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# GEOTHERMAL ENERGY CONFERENCE

## LOOK-BACK ON 5 YEARS OF SCAN 2D SEISMIC ACQUISITION AND (RE)PROCESSING

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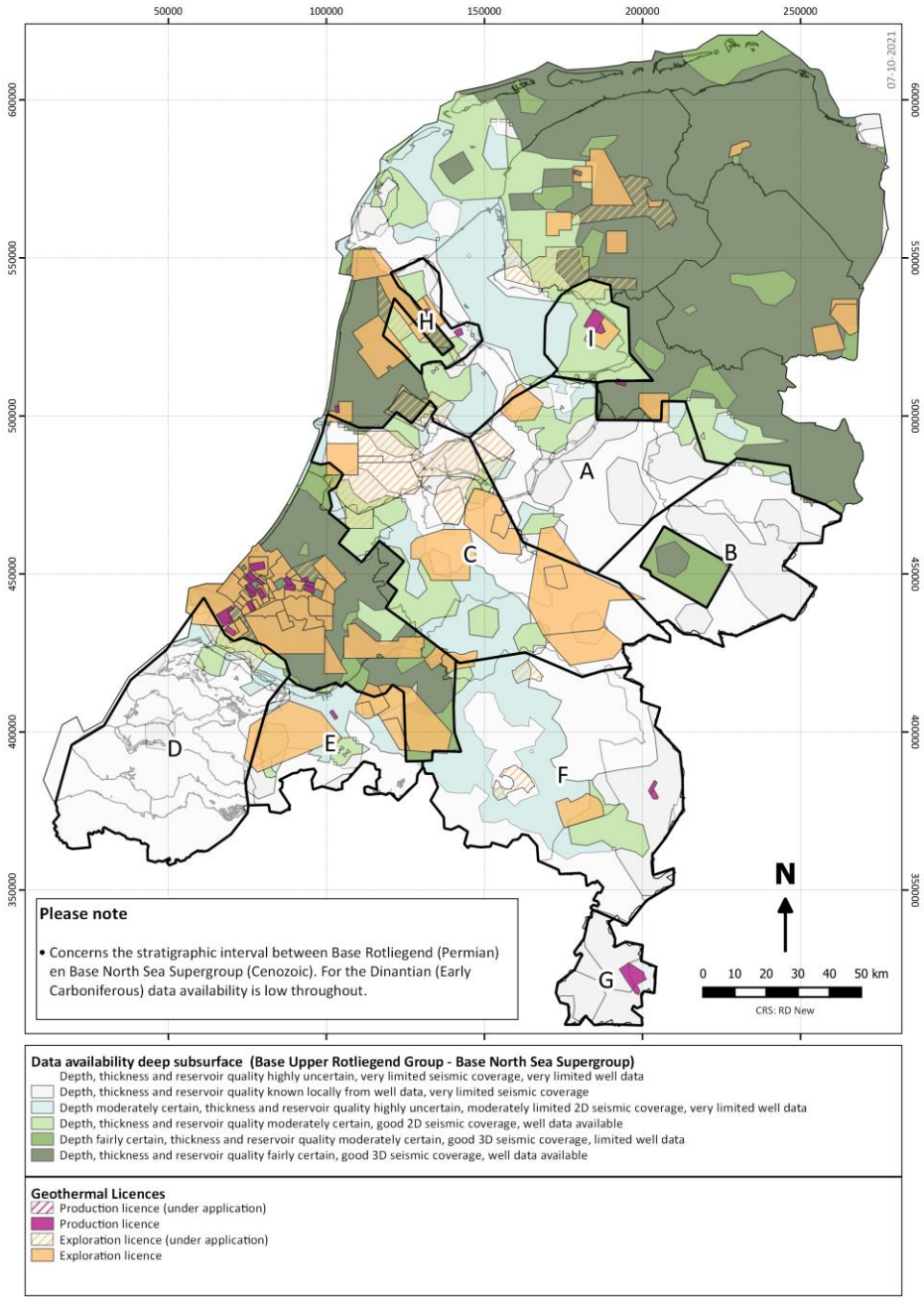
# Agenda

- Introduction to the SCAN programme
- SCAN 2D seismic acquisition
- 2D PreSTM processing examples
- 3D cross-spread acquisition & processing
- Lessons learned from the SCAN 2D seismic acquisition
- 2D reprocessing summary & examples
- Summary
- SCAN 4 – The next phase of SCAN seismic acquisition

# The SCAN programme

- The aim of SCAN is to collect data in areas of the Dutch subsurface that have historically been left underexplored to accelerate the development of geothermal projects in the energy transition
- The SCAN programme is implemented by EBN in collaboration with TNO and financed by the Dutch Ministry of Climate Policy and Green Growth (KGG)
- The SCAN data collection comprises:
  - Acquisition of new 2D seismic data (1950 km) ✓
  - Reprocessing existing 2D seismic data (7500 km) ✓
  - Drilling of several research wells ongoing
  - SCAN 4 – additional seismic data acquisition
- All data SCAN collects is public and can be used by municipalities and project developers to better evaluate where opportunities lie for geothermal projects
- SCAN is a research programme to collect subsurface data and will not develop geothermal projects



# SCAN 2D seismic acquisition & data availability

- Acquired 1.837 line km of new regional 2D (46 lines) and 20 local lines (106 km) to support the SCAN well locations with zero LTIs
- Recorded 30.196 shots and 383.467 receivers planted
- SCAN acquisition was combined with 2D seismic acquisition programs for UDG and MRA
- Visited 164 municipalities, distributed 135.000 letters into the neighbourhoods prior to acquisition
- Land access permissions from some 6.200 land users
- All 46 regional lines & 20 local lines are available on the NLOG website (https://www.nlog.nl/scan-2d-seismische-data)

MRA = MetropoolRegio Amsterdam

# SCAN 2D seismic acquisition

Key acquisition parameter:

- Shot spacing: 60 m
- Shot depth: Nominally 20 m
- Shot type: Seismic explosives
- Receiver spacing: 5 m
- Receiver type: Wireless nodes
- Spread type: Split-spread
- Maximum offset: 7 km
- Recording length: 10 seconds

Key SCAN HSE numbers (30.11.2023):

- Zero LTIs
- Manhours worked: 1.090.750
- KMs driven: 2.668.779

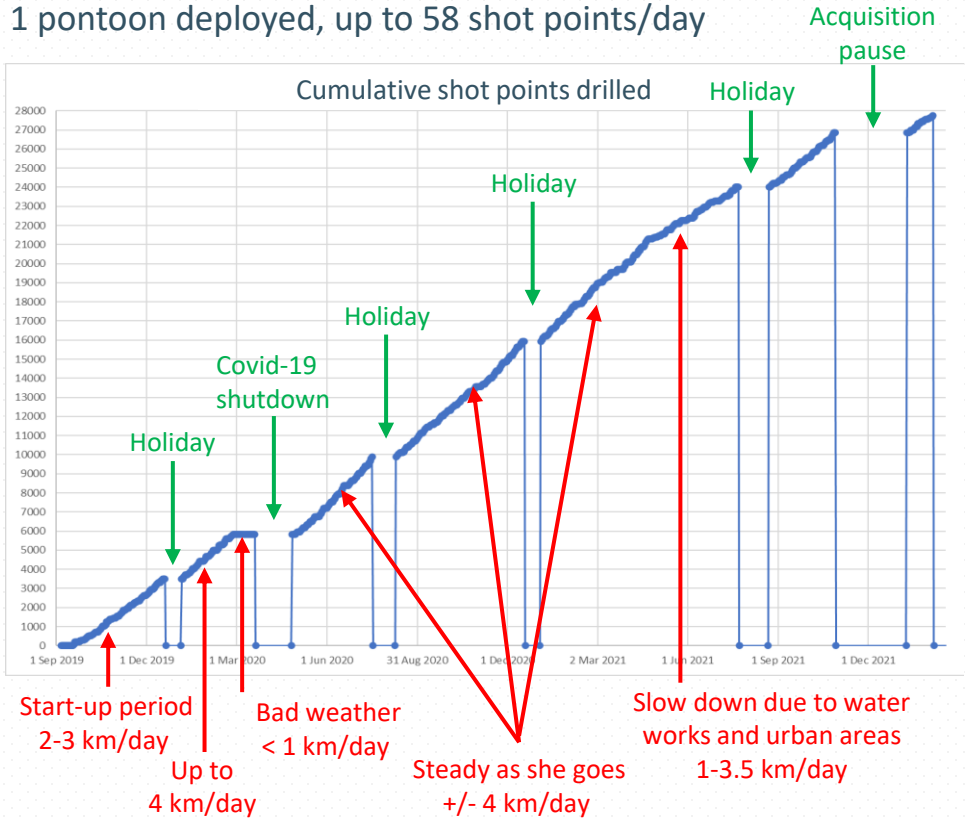
(Numbers include the EBN test line (SCAN001), and all local 2D seismic acquisition).

Land drill tractor,
usually 5 tractors deployed,
up to 100 shot points/day

Shooting crew,
up to 160 shot points/day,
usually 1 crew deployed

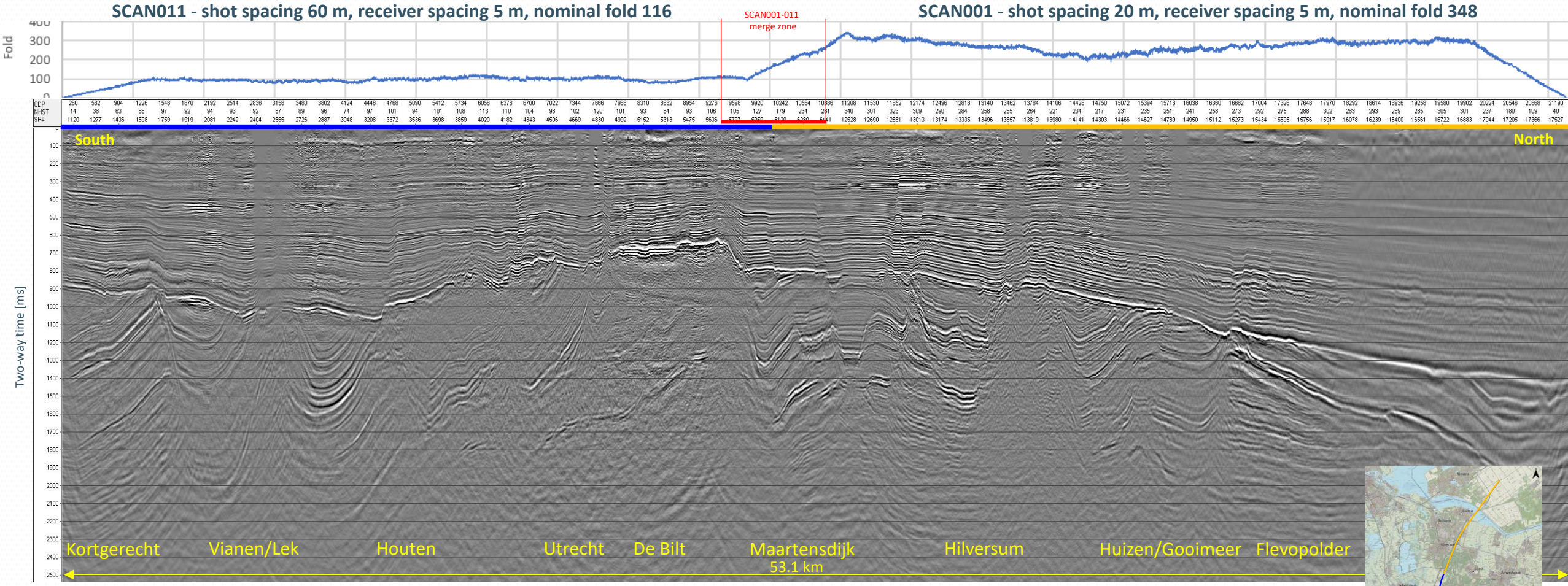
Geophones

Barge/pontoon mounted drill tractor, usually 3 barges and 1 pontoon deployed, up to 58 shot points/day



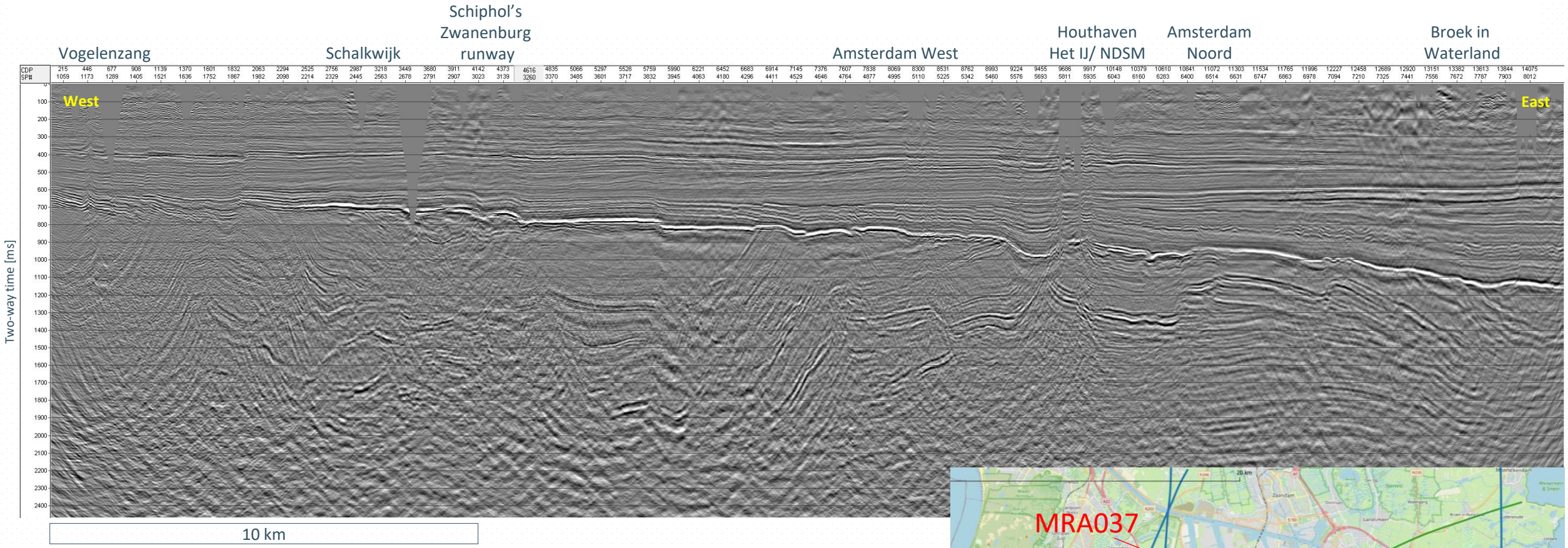

Average acquisition production
(Sept. 2019 to May 2022) was some 4 km/day

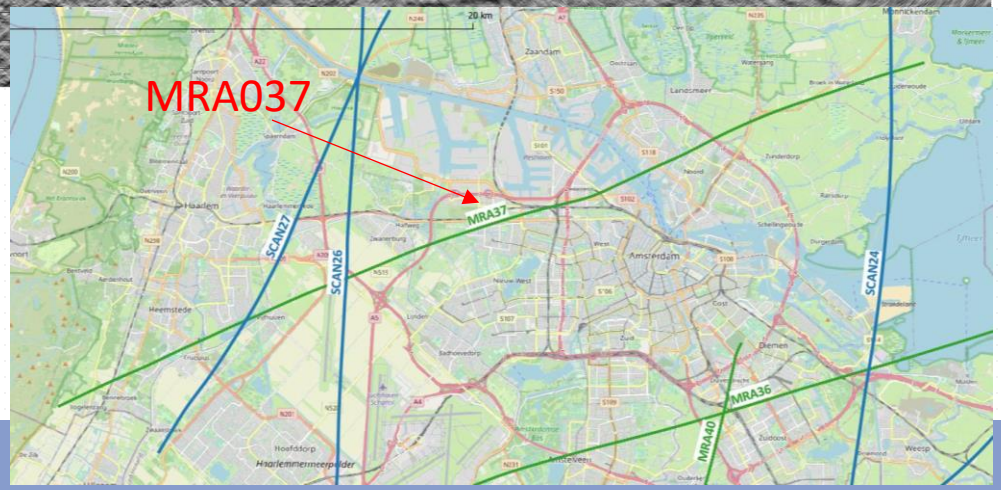
# SCAN 2D PreSTM processing – SCAN011 & SCAN001




- Shot spacing of 60 m shot & 5 m receiver spacing provide adequate data quality for 2D regional seismic interpretation
- No significant data quality reduction compared to 2019 test line that would compromise seismic interpretability

# SCAN 2D PreSTM processing – MRA037

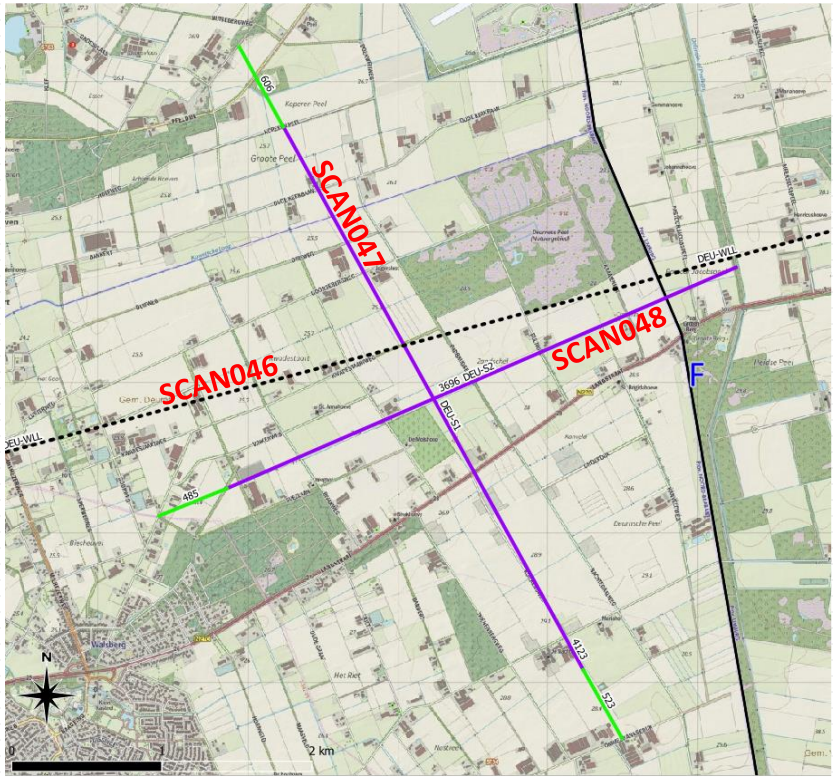



- With careful planning it was possible to acquired several 2D seismic lines in close proximity to Amsterdam.

# SCAN 3D cross-spread acquisition – Deurne area

- To de-risk the subsurface at the SCAN well locations as much as possible, often additional short 2D lines have been acquired since the completion of the regional SCAN 2D seismic acquisition
- Whenever possible, the design was chosen such that 3D cross-spread data could be acquired simultaneously




Regional line SCAN046
Two local lines SCAN047 & 048

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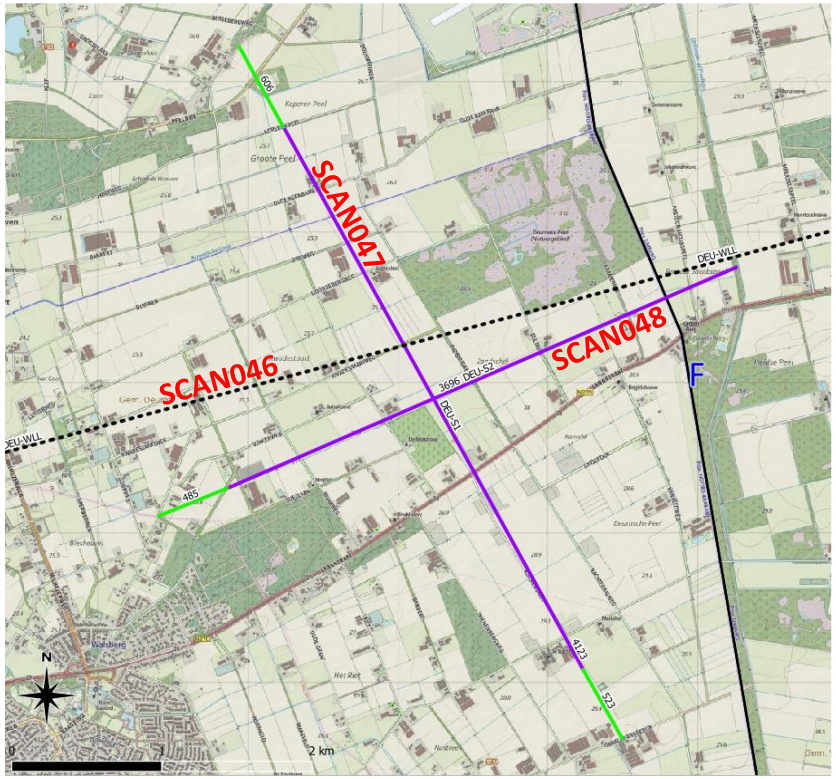


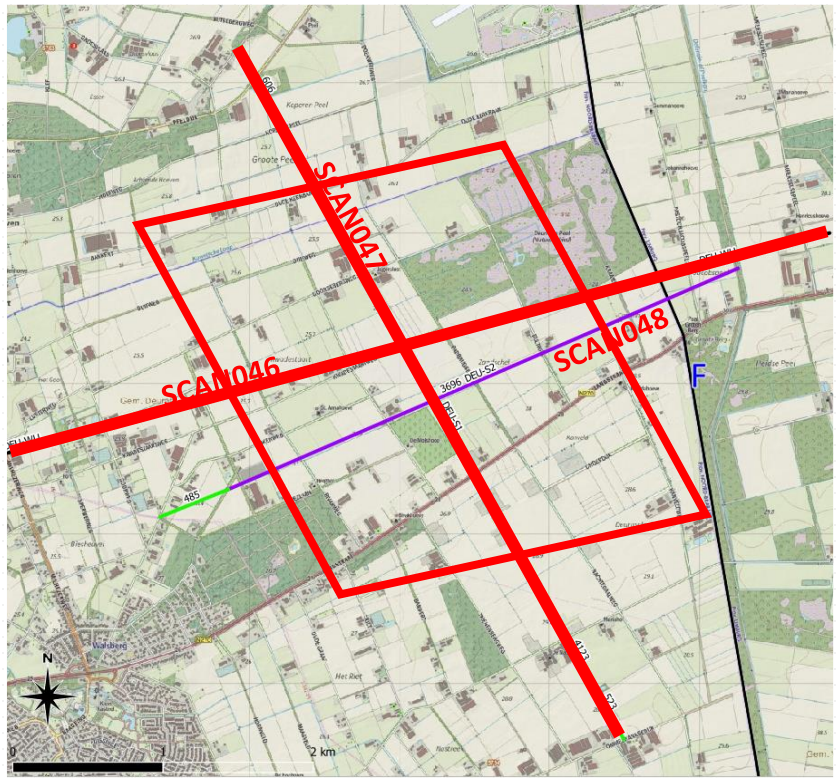

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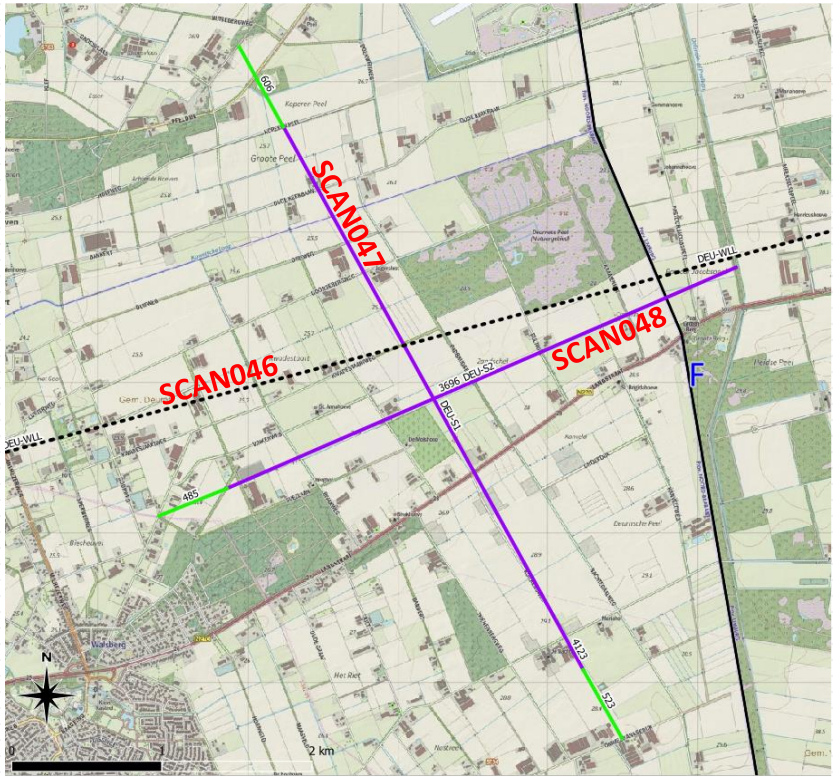


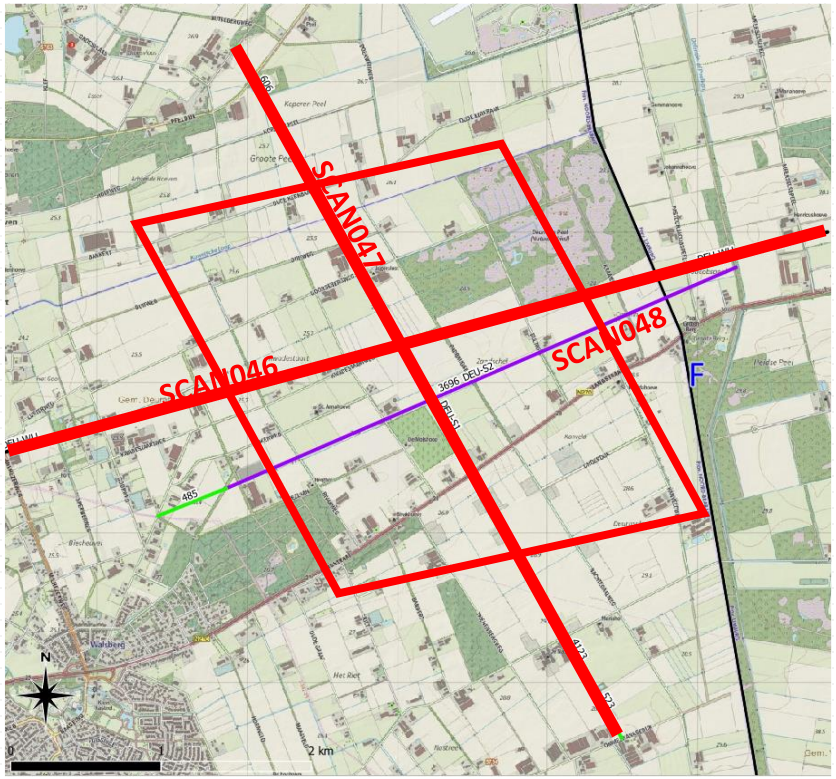


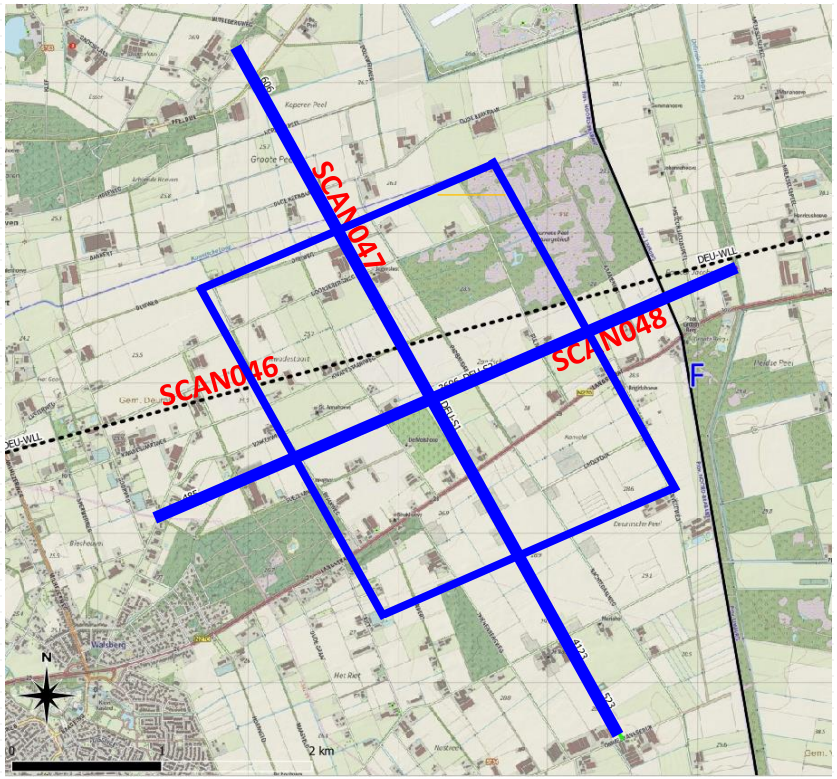

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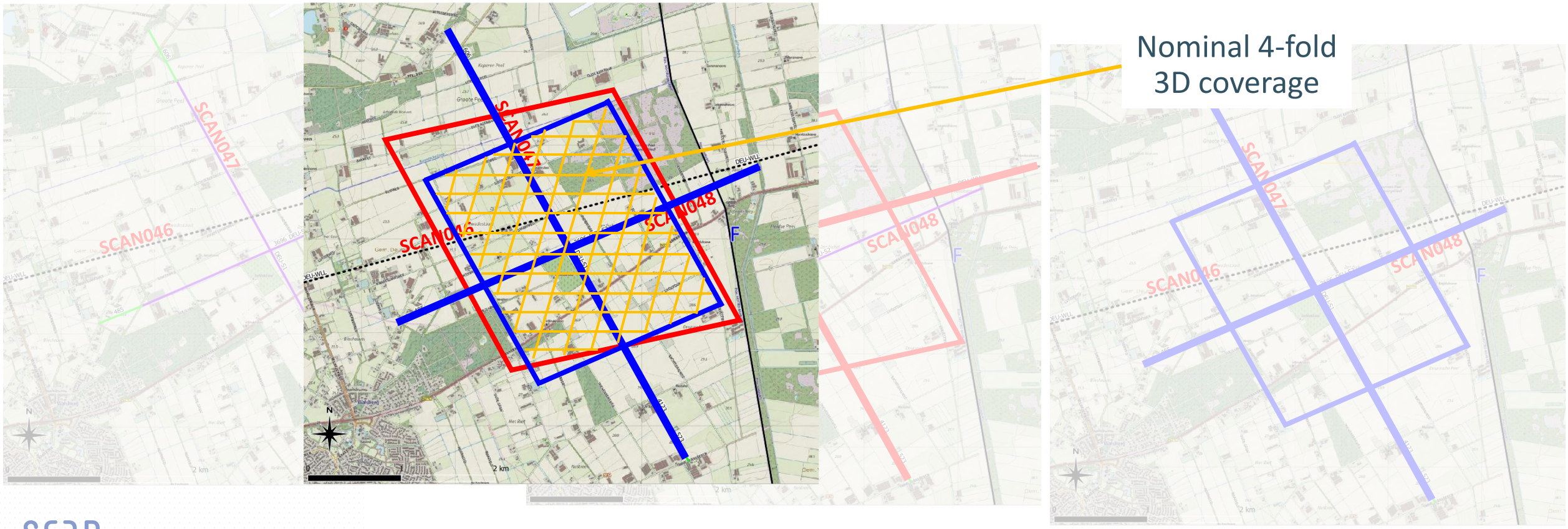

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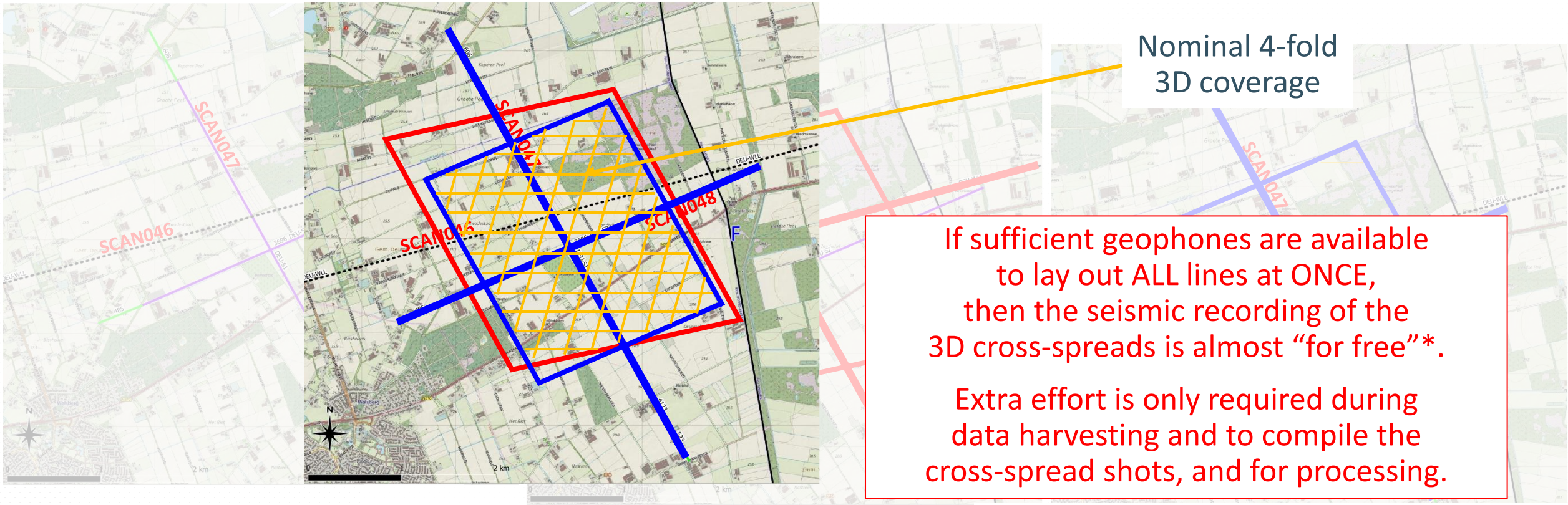


*: This requires a seismic source strong enough to record the wide crossline offsets.

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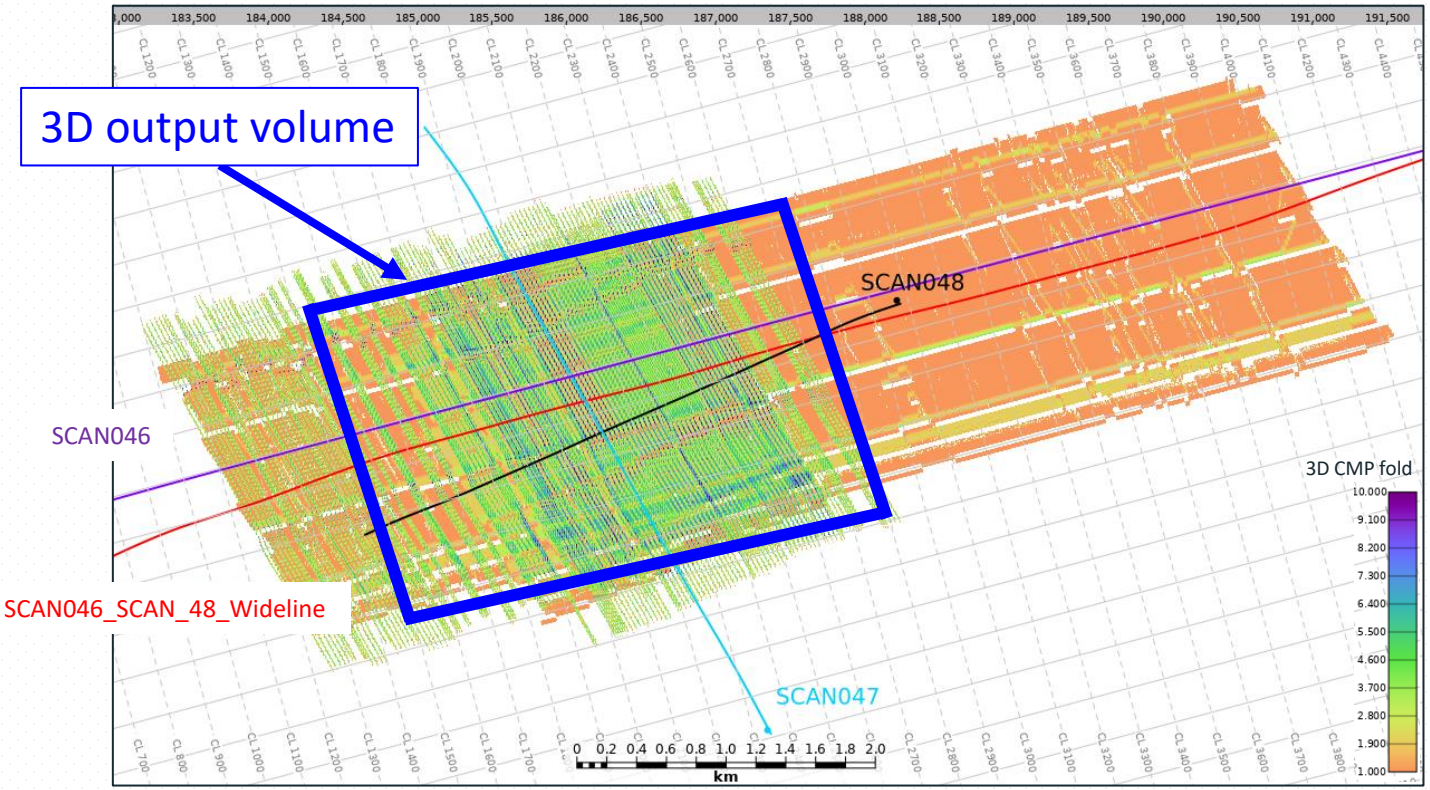
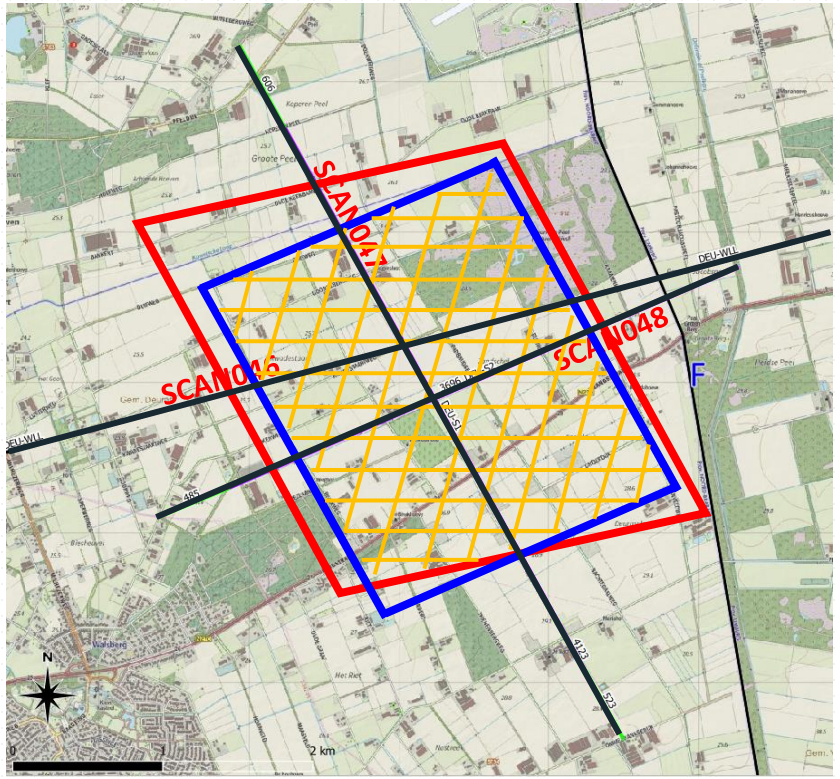
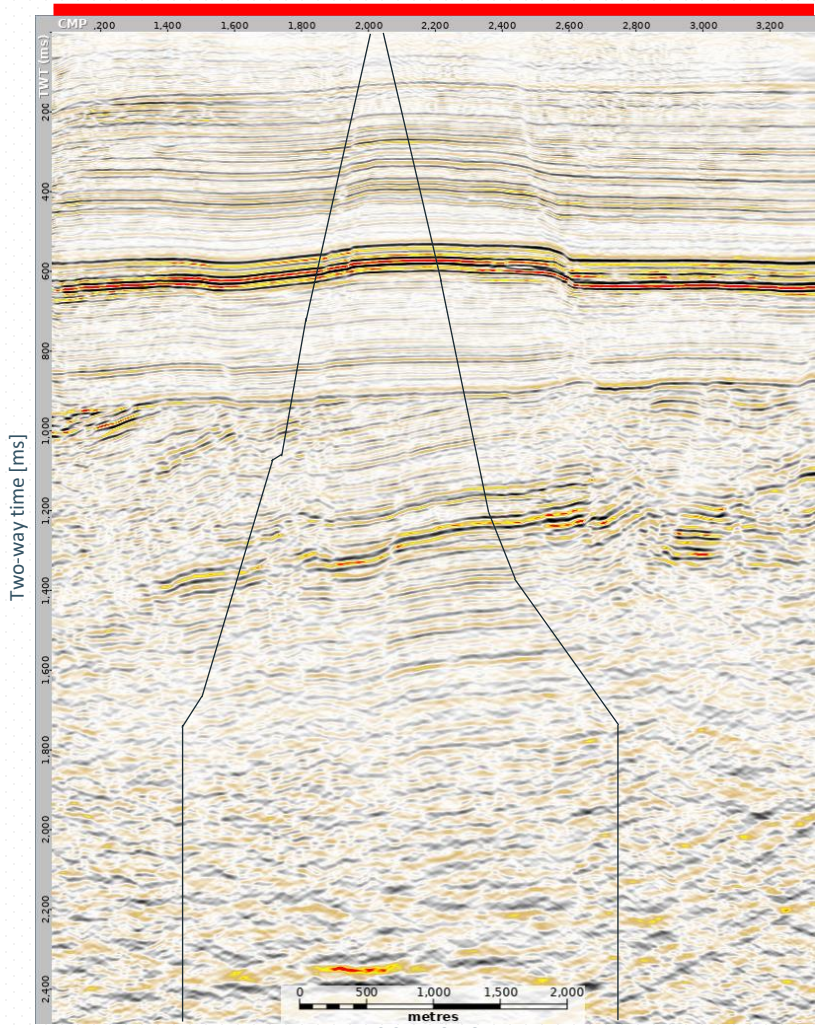


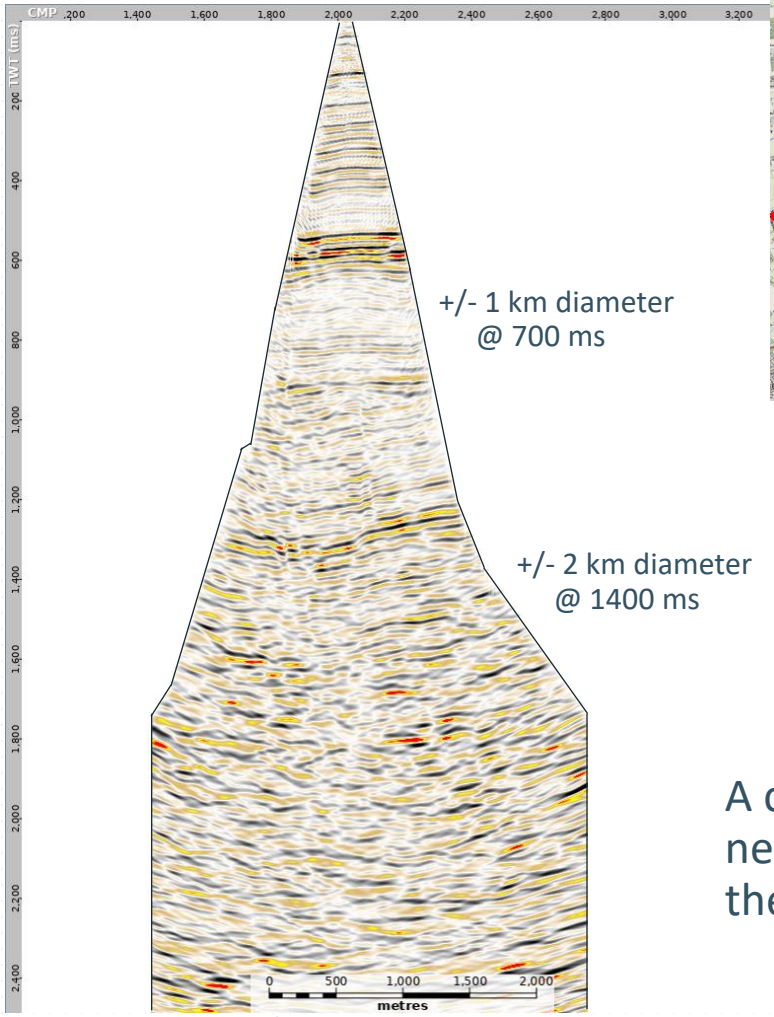

SCAN acquisition, Deurne area

# SCAN 3D cross-spread acquisition – Deurne area

3D cross-spread comparison with SCAN046 (AGC version), 3D cross-spread data extracted from 3D volume along SCAN046



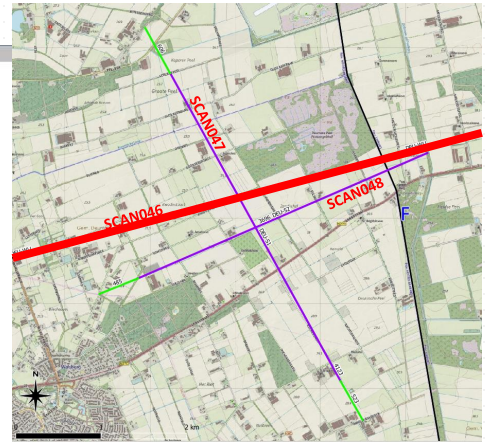

SCAN046




+/- 1 km diameter
@ 700 ms

+/- 2 km diameter
@ 1400 ms

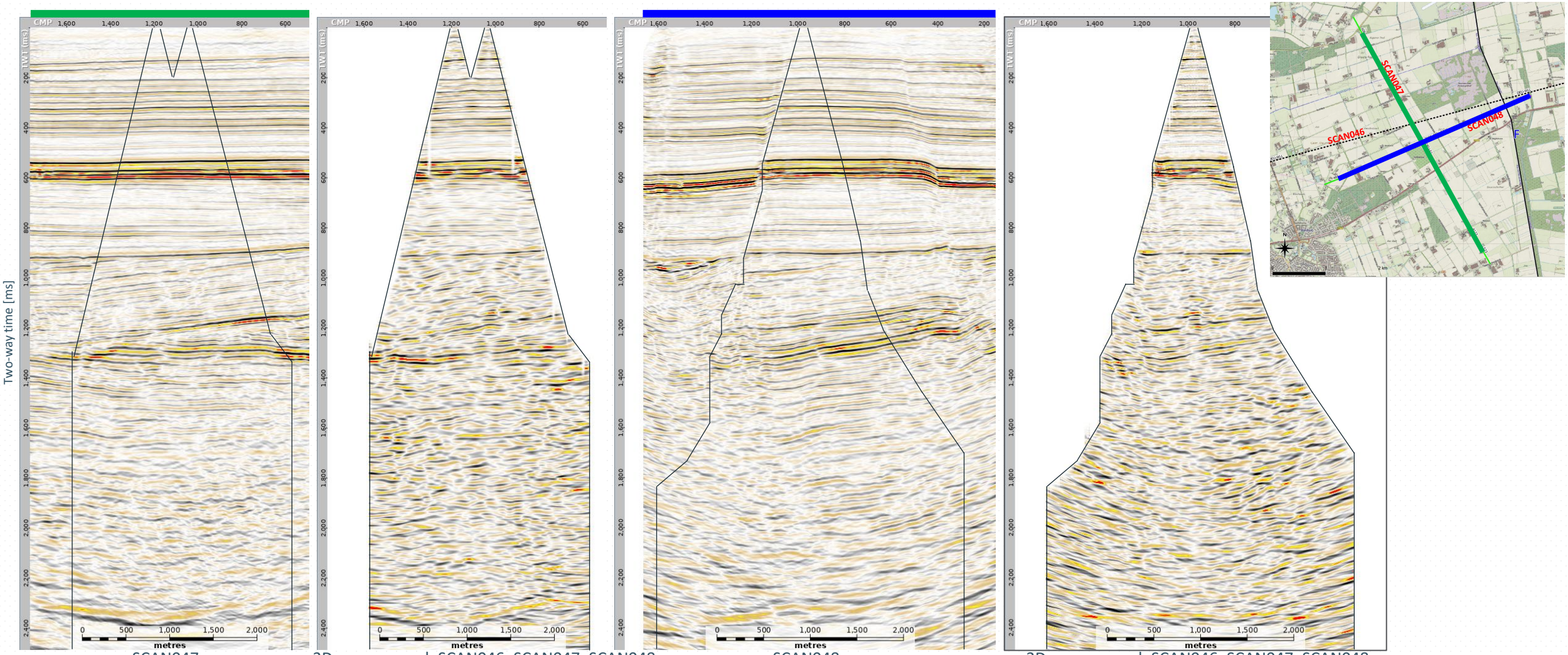
3D cross-spread_SCAN046_SCAN047_SCAN048




A cross-spread is lacking near offset data, hence the cone appearance.

# SCAN 3D cross-spread acquisition – Deurne area

3D cross-spread comparison with SCAN047 & 048 (AGC version), 3D cross-spread data extracted from 3D volume along SCAN047 & SCAN048




SCAN047 | 3D cross-spread_SCAN046_SCAN047_SCAN048 | SCAN048 | 3D cross-spread_SCAN046_SCAN047_SCAN048

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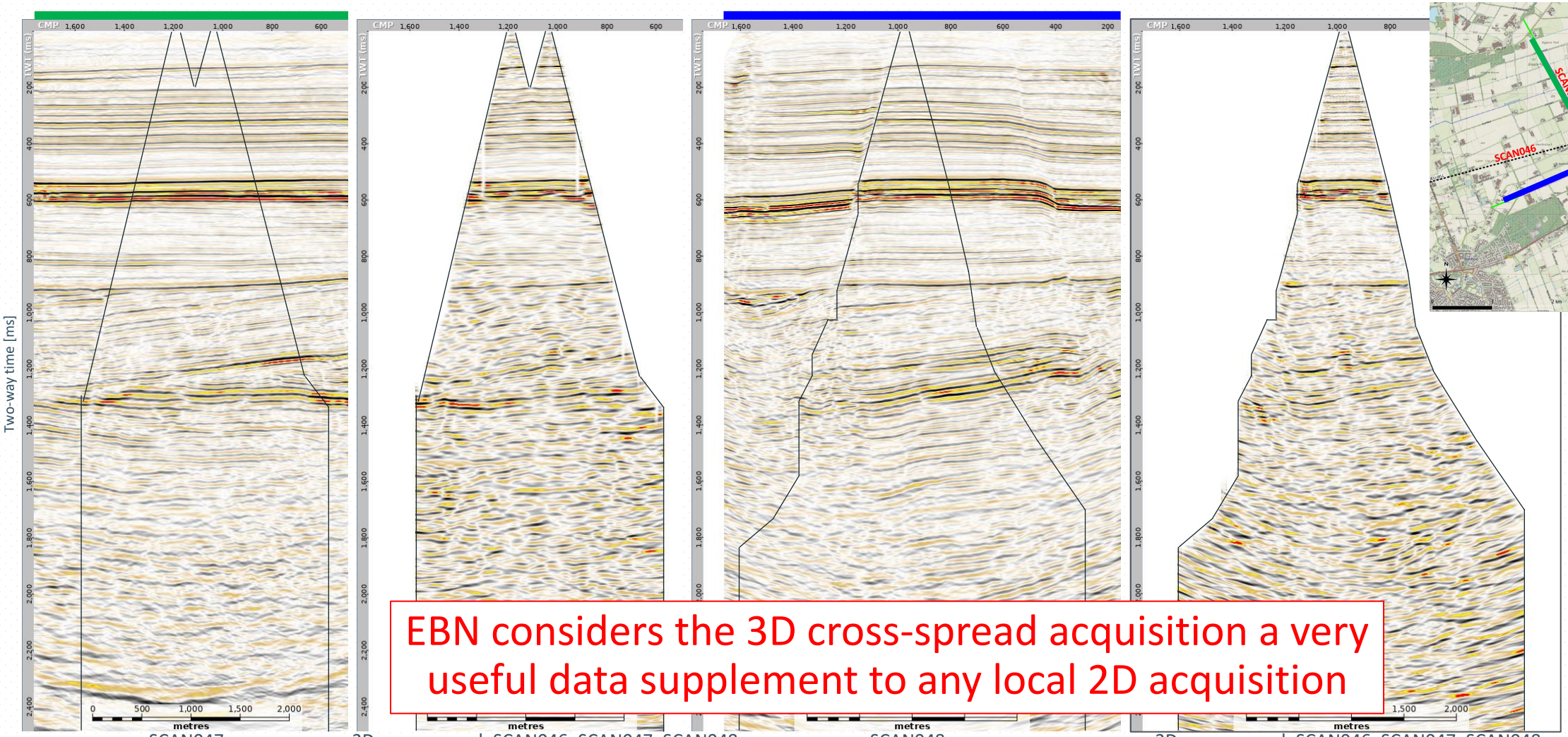



EBN considers the 3D cross-spread acquisition a very useful data supplement to any local 2D acquisition

SCAN047 | 3D cross-spread_SCAN046_SCAN047_SCAN048 | SCAN048 | 3D cross-spread_SCAN046_SCAN047_SCAN048

# Lessons learned from the SCAN 2D seismic acquisition

- Acquisition of 2019 EBN test line (SCAN001) was fundamental to survey design
  - Through seismic processing 7 different 2D acquisition designs could be tested, allowing for a balanced decision between data quality, survey costs and survey duration
- Wireless node technology allowed for very high receiver density & long offsets, which resulted in very dense subsurface sampling of 2.5m and a nominal high fold of 116
  - Little visibility of nodes resulted in low numbers of theft and vandalism
- Sonic drilling & explosive sources ensured powerful seismic energy source and limited source generated noises, e.g., ground roll
  - Vibroseis sources often suffer from weak near surface conditions, resulting in poor coupling and relatively little seismic energy being delivered into the subsurface

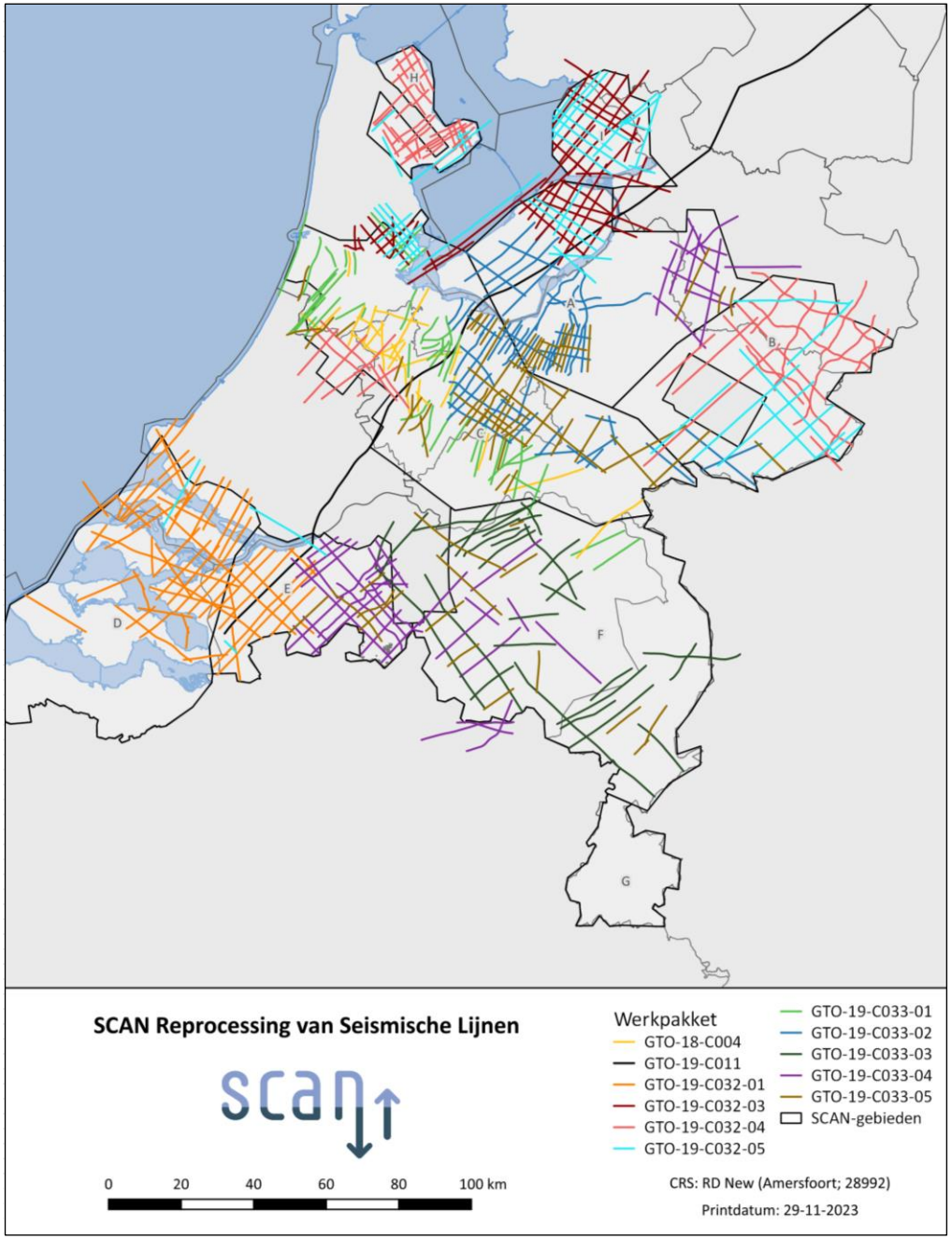
# Lessons learned from the SCAN 2D seismic acquisition

- Careful survey planning, using modern GPS & GIS systems, allowed for placing of more than 92,8% of all theoretical shot points, ensuring the “desired energy” got into the subsurface
- The SCAN lines were kept as straight as possible in survey planning, so the seismic data is “perfectly” projected onto the 2D line with as little cross-line offsets as possible, resulting in better seismic quality
  - Vibroseis trucks usually must stay on roads which results in “crooked” 2D seismic lines, while drill tractors can go almost anywhere as long as the required safety distance to building is maintained
- With a combination of deep shot holes of 34 m and a small charge size of 120 g, SodM granted an exemption to the mining law allowing for the reduction of safety distance to houses from 50 m to 30 m within the city limits of Amsterdam, resulting in an average seismic fold of 85* (line MRA037)

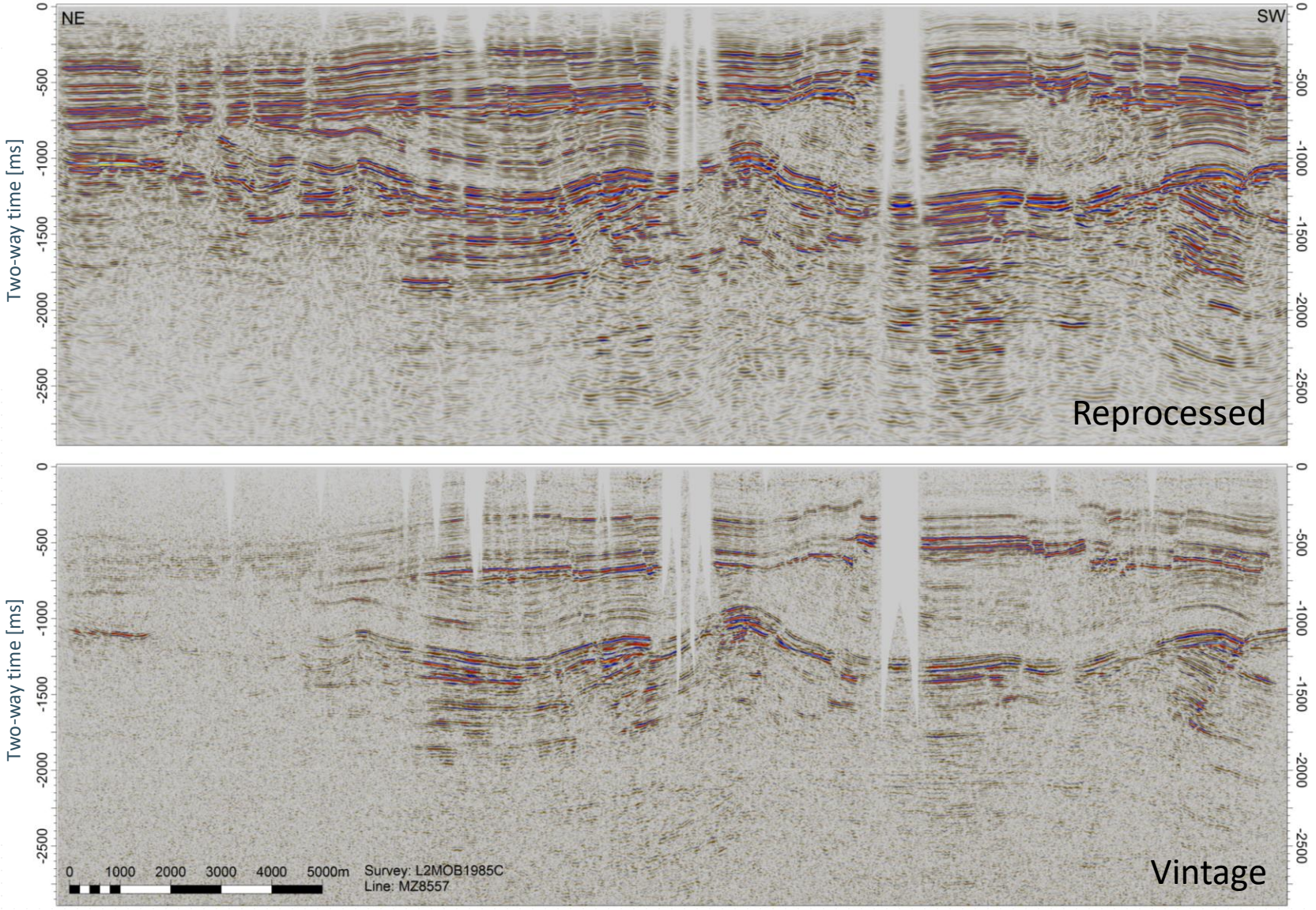
*Excluding 2.5km run-in & run-out

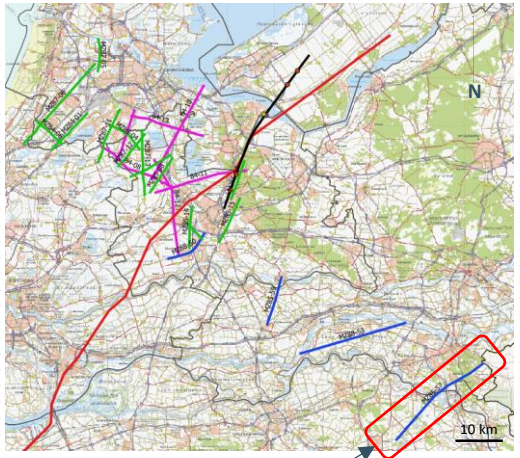
# SCAN 2D reprocessing summary

- 2D seismic data, acquired mainly from the early 70s to early 90s, is reprocessed through a broad-band Pre-Stack Time Migration sequence
- Retrieval and QC of vintage data performed by TNO and EBN took more than 6.500 hrs (> 3.5 FTE years)
  - Completeness check of raw field shots, observer logs and navigation data
  - Readability check of raw field shots (SEGY format)
  - If need be, reconstruction of navigation data
  - If need be, reconstruction of elevation data
- A total of 11 reprocessing projects have been released to NLOG, which amounts to 7.504 line km (451 lines)
- Time spend by EBN on QA/QC of seismic processing contractors was more than 5.100 hrs



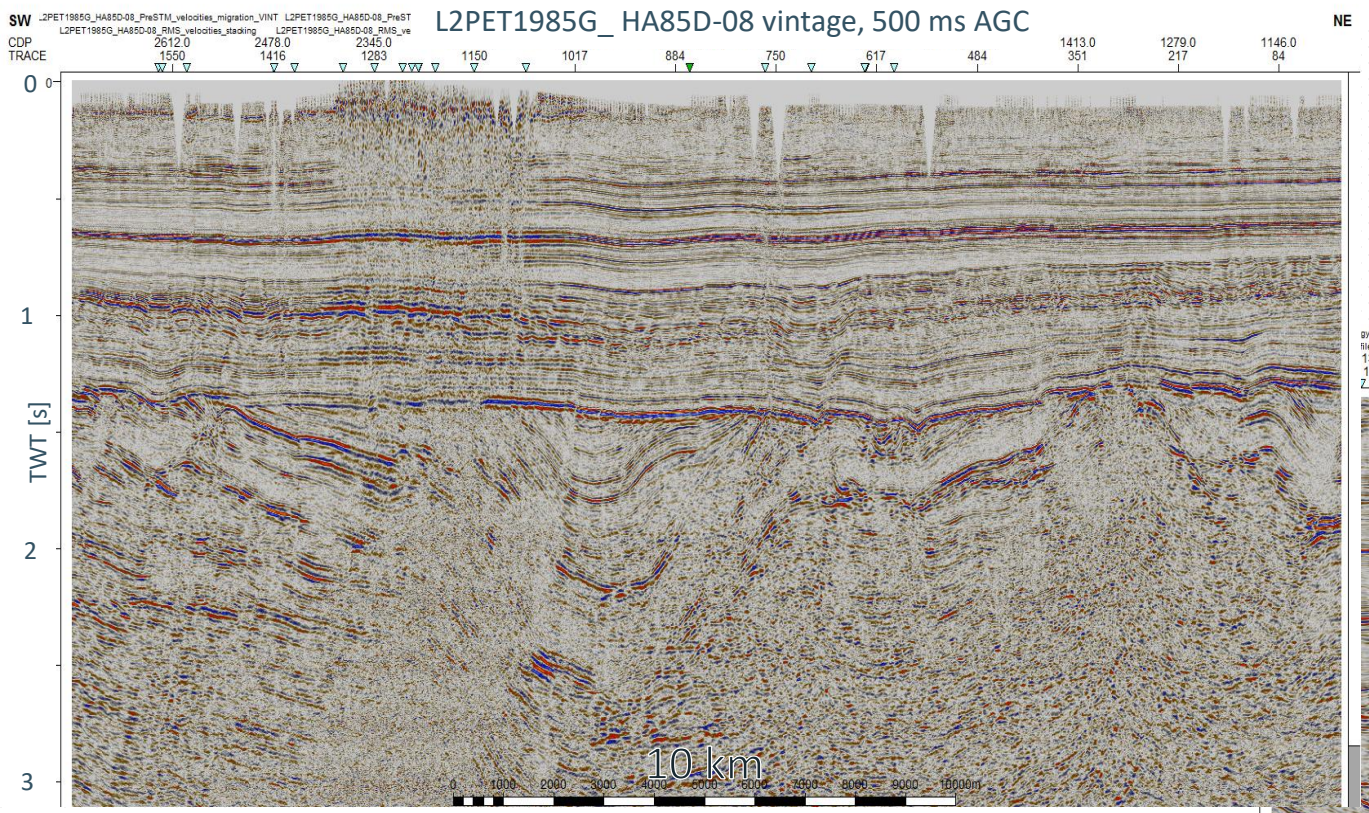
# SCAN 2D reprocessing – Old digital vs. new digital



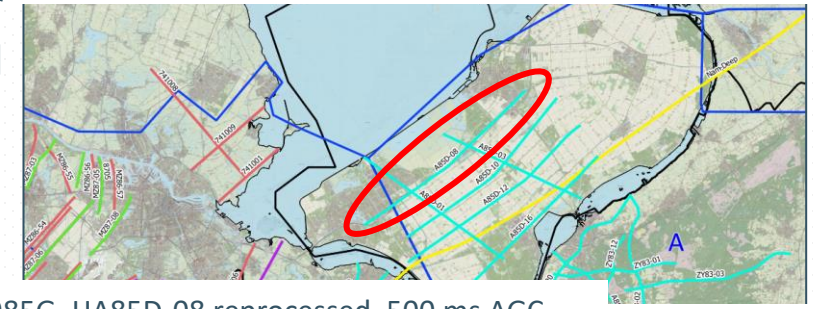




- Reprocessing usually improves Signal-to-Noise, event continuity as well as fault imaging

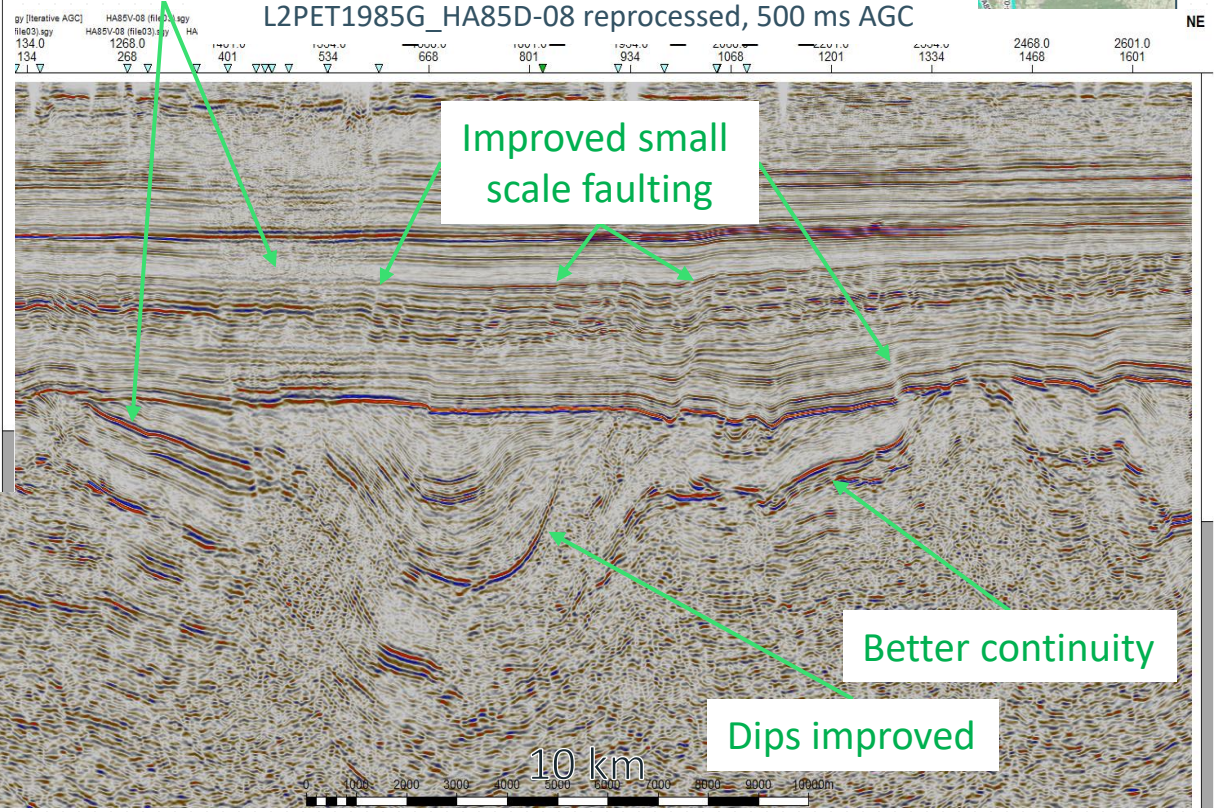
# SCAN 2D reprocessing – Old digital vs. new digital line




Flevopolder
Almere-Lelystad

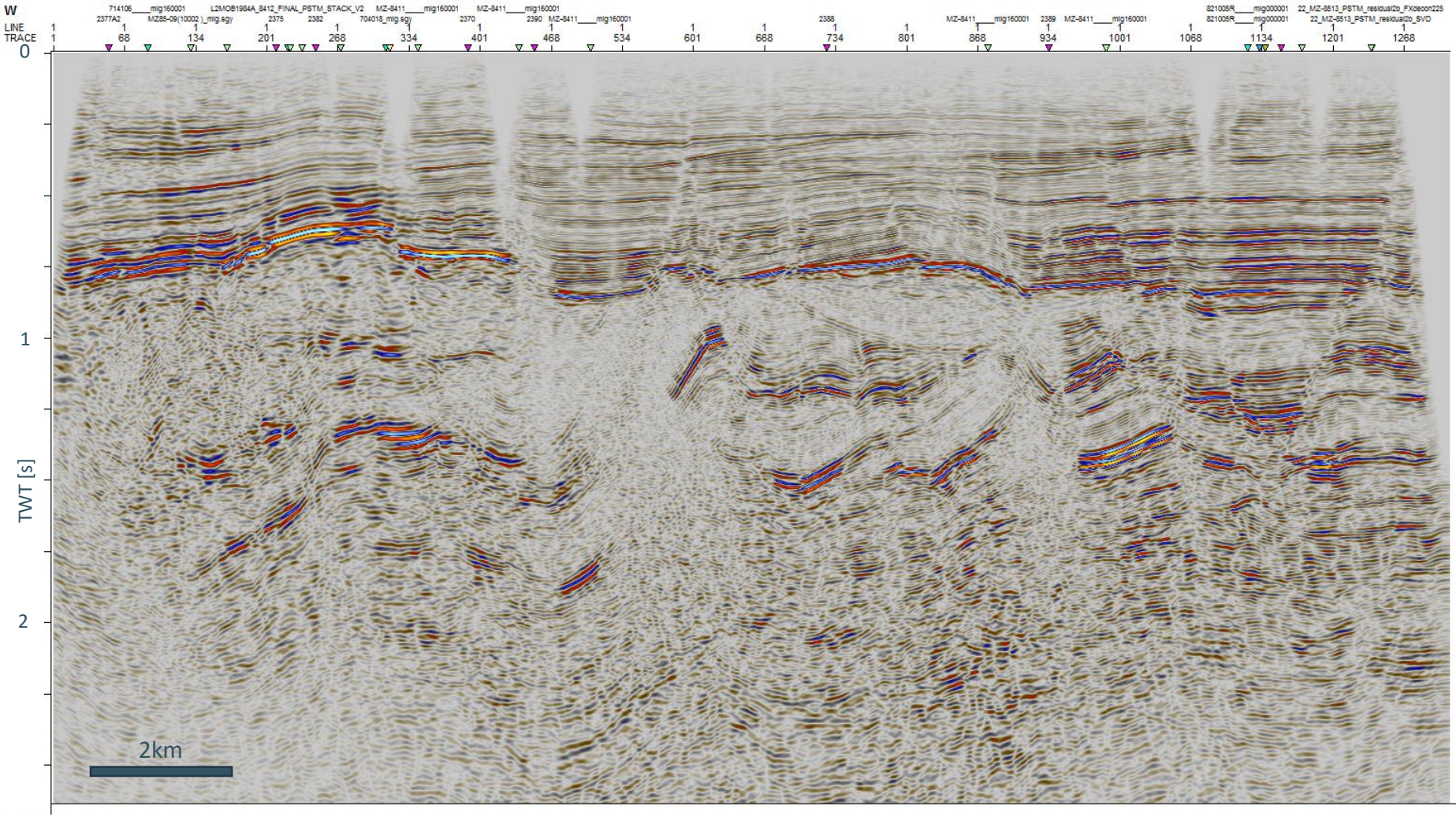



Better S/N



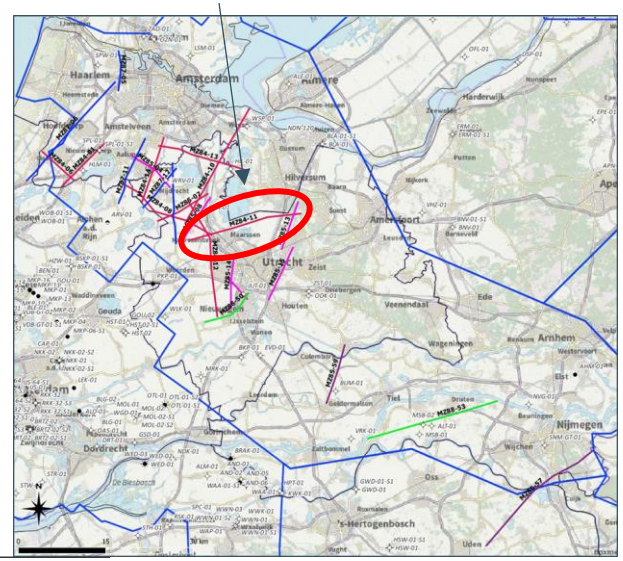

- Reprocessing usually improves Signal-to-Noise, event continuity as well as fault & dip imaging

# SCAN 2D reprocessing – “New” digital vintage line




- No digital or paper section present in TNO archive for this line.
- Used vintage field data to create a “new” line

Line MZ84-11 north of Utrecht



# Summary

- The SCAN programme is providing a wealth of new and improved subsurface data:
  - A little over 1.950* line km of new high quality broad-band 2D seismic in areas with low seismic coverage
  - A total of 7.504 line km of reprocessed vintage 2D seismic
  - A data well campaign commenced in October 2023 to focus on data acquisition of all potentially attractive geothermal reservoirs, expected completion by end 2025

- All data is released for free at completion and ready for use for further geothermal exploration and development

*: 2D regional lines, local lines and widelines.

# SCAN 4 – The next phase of SCAN seismic acquisition

- The Ministry of Climate Policy and Green Growth (KGG) granted an extension to the SCAN project in December 2023 for the years 2024 to 2027, now called SCAN 4
- The seismic acquisition scope now includes 2D and 3D seismic acquisition
- This required a new land 2D & 3D seismic acquisition contract, and a European Tender was executed over the summer 2024
- In preparation for the first SCAN 3D survey, EBN commissioned 3D survey design studies with two companies in Q2.2024 to obtain a nominal 3D survey design
- Work is ongoing to identify a suitable location for the first survey and three areas of interest have just been announced

# Acknowledgements

Thanks go to:

- EBN and the Dutch Ministry of Climate Policy and Green Growth (KGG) for the permission to present this work
- The Warmtetransitie Operations & Technology teams at EBN as well as TNO for their work contributions and availability for peer reviews
- EBN's seismic service providers
  - Rossingh Drilling & Geophysics B.V.  for the acquisition of the new 2D data
  - DownUnder GeoSolutions (DUG) for the processing of the new 2D data
  - Geofizyka Toruń S.A., TEEC GmbH and DMT Petrologic GmbH for the 2D reprocessing and
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