UNITED NATIONS
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The United Nations/United States of America Workshop on the International Space Weather Initiative

An IGS-based simulator of ionospheric conditions for GNSS positioning quality assessment

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The UN/USA Workshop on ISWI, Boston, MA, 2017

IGS-based ionospheric conditions simulator for GNSS performance assessment

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- **Introduction and motivation**

- Space weather as the single most influential natural source of GNSS positioning performance degradation
- Risk assessment of satellite navigation utilisation in application and services development calls for ability to assess the GNSS positioning performance in different positioning environment scenarios
- The introduction of GNSS Software-Defined Radio (SDR) receivers invaluable for scientists and engineers as a test-bed for models, methods, algorithms and products performance validation and testing
- Accurate and low-cost simulation of different positioning environment scenarios in laboratory is recognised as essential for GNSS applications development

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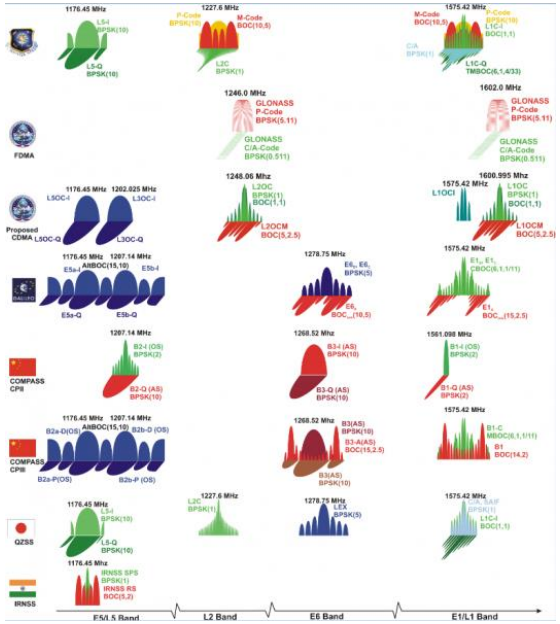
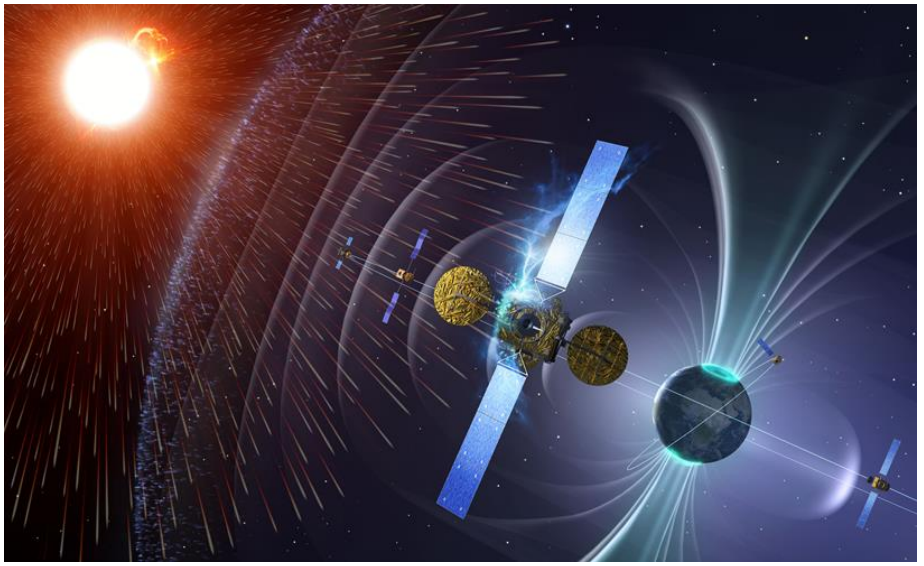
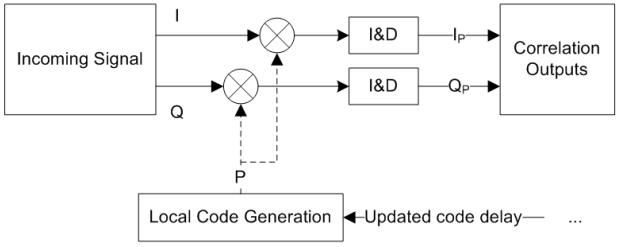
- **GNSS signal and information processing domains**



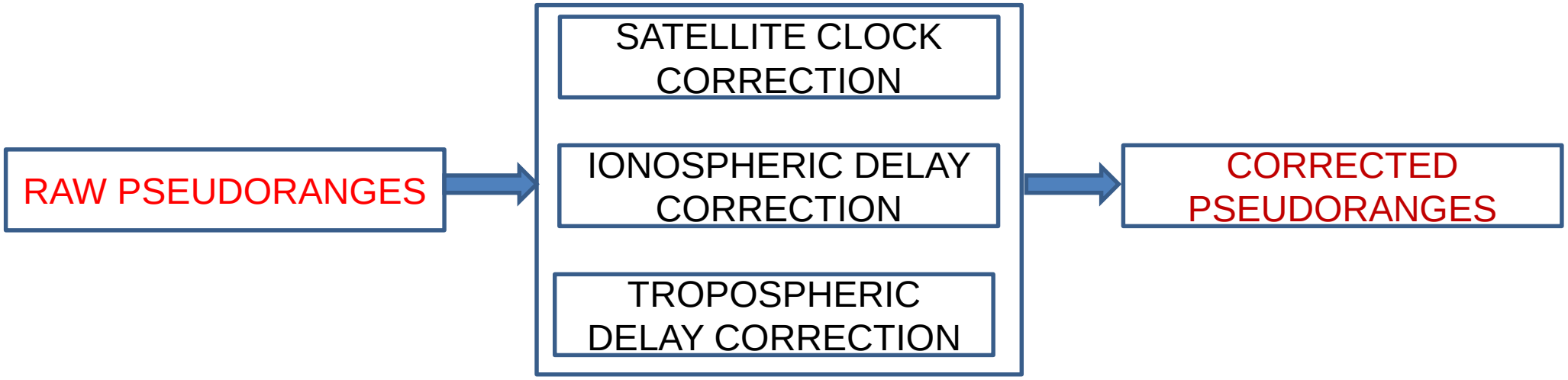




$$\begin{bmatrix} R^1 - \rho_0^1 - D^1 \\ \vdots \\ R^n - \rho_0^n - D^n \end{bmatrix} = \begin{pmatrix} \frac{x_0 - x^1}{\rho_0^1} & \frac{y_0 - y^1}{\rho_0^1} & \frac{z_0 - z^1}{\rho_0^1} & 1 \\ \vdots & \vdots & \vdots & \vdots \\ \frac{x_0 - x^n}{\rho_0^n} & \frac{y_0 - y^n}{\rho_0^n} & \frac{z_0 - z^n}{\rho_0^n} & 1 \end{pmatrix} \begin{bmatrix} dx \\ dy \\ dz \\ c\,\delta t \end{bmatrix}$$

RADIO FREQUENCY (RF) DOMAIN	BASE-BAND (BB) DOMAIN	NAVIGATION APPLICATIONS (NA) DOMAIN

- **Pseudorange correction process**



$$\rho_r = R + \varepsilon_{syst} + \varepsilon_{rand} \qquad \rho_c = R + \varepsilon_{rand}$$

Satellite-based position estimation is a measurement-based process, thus exposed to systematic and random errors sources of both natural and artificial origin.

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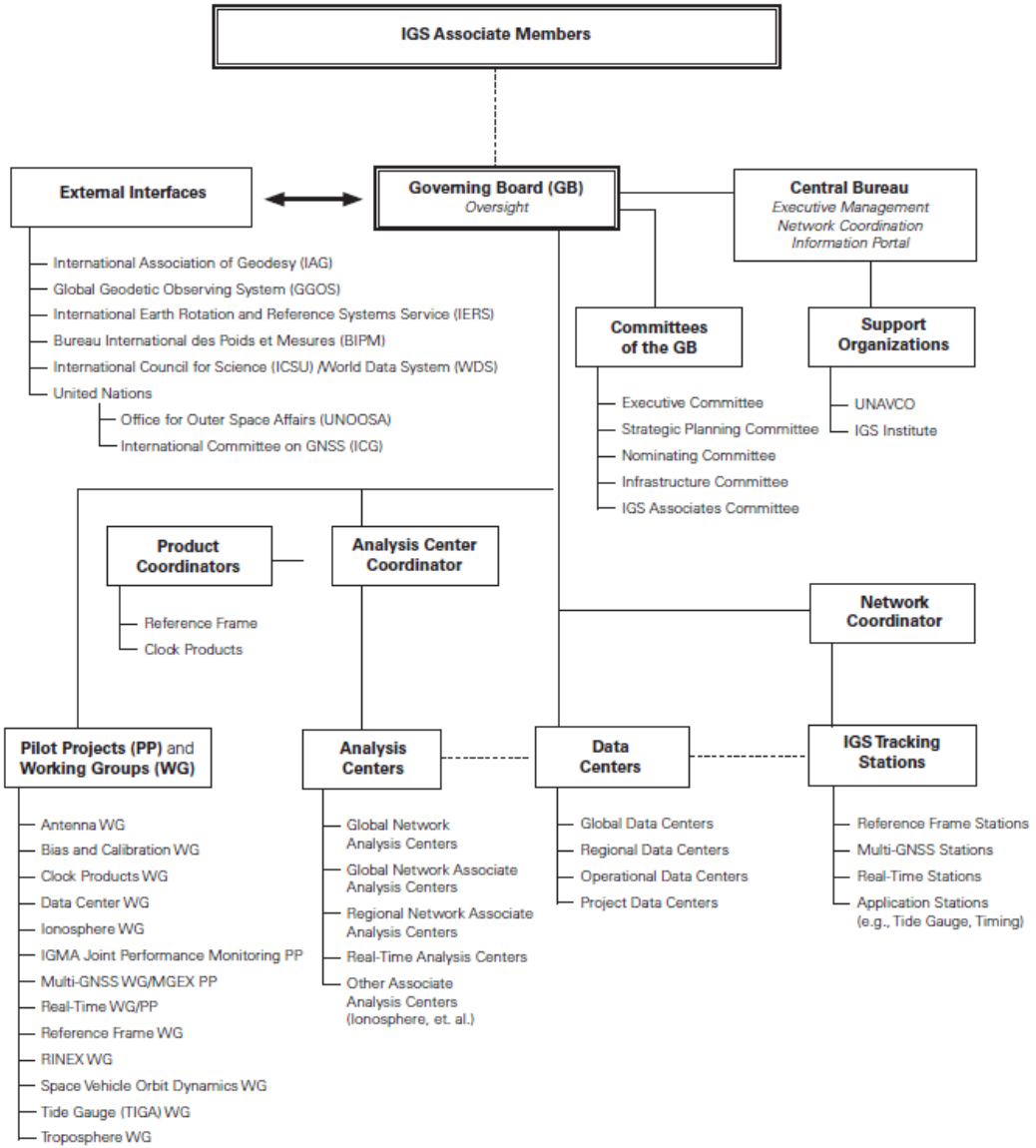
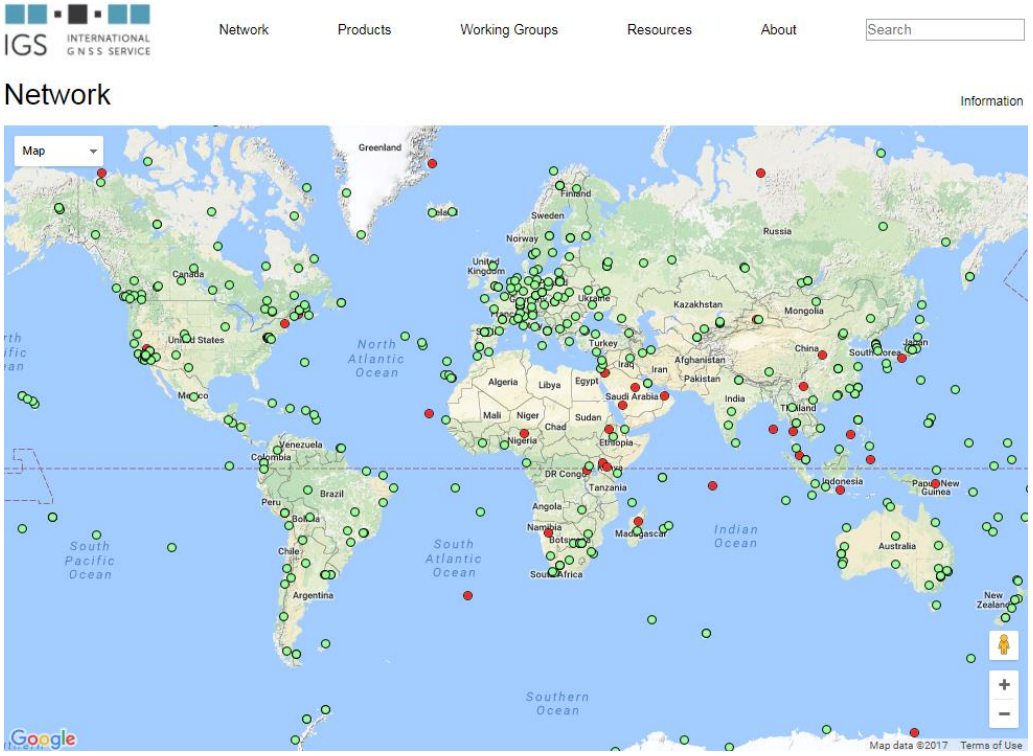
- **International GNSS Service (IGS)**





RINEX Files:
o – observation (raw pseudoranges)
d - observation file (compressed)
n – navigation file
m – meteorological data
g – GLONASS navigation file
c – clock file

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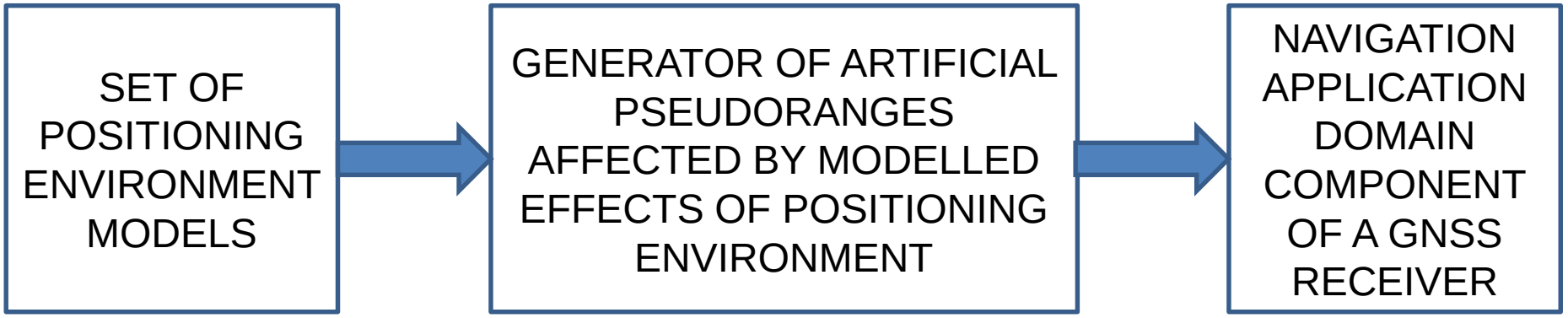
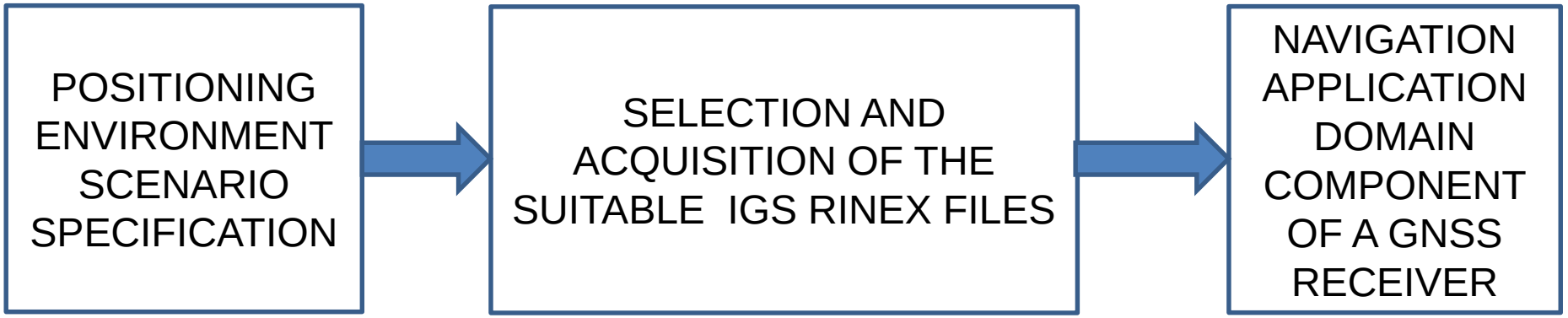
▪ Candidate approaches to GNSS simulator development

Model-based simulator



Simulator based on real positioning environment observations



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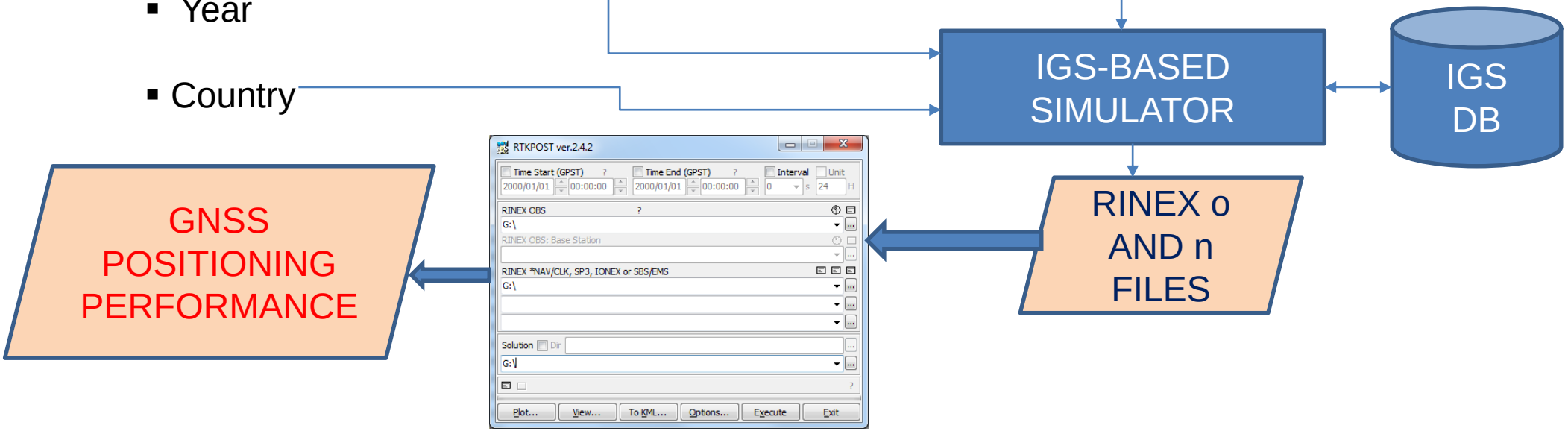
- **IGS-based ionospheric conditions simulator for GNSS performance assessment**

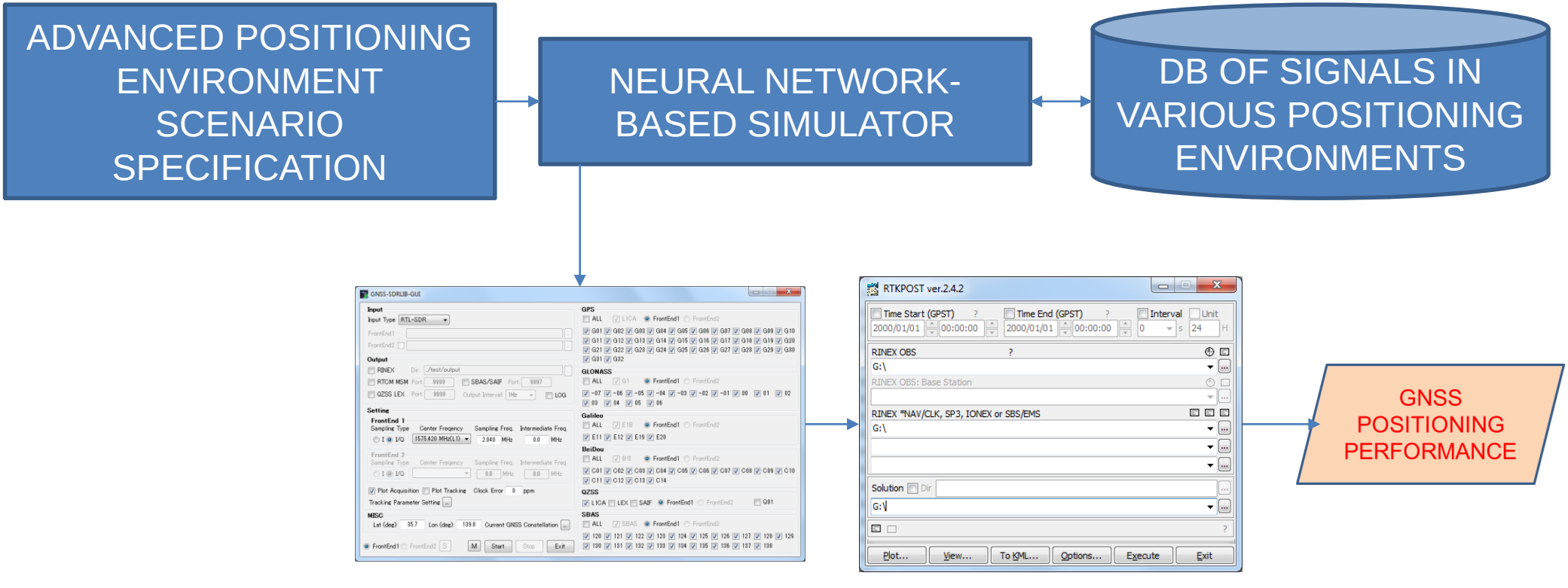
- Selection method: *naïve decision tree* (to be replaced with a neural network in the forthcoming development phase)
- Positioning environment scenario specification:
  - NOAA Geomagnetic Storm Scale mapped to Kp-index range
  - Year
  - Country



▪ Planned future activities

▪ Advanced (more detailed) specification of the positioning environment scenario

▪ Transition towards signal-feeding concept, rather than pseudorange-feeding one



▪ Proposal for recommendations

▪ IGS data and services, and the introduction of GNSS SDR receivers should be recognised as valuable resources for GNSS and GNSS-related specialists addressing resilient GNSS development, as well as for space weather scientists exploiting GNSS as the means for space weather sensing.

▪ Utilisation of GNSS positioning environment simulators should be recognised as essential in development, verification and validation of GNSS base-band and navigation domain models, methods and algorithms.

▪ International co-operation in collection, aggregation, standardisation, storage, access provision, analysis and exchange of records of both GNSS base-band signals and pseudoranges in different positioning environments (in different space weather conditions, in particular) should be facilitated and encouraged.

- Reference

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THANK YOU FOR YOUR ATTENTION !

With the invitation to 12th Annual Baška GNSS Conference, Baška, Krk Island, Croatia, 6 – 9 May, 2018

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