Global Navigation Satellite Systems (GNSS) are the prime source of position information for geodetic and geodynamics applications. For instance, the well-known application is the monitoring of Earth surface deformation, slope creep, glacier and shelf ice movements, ground subsidence or deformation of engineering structures. For such applications, the provided information needs to be of a high level of quality. However, any GNSS positioning system is subject to a series of hazardous faults, which can dramatically deteriorate the quality of solutions. As such, it is crucial to have a proper quality control framework in place for timely diagnostics of hazardous faults.

The quality control framework of GNSS data processing can be divided into two parts. The former is the validation of so-called underlying functional model and the latter is the quality description of final model parameter estimates. The underlying functional model is formulated based on physical or mathematical laws or geometric connections and it describes the relation between GNSS observations and their explanatory parameters (most often, point positions on the Earth and/or some atmospheric parameters). Since there may be some faults in observations that cannot be disclosed from the above laws and connections and which can dramatically deteriorate the quality of final estimates, the underlying model is validated using statistical mechanisms. It is usually done by so-called DIA testing procedure to detect, identify and model possible faults. Admittedly, the DIA procedure is mathematically rigorous and optimal under a single fault in underlying model. Nevertheless, it is not the case under multiple faults that appear increasingly in GNSS observations due to the rapidly growing GNSS constellation – extending the number of satellites, available signals and frequencies. Thus, the first part of the project is devoted to a new DIA validation procedure. Today's advent of powerful computers opens possibilities to develop the combinatorial DIA procedure which will be mathematical rigorous and optimal also under multiple faults. Thanks to an appropriately used the possibilities of combinatorics and suitable statistical tests performed in DIA sequences, the weakness of existing DIA procedure can be overcome at no significant cost. Thanks to this, the reliability of validation and, then, the quality of estimates will be higher than before. The second part of the project is devoted to validation the second portion of mathematical model, i.e., so-called probabilistic (Gaussian) model. In GNSS practice, such a model usually is not validated. It is due to the lack of an efficient procedure. However, thanks to the involvement of more composite distributions and an appropriate combinatorial DIA procedure, some Gaussian anomalies – possible in some GNSS observations – can be efficiently detected, identified and modeled. Thanks to this, the quality of estimates will be higher than before, under possible non-Gaussian observations. Since the estimation and testing are intimately linked in the DIA procedures and the outcome of testing determines how the parameters get estimated, the quality description of the estimates obtained from the estimation-testing scheme is not a trivial task. The customarily calculated error regions of such solutions do not reflect the true precision of the solutions – they are too optimistic. This task constitutes the third part of the project. Finally, the whole quality control framework developed within this project will be implemented – in a user-friendly form – in the Matlab environment and made available on-line.

As a result of the project, the mathematical modeling of GNSS observations should be more reliable under multiple faults and/or anomalies than before. Subsequently, the estimates of GNSS model parameters should be more accurate. Consequently, the Earth research based on GNSS observations should have a higher quality than before. What is more, thanks to the available error regions, the quality of calculated parameters will be known.