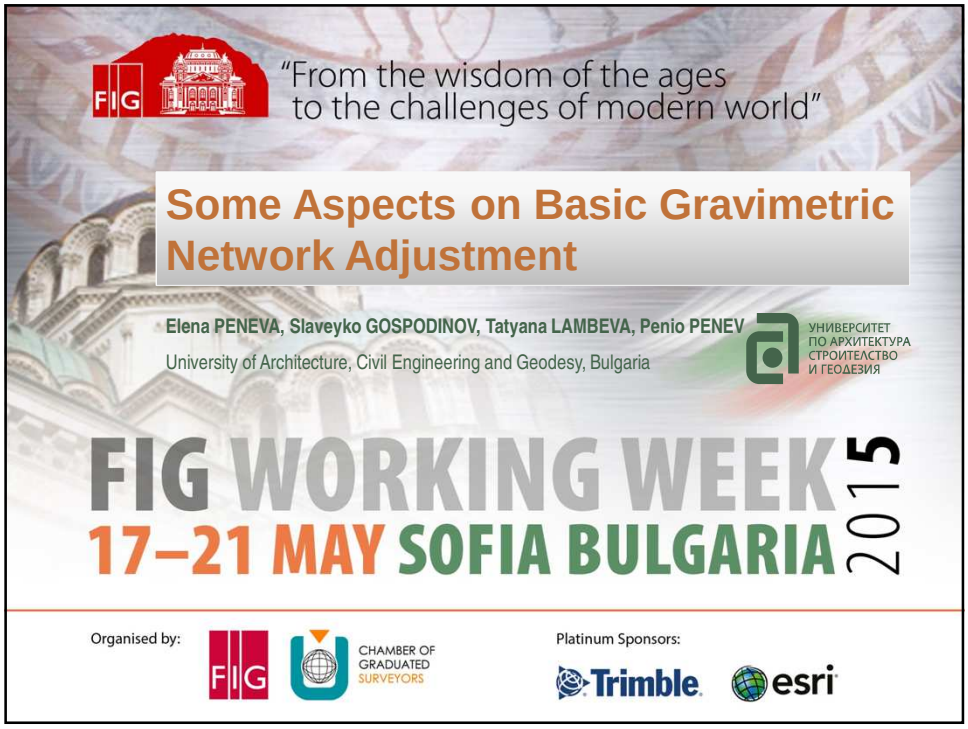
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Some Aspects on Basic Gravimetric Network Adjustment
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University of Architecture, Civil Engineering and Geodesy, Bulgaria
УНИВЕРСИТЕТ ПО АРХИТЕКТУРА СТРОИТЕЛСТВО И ГЕОДЕЗИЯ
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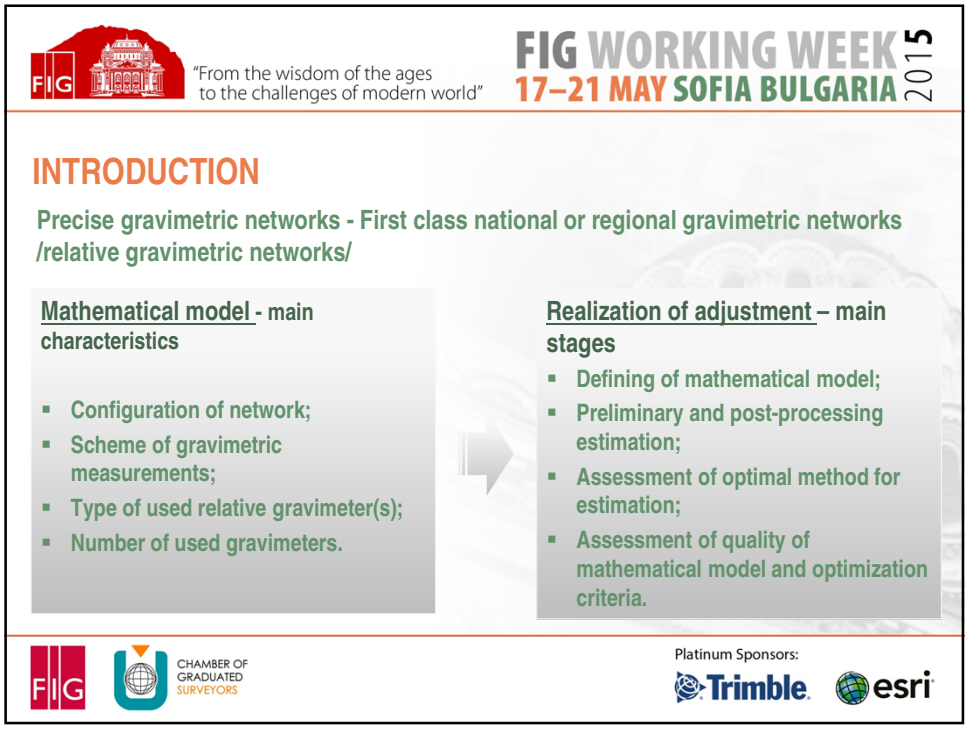
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INTRODUCTION
Precise gravimetric networks - First class national or regional gravimetric networks /relative gravimetric networks/
Mathematical model - main characteristics
Configuration of network;
Scheme of gravimetric measurements;
Type of used relative gravimeter(s);
Number of used gravimeters.
Realization of adjustment – main stages
Defining of mathematical model;
Preliminary and post-processing estimation;
Assessment of optimal method for estimation;
Assessment of quality of mathematical model and optimization criteria.
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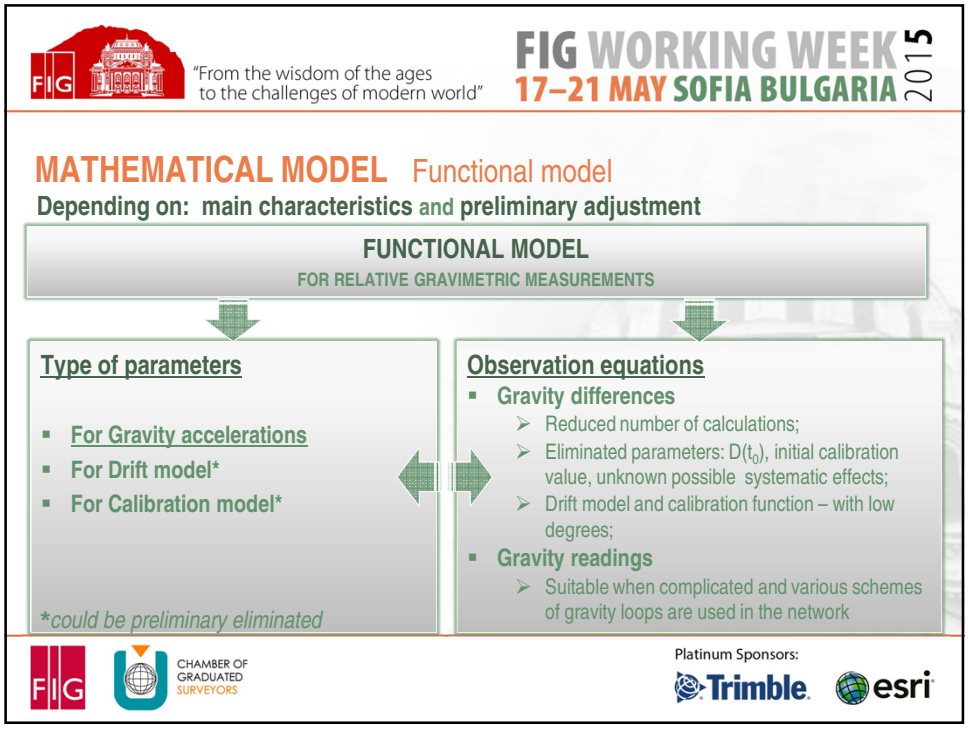
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MATHEMATICAL MODEL Functional model
Depending on: main characteristics and preliminary adjustment
FUNCTIONAL MODEL
FOR RELATIVE GRAVIMETRIC MEASUREMENTS
Type of parameters
For Gravity accelerations
For Drift model*
For Calibration model*
*could be preliminary eliminated
Observation equations
Gravity differences
Reduced number of calculations;
Eliminated parameters: D(t0), initial calibration value, unknown possible systematic effects;
Drift model and calibration function – with low degrees;
Gravity readings
Suitable when complicated and various schemes of gravity loops are used in the network
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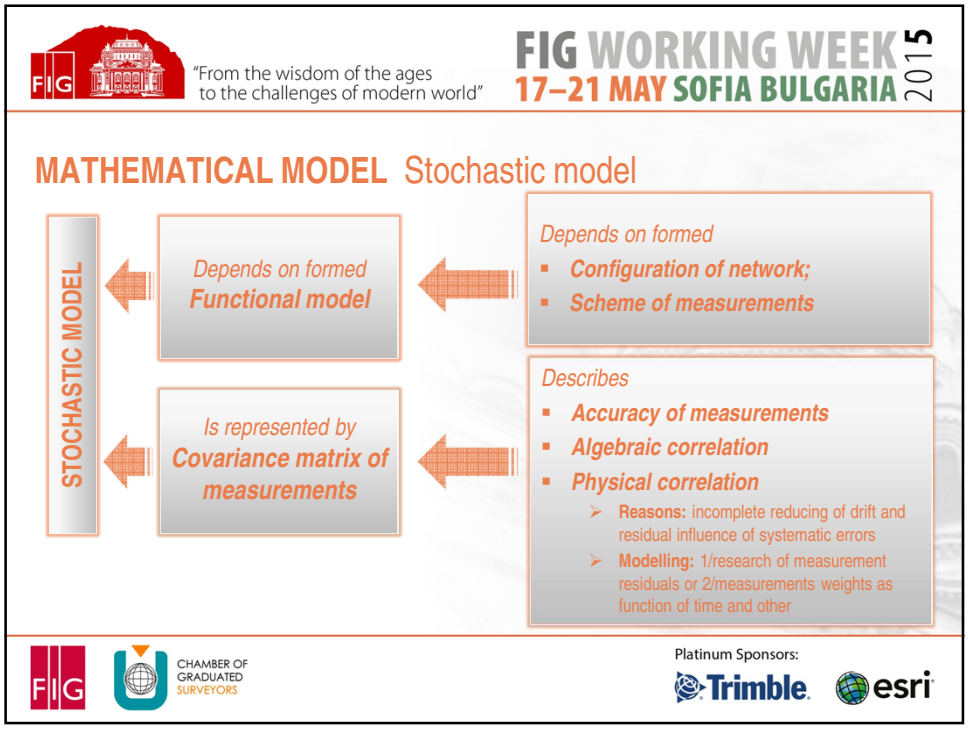
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MATHEMATICAL MODEL Stochastic model
STOCHASTIC MODEL
Depends on formed
Functional model
Is represented by
Covariance matrix of measurements
Depends on formed
Configuration of network;
Scheme of measurements
Describes
Accuracy of measurements
Algebraic correlation
Physical correlation
Reasons: incomplete reducing of drift and residual influence of systematic errors
Modelling: 1/research of measurement residuals or 2/measurements weights as function of time and other
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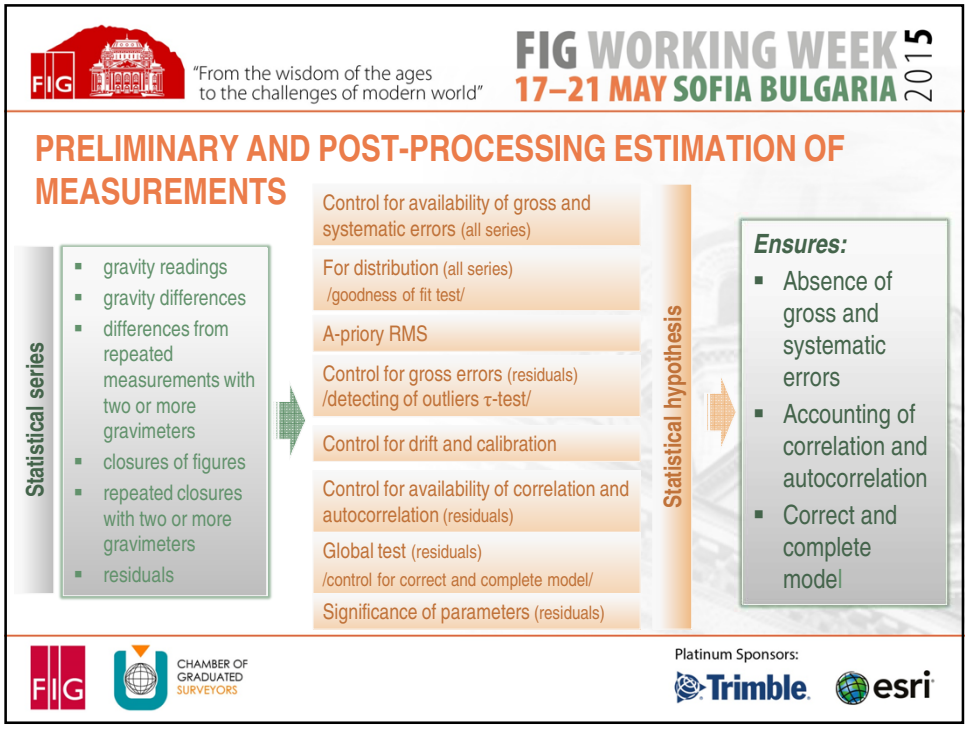
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PRELIMINARY AND POST-PROCESSING ESTIMATION OF MEASUREMENTS
Statistical series
gravity readings
gravity differences
differences from repeated measurements with two or more gravimeters
closures of figures
repeated closures with two or more gravimeters
residuals
Control for availability of gross and systematic errors (all series)
For distribution (all series) /goodness of fit test/
A-priory RMS
Control for gross errors (residuals) /detecting of outliers τ-test/
Control for drift and calibration
Control for availability of correlation and autocorrelation (residuals)
Global test (residuals) /control for correct and complete model/
Significance of parameters (residuals)
Statistical hypothesis
Ensures:
Absence of gross and systematic errors
Accounting of correlation and autocorrelation
Correct and complete model
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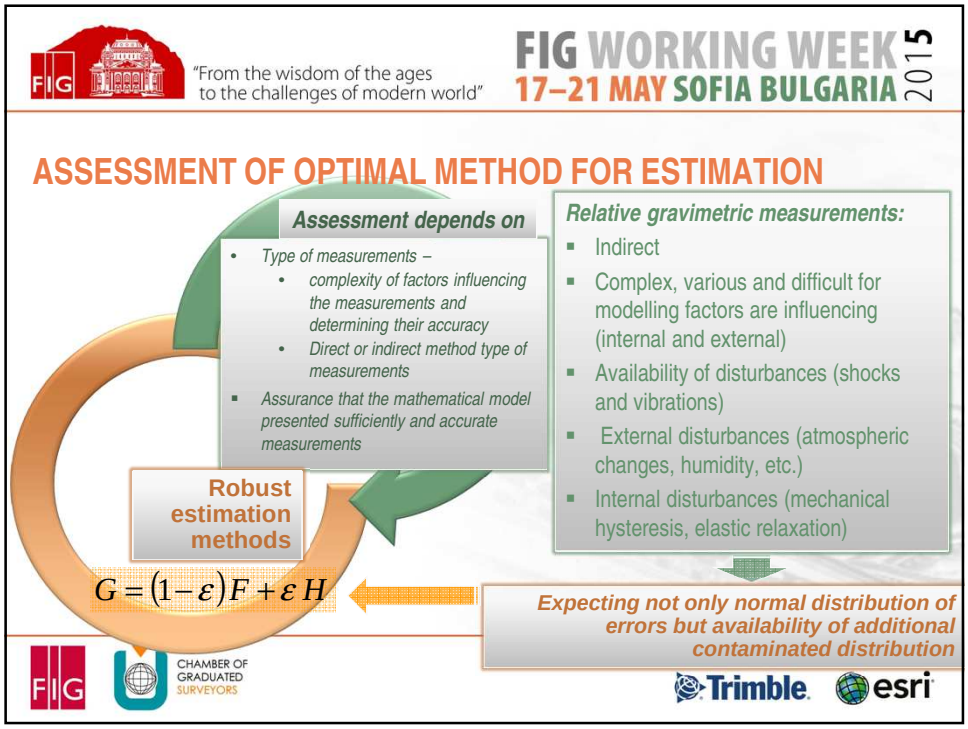
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ASSESSMENT OF OPTIMAL METHOD FOR ESTIMATION
Assessment depends on
Type of measurements –
complexity of factors influencing the measurements and determining their accuracy
Direct or indirect method type of measurements
Assurance that the mathematical model presented sufficiently and accurate measurements
Robust estimation methods
$G = (1-\varepsilon)F + \varepsilon H$
Relative gravimetric measurements:
Indirect
Complex, various and difficult for modelling factors are influencing (internal and external)
Availability of disturbances (shocks and vibrations)
External disturbances (atmospheric changes, humidity, etc.)
Internal disturbances (mechanical hysteresis, elastic relaxation)
Expecting not only normal distribution of errors but availability of additional contaminated distribution
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ASSESSMENT OF QUALITY OF MATHEMATICAL MODEL AND OPTIMIZATION CRITERIA

Formed and analysed many mathematical models

Different estimation methods

Too many variants of realizations for the network

Regulations for quality of network

- *M-criterion* (Peevski,Zlatanov,1970)
- *Generalized variance* (Graferend et al.,1979)
- *Criteria given by Mierlo (1982)*

MOST QUALITIED REALIZATION

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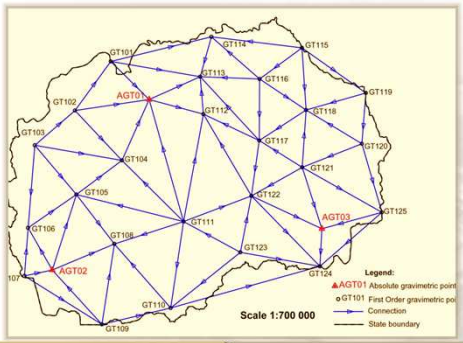
BASIC GRAVIMETRIC NETWORK OF REPUBLIC OF MACEDONIA

Basic gravimetric network of republic of Macedonia (28 pts)

Zero Order Gravity Network (3 pts)

+

First Order Gravity Network (25 pts)



Configuration:
Absolute points = 3 pts
First order gravity points = 25 pts
Figures = 41 triangles
Connections = 68 differences

Scheme of measurement :
star/difference method
(1-2-1'-3-1")
Two gravimeters simultaneously:
Scintrex CG3+ and CG-5

Linear drift model:
$d_{12}(1\text{-}2\text{-}1')$; $d_{13}(1'\text{-}3\text{-}1'')$
Calibration measurements:
three times

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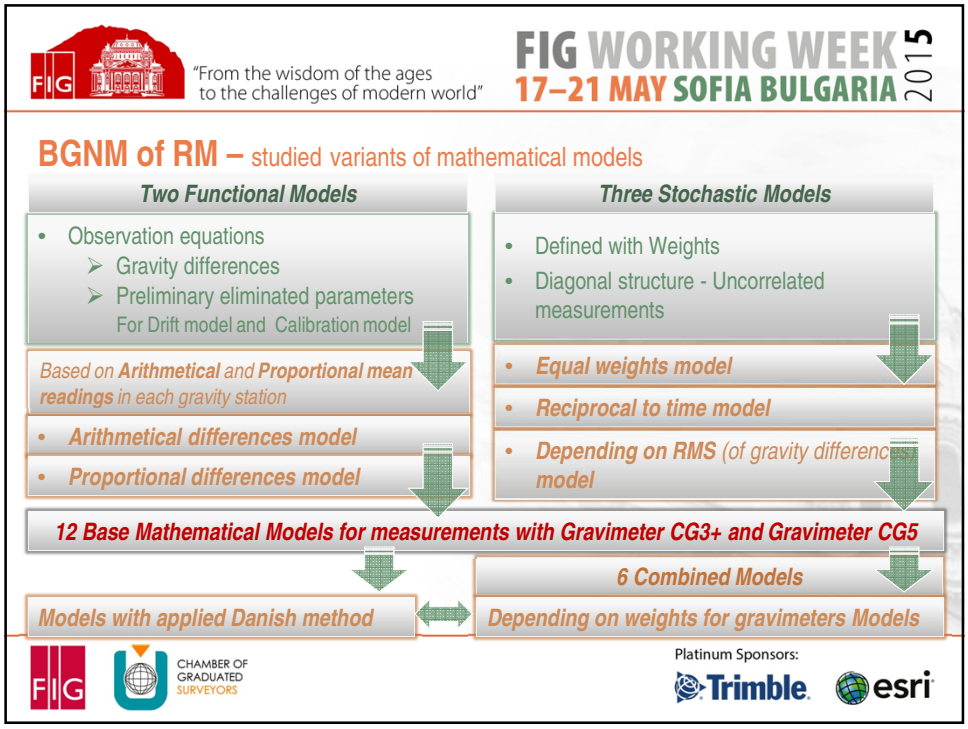
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BGNM of RM – studied variants of mathematical models
Two Functional Models
Observation equations
Gravity differences
Preliminary eliminated parameters
For Drift model and Calibration model
Based on Arithmetical and Proportional mean readings in each gravity station
Arithmetical differences model
Proportional differences model
Three Stochastic Models
Defined with Weights
Diagonal structure - Uncorrelated measurements
Equal weights model
Reciprocal to time model
Depending on RMS (of gravity differenc
model
12 Base Mathematical Models for measurements with Gravimeter CG3+ and Gravimeter CG5
6 Combined Models
Models with applied Danish method
Depending on weights for gravimeters Models
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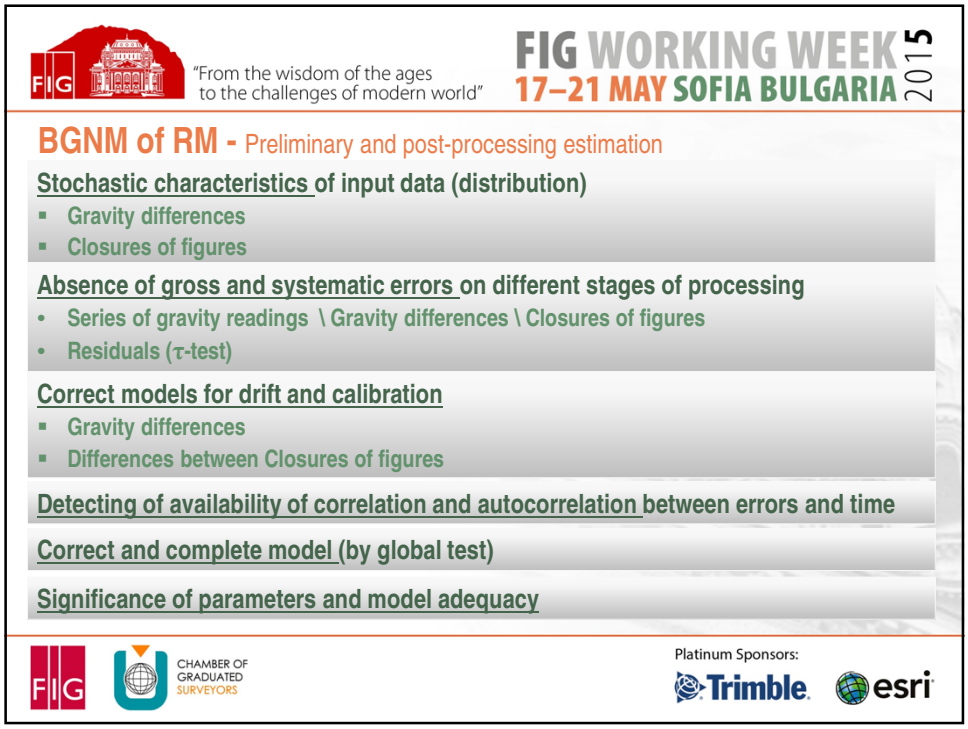
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BGNM of RM - Preliminary and post-processing estimation
Stochastic characteristics of input data (distribution)
Gravity differences
Closures of figures
Absence of gross and systematic errors on different stages of processing
Series of gravity readings \ Gravity differences \ Closures of figures
Residuals (τ-test)
Correct models for drift and calibration
Gravity differences
Differences between Closures of figures
Detecting of availability of correlation and autocorrelation between errors and time
Correct and complete model (by global test)
Significance of parameters and model adequacy
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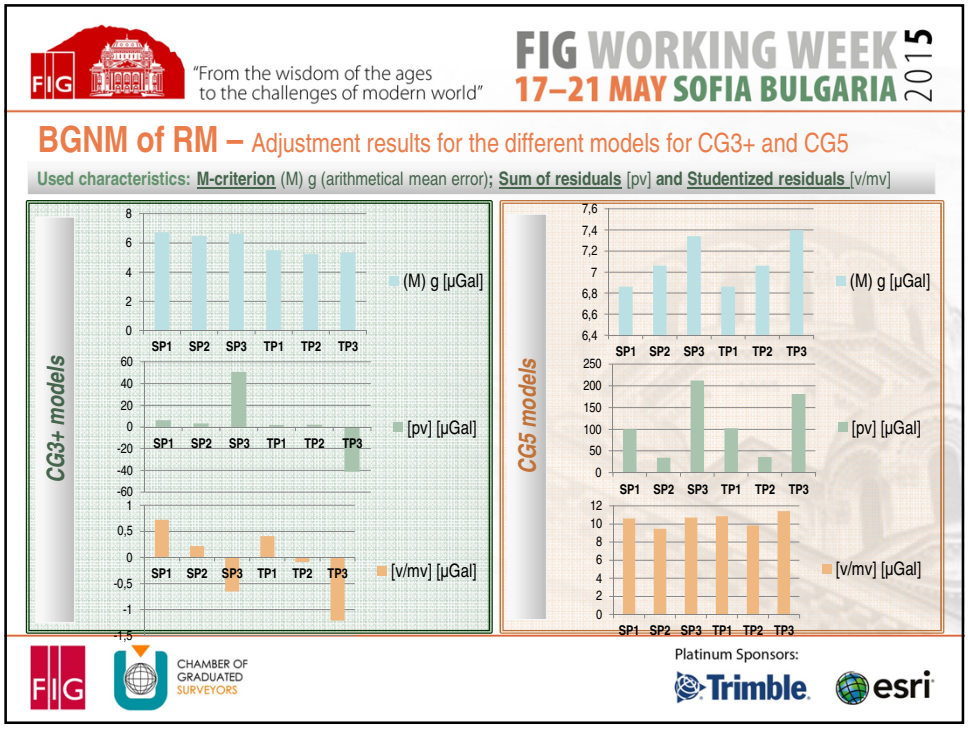
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BGNM of RM – Adjustment results for the different models for CG3+ and CG5
Used characteristics: M-criterion (M) g (arithmetical mean error); Sum of residuals [pv] and Studentized residuals [v/mv]
CG3+ models
CG5 models
(M) g [µGal]
[pv] [µGal]
[v/mv] [µGal]
SP1 SP2 SP3 TP1 TP2 TP3
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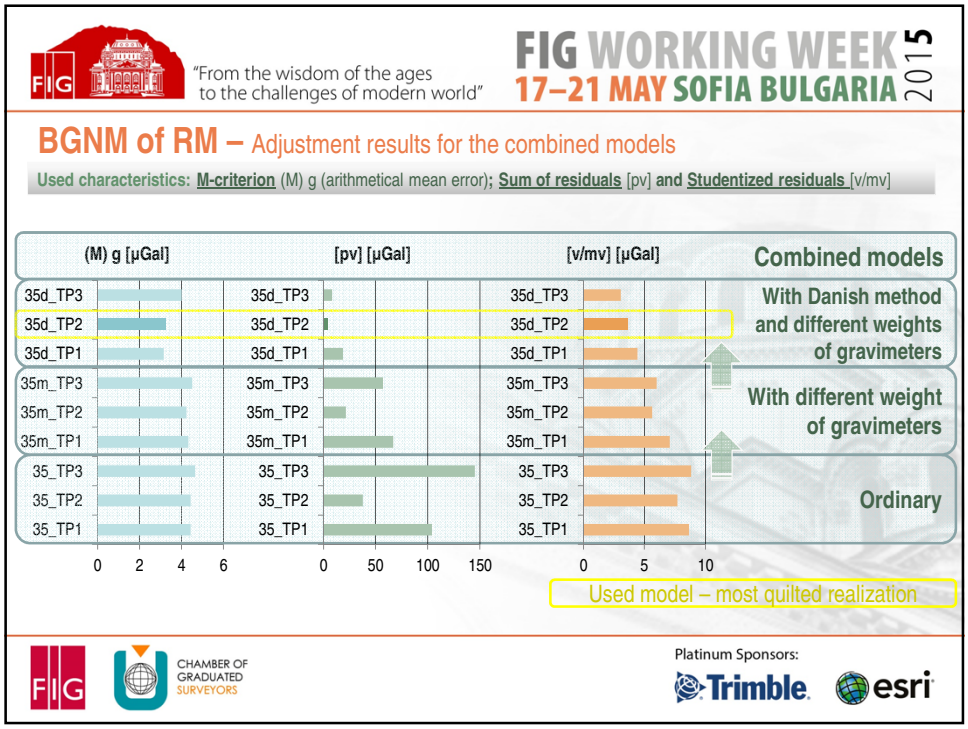
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BGNM of RM – Adjustment results for the combined models
Used characteristics: M-criterion (M) g (arithmetical mean error); Sum of residuals [pv] and Studentized residuals [v/mv]
(M) g [µGal]
[pv] [µGal]
[v/mv] [µGal]
Combined models
35d_TP3
35d_TP2
35d_TP1
With Danish method and different weights of gravimeters
35m_TP3
35m_TP2
35m_TP1
With different weight of gravimeters
35_TP3
35_TP2
35_TP1
Ordinary
0 2 4 6
0 50 100 150
0 5 10
Used model – most quilted realization
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CONCLUSION

- Appropriate structure of gravimetric network
  - ✓ Guaranteed the control of the relative gravimetric measurements in preliminary and post-processing estimation of the accuracy
- Realized scheme of measurements
  - ✓ Important for the adjustment of gravimetric networks
  - ✓ defines the characteristics and the possibilities to form the mathematical model
- Estimation method selection depends on
  - ✓ the availability of a contaminant distribution in the measured quantities
- Application of robust estimation method - Danish method
  - ✓ established lower values of RMSs defining global accuracy of the network
  - ✓ optimal values for [pv]
  - ✓ optimal values for the sum of Studentized residuals [v/mv]
  - ✓ Absence of systematic or inadmissible errors is guaranteed

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