# Seismic Exploration in urban Areas

**Boris Dombrowski, Rene Pool, Franco Rost**

**DMT GmbH & Co. KG**

**Symposium: Reflections on Seismic Acquisition, EBN Utrecht**

# Who is DMT ?
## Facts & Figures

**TÜV NORD GROUP**

- Headquarters in Hannover, Germany
- €1,000 Mio. annual turnover approx.
- 10,000 Employees in 70 countries approx.

**DMT** (Member of TÜV Nord Group)

- Founded 1990 in Germany, headquarters in Essen (roots dating back to 1737)
- Global group of 15 consulting and engineering firms and 30 offices outside of Germany
- 120 Mio. €annual turnover x, 1,000 employees approx.
- DMT-Expert Bodies
  - 16 government approved expert bodies for safety
  - 3 accredited testing laboratories
  - 75 accredited experts

**DMT Petrologic** (Member of DMT Group)

- Founded 1998 in Germany, headquarters in Hannover
- former Prakla-Seismos

# DMT Services
## for the oil/gas & geothermal markets

- Seismic exploration (2D, 3D, VSP)
- Data processing (-> DMT Petrologic)
- Geological interpretation & modeling
- 3D Heatflow simulation
- Vibration monitoring (structural vibrations, micro-seismicity)

- Further geophysical measurements
- DMT Corescan

# DMT Petrologic Services

## re-processing, standard & high-tech processing, own developments

- Seismic data processing (land, marine) TZ (ProMAX/SeisSpace, OpenCPS)
- Prestack time/depth imaging (Tsunami Development, OpenCPS)
- Isotropic/Anisotropic velocity-depth modeling (Paradigm GeoDepth)
- Advanced CRS processing (WIT consortium, inhouse development)
- 3D SRME/IME (OpenCPS, DELPHI consortium, inhouse development)
- Converted-wave processing (ProMAX, OpenCPS, Tsunami Development)
- Fracture analysis (HTI) (Paradigm EarthStudy 360, OpenCPS)
- AVO processing and modelling, amplitude inversion and seismic reservoir characterization (Hampson-Russell, Paradigm)
- Time-lapse 3D (4D) processing (ProMAX, Hampson-Russell)
- Acquisition planning and survey design incl. illumination studies (MESA/OMNI) (NORSAR-2D/3D Modelling)

# Seismic Exploration in urban Areas

Boris Dombrowski, Rene Pool, Franco Rost

**Content:**

- **Work steps** of 2D/3D-Seismic and **challenges** in urban areas
  - during planning & preparation
  - during field data acquisition
  - during data processing
- **Case history „GRAME“ 3D-Seismic** (Munich)
- **Conclusions & recommendations**

# Performance of 3D/2D-Seismic in rural areas
## Typical Field Environment



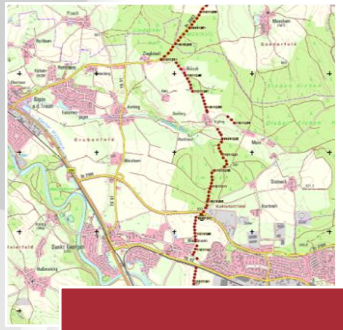



# Performance of 3D/2D-Seismic in urban areas
## Typical Field Environment



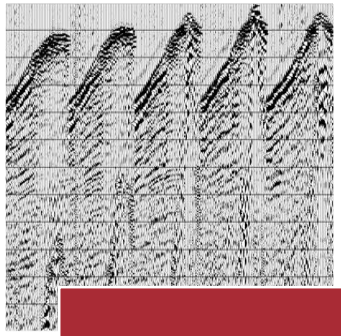



# Work steps of 2D/3D-seismic exploration

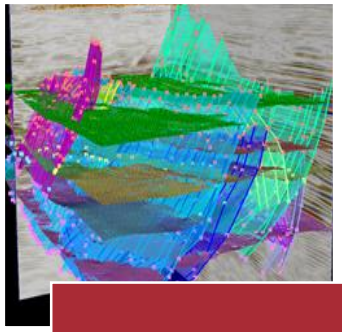


planning
& preparation

data
acquisition

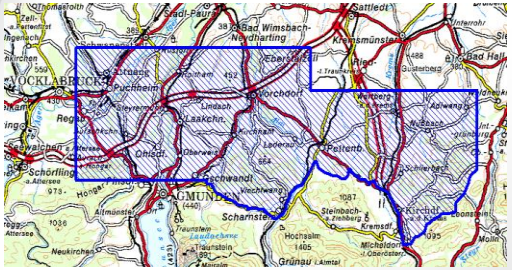


data
processing

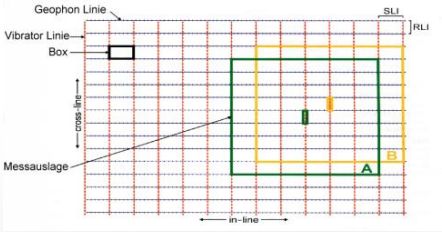


interpretation
& modeling

# Work steps of 2D/3D-seismic exploration
## Planning & Preparation



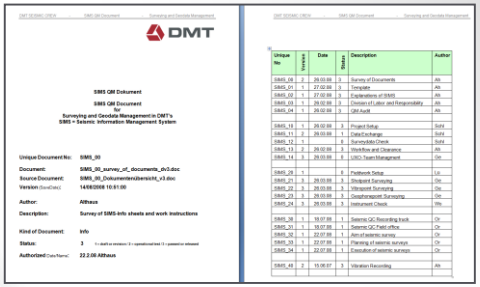
Field scouting; production planning (time schedule, personel, equipment)




measuring geometry, production plan


Public relations work

# Planning & Preparation




SIMS Seismic Information-Management System

Permitting

Initial acceptance test

# Challenges in urban Areas

## Equipment Selection & Information Management / Communication

**During Planning & Preparation:**

- Emissions of the vibrators (vibrations, sound volume, exhaust gases)
- Underground cables, pipes and installations (gas, water, sewage, kerosene, communication, etc)
- High traffic density
- Interference with traffic control plans (traffic lights, street bypasses or redirections, road closures, etc.)
- Strong difference between regular (planned) and possible measuring grid
- Impairment by rail infrastructures, roads and metro lines ....
- Little space for the geophone layout
- Vibration sensitive buildings and plants (banks, printing plants, research facilities, buildings under historical preservation, etc)
- High communication effort with all stakeholders

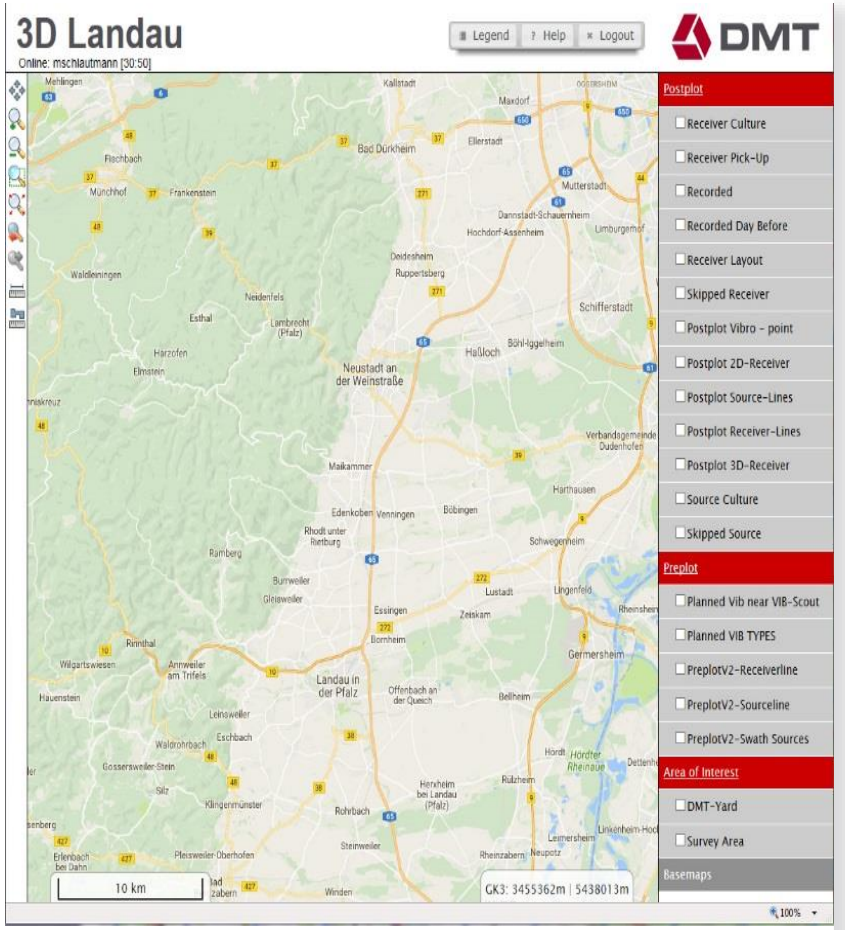
# Challenges in urban Areas
## Information Management / Communication

### DMT WebView

Displays all seismic information for different stakeholders

- Production (planned, past)
- Vibrator points today (planned)
- Actual Vibrator position
- Receiver layout
- Skipped source points
- ….

WebView is customized for the different stakeholders



# Challenges in urban Areas
## Equipment Planning & Information Management

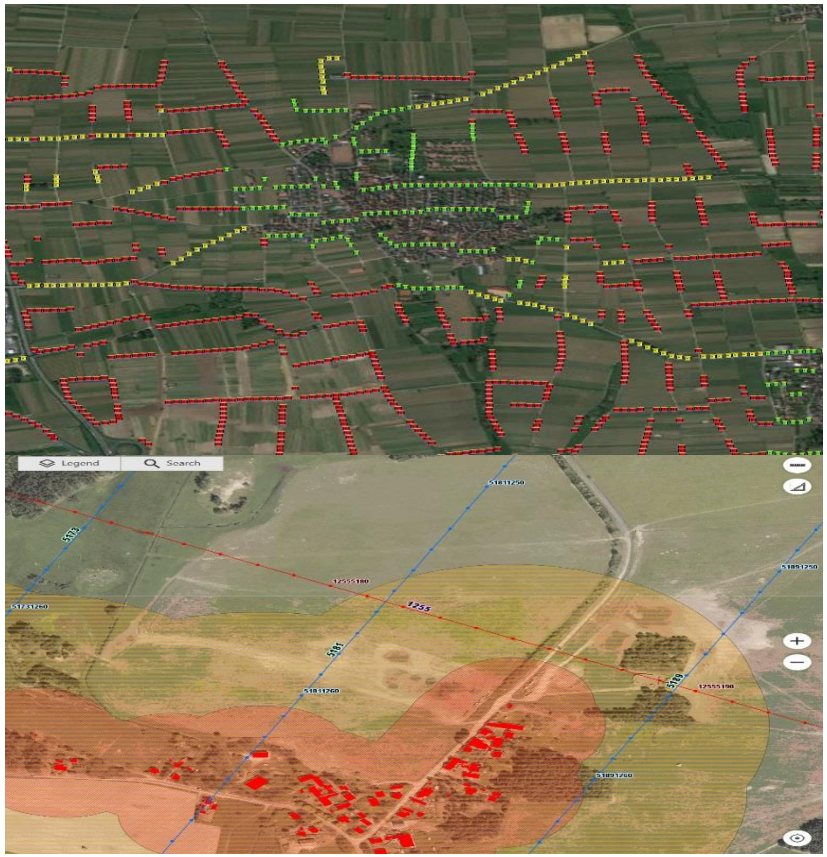
### DMT SIMS

Detailled operation planning of different seismic Vibrator types

- Low force (green)
- Reduced force (yellow)
- Regular force (red)

### CarryMap

Online display of restrictions for source and receiver positions



# Work steps of 2D/3D-seismic exploration
## Data acquisition

Infil operation

Workshop setup

Quality control

Surveying

Structural vibration monitoring

**Daten-acquisition**

Refraction seismic

3D-Seismic measurement

Communication-management

# Challenges in urban areas

## During Data acquisition:

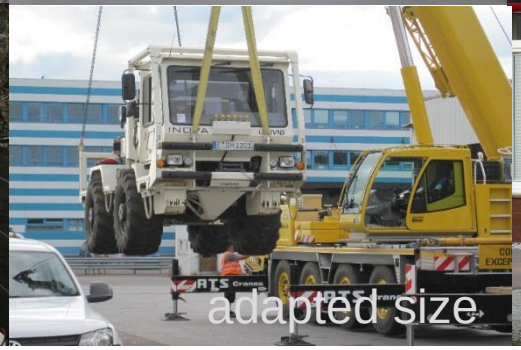
- A seismic information management system (SIMS) is indispensable. It contains all the information required for the interruption-free execution of 3D seismic (measurement geometry, supply lines, permissions, traffic plans, etc)
- The SIMS is a living document hence to be updated continuously
- Real-time monitoring of the structural vibrations of buildings is carried out continuously during acquisition (Guideline DIN-4150 Part III)
- If structural vibrations caused by the vibrators tend to exceed the predetermined limits, the force level of the vibrators will be reduced (force level reduction, sweep changes, etc.)
- In the case of high traffic density (random noise), work is carried out avoiding peak traffic hours as much as possible
- Measuring equipment setup requires more staff and material (cable bridges, cable mats, etc.) due to roads, rails, etc.
- No regular grid of the measuring geometry possible -> complex measuring geometry
- Master-slave technology (2 measuring units) for 'separated' measurement areas (due to river, etc.)

# Performance of 3D/2D-Seismic in urban Areas
## Equipment Adaptation

### Crossing method, cable-less, confined space

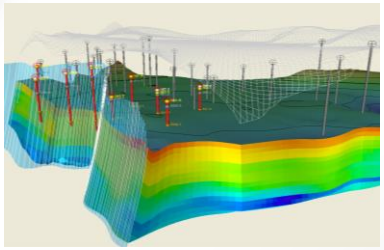




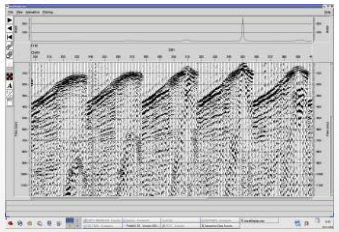



# Work steps of 2D/3D-seismic exploration

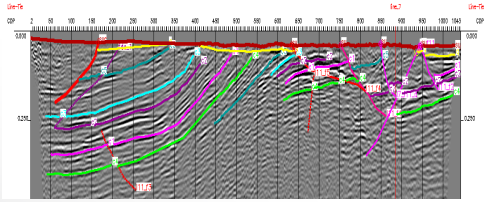
## Data Processing, interpretation & modeling



3D block model: facies & geological properties

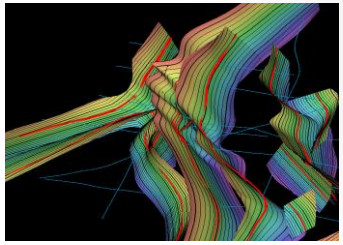


Seismic - processing

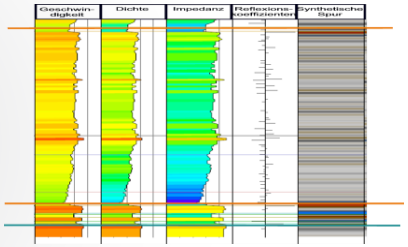


Interpretation

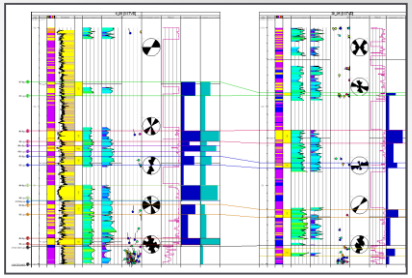
Data Processing, interpretation & modeling



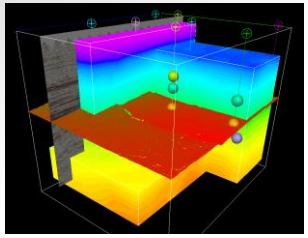
Structural geological modelling: Horizons & faults, intersection lines




Synthetic seismograms



Bohehole - interpretation & - correlation



Velocity modelling & Time-Depth Conversion

## During data processing, -interpretation, -modelling:

- Data processing is more complex because of the complicated geometry
- Quality control, especially of the survey data, is very important
- The increased noise level requires additional processing steps for noise suppression / filtering

- There are no differences concerning interpretation & modeling in rural or urban areas

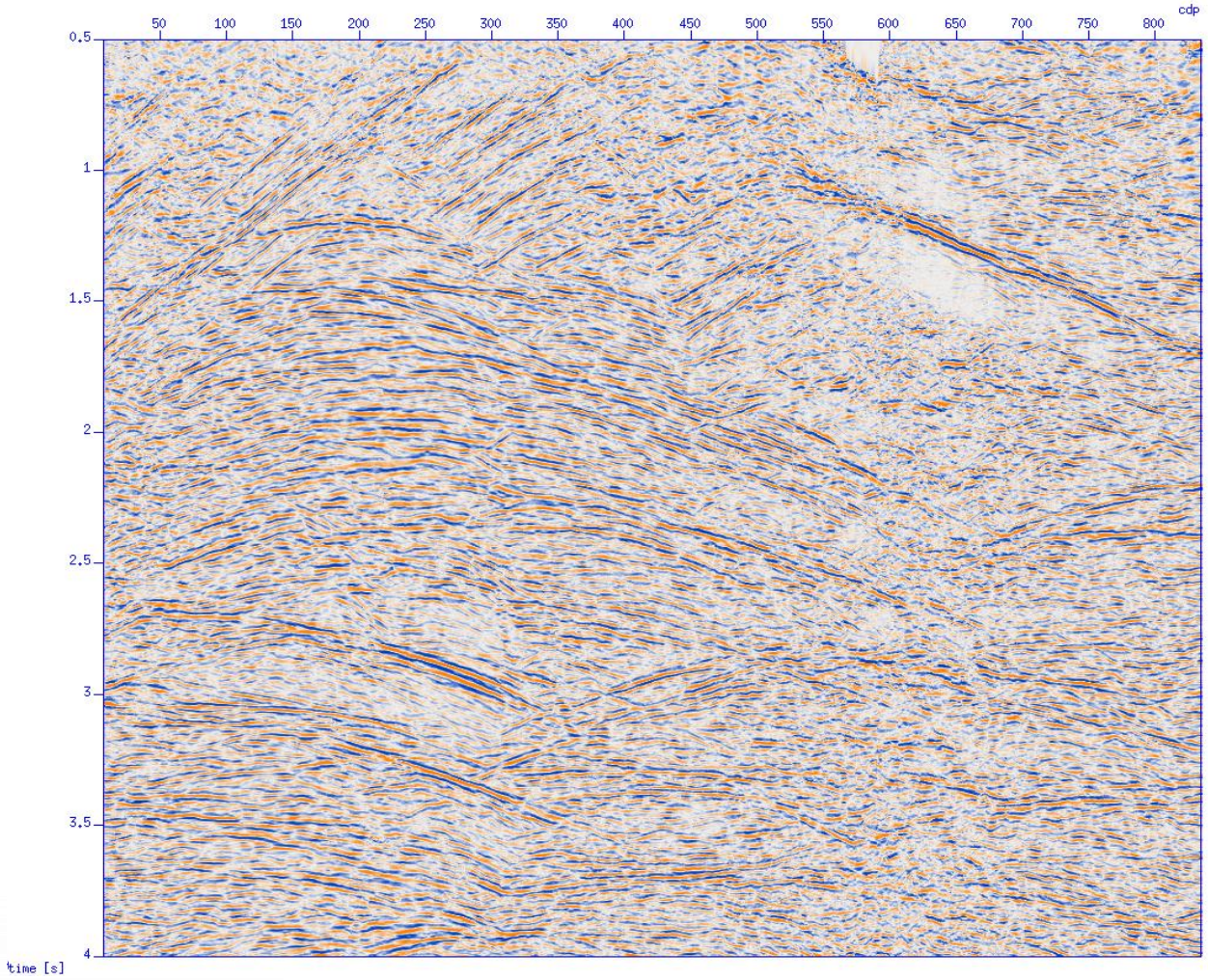
# Common-Reflection Surface (CRS) Processing

Data-adaptive coherency filtering

- Efficient noise suppression
- Better Interpolation and regularization
- Improvement in the interbed-multiple estimation process
- Reliable velocity analysis in poor data areas

# Conventional 3D CMP Stack vs. Operator-oriented 3D CRS Stack

## In crystalline rock environment



# Case history: Project GRAME 2015/2016

SWM Stadtwerke München

## Survey details:

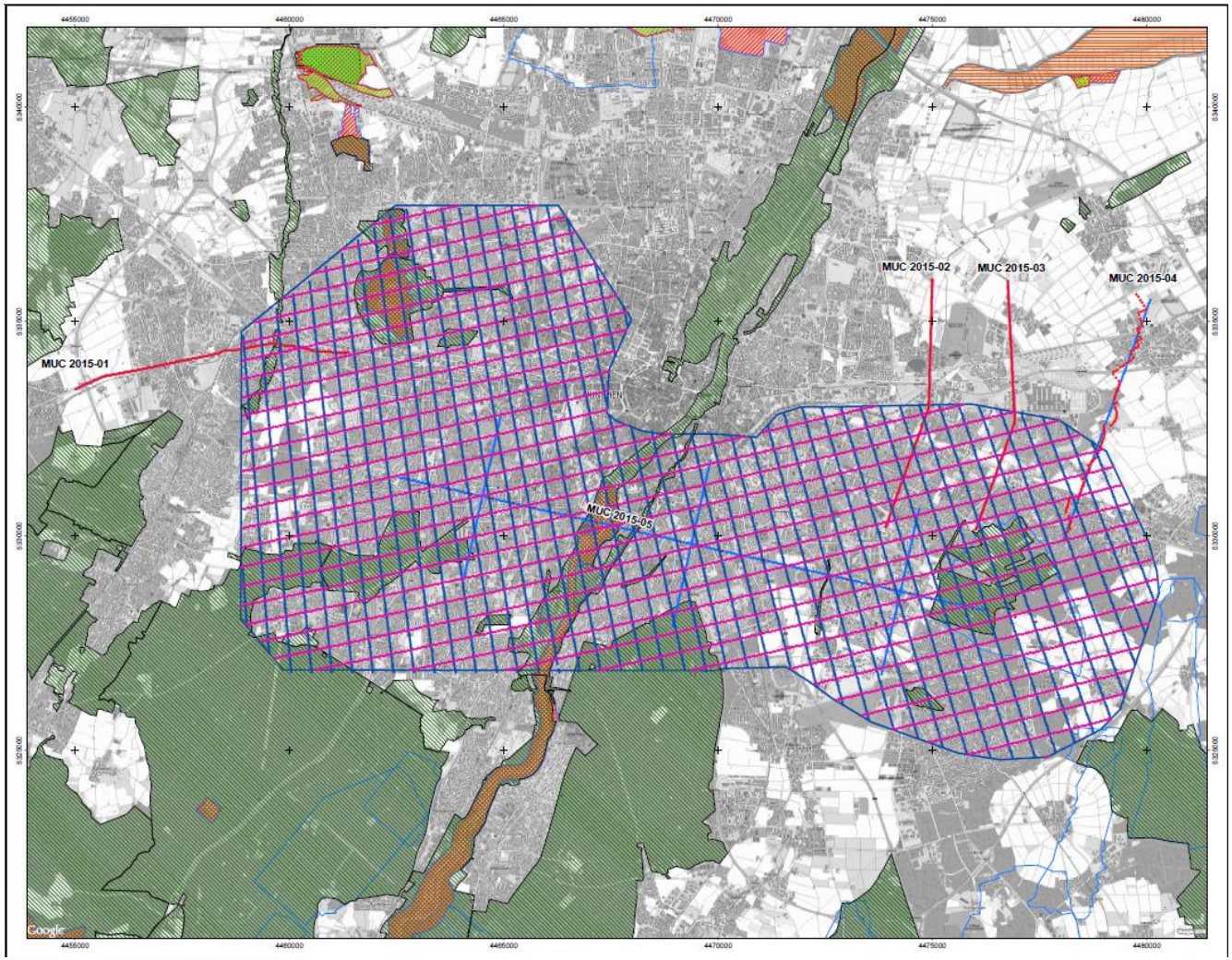
- 170 km² 3D-Seismic + 36 km 2D-Seismic (Nov. 2015 – April 2016)
- No. Of channelsl: 5000 (active 2560)
- Seismic source: Vibrators AHV (3+1)
- Sheer wave meaurement under additional supervision of LIAG
- 2 vertical seismic profiling surveys (VSP) in the drillings Riem und Freiham
- Processing (Standard & PSDM)
- Interpretation & Modelling

## Special Challenges:

- Data Acquisition in urban areas (regulations, traffic, buildings, snow)
- Between Oktoberfest and “Tollwood” (Christmas market) as well as breeding and planting seasons

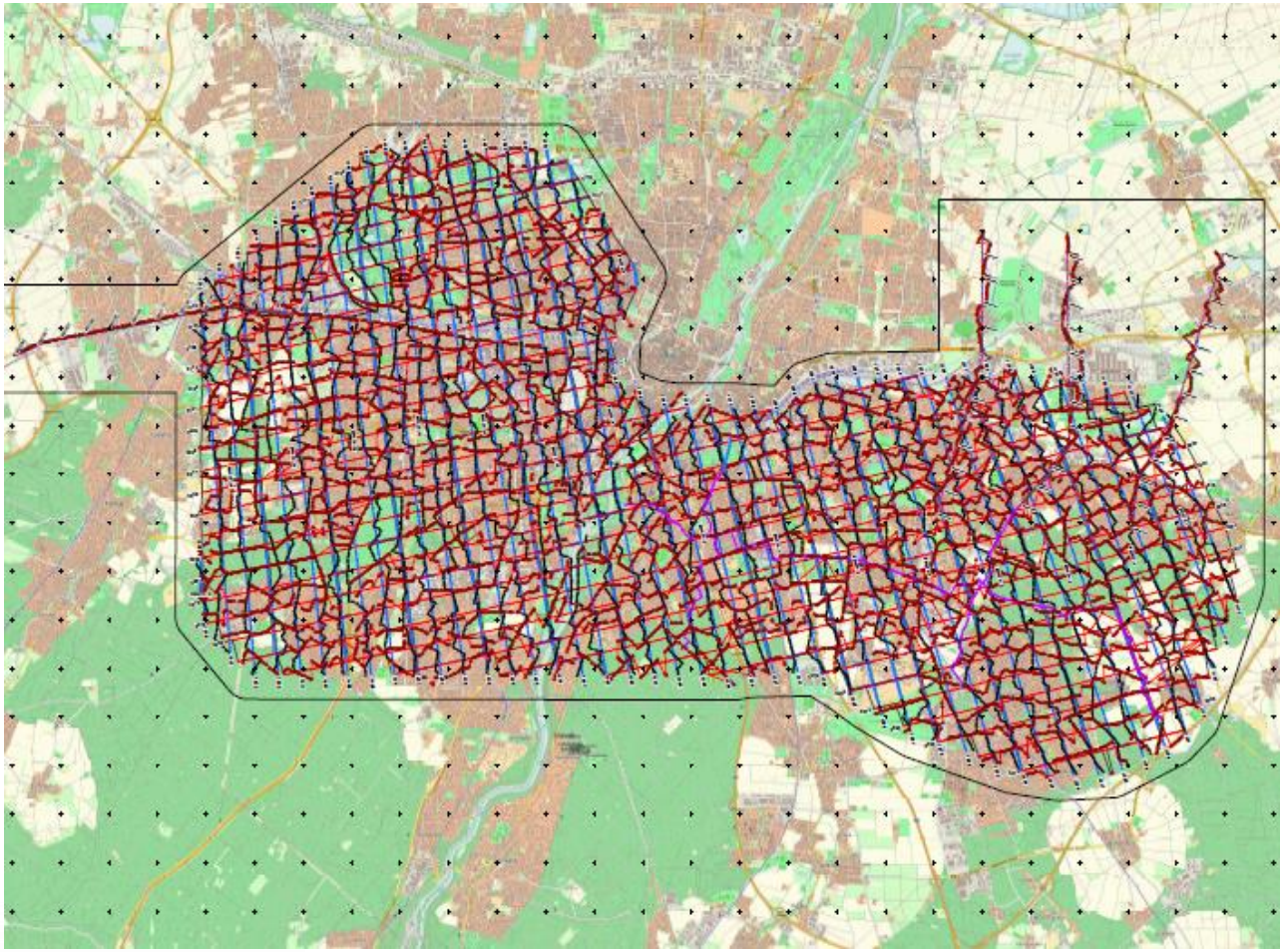
# Case history: Project GRAME 2015/2016

## Planed survey geometry



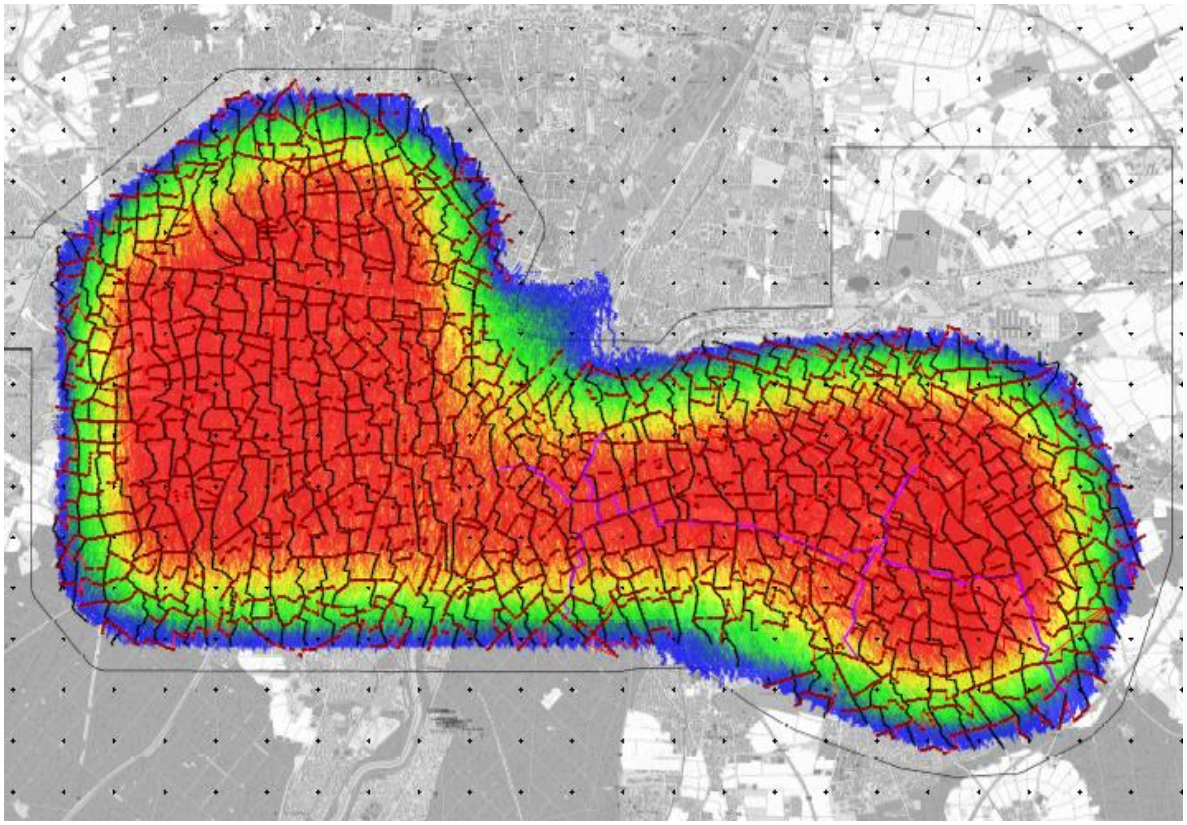
# Case history: Project GRAME 2015/2016

## Actual performed survey geometry



# Case history: Project GRAME 2015/2016

## Seismic coverage reached with the performed survey geometry

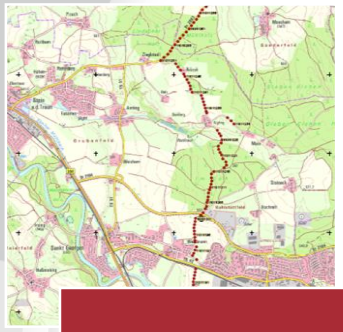


# Performance of 2D-/3D-Seismic in urban areas
## Conclusions & recommendations

- 3D seismic in urban environment is possible and feasible
- The costs for planning and preparation as well as for the execution are increased
- Additional processing expenditure is caused by `noise suppression‘
- A perfect Seismic Information Management System (SIMS) is indispensable. It contains all the information required for interruption-free execution of seismic exploration
- The SIMS must be updated continuously
- Real-time monitoring of the structural vibrations of buildings is carried out continuously accompanying the vibrator group(s)
- In case of exceeding predetermined limits, vibrator parameters are adapted in real-time
- Concerning interpretation and modelling there is no additional effort

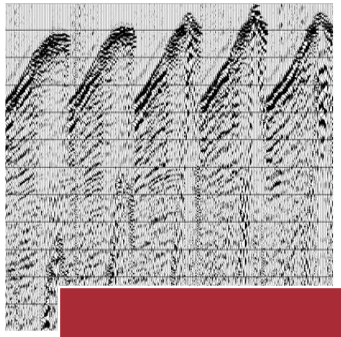
# Performance of 2D-/3D-Seismic in urban areas

## Additional effort during the different work steps

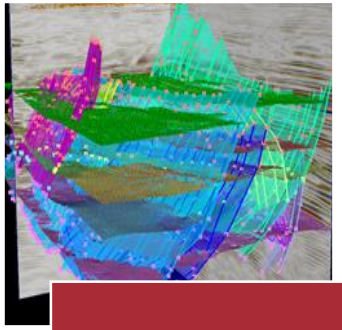


planning & preparation

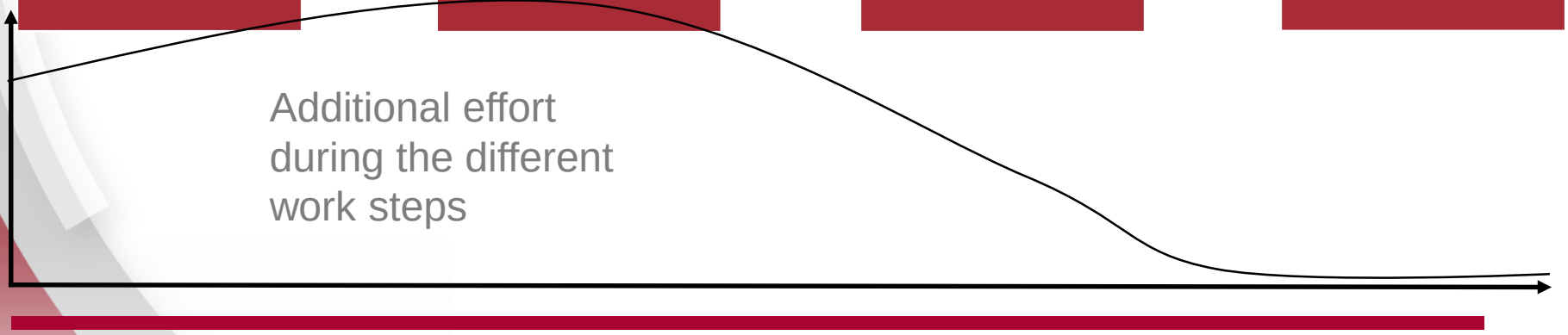
data acquisition



data processing



interpretation & modeling



# Work steps of 2D/3D-seismic exploration
# Data Acquisition

- **Maßnahmen Challenges?**
- Compilation QHSE contract plan, main objective No LTI's (Lost Time Injury)
- Stakeholder involvement at earliest possible date (support PR campaign)
- Maintaining through infotainment method constant communication flow with pre-selected stakeholders

- Daily toolbox meetings with all crew personnel and client reps
- Close liaison on daily basis with permit, section heads and client rep. on progress and planning (operational meetings)
- Daily QC of acquired seismic data, monitoring pre-pegged source/receiver coverage against client objectives and mitigate quality drops
- Weekly QHSE meeting section head level
- Monthly QHSE Committee Meeting
- On-site field processing up to brute-stack
- Data delivery to client or processing within 2 weeks after completion of survey

# Data acquisition
## Field crew organisation

**Crew Mangement**
1 Party Chief
1 Vehicles

**QHSE**
1 QHSE Advisor
1 Vehicles

**Controlling**
1 Administrator
(in Essen)

**Permitting**
Sub-Contractor

**Survey**
1 Senior Surveyor &
GIS Operator
1 4x4

**Data Management**
1 QC Operator

**Field Operations**
1 Field Manager
1 4x4

**Surveyors**
2 Surveyors
2 Helper
2 4x4

**Vibroseis**
1 Vibpusher

**Spread**

**Recording**
1 Chief Observer
1 4x4 & 1 Rec.Truck

**LvL**
1 Source Operator
1 Operator/ 1 Helper
1 4x4 & 1 Source Truck

**Vibdriver**
4 Driver
4 Vibs
1 Unimog Refuel

**Vibmechanic**
1 Mechnic
1 Helper
1 Service Truck

**Traffic Control/PPV**
2 Formen
2 PPV Operator
2 4x4

**Cable Crews(average)**
1 Foreman
3 Helper
1 4x4

**Bridging/Extens.**
2 Operator
1 4x4

**Line Check**
1/2 Linechecker
1 Line Support
2 4x4

# Challenges in urban Areas
## Equipment Selection & Information Management

- **Field reconnaissance**
- **Source/Receiver determination /effort**

  Explosives/Vibroseis/Airgun

  Equipment type Cable/Cable-less
  - a) Smart
  - b) Semi-Smart
  - c) Blind
- **Time window 12/24-5,6,7**
- **Production calculation**
- **Determination external resources**
  - a) legally required
  - b) permitting
  - c) others (UXO, training)

# Performance of 3D/2D-Seismic in urban Areas
## Field Equipment Adaptation

### Crossing method, cable-less, confined space