World Tunnel Congress & Exhibition

WTC 2019

ITA - AITES General Assembly and World Tunnel Congress

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MOSTRA D'OLTREMARE
NAPLES 2019

TUNNELS AND UNDERGROUND CITIES: ENGINEERING AND INNOVATIONMEET ARCHAEOLOGY, ARCHITECTURE AND ART

Società Italiana Gallerie
Italian Tunnelling Society

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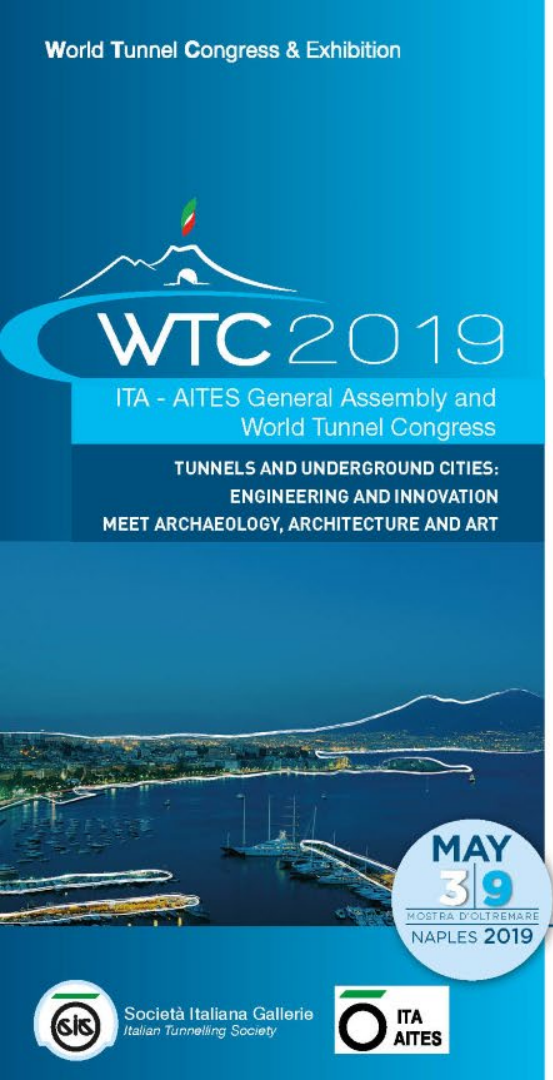


Model for Fair Compensation of Construction Costs in TBM Tunneling: A Novel Contribution

N. Radončić, Amberg Engineering AG, Innsbruck
W. Purrer, CCC-Purrer, Innsbruck
K. Pichler, BBT SE, Innsbruck

Presenting Authors: W. Purrer and N. Radončić

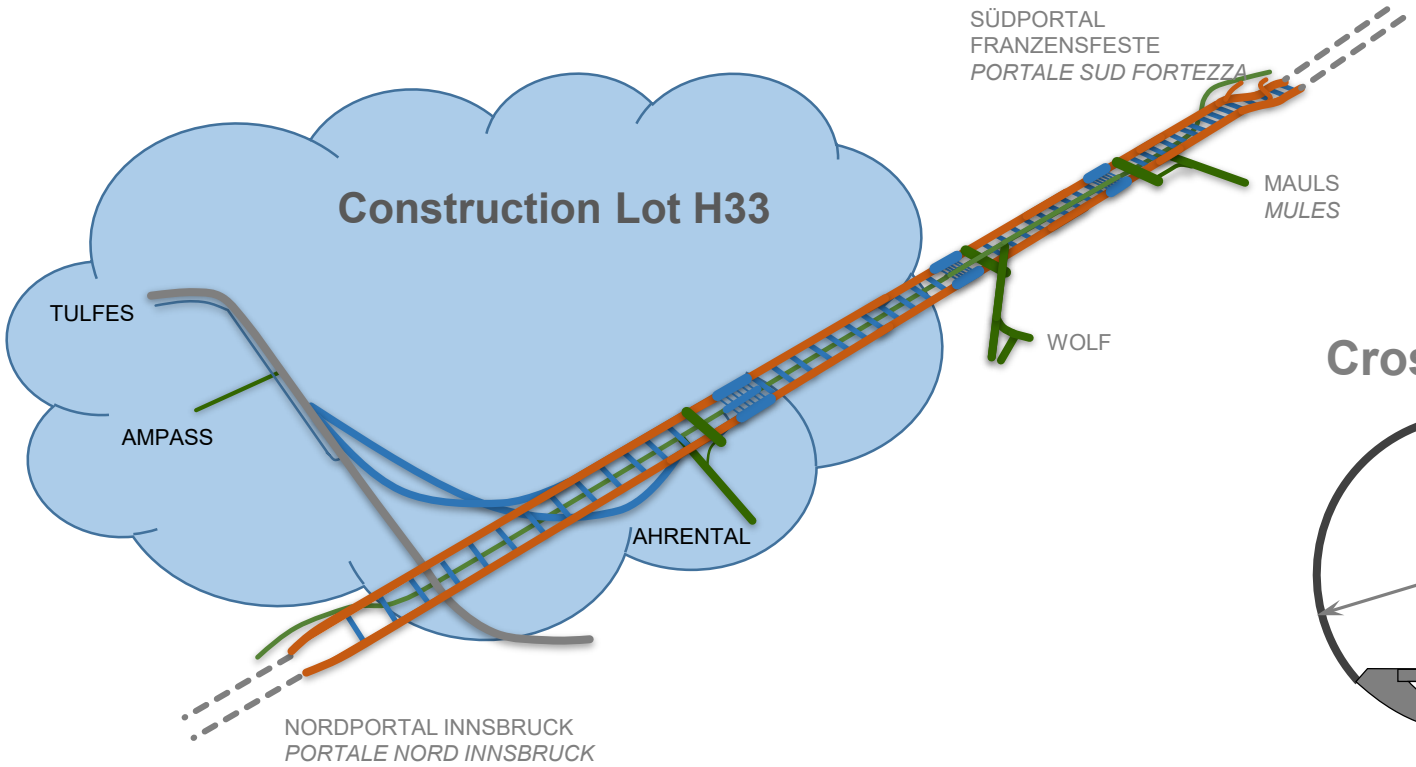
AMBERG ENGINEERING

PICHLER Consulting Engineers

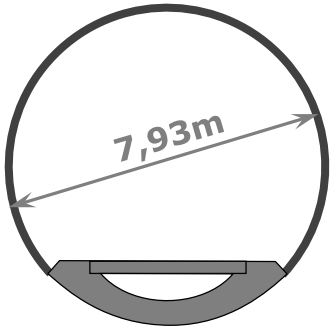
PURRER Dipl.-Ing. Dr. mont.

Brenner Base Tunnel

15km TBM-Drive of Exploratory / Service Tunnel

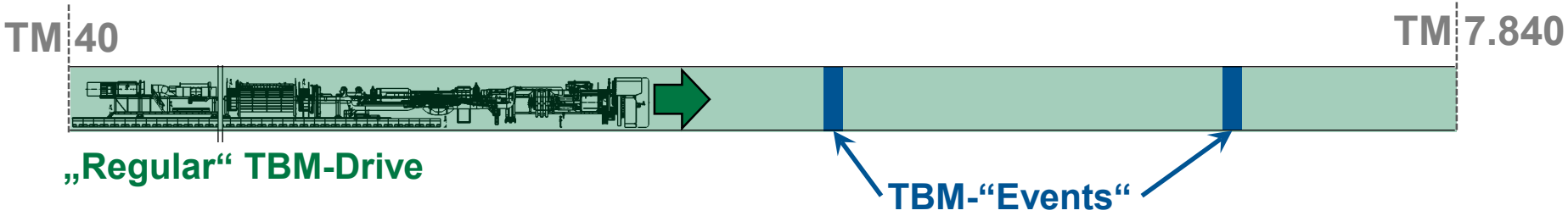


Cross Section

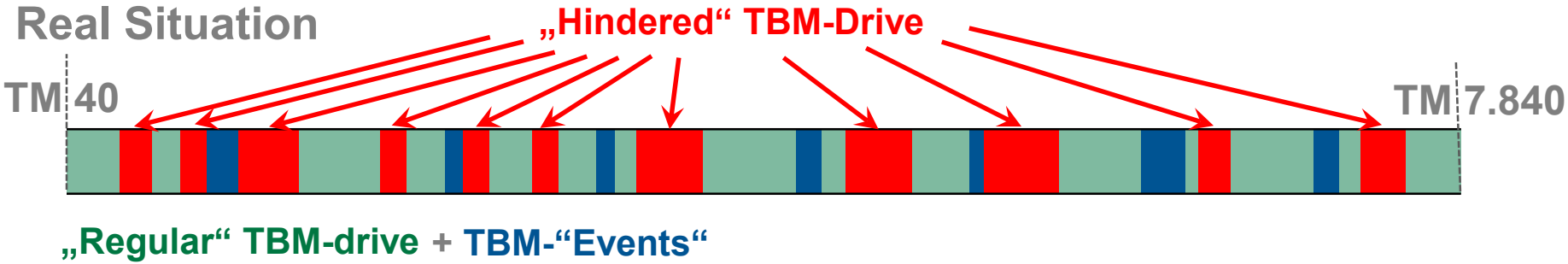


7,8 km TBM-Drive in Quartzphyllite

Contractual Expectations



Real Situation

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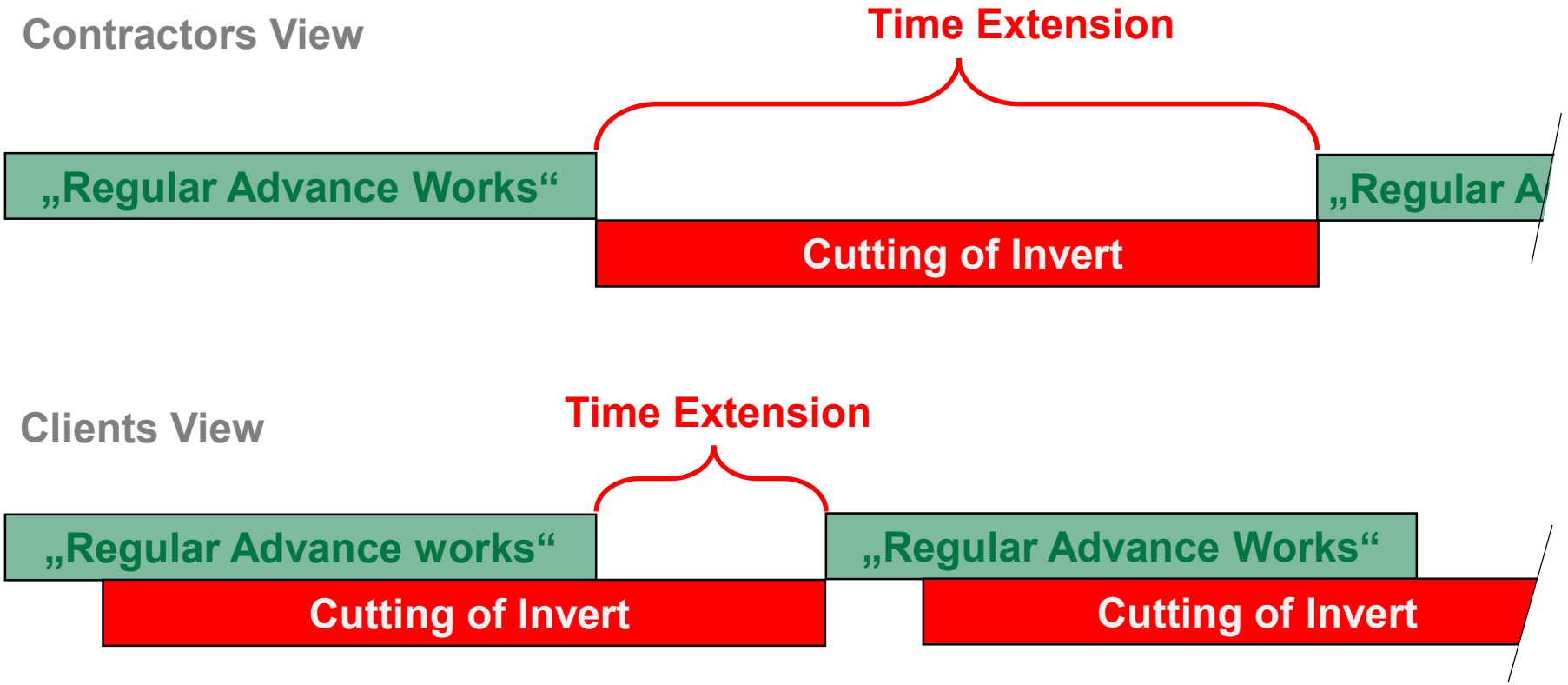
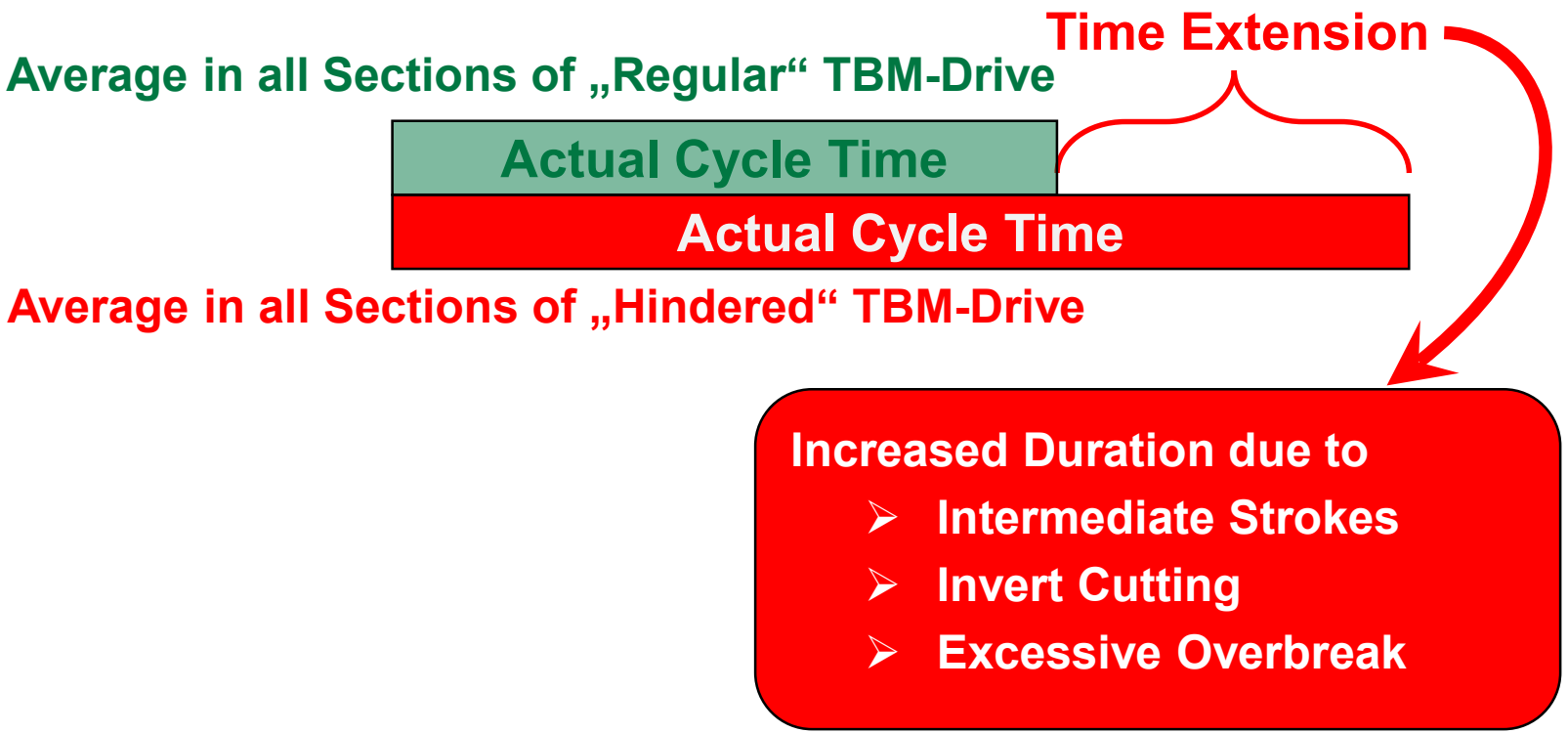
Impact on Cycle Duration „Hindered“TBM-Drive



Model to determine Realistic Impact on Cycle Duration



Defining „regular advance“

- No additional measures implemented in order to ensure safe tunnelling
- No overloads of mucking system due to water and/or muck ingress
- No need for very high hydraulics pressure and performance loss
- „regular penetration process“

Defining „regular penetration“

- Majority of the disc cutters must be in firm contact with the face, outbreaks and mixed-face conditions are not „regular penetration“!

taken from Özdemir „Hard rock TBMs“

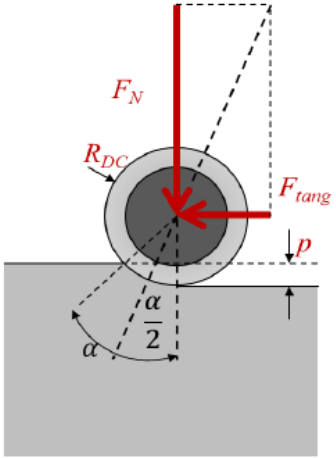
taken from Radončić et al. (2014)

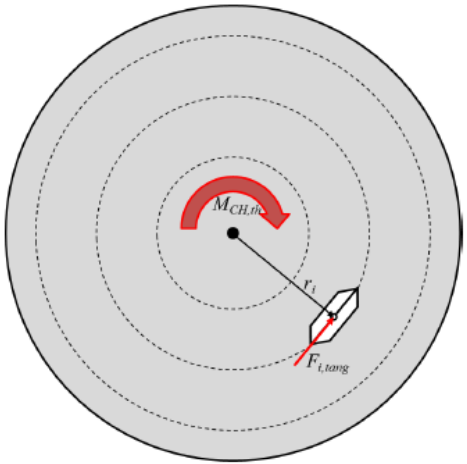
Defining „regular penetration“

- Majority of the disc cutters must be in firm contact with the face, outbreaks and mixed-face conditions are not „regular penetration“!

$$\alpha = cos^{-1}\left(\frac{R_{DC} - p}{R_{DC}}\right)$$

$$M_{CH,th} = \sum_{i=1}^{n} F_{tang} \cdot r_i + M_0$$



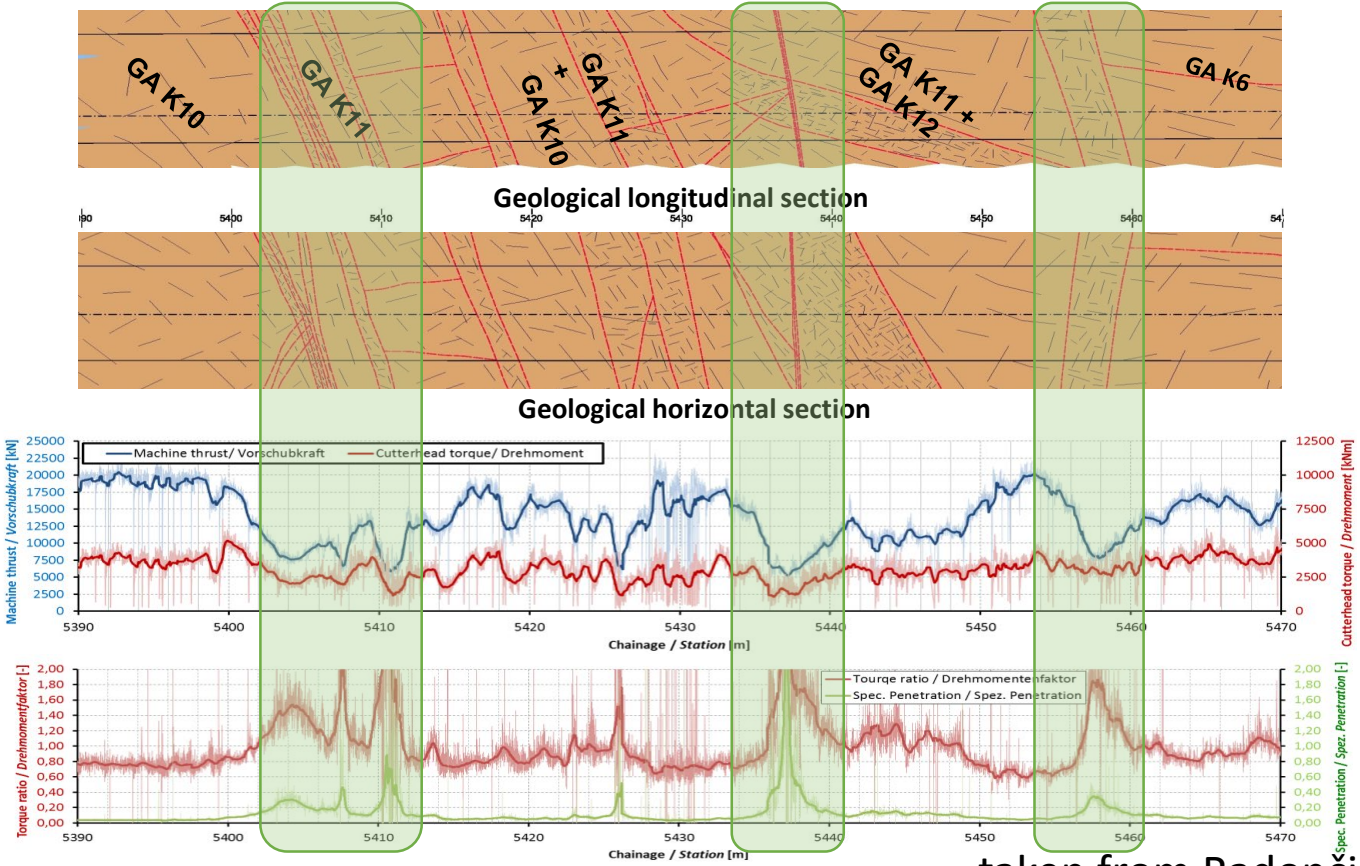


Torque ratio: $f_{Torque} = \frac{M_{real}}{M_{CH,th}}$

$f_{Torque} \approx 0.80 - 1.20$

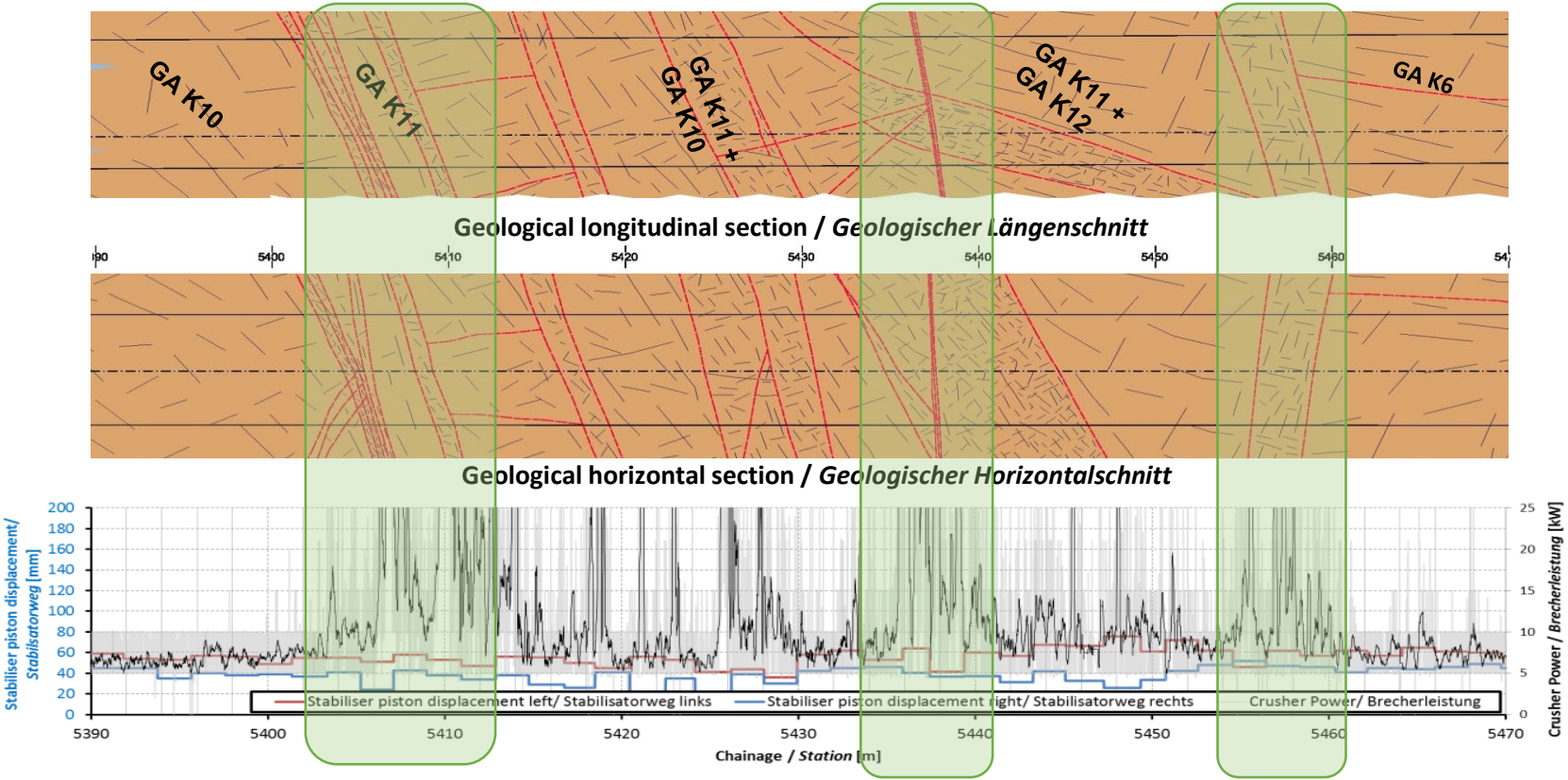
taken from Radončić et al. (2014)

Defining „regular penetration“



taken from Radončić et al. (2014)

Defining „regular penetration“



taken from Radončić et al. (2014)

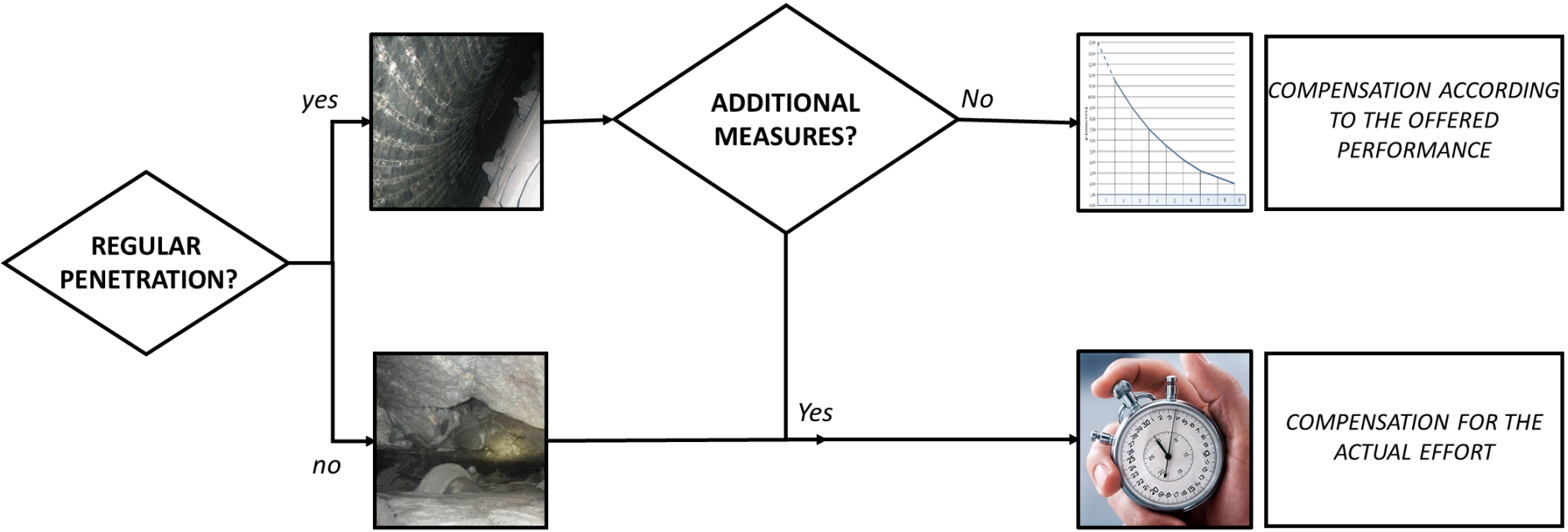
Indicators

Stable face conditions are verified by:

- „Torque factor“ between 0.8 und 1.20
- Visual inspection
- Camera
- Cutter force logging
- Muck inspection
- No observed cutter damage (only “normal” wear)

taken from Pötsch & Gaich (2016)

Summary



After Bach et al. (2018) / Austrian Committee for Standardisation

Conclusions

- Fairness: the amount of services based on „actual effort“ model rises with the degree of uncertainty
- Fairness: currently there is no model for performance prediction in blocky/mixed-face ground. The risk is shared between the owner and the contractor.
- The contractor has a strong additional incentive to deliver high performance in „regular advance“ parts of tunnel
- The site supervision teams must have a strong and highly competent presence!

Thank you for your attention!

Dr. Walter Purrer
CCC-Purrer
w.purrer@me.com

Dr. Nedim Radoncic
Amberg Engineering AG
nradoncic@ambergengineering.com