The Dutch SCAN Geothermal Seismic Exploration Program

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EBN B.V.

Agenda

Introduction to EBN

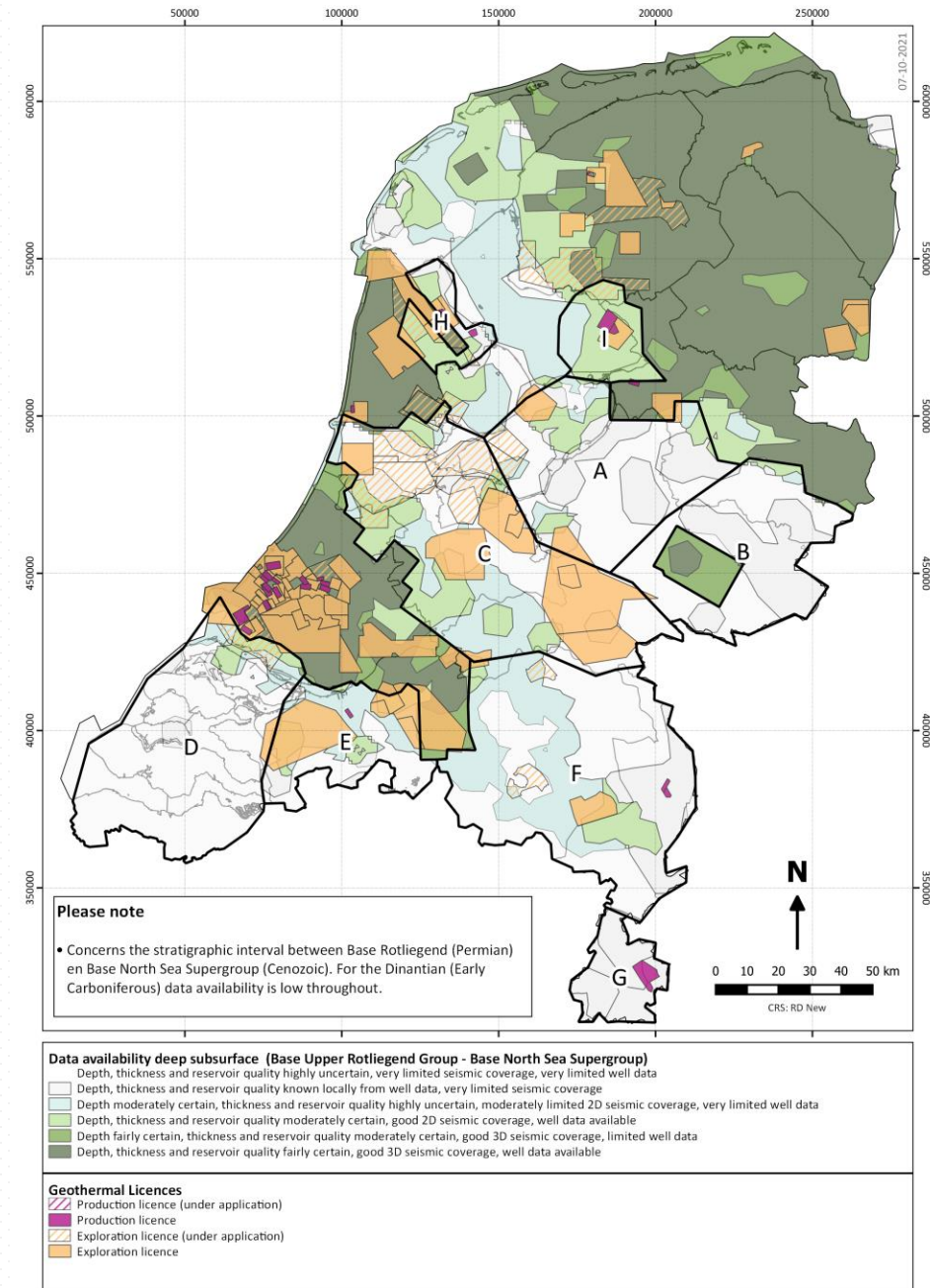- EBN (Energie Beheer Nederland, www.ebn.nl) was founded 50 years ago. It is a 100% state-owned company with 185 employees based in Utrecht, The Netherlands.

- Our mission is 'Towards a sustainable energy system, faster, together'
  - In line with its public role, EBN as a connecting force, uses its knowledge of the subsurface and expertise to accelerate the implementation of the Dutch energy and climate policy with the aim of achieving a sustainable, reliable and CO_2-neutral energy system by 2050, at the lowest possible cost to society.

- Our strategic pillars:
  - A sustainable gas system
  - Responsible CO_2 storage
  - System Development for the public interest
  - A sustainable heat transition

A sustainable **heat transition**

Implementing collective and sustainable heat systems

- Geothermal energy
- SCAN
- Heat systems
- Heat storage
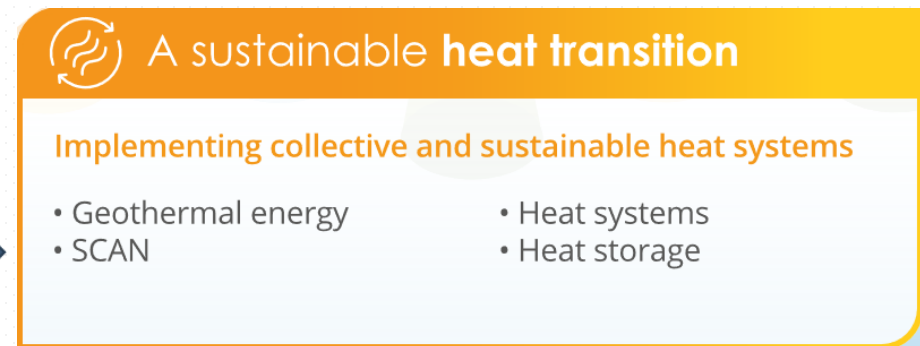
scan

Introduction to SCAN

- SCAN stands for
  Seismische **C**ampagne **A**ardwarmte **N**ederland

- SCAN accelerates the development of geothermal energy by filling subsurface data gaps

- The SCAN target depth for geothermal projects ranges from 500 to 4000 m

- Funded by the Ministry of Economic Affairs and Climate (EZK) and executed by EBN and TNO

- Part of the 2D seismic acquisition is subsidised by the EU Interreg program DGE-ROLLOUT

Please note

- Concerns the stratigraphic interval between Base Rotliegend (Permian) en Base North Sea Supergroup (Cenozoic). For the Dinantian (Early Carboniferous) data availability is low throughout.

0 10 20 30 40 50 km

CRS: RD New

Data availability deep subsurface (Base Upper Rotliegend Group - Base North Sea Supergroup)
- Depth, thickness and reservoir quality highly uncertain, very limited seismic coverage, very limited well data
- Depth, thickness and reservoir quality known locally from well data, very limited seismic coverage
- Depth moderately certain, thickness and reservoir quality highly uncertain, moderately limited 2D seismic coverage, very limited well data
- Depth, thickness and reservoir quality moderately certain, good 2D seismic coverage, well data available
- Depth fairly certain, thickness and reservoir quality moderately certain, good 3D seismic coverage, limited well data
- Depth, thickness and reservoir quality fairly certain, good 3D seismic coverage, well data available

Geothermal Licences
- Production licence (under application)
- Production licence
- Exploration licence (under application)
- Exploration licence

The 3 key components of the SCAN program

1. Acquisition of new 2D seismic data

   - Started in February 2019 with the EBN test line and the regional campaign commenced in September 2019 and was completed in January 2022

2. Reprocessing of existing 2D seismic data

   - The reprocessing effort started in Oct. 2018 and will complete in Q2.2023
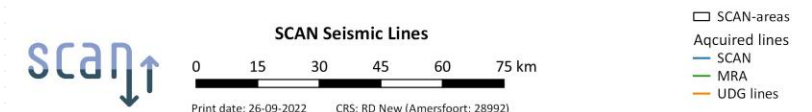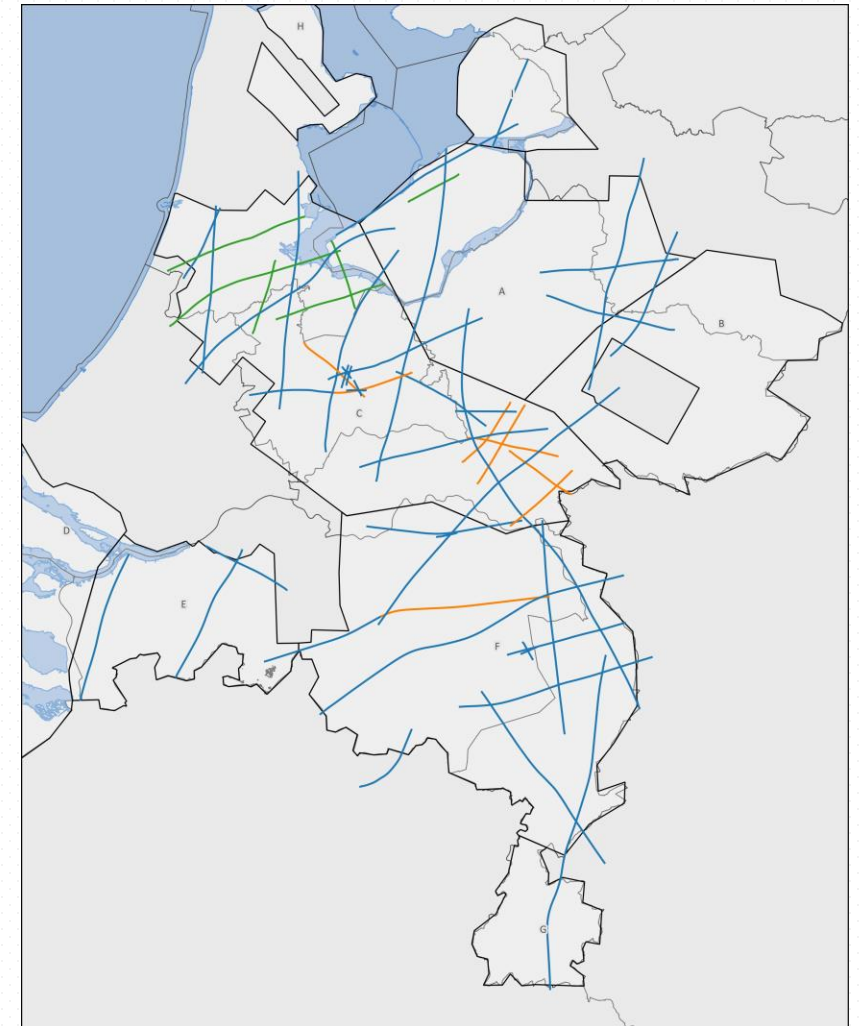
3. Data well campaign

   - The well campaign will start with the first well spud planned for Q3.2023

All data and study results are immediately released to the public domain at completion and published on the websites scanaardwarmte.nl and nlog.nl/scan

SCAN 2D seismic acquisition & data availability

- Acquired 1.761 line km of new regional 2D (46 lines) and 11 local lines to support the SCAN well locations with zero LTIs

- Recorded 29.296 shots and 371.365 receivers planted

- SCAN acquisition is combined with local seismic acquisition programs for UDG and MRA

- Visited 163 municipalities, distributed 130.000 letters into the neighbourhoods prior to acquisition

- Land access permissions from 6.000 land users

- All 46 regional lines & 11 local lines are available on the NLOG website (https://www.nlog.nl/scan-2d-seismische-data)

MRA = Metropoolregio Amsterdam

SCAN Seismic Lines

0   15   30   45   60   75 km

Print date: 26-09-2022   CRS: RD New (Amersfoort; 28992)

SCAN-areas
Aqcuired lines
— SCAN
— MRA
— UDG lines

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 (31.09.2022):

- Zero LTIs
- Manhours worked: 1.079.737
- KMs driven: 2.573.344
 (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

Geophones

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

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

Cumulative shot points drilled

- Acquisition pause
- Holiday
- Holiday
- Holiday
- Holiday
- Covid-19 shutdown
- Start up period 2-3 km/day
- Up to 4 km/day
- Bad weather < 1 km/day
- Steady as she goes +/- 4 km/day
- Slow down due to water works and urban areas 1-3.5 km/day
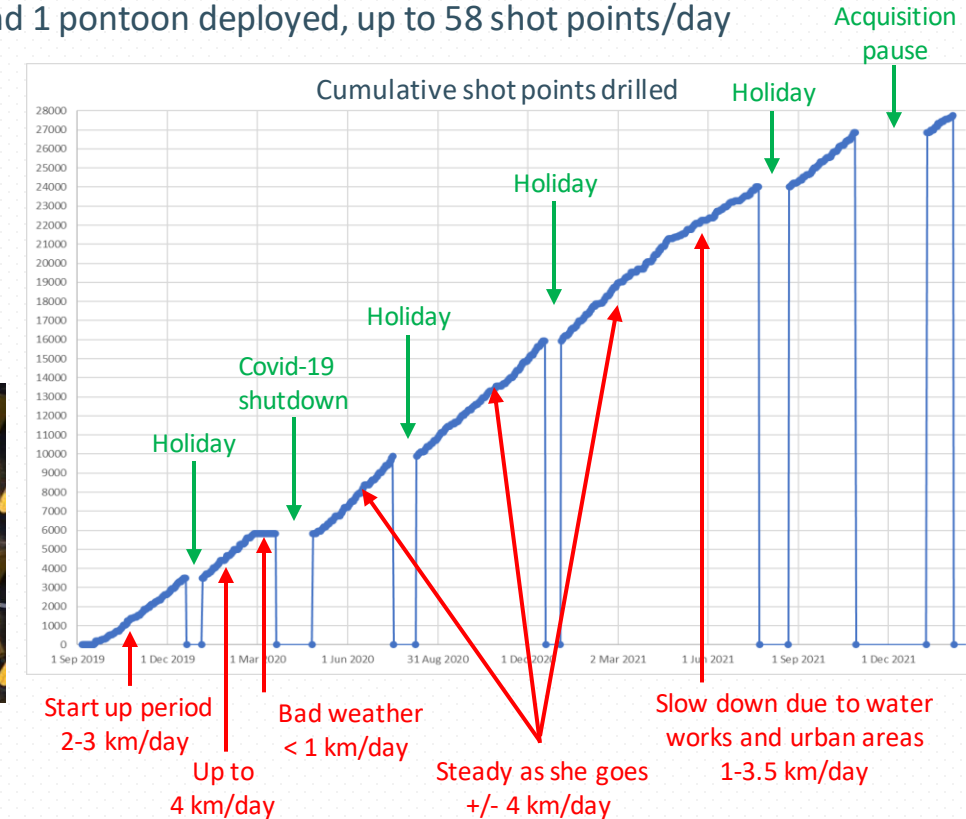
Average shot point drilling since acquisition start (477 days of shot point drilling) is 3.7 km/day.

SCAN 2D PreSTM processing – SCAN011 & SCAN001
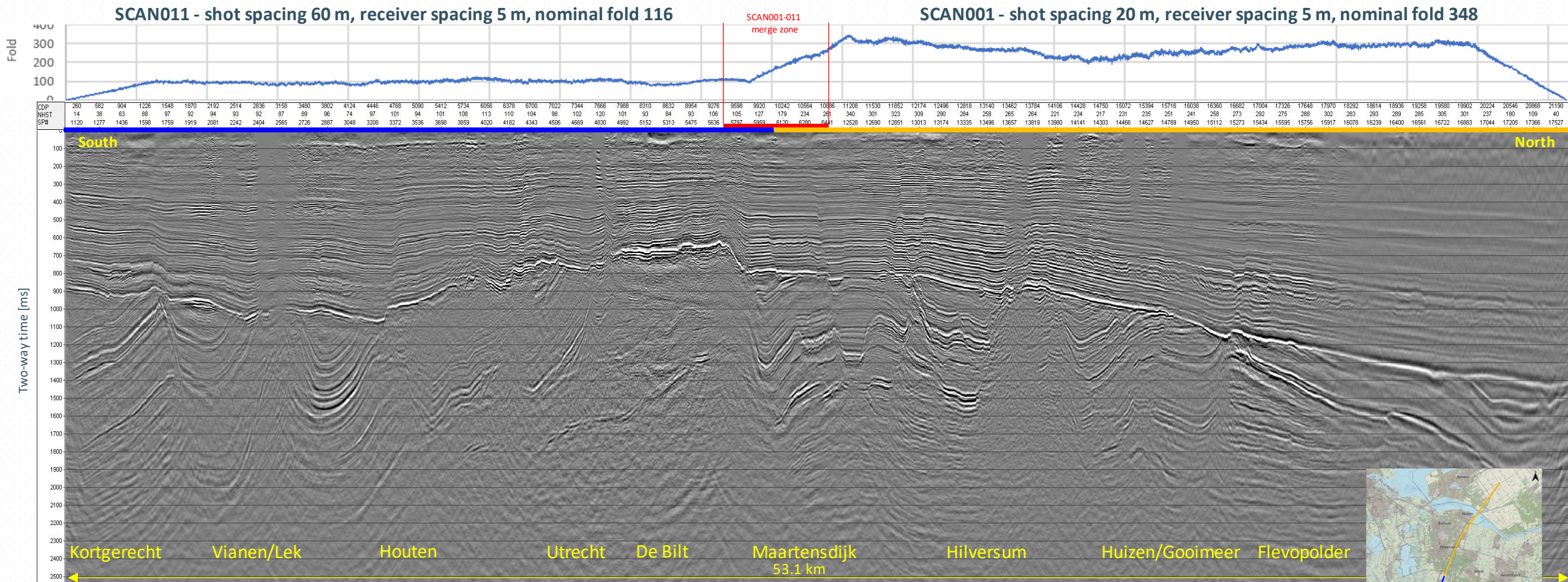
- Shot spacing of 60 m shot & 5 m receiver spacing provide adequate data quality for 2D regional seismic interpretation
- No significant data quality reduction compared to 2019 test line that would compromise seismic interpretability

www.scanaardwarmte.nl
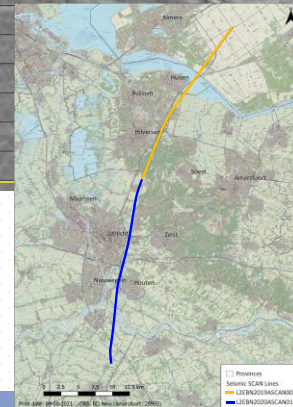
SCAN 2D PreSTM processing – MRA037
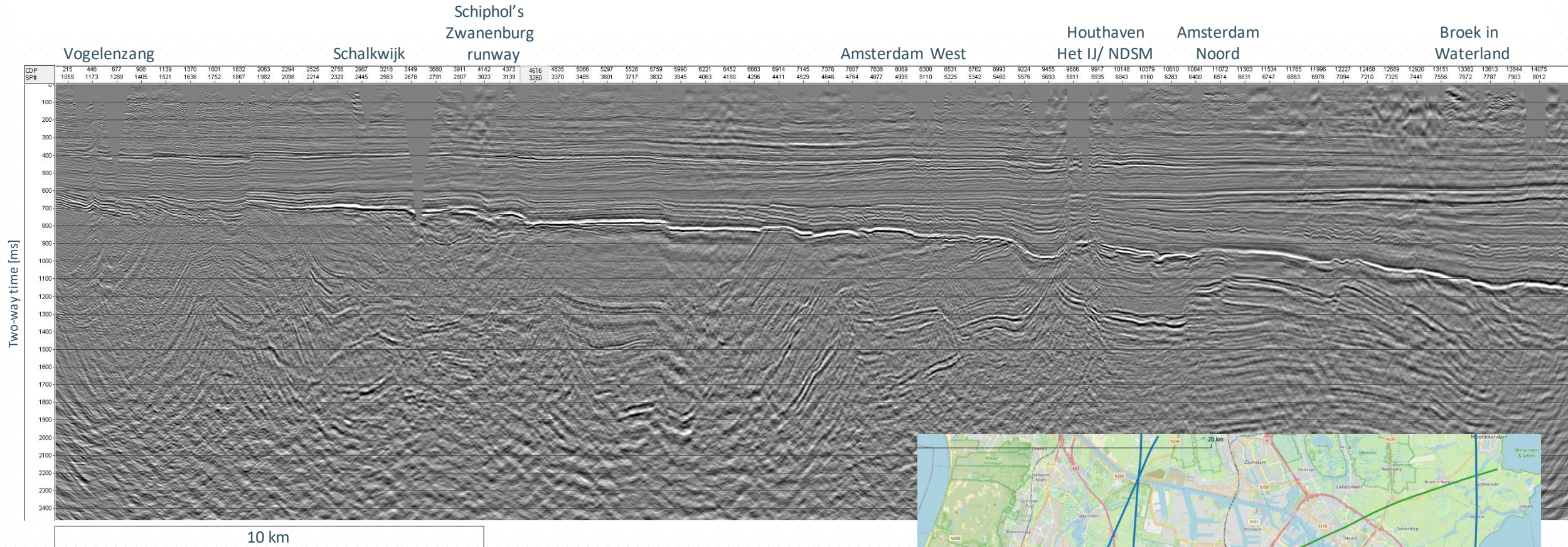
- With careful planning it was possible to acquired several 2D seismic lines in close proximity to Amsterdam.
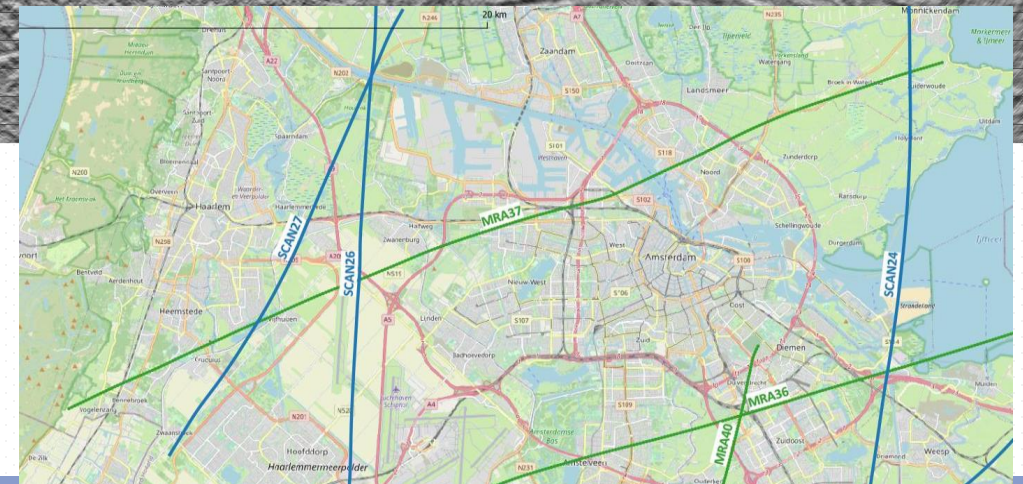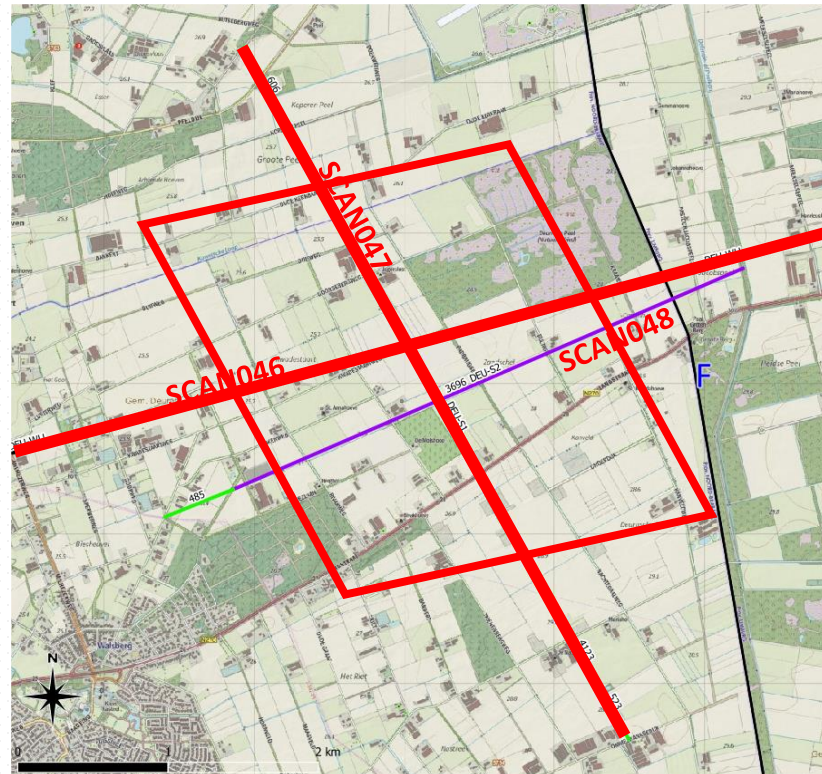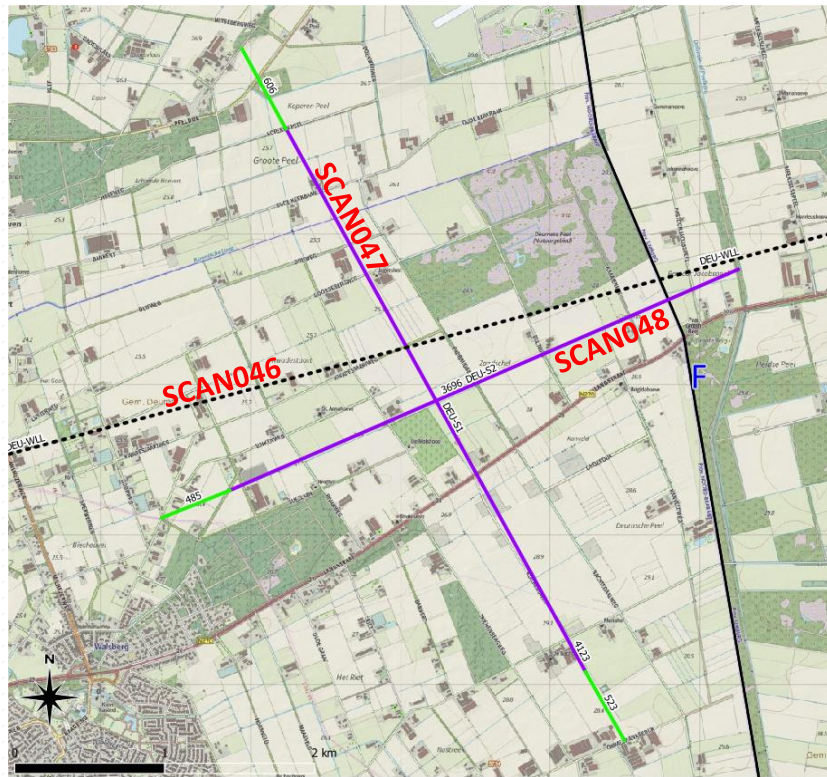
SCAN 3D cross-spread acquisition – Deurne area

- 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.
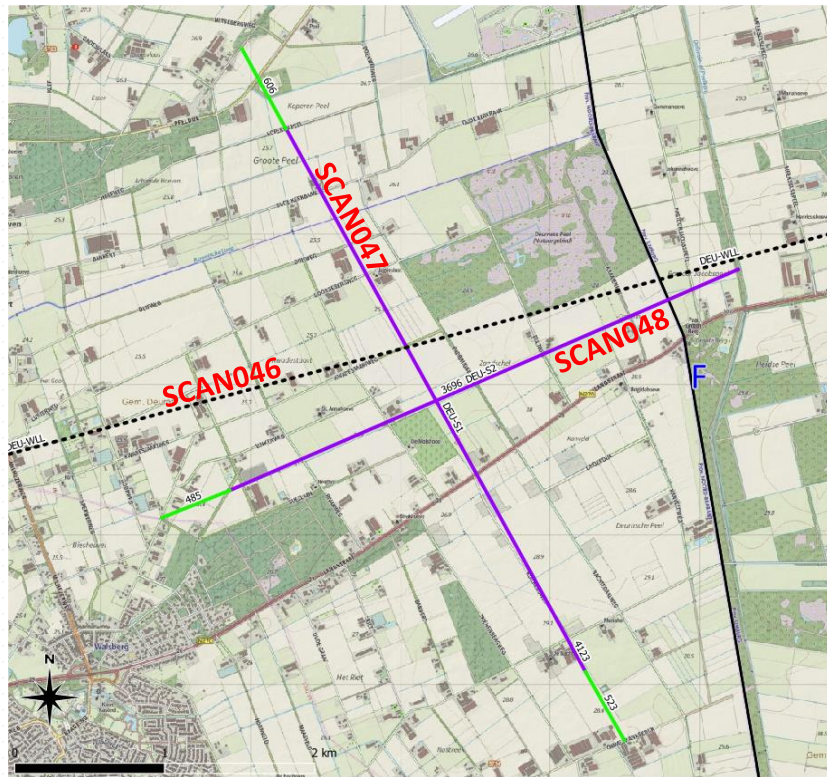
Regional line SCAN046
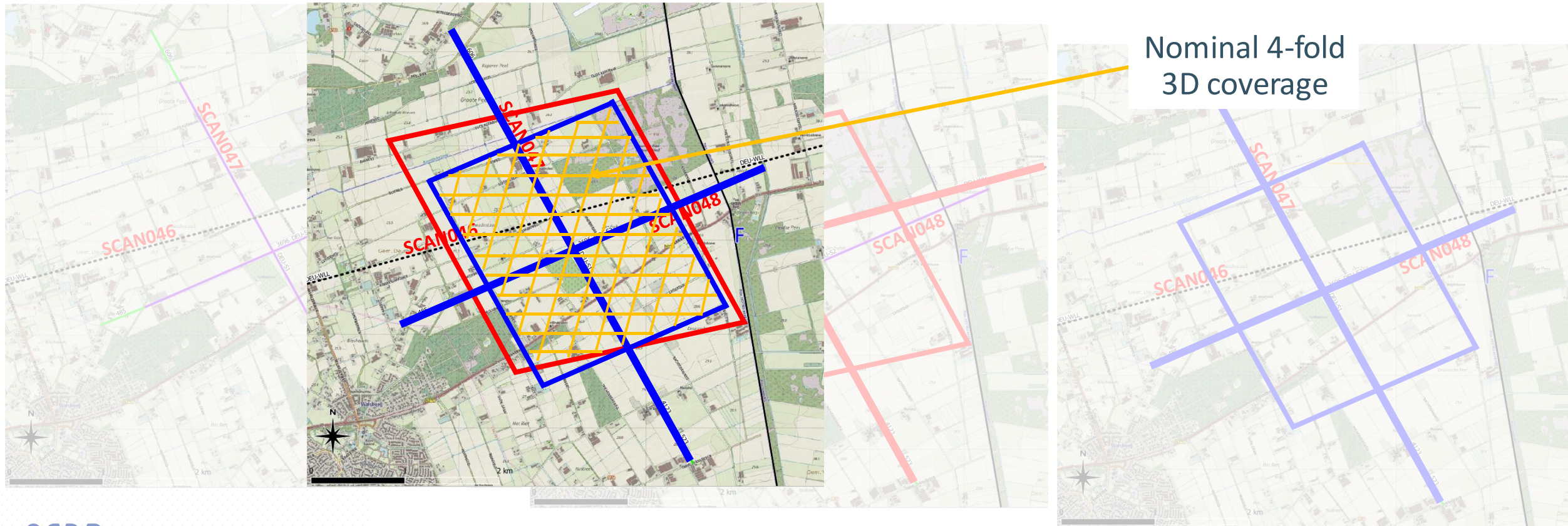Two local lines SCAN047 & 048

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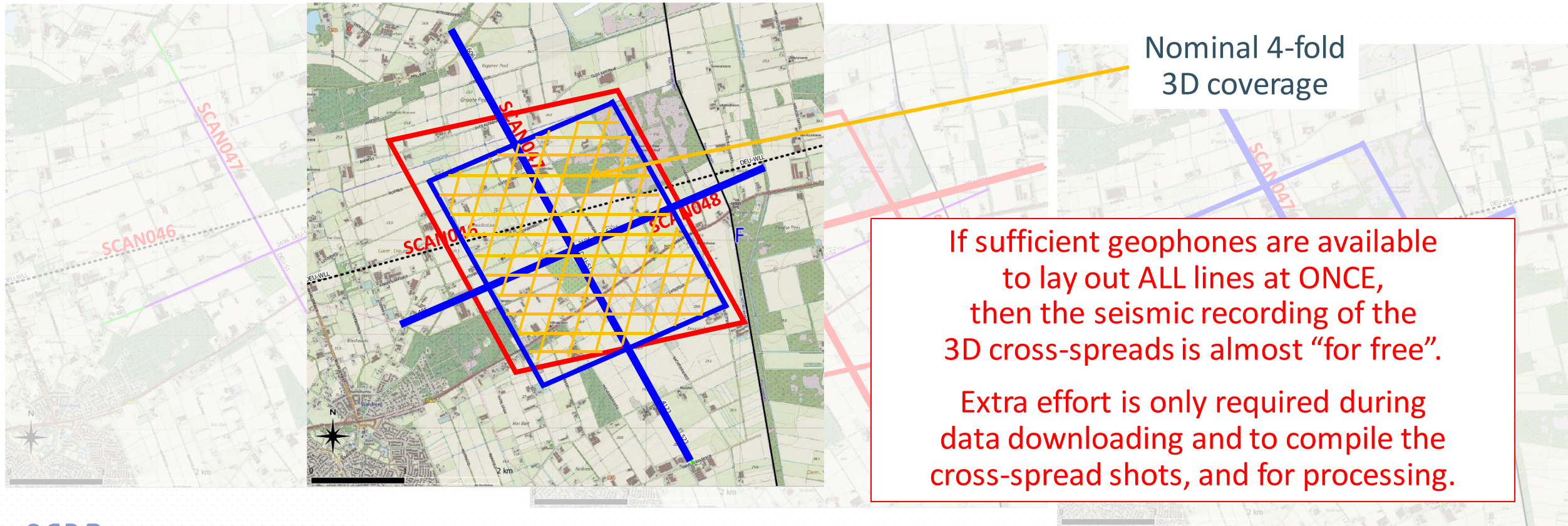
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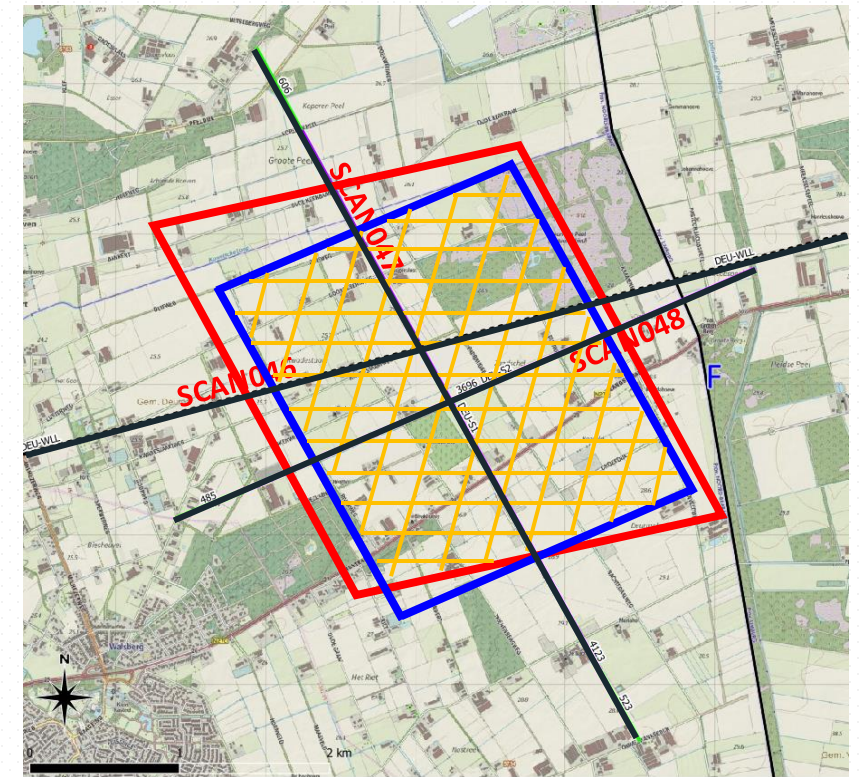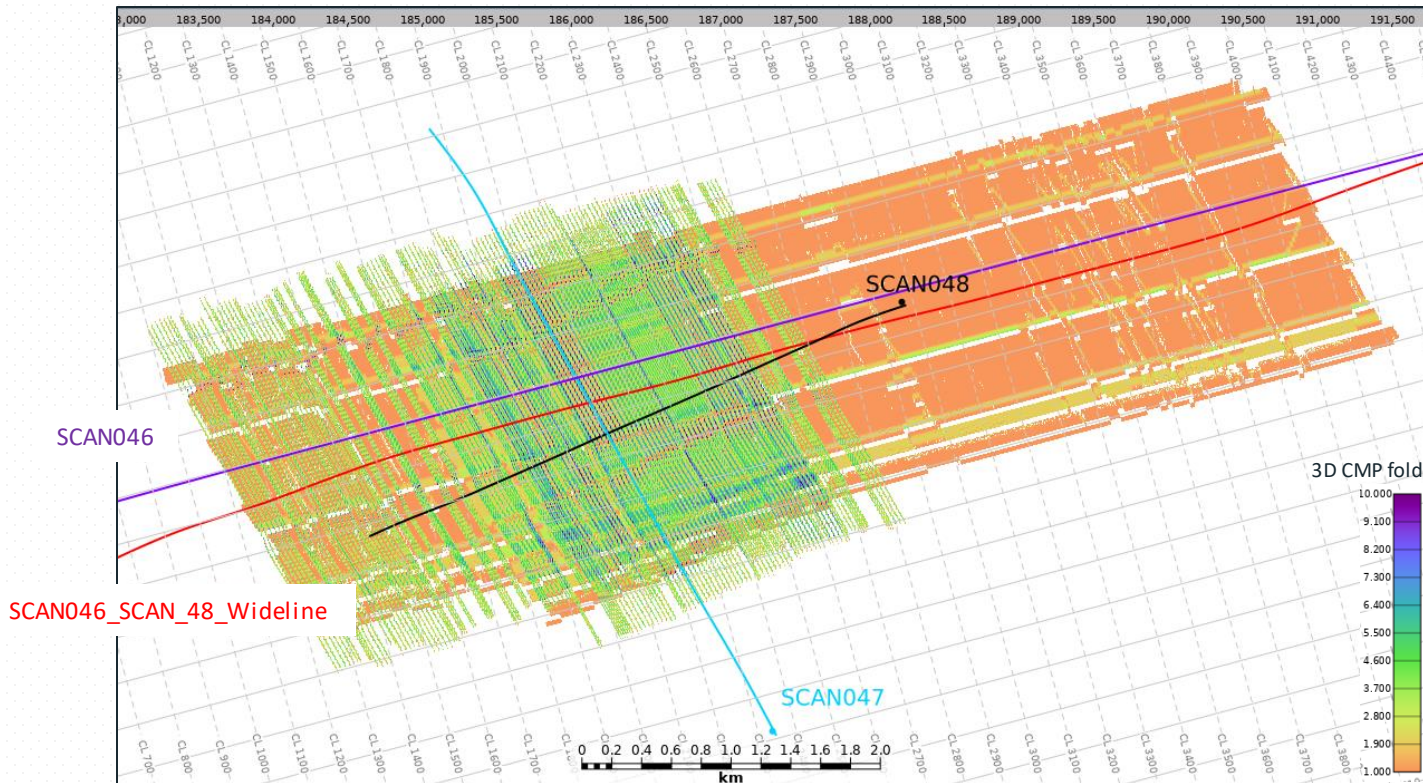
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Nominal 4-fold
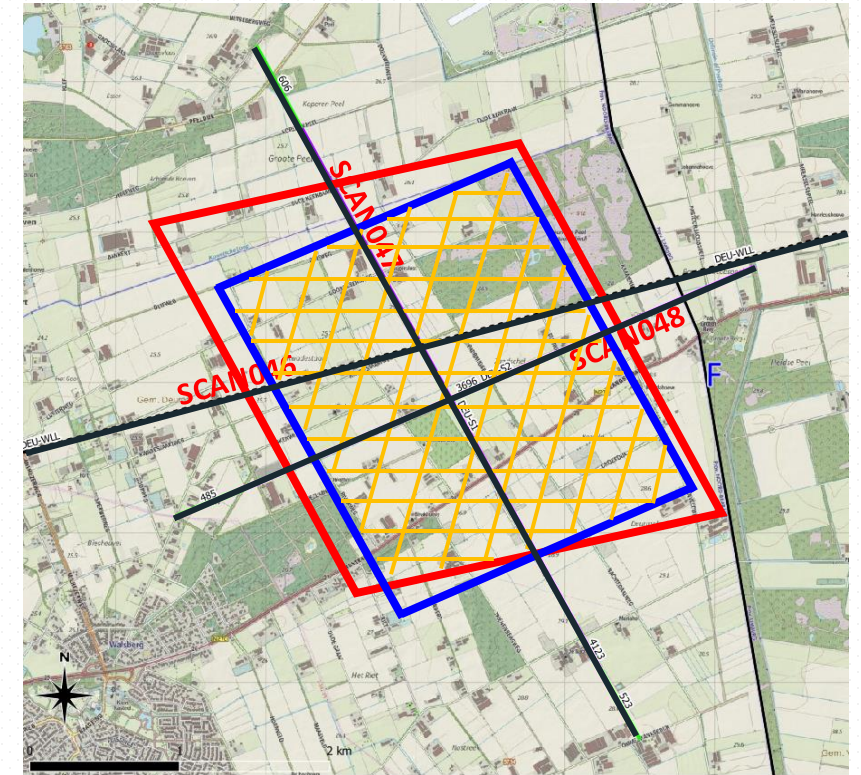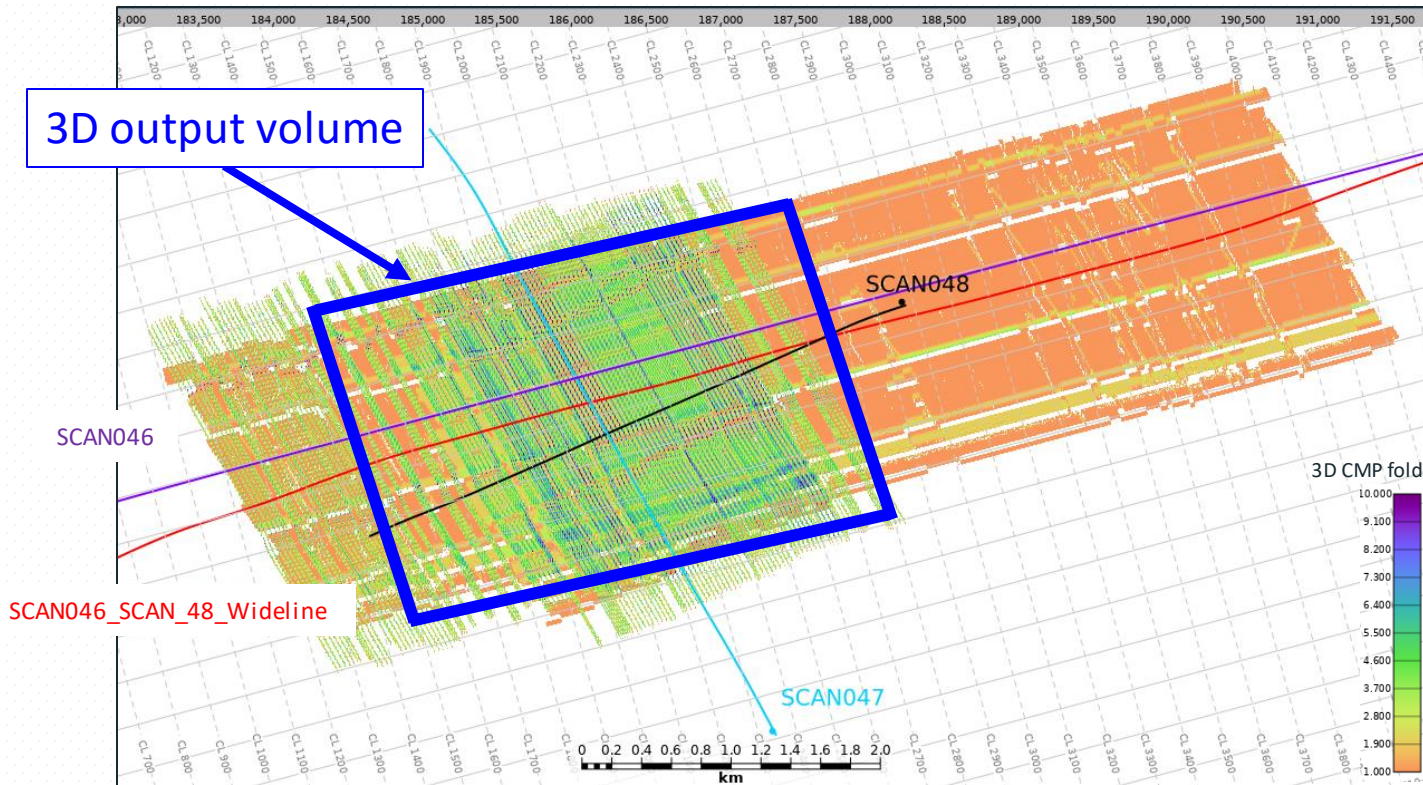3D coverage

SCAN 3D cross-spread acquisition – Deurne area

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Nominal 4-fold
3D coverage

If sufficient geophones are available
to lay out ALL lines at ONCE,
then the seismic recording of the
3D cross-spreads is almost "for free".

Extra effort is only required during
data downloading and to compile the
cross-spread shots, and for processing.
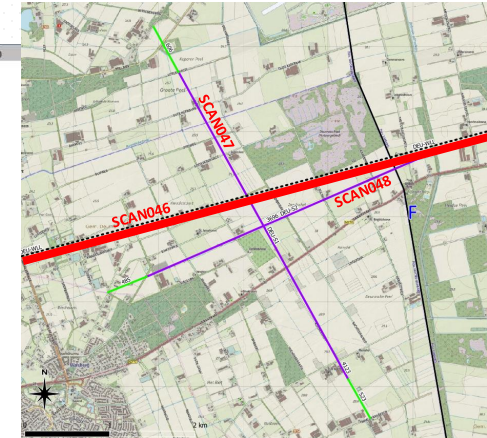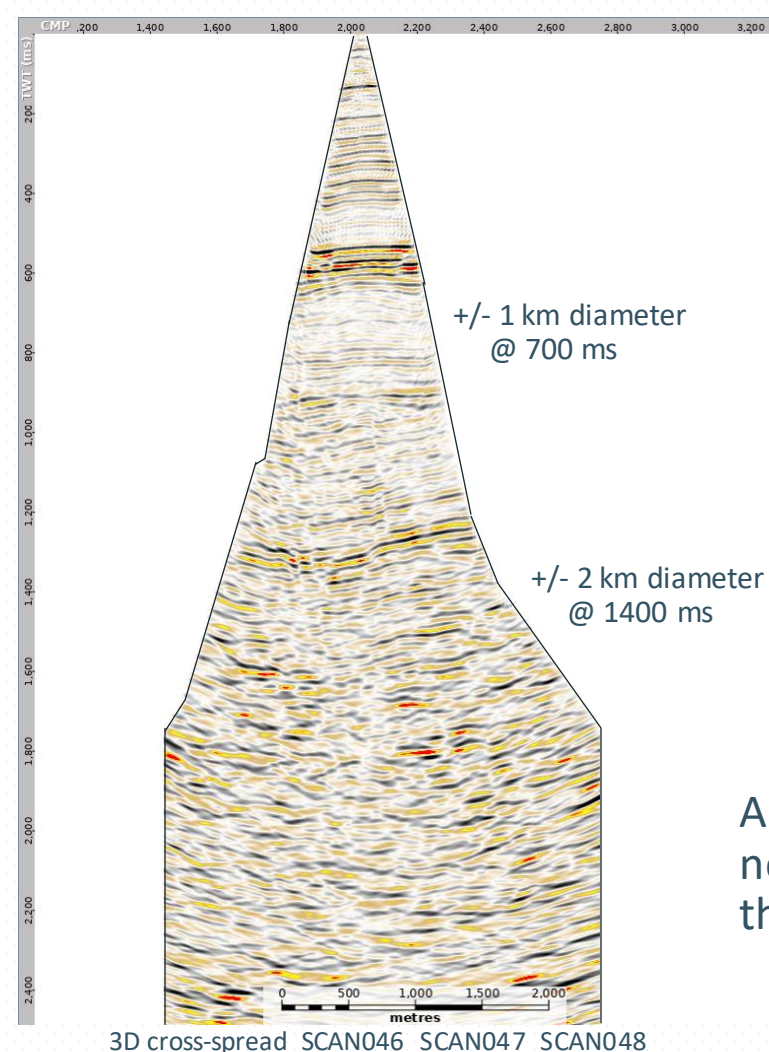
SCAN 3D cross-spread acquisition – Deurne area

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SCAN acquisition, Deurne area
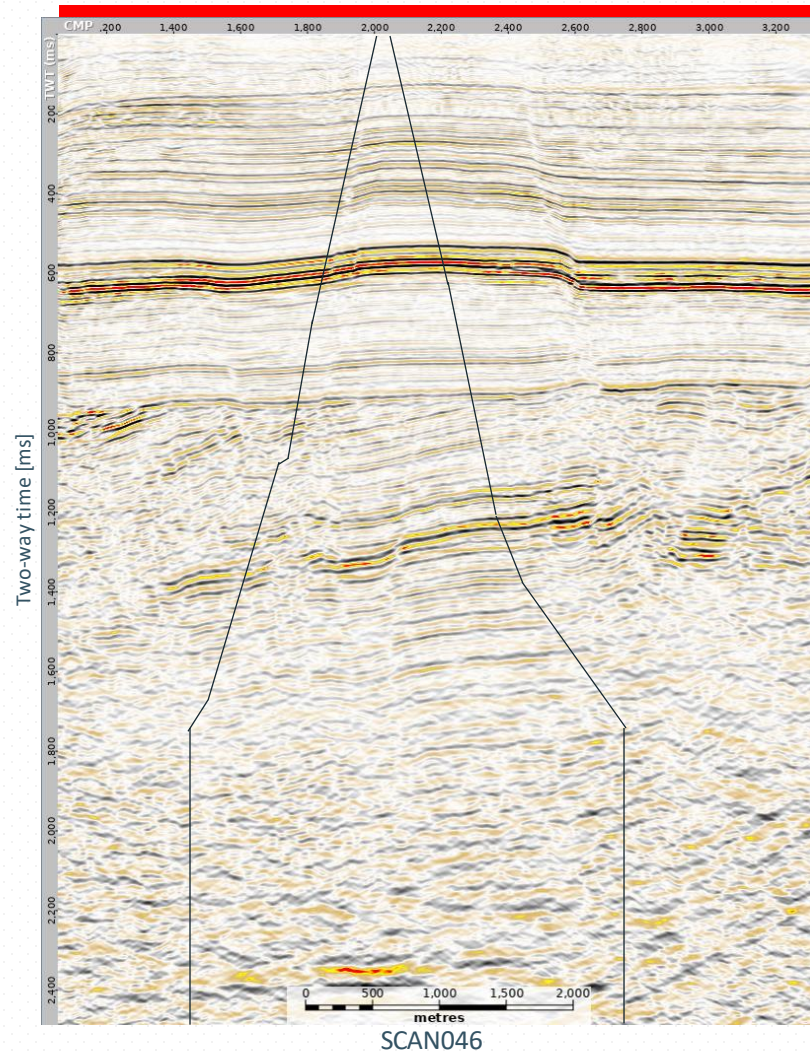
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SCAN acquisition, Deurne area
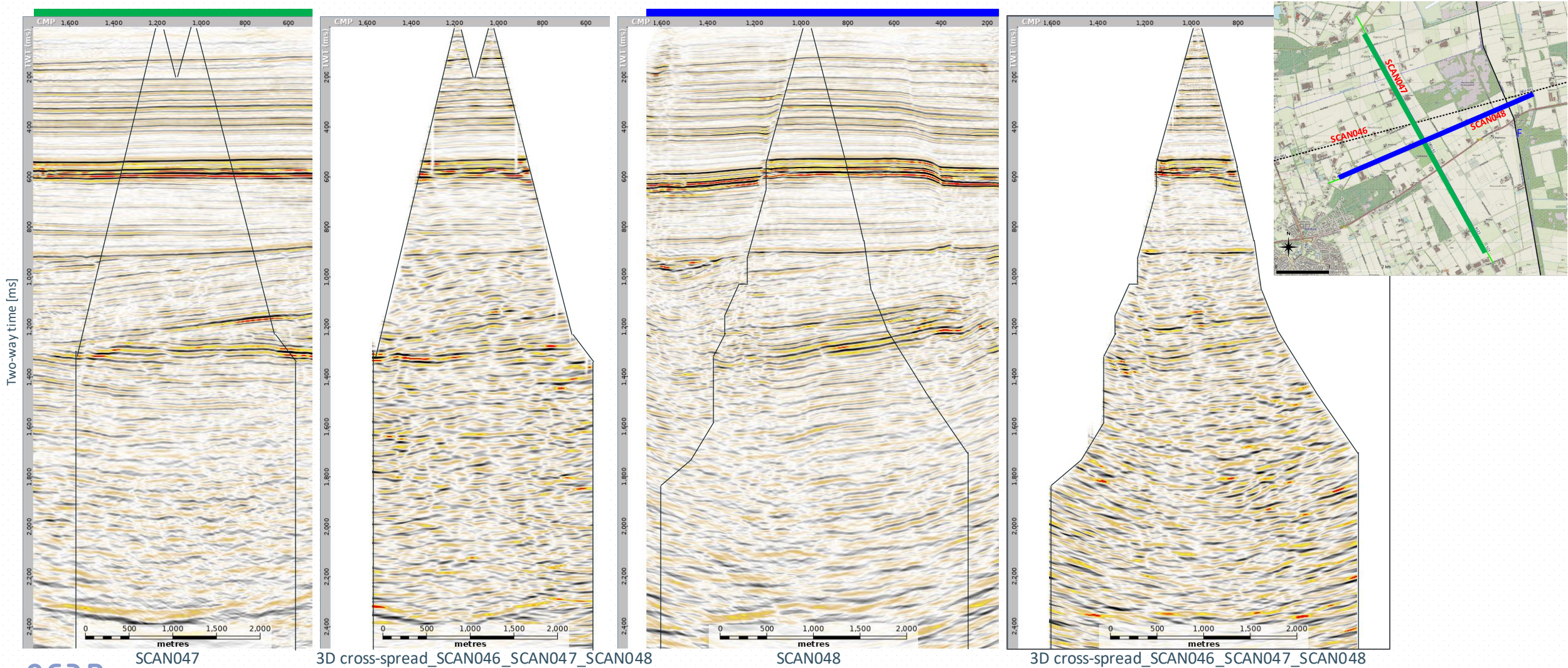
SCAN 3D cross-spread acquisition – Deurne area

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

+/- 1 km diameter @ 700 ms

+/- 2 km diameter @ 1400 ms

SCAN046

3D cross-spread_SCAN046_SCAN047_SCAN048

A cross-spread is lacking near offset data, hence the cone appearance.
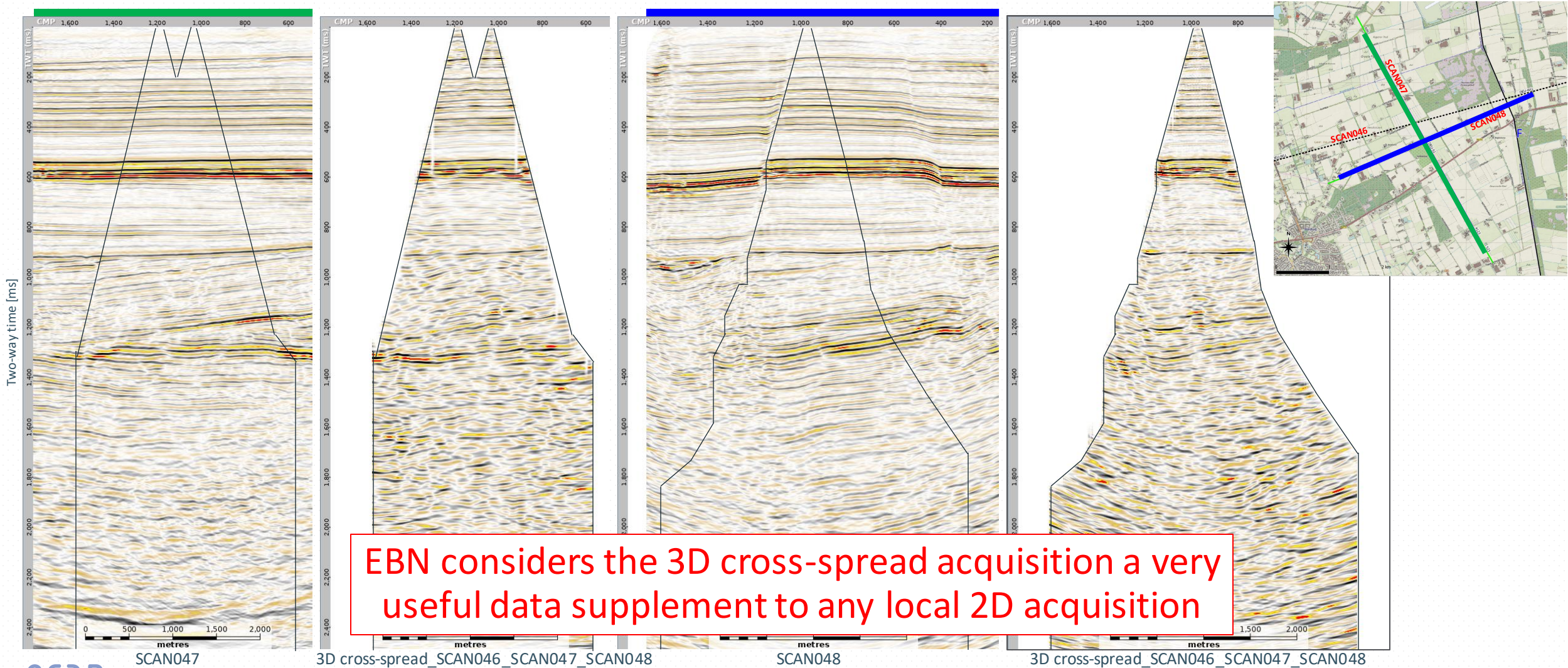
SCAN 3D cross-spread acquisition – Deurne area

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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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.

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

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SCAN 2D reprocessing

- 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)

- To date results of 8 reprocessing projects have been released, which amounts to 4.933 line km (283 lines)

- A further 3 reprocessing projects are still ongoing, totalling some 2.553 line km (169 lines)

- Time spend by EBN on QA/QC of seismic processing contractors in excess of 4.380 hrs (status end April)
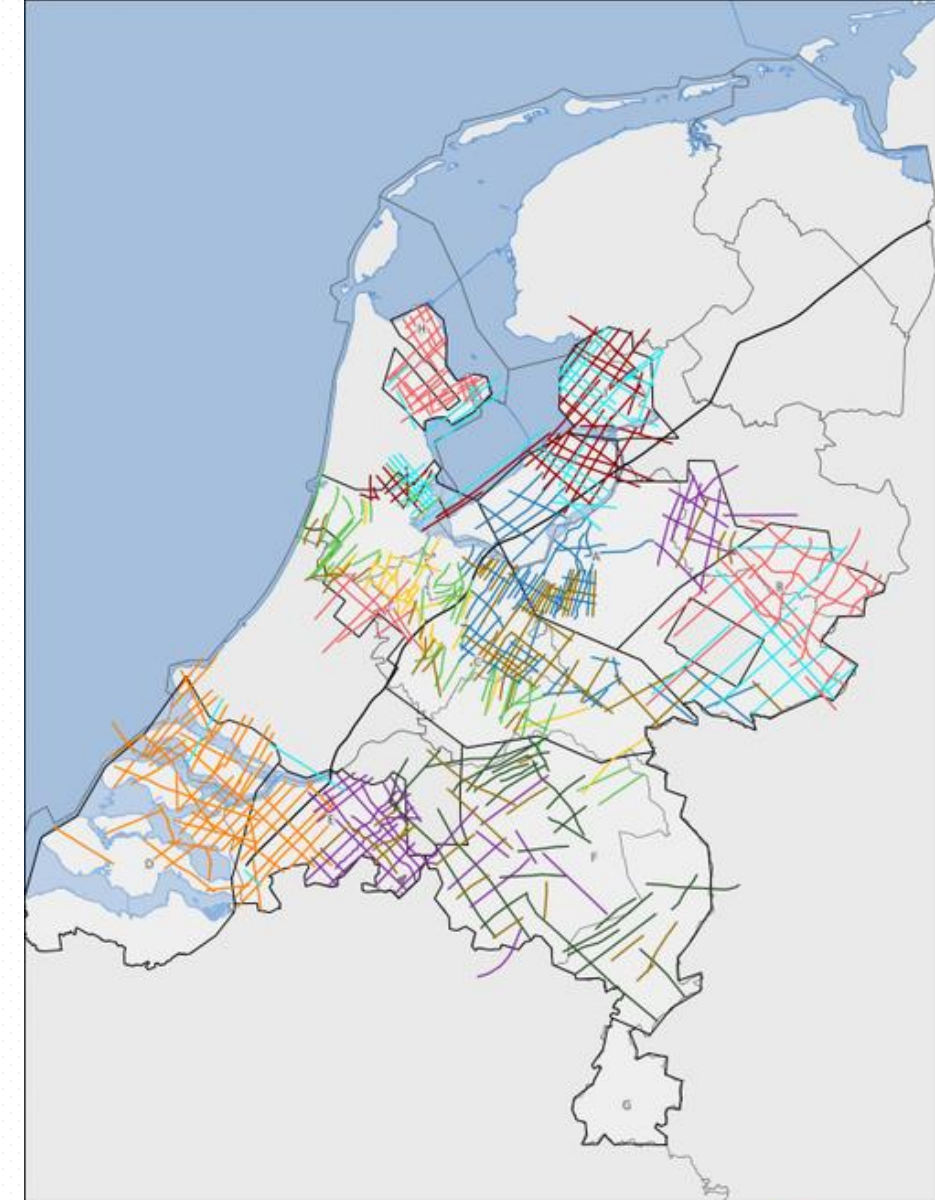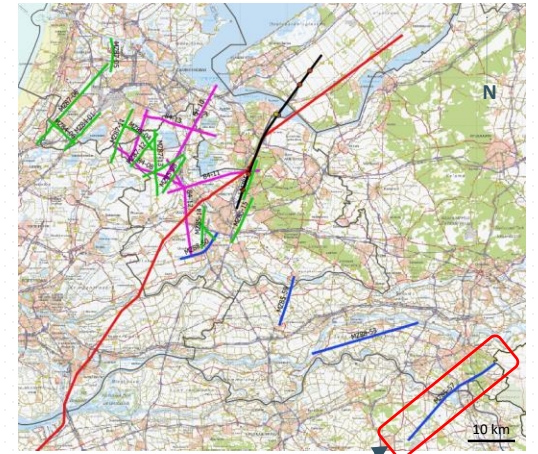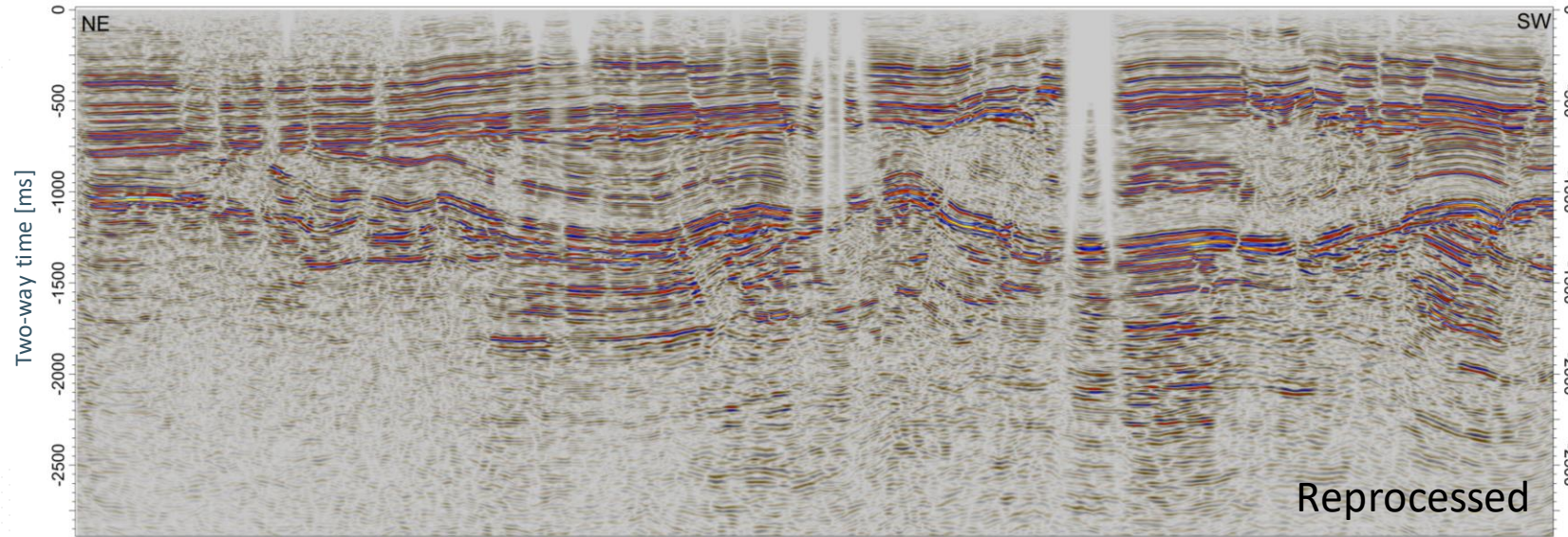

SCAN Reprocessing van Seismische Lijnen

Werkpakket
- GTO-18-C004
- GTO-19-C011
- GTO-19-C032-01
- GTO-19-C032-03
- GTO-19-C032-04
- GTO-19-C032-05
- GTO-19-C033-01
- GTO-19-C033-02
- GTO-19-C033-03
- GTO-19-C033-04
- GTO-19-C033-05
- SCAN-gebieden

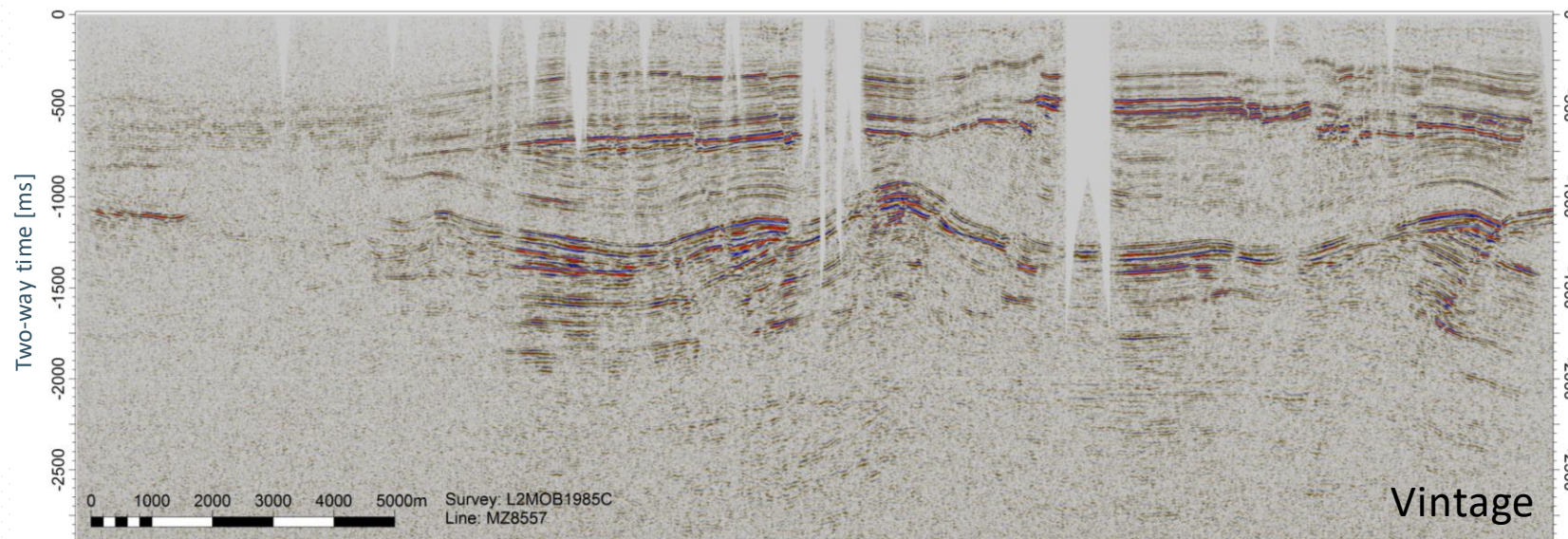0   20   40   60   80   100 km

CRS: RD New (Amersfoort; 28992)
Printdatum: 16-09-2022

SCAN 2D reprocessing – Old digital vs. new digital
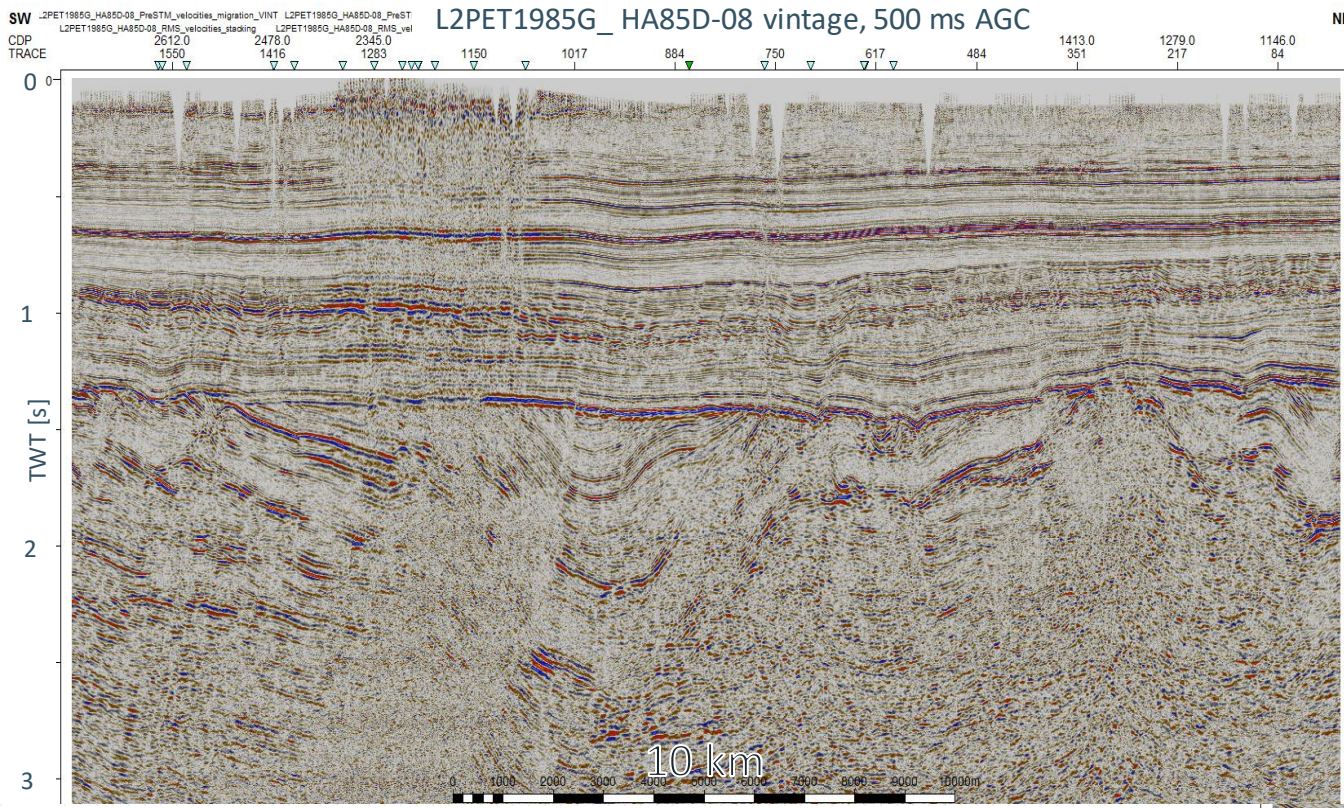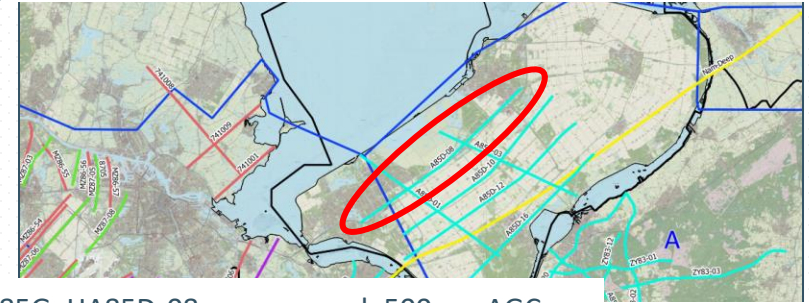

Line MZ8557

- Reprocessing usually improves Signal-to-Noise, event continuity as well as fault imaging
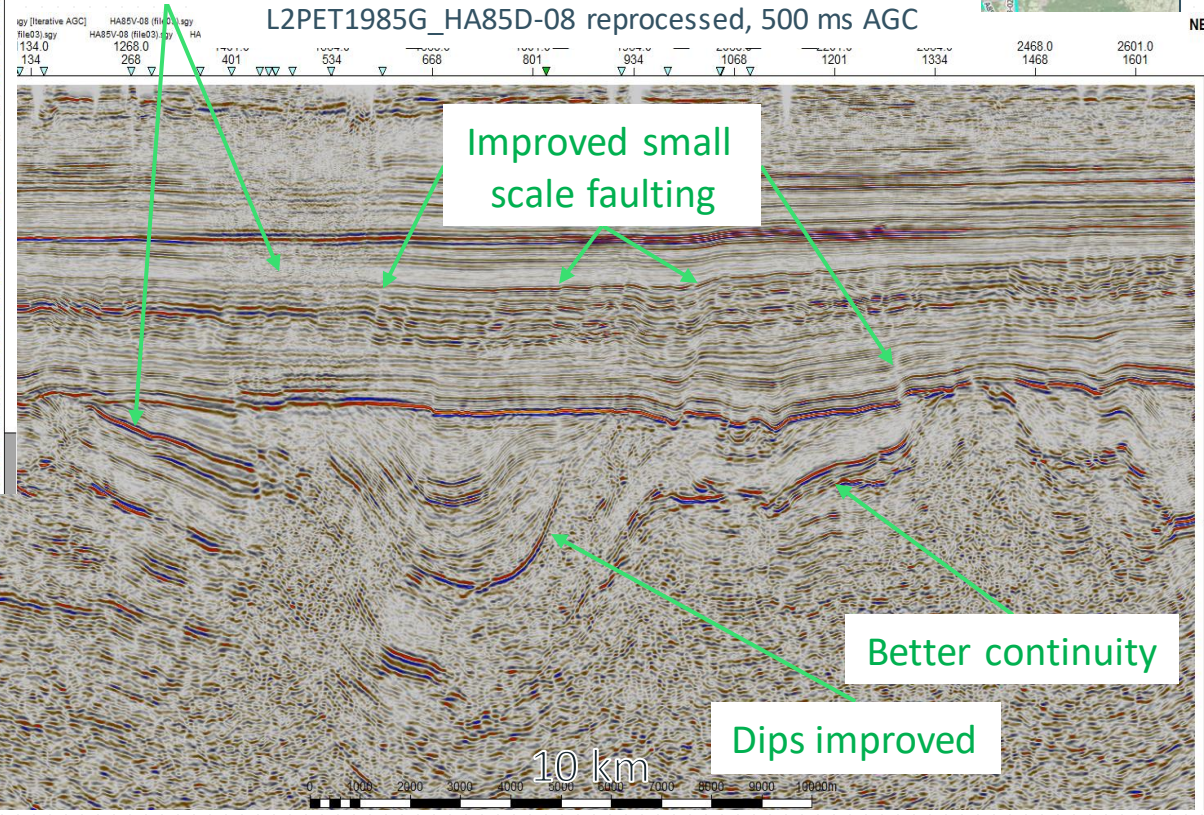
SCAN 2D reprocessing – Old digital vs. new digital line

L2PET1985G_ HA85D-08 vintage, 500 ms AGC
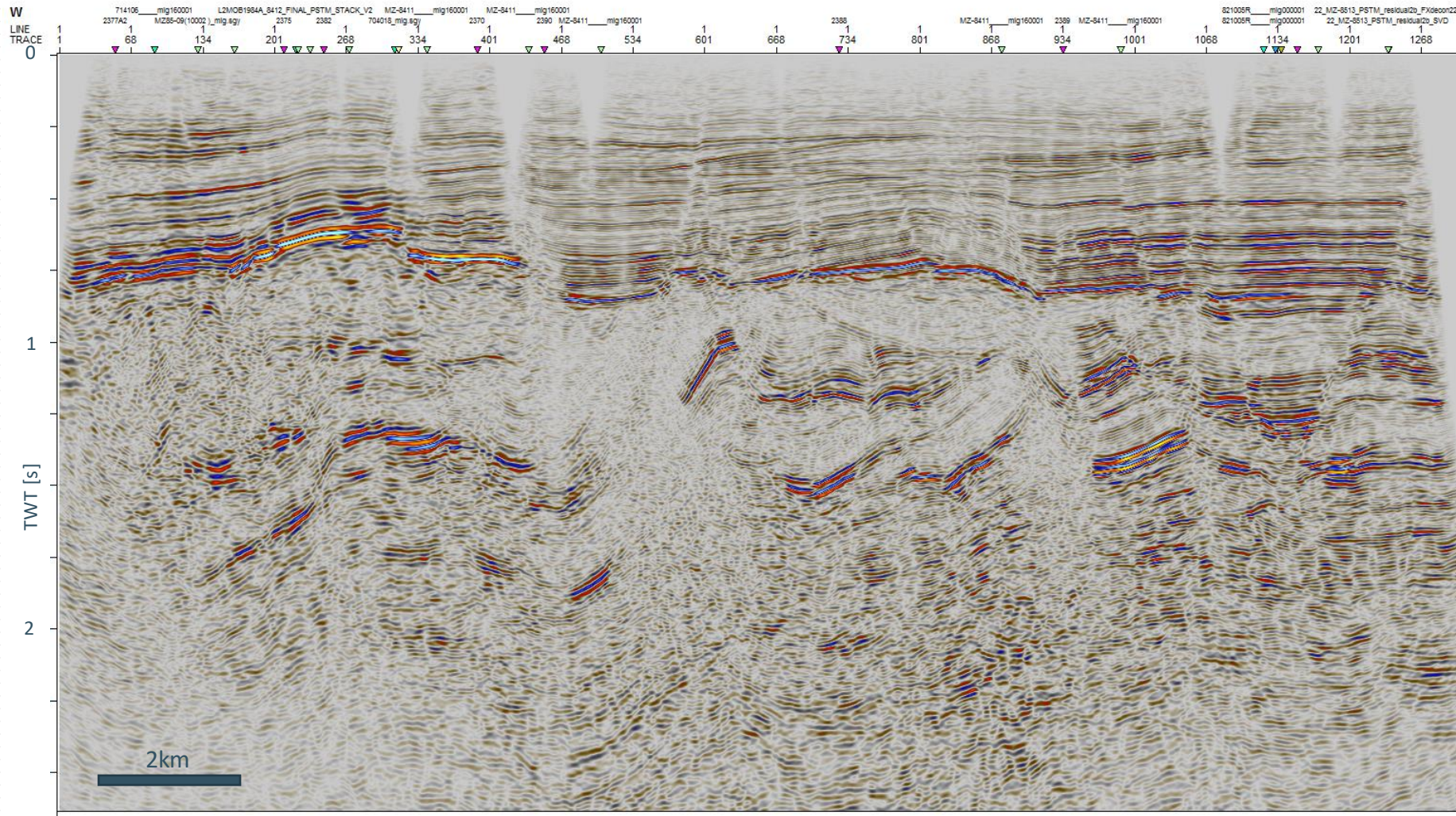
Flevopolder
Almere-Lelystad

Better S/N

L2PET1985G_HA85D-08 reprocessed, 500 ms AGC

Improved small
scale faulting

Better continuity

Dips improved

10 km

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

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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
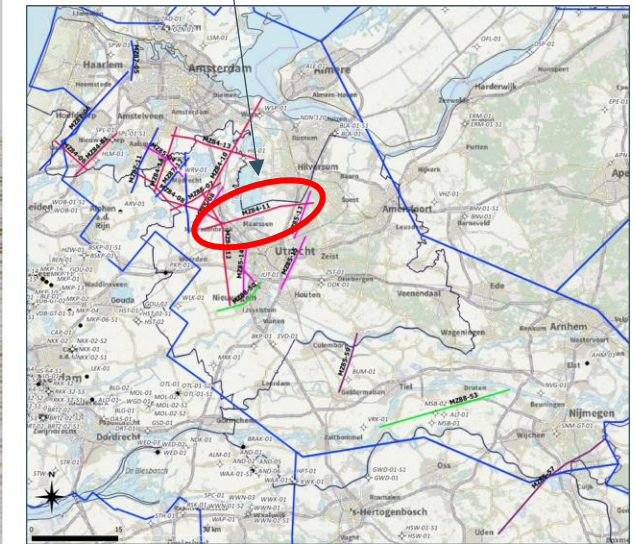
Conclusions

- The SCAN program is providing a wealth of new and improved subsurface data:
  - Almost 1.800 line km of new high quality broad-band 2D seismic in areas with low seismic coverage
  - A total of 7.486 line km of reprocessed vintage 2D seismic, expected completion end Q2 2023
  - A data well campaign will follow to focus on data acquisition of all potentially attractive geothermal reservoirs, expected completion mid 2025

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

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Acknowledgements

Thanks go to:

- EBN and the Dutch Ministry of Economic Affairs and Climate for the permission to present this work

- The Warmtetransitie Operations & Technology teams at EBN, particularly Eddie Siemerink 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
  - Petrosys Pty Ltd for the use of their GLOBEClaritas software

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