

UNR's Universal Thermal Model Tests for RA Performance Verification

Presenter

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Contributed by

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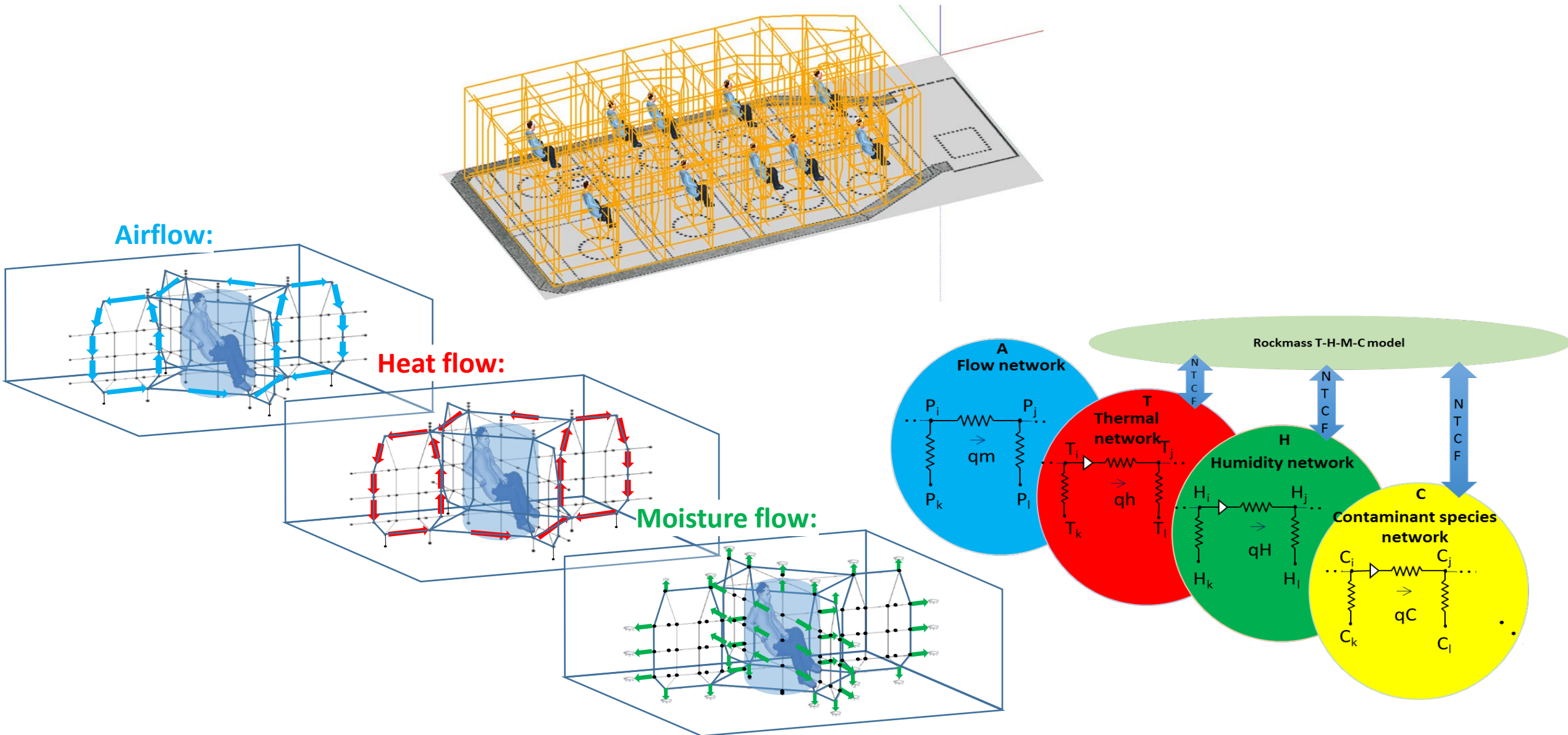
Refuge Alternatives Workshop, June 7, 2017

OUTLINE

- What is UNR's **U**niversal **T**hermal, **H**umidity, and **A**ir (UTHA) Model?
- How can mines use the UTHA to verify RA compliance with regulations?
- What needs to be done to release a commercial version of the UTHA?
- Results to date
- Next steps

What is UNR's UTHA Model?

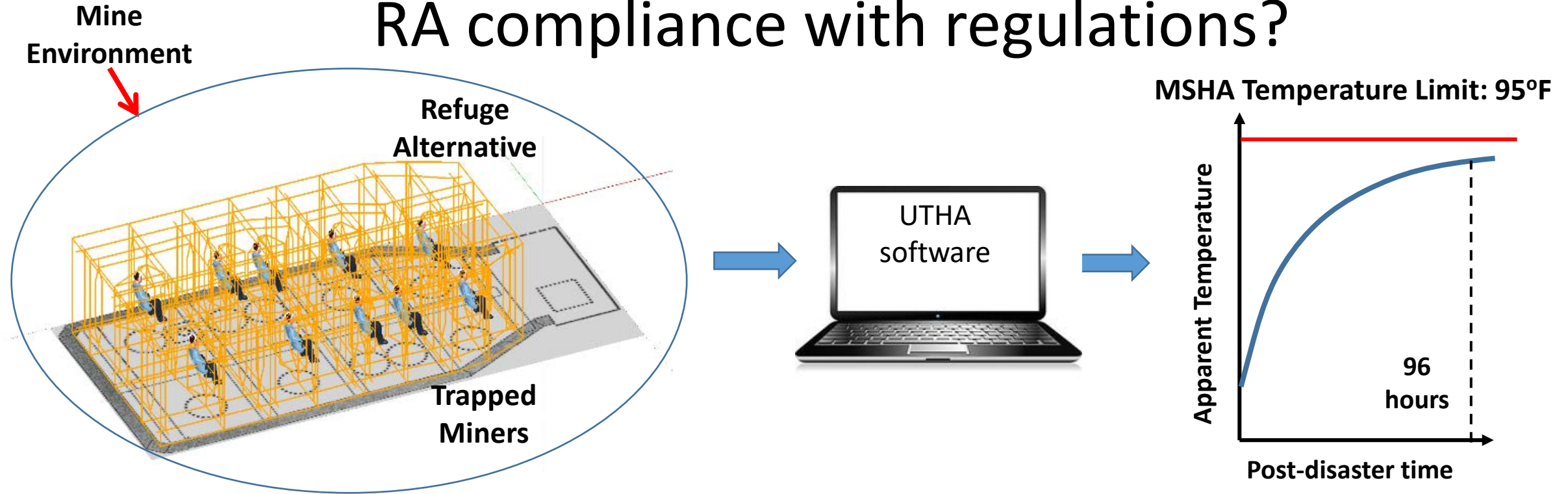
Example: Thermal network model of 10-person RA from initial NIOSH tests



How can mines use the UTHA to verify RA compliance with regulations?

- The **MINER Act** (Public Law 109-236) passed by Congress in 2006 requires installation of refuge alternatives in underground coal mines
- RAs must comply with the regulations set by MSHA on March 2, 2009 (30 CFR 7 and 30 CFR 75)
- The requirements include that the RAs must support life for **96 hours** by providing breathable air
 - Maximum **CO₂** concentration of **1% (0.5% in WV)**
 - Maximum **apparent temperature** of **95°F**

How can mines use the UTHA to verify RA compliance with regulations?



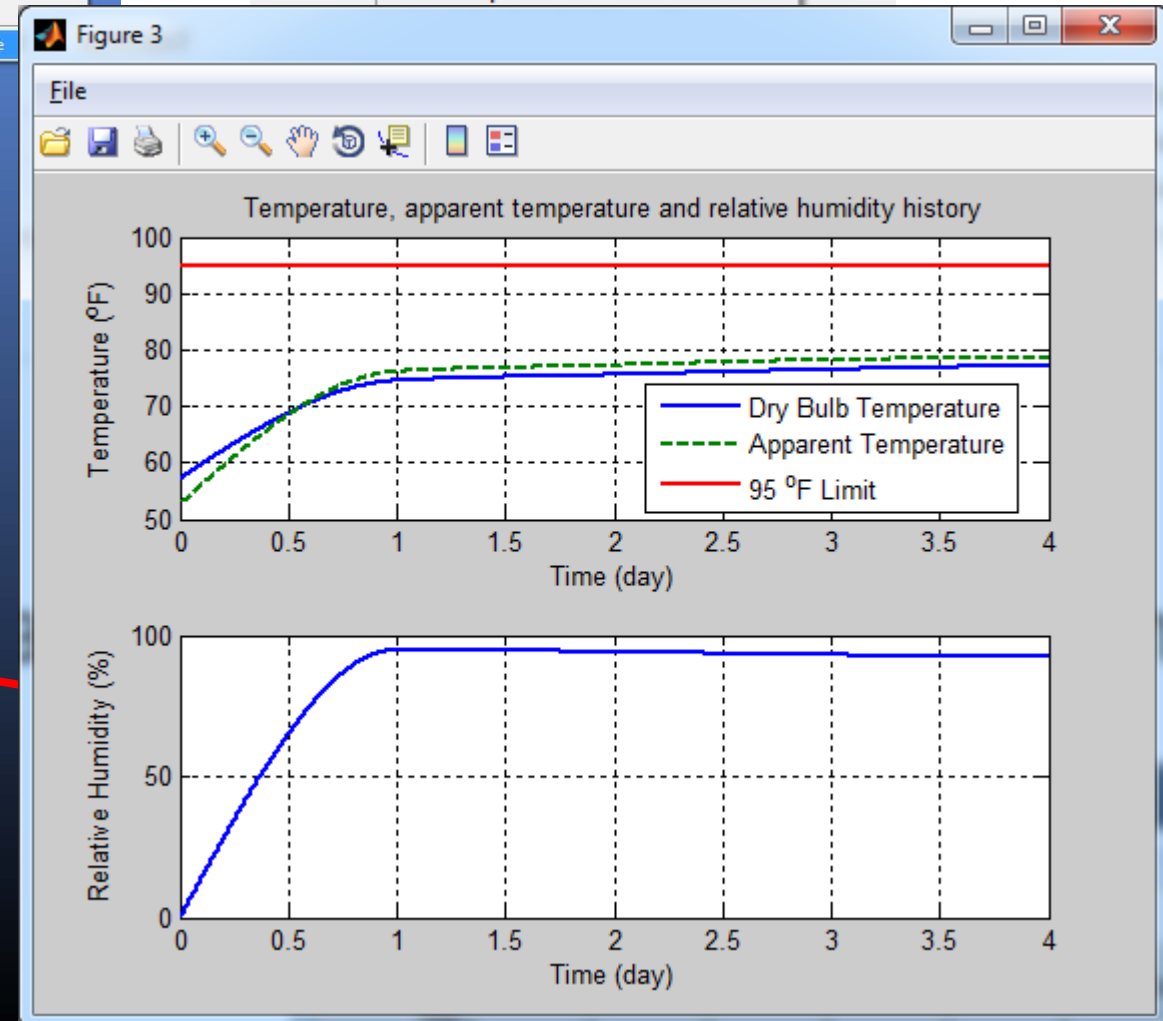
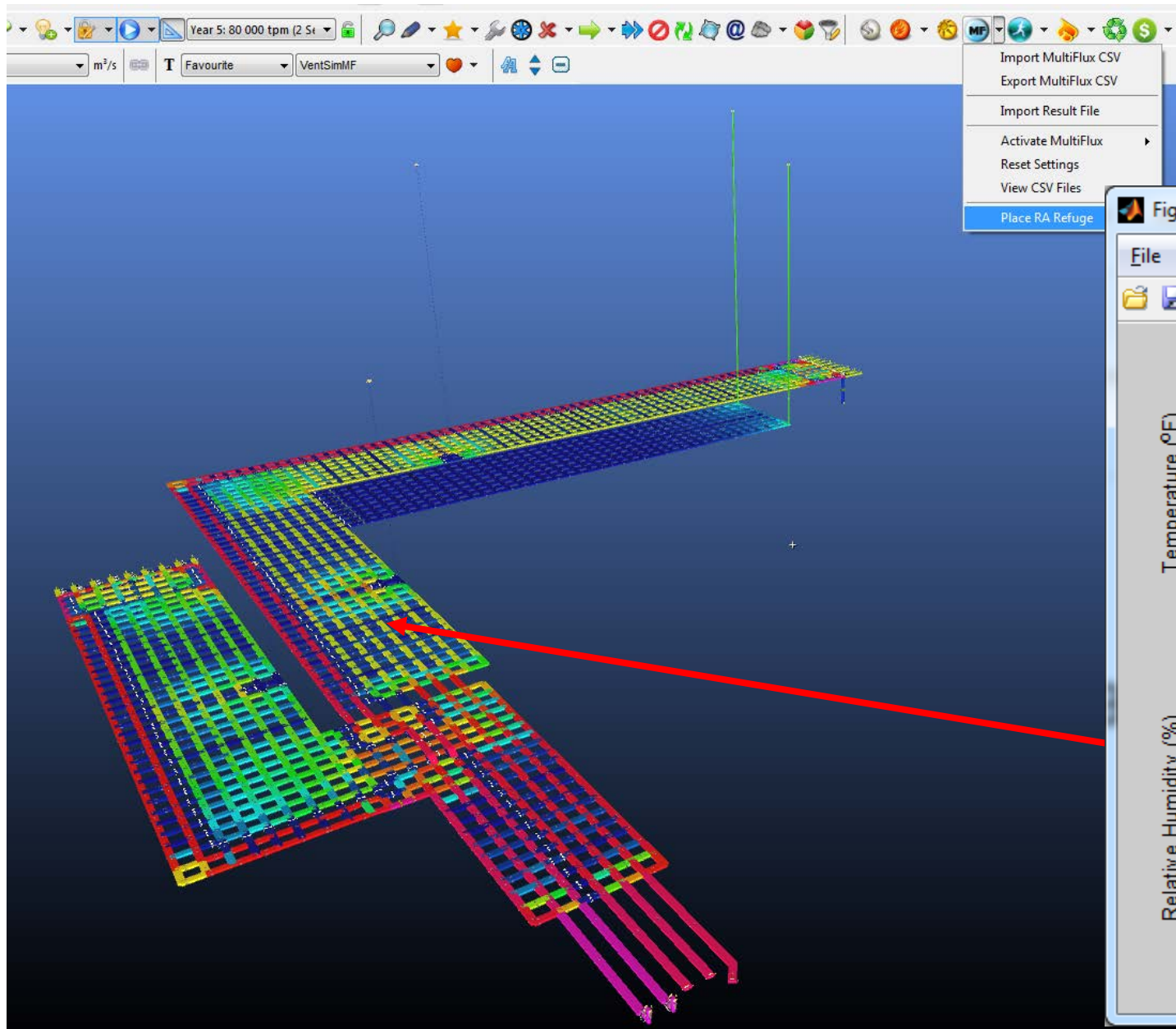
Step 1. Set-up **UTHA** for the RA from easy-to-use Graphical User Interface (GUI) in Ventsim

Step 2. Enter ambient conditions for the given mine at the RA

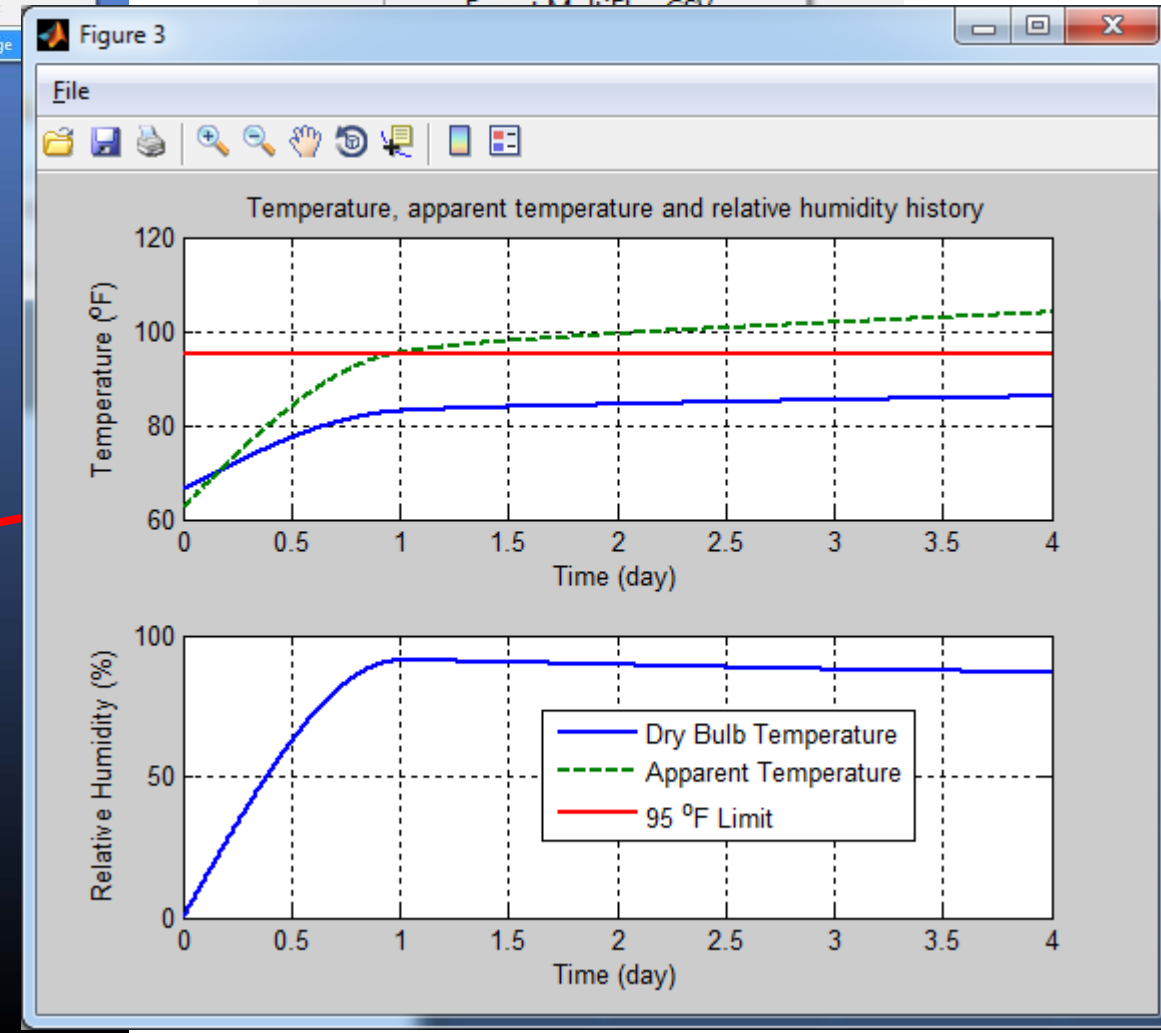
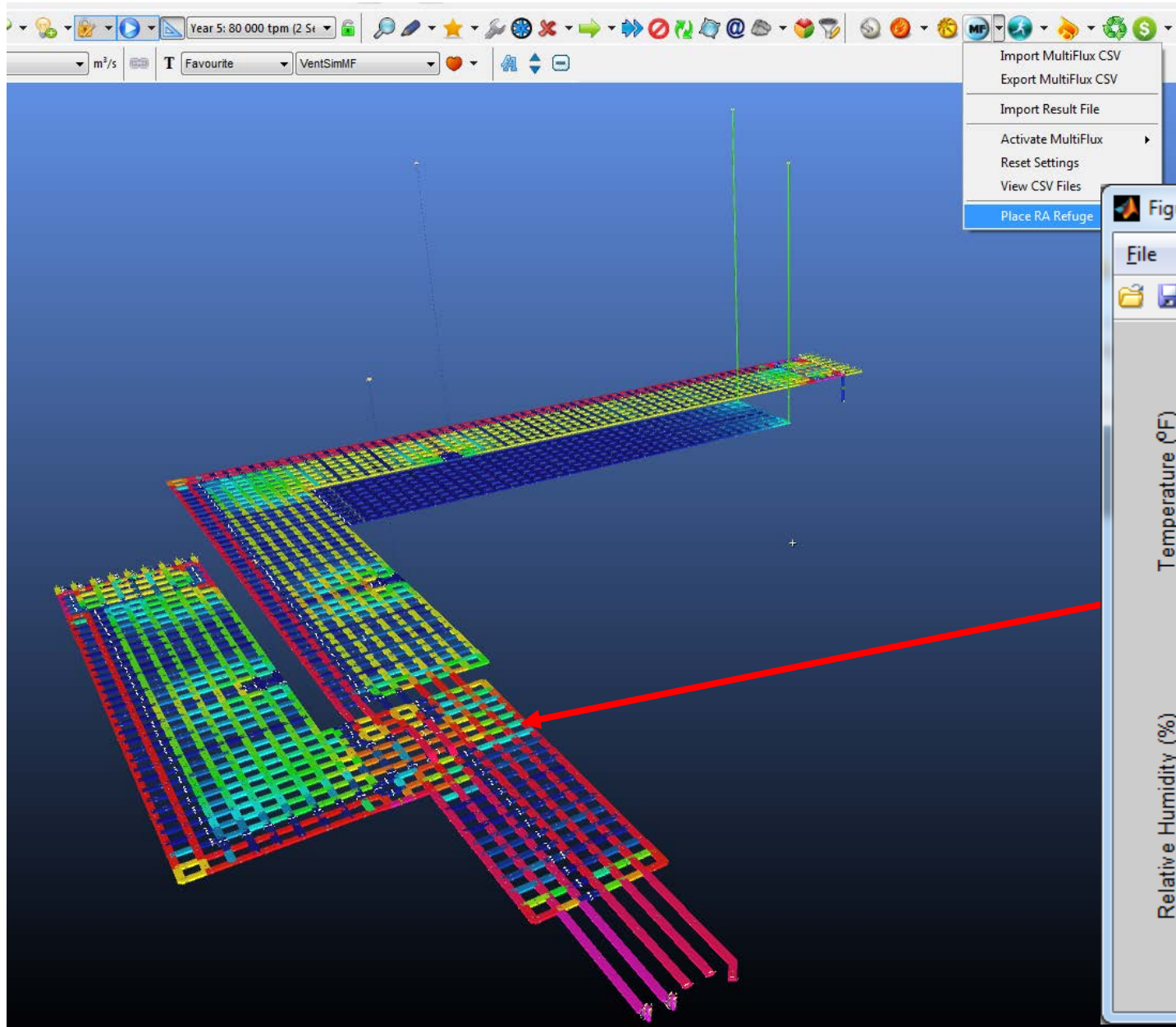
Step 3. Run the UTHA model for the mine and check for compliance

Step 4. If the RA is not in compliance (too hot or too cold), use mitigation techniques simulated by **UTHA**

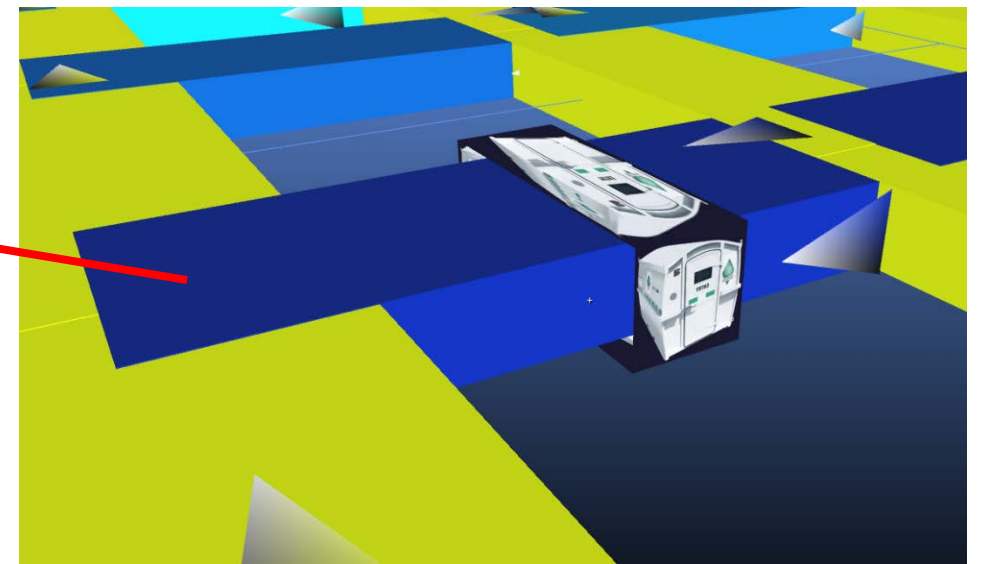
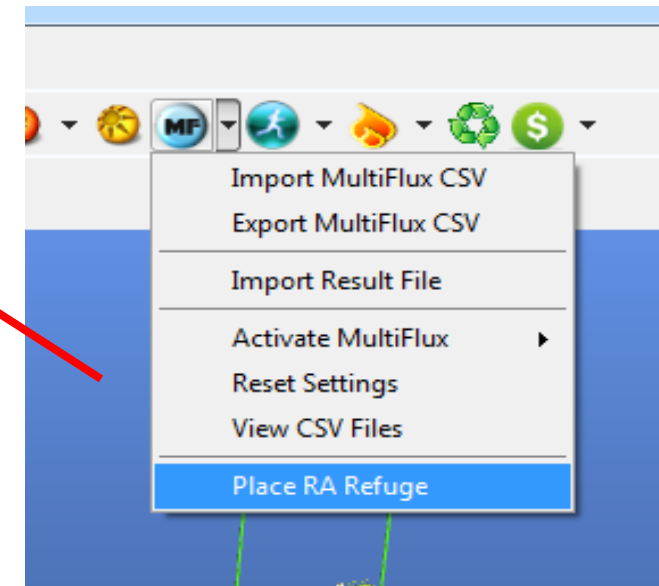
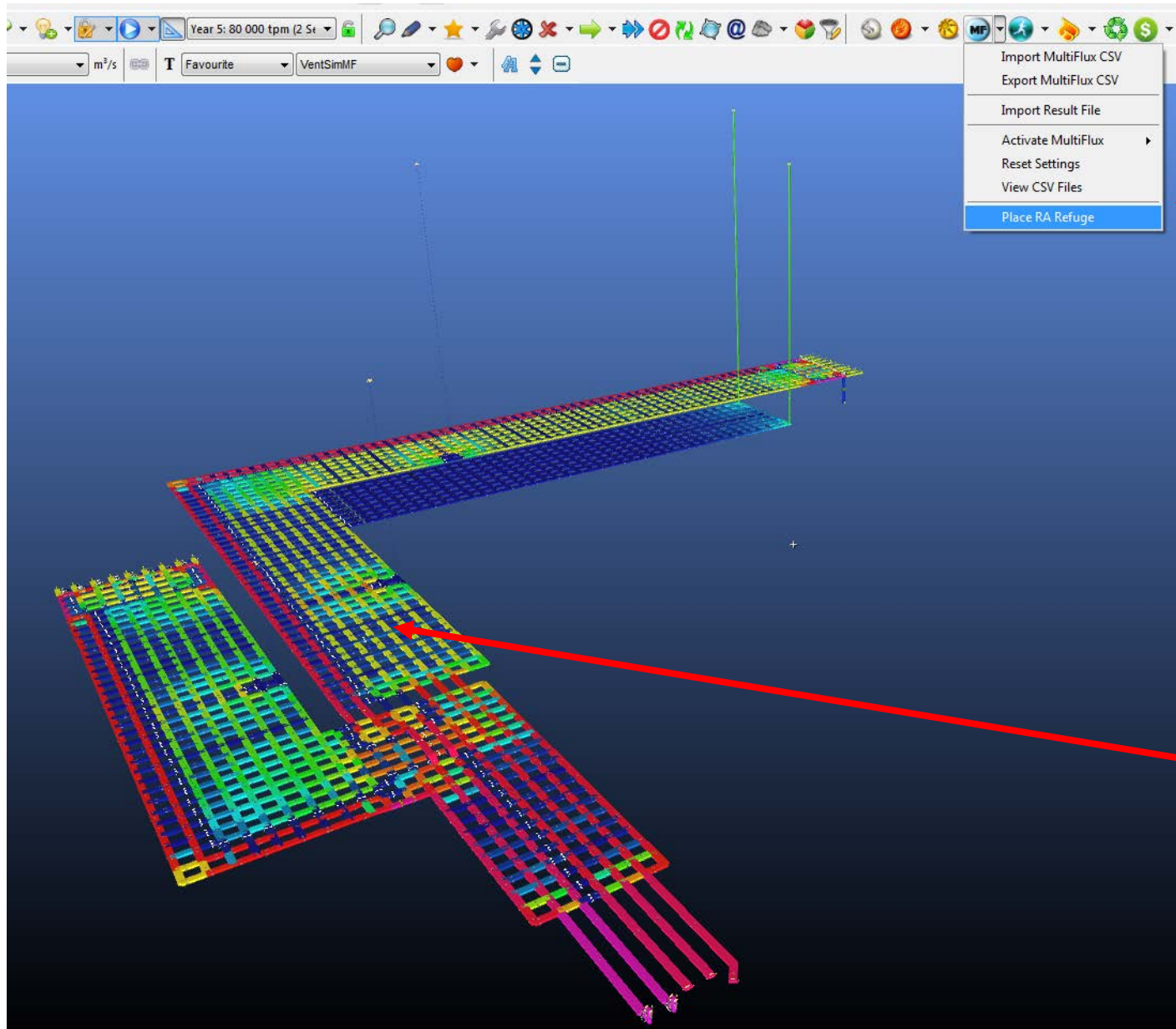
The UTHA model may show that the RA **is** in compliance with the AT limit (the AT limit is not reached within 96 hours)



The UTHA model may show that the RA **is not** in compliance with the AT limit (the AT limit is reached in less than 96 hours)



The UTHA model for heat transfer is undergoing the last tests and will be included in the Ventsim mine ventilation and fire simulation software

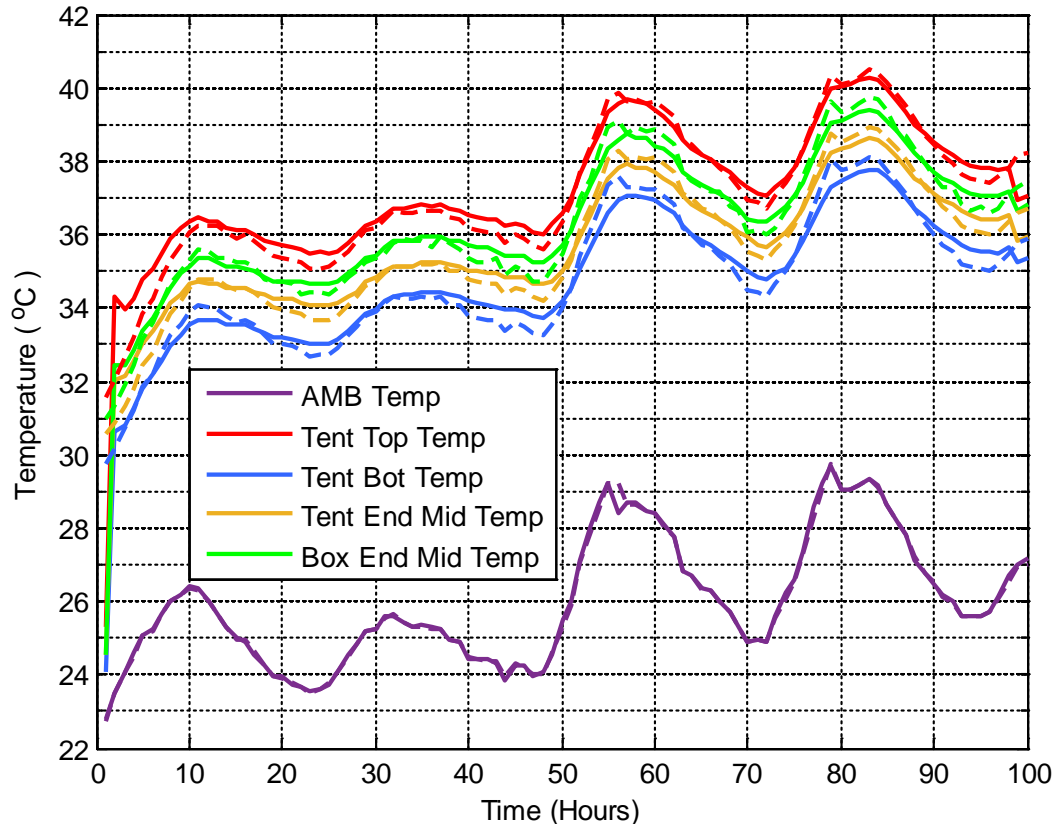


What needs to be done before releasing a commercial version of the UTHA?

The UTHA model is undergoing the last steps prior to being included in the Ventsim mine ventilation and fire simulation software:

Report comparing model data and dry test data for the 23-person tent-type RA.	Completed, accepted
Report comparing model data and all dry/wet test data for the 23-person tent-type RA.	Completed, accepted
Report comparing model data and dry test data for the 6-person rigid-type RA.	Completed, accepted
Report comparing model data and all dry/wet test data for the 6-person rigid-type RA.	Completed, accepted
Report summarizing changes to UHTA model including verified model elements (6/15/17)	Ongoing, to be completed
Non-commercial-use copy of UHTA software with updates resulting from this contract (7/15/17)	Ongoing, to be completed

Results to date: a challenging model verification example



10-person RA: Temperature comparison between UTHA and NIOSH measurements averaged over 92-96 hours:

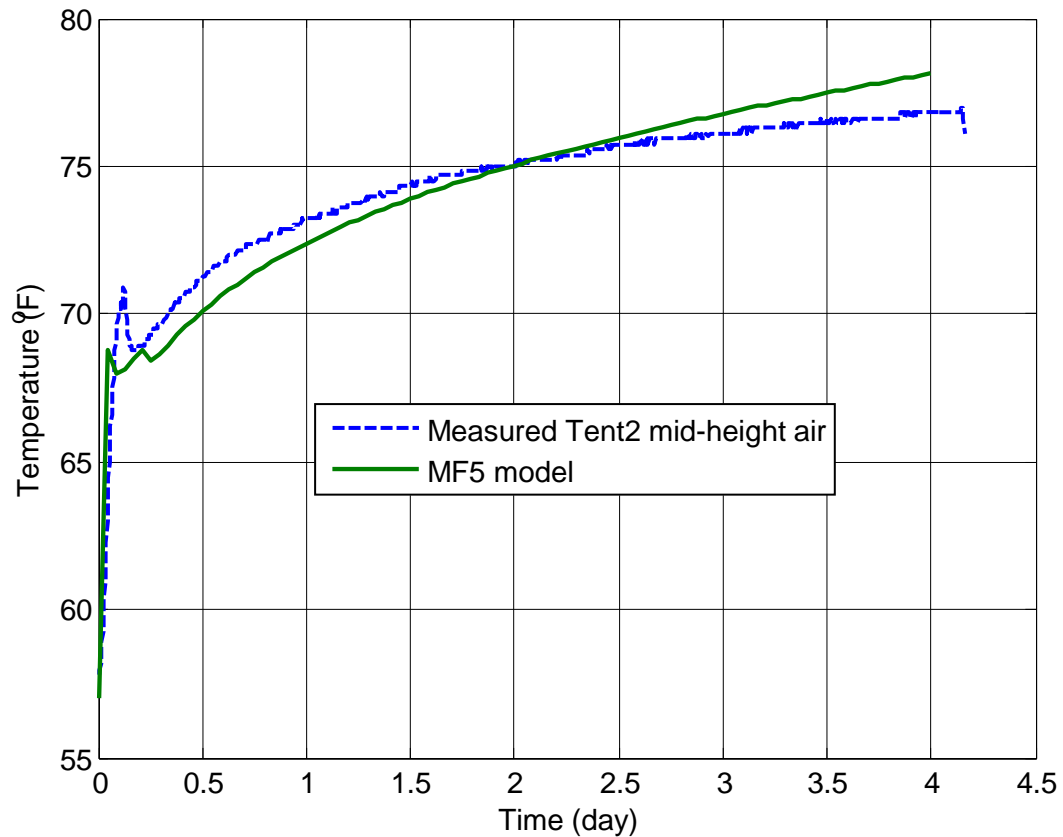
Location	Measured [°C]	Simulated [°C]	Difference [°C]
Tent Top Temp	37.9	37.6	0.3
Tent Bottom Temp	35.7	35.2	0.5
Tent End Mid Temp	36.6	36.2	0.4
Box End Mid Temp	37.2	36.8	0.3

- The UTHA model can predict temperatures in the RA to within 0.4 °C (0.7 °F) error of fit
- The agreement is excellent even under strong dynamic outside temperature variations

Results to date: typical model verification example results comparing UTHA simulations and NIOSH measurements

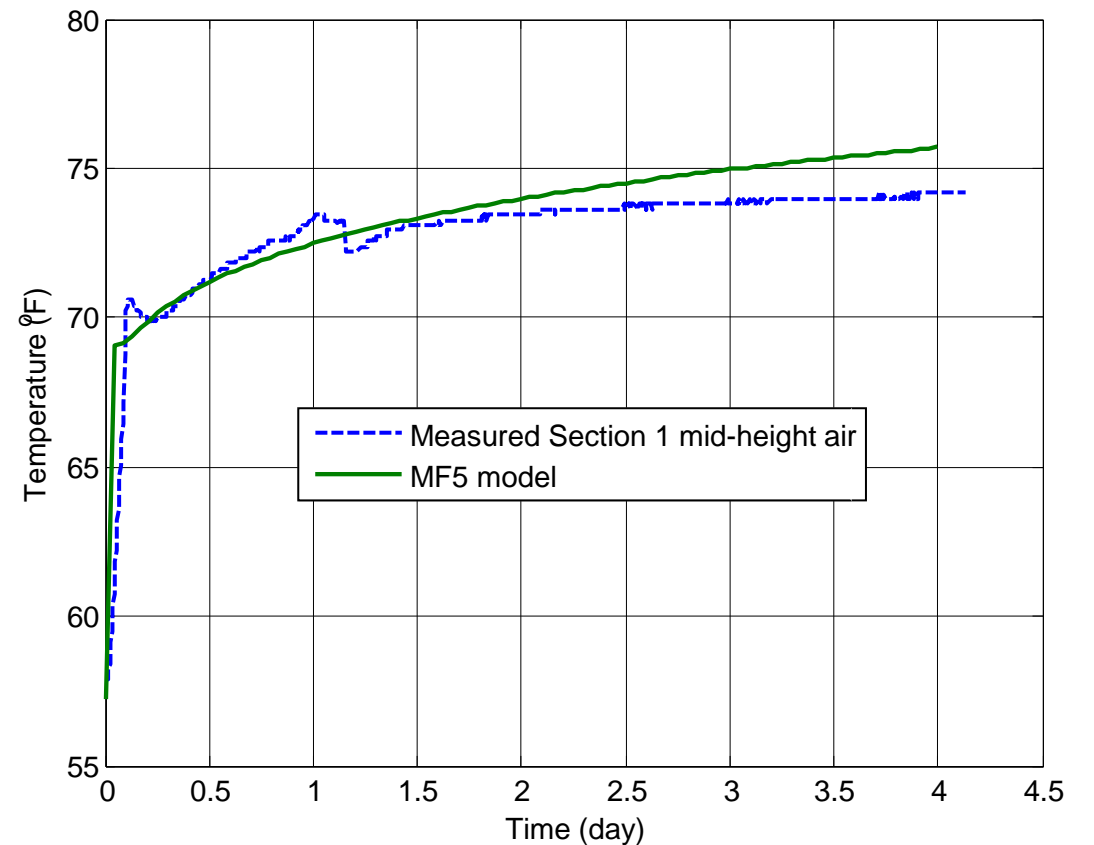
23-person RA:

Comparison between the measured and simulated air temperatures at section 2, mid height location



6-person RA:

Comparison between the measured and simulated air temperatures at section 1, mid height location



Next steps for built-in UTHA features

- Complete the GUI tests in Ventsim with expanded menu for mitigations if thermal compliance is not met for the RA at the mine site defining:
 1. Rate of Air Exchange in the drift/alcove by outside air movement
 2. Rate of Air Exchange in the RA, with compressed air supply at initial air temperature
 3. Rate of Air Exchange in the RA, with compressed air supply at T_{in} air temperature
 4. Rate of Air Exchange in the RA, with internal air re-circulation by battery-powered fan
 5. Floor pad cooling by water circulation under RA
 6. Evaporative RA cooling by drip-wetted outside surface
- Complete the GUI tests in Ventsim for configuring sweating human occupants with wet skin and clothing dripping sweat instead of vapor injection into the air space of the RA

Conclusions and Recommendations

- UNR's UTHA RA model is easy to configure in a graphical environment
- Only the RA manufacturer's data, and some common data from the mine are needed to start the model simulation
- The UTHA model solves for temperature, humidity, condensation, and air movement within the RA space over 96 hrs in a few minutes run time
- The UTHA model can determine acceptability of RAs for any in situ mine condition without the need to test RAs at the mines
- The UTHA model (both beta-test and commercial versions) has acceptably matched the results of over one dozen NIOSH RA heat/humidity tests

ACKNOWLEDGMENTS

- NIOSH for the financial support for the development and extended tests of the UTHA model for RAs
- Craig Stewart and Craig Christensen at Chasm Consulting, Australia, for the cooperation with UNR in the development of the GUI for the RA UTHA model

Thank You !

Questions?