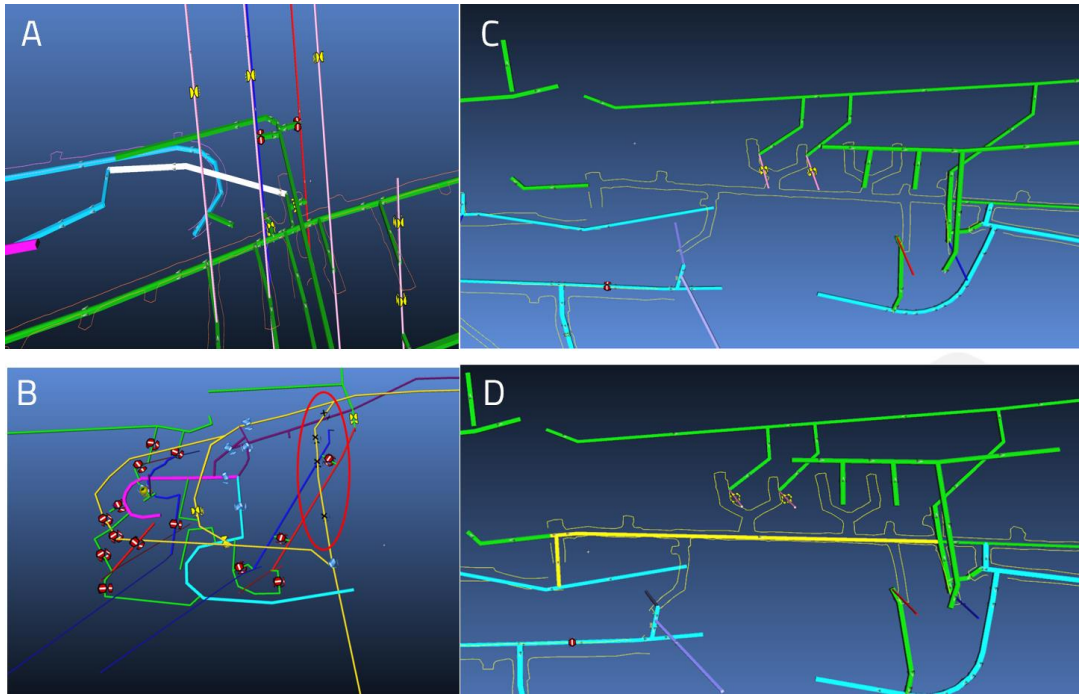
- Production drifts
- Auxiliary fans and ducts
- Old ventilation shafts without level connections, especially on the uppermost level
- Konsuln test mine

Ventilation model building process – Current status



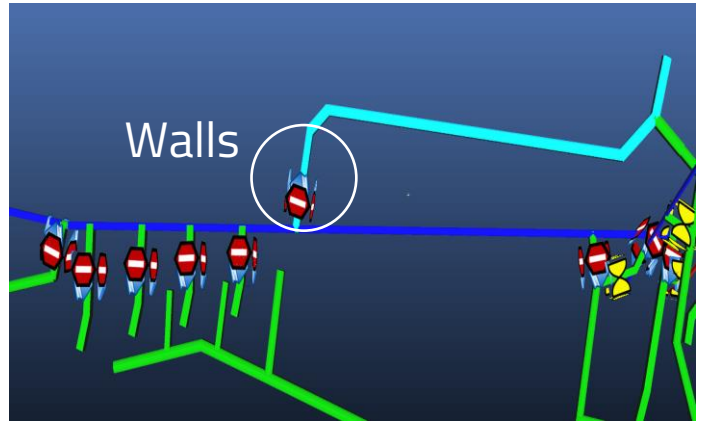
Ventilation model building process – Improvements

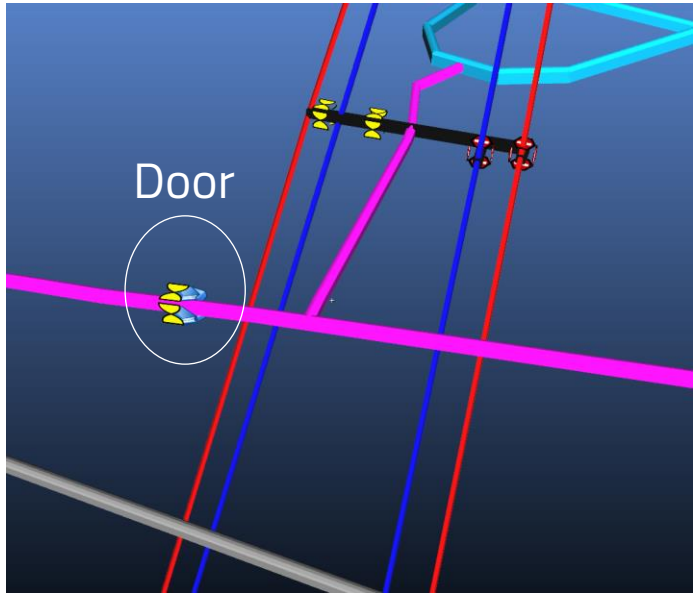
- Organizing the model based on functionality, such as creating new airway types, mining blocks, and level separation
  - ➢ Improve usability of the model
- Performing site visits to confirm or correcting airways based on old, inaccurate references
  - ➢ Reduce erroneous airflow distribution
- Adding previously excluded old tunnel sections and levels as well as well as recent developments
  - ➢ Better represent the current airflow circuits

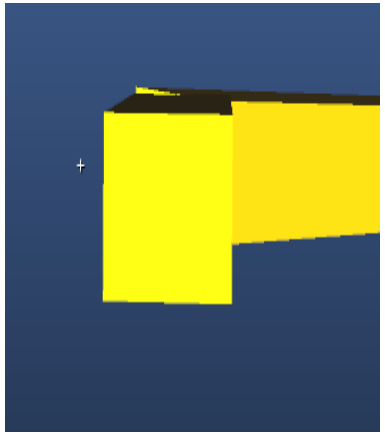


Ventilation model building process – Improvements

- Adding resistances (e.g., doors, regulators) into the ventilation model
- Updating of standard airway dimensions to actual profiles







Default 3D tunnel profile

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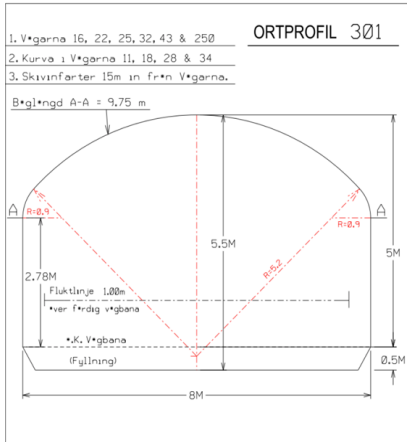

Actual tunnel profile

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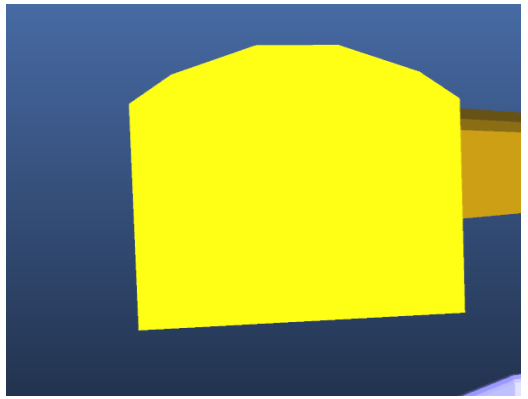
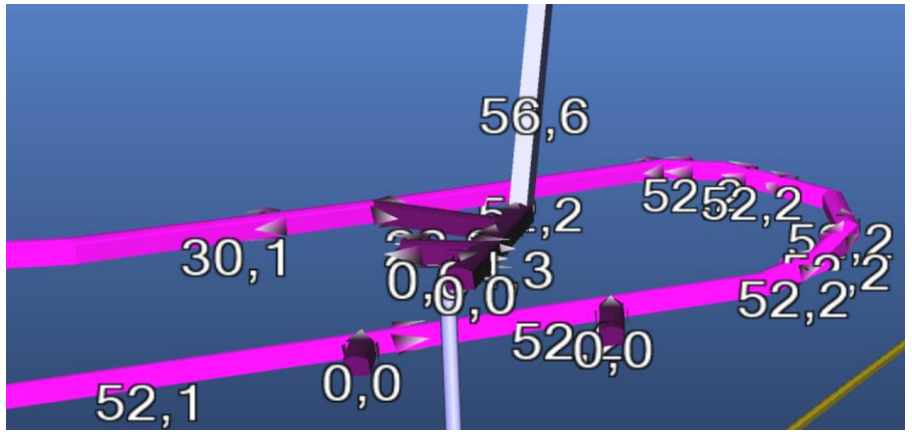


Updated 3D tunnel profile

Ventilation model building process – Improvements

- Airflows disturbed by added relevant infrastructure, lowering model accuracy
- Limited resources, information, and accessibility of the area often required assumptions to be made
  - Assumptions based on available information and field work
- Accuracy of modelled airflows improved



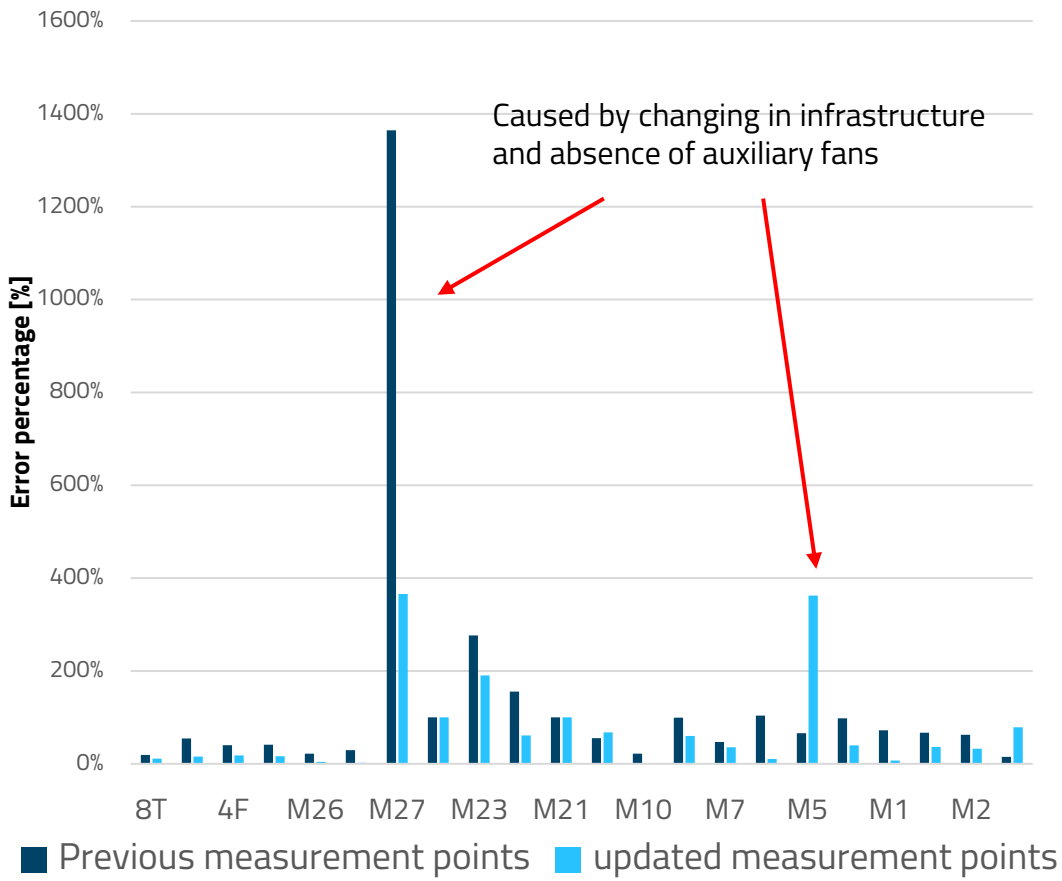
Before closing the shaft connection

Type of blockage between the old shafts and its connection

After applying resistance

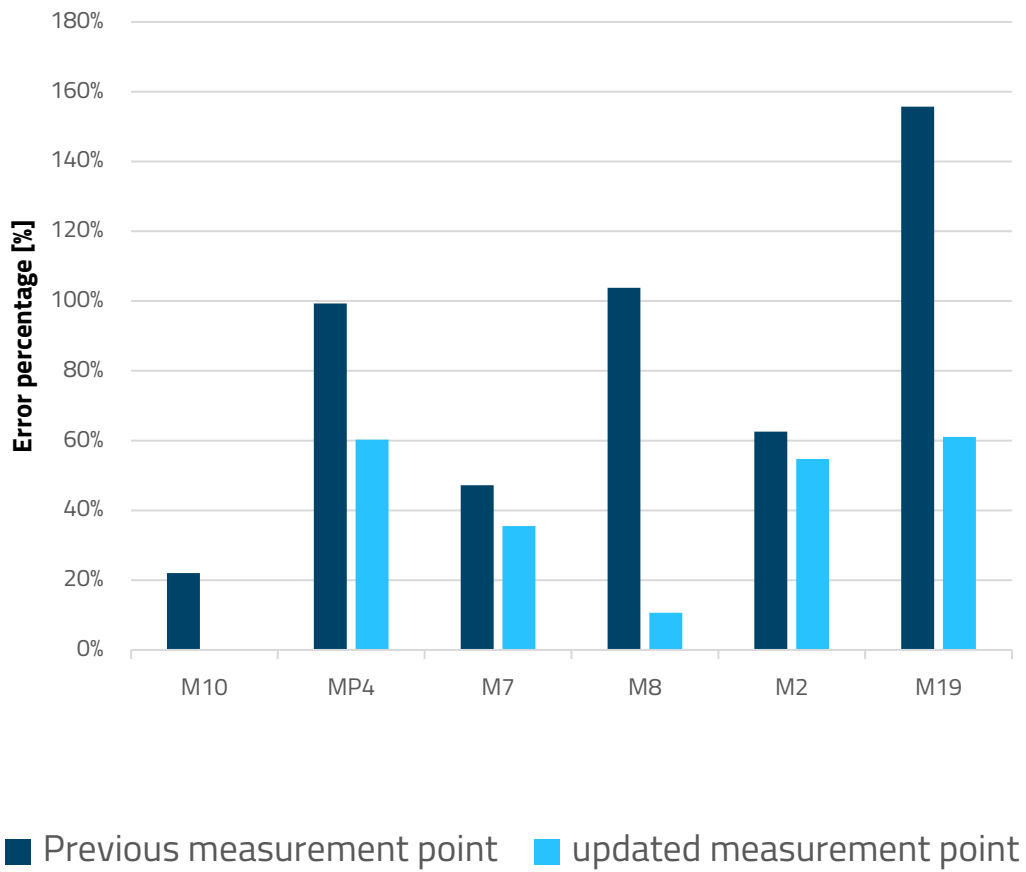
Model update results and discussion

- Airflow measurements were performed at several points used for previous model calibration
- Results were compared with model values of the previous and updated model
- Overall, considering the added infrastructure, an improvement was observed
- Current model shows better results with roughly 73% level of inaccuracy compared to previous model measurement



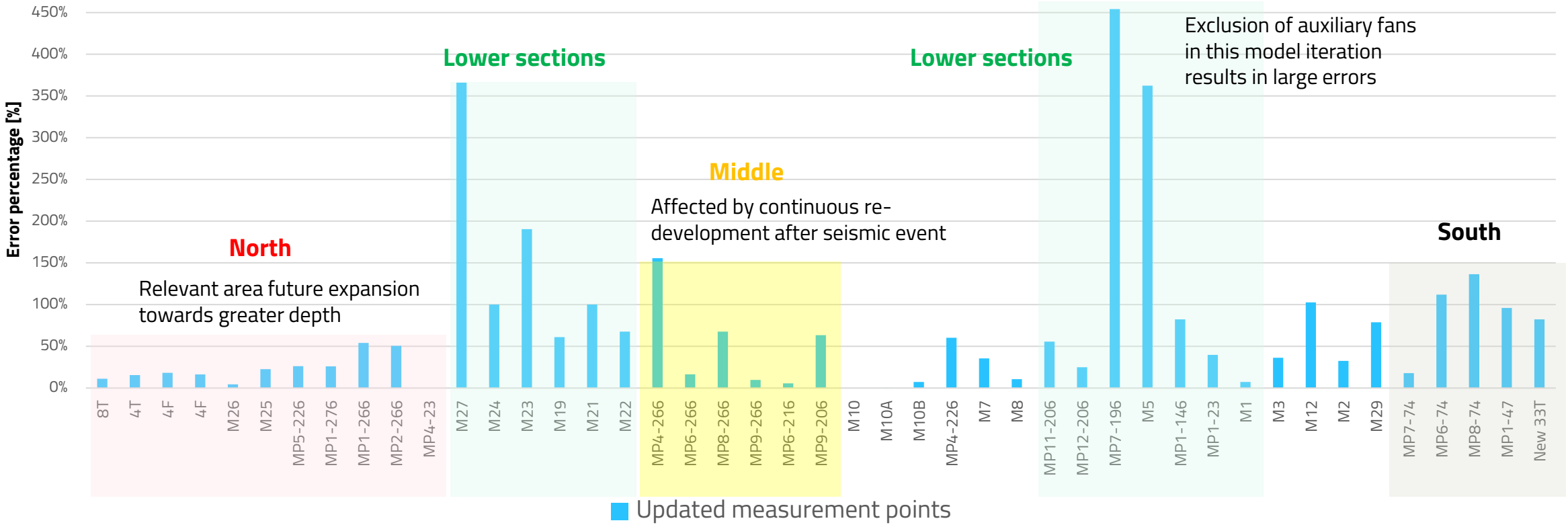
Model update results and discussion – Example

- Previously, the model showed high flow in the airway connections between the main mine and the mine hoist – affecting the overall airflow in the model
- Observed reduction to 37% average error after updates performed



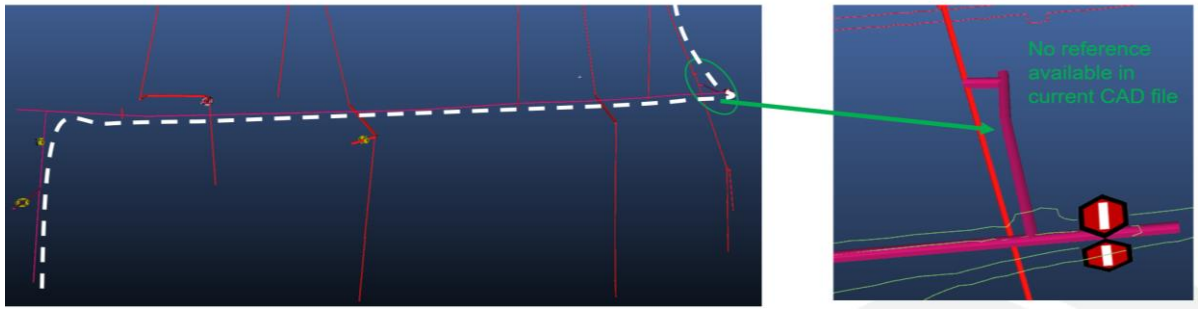
Model update results and discussion

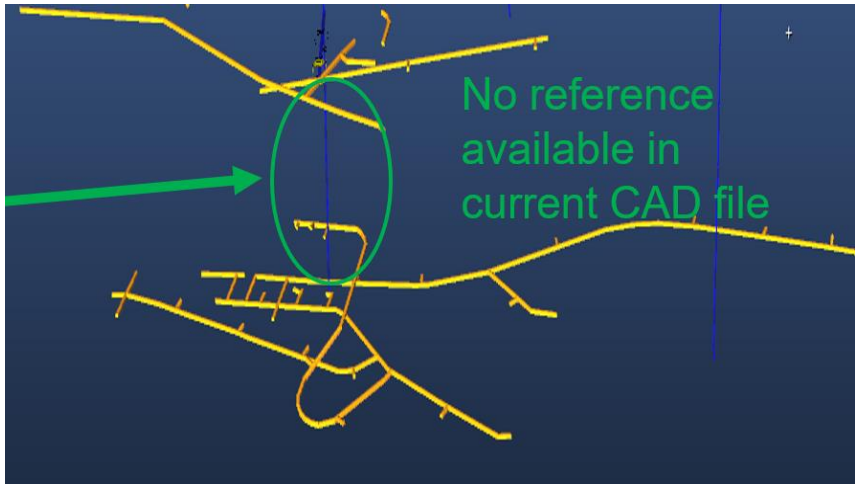
- Airflow quantity of the updated model and the measurement still have some big value gaps
- For the upper parts, no conclusion due to the lower number of taken data



Challenges

- New added main ventilation routes cause high differences in values
- New added blockage information could potentially create high discrepancy, which leads to inadequate airflow distribution
- Absence of auxiliary fans was recognized as a main contributor for high-value differences
- Assumed upper-level sections could bring the imbalance into the model as well
- Time gap between the change in infrastructure and documentation can cause missing airways that lead to an inaccurate model



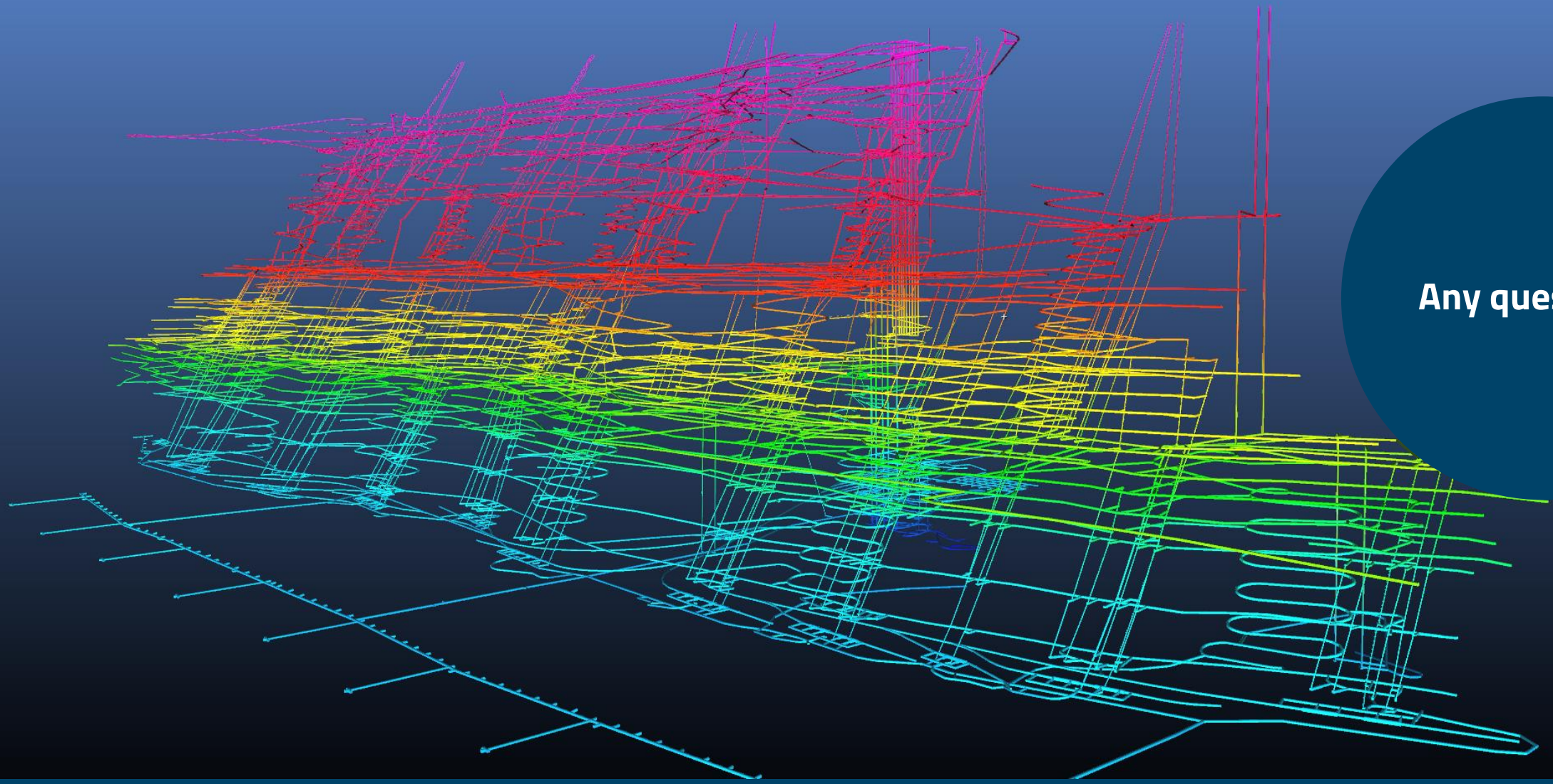


Further work

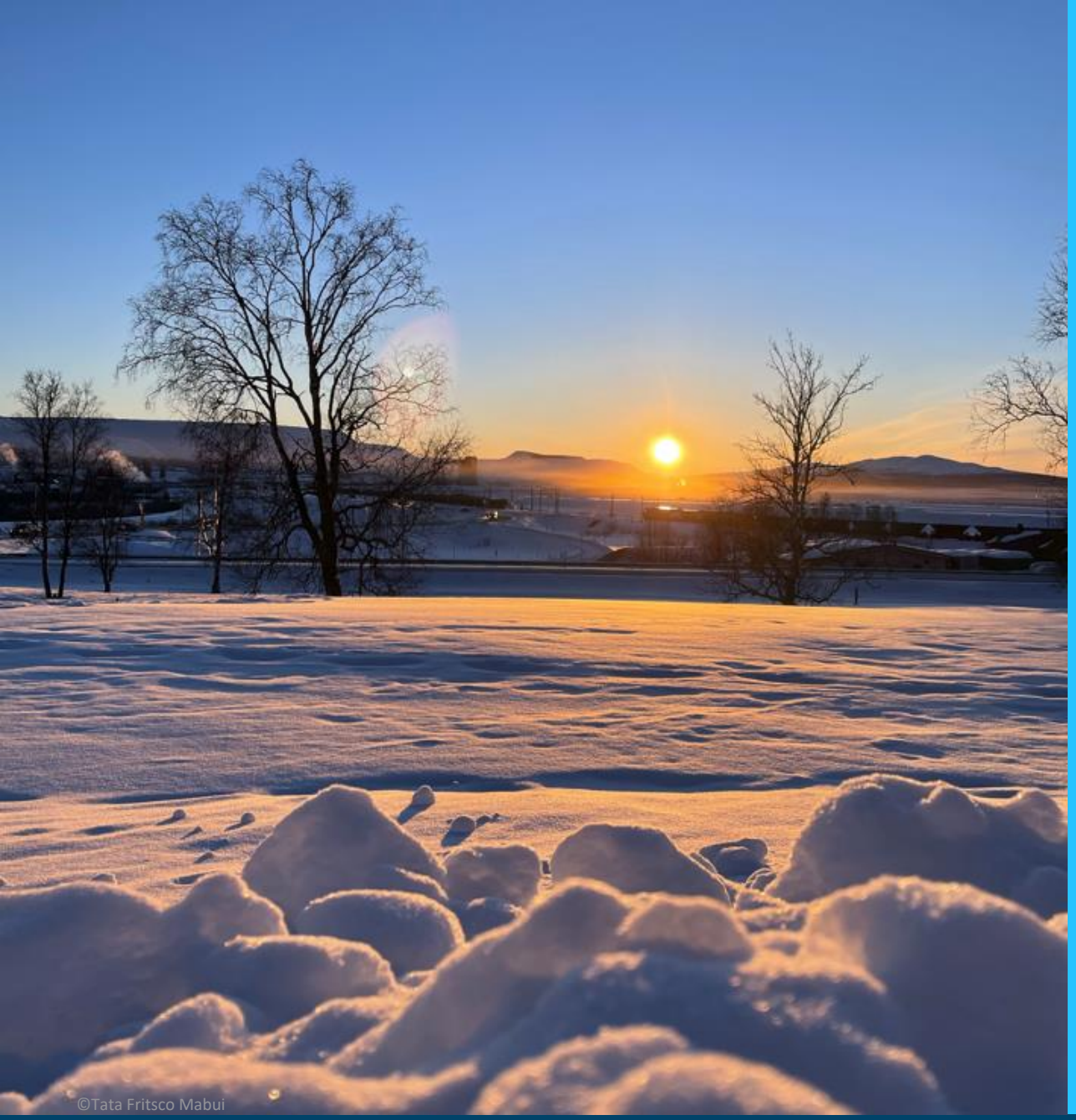
1. Inclusion of secondary fans and footwall drift ducts
2. More accurate evaluation of resistance values
3. Taken more detailed information from upper-level
4. Continue mine ventilation mapping to find blockages for proper airflow distribution
5. Continue updating the airways

Summary

- The level of detail of the previous Kiruna mine ventilation model was increased
  - More detailed parameters were used (e.g. old shafts, upper-level areas, and other previously excluded connections)
  - Adjusting the model based on the available information (e.g. Deswik files actual airway profile size) and the findings through fieldwork (e.g. blockages)
- The usability of the model was improved
  - The model is now organized based on functionality (airway types, mining blocks, and level separation)
  - Changes are available in the model
  - Overall, the discrepancy between measured and modelled airflows is still high, but improvements have been observed
- Continued work to further strengthen the model



Any questions?



Thank you for your attention