New Directions in R&D in order to decrease methane hazard and to increase CMM capture - based on GIG experience

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Experimental mine „Barbara”
Department of Gas Hazard Control

Typical problems at gassy coal mines

- Ventilation and Gas Emissions Management in Coal Mines
- Development of Improved Methane Drainage Technologies by Stimulating Coal Seams for Major Risk Prevention and Increased Coal Output
- Monitoring, Assessment, Prevention and Mitigation of Rock Burst and Gas Outburst Hazards in Coal Mines
- Prediction and mitigation of methane explosion effects for improved protection of mine infrastructure and critical equipment

CMM related projects

- **AVENTO** (Ventilation and Gas Emissions Management in Coal Mines),
- **MAPROC** (Monitoring, Assessment, Prevention and Mitigation of Rock Burst and Gas Outburst Hazards in Coal Mines),
- **GASDRAIN** (Development of Improved Methane Drainage Technologies by Stimulating Coal Seams for Major Risk Prevention and Increased Coal Output),
- **EXPRO** (Prediction and mitigation of methane explosion effects for improved protection of mine infrastructure and critical equipment),
- **EPA2** (A first feasibility study for cost effective methane degassing and capture ahead of mining operations to reduce methane emissions in Poland during mining (Pawłowice 1 coal field).

AVENTO

Advanced Tools for Ventilation and Methane Emissions Control

Research Fund for Coal and Steel (RFCS)

AVENTO had four basic aims:

1. To develop **new concepts** on environmental (**methane** and **ventilation monitoring systems**), taking into account the new risks appearing in the current and future production fields, in order to improve the safety and climatic conditions at the working areas.

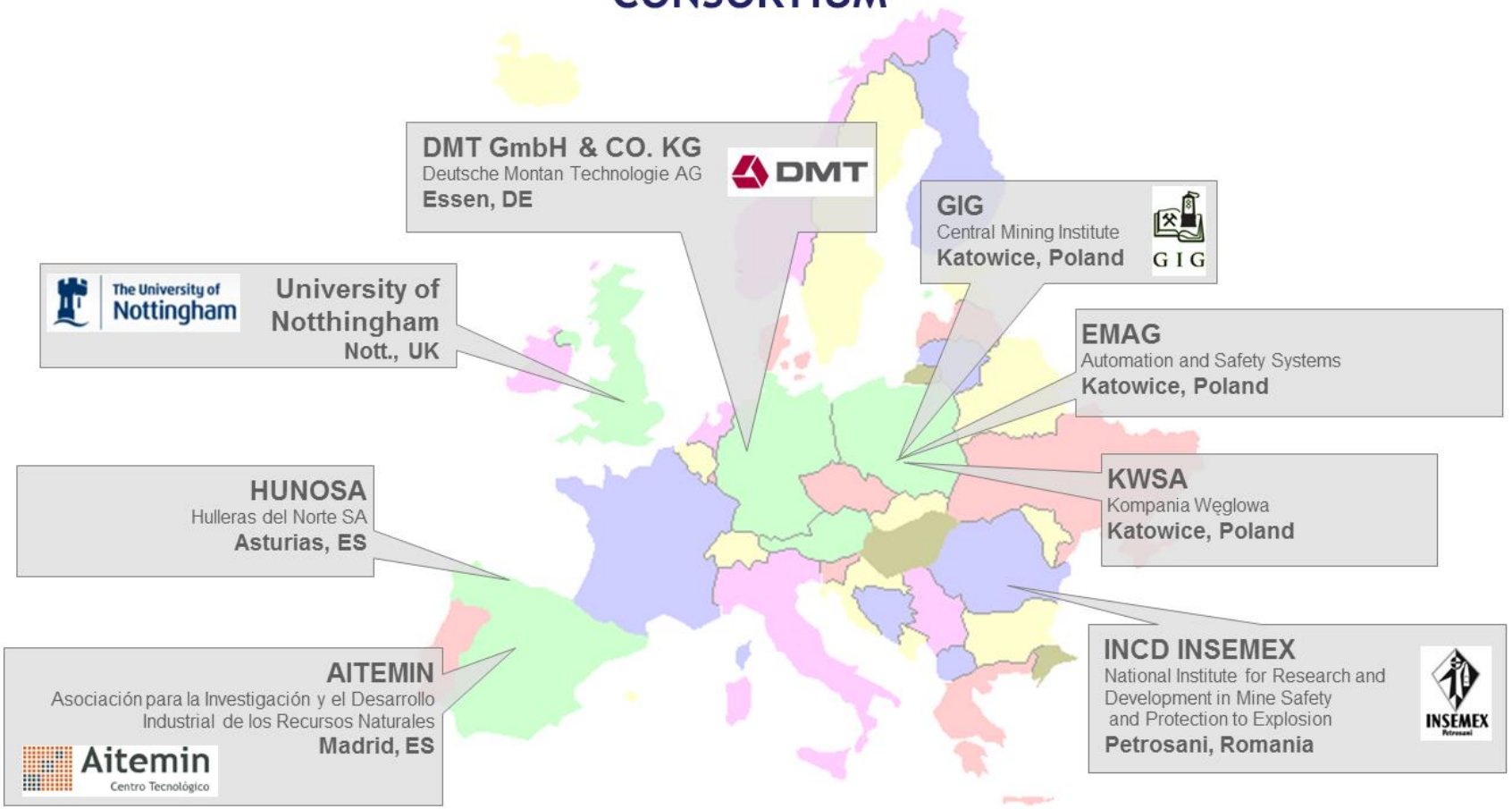
2. To use these new concepts for promoting a transition from a ***Prescriptive*** ventilation implementation / management model (fixed air flows have to be maintained) to a ***Performance- based*** one (*VOD* or *Ventilation on Demand*, supply the air when and in the amount actually needed).

3. To use these new concepts as an important aid to manage emergency / post-emergency situations: fires, fire-fighting, collapses, gas outburst and explosions, etc.

4. To **reduce the costs** involved in **ventilation**, analysing different aspects such as the dynamic regulation of air flow (the aforesaid *"Ventilation on Demand"*, and new systems of main fans control for better efficiency and reliability.

AVENTO

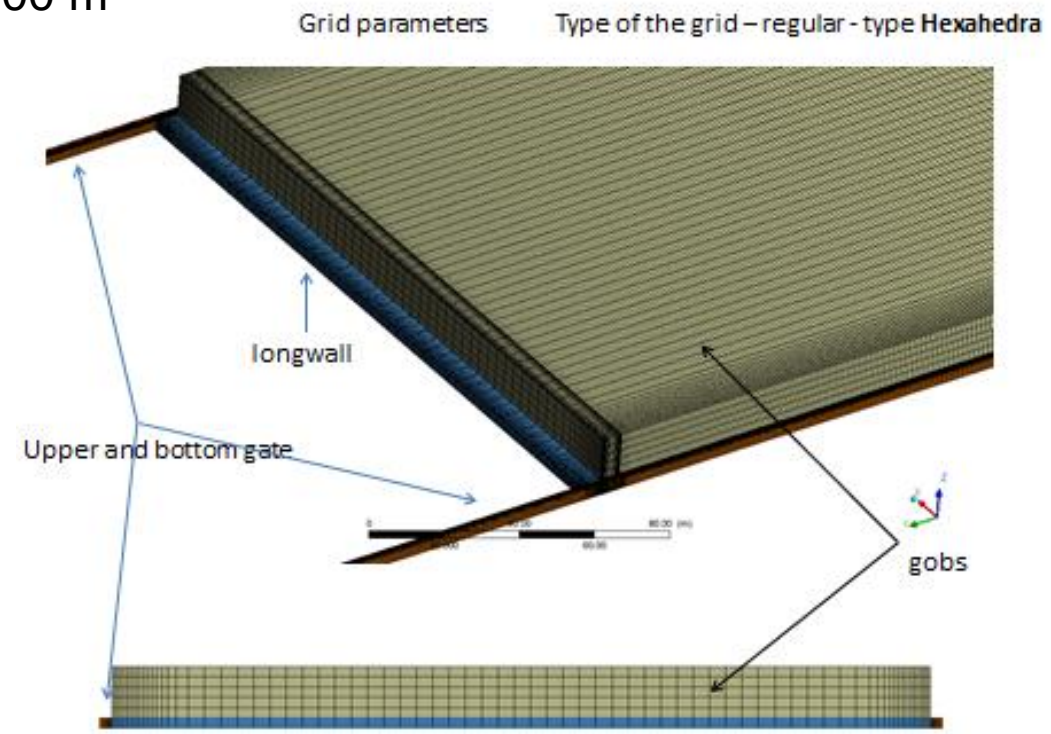
CONSORTIUM



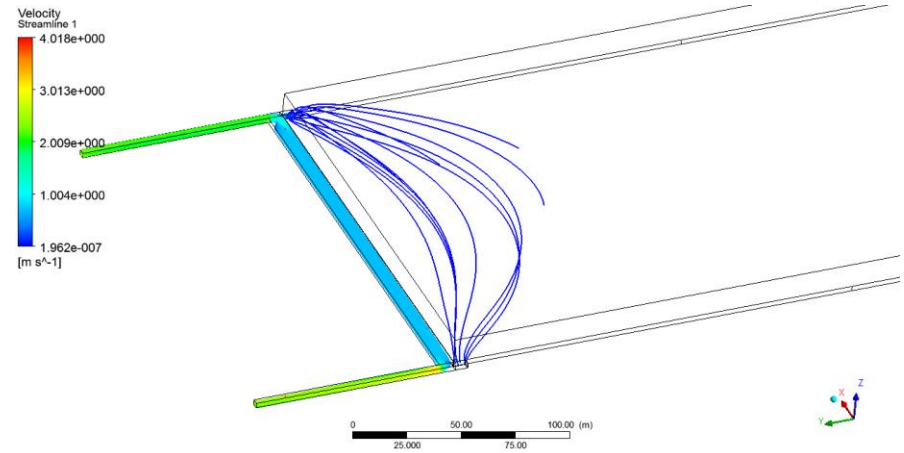
Discretization of the Model 3D nr 1 – variant ventilation of the longwall at Y

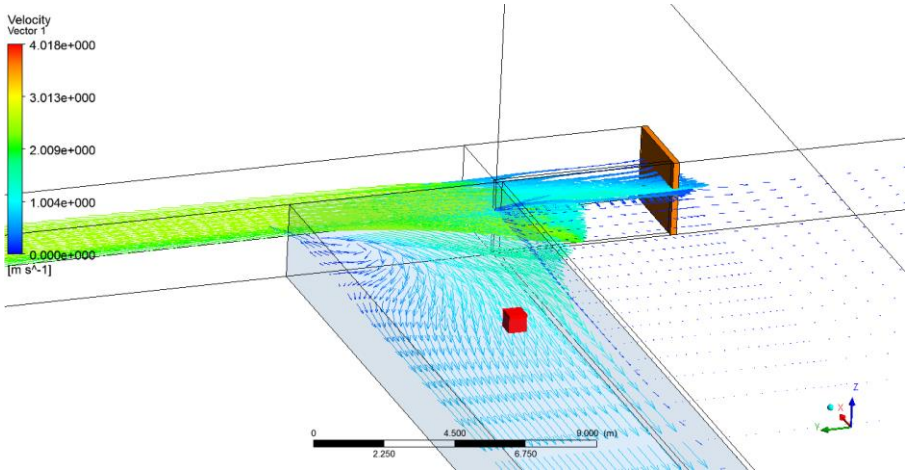
The assumptions for the geometric model are as follows:

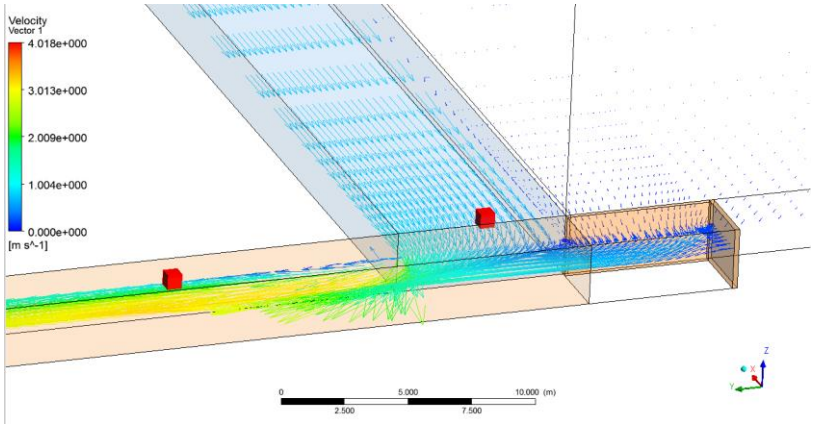
- The width of the longwall panel: 200 m
- The length of the longwall panel: 1000 m
- Longwall height: 2,5 m
- Roadway working's high: 2,5 m,



Velocity distribution simulation results in the environment of the ventilated longwall in „U" type system with the locations of the methanometry sensors

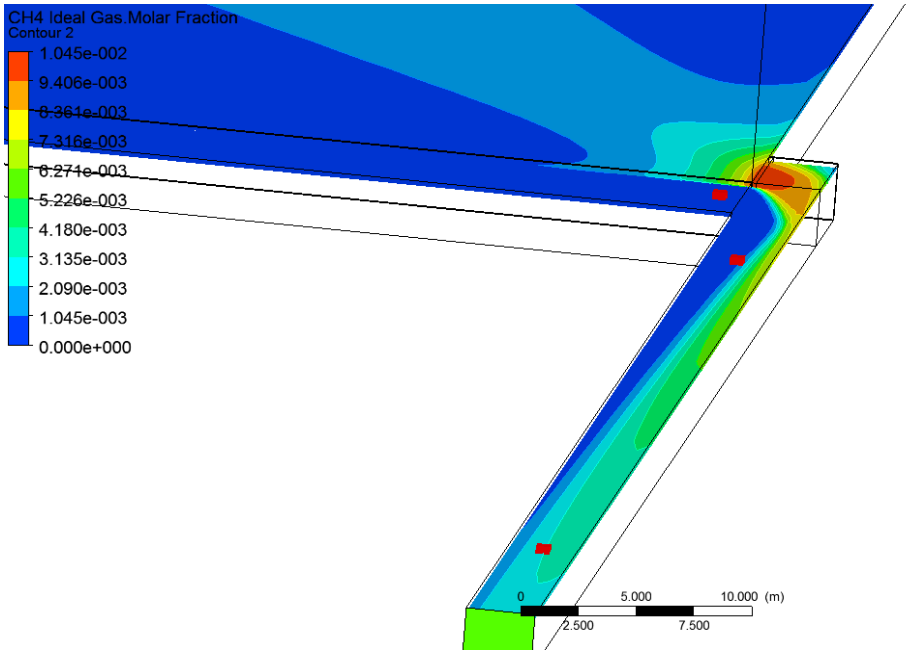


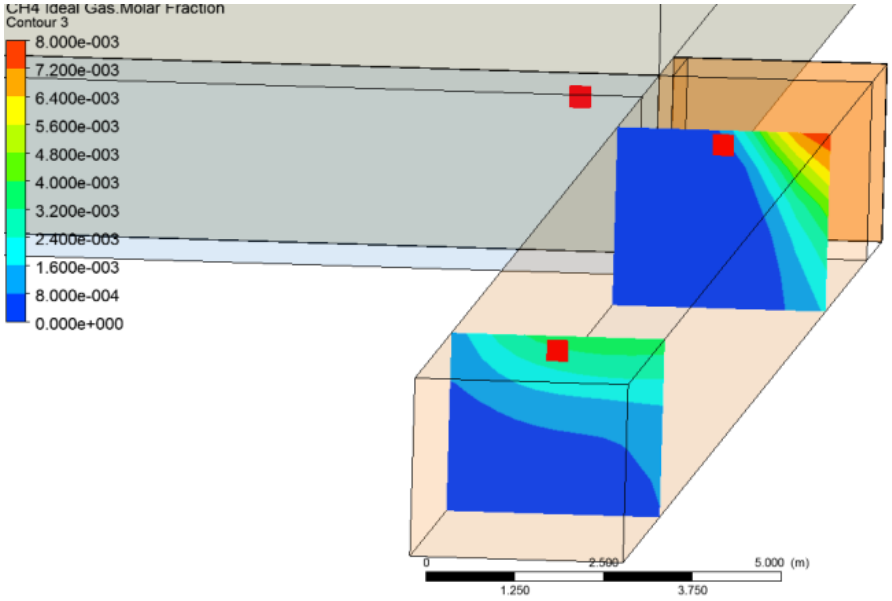




GIG

The methane concentration simulation results in the environment of the longwall outlet ventilated in „U" type system with the locations of the methanometry sensors.





The following figures show the proposed location of the methane sensors in the area of intersection of the wall with ventilation gangways with the “U” type ventilation system along the body of coal using geometric models at the assumed conditions of gas ventilation system 3D and 2D graphical diagram of the intersection.

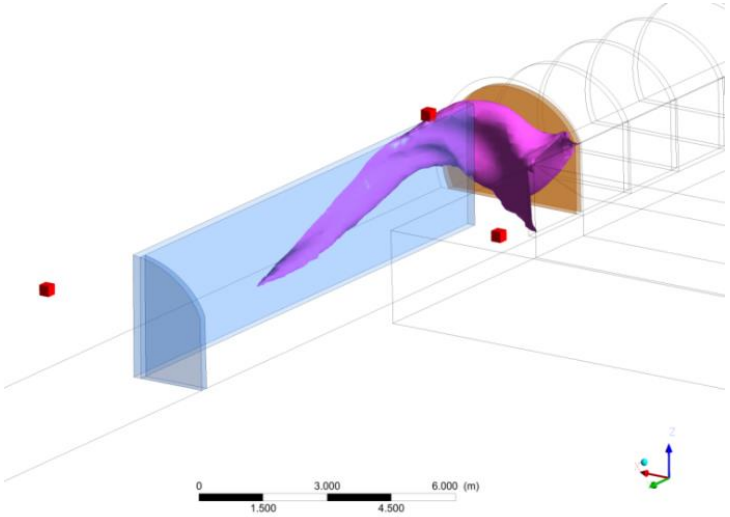
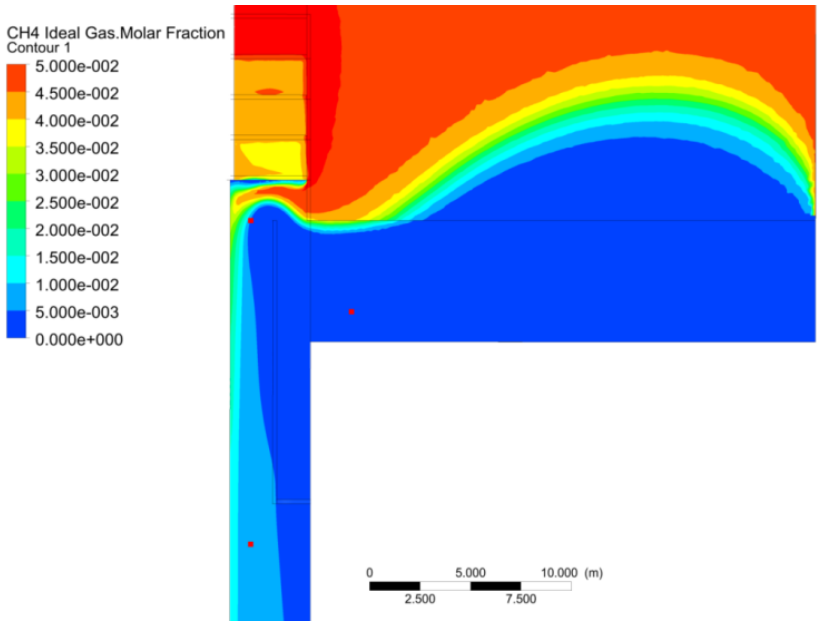


Figure shows the re-formation of the boundary surface of 3% methane concentration in the ventilation roadway (2m) liquidated by insulation dams, the conditions of ventilation and methane Q = 10 m^3/min,



Location of methane sensors at the intersection of longwall ventilated in the “U” type system with the ventilation roadway (imprinted boundary surface of 3% CH_4 methane concentration in the ventilation roadway liquidated by dams insulation, the conditions of ventilation and methane Q = 10m^3/min,

GasDrain

Research Fund for Coal and Steel (RFCS)

Developement of Improved Methane Drainage Technologies by Stimulating Coal Seams for Major Risks Prevention and Increased Coal Output

Primary Objective of proposed GASDRAIN project is to:

"*investigate and research into borehole stimulation techniques and develop novel and improved methane drainage technologies, which will break the existing technological barriers and help increase safety and productivity in coal mines*"

The GasDrain project aims to investigate the potential for the application of four different borehole stimulation techniques, namely:

1. hydraulic fracturing,
2. open or cased hole cavitation,
3. high pressure water jet slotting,
4. and the use of explosives to stimulate coal seams and the surrounding rock strata through laboratory experiments, numerical modelling and extensive field testing of the developed techniques at different mining conditions.

GIG

GasDrain - basic facts:

- **Realisation time: July 2015 – June 2018** (48 months)
- **Budget:** 3.8 mln €, including 1.1 mln € GIG
- **Partners:**
  - **GIG (Poland) – project coordinator (prof. Janusz Makówka)**
  - **JSW (Poland),**
  - **INIG-PIB (Poland),**
  - **Imperial College (UK), RWTH (Germany),**
  - **INERIS (France),**
  - **HUNOSA (Spain).**

GasDrain structure of the project (Work Packages (WP's)

WP0: Project Coordination and Reporting (GIG)

WP1: Characterisation of Coal Seams and Surrounding Rocks: Field Site Characterisation (RWTH)

WP2: Development of Borehole Stimulation Technologies for Coal and Rock Formations (GIG)

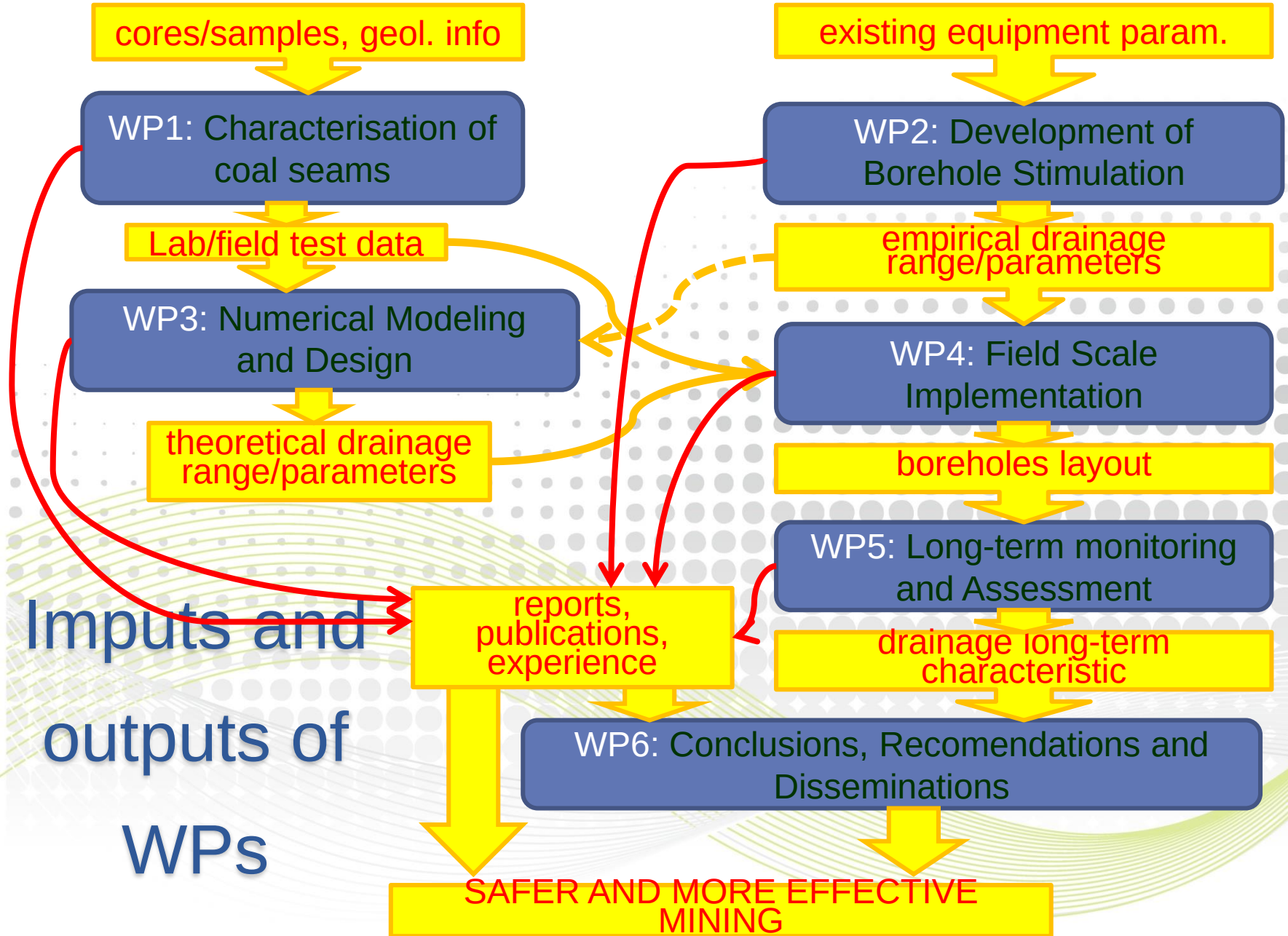
WP3: Numerical Modelling and Design of Field Scale Stimulated Methane Drainage Processes (Imperial College, INIG)

WP4: Field Scale Implementation of Improved Methane Drainage Systems at Mine Sites (JSW SA)

WP5: Long-term Monitoring and Assessment of Improved Methane Drainage Efficiency (AITEMIN)

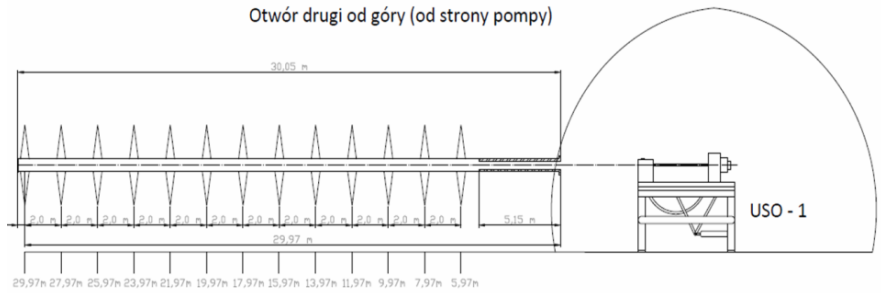
WP6: Conclusions, Recommendations and Dissemination (INERIS)

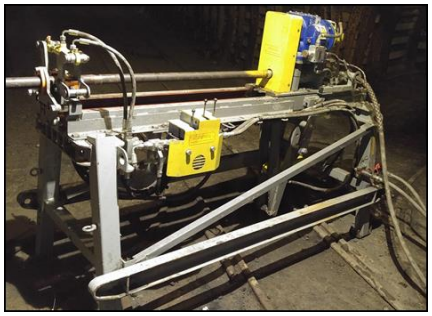
Imputs and outputs of WPs

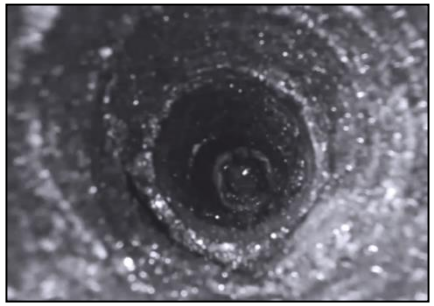


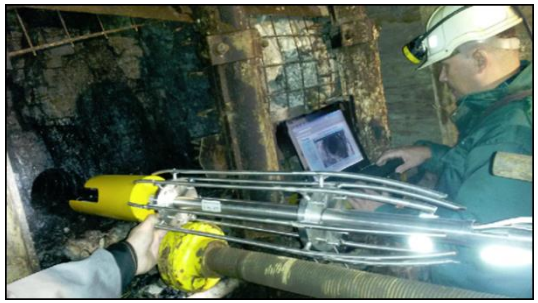
GIG

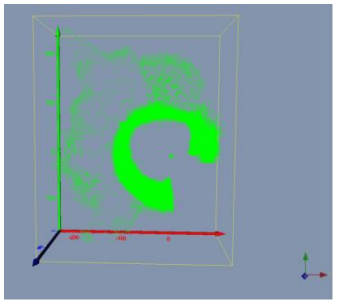
Examples of in situ tests performed in Experimental Mine „Barbara”











EXPRO

Prediction and Mitigation of Methane Explosions Effects for Improved Protection of Mine Infrastructure and Critical Equipment

Research Fund for Coal and Steel (RFCS)

EXPRO - basic facts:

- Realisation time: July 2015 – December 2017 (42 months)
- Total Budget: 2,402,465 €uros
- Coordinator: Central Mining Institute, prof. Krzysztof Cybulski
- Consortium:

Aitemin Centro Tecnológico, INERIS, EMAG, KOMPANIA WĘGLOWA S.A., DTEK, ifsb, GIG

GIG

EXPRO Project overview

The main aim of the EXPRO project is to develop tools and means that can help to adopt measures for mitigating the damages of methane explosions in the mine infrastructure and particularly in critical equipment

The project includes research work in the following areas:

- Obtaining a better understanding of the mechanical and thermal effects caused by methane explosions, by developing numerical models of explosions in different mine geometries and conditions, which will be validated with real scale explosion tests,

- Developing innovative air pressure monitoring systems specifically designed to record data that could serve for the purposes in the investigation after the occurrence of an explosion, and in particular for the determination of the ignition point.

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EXPRO project summary

EXPRO project partners were focused on the realization of WP1,WP2 and WP3 referring to the following activities:

WP1 - Project coordination:

- management and coordination activities,
- organization of project meetings.

WP2 - Development and calibration of explosion numerical models:

- implementation of laminar burning velocity models,
- series of tests to verify the models,
- simulation of gas distribution in large volume (400 m gallery).

WP3 - Development of fast air pressure monitoring system:

- development of a modified sensor with a high response time,
- finalizing the ATEX certification process,
- completion of the software development,
- installation and testing of the system at the “Halemba” mine and during explosion tests at Barbara mine.

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WP 2 Development and calibration of explosion numerical models

Task 2.2: Development of numerical models (led by GIG, AITEMIN, INERIS)

- **Adjustments in combustion models for the following:**
  - 20 dm^3 sphere,
  - 5 m^3 chamber (comparison Gulder model and SCOPE model)
  - 24 m tube for different diameters (150, 250 mm) and shapes (straight, bends)

- **Modeling of gas mixture distribution during real scale tests conditions for:**
  - slow methane occurrence in the working,
  - rapid release of a big methane volume.

- **Modeling of combustion development in real scale tests conditions for:**
  - flame propagation
  - pressure development
  - ignition time
  - temperature

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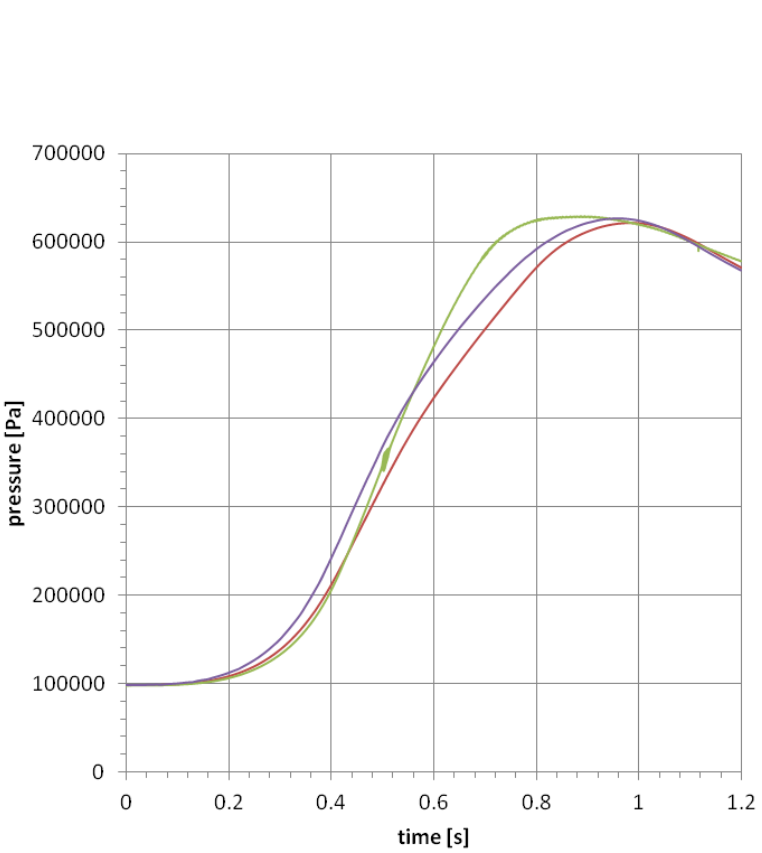
Comparison of pressure in time for tested models (5m^3 chamber)



5m^3 chamber test

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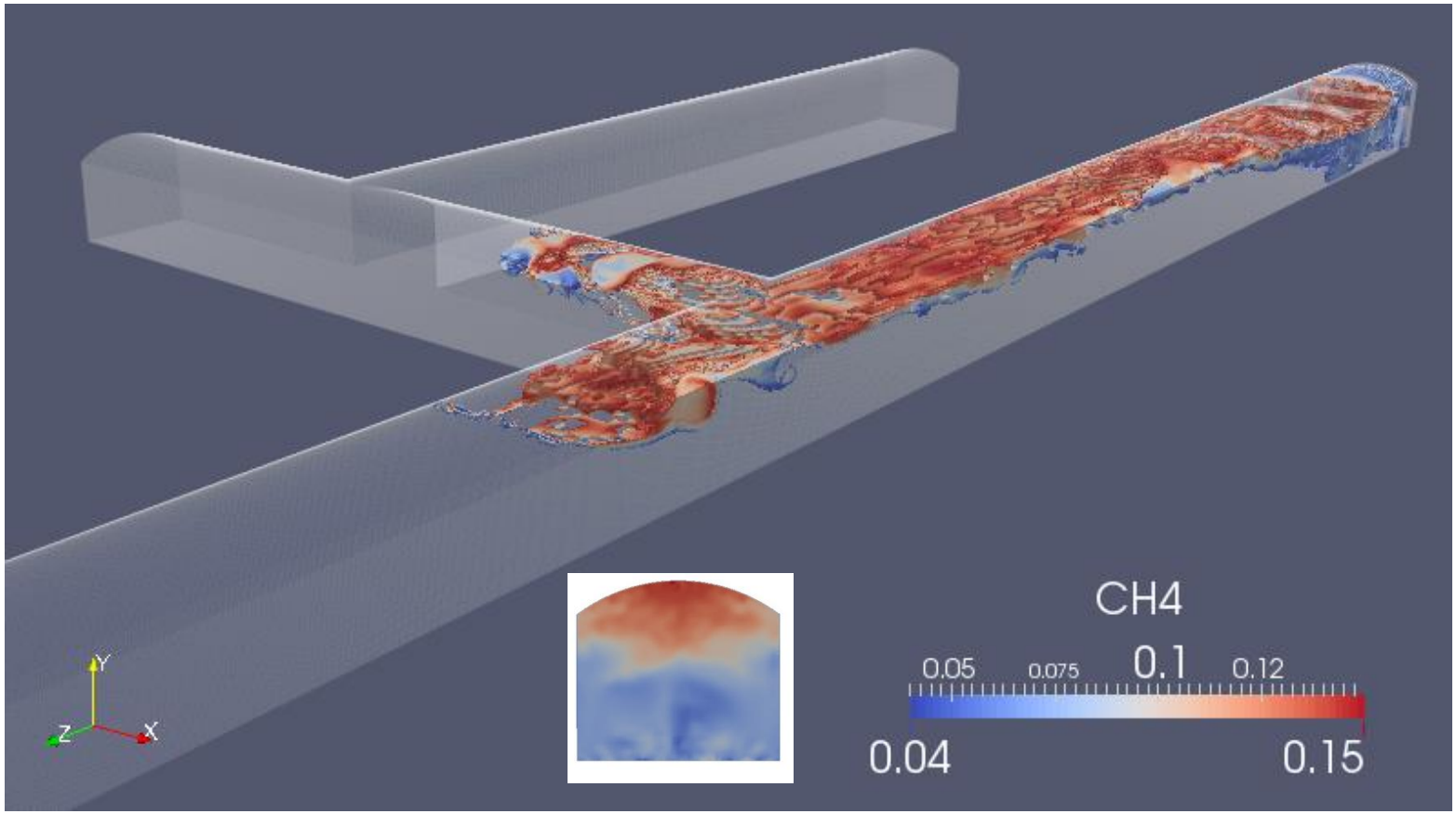
EXPRO modeling of methane distribution for real scale tests conditions (400m gallery)



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WP 2 Development and calibration of explosion numerical models

Task 2.3: Real scale tests (led by AITEMIN & FSB, INERIS, GIG, EMAG)

- **9 tests in the 400 m gallery at Experimental Mine Barbara with two ways in methane distribution applied**:
  - directly from the set of bottles, (slow methane occurrence),
  - using special PCV sleeve (rapid release of a big methane volume).

- **20 tests in the gallery in different configurations at FSB facility**:
  - small scale tests,
  - full gallery tests.

- **Series of tests covering a wide range of set-ups by INERIS:**
  - tube diameter (150, 250 mm),
  - tube inner roughness (plastic, steel),
  - shape of the pipework,

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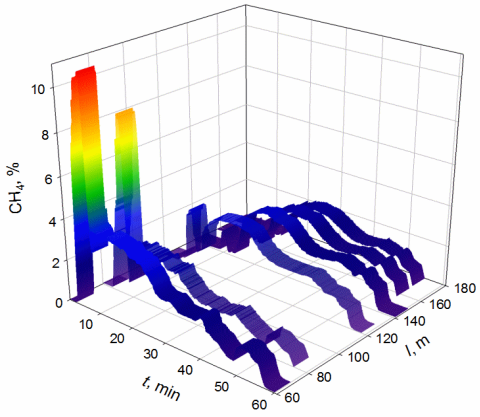
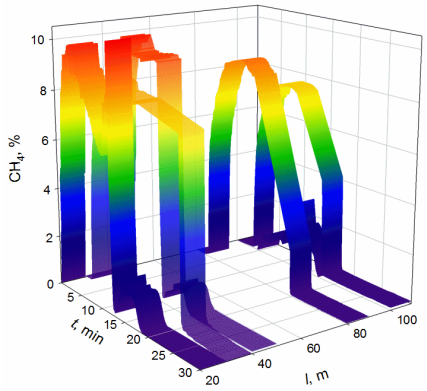
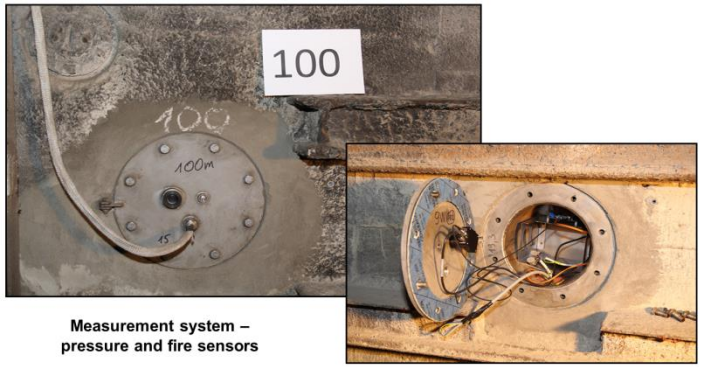
Real scale tests conditions: 400 m gallery, GIG Experimental Mine Barbara)





Methane dispersion in 400 m gallery under different conditions



Measurement system – pressure and fire sensors

Measurement system – methane sensor

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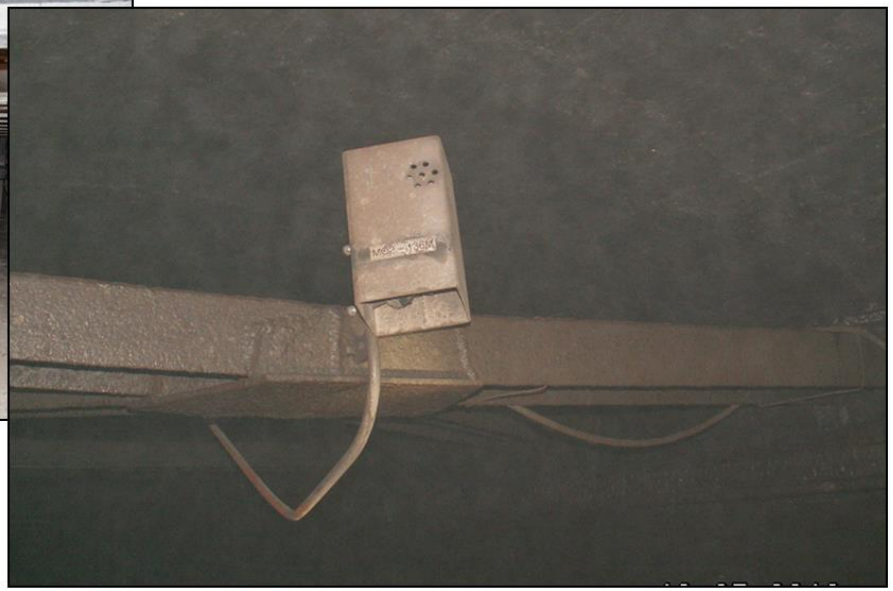
EXPRO Visual results obtained

Short Video

before



after

Equipment before and after experiments

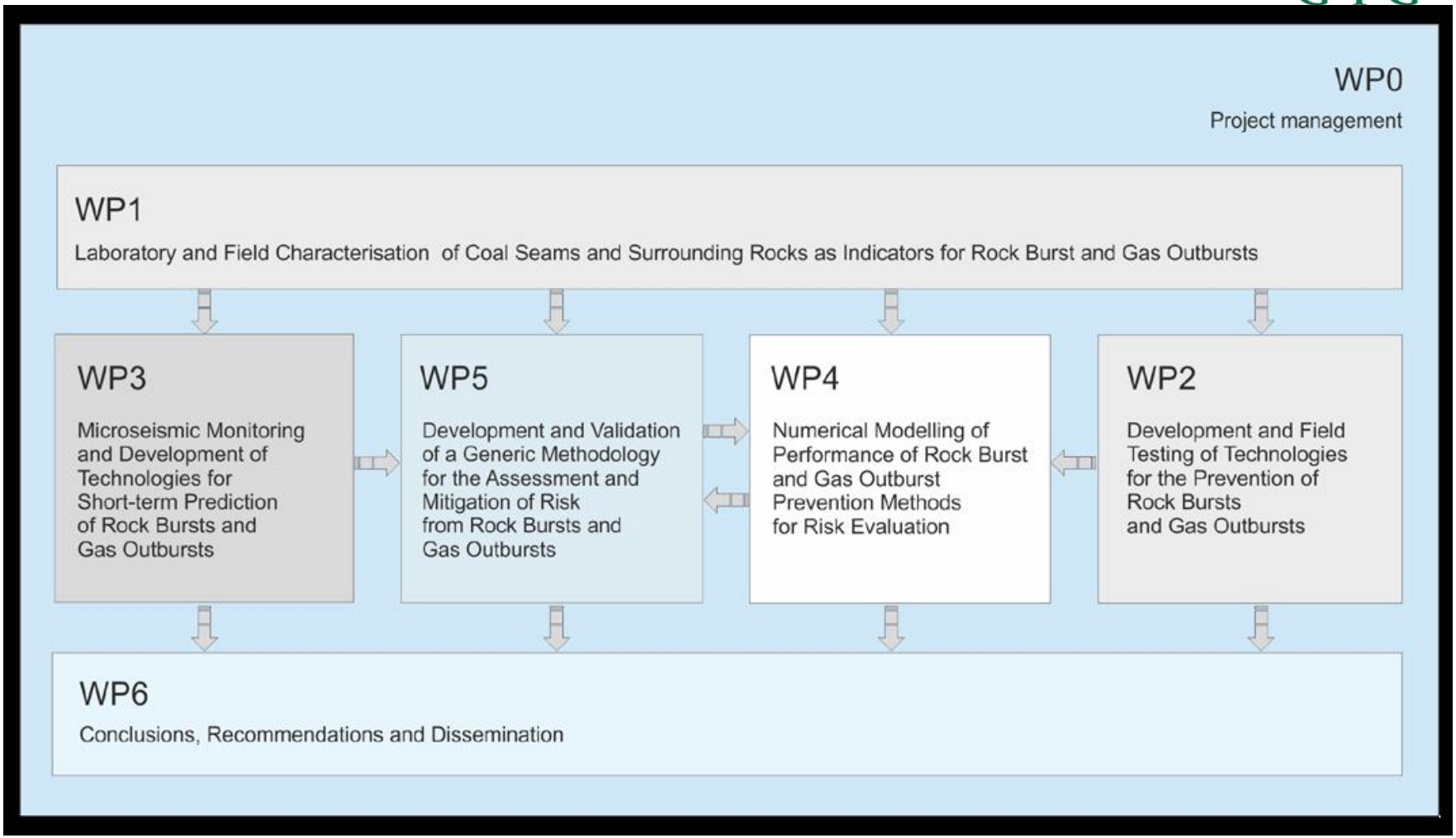
GIG

MAPROC (Monitoring, Assessment, Prevention and Mitigation of Rock Burst and Gas Outburst Hazards in Coal Mines),

The main objectives of **MapROC** are to:

- develop and field test rock burst/outburst prevention techniques based on the use of large diameter boreholes with alternative stress and gas pressure relief techniques;
- formulate a methodology to couple the near-real time processing of monitored microseismic data with Artificial Neural Networks and Fractal Dimension analysis to develop a short-term prediction method for rock bursts/outbursts;
- demonstrate the use of this prediction method as a tool for early risk assessment, prevention, and mitigation of these hazards;
- numerically model the application stress relief, stress control and protective mining options;
- develop and validate a generic risk assessment methodology for rock bursts/outbursts.

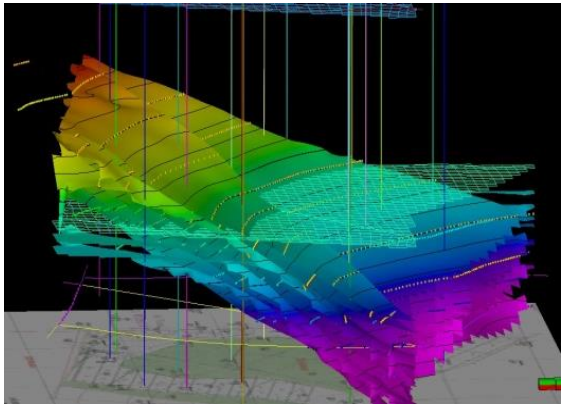
MapRoc

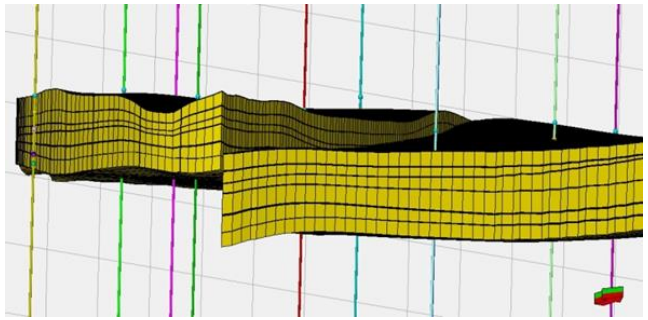

WP0
Project management
WP1
Laboratory and Field Characterisation of Coal Seams and Surrounding Rocks as Indicators for Rock Burst and Gas Outbursts
WP3
Microseismic Monitoring and Development of Technologies for Short-term Prediction of Rock Bursts and Gas Outbursts
WP5
Development and Validation of a Generic Methodology for the Assessment and Mitigation of Risk from Rock Bursts and Gas Outbursts
WP4
Numerical Modelling of Performance of Rock Burst and Gas Outburst Prevention Methods for Risk Evaluation
WP2
Development and Field Testing of Technologies for the Prevention of Rock Bursts and Gas Outbursts
WP6
Conclusions, Recommendations and Dissemination

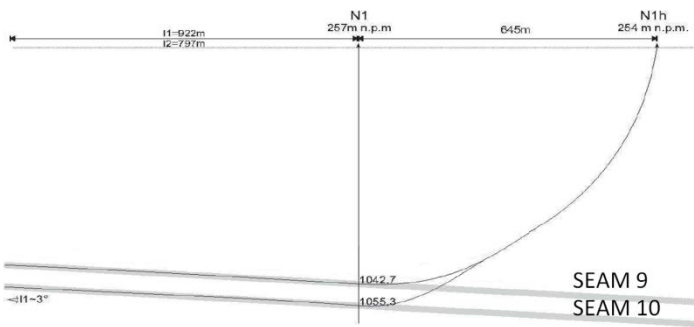
EPA2 grant

A FIRST FEASIBILITY STUDY FOR COST EFFECTIVE METHANE DEGASSING AND CAPTURE AHEAD OF MINING OPERATIONS TO REDUCE METHANE EMISSIONS IN POLAND DURING MINING (PAWLOWICE 1 COAL FIELD, UPPER SILESIA)

Budget: 340,000 USD, funded by US EPA grant.
Coordinator: Central Mining Institute of Katowice, Ph.D.Eng Jacek Skiba
Duration: 10.07.2009 – 10.07.2013



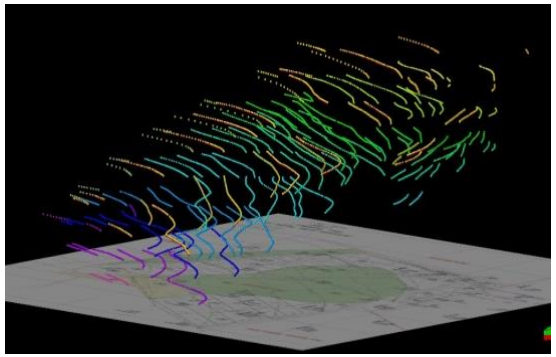


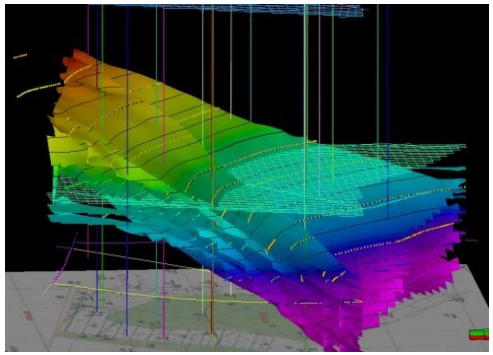


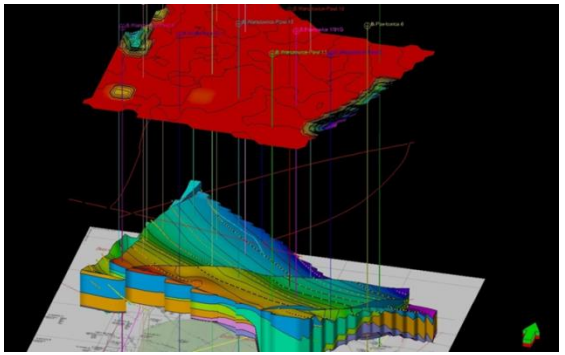
EPA2 grant

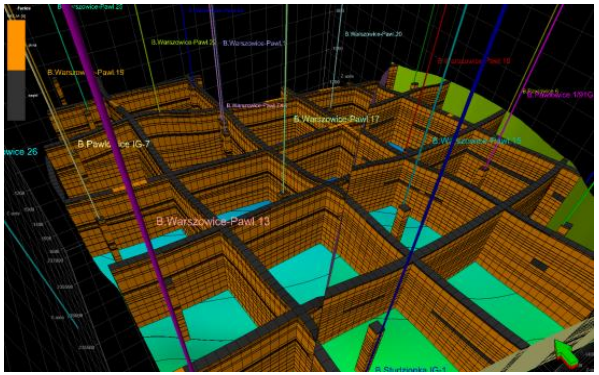
Technical feasibility	T1	Identification of coal seams to be the target of mining operations
	T2	Methane predictions for the planned mining operations
	T3	Design of CBM production and degassing system using surface-bored wells which include:
	T3.1	*data collection*
	T3.2	*determination of coal reservoir parameters*
	T3.3	*determination of coal seam continuity (depositional characteristics, structural features);*
	T3.4	*selection of appropriate drilling technology based on the US CBM experience;*
	T3.5	*preparation of CBM drilling, completion and production design;*
	T3.6	*determination of well locations and well spacing;*
	T3.7	*determination of production volumes using reservoir simulator*
	T3.8	*determination of methane drainage effectiveness using reservoir modeling techniques;*
	T3.9	*planning of produced water disposal*
	T4	Estimation of methane emission reductions
Economic analysis	T5	Estimates of the CBM production implementation cost
	T6	Review of methane end-use strategies
	T7	Calculating of net revenues and estimating of the CBM production project lifetime
	T8	Development of an economic model and calculating NPV and IRR
	T9	Converting estimated methane emission reductions to carbon credits
	T10	Estimates of possible cost savings for the Pniowek coal
	T11	Final economic analysis
	T12	Conclusions and recommendations

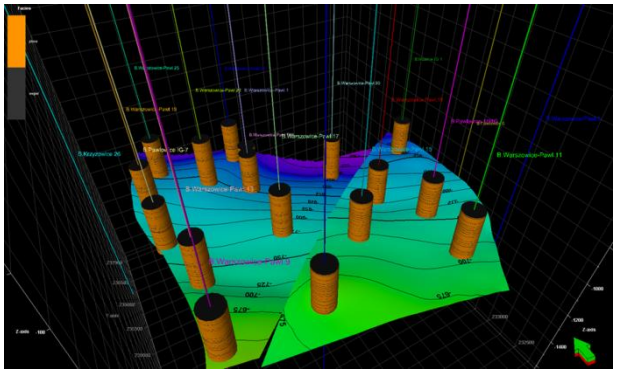
EPA2 grant

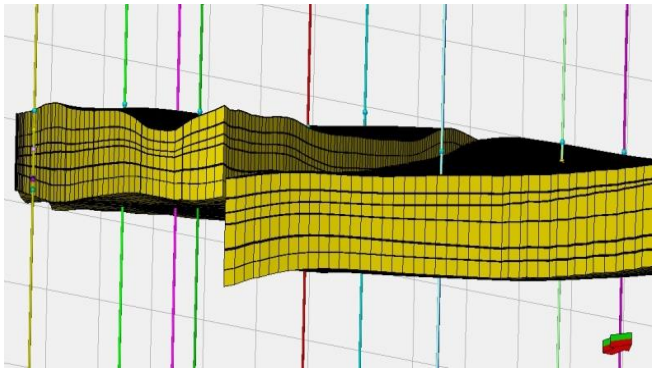




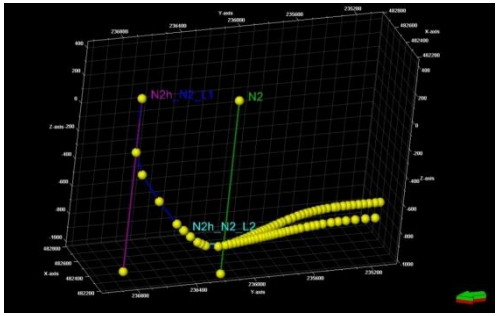








EPA2 grant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N2
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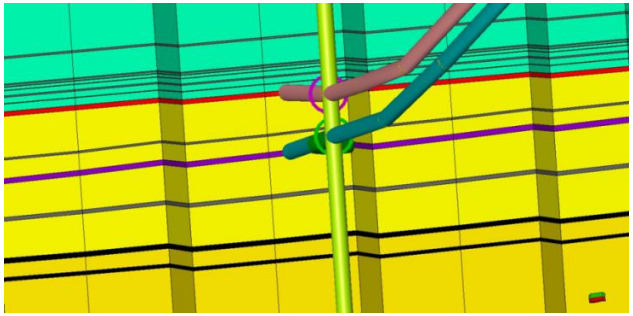
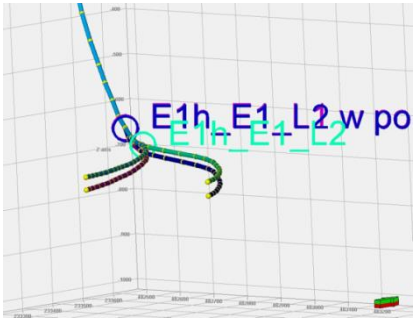
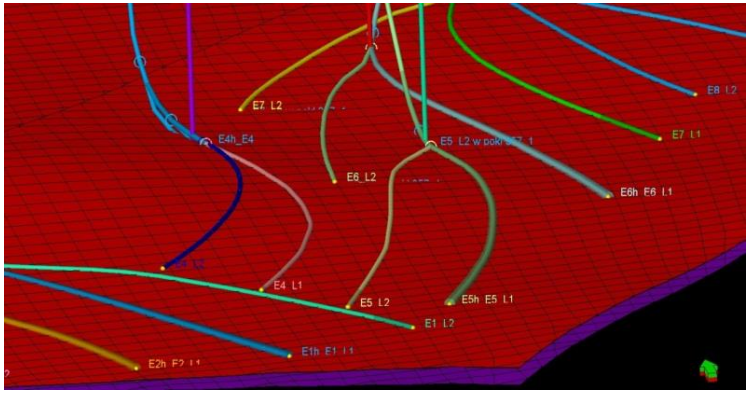
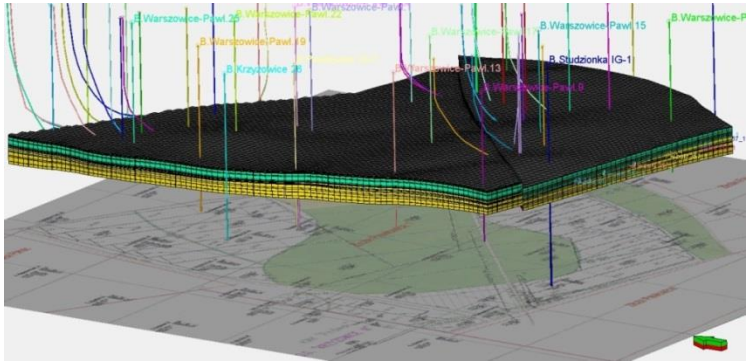
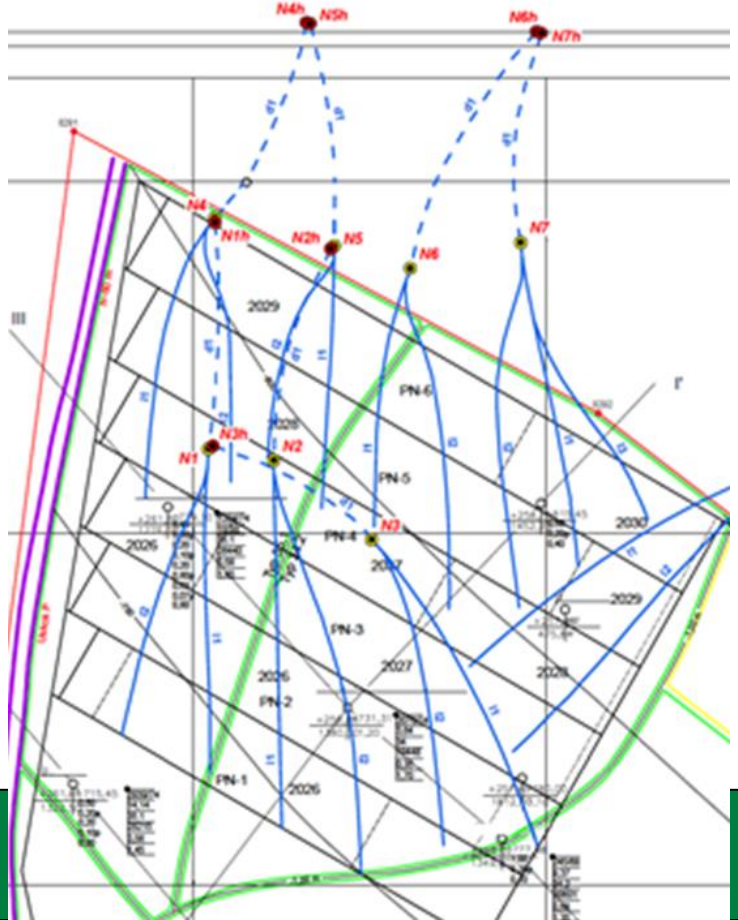



E1h_E1_L2 w po
E1h_E1_L2


E7_L2
E8_L2
E7_L1
E4h_E4
E5_L2 w pokł
E6_L2
E6h E6_L1
E4_L1
E5_L2
E5h_E5_L1
E1_L2
E1h_E1_L1


B.Warszowice-Pawl.25
B.Warszowice-Pawl.19
B.Krzyżowice 26
B.Warszowice-Pawl.15
B.Studzionka IG-1


N4h
N5h
N6h
N7h
N1h
N2h
N4
N5
N6
N7
N1
N2
N3
PN-6
PN-5
PN-4
PN-3
PN-2
PN-1
2029
2026
2027

Analysis of methane drainage from directional wells was made based on **the results of numerical calculations for the period of 5 years.**

Symulations were performed using AnsysCFX software - group CFD (**Computational Fluid Dynamics) software using finite volume method.**

For the calculations the **izothermal process of drainage was assumed.**

The temperature of gas was assumed the same as the rock mass t=41 ^{o}C and non-stationary conditions for methane filtration and desorption from the coal beds.

Coal was treated as dry medium (without water) with following parameters :
- **Porosity γ = 5%,**
- **Permeability K = 2 mD**.

Assumed **methane content of the coal seam:**
- **SEAM 9 = 12.75 m^3/t_{daf},**
- **SEAM 10 = 13.70 m^3/t_{daf}.**

The sorption kinetics was assumed k=0.0001 and bed pressure from Langmuira isotherm, which was determined during borehole tests.

Conclusions

1. All of above mentioned R&D Projects focus on mitigating CMM hazard and its effective utilisation

2. Most of above mentioned R&D Projects were/are cofinanced by Research Fund for Coal and Steel (60%), remaining 40% by individual project partners countries

3. Very high factor of implementation the R&D results in mining sector !

4. RFCS activities are effective European Commission support of not only CMM related R&D projects but also projects focused on „accompanying measures”.

GIG

Thank you for your attention

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