GGOS-D: A GERMAN PROJECT ON THE INTEGRATION OF SPACE GEODETIC TECHNIQUES

A. NOTHNAGEL[1], M. ROTHACHER[2], D. ANGERMANN[3], T. ARTZ[1], S. BÖCKMANN[1], W. BOSCH[3], H. DREWES[3], M. GERSTL[3], R. KELM[3], M. KRÜGEL[3], D. KÖNIG[2], R. KÖNIG[2], B. MEISEL[3], H. MÜLLER[3], B. RICHTER[4], N. PANAFIDINA[2], S. RUDENKO[2], W. SCHWEGMANN[4], P. STEIGENBERGER[2], V. TESMER[3], D. THALLER[2]
[1] Institut für Geodäsie und Geoinformation der Universität Bonn (IGGB)
Nußallee 17, D-53115 Bonn, Germany
e-mail: nothnagel@uni-bonn.de
[2] GeoForschungsZentrum (GFZ)
Telegrafenberg D-14473 Potsdam, Germany
[3] Deutsches Geodätisches Forschungsinstitut (DGFI)
Alfons-Goppel-Straße 11, D-80539 München
[4] Bundesamt für Kartographie und Geodäsie (BKG)
Richard-Strauß-Allee 11, D-60598 Frankfurt am Main, Germany

1. INTRODUCTION

Since September 2005 the German Ministry for Research and Education has been funding a group of scientists at GeoForschungsZentrum (GFZ Potsdam), Deutsches Geodätisches Forschungsinstitut (DGFI Munich), Bundesamt für Kartographie und Geodäsie (BKG Frankfurt am Main) and Institut für Geodäsie und Geoinformation der Universität Bonn (IGGB Bonn) in a project related to the integration of space geodetic techniques. These groups comprise experience in GPS, SLR, and VLBI observing techniques as well as in satellite altimetry, global gravity field investigations and large scale combinations. They cooperate with the aim to investigate the production of reference frames and related time series which are consistent across techniques by adapting software packages to common standards and by refining combination procedures. Since the aims of the project closely resemble the general ideas of the GGOS initiative (Global Geodetic Observing System) by the International Association of Geodesy (IAG), the group has gathered under the acronym GGOS-D.

Parameter Type	VLBI	GPS/GLON.	SLR	Altimetry
Quasar Positions (CRF)	x			
Nutation	x	(x)	(x)	
Polar Motion	x	x	x	
UT1	x			
Length of Day	x	x	x	
Ionosphere	x	x		x
Troposphere	x	x		x
Coord. & Velocity (TRF)	x	x	x	(x)
Geocenter		x	x	x
Satellite Orbits		x	x	x
Gravity Field		x	x	x

Table 1: Recent parameter space for rigorous combination.

2. CURRENT STATUS

Space geodetic observing techniques like GPS, SLR, and VLBI, as well as satellite altimetry and satellite gravity missions are sensitive to a certain set of parameters and in this have strengths as well as limitations. Combining these techniques and their results will ultimately lead to a consistent set of

parameters which will be superior to one from individual techniques alone. In Table 1 all techniques and their sensitivities to the respective parameters are depicted linking the inertial reference frame of the quasar positions via the satellite orbits to the low degree harmonics of the gravity field through a cascading of the information through intermediate levels of observations.

In order to prepare for a consistent and rigorous combination across techniques a number of organisational issues had to be decided on first. Since the group possesses expertise in several space geodesy analysis software packages it was decided that two packages each for VLBI, GPS and SLR be used in this project. The other techniques are represented just once each (see Tab. 2). The set of parameters to be combined has been selected to include whatever is supposed to be identical. For this, most of the analysis software packages had to be augmented so that each of them is able to generate datum-free normal equations in SINEX format with the full parameter space at pre-defined reference epochs. This is of particular importance for quickly changing effects like the atmosphere where non-identical epochs would require interpolations which introduce an additional level of noise.

The identification of systematic errors of the individual techniques is a necessary step towards optimal results which has to be done before the observations of all techniques can be combined consistently. The first step here is that all techniques are analysed on the basis of the same geophysical models. For this reason a catalogue has been established listing all models which are to be used in the different software packages. When the combination will have been carried out other systematic effects may become obvious and will have to be taken care of.

Technique (Software)	Site Coord.	UT1/ LOD	Nut.	C_{nm}/ S_{nm}	Geo-center	Trop. ZD	Trop. Grad.	Range Bias	Radio Source Positions
VLBI (OCCAM)	x	x	x			x	x		x
VLBI (Calc/Solve)	x	x	x			x	x		x
GPS (Bernese)	x	x	x		x	x	x		
GPS (EPOS)	o	o	o		(o)	o	o		
SLR (DOGS-OC)	x	x		x	(x)			x	
SLR (EPOS)	x	x		x	(x)			x	
LEO	x	o		x	(o)				
Altimetry	(x)	(o)		(x)	(x)				

Table 2: GGOS-D Extended Parametrization (x: realized; o: planned); C_{nm}/S_{nm} = Low degree harmonics of the gravity field, ZD = Zenith Delay, LEO = Low Earth Orbiters.

Some of the analysis software packages are being modified specifically for this very purpose since the extended list of parameters is normally not foreseen for standard use. In some cases the solution setup is heavily over-parametrized which leads to singularity of the normal equation system. However, since the SINEX files are only generated for further combination steps, singularity in the stand-alone files are not critical. The full strength of each technique will only be activated when the combination is carried out and datum information will be carried over from the technique most sensitive to the respective datum parameter.

3. OUTLOOK

In the next few months, a consistent terrestrial reference frame will be generated from a rigorous combination of all software packages in use by the collaborators. This will be the basis to compute consistent time series of all parameters which will be analyzed in further detail. We expect that these time series will show a much better agreement than any other existing combination products because models and parametrizations have been laid out specifically for the purpose of combination. The GGOS-D project will, thus, produce some very valuable insights in the processes and requirements necessary for the establishment of a Global Geodetic Observing System.