International VLBI Service for Geodesy and Astrometry

6th IVS General Meeting

2010

Hobart, Tasmania, Australia
February 7—13

Hosted by The University of Tasmania
http://ivscc.gsfc.nasa.gov/meetings/gm2010

Sixth IVS General Meeting
Hobart, Tasmania, Australia

EXTENDED SCHEDULE OF EVENTS

All events take place at University of Tasmania, School of Mathematics and Physics.
Exceptions are indicated in angular brackets.

Sunday, February 7, 2010

14:00–18:00	Registration [Zero Penthouse at Zero Davey]
16:00–18:00	Icebreaker Reception [Zero Penthouse at Zero Davey]

Monday, February 8, 2010

08:30–10:30	Opening and Session 1: Realization and New Perspectives of VLBI2010
10:30–11:00	Coffee break
11:00–13:00	Session 1: Realization and New Perspectives of VLBI2010 (cont'd)
13:00–14:00	Lunch break
14:00–16:00	Session 2: Network Stations, Operation Centers, Correlators
16:00–18:00	Poster Session (Sessions 1–5) with coffee and refreshments

Tuesday, February 9, 2010

08:30–10:00	Session 2: Network Stations, Operation Centers, Correlators (cont'd)
10:00–10:30	Session 3: VLBI Data Structure, Analysis Strategies and Software
10:30–11:00	Coffee break
11:00–12:45	Session 3: VLBI Data Structure, Analysis Strategies and Software (cont'd)
12:45–13:15	Lunch break
13:15–18:30	Excursion to Hobart station and dedication of AuScope antenna [Mt. Pleasant Observatory]

Wednesday, February 10, 2010

08:30–09:15	Session 3: VLBI Data Structure, Analysis Strategies and Software (cont'd)
09:15–10:35	Session 4: Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics
10:35–11:05	Coffee break
11:05–13:00	Session 4: Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics
13:00–14:00	Lunch break
14:00–15:00	Session 4: Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics (cont'd)
15:00–16:00	Session 5: Progress in Technology Development
16:00–16:30	Coffee break
16:30–17:45	Session 5: Progress in Technology Development (cont'd) and GM Closing
18:30–23:15	Banquet [Barilla Bay Restaurant]

Thursday, February 11, 2010

08:30–10:30	Joint VLBI2010 and Analysis meeting
10:30–11:00	Coffee break
11:00–13:00	Joint VLBI2010 and Analysis meeting (cont'd)
13:00–14:00	Lunch break
14:00–16:00	Joint VLBI2010 and Analysis meeting (cont'd)
16:00–16:30	Coffee break
16:30–18:30	Joint VLBI2010 and Analysis meeting (cont'd)
20:00–22:00	Public lecture "Creating a Radio Telescope the Diameter of the Earth" by Alan Whitney, MIT Haystack Observatory

Friday, February 12, 2010

09:00–10:45	IVS Directing Board meeting
10:45–11:15	Coffee break
11:15–13:00	IVS Directing Board meeting (cont'd)
13:00–14:00	Lunch break
14:00–15:45	IVS Directing Board meeting (cont'd)
15:45–16:15	Coffee break
16:15–18:00	IVS Directing Board meeting (cont'd)

Saturday, February 13, 2010

09:00–10:45	mini-TOW [Mt. Pleasant Observatory]
10:45–11:15	Coffee break
11:15–13:00	mini-TOW (cont'd) [Mt. Pleasant Observatory]
13:00–14:00	Lunch break
14:00–15:45	mini-TOW (cont'd) [Mt. Pleasant Observatory]
15:45–16:15	Coffee break
16:15–18:00	mini-TOW (cont'd) [Mt. Pleasant Observatory]

Sixth IVS General Meeting
Hobart, Tasmania, Australia

PROGRAM

Sunday, February 7, 2010

14:00–18:00 Registration
Zero Penthouse at Zero Davey
(15 Hunter Street, Sullivans Cove, Hobart Waterfront)

16:00–18:00 Icebreaker Reception
Zero Penthouse at Zero Davey
(15 Hunter Street, Sullivans Cove, Hobart Waterfront)

Monday, February 8, 2010

Opening

08:30 Opening Ceremony
(1) Welcome by Prof. Margaret Britz, Dean of the Faculty of Science, Engineering and Technology
(2) Welcome by Harald Schuh, IVS Chair, and Chair's Report

Session 1: Realization and New Perspectives of VLBI2010

Chair: Bill Petrachenko

08:50 S1-T01 VLBI2010: An Overview
Bill Petrachenko (Natural Resources Canada)

09:05 S1-T02 VLBI2010: The Astro-Geo Connection *(invited)*
Richard Porcas (MPIfR Bonn)

09:30 S1-T03 Differences between VLBI2010 and S/X Hardware
Brian Corey (MIT Haystack Observatory)

09:45 S1-T04 The NASA VLBI2010 Proof-of-Concept Demonstration and Future Plans
Arthur Niell (MIT Haystack Observatory) and the Broadband Development Team

10:00 S1-T05 Differences between S/X and VLBI2010 Operations
Hayo Hase[1], Ed Himwich[2], Alexander Neidhardt[3] ([1]BKG, [2]NVI, Inc./NASA GSFC, [3]FESG Wettzell)

10:15 S1-T06 Post-Correlation Processing for the VLBI2010 Proof-of-Concept System
Christopher Beaudoin, Arthur Niell (MIT Haystack Observatory)

10:30 Coffee Break

Chair: Arthur Niell

11:00 S1-T07 GPU Based Software Correlators – Perspectives for VLBI2010
Thomas Hobiger[1], Moritaka Kimura[1], Kazuhiro Takefuji[1], Tomoaki Oyama[2], Yasuhiro Koyama[1], Tetsuro Kondo[1], Tadahiro Gotoh[1], Jun Amagai[1] ([1]NICT Japan, [2]NAOJ Japan)

11:15 S1-T08 VLBI2010 Imaging and Structure Corrections
Arnaud Collioud, Patrick Charlot (Laboratoire d'Astrophysique de Bordeaux)

11:30 S1-T09 The AuScope Project and Trans-Tasman VLBI
Jim Lovell[1], John Dickey[1], Sergei Gulyaev[2], Tim Natusch[2], Oleg Titov[3], Steven Tingay[4] ([1]University of Tasmania, [2]Auckland University of Technology, [3]Geoscience Australia, [4]Curtin University of Technology)

11:45 S1-T10 Current Status of the Development of a Transportable and Compact VLBI System by NICT and GSI
Atsutoshi Ishii[1,2,4], Ryuichi Ichikawa[2], Hiroshi Takiguchi[2], Kazuhiro Takefuji[2], Hideki Ujihara[2], Yasuhiro Koyama[2], Tetsuro Kondo[2,3], Shinobu Kurihara[1], Yuji Miura[1], Shigeru Matsuzaka[1], Daisuke Tanimoto[1,4] ([1]GSI Japan, [2]NICT Japan, [3]Ajou University, [4]AES Co. Ltd.)

12:00 S1-T11 VLBI2020: From Reality to Vision
Oleg Titov (Geoscience Australia)

12:15 S1-T12 How and Why to Do VLBI on GNSS Spacecraft
John Dickey (University of Tasmania)

12:30 S1-T13 Planning of an Experiment for VLBI Tracking of GNSS Satellites
Vincenza Tornatore[1], Rüdiger Haas[2] ([1]Politecnico di Milano, [2]Chalmers University of Technology)

12:45 S1-T14 Multi-source Geodetic VLBI – A New Observing and Analysis Technique
Victus Uzodinma (University of Nigeria)

13:00 Lunch Break

Session 2: Network Stations, Operation Centers, Correlators

Chair: Kerry Kingham

14:00 S2-T01 An Introduction to SKED *(invited)*
John Gipson (NVI, Inc./NASA GSFC)

14:20 S2-T02 The State and Development Direction of the Geodetic VLBI Station in Korea *(invited)*
Hyunhee Ju[1], Myungho Kim[1], Suchul Kim[1], Jinsik Park[1], Tetsuro Kondo[2,3], Tuhwan Kim[2], Hongjong Oh[2], Sangoh Yi[2] ([1]NGII Korea, [2]Ajou University, [3]NICT Japan)

14:45 S2-T03 RAEGE: An Atlantic Network of Geodynamical Fundamental Stations
Jesús Gómez-González[1], Francisco Colomer[1], José Antonio López-Fernández[1], Marlene Assis[2] ([1]IGN Spain, [2]SRCTE Portugal)

15:00 S2-T04 The New Generation Russian VLBI Network
Andrey Finkelstein, Alexander Ipatov, Sergey Smolentsev, Vyacheslav Mardyshkin, Leonid Fedotov, Igor Surkis, Dmitrij Ivanov, Iskandar Gayazov (Institute of Applied Astronomy)

15:15 S2-T05 Towards Establishing a Chinese Geodetic VLBI Observing System
Fengchun Shu[1], Weimin Zheng[1], Xiuzhong Zhang[1], Xiaoyu Hong[1], Aili Yusup[2], Ming Wang[3] ([1]Shanghai Astronomical Observatory, [2]Urumqi Astronomical Observatory, [3]Yunnan Astronomical Observatory)

15:30 S2-T06 Characterization and Calibration of the 12-m Antenna in Warkworth, New Zealand
Sergei Gulyaev, Tim Natusch (Auckland University of Technology)

15:45 S2-T07 COLD MAGICS – Continuous Local Deformation of an Arctic Geodetic Fundamental Station
Rüdiger Haas[1], Sten Bergstrand[2] ([1]Chalmers University of Technology, [2]SP Technical Research Institute)

Poster Session (Sessions 1–5) with coffee and refreshments

16:00-18:00 Core Poster Time for All Sessions
S1-P01…S1-P04, S2-P01…S2-P16, S3-P01…S3-P08, S4-P01…S4-P09, S5-P01…S5-P12

Tuesday, February 9, 2010

Session 2: Network Stations, Operation Centers, Correlators (cont'd)

Chair: Kazuhiro Takashima

08:30 S2-T08 Homologous Deformation of the Effelsberg 100-m Telescope Determined with a Total Station
Axel Nothnagel, Judith Pietzner, Christian Eling (University of Bonn)

08:45 S2-T09 Ultra-rapid dUT1 Experiments on Japan–Fennoscandian Baselines – Application to 24-hour Sessions
Shigeru Matsuzaka[1], Shinobu Kurihara[1], Mamoru Sekido[2], Thomas Hobiger[2], Rüdiger Haas[3], Jouko Ritakari[4], Jan Wagner[4] ([1]GSI Japan, [2]NICT Japan, [3]Chalmers University of Technology, [4]Helsinki University of Technology)

09:00 S2-T10 MPIfR/BKG Correlator Report
Walter Alef[1], David Graham[1], Helge Rottmann[1], John Morgan[1], Richard Porcas[1], Arno Müskens[2], Alessandra Bertarini[2], Simone Bernhart[2] ([1]MPIfR Bonn, [2]University of Bonn)

09:15 S2-T11 Implementation and Testing of VLBI Software Correlation at USNO
Alan Fey[1], David Boboltz[1], Ralph Gaume[1], David Hall[1], Ken Johnston[1], Kerry Kingham[1], Roopesh Ojha[2] ([1]U.S. Naval Observatory, [2]NVI, Inc./USNO)

09:30 S2-T12 The Software Correlator of the Chinese VLBI Network
Weimin Zheng, Ying Quan, Fengchun Shu, Zhong Chen, Shanshan Chen, Weihua Wang (Shanghai Astronomical Observatory)

09:45 S2-T13 Zodiac Extragalactic Sources Densification Using Phase-Referencing Techno-logy
Guangli Wang (Shanghai Astronomical Observatory)

Session 3: VLBI Data Structure, Analysis Strategies and Software

Chair: Thomas Hobiger

10:00 S3-T01 IVS Working Group 4: Proposed VLBI Data Format
John Gipson (NVI, Inc./NASA GSFC)

10:15 S3-T02 Development of a New VLBI Data Analysis Software
Sergei Bolotin, John Gipson, Dan MacMillan (NVI, Inc./NASA GSFC)

10:30 Coffee Break

11:00 S3-T03 Estimation of Geodetic and Geodynamical Parameters with VieVS
Hana Spicakova, Johannes Böhm, Sigrid Böhm, Tobias Nilsson, Andrea Pany, Lucia Plank, Kamil Teke, Harald Schuh (Vienna University of Technology)

11:15 S3-T04 VLBI Analysis with the Multi-technique Software GEOSAT
Halfdan Kierulf[1], Per-Helge Andersen[2], Sarah Böckmann[3], Oddgeir Kristiansen[1] ([1]Norwegian Mapping Authority, [2]Norwegian Defence Research Establishment, [3]University of Bonn)

11:30 S3-T05 Comparison Campaign of VLBI Data Analysis Software – First Results
Lucia Plank (Vienna University of Technology)

11:45 S3-T06 Consideration of Correlations between the Different Input Series in IVS Intra-technique Combination
Sarah Böckmann, Thomas Artz, Axel Nothnagel (University of Bonn)

Chair: John Gipson

12:00 S3-T07 VLBI–SLR Combination Solution Using GEODYN
Dan MacMillan[1], Frank Lemoine[2], Despina Pavlis[3], Douglas Chinn[3], David Rowlands[2] (NVI, Inc./NASA GSFC, [2]NASA GSFC, [3]SGT Inc./NASA GSFC)

12:15 S3-T08 Application of Ray-tracing through the High Resolution Numerical Weather Model HIRLAM for the Analysis of European VLBI
Susana García-Espada[1], Rüdiger Haas[2], Francisco Colomer[1] ([1]IGN Spain, [2]Chalmers University of Technology)

12:30 S3-T09 Atmospheric Delay Reduction Using KARAT for GPS Analysis and Implications for VLBI
Ryuichi Ichikawa[1], Thomas Hobiger[1], Yasuhiro Koyama[1], Tetsuro Kondo[1,2] ([1]NICT Japan, [2]Ajou University)

12:45 Lunch Break

Visit of Mt. Pleasant Observatory and Dedication of AuScope Antenna

Master of Ceremonies: Jim Lovell

13:15 Bus departure from University of Tasmania

14:00-18:00 Excursion to Hobart Station and dedication of AuScope Antenna

18:00 Bus departure from Mt Pleasant Observatory

Wednesday, February 10, 2010

Session 3: VLBI Data Structure, Analysis Strategies and Software (cont'd)

Chair: John Gipson

08:30 S3-T10 Use of GPS TEC Ionosphere Maps for Calibrating Single Band VLBI Sessions
David Gordon (NVI, Inc./NASA GSFC)

08:45 S3-T11 Universal Time from VLBI Single Baseline Observations during CONT08
Johannes Böhm, Tobias Nilsson, Harald Schuh (Vienna University of Technology)

09:00 S3-T12 Application of Geodetic VLBI Data to Obtaining Long-term Light-curves for Astrophysics
Masachika Kijima (Sokendai Graduate University)

Session 4: Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics

Chair: Rüdiger Haas

09:15 S4-T01 The Second International Celestial Reference Frame (ICRF2) *(invited)*
Chopo Ma (NASA GSFC)

09:35 S4-T02 Time-dependent Selection of an Optimal Set of Sources to Define a Stable Celestial Reference Frame
Karine Le Bail, David Gordon (NVI, Inc./NASA GSFC)

09:50 S4-T03 X/Ka-band Celestial Reference Frame Work: Recent Improvements
Chris Jacobs[1], Ojars Sovers ([1]Jet Propulsion Laboratory, [2]Remote Sensing Analysis Systems Inc.)

10:05 S4-T04 Effects of ICRF2 on Estimates of Earth Orientation Parameters and the Terrestrial Reference Frame
Robert Heinkelmann (DGFI Munich)

10:20 S4-T05 Long-term Variations of the EOP and ICRF2
Vladimir Zharov, Mikhail Sazhin, Valerian Sementsov (Sternberg State Astronomical Institute)

10:35 Coffee Break

11:05 S4-T06 Long-term Stability of Radio Sources in VLBI Analysis
Gerald Engelhardt, Volkmar Thorandt (BKG Leipzig)

11:20 S4-T07 The Position Stability of Four ICRF2 Radio Sources
Ed Fomalont[1], Ken Johnston[2], Alan Fey[2], David Boboltz[2], Tomoaki Oyama[3], Mareki Honma[3] ([1]NRAO, [2]U.S. Naval Observatory, [3]NAOJ Japan)

11:35 S4-T08 Study of the Low Luminosity GPS Radio Source PKS B2254-367 (IC 1459) from VLBI Observations
Julia Sokolova, Steven Tingay (Curtin University of Technology)

Chair: Dan MacMillan

11:50 S4-T09 Global VLBI Observations of Weak Extragalactic Radio Sources: Imaging of Candidates to Align the ICRF and the Future GAIA Frame
Géraldine Bourda[1], Patrick Charlot[1], Arnaud Collioud[1], Richard Porcas[2], Simon Garrington[3] ([1]Laboratoire d'Astrophysique de Bordeaux, [2]MPIfR Bonn, [3]Jodrell Bank Observatory)

12:05 S4-T10 Enabling High Precision VLBI Relative Astrometry at the Highest Frequencies
Maria Rioja[1,2], Richard Dodson[1] ([1]ICRAR/UWA, [2]OAN Spain)

12:20 S4-T11 An Improved Lunar Gravity Field Model from SELENE and Historical Tracking Data *(invited)*
Koji Matsumoto[1], Sander Goossens[1], Yoshiaki Ishihara[1], Quinghui Liu[2], Fuyuhiko Kikuchi[1], Takahiro Iwata[3], Noriyuki Namiki[4], Hirotomo Noda[1], Hideo Hanada[1], Nobuyuki Kawano[2], and RSAT/VRAD Mission Team ([1]NAOJ Japan, [2]Shanghai Astronomical Observatory, [3]JAXA, [4]Chiba Institute of Technology)

12:45 S4-T12 Planetary Radio Interferometry and Doppler Experiment (PRIDE) in the IVS Context
Leonid Gurvits, Sergei Pogrebenko, Giuseppe Cimò (JIVE) and the PRIDE Team

13:00 Lunch Break

14:00 S4-T13 The First Experiment with VLBI–GPS Hybrid System
Younghee Kwak[1,3], Tetsuro Kondo[1,2], Tadahiro Gotoh[2], Jun Amagai[2], Hiroshi Takiguchi[2], Mamoru Sekido[2], Ryuichi Ichikawa[2], Tetsuo Sasao[1], Jungho Cho[3], Tuhwan Kim[1] ([1]Ajou University, [2]NICT Japan, [3]KASI Korea)

14:15 S4-T14 Ionospheric Response to the Total Solar Eclipse of July 22, 2009 as Deduced from VLBI and GPS Data
Li Guo[1], Fengchun Shu[1], Weimin Zheng[1], Tetsuro Kondo[2,3], Ryuichi Ichikawa[2], Shingo Hasegawa[2], Mamoru Sekido[2] ([1]Shanghai Astronomical Observatory, [2]NICT Japan, [3]Ajou University)

14:30 S4-T15 Reliability and Stability of VLBI-derived Sub-daily EOP Models
Thomas Artz[1], Sarah Böckmann[1], Axel Nothnagel[1], Peter Steigenberger[2] ([1]University of Bonn, [2]TU Munich)

14:45 S4-T16 Extracting Independent Local Oscillatory Geophysical Signals in Geodetic Tropospheric Delay
Ondego Joel Botai[1], Ludwig Combrinck[1,2], Venkataraman Sivakumar[1,3], C.J. de W. Rautenbach[1], Harald Schuh[4], Johannes Böhm[4] ([1]University of Pretoria, [2]Hartebeesthoek RAO, [3]South African National Laser Center, [4]Vienna University of Technology)

Session 5: Progress in Technology Development

Chair: Alan Whitney

15:00 S5-T01 The Mark 5C VLBI Data System
Alan Whitney[1], Chester Ruszczyk[1], Jon Romney[2], Ken Owens[3] ([1]MIT Haystack Observatory, [2]NRAO, [3]Conduant Corp.)

15:15 S5-T02 Cryogenic Integration of 2-14 GHz Eleven Feed in Wideband Receiver for VLBI2010
Miroslav Pantaleev[1], Jian Yang[1], Yogesh Karadikar[1], Leif Helldner[1], Benjamin Klein[2], Rüdiger Haas[1], Ashraf Zaman[1], Mojtaba Zamani[1], Per-Simon Kildal[1] ([1]Chalmers University of Technology, [2]Hartebeesthoek Radio Astronomy Observatory)

15:30 S5-T03 Next Generation A/D Sampler ADS3000+ for VLBI2010
Kazuhiro Takefuji[1], Hiroshi Takeuchi[2], Masanori Tsutsumi[1], Yasuhiro Koyama[1] ([1]NICT Japan, [2]JAXA/ISAS)

15:45 S5-T04 e-control: First Public Release of Remote Control Software for VLBI Telescopes
Alexander Neidhardt[1], Martin Ettl[1], Helge Rottmann[2], Christian Plötz[3], Matthias Mühlbauer[3], Hayo Hase[3], Walter Alef[2], Sergio Sobarzo[4], Cristian Herrera[4], Ed Himwich[5] ([1]FESG Wettzell, [2]MPIfR Bonn, [3]BKG Wettzell, [4]Universidad de Concepción, [5]NVI, Inc./NASA GSFC)

16:00 Coffee Break

16:30 S5-T05 The Wettzell System Monitoring Concept and First Realizations
Martin Ettl[1], Alexander Neidhardt[1], Matthias Mühlbauer[2], Christian Plötz[2] ([1]FESG Wettzell, [2]BKG Wettzell)

16:45 S5-T06 Lunar, Martian, and Jovian Geodesy and Science Mission Using VLBI and Astrometrical Technology
Takahiro Iwata[1], Hideo Hanada[2], Hirotomo Noda[2], Fuyuhiko Kikuchi[2], Seiichi Tazawa[2], Hiroo Kunimori[3], Koji Matsumoto[2], Kazumasa Imai[4], Yoshiaki Ishihara[2], Yuji Harada[2], Sho Sasaki[2] ([1]JAXA, [2]NAOJ Japan, [3]NICT Japan, [4]Kochi National College of Technology)

17:00 S5-T07 The Development of VLBI Technologies at SHAO
Xiuzhong Zhang (Shanghai Astronomical Observatory)

17:15 S5-T08 The Progress of CDAS
Renjie Zhu, Ying Xiang, Yajun Wu (Shanghai Astronomical Observatory)

Closing

17:30 Closing Remarks
Harald Schuh, IVS Chair

17:45 Adjourn GM

General Meeting Banquet at Barilla Bay Restaurant

18:30 Bus departure from University of Tasmania

19:00-22:45 Banquet at Barilla Bay Restaurant

22:45 Bus departure from Barilla Bay Restaurant (back to accommodation)

Posters

Session 1: Realization and New Perspectives of VLBI2010

S1-P01 IVS Status Report 2008-2010
Dirk Behrend[1], Harald Schuh[2] ([1]NVI, Inc./NASA GSFC, [2]Vienna University of Technology)

S1-P02 Summary of the VLBI2010 Monte Carlo Simulations
Andrey Pany[1], Johannes Böhm[1], John Gipson[2], Rüdiger Haas[3], Dan MacMillan[2], Arthur Niell[4], Tobias Nilsson[1], Bill Petrachenko[5], Harald Schuh[1], Anthony Searle[5] ([1]Vienna University of Technology, [2]NVI, Inc./NASA GSFC, [3]Chalmers University of Technology, [4]MIT Haystack Observatory, [5]Natural Resources Canada)

S1-P03 DBBC VLBI2010
Gino Tuccari[1], Walter Alef[2], Alessandra Bertarini[3], Salvatore Buttaccio[1], Gianni Comoretto[4], David Graham[2], Alexander Neidhardt[5], Pier Raffaele Platania[1], Alan Roy[2], Michael Wunderlich[2], Reinhard Zeitlhöfler[6] ([1]Istituto di Radioastronomia/INAF, [2]MPIfR Bonn, [3]University of Bonn, [4]Osservatorio Astrofisico di Arcetri/INAF, [5]FESG Munich, [6]BKG Wettzell)

S1-P04 VLBI2010 Related Research Activities at SHAO
Guangli Wang, Ming Zhao, Yong Zheng, Zhihan Qian (Shanghai Astronomical Observatory)

Session 2: Network Stations, Operation Centers, Correlators

S2-P01 The Composition of the Master Schedule
Cynthia Thomas, Dan MacMillan, Dirk Behrend (NVI, Inc./NASA GSFC)

S2-P02 Coordinating, Scheduling, Processing and Analyzing IYA2009
John Gipson[1], Dirk Behrend[1], Cynthia Thomas[1], David Gordon[1], Ed Himwich[1], Dan MacMillan[1], Mike Titus[2], Brian Corey[2] ([1]NVI, Inc./NASA GSFC, [2]MIT Haystack Observatory)

S2-P03 TIGO Station Report
Sergio Sobarzo (Universidad de Concepción)

S2-P04 Update on the TWIN Telescope Wettzell Project
Hayo Hase[1], Gerhard Kronschnabl[1], Reiner Dassing[1], Thomas Klügel[2], Christian Plötz[1], Ullrich Schreiber[1], Walter Schwarz[1], Alexander Neidhardt[2], Pierre Lauber[2] ([1]BKG Wettzell, [2]FESG Wettzell)

S2-P05 Update on the Fundamental Station Project in Ny-Ålesund
Per Erik Opseth, Line Langkaas, Terje Dahlen, Bjørn Engen, Frode Koppang (Norwegian Mapping Authority)

S2-P06 Reduction of GPS Observations in the Local Ties
Li Liu, Jinling Li, Zongyi Cheng (Shanghai Astronomical Observatory)

S2-P07 Permanent Monitoring of the Reference Point of the 20-m Radio Telescope Wettzell
Alexander Neidhardt[1], Michael Lösler[2], Cornelia Eschelbach[2], Andreas Schenk[2] (FESG Wettzell, University of Karlsruhe)

S2-P08 Proof-of-Concept Studies for a Local Tie Monitoring System
Benno Schmeing[1,2], Dirk Behrend[2], John Gipson[2], Axel Nothnagel[1] ([1]University of Bonn, [2]NVI, Inc./NASA GSFC)

S2-P09 The QUASAR Network Observations in e-VLBI Mode within Domestic VLBI Programs
Ilia Bezrukov, Andrey Finkelstein, Alexander Ipatov, Michael Kaidanovsky, Andrey Mikhailov, Alexander Salnikov, Elena Skurikhina, Igor Surkis (Institute of Applied Astronomy)

S2-P10 Implantation of Geodetic Networks of High Precision for the Monitoring of Deformations of the Crust at the Local Level
Niel Teixeira (State University of Santa Cruz)

S2-P11 Venus Express Spacecraft Observations with the Wettzell Radio Telescope – First Results
Alexander Neidhardt[1], Gerhard Kronschnabl[2], Jan Wagner[3], Guifre Molera Calves[3], Miguel Perez Ayucar[4], Giuseppe Cimò[5], Sergei Pogrebenko[5] ([1]FESG Wettzell, [2]BKG Wettzell, [3]HUT-MRO Metsahovi, [4]ESA-ESAC Madrid, [5]JIVE)

S2-P12 RDV77 VLBA Hardware/Software Correlator Comparison
David Gordon (NVI, Inc./NASA GSFC)

S2-P13 The JPL VLBI Correlator and SoftC
Stephen Rogstad, Stephen Lowe (Jet Propulsion Laboratory)

S2-P14 The IAA RAS Correlator Processing: First Results
Igor Surkis, Vladimir Zimovsky, Violetta Shantyr, Alexey Melnikov (Institute of Applied Astronomy)

S2-P15 CRF Network Simulations for the South
Oleg Titov[1], Dirk Behrend[2], Fengchun Shu[3], Dan MacMillan[2], Alan Fey[4] ([1]Geoscience Australia, [2]NVI, Inc./NASA GSFC, [3]Shanghai Astronomical Observatory, [4]U.S. Naval Observatory)

S2-P16 About the Compatibility of DORIS and VLBI Observations
Gennady Il'in, Sergey Smolentsev, Roman Sergeev (Institute of Applied Astronomy)

Session 3: VLBI Data Structure, Analysis Strategies and Software

S3-P01 VLBI Data Interchange Format
Alan Whitney[1], Mark Kettenis[2], Chris Phillips[3], Mamoru Sekido[4] ([1]MIT Haystack Observatory, [2]JIVE, [3]CSIRO/ATNF, [4]NICT Japan)

S3-P02 Combination Analysis at KASI
Younghee Kwak[1,2], Jungho Cho[1] ([1]Korea Astronomy and Space Science Institute, [2]Ajou University)

S3-P03 c5++ Multi-technique Analysis Software for Next Generation Geodetic Instruments
Thomas Hobiger[1], Toshimichi Otsubo[2], Tadahiro Gotoh[1], Toshihiro Kubooka[1], Mamoru Sekido[1], Hiroshi Takiguchi[1], Hiroshi Takeuchi[3] ([1]NICT Japan, [2]Hitotsubashi University, [3]JAXA)

S3-P04 OCCAM-LSM for Linux: New Developments at DGFI
Robert Heinkelmann, Michael Gerstl (DGFI Munich)

S3-P05 SAI Analysis Center Activity
Vladimir Zharov (Sternberg State Astronomical Institute)

S3-P06 Antenna Axis Offset Estimation from VLBI
Sergey Kurdubov, Elena Skurikhina (Institute of Applied Astronomy)

S3-P07 Strategies for Improving the IVS-INT01 UT1 Estimates: Results of RD0907–RD0910
John Gipson, Karen Baver, Dan MacMillan (NVI, Inc./NASA GSFC)

S3-P08 CPO Prediction: Accuracy Assessment and Impact on UT1 Intensive Results
Zinovy Malkin (Pulkovo Observatory)

Session 4: Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics

S4-P01 Cartography in Space Geodesy
Hayo Hase (BKG Concepción) and the TANAMI Team

S4-P02 Forthcoming Occultations of Astrometric Radio Sources by Planets
Victor L'vov, Zinovy Malkin, Svetlana Tsekmeister (Pulkovo Observatory)

S4-P03 LBA Calibrator Survey of the Southern Sky
Leonid Petrov[1], Chris Phillips[2], Alessandra Bertarini[3], Roy Booth[4], Sarah Burke-Spolaor[5], Ed Fomalont[6], Ron Ekers[2], Kee-Tae Kim[7], Tara Murphy[8], Sergei Pogrebenko[9], Elaine Sadler[8], Tasso Tzioumis[2] ([1]ADNET Systems, Inc./NASA GSFC, [2]CSIRO/ATNF, [3]University of Bonn, [4]Hartebeesthoek Radio Astronomical Observatory, [5]Swinburne University of Technology, [6]NRAO, [7]KASI, [8]University of Sydney, [9]JIVE)

S4-P04 Finding Extremely Compact Sources using the ASKAP VAST Survey
Hayley Bignall[1], Cormac Reynolds[1], Roopesh Ojha[2], Jim Lovell[3], Dave Jauncey[4] ([1]ICRAR/Curtin University, [2]NVI, Inc./USNO, [3]University of Tasmania, [4]ATNF) and the ASKAP VAST Collaboration

S4-P05 The Tropospheric Products of the International VLBI Service for Geodesy and Astrometry
Christian Schwatke, Robert Heinkelmann (DGFI Munich)

S4-P06 Station Positions Intraday Variations
Elena Skurikhina (Institute of Applied Astronomy)

S4-P07 Simulation of Local Tie Accuracy on VLBI Antennas
Ulla Kallio, Markku Poutanen (Finnish Geodetic Institute)

S4-P08 Sub-diurnal EOP Variations from the Analysis of the CONT Campaigns
Rüdiger Haas (Chalmers University of Technology)

S4-P09 VLBI and GPS-based Time Transfer Using CONT08 Data
Carsten Rieck[1], Rüdiger Haas[2], Kenneth Jaldehag[2], Jan Johansson[1] ([1]SP Technical Research Institute, [2]Chalmers University of Technology)

Session 5: Progress in Technology Development

S5-P01 Development of a Compact Eleven Feed Cryostat for the Patriot 12-m Antenna
Christopher Beaudoin[1], Per-Simon Kildal[2], Jian Yang[2], Miroslav Pantaleev[2] ([1]MIT Haystack Observatory, [2]Chalmers University of Technology)

S5-P02 Radio Telescope Focal Container for the Russian VLBI Network of New Generation
Alexander Ipatov[1], Vyacheslav Mardyshkin[1], Andrey Cherepanov[2] ([1]Institute of Applied Astronomy, [2]SPbSPU)

S5-P03 Digital Backend for JPL VLBI Data Acquisition Terminal
Robert Navarro (Jet Propulsion Laboratory)

S5-P04 DBBC2 Backend: Status and Development Plan
Gino Tuccari[1], Walter Alef[2], Alessandra Bertarini[3], Salvatore Buttaccio[1], Gianni Comoretto[4], David Graham[2], Alexander Neidhardt[5], Pier Raffaele Platania[1], Alan Roy[2], Michael Wunderlich[2], Reinhard Zeitlhöfler[6] ([1]Istituto di Radioastronomia/INAF, [2]MPIfR Bonn, [3]University of Bonn, [4]Osservatorio Astrofisico di Arcetri/INAF, [5]FESG Munich, [6]BKG Wettzell)

S5-P05 RDBE – A Second-Generation Digital Backend System
Alan Whitney[1], Shephard Doeleman[1], Alan Hinton[1], Russell McWhirter[1], Arthur Niell[1], Chester Ruszczyk[1], Michael Taveniku[1], Miguel Guerra[2], Matthew Luce[2] ([1]MIT Haystack Observatory, [2]NRAO)

S5-P06 The Digital Data Acquisition System for the Russian VLBI Network of New Generation
Leonid Fedotov, Eugene Nosov, Sergey Grenkov (Institute of Applied Astronomy)

S5-P07 Round Trip System Available to Measure Path Length Variation in Korean VLBI System for Geodesy
Hongjong Oh[1], Tetsuro Kondo[1,2], Tuhwan Kim[1], Sangoh Yi[1], Myungho Kim[3], Suchul Kim[3], Jinsik Park[3], Hyunhee Ju[3] ([1]Ajou University, [2]NICT Japan, [3]NGII Korea)

S5-P08 Experiment of Injecting Phase Cal ahead of the Feed: First Results
Dmitrij Ivanov, Anatolij Maslenikov, Alexander Vytnov (Institute of Applied Astronomy)

S5-P09 First Phase Development of Korea-Japan Joint VLBI Correlator and its Current Progress
Se-Jin Oh[1], Duk-Gyoo Roh[1], Jae-Hwan Yeom[1], Hideyuki Kobayashi[2], Noriyuki Kawaguchi[2] ([1]KASI, [2]NAOJ Japan)

S5-P10 Development of an e-VLBI Data Transport Software Suite with VDIF
Mamoru Sekido[1], Kazuhiro Takefuji[1], Moritaka Kimura[1], Takuya Shinno[2], Fujinobu Takahashi[2] ([1]NICT Japan, [2]Yokohama University)

S5-P11 The Progress of the Hardware Correlator Development at SHAO
Zhijun Xu, Xiuzhong Zhang, Renjie Zhu, Ying Xiang, Yajun Wu (Shanghai Astronomical Observatory)

S5-P12 The Impact of Radio Frequency Interference (RFI) on VLBI2010
Bill Petrachenko (Natural Resources Canada)

Sixth IVS General Meeting
Hobart, Tasmania, Australia

ABSTRACTS

Session 1: VLBI in Science and Application

S1-T01 VLBI2010: An Overview

Bill Petrachenko (Natural Resources Canada)

The first concrete actions toward a next generation system for geodetic VLBI began in 2003 when the IVS initiated Working Group 3 to investigate requirements for a new system. The working group set out ambitious performance goals and sketched out initial recommendations for the system. Starting in 2006, developments continued under the leadership of the VLBI2010 Committee (V2C) in two main areas: Monte Carlo simulators were developed to evaluate proposed system changes according to their impact on IVS final products, and a proof-of-concept effort sponsored by NASA was initiated to develop next generation systems and verify the concepts behind VLBI2010. In 2009, the V2C produced a progress report that summarized the conclusions of the Monte Carlo work, and outlined recommendations for the next generation system in terms of systems, analysis, operations and network configuration. At the time of writing: two complete VLBI2010 signal paths have been completed and data is being produced; a number of VLBI2010 antenna projects are under way; and a VLBI2010 Project Executive Group (V2PEG) has been initiated to provide strategic leadership.

S1-T02 VLBI2010: The Astro-Geo Connection *(invited)*

Richard Porcas (MPIfR Bonn)

VLBI2010 holds out promise for greatly increased precision in measuring geodetic and Earth rotation parameters. As a by-product there will be a wealth of interesting new astronomical data; at the same time astronomical knowledge may be needed to disentangle the astronomical and geodetic contributions to the measured delays—and phases. This presentation will explore this astro-geo "link".

S1-T03 Differences between VLBI2010 and S/X Hardware

Brian Corey (MIT Haystack Observatory)

The primary VLBI2010 observable will be the broadband delay, which is constructed from observations in four or more frequency bands, as opposed to the two bands of current S/X. This change, together with the stricter accuracy requirements of VLBI2010, has necessitated the development of new electronic hardware, from the antenna through the recorders. This tutorial will treat the differences and similarities between VLBI2010 and S/X hardware systems, with emphasis on the NASA VLBI2010 proof-of-concept hardware.

S1-T04 The NASA VLBI2010 Proof-of-Concept Demonstration and Future Plans

Arthur Niell (MIT Haystack Observatory) and the Broadband Development Team

The next generation geodetic VLBI instrument is being developed with a goal of 1 mm position uncertainty in twenty-four hours. Knowing that spatial and temporal fluctuations in the atmosphere delay are a major component of the error in position determination, the VLBI2010 Committee has carried out a large number of simulations to arrive at design goals for the antenna system. These goals are fast slewing antennas that attain high delay precision per observation. With existing and anticipated data recording capabilities, these translate to antenna diameter of 12 m or larger and delay precision of approximately 4 psec. We have implemented a proof-of-concept system for a possible VLBI2010 signal chain, from feed through recorder, on both the 18-m Westford and 5-m MV-3 antennas. Data have been obtained in 512-MHz bands spanning the range 3.5 to 11 GHz to investigate the sensitivity and phase delay capability of the system. A description of the system and some preliminary results will be presented. Several components of the system will be improved for the prototype version of VLBI2010, such as the feed, digital backend, and recorder, and these will be installed on a 12-m antenna at the GGAO location. The development of other elements of the geodetic system that are new for VLBI2010, including monitor and control systems and a software correlator, will be described.

S1-T05 Differences between S/X and VLBI2010 Operations

Hayo Hase[1], Ed Himwich[2], Alexander Neidhardt[3] ([1]BKG, [2]NVI, Inc./NASA GSFC, [3]FESG Wettzell)

The intended VLBI2010 operation has some significant differences to the current S/X operation. The presentation will focus on the problem of extending the operation of a global VLBI network to continuous operation within the frame of the same given amount of human resources. Remote control operation seems to be unavoidable, for which reason several site-specific pieces of information must be made available. A concept of a distributed-centralized remote control of the operation and its implications will be presented.

S1-T06 Post-Correlation Processing for the VLBI2010 Proof-of-Concept System

Christopher Beaudoin, Arthur Niell (MIT Haystack Observatory)

For the past three years, the MIT Haystack Observatory and the Broadband Development Team have been developing a proof-of-concept broadband geodetic VLBI microwave (2−12 GHz) receiver. Also on-going at Haystack is the development of post-correlation processing needed to extract the geodetic observables. Using this processing, the first fully phase-calibrated geodetic fringes have been produced from observations conducted with the proof-of-concept system. In this paper, we will present the post-correlation processing, discuss the engineering observations performed to demonstrate our understanding of the broadband data, and most importantly, show results. In order to realize the goals of VLBI2010 further modifications to the post-correlation processor are also needed; these enhancements will also be addressed.

S1-T07 GPU Based Software Correlators – Perspectives for VLBI2010

Thomas Hobiger[1], Moritaka Kimura[1], Kazuhiro Takefuji[1], Tomoaki Oyama[2], Yasuhiro Koyama[1], Tetsuro Kondo[1], Tadahiro Gotoh[1], Jun Amagai[1] ([1]NICT Japan, [2]NAOJ Japan)

Caused by historical separation and driven by the requirements of the PC gaming industry, Graphics Processing Units (GPUs) have evolved to massive parallel processing systems which entered the area of non-graphic related applications. Although a single processing core on the GPU is much slower and provides less functionality than its counterpart on the CPU, the huge number of these small processing entities outperforms the classical processors when the application can be parallelized. Thus, in the recent years various radio astronomical projects have started to make use of this technology either to realize the correlator on this platform or to establish the post-processing pipeline with GPUs.

Therefore, we are going to discuss the feasibility of GPUs as choice for the VLBI2010 correlator, including pros and cons of this technology. Additionally, a GPU based software correlator will be reviewed from the points of energy consumption/GFlop/sec. and cost/GFlop/sec. The presentation will also give an outlook on future GPU technology and the requirements for a VLBI2010-like software correlator, running on off-the-shelf graphics boards.

S1-T08 VLBI2010 Imaging and Structure Corrections

Arnaud Collioud, Patrick Charlot (Laboratoire d'Astrophysique de Bordeaux)

Simulations show that the next generation VLBI system is generally well suited for imaging extragalactic radio sources. In addition to revealing the morphology of the sources, simulated VLBI2010 images may also be used to generate structure correction maps which characterize the impact of source structure on the VLBI measurements. By comparing structure corrections for a set of simulated images based on Monte-Carlo generated visibilities with theoretical structure corrections derived from the model, we assess the accuracy of VLBI2010 structure corrections.

S1-T09 The AuScope Project and Trans-Tasman VLBI

Jim Lovell[1], John Dickey[1], Sergei Gulyaev[2], Tim Natusch[2], Oleg Titov[3], Steven Tingay[4] ([1]University of Tasmania, [2]Auckland University of Technology, [3]Geoscience Australia, [4]Curtin University of Technology)

Four 12-m radio telescopes have been built in Australia (the AuScope project) and New Zealand during 2009. These facilities are fully equipped for undertaking S/X-band geodetic VLBI observations. All sites are equipped with permanent GPS receivers to provide co-location of several space geodetic techniques. The following scientific tasks of geodesy and astrometry are considered: (1) Improvement and densification of the International Celestial Reference Frame in the southern hemisphere; (2) Improvement of the International Terrestrial Reference Frame in the region; (3) Measurement of intraplate deformation of the Australian tectonic plate.

S1-T10 Current Status of the Development of a Transportable and Compact VLBI System by NICT and GSI

Atsutoshi Ishii[1,2,4], Ryuichi Ichikawa[2], Hiroshi Takiguchi[2], Kazuhiro Takefuji[2], Hideki Ujihara[2], Yasuhiro Koyama[2], Tetsuro Kondo[2,3], Shinobu Kurihara[1], Yuji Miura[1], Shigeru Matsuzaka[1], Daisuke Tanimoto[1,4] ([1]GSI Japan, [2]NICT Japan, [3]Ajou University, [4]AES Co. Ltd.)

Multiple Antenna Radio-interferometer for Baseline Length Evaluation (MARBLE) is under development by NICT and GSI. The main part of MARBLE is a transportable VLBI system with compact antenna. The aim of this system is to provide reference baseline lengths for calibration pillars. The calibration baselines are used to check and validate surveying instruments such as GPS receiver and EDM (Electronic-optical Distance Meter). It is necessary to examine the calibration baselines regularly to keep the quality of validation. The long (10 km) calibration baselines have been examined only by GPS receiver so far. However, it is required to examine the 10 km calibration baselines with another technique. The VLBI technique can give an independent measurement to examine the long calibration baselines. It is effective for the improvement of the reliability of validation to measure the calibration baselines by VLBI technique.

On the other hand, the following roles are expected from a compact VLBI antenna of the VLBI2010 project. It is well known that to deal with the problem of thermal and gravitational deformation of the antenna it is necessary to achieve the challenging measurement precision of VLBI2010. One promising approach that has been suggested is applying connected-element interferometry between a compact antenna (~2 m) and the VLBI2010 antenna. By measuring repeatedly the baseline between the small stable antenna and the VLBI2010 antenna, the deformation of the primary antenna can be measured and one will be able to construct the thermal and gravitational models of the primary antenna. At present the MARBLE compact VLBI antenna is equipped with X and S band receivers. However, since this antenna uses a broadband feed, it can easily be expanded to broadband observations of the VLBI2010 type. In this presentation, we will explain the current status of the development and future plans for the compact MARBLE VLBI system.

S1-T11 VLBI2020: From Reality to Vision
Oleg Titov (Geoscience Australia)

The individual apparent motion of distant radio sources is supposed to be caused by the effect of intrinsic structure variations of the active galactic nuclei (AGN) and not correlated over the sky. However, some models of the expanded universe predict that systematic astrometric proper motion of distant radio sources do not vanish as radial distance from the observer to the source grows. These systematic effects can even increase with the distance making possible to measure them with high-precision astrometric techniques like VLBI. The galactocentric acceleration of the solar system barycenter might cause a secular aberration drift with magnitude 4 µas/year. Also the solar system motion relative to the cosmic microwave background produces an additional dipole effect, dependent on red shift. We analyzed a large set of geodetic VLBI data spanning from 1979 to 2008 to estimate the dipole, the rotational, and the quadrupole harmonics in the expansion of the vector field of the proper motions of quasars in the sky. The dipole and quadrupole vector spherical harmonics from the individual apparent motion of 687 radio sources were estimated. In addition, the estimates have been obtained separately for different red shift zones. We show that for the next decade the geodetic VLBI technique might approach to the level of accuracy to test the cosmological models of the universe. It is important to organize a dedicated observational program to increase the number of sources with measured proper motion to ~3000.

S1-T12 How and Why to Do VLBI on GNSS Spacecraft
John Dickey (University of Tasmania)

The location of the Earth's barycenter is a critical parameter in geodesy. If the IVS could routinely measure the 3-D positions of GPS spacecraft in the ICRF, then the barycenter could be fixed directly in the ICRF, for comparison with ITRF methods. This could possibly be done using omnidirectional GPS receivers sited close enough to IVS antennas that an accurate frame-tie could be done. The local oscillators of both systems would be locked to the station clocks.

S1-T13 Planning of an Experiment for VLBI Tracking of GNSS Satellites
Vincenza Tornatore[1], Rüdiger Haas[2] ([1]Politecnico di Milano, [2]Chalmers University of Technology)

In view of orbit determination of GNSS satellites by VLBI interferometric observations an initial three-station experiment is planned to verify the feasibility of using the method for accurate satellite tracking. GNSS satellite orbits are commonly expressed in the Terrestrial Reference Frame related to each satellite constellation. VLBI observations of GNSS signals can give valuable information to relate the GNSS and VLBI reference frames.

Initial tests were performed at Medicina and Onsala in early October 2009 and a three-station experiment is planned for early 2010. To perform satellite tracking some attempts have been carried out at the stations to install the Field System (FS) module SatTrack that allows tracking of satellites with apriori orbital elements directly from the FS. We present GNSS transmitter specifications and experimental results of the observations of some GLONASS satellites together with evaluations for each telescope of the network of the expected signal strengths. The detected satellites flux densities on the earth are very high compared to the natural radio source signals usually observed in VLBI. Consideration of necessary signal attenuation will be also discussed.

S1-T14 Multi-source Geodetic VLBI – A New Observing and Analysis Technique
Victus Uzodinma (University of Nigeria)

The IVS VLBI2010 Project is a classical case of a dynamic group of scientists who know when to move forward. The challenges of such natural hazards as earthquakes, volcanoes, hurricanes and sea-level rise; as well as the inability of the existing VLBI instrumentation to meet these challenges due to old age, sluggishness and radio interference necessitated the need for new techniques and technologies. The VLBI2010 Committee (V2C) has set standards to meet these challenges. These include the achievement of 1-mm repeatability on global baselines, high slew rate for smaller (12 m) antennas, high data rate digital data recording system (among others). These are meant to achieve both continuous observation and higher number of observations per observing session. These requirements call for improved observing and error handling/analysis techniques.

Geodetic VLBI, as currently practiced, observes one radio source simultaneously from two independent terminals of a baseline. Estimating geodetic and geophysical parameters (e.g., long geodetic distances, astrometric positions of radio sources, Earth orientation parameters), requires observing at least three radio sources (one-at-a-time) from more than one baseline in a 24-hour session. Following this method of observation, there is usually a need to model the systematic and random errors to mimic their variability from one epoch of observation to another for each 24-hour session. This has not been fully achieved for some of the errors such as the tropospheric (especially wet) effect.

In this paper, we present the "multi-source" geodetic VLBI technique, which is a new observing technique that does not require a 24-hour session to determine the required parameters. Rather, it determines very accurate values from a single-epoch observation of 10 to 20 minutes. The technique is able to achieve this by observing five or more radio sources simultaneously from a single baseline. Its data analysis technique also differs markedly from the "single-source" technique widely in use at present. Instead of modeling the observed time delay (and its derivatives) as functions of the required parameters, the new technique models the "observed" arc-distances connecting the five or more sources as functions of four major sources of systematic errors and some independent arc-distances. A block-diagonal weight matrix is applied in the least squares estimation process. Simulation studies show that the method meets all the standards of the VLBI2010 Project. Two strategies for the practical realization of the technique are given.

S1-P01 IVS Status Report 2008-2010

Dirk Behrend[1], Harald Schuh[2] ([1]NVI, Inc./NASA GSFC, [2]Vienna University of Technology)

In this presentation we will give a report on and discuss the major activities and accomplishments of the International VLBI Service for Geodesy and Astrometry since the fifth IVS General Meeting in Saint Petersburg, Russia. The topics include, but are not limited to, VLBI2010 related activities, organized meetings and special observational campaigns, publications, as well as organizational extensions. Plans and future perspectives will complete the presentation.

S1-P02 Summary of the VLBI2010 Monte Carlo Simulations

Andrey Pany[1], Johannes Böhm[1], John Gipson[2], Rüdiger Haas[3], Dan MacMillan[2], Arthur Niell[4], Tobias Nilsson[1], Bill Petrachenko[5], Harald Schuh[1], Anthony Searle[5] ([1]Vienna University of Technology, [2]NVI, Inc./NASA GSFC, [3]Chalmers University of Technology, [4]MIT Haystack Observatory, [5]Natural Resources Canada)

In the process of defining the specifications for VLBI2010, the IVS next generation VLBI system, a lot of efforts have been put into Monte Carlo simulation studies. Taking into account the three most important error sources in VLBI—the wet troposphere, station clock and measurement error—artificial delay observables were generated. Based on real physical properties of the troposphere and clocks, the simulation results served as a basis for the VLBI2010 Committee to give recommendations to the IVS Directing Board concerning antenna specifications, network size, and clock accuracy required to reach VLBI2010's goal of 1-mm position accuracy and 0.1 mm velocity accuracy per year on a global scale. With three independent software packages, based on the VLBI analysis software packages Calc/Solve and Occam, and a special PPP software, we tested the impact of scheduling strategies, source-switching interval, analysis strategies, random errors, and network size on the repeatability of station positions and baseline lengths. We will present a summary of the results and discuss future simulation ideas.

S1-P03 DBBC VLBI2010

Gino Tuccari[1], Walter Alef[2], Alessandra Bertarini[3], Salvatore Buttaccio[1], Gianni Comoretto[4], David Graham[2], Alexander Neidhardt[5], Pier Raffaele Platania[1], Alan Roy[2], Michael Wunderlich[2], Reinhard Zeitlhöfler[6] ([1]Istituto di Radioastronomia/INAF, [2]MPIfR Bonn, [3]University of Bonn, [4]Osservatorio Astrofisico di Arcetri/INAF, [5]FESG Munich, [6]BKG Wettzell)

The DBBC2 backend system has been adapted for supporting the VLBI2010 demands. The system architecture for this application is presented.

S1-P04 VLBI2010 Related Research Activities at SHAO

Guangli Wang, Ming Zhao, Yong Zheng, Zhihan Qian (Shanghai Astronomical Observatory)

In this report we will give an introduction to the VLBI research work at the Shanghai Astronomical Observatory. We will include a discussion on plans and goals, and especially some aspects related to VLBI2010.

Session 2: Network Stations, Operation Centers, Correlators

S2-T01 An Introduction to SKED *(invited)*

John Gipson (NVI, Inc./NASA GSFC)

I give an overview of *sked*, describing how observations are selected for scheduling. I discuss how changing *sked* parameters influences the final schedule. I discuss various ways of looking at a schedule to determine if it meets its objectives. I include a cook-book example of several simple schedules. I also discuss strategies for scheduling large networks, such as the IYA09 session, or the RDV sessions. I conclude with a discussion of the future of *sked*.

S2-T02 The State and Development Direction of the Geodetic VLBI Station in Korea *(invited)*

Hyunhee Ju[1], Myungho Kim[1], Suchul Kim[1], Jinsik Park[1], Tetsuro Kondo[2,3], Tuhwan Kim[2], Hongjong Oh[2], Sangoh Yi[2] ([1]NGII Korea, [2]Ajou University, [3]NICT Japan)

A permanent geodetic VLBI station with a 22-m diameter antenna will be newly constructed in Korea by the National Geographic Information Institute, Korea (NGII) for the project named Korea VLBI system for Geodesy (KVG) that aims at maintaining the Korean geodetic datum accurately on the International Terrestrial Reference Frame (ITRF). KVG can receive 2, 8, 22, and 43 GHz bands simultaneously in order to conduct geodetic and astronomical VLBI observations with Korean astronomical VLBI stations along with geodetic observations with IVS stations. This simultaneous four-band receiving capability is a unique feature of the KVG system. The KVG has started officially in October, 2008. A new geodetic VLBI station will be constructed at Sejong city (about 120 km south of Seoul and about 20 km north-northwest of Daejeon) and construction of all systems will be completed in 2011.

S2-T03 RAEGE: An Atlantic Network of Geodynamical Fundamental Stations

Jesús Gómez-González[1], Francisco Colomer[1], José Antonio López-Fernández[1], Marlene Assis[2] ([1]IGN Spain, [2]SRCTE Portugal)

Project RAEGE (“Red Atlántica de Estaciones Geodinámicas y Espaciales”) intends to set up a Spanish-Portuguese network of four Geodetic Fundamental Stations in Yebes (1), Canary Islands (1), and Açores Islands (2), as part of the developments needed for the IVS VLBI2010 scenario. It is envisaged that each Geodetic Fundamental Station will be equipped with one radio telescope of VLBI2010 specifications (at least 12-m diameter, fast slewing speed, but also able to operate up to 40 GHz), one superconducting gravimeter, one permanent GPS station and, at least at the Yebes site, one SLR facility.

The National Geographical Institute of Spain (IGN) has experience in VLBI, being a member of the European VLBI Network since 1993 and one of the founding institutions of the Joint Institute for VLBI in Europe (JIVE), and it is participating in geodetic VLBI campaigns with the 14-m radio telescope in Yebes since 1995. A new 40-m radio telescope has been built and was recently put into operation. It regularly participates in IVS sessions. There is infrastructure available for the new stations in Yebes and on Canary Islands. An agreement between IGN, the Portuguese Geographical Institute (IGP), and the Regional Government of the Açores ensures that the RAEGE project can become a reality by 2012.

S2-T04 The New Generation Russian VLBI Network

Andrey Finkelstein, Alexander Ipatov, Sergey Smolentsev, Vyacheslav Mardyshkin, Leonid Fedotov, Igor Surkis, Dmitrij Ivanov, Iskandar Gayazov (Institute of Applied Astronomy)

The most important contribution of the VLBI technique to the problem of Earth orientation parameter investigation is fast determination of Universal Time UT1 with unprecedented accuracy. The main goal of this paper is to describe briefly the new project of creating a special 2-element (or 3-element) VLBI network of next generation with 12-meter small antennas with the aim of UT1 determination in operational regime. With the technical image of the project currently being worked out, the project is planned to be completed in 2012−2014.

It is obvious that the new instruments need to be placed at the observatories of the Quasar VLBI network supplied with the advanced co-located observational techniques. The technical characteristics of these antennas should adhere to the requirements for the recording system formats recommended by the IVS Working Group 3 within the frame of the VLBI2010 project. This condition will allow us to participate not only in domestic applied projects, but also in international observational programs.

The main difference between the Quasar-2012 project and the similar VLBI2010 project is the use of a broadband receiving complex which provides reception of signals in two circular polarizations. This problem is to be solved by means of a cooled feed based on a travelling-wave resonator ensured signal reception in the 2−14 GHz range. This peculiarity guarantees compatibility with the current VLBI telescopes, effective interference filtering, and use of current software for ephemerides and algorithms of correlation processing.

S2-T05 Towards Establishing a Chinese Geodetic VLBI Observing System

Fengchun Shu[1], Weimin Zheng[1], Xiuzhong Zhang[1], Xiaoyu Hong[1], Aili Yusup[2], Ming Wang[3] ([1]Shanghai Astronomical Observatory, [2]Urumqi Astronomical Observatory, [3]Yunnan Astronomical Observatory)

In the framework of the project "Crustal Movement Observation Network of China (CMONC)", Shanghai, Urumqi, and Kunming stations, which co-locate multiple space geodetic techniques, are defined as fiducial stations. In order to be able to carry out a regular observing program from 2011 onward, a Chinese geodetic VLBI observing system, which includes the three stations and the Shanghai correlator system, will be established as an operational, fully functional, and internationally compatible system. All stations will be upgraded to adopt the Mark 5B recording system soon. The software correlator, which was originally designed for the tracking of the Chang'E-1 lunar satellite, has been upgraded to be compatible with geodetic sub-array mode and Mark 5B data format. The hardware platform for the correlator has been ordered. The correlator has five Mark 5B units and will share five additional Mark 5B units with the satellite tracking system. A few experiments have been conducted to debug the system and the results will be analyzed.

S2-T06 Characterization and Calibration of the 12-m Antenna in Warkworth, New Zealand

Sergei Gulyaev, Tim Natusch (Auckland University of Technology)

Characterization procedures and results of calibration of the New Zealand radio telescope are presented, including the main reflector surface accuracy measurements, pointing modeling and system equivalent flux density (SEFD) determination in both S and X bands.

S2-T07 COLD MAGICS – Continuous Local Deformation of an Arctic Geodetic Fundamental Station

Rüdiger Haas[1], Sten Bergstrand[2] ([1]Chalmers University of Technology, [2]SP Technical Research Institute)

In the summer of 2009 we performed the COLD MAGICS project at the Geodetic Observatory at Ny-Ålesund. The goal of this ARCFAC sponsored project was to install a continuous local deformation monitoring system at a geodetic fundamental station in a harsh arctic environment with permafrost conditions. The plan was to involve as many as possible of the existing geodetic and geophysical sensors in a continuous and automated survey with high temporal resolution and sub-mm accuracy. The project duration was 10 days and resulted in interesting results that indicate short term differential movements of order 1 mm or more between the foundations of different space geodesy techniques. During the campaign the weather was very stable with a period of more than 100 consecutive solar hours. This period stands out in our time series and indicates a diurnal deformation effect of the space geodetic instrumentation that we did not anticipate. The results indicate local movements that probably are not restricted to the arctic, and hence the monitoring system would be applicable to geodetic fundamental stations in any environment.

S2-T08 Homologous Deformation of the Effelsberg 100-m Telescope Determined with a Total Station

Axel Nothnagel, Judith Pietzner, Christian Eling (University of Bonn)

The main reflector of the 100-m radio telescope of the Max-Planck-Institute for Radio Astronomy at Effelsberg had been built about 30 years ago with the premise to follow a homologous deformation when being tilted to varying elevations. Through this specification, it was projected that the reflector always has a parabolic shape, though with varying parameters including the location of the focus. To compensate for this, the sub-reflector is relocated according to an elevation-dependent model. In May 2008, the deformation of the telescope's paraboloid was subject to a new type of survey being carried out with a total station being mounted head-down close to the sub-reflector of the telescope. 25 mini-reflectors have been mounted on the paraboloid and on the super-structure, and these have been observed with the total station in seven different elevations between 7 and 90 degrees. The analysis has to take into account that the location and orientation of the instrument changes due to gravitational deformations of the structure. Here, we present the models for the deformations of the paraboloid and their effects on the interferometric delay observables.

S2-T09 Ultra-rapid dUT1 Experiments on Japan–Fennoscandian Baselines – Application to 24-hour Sessions

Shigeru Matsuzaka[1], Shinobu Kurihara[1], Mamoru Sekido[2], Thomas Hobiger[2], Rüdiger Haas[3], Jouko Ritakari[4], Jan Wagner[4] ([1]GSI Japan, [2]NICT Japan, [3]Chalmers University of Technology, [4]Helsinki University of Technology)

The VLBI groups of GSI, NICT, OSO, and MRO have been involved in ultra-rapid dUT1 experiments since 2007, investigating the technological possibility of real-time dUT1 results with the e-VLBI technique. Already in 2008 we have successfully obtained a dUT1 solution for an Intensive session in less than four minutes. By now we routinely get the results within 30 minutes for Intensive-type sessions. In 2009 we applied the technique to a 24-hour session and obtained continuous dUT1 values by processing and analyzing Tsukuba–Onsala baseline data in almost real-time. It showed a detailed behavior of dUT1 variations. With more baselines, it could be possible to obtain wobble parameters as well and should contribute to the geodetic/geophysical sciences and deep space surveys.

S2-T10 MPIfR/BKG Correlator Report

Walter Alef[1], David Graham[1], Helge Rottmann[1], John Morgan[1], Richard Porcas[1], Arno Müskens[2], Alessandra Bertarini[2], Simone Bernhart[2] ([1]MPIfR Bonn, [2]University of Bonn)

We report on the status of the Bonn correlator center where the 4th generation of VLBI correlators—the Mark IV hardware correlator—is being replaced by the DiFX software correlator. We will describe the available hardware and the software for realizing a production environment and where it differs from NRAO's approach. Special emphasis will be on the implementation of phase-cal and the further verification of the geodetic performance of DiFX. MPIfR's involvement in the development of the DBBC will be depicted as well as tests done with the DBBC hardware using the DiFX correlator.

S2-T11 Implementation and Testing of VLBI Software Correlation at USNO

Alan Fey[1], David Boboltz[1], Ralph Gaume[1], David Hall[1], Ken Johnston[1], Kerry Kingham[1], Roopesh Ojha[2] ([1]U.S. Naval Observatory, [2]NVI, Inc./USNO)

The Washington Correlator (WACO) at the U.S. Naval Observatory (USNO) is a dedicated VLBI processor based on dedicated hardware of ASIC design. The WACO is currently over 10-years old and is nearing the end of its expected lifetime. Plans for implementation and testing of software correlation at the USNO are currently being considered. The VLBI correlation process is, by its very nature, well suited to a parallelized computing environment. Commercial off-the-shelf computer hardware has advanced in processing power to the point where software correlation is now both economically and technologically feasible. The advantages of software correlation are manifold but include flexibility, scalability, and easy adaptability to changing environments and requirements. We discuss our experience with and plans for use of software correlation at USNO with emphasis on the use of the DiFX software correlator.

S2-T12 The Software Correlator of the Chinese VLBI Network

Weimin Zheng, Ying Quan, Fengchun Shu, Zhong Chen, Shanshan Chen, Weihua Wang (Shanghai Astronomical Observatory)

The software correlator has played an irreplaceable role in the Chinese VLBI Network (CVN) data processing, such as in the case of the lunar exploration project. After upgrading, this correlator is able to process geodetic and astronomical observation data. In the near future, CVN will be expanded with several new stations and it will carry out crustal movement observation, quick UT1 measurement, astronomical mapping, as well as deep space exploration activities. For the geodetic and astronomical observations, we need a wideband 10-station correlator. In the case of spacecraft tracking, a real-time and high reliable correlator is needed. To meet the scientific and navigation requirements of CVN, two parallel software correlators under multiprocessor environments are under development. A high speed, 10-station prototype correlator using mixed Pthreads and MPI (Massage Passing Interface) parallel algorithm is realized on a computer cluster platform. Another real-time correlator for spacecraft tracking adopts the pipelining and thread-parallel technology, and runs on SMP (Symmetric Multiple Processor) servers. Both correlators have the characteristics of flexible structure and scalability.

S2-T13 Zodiac Extragalactic Sources Densification Using Phase-Referencing Technology

Guangli Wang (Shanghai Astronomical Observatory)

In this report I will introduce the application of phase referencing observation to the densification of the zodiac radio sources, and present the observation strategy and data analysis consideration, and some results from experiments.

S2-P01 The Composition of the Master Schedule

Cynthia Thomas, Dan MacMillan, Dirk Behrend (NVI, Inc./NASA GSFC)

Each year the IVS Coordinating Center (CC) creates a master schedule over a period of about four months. The process begins around mid-year when the CC contacts the geodetic stations and requests their holiday and maintenance schedule, plus their station availability for the upcoming year. A Station Usage and a Correlator Projection Chart for the next year's observing schedule are put together and presented to the IVS Observing Program Committee (OPC) for review. Comments and suggestions made by the OPC are incorporated into the plan. The CC then creates the station networks for the IVS sessions based on available resources. The CC uses the software packages *sked* and *solve* to determine the best networks based, among other things, on the simulated Earth Orientation Parameters (EOP) formal errors. A draft Network Chart is presented to the OPC for approval and then requests for antenna time are sent to the stations. We show examples of the various charts used to compose the 2010 Master Schedule as well as graphs and tables displaying the usefulness of the *solve* simulations for the networks in the Master Schedule.

S2-P02 Coordinating, Scheduling, Processing and Analyzing IYA2009

John Gipson[1], Dirk Behrend[1], Cynthia Thomas[1], David Gordon[1], Ed Himwich[1], Dan MacMillan[1], Mike Titus[2], Brian Corey[2] ([1]NVI, Inc./NASA GSFC, [2]MIT Haystack Observatory)

The International VLBI Service for Astrometry and Geodesy (IVS) scheduled a special VLBI session for IYA2009 commemorating 400 years of optical astronomy and 40 years of VLBI. The schedule involved 35 globally distributed VLBI antennas. A goal of the session was to observe as many sources as possible of the 295 ICRF2 defining sources. However, because of limited coverage in the Southern Hemisphere only 239 sources were observed at least twice. In terms of network size, number of sources, and number of observations, this is the most ambitious geodetic VLBI experiment ever. For example, the number of stations is four times larger than a typical geodetic VLBI session, and this session has eight times as many observations. A project of this size stresses all aspects of VLBI. We discuss the process of coordinating, scheduling, correlating, and analyzing this experiment. We focus on lessons learned in this process, and the necessary software modifications needed.

S2-P03 TIGO Station Report

Sergio Sobarzo (Universidad de Concepción)

The first VLBI observations in Chile were carried out in 2002 when TIGO arrived in Concepción through an agreement between the German and Chilean governments. Due to the low VLBI stations density in the southern hemisphere, TIGO has become one of the most scheduled IVS stations, with 117 successful observations during 2009. An overview of major milestones, current status, research lines and future activities are presented.

S2-P04 Update on the TWIN Telescope Wettzell Project

Hayo Hase[1], Gerhard Kronschnabl[1], Reiner Dassing[1], Thomas Klügel[2], Christian Plötz[1], Ullrich Schreiber[1], Walter Schwarz[1], Alexander Neidhardt[2], Pierre Lauber[2] ([1]BKG Wettzell, [2]FESG Wettzell)

The Twin Telescope Wettzell Project is funded to be executed during the period of 2008−2011. The design of the TTW was based on the VLBI2010 vision of the corresponding IVS Working Group. In the first two project years the design passed the simulations with respect to its specifications and was approved for production. At the Geodetic Observatory Wettzell a thorough soil analysis was made in order to define the sites for the towers of the new radio telescopes. Meanwhile the construction work has begun and acceptance tests of several telescope parts, e.g. azimuth bearings, took place. The full assembly of the radio telescopes is scheduled for the next two years. In parallel to the construction work at the Wettzell site, the design work for the different feed options progressed.

S2-P05 Update on the Fundamental Station Project in Ny-Ålesund

Per Erik Opseth, Line Langkaas, Terje Dahlen, Bjørn Engen, Frode Koppang (Norwegian Mapping Authority)

In December 2009 NMA applied for 26 million Euros to upgrade the Geodetic Observatory in Ny-Ålesund to a Geodetic Fundamental Station. The amount of money that was applied for will cover the costs for a twin telescope according to the VLBI2010 vision, an SLR system, an automatic stability control system, and new facilities such as control buildings, about 1 km away from the existing antenna. If granted during 2010, the project will start in January 2011. The challenge now is to convince politicians and the funding agency.

S2-P06 Reduction of GPS Observations in the Local Ties

Li Liu, Jinling Li, Zongyi Cheng (Shanghai Astronomical Observatory)

The reduction of GPS observations in the site survey at Sheshan 25-m radio telescope in August 2008 is reported. Because each session is only 6 hours and the subdaily high frequency variations in the station coordinates could not be smoothed, and there are serious cycle slips in the observations, large volume of data would be rejected during the software automatic adjustment of slips, the ordinary solution settings of GAMIT is accordingly adjusted, as losening the constraints in the a priori coordinates to 10 m, adopting the “quick” mode in solution iteration to avoid large volume of data be deleted, and combining Cview manual operation with GAMIT automatic fixing of the slips. The resulted coordinates of stations in ITRF2005 are then compared with the conventional geodetic observations of the control polygon. Due to the large rotations and translations in the two coordinate sets (geocentric versus near-topocentric), the seven transformation parameters failed to be solved for directly. With various trial solutions it is shown that with a partial pre-removal of the large parameters, the high precision transformation parameters could be reached with postfit residuals at the millimeter level. This analysis creates necessary preparation for the follow-on site survey and local tie survey of VLBI and SLR at Sheshan.

S2-P07 Permanent Monitoring of the Reference Point of the 20-m Radio Telescope Wettzell

Alexander Neidhardt[1], Michael Lösler[2], Cornelia Eschelbach[2], Andreas Schenk[2] (FESG Wettzell, University of Karlsruhe)

In the VLBI2010 agenda and in the framework of the Global Geodetic Observing System (GGOS) an automated monitoring of the reference points of different geodetic space techniques, such as Very Long Baseline Interferometry (VLBI), and therefore of the local-tie vectors at co-location stations are desirable in order to obtain the sub-millimeter level. For this reason a monitoring system was installed by the University of Karlsruhe to observe the 20-m radio telescope for VLBI at the Geodetic Observatory Wettzell from May to August. A specially developed software from the University of Karlsruhe collected data from automated tachymeter measurements, meteorological sensors, and sensors in the telescope monument (e.g., Invar cable data). A real-time visualization directly offered a live view of the measurements during the regular observation operations. Additional scintillometer measurements allowed refraction corrections during the post-processing. This project is one of the first feasibility studies aimed at determining significant deformations of the VLBI antenna due to, for instance, changes in temperature.

S2-P08 Proof-of-Concept Studies for a Local Tie Monitoring System

Benno Schmeing[1,2], Dirk Behrend[2], John Gipson[2], Axel Nothnagel[1] ([1]University of Bonn, [2]NVI, Inc./NASA GSFC)

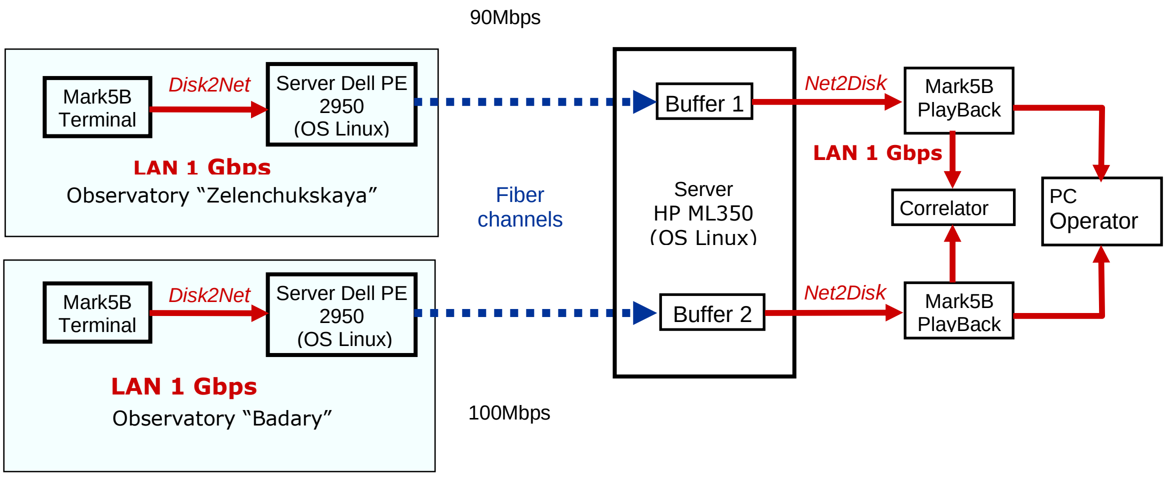
We will present preliminary results of proof-of-concept studies for an automatic monitoring system of local site ties. The system is based on the usage of robotic total stations. A set of tests were performed with a Leica TCA2003 total station on the local network of Goddard’s Geophysical and Astronomical Observatory (GGAO) and the 5-m VLBI antenna at this site. Both the TCA2003 and the VLBI antenna are controlled from a Matlab-coded control program. Running specific observational programs, data were collected that indicate that the reference point of the VLBI antenna can be automatically determined with an accuracy of 1 mm or better.

S2-P09 The QUASAR Network Observations in e-VLBI Mode within Domestic VLBI Programs

Ilia Bezrukov, Andrey Finkelstein, Alexander Ipatov, Michael Kaidanovsky, Andrey Mikhailov, Alexander Salnikov, Elena Skurikhina, Igor Surkis (Institute of Applied Astronomy)

The guideline of the Russian Quasar VLBI Network is to carry out astrometrical and geodynamical investigations. Since 2006 pure domestic observational programs with data processing at the IAA correlator have been performed. To maintain these geodynamical programs the e-VLBI technology is being developed and tested now. This paper describes the IAA activity in developing the real-time VLBI system using high speed digital communication links.

Now all observatories of the Quasar network are equipped with UNIX servers for data buffering. The observatories have communication channels ("last mile") with a rate of 100 Mbps and via Internet of 100 Mbps, 90 Mbps, and 100 Mbps for Badary, Zelenchukskaya, and Svetloe, respectively. Some experiments were made for the transmission of Intensive VLBI session data from Svetloe, Badary, and Zelenchukskaya observatories to the Control and Processing Center at the IAA. An Intensive session of about 40 Gbytes was transmitted at 50 Mbps over shared networks using the Tsunami UDP protocol in the near real-time e-VLBI mode. Algorithm of data transmission in e-VLBI mode Mark 5B – LAN – Buffer Server – Internet – Buffer Server – LAN – Mark 5B – Correlator is shown in the figure.



Up to now 15 Intensive sessions were transmitted from Zelenchukskaya and Badary observatories and two Intensive sessions from Svetloe and Badary observatories to the IAA Control and Processing Center. The date transmitted were processed at the IAA Analysis Center to obtain corrections to UT1. The values of UT1 corrections obtained from all sessions lies in the 3−113 μs range with an RMS deviation of about 52 μs.

S2-P10 Implantation of Geodetic Networks of High Precision for the Monitoring of Deformations of the Crust at the Local Level

Niel Teixeira (State University of Santa Cruz)

The monitoring of deformations of the crust using, specifically, geodetic techniques constitutes an important tool for the control and the security of structures. Global Positioning System has been used in the establishment of active and passive geodetics networks of high precision for applications in geodynamics. Applications of GPS for monitoring movements of the crust can be found in the literature for global, continental, regional, and local levels. In this paper we present the involved factors in the establishment of a geodetic network of high precision for the monitoring of movements of the crust at the local level using GPS, where special emphasis is put on the corrections of the factors intrinsic geodynamics. Results and conclusions will be presented.

S2-P11 Venus Express Spacecraft Observations with the Wettzell Radio Telescope – First Results

Alexander Neidhardt[1], Gerhard Kronschnabl[2], Jan Wagner[3], Guifre Molera Calves[3], Miguel Perez Ayucar[4], Giuseppe Cimò[5], Sergei Pogrebenko[5] ([1]FESG Wettzell, [2]BKG Wettzell, [3]HUT-MRO Metsahovi, [4]ESA-ESAC Madrid, [5]JIVE)

The ESA Venus Express spacecraft was observed at X-band with the Wettzell radio telescope during October-December 2009 within the framework of the assessment study of the possible contribution of the European VLBI network to the upcoming ESA deep space missions. The first goal of these observations was to develop and test the scheduling, data capture, transfer, processing and analysis pipeline. Recorded data were transferred from Wettzell to Metsahovi for processing, and processed data from Metsahovi to JIVE for analysis. A turnover time of 24 hours was achieved. A high dynamic range of the detections allowed us to achieve a milli-Hz level of the spectral resolution accuracy and extract the phase of the spacecraft signal carrier line. Several physical parameters can be determined from these observational results with more observational data collected. Apart from other results, the measured phase fluctuations of the carrier line at different time scales can assess to determine the influence of the solar wind plasma density fluctuations on the accuracy of the astrometric VLBI observations.

S2-P12 RDV77 VLBA Hardware/Software Correlator Comparison

David Gordon (NVI, Inc./NASA GSFC)

The VLBA is in the process of switching from a hardware correlator to the DiFX software correlator. The RDV77 session, which ran on October 7−8, 2009, was correlated on both the hardware and the software correlators to allow an extensive comparison of the two systems before the hardware correlator is retired. Both versions were fringed at GSFC using AIPS to determine the total observables and other quantities. The comparison between group delays, phase delay rates, fringe phases, SNRs, and other quantities will be presented.

S2-P13 The JPL VLBI Correlator and SoftC

Stephen Rogstad, Stephen Lowe (Jet Propulsion Laboratory)

This poster will present the current capabilities of the JPL VLBI Correlator (JVC) and the general architecture of the equipment. In addition, the scientific and navigation uses of the JVC will be enumerated for background purposes. The JVC is a software correlator based on a Beowulf cluster of computers. It replaces a thirty year old correlator based on custom designed digital hardware. General comparisons between the old and new equipment will be made. The JVC makes use of a separate program, SoftC, to do the actual correlations. The JVC manages the sending of data to multiple machines in a Beowulf cluster each running SoftC in parallel on small chunks of the data. The basic architecture of SoftC will also be described.

S2-P14 The IAA RAS Correlator Processing: First Results

Igor Surkis, Vladimir Zimovsky, Violetta Shantyr, Alexey Melnikov (Institute of Applied Astronomy)

The 6-station VLBI correlator of the IAA RAS started its regular operation in February 2009. It is equipped with Mark 5B playback system and conforms to the VSI-H specifications. Using this correlator the national Russian VLBI observations were processed. There were two geodetic programs which were performed by Svetloe, Zelenchukskaya and Badary observatories during 2009. The first is the Ru-E observational program aimed at EOP determination. Ru-E observed 24-hour sessions on the three-station network. The observing mode included 16 MHz VC bandwidth and one-bit sampling with total bit rate of 512 Mbit/s per station. The second program, Ru-U, is to estimate UT1-UTC. Ru-U started with 2 hours of observation time and has now become 1-hour sessions. The observing mode included 8 MHz VC bandwidth and one-bit sampling with total bit rate of 256 Mbit/s per station. The 1-hour sessions were transferred to the Correlator Center in e-VLBI mode. The group delays in X and S bands were calculated as result of correlator processing and NGS card files were created. 24 Ru-E and 26 Ru-U sessions were observed and correlated. The IAA RAS Analysis Center using these NGS files calculated EOP and UT1-UTC; formal errors were about 1 mas for pole coordinates and 0.1 ms for UT1-UTC. The closure relation for group delays on the baselines Badary–Svetloe, Svetloe–Zelenchukskaya, and Zelenchukskay–Badary allowed checking the correlator accuracy, which was 60−70 ps for the presented time. Work to improve the correlator internal algorithms has started and we are planning to achieve the Mark IV correlator precision soon.

S2-P15 CRF Network Simulations for the South

Oleg Titov[1], Dirk Behrend[2], Fengchun Shu[3], Dan MacMillan[2], Alan Fey[4] ([1]Geoscience Australia, [2]NVI, Inc./NASA GSFC, [3]Shanghai Astronomical Observatory, [4]U.S. Naval Observatory)

In order to monitor and improve the CRF in the Southern Hemisphere as well as along the ecliptic, we will perform various simulations using station networks based mostly on the Australian AuScope and New Zealand's Warkworth antennas as well as several Chinese antennas. Other stations such as HartRAO and Kokee Park will be added optionally to enhance the East-West baseline coverage. It is anticipated that the simulation results will help decide on the composition of the CRF sessions of the IVS to be run from 2011 onward. We will investigate different approaches for source selection and scheduling strategies.

S2-P16 About the Compatibility of DORIS and VLBI Observations

Gennady Il'in, Sergey Smolentsev, Roman Sergeev (Institute of Applied Astronomy)

We investigated the compatibility of the DORIS and VLBI observations at "Badary" observatory. The DORIS beacon stands at 100-m distance from the main radio telescope dish and transmits signals on two frequencies: 2036.25 MHz and 401.25 MHz. Both of them affect the S/X band radio telescope receivers. The parameters of the DORIS signals were measured at the outputs of the S/X band intermediate frequency amplifier. It was found that: (1) The level of RFI, produced by the DORIS beacon, practically corresponds to the level of the system (antenna plus receiver) noise signal and does not overload the S/X band receivers. (2) The DORIS 401.25 MHz signal is out of the frequency bands recorded during standard VLBI sessions. As a result, RFI from DORIS does not affect VLBI observations. This conclusion was confirmed after data correlations of actual VLBI observations that were conducted with the DORIS beacon turned on/off.

Session 3: VLBI Data Structure, Analysis Strategies and Software

S3-T01 IVS Working Group 4: Proposed VLBI Data Format

John Gipson (NVI, Inc./NASA GSFC)

I present a proposed data structure for storing, archiving, and processing VLBI data. In this scheme, most VLBI data is stored in NetCDF files. NetCDF has the advantage that there are interfaces to most common computer languages including Fortran, Fortran-90, C, C++, Perl, among others, and the most common operating systems including Linux, Windows, and Mac. The data files for a particular session are organized by special ASCII "wrapper" files which contain pointers to the data files. This allows great flexibility in the processing and analysis of VLBI data, and also allows for extending the types of data used, e.g., source maps. I discuss the implications for processing and analysis of the data. I conclude with a timetable for conversion of the current Mark III databases to the new format.

S3-T02 Development of a New VLBI Data Analysis Software

Sergei Bolotin, John Gipson, Dan MacMillan (NVI, Inc./NASA GSFC)

We present an overview of a new VLBI analysis software under development at GSFC NASA. The new software will replace *solve* and many related utility programs. It will have the abilities of the current system as well as be able to incorporate new models and data analysis techniques. In this presentation we give a conceptual overview of the new software. We formulate the main goals of the software. The software should be flexible and modular to implement models and estimation techniques that currently exist or will appear in future. On the other hand, it should be reliable and possess an "industrial-type quality" for processing "standard VLBI sessions". Also, it needs to be able to process observations from a fully deployed network of VLBI2010 stations in a reasonable time. We describe the software development process and outline the software architecture.

S3-T03 Estimation of Geodetic and Geodynamical Parameters with VieVS

Hana Spicakova, Johannes Böhm, Sigrid Böhm, Tobias Nilsson, Andrea Pany, Lucia Plank, Kamil Teke, Harald Schuh (Vienna University of Technology)

Since 2008 the VLBI group at the Institute of Geodesy and Geophysics (TU Vienna) has focused on the development of a new VLBI data analysis software called VieVS (Vienna VLBI Software). Our goal is to develop on the one hand a tool for VLBI data analysis based on highly sophisticated computational approaches and on the other hand a user friendly software which will be clearly arranged and easy to handle. At the beginning of our work we relied on comparisons with the software Occam, which is used worldwide, but later on we implemented many new models and strategies. One of the upgrades that we are developing now is an extra program unit for parameter estimation with so-called global solutions, where the connection of the single sessions will be done by stacking at the normal equation level. The time varying parameters (such as Earth orientation or troposphere parameters) are always modeled by piecewise linear offsets at integer hours or at integer fractions of integer hours which simplifies the connection to the next session where applicable. We also focus on the determination of time independent geodynamical parameters like the amplitudes of periodic variations of Earth rotation parameters at tidal frequencies or Love and Shida numbers of the solid Earth tides. Apart from the estimation of the constant nominal values of Love and Shida numbers for the second degree of the tidal potential, we determine frequency dependent values in the diurnal band. In this presentation we focus on the results from continuous VLBI campaigns such as CONT05 and CONT08.

S3-T04 VLBI Analysis with the Multi-technique Software GEOSAT

Halfdan Kierulf[1], Per-Helge Andersen[2], Sarah Böckmann[3], Oddgeir Kristiansen[1] ([1]Norwegian Mapping Authority, [2]Norwegian Defence Research Establishment, [3]University of Bonn)

GEOSAT is a multi-technique geodetic analysis software developed at the Norwegian Defence Research Establishment (FFI). The Norwegian Mapping Authority has now installed the software and has, together with FFI, adapted the software to deliver normal equation solutions in SINEX format. The goal is to be accepted as an IVS Associated Analysis Center and to deliver solutions to IVS on a routine basis.

GEOSAT is based on a Square Root Information Filter (SRIF) which allows estimating time variable parameters like troposphere and clocks as stochastic parameters. The tropospheric delays in various directions are mapped to tropospheric zenith delays using ray-tracing. Meteorological data from ECMWF with a time resolution of six hours is used to perform this ray-tracing, which depends both on elevation and azimuth angle. Other models are following IERS and IVS conventions.

NMA has submitted test SINEX files to IVS. The results have been compared with the existing IVS combined products. We will present the outcome of this comparison.

S3-T05 Comparison Campaign of VLBI Data Analysis Software – First Results

Lucia Plank (Vienna University of Technology)

Strictly speaking, the IERS Conventions give an instruction manual how to calculate the theoretical delay including all corrections for geodetic VLBI observations. In practice, different software packages follow different calculation strategies, vary in the usage of correction models, and are sometimes limited in their ability to adopt recently updated Conventions. This might lead to systematic errors and different results in VLBI data analysis. Goal of the delay and partial derivatives comparison campaign (DeDeCC) is to compare different VLBI analysis software packages (e.g., VieVS and Occam) on the basis of the computed delay and its partial derivatives in order to detect present inadequacies in the modeling part. Therefore various sessions will be simulated, using a single baseline over different time periods, considering short-term as well as long-term effects (one second intervals up to 10 years).

S3-T06 Consideration of Correlations between the Different Input Series in IVS Intra-technique Combination

Sarah Böckmann, Thomas Artz, Axel Nothnagel (University of Bonn)

Within almost all space geodetic techniques, contributions of different analysis centers (ACs) are combined in order to improve the robustness of the final product. So far, the contributing series are assumed to be independent as each AC processes the observations in a slightly different way, such as with different software, using different mathematical and stochastic models, and outlier rejection. However, the series cannot be completely independent as each analyst uses the same set of original observations and many models applied are subject to conventions used by each AC. Neglecting correlations between the contributing series is expected to yield too optimistic formal errors and possible small errors in the estimated parameters derived from the adjustment of the combined solution.

In this presentation, a first concept about how to account for the correlations is given and the effect on the estimated combined parameters and their formal errors is discussed. At the moment, the IVS intra-technique combination is carried out at the normal equation level. Since correlations can only be considered if observation equations are used, different input series are simulated with the *Calc/Solve* analysis software and their observation equations are extracted. The combination is then done at the level of observation equations for this purpose.

S3-T07 VLBI–SLR Combination Solution Using GEODYN

Dan MacMillan[1], Frank Lemoine[2], Despina Pavlis[3], Douglas Chinn[3], David Rowlands[2] (NVI, Inc./NASA GSFC, [2]NASA GSFC, [3]SGT Inc./NASA GSFC)

The traditional procedure followed by the IERS for generating an ITRF is to combine technique solutions generated by each technique combination center. Alternatively, we would like to generate a multi-technique solution using the same software and using the same a priori models. Our goal is to produce such a solution combining all of the geodetic techniques at the normal equation level using GEODYN but here consider only the SLR–VLBI combination. The data from each 24-hour session of VLBI data is initially processed with the VLBI *Calc/Solve* software to generate VLBI input files to GEODYN containing: 1) observed delays, 2) solution parameterization, and 3) theoretical delays. Tests have been performed to ensure that the VLBI theoretical delay as calculated by the VLBI *Calc/Solve* software is the same (to 1 ps) as that calculated by GEODYN. We first consider solutions with GEODYN using only VLBI data to verify that VLBI solution results produced with GEODYN agree with results using *Calc/Solve*. Then we combine the VLBI normal equations in GEODYN with weekly SLR normal equations for the period 2007−2008 for Lageos1/2 and Starlette/Stella to estimate station positions and Earth orientation parameters. To connect the techniques, we apply the ground ties used by the IERS. Here we report on the results of the combination.

S3-T08 Application of Ray-tracing through the High Resolution Numerical Weather Model HIRLAM for the Analysis of European VLBI

Susana García-Espada[1], Rüdiger Haas[2], Francisco Colomer[1] ([1]IGN Spain, [2]Chalmers University of Technology)

An important limitation for the precision in the results obtained by space geodetic techniques like VLBI and GPS are caused by the tropospheric effects caused by the neutral atmosphere. In recent years numerical weather models (NWM) have been applied to improve mapping functions which are used for tropospheric delay modeling in VLBI and GPS data analyses. A model of the troposphere based on direct calculation of the mapping functions via ray-tracing through the limited area numerical weather prediction (NWP) HIRLAM 3D-VAR model is developed and applied to Europe VLBI data. The advantages of this model are the high spatial resolution (0.2° x 0.2°) and the high temporal resolution in prediction mode (every 3 hours).

S3-T09 Atmospheric Delay Reduction Using KARAT for GPS Analysis and Implications for VLBI

Ryuichi Ichikawa[1], Thomas Hobiger[1], Yasuhiro Koyama[1], Tetsuro Kondo[1,2] ([1]NICT Japan, [2]Ajou University)

We have been developing a state-of-art tool to estimate the atmospheric path delays by ray-tracing through meso-scale analysis (MANAL) data, which is operationally used for numerical weather prediction by the Japan Meteorological Agency (JMA). The tools, which we have named “KAshima RAytracing Tools (KARAT)”, are capable of calculating total slant delays and ray-bending angles considering real atmospheric phenomena. KARAT can estimate atmospheric slant delays by three different calculation schemes. These are (1) a piece-wise linear propagation, (2) an analytical 2-D ray-propagation model by Thayer, and (3) a 3-D Eikonal solver. By computing GPS PPP solutions for 57 GPS sites of the GEONET (GPS Earth Observation Network System) operated by Geographical Survey Institute (GSI), it could be shown that KARAT performs slightly better than results based on the Global Mapping Function (GMF) and the Vienna Mapping Function 1 (VMF1), whereas for the latter two also linear gradient models had to be applied. For single baseline Intensive VLBI sessions, the fact that the KARAT strategy provides useful information about the atmospheric asymmetry around the site becomes an important issue in improving the quality of UT1 estimates. It can be shown that unmodeled East-West gradients are influencing the UT1 results on a noticeable level. Thus, ray-traced troposphere corrections seem to be a suitable way to model the troposphere properly for the Intensive experiments.

S3-T10 Use of GPS TEC Ionosphere Maps for Calibrating Single Band VLBI Sessions

David Gordon (NVI, Inc./NASA GSFC)

The K/Q collaboration group used GPS TEC (total electron content) ionosphere maps to calibrate a set of K-band (24 GHz) and Q-band (43 GHz) VLBA reference frame sessions. Before calibration, K and Q band source positions obtained from these data sets show biases in declination compared to X/S source positions. Application of GPS ionosphere values reduces these biases, but does not completely eliminate them. The use of GPS ionosphere data at X-band is also being studied and appears to be more successful than at K or Q bands. Results of these studies will be presented and discussed.

S3-T11 Universal Time from VLBI Single Baseline Observations during CONT08

Johannes Böhm, Tobias Nilsson, Harald Schuh (Vienna University of Technology)

IVS Intensive sessions are important contributors to the prediction of Universal Time (UT), in particular with improving timeliness of the results if using e-transfer of the observations to the correlator. However, there is a discrepancy between the formal errors (approximately 10 micro-seconds) and the accuracy (approximately 20 micro-seconds) of the UT estimates from these one-hour single-baseline sessions which is not fully understood. We compare UT from the complete CONT08 analysis with UT estimates from extracted single baselines over short time intervals (e.g., one or two hours). Thus, we do not only have a very accurate reference for comparison, but we can also use other estimated parameters from the full CONT08 series as a priori values for the single-baseline solutions (e.g., polar motion, nutation, and tropospheric parameters). This will allow a detailed assessment of all errors sources affecting the analysis of IVS Intensive sessions.

S3-T12 Application of Geodetic VLBI Data to Obtaining Long-term Light-curves for Astrophysics

Masachika Kijima (Sokendai Graduate University)

The long-term light-curve is important for the research of binary black holes and disk instability of AGNs. The light-curves have been drawn mainly using single-dish data provided by Michigan University and Metsahovi Observatory. Up to now, we have done our research on a limited number of sources. I attempt to draw the light-curves using VLBI data for other sources, which have not been observed in single-dish mode by any observatory. I developed software, analyzed all geodetic VLBI archive data integrated on the IVS Web site, and drew the light-curves at 8 GHz. I compared two light-curves for the same source, which were drawn from single-dish data and from VLBI data. I confirmed that the two light-curves were consistent. And I succeeded in drawing the light-curves for individual sources with VLBI data, which have not been observed by any observatory with single-dish. In my presentation, I suggest that the geodetic VLBI archive data is useful to obtain the long-term light-curves at radio bands for astrophysics.

S3-P01 VLBI Data Interchange Format

Alan Whitney[1], Mark Kettenis[2], Chris Phillips[3], Mamoru Sekido[4] ([1]MIT Haystack Observatory, [2]JIVE, [3]CSIRO/ATNF, [4]NICT Japan)

One important outcome of the 7th International e-VLBI Workshop in Shanghai in June 2008 was the creation of a task force to study and recommend a universal VLBI data format that is suitable for both on-the-wire e-VLBI data transfer, as well as direct disk storage. This task force, called the VLBI Data Interchange Format (VDIF) Task Force, is the first part of a two-part effort, the second of which will address standardization of e-VLBI data-transmission-protocols. The formation of the VDIF Task Force was prompted particularly by increased e-VLBI activity and the difficulties encountered when data arrive at a correlator in different formats from various instruments in various parts of the world. The task force created a streaming packetized data format that may be used for real-time and non-real-time e-VLBI, as well as direct disk storage. The data may contain multiple channels of time-sampled data with an arbitrary number of channels, arbitrary #bits/sample up to 32, 'real' or 'complex' data; data rates in excess of 100 Gbps are supported. Each data packet is completely self-identifying via a short header, and data may be decoded without reference to any external information. The VDIF task force has completed its work and the VDIF standard was ratified at the 2009 e-VLBI workshop in Madrid.

S3-P02 Combination Analysis at KASI

Younghee Kwak[1,2], Jungho Cho[1] ([1]Korea Astronomy and Space Science Institute, [2]Ajou University)

This paper introduces the activities of the Korea Astronomy and Space Science Institute (KASI) as an IVS Combination Center and shows preliminary combination results. KASI Combination Center was inaugurated in October 2008. We adopted ADDNEQ2, which is a subprogram of the Bernese GPS software, to stack the normal equations and to estimate the parameters. We also modified the program to apply it to VLBI daily SINEX format. We plan to provide our official combination products from the second half of 2010.

S3-P03 c5++ Multi-technique Analysis Software for Next Generation Geodetic Instruments

Thomas Hobiger[1], Toshimichi Otsubo[2], Tadahiro Gotoh[1], Toshihiro Kubooka[1], Mamoru Sekido[1], Hiroshi Takiguchi[1], Hiroshi Takeuchi[3] ([1]NICT Japan, [2]Hitotsubashi University, [3]JAXA)

An analysis software package based on Java and named CONCERTO4 (Otsubo and Gotoh, IVS GM 2002) enabled the user to consistently process SLR, GPS, and other satellite tracking data. The next version of this program package will also include VLBI as additional space-geodetic technique. As the software is currently being redesigned and completely re-written in C++, the requirements for complete VLBI data analysis (i.e., starting from ambiguity resolution until parameter estimation) could be taken into account. Considering the demand of VLBI2010, a focus will be set on automated and unattended processing of observations, which has been already implemented for SLR. Since CONCERTO was originally designed for satellite techniques, existing modules and models can also be utilized to do spacecraft tracking either by VLBI or by a combination of several techniques which monitor the satellite.

The presentation will give an overview of the planned capabilities of c5++ (concerto v5) and introduces the interoperability of the modules with different space geodetic techniques. It will be shown how the code is designed to be consistent and re-usable between the techniques. Using an object-oriented programming language allows us to combine the knowledge from colleagues with different scientific background and helps to maintain the readability of the code. Depending on the development progress until the general meeting, first results are expected to be shown in the presentation. The presentation will be concluded with an outlook and a road-map of c5++ and its interaction with VLBI2010 and upcoming satellite missions.

S3-P04 OCCAM-LSM for Linux: New Developments at DGFI

Robert Heinkelmann, Michael Gerstl (DGFI Munich)

The OCCAM VLBI analysis software version 6.1 least-squares method (LSM) has been significantly updated at DGFI. Among the changes are the move to the 64-bit Linux system and a completely new internal data transfer and data storage. FORTRAN 2003 has been used for the programming language with a modular program structure. In addition, the mathematical algorithms got significantly optimized using state-of-the-art numerics. The new modular structure enables this version of OCCAM to become a part of the DGFI Orbit and Geodetic Parameter Estimation Software (DOGS), which is already extensively used for Satellite Laser Ranging (SLR) analyses and combinations, such as terrestrial reference frame or EOP combinations, e.g., by the IVS Combination Center BKG/DGFI. In this presentation we show first results of the new version of OCCAM and compare the performance of old and new versions in terms of quality of the results and run-time improvements.

S3-P05 SAI Analysis Center Activity

Vladimir Zharov (Sternberg State Astronomical Institute)

An overview of the Sternberg Astronomical Institute (SAI) VLBI Analysis Center (AC) activities during 2008−2009 and the plans for the coming year are presented. The SAI AC analyzes all IVS sessions for computations of the Earth orientation parameters (EOP), time series of source positions at the scope of future realization of the ICRF, and performs research and software development aimed at improving the VLBI technique. The original ARIADNA (Analysis and ReductIon of rADiointerferometry observations (NAbludenij)) software was developed for solving these tasks. The delay model is realized in accordance with the IERS Conventions (2003). Four precession/nutation models (IAU1980, IAU2000, ZP2003 (Zharov/Pasynok) and GF1999 (Getino/Ferrandiz)) can be used both for operational work and for the improvement of models. The Celestial Reference Frame can be fixed to ICRF, ICRF2, and an original catalogue with coordinates and motions of the radio sources. Different mapping functions can be applied for troposphere correction modeling: Niell (NMF), Vienna (VMF), Zharov (ZMF) and Duev (DMF) functions. All parameters under estimation have been adjusted using least-squares adjustment with constraints. Comparison of the derived EOP series with the IVS series is presented.

S3-P06 Antenna Axis Offset Estimation from VLBI

Sergey Kurdubov, Elena Skurikhina (Institute of Applied Astronomy)

The antenna axis offsets were estimated from global solutions and single sessions. We have built a set of global solutions from all sessions available and from a set of sessions between stations with discontinuous observational series. We compared offsets estimated for different intervals for several stations which have discontinuous series due to repair work. For the stations of the QUASAR network we compared our estimates with local survey data. For some stations the axis offset values have been changed after repair. For non-global networks, the axis offset value of a single station can significantly affect the EOP estimations.

S3-P07 Strategies for Improving the IVS-INT01 UT1 Estimates: Results of RD0907–RD0910
John Gipson, Karen Baver, Dan MacMillan (NVI, Inc./NASA GSFC)

The main purpose of the IVS-INT01 sessions is the estimation of UT1. Improving the accuracy of the UT1 estimates is an important goal in the scheduling and the analysis of these sessions. In 2009 the GSFC VLBI Analysis Center requested and received the use of four IVS R&D sessions, RD0907–RD0910, for the evaluation of a new strategy for scheduling the IVS-INT01 sessions. In the R&D sessions, the Kokee–Wettzell baseline observes a series of Intensives, which alternate between using the standard observing strategy and a new strategy that emphasizes sky coverage (which is empirically linked with improved precision and accuracy of VLBI estimates). The remaining six stations observe independently and serve as an independent benchmark. Compared to the standard Intensives, the new strategy observes more sources and has better sky distribution, although it produces fewer observations, since the sources are weaker. We compare these two strategies from the point of view of robustness and accuracy. We also briefly consider potential strategies for reducing the UT1 formal errors by improving the analysis of the IVS-INT01 sessions.

S3-P08 CPO Prediction: Accuracy Assessment and Impact on UT1 Intensive Results
Zinovy Malkin (Pulkovo Observatory)

The UT1 Intensives results obtained from single-baseline observations heavily depend on the celestial pole offset (CPO) used during data processing. Our results of test processing of UT1 Intensive observations show that the error of 15 μas in CPO may cause a UT1 systematic error of about 1 μs. Since accurate CPO values can be obtained only from 24-hour VLBI sessions, which are available with a delay of one to four weeks, CPO predictions are necessarily applied to the UT1 Intensive data analysis. In this paper the real accuracy of CPO prediction is investigated using the actual IERS and PUL predictions made in 2007−2009. Also, the results of several months of operational UT1 processing with different CPO models are analyzed. This test has shown that using different CPO models for single-baseline data analysis can cause UT1 systematic differences up to 10 μs.

Session 4: Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics

S4-T01 The Second International Celestial Reference Frame (ICRF2) *(invited)*
Chopo Ma (NASA GSFC)

The work for the ICRF2, the second realization of the ICRS, was started by the IERS/IVS working group after the XXVI IAU General Assembly in 2006 and completed in time for the XXVII IAU General Assembly in 2009. Using 14 additional years of date beyond the original ICRF, the number of sources was increased to 3414 and the noise floor was reduced to ~40 μas by improved observations, modeling, and analysis. The 295 defining sources were selected rigorously using position time series and source structure information. The analysis, strengths, and limitations of the ICRF2 will be discussed.

S4-T02 Time-dependent Selection of an Optimal Set of Sources to Define a Stable Celestial Reference Frame

Karine Le Bail, David Gordon (NVI, Inc./NASA GSFC)

In 2003, Martine Feissel-Vernier proposed a set of stable sources in her paper in A&A “Selecting stable extragalactic compact radio sources from the permanent astrogeodetic VLBI program”. The first part of this study is an update of her work applied to ICRF2 sources (GSFC time series solution). This analysis shows the relevance of the choice of the 295 ICRF2 defining sources: most of them are chosen because of their temporal stability, the others to cover the Southern Hemisphere or to densify the source distribution across the sky. In the second part, we propose an alternate method of analyzing VLBI source time series and evaluating the statistical time stability of VLBI sources using the same statistical tool as Martine Feissel-Vernier, the Allan variance. This method takes into account the non-stationarity of the VLBI sources, generating a stability index function of time. Indeed some sources show different statistical characteristics depending on time, which could be explained by changes and evolution of station infrastructure, observation configuration (different baselines taken into account), and analysis strategy.

S4-T03 X/Ka-band Celestial Reference Frame Work: Recent Improvements

Chris Jacobs[1], Ojars Sovers ([1]Jet Propulsion Laboratory, [2]Remote Sensing Analysis Systems Inc.)

In order to extend the International Celestial Reference Frame from its S/X-band (2.3/8.4 GHz) basis to a complementary frame at X/Ka-band (8.4/32 GHz), we began an ongoing series of X/Ka observations starting in mid-2005 using NASA’s Deep Space Network (DSN) radio telescopes. We have detected 346 radio sources. This paper will report global astrometric results from the first 45 sessions. These sessions covered the full 24 hours of right ascension and declination down to −45 degrees.

Source position accuracy is at approximately the part-per-billion level. We have developed an error budget which shows the main errors are caused by limited sensitivity, mis-modelling of the troposphere, uncalibrated instrumental effects, and the lack of a southern baseline. Recent work has improved sensitivity by improving pointing calibrations and by increasing the data rate four-fold. Troposphere calibration has been demonstrated at the mm level. Construction of instrumental phase calibrators for Ka-band began in recent months. We will show projections for the expected effect on the X/Ka frame as these improvements enter the production data stream. The research described in this paper was carried out under contract with NASA. Government sponsorship acknowledged.

S4-T04 Effects of ICRF2 on Estimates of Earth Orientation Parameters and the Terrestrial Reference Frame

Robert Heinkelmann (DGFI Munich)

Following Resolution B3 (2009) of the IAU General Assembly, the recently determined ICRF2 becomes the new conventional celestial reference frame for geodesy and astronomy as of 1 January 2010. ICRF2 realizes the International Celestial Reference System with a new, unprecedented accuracy of about twice the axes’ stability and four to five times better mean source coordinate repeatabilities than the previous quasar catalog ICRF-Ext.2. Thus, applying the new ICRF2 catalog in the analysis of geodetic and astrometric Very Long Baseline Interferometry could achieve significantly better and more stable estimates of both the Earth Orientation Parameters and the VLBI station positions. Within this paper two similarly set-up solutions are computed based on the global VLBI solution of the DGFI IVS Analysis Center and compared against each other; one solution fixes the source coordinates to the new ICRF2 and the other solution fixes these coordinates to ICRF-Ext.2. The differences between EOP and TRF of these solutions are than quantified and assessed. Within another approach it is possible to perform a similar analysis; however, the quasar coordinates are not fixed, but adjustments to them are estimated as well.

S4-T05 Long-term Variations of the EOP and ICRF2

Vladimir Zharov, Mikhail Sazhin, Valerian Sementsov (Sternberg State Astronomical Institute)

VLBI is currently the only method available for measuring Universal Time (UT). Rotation of the Earth is described as motion of the Earth's figure axis relative to the International Celestial Reference Frame (ICRF), which is defined by the precise coordinates of extragalactic radio sources. The rotational stability of the frame is based on the assumption that the sources have no proper motion and it means that there is no global rotation of the universe. Analysis of time series of coordinates of the ICRF radio sources shows that many of them, including the defining sources, have significant apparent motion. Rotation of the ICRF is estimated in our work for different sets of sources. The effect of the source apparent motion is shown to have an impact on the determination of UT and other Earth orientation parameters (EOP). Calculations of UT were done both for Intensive and 24-hour VLBI sessions. The software ARIADNA was used for the estimation of the EOP. The first solution was obtained using the ICRF and ICRF2 catalogs for the radio sources. The second solution was obtained using an improved catalog: velocities of the sources were added. It was shown that rotation of the ICRF due to the motion of sources is transformed to the secular variations of EOP.

S4-T06 Long-term Stability of Radio Sources in VLBI Analysis

Gerald Engelhardt, Volkmar Thorandt (BKG Leipzig)

Positional stability of radio sources is an important requirement for modeling of only one source position for the complete length of VLBI data of presently more than 20 years. The stability of radio sources can be verified by analyzing time series of radio source coordinates. One approach is a statistical test for normal distribution of residuals to the weighted mean for each radio source component of the time series. Systematic phenomena in the time series can thus be uncovered. Nevertheless, an inspection of rate estimation and weighted root-mean-square (WRMS) variations about the mean is also necessary.

On the basis of the time series computed by the BKG group in the frame of the ICRF2 working group, 226 stable radio sources with an axis stability of 10 μas could be identified. They include 100 ICRF2 axes-defining sources determined independently from the method applied in the ICRF2 working group. Also 28 stable radio sources with a source structure index of less than 3.0 can be used to increase the number of 295 ICRF2 defining sources.

S4-T07 The Position Stability of Four ICRF2 Radio Sources

Ed Fomalont[1], Ken Johnston[2], Alan Fey[2], David Boboltz[2], Tomoaki Oyama[3], Mareki Honma[3] ([1]NRAO, [2]U.S. Naval Observatory, [3]NAOJ Japan)

We have measured the structure evolution and position stability at the 10 microarcsecond (μas) level of four compact ICRF2 radio sources over 1.5 years. The sources chosen are within a 2.5° region so that phase referencing with the VLBA at 24 and 43 GHz and VERA at 24 GHz could be used to obtain high precision relative positions. Two of the sources are >95% core-dominated and two of the sources have significant jet emission. The radio source positions, given by the location of the most compact component, change up to 40 μas over the observing period, and the location of the core is frequency dependent even between 24 and 43 GHz. Consequently, the adopted ICRF2 position at 8 GHz for some of these sources does not represent the true position of the core because of the extended emission. The limitations on the definition of the ICRF at the 1 μas level will be discussed.

S4-T08 Study of the Low Luminosity GPS Radio Source PKS B2254-367 (IC 1459) from VLBI Observations

Julia Sokolova, Steven Tingay (Curtin University of Technology)

The gigahertz peaked-spectrum (GPS) radio sources are compact (~1 kpc) and have convex radio spectra that peak between about 500 MHz and 10 GHz. They are important because they may represent the early stages of powerful large-scale radio sources, Fanaro-Riley type I (FR-I) and FR-II radio galaxies, giving us insight into radio source genesis and evolution. The GPS source samples, made in the past, include high luminosity GPS sources with $log(L\cdot W/Hz)>24$ at 5 GHz which are generally dominated by what appears to be an analogue of lobe hot spots in the FRII radio galaxies. But recently, two low-luminosity GPS sources, which have no lobe hot spots and are dominated by jets, have been found (NGC 1052 and IC 1459; Vermeulen et al. 2003, Tingay et al. 2003). This fact raises the possibility that there exists a luminosity/morphology relationship in analogy to large-scale radio galaxies. On the other hand, the low-luminosity GPS sources may have a different nature to the higher luminosity GPS sources, i.e. have different absorption mechanisms (free-free absorption perhaps dominates in the low-luminosity sources and synchrotron self-absorption in the high-luminosity sources).

VLBA observations of the GPS radio source of low luminosity ($log(L\cdot W/Hz)=23$ at 5 GHz) GPS radio galaxy PKS B2254-367 (IC 1459) at four frequencies (L,C,S,X bands) in 2003 and at two frequencies (X,U bands) in 2005 have been processed using AIPS and DIFMAP. A detailed study of this source has been undertaken, including analysis of its radio-source structure, component motion, and discussion of possible absorption mechanism. This investigation may help us to understand the class of low luminosity radio galaxies and to address questions about possible luminosity/morphology relationships.

S4-T09 Global VLBI Observations of Weak Extragalactic Radio Sources: Imaging of Candidates to Align the ICRF and the Future GAIA Frame

Géraldine Bourda[1], Patrick Charlot[1], Arnaud Collioud[1], Richard Porcas[2], Simon Garrington[3] ([1]Laboratoire d'Astrophysique de Bordeaux, [2]MPIfR Bonn, [3]Jodrell Bank Observatory)

The space astrometry mission GAIA will construct a dense optical QSO-based celestial reference frame. For consistency between optical and radio positions, it will be important to align the GAIA frame and the International Celestial Reference Frame (ICRF) with the highest accuracy. Currently, it is found that only 10% of the ICRF sources are suitable to establish this link (70 sources), either because they are not bright enough at optical wavelengths or because they show extended radio emission which precludes reaching the highest astrometric accuracy. In order to improve the situation, we have initiated a multi-step VLBI observational project, dedicated to finding additional suitable radio sources for aligning the two frames. The sample consists of about 450 sources, typically 20 times weaker than the current ICRF sources, which have been selected by cross-correlating optical and radio catalogues. The observing strategy has been carefully established to detect, image, and measure accurate positions for these sources. The initial experiments, aimed at checking that these sources are detectable with VLBI, and conducted with the European VLBI Network (EVN), show very good results, with a 90% detection rate. This paper reports about global VLBI observations carried out in March 2008 to image 105 sources from the 398 previously detected. All sources were successfully imaged, revealing compact VLBI structure for most of them. This is very promising for the ICRF–GAIA frame alignment. While the remaining ~300 detected sources from our initial sample will be imaged in the same way, the next step, dedicated to measuring accurately the position of these sources, will be tackled in the near future.

S4-T10 Enabling High Precision VLBI Relative Astrometry at the Highest Frequencies

Maria Rioja[1,2], Richard Dodson[1] ([1]ICRAR/UWA, [2]OAN Spain)

We present a new method that enables high precision relative astrometry at the highest frequencies, beyond the limits set by the rapid tropospheric fluctuations with conventional phase referencing, using dual frequency observations. Also, we present the results from a successful demonstration of the method using VLBI observations at 43 and 86 GHz. This method is specially suited for astrometric measurements of "core-shift" in radio sources. We will discuss the prospects of this technique applied to the alignment of the optical/radio reference frames, and the study of the physical conditions in the jets in AGNs.

S4-T11 An Improved Lunar Gravity Field Model from SELENE and Historical Tracking Data *(invited)*

Koji Matsumoto[1], Sander Goossens[1], Yoshiaki Ishihara[1], Quinghui Liu[2], Fuyuhiko Kikuchi[1], Takahiro Iwata[3], Noriyuki Namiki[4], Hirotomo Noda[1], Hideo Hanada[1], Nobuyuki Kawano[2], and RSAT/VRAD Mission Team ([1]NAOJ Japan, [2]Shanghai Astronomical Observatory, [3]JAXA, [4]Chiba Institute of Technology)

A new spherical harmonic solution of the lunar gravity field to degree and order 100, called SGM100h, has been developed using historical tracking data and 14.2 months of SELENE tracking data. Owing to 4-way Doppler data which allowed direct observations of the far-side gravity, the new model successfully reveals far-side features in free-air gravity anomalies which are characterized by ring-shaped structures for large impact basins and negative spots for large craters. SGM100h produces a correlation with SELENE-derived topography as high as about 0.9, through degree 70. We will also present the latest gravity field model including S-band same-beam differential VLBI data. The VLBI data improve the low-degree gravity coefficients as well as the orbit consistency of the two SELENE sub-satellites.

S4-T12 Planetary Radio Interferometry and Doppler Experiment (PRIDE) in the IVS Context

Leonid Gurvits, Sergei Pogrebenko, Giuseppe Cimò (JIVE) and the PRIDE Team

The Planetary Radio Interferometry and Doppler Experiment (PRIDE) is a multi-disciplinary enhancement of the scientific suite of several planetary science missions which are currently in various stages of preparation for launches in the next decade. These include the ESA-JAXA BepiColombo mission to Mercury, European Venus Explorer (EVE), RSA-CSA Phobos-Gruntt and YH-1 for studies of the Martian system, the joint ESA-NASA Europa Jupiter System Mission (EJSM), and Titan Saturn System Mission (TSSM). The essence of PRIDE is the estimation of the state-vector of a spacecraft using VLBI tracking and multi-station Doppler measurements in phase-referencing mode. Elements of PRIDE have been demonstrated in the VLBI experiment with the Huygens Probe carried out during its descent on the surface of Titan, observations of the ESA's lunar probe SMART-1, and Venus Express (VEX).

Several scientific topics can be addressed by PRIDE measurements. These include studies of ultra-precise celestial mechanics models various constituents of the Solar System, accurate measurements of the shape and internal structure of celestial bodies, search for under-surface deposits of liquid water, gravimetric, and fundamental physics experiments. PRIDE can also help in studies of electric properties of planetary body surface and their plasma environments. PRIDE offers a high degree of synergy with generic on-board instrumentation of planetary science missions and does not include components requiring mission-critical technology developments. The Earth-based segment of PRIDE includes a network of radio telescopes and a specialized data processing center. In addition to science topics, PRIDE will provide support to mission operations, in particular, mission navigation and trajectory determination as well as on-board systems and instrumentation diagnostics. A separate and potentially beneficial application of PRIDE is its ability to provide limited Direct-to-Earth delivery of data from planetary missions as an emergency and back-up means.

S4-T13 The First Experiment with VLBI–GPS Hybrid System

Younghee Kwak[1,3], Tetsuro Kondo[1,2], Tadahiro Gotoh[2], Jun Amagai[2], Hiroshi Takiguchi[2], Mamoru Sekido[2], Ryuichi Ichikawa[2], Tetsuo Sasao[1], Jungho Cho[3], Tuhwan Kim[1] ([1]Ajou University, [2]NICT Japan, [3]KASI Korea)

In this paper, we introduce our VLBI–GPS hybrid system and show the results of the first experiment which is now under way. In this hybrid system, GPS signals are caught by a normal GPS antenna, down-converted to IF signals, and then sampled by the VLBI sampler VSSP32 developed by NICT. The sampled GPS data are recorded and correlated in the same way as VLBI observation data. The correlator outputs are the group delay and the delay rate. Since the whole system uses the same frequency standard, many sources of systematic errors are common between the VLBI system and the GPS system. In this hybrid system, the GPS antenna can be regarded as an additional VLBI antenna having multiple beams towards GPS satellites. Therefore, we expect that this approach will provide enough data to improve zenith delay estimates and geodetic results.

S4-T14 Ionospheric Response to the Total Solar Eclipse of July 22, 2009 as Deduced from VLBI and GPS Data

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A total solar eclipse occurred over China at a latitude of about 30°N in the morning of 22 July 2009, providing a unique opportunity to investigate the influence of the sun on the earth upper ionosphere. GPS observations from Shanghai GPS Network and VLBI observations from stations Shanghai, Urumqi, and Kashima were used to observe the response of TEC to the total solar eclipse. From the GPS data reduction, the sudden decrease of TEC at the time of the eclipse, amounting to 2−5 TECU, and gradual increase of TEC after the eclipse by analyzing the diurnal variations and more distinctly in the variations of TEC along individual satellite passes. The delay of a minimum level of TEC with the maximum phase of eclipse was 10−30 min. The high-resolution TEC maps produced with high temporal resolution (5 min intervals) show the changes in the structure of the ionosphere. Besides, we also compare the ionospheric activity derived from different VLBI stations with the GPS results and find a high correlation between them.

S4-T15 Reliability and Stability of VLBI-derived Sub-daily EOP Models

Thomas Artz[1], Sarah Böckmann[1], Axel Nothnagel[1], Peter Steigenberger[2] ([1]University of Bonn, [2]TU Munich)

The Earth's rotation is, in general, forced by the interaction of sub-systems of the Earth. At periods around one day and less the major part results from the gravitational forces of the Sun and the Moon acting on the oceans. By a minor part tidal effects in the atmosphere, non-tidal oceanic variations (e.g., due to the solar heating) as well as effects of the tri-axial shape of the Earth have to be considered. The Conventions of the International Earth Rotation and Reference Systems Service (IERS) contain a model that explains most of these variations. However, several investigations using space geodetic techniques, such as the Global Positioning System (GPS) or Very Long Baseline Interferometry (VLBI), demonstrated the incompleteness of this model.

When estimating empirical sub-daily EOP models from space geodetic techniques, care has to be taken, as these models are subject to geophysical as well as technical restrictions. In this paper, the estimation of an empirical sub-daily EOP model from VLBI observations is studied. We compare models which have been estimated on the solution, the normal equation, and the observation level. Furthermore, the impact of several analysis options on the estimated coefficients of the sub-daily EOP model will be investigated. Finally, the impact of the considered time span is analyzed to figure out the influence of the observations' quality.

S4-T16 Extracting Independent Local Oscillatory Geophysical Signals in Geodetic Tropospheric Delay

Ondego Joel Botai[1], Ludwig Combrinck[1,2], Venkataraman Sivakumar[1,3], C.J. de W. Rautenbach[1], Harald Schuh[4], Johannes Böhm[4] ([1]University of Pretoria, [2]Hartebeesthoek RAO, [3]South African National Laser Center, [4]Vienna University of Technology)

Tropospheric delay due to water vapor as derived from space geodetic techniques and numerical weather prediction simulated-reanalysis data, provides additional information to the source of geophysical signals available to the geodetic research community. These time series could be decomposed into additive components that contain information about global change (the trend) and other interpretable (quasi-) periodic components such as seasonal cycles and noise. For instance, in this non-linear and non-stationary time series, one of the stochastic component(s) could be a function which exhibits at most one extremum within a data span or monotonic function within a certain temporal span. In this contribution, we examine the use of the combined Ensemble Mode Decomposition (EEMD) and Independent Component Analysis (ICA), the EEMD-ICA algorithm, to extract the independent local oscillatory stochastic components in the tropospheric delay derived from the European Centre for Medium-Range Weather Forecasts over six geodetic sites (HartRAO, Hobart26, Wettzell, Gilcreek, Westford and Tsukuba32). The proposed methodology allows independent geophysical processes in the data to be extracted and assessed. Analysis of the quality index of the Independent Components (ICs) derived for each cluster of local oscillatory components (also called the Intrinsic Mode Functions (IMFs)) for all the geodetic stations considered in the study suggest that they are strongly site dependent. This strong dependency could be an indicator that the localized geophysical signals (partially captured in the tropospheric delay due to water vapor over the individual geodetic sites) are not correlated.

S4-P01 Cartography in Space Geodesy

Hayo Hase (BKG Concepción) and the TANAMI Team

The best image of the radio source Centaurus-A at 8.4 GHz was achieved within the Tanami-Project combining the Australian Long Baseline Array with TIGO in Chile and O'Higgins in Antarctica. The poster shows the difference between the long baseline image and the very long baseline image.

S4-P02 Forthcoming Occultations of Astrometric Radio Sources by Planets

Victor L'vov, Zinovy Malkin, Svetlana Tsekmeister (Pulkovo Observatory)

Astrometric VLBI observations of radio source occultations by solar system bodies may be of large interest for testing gravity theories, dynamical astronomy, and planetary physics. In this paper, we present an updated list of the occultations of astrometric radio sources by planets expected in the upcoming years. Such events, similar to solar eclipses, can only be observed in a limited region. For events that will occur in regions with several VLBI stations, being the most interesting for IVS experiments, we will provide a map of the shadow path.

S4-P03 LBA Calibrator Survey of the Southern Sky

Leonid Petrov[1], Chris Phillips[2], Alessandra Bertarini[3], Roy Booth[4], Sarah Burke-Spolaor[5], Ed Fomalont[6], Ron Ekers[2], Kee-Tae Kim[7], Tara Murphy[8], Sergei Pogrebenko[9], Elaine Sadler[8], Tasso Tzioumis[2] ([1]ADNET Systems, Inc./NASA GSFC, [2]CSIRO/ATNF, [3]University of Bonn, [4]Hartebeesthoek Radio Astronomical Observatory, [5]Swinburne University of Technology, [6]NRAO, [7]KASI, [8]University of Sydney, [9]JIVE)

The objective of the project that started in 2008 is to observe at 8.4 GHz a list of candidate flat spectrum radio sources with declinations <−40° with using the Australian LBA and to 1) determine their positions with milliarcsec accuracy, 2) measure their correlated flux densities, and 3) determine their suitability as calibrators for phase referencing observations and as targets for astrometry and geodesy observations. The overall goal of this on-going project is to match the density of phase calibrators at the southern hemisphere to the calibrator density at the northern hemisphere in order to make phase referencing observations feasible. The current status and preliminary results of the project are presented. In summary, by November 2009 we observed 422 sources in four out of eight planned sessions and determined positions and correlated flux densities of 410 objects. As a result, the number of known calibrators with declinations <−40 deg increased by the factor of 4.

S4-P04 Finding Extremely Compact Sources using the ASKAP VAST Survey

Hayley Bignall[1], Cormac Reynolds[1], Roopesh Ojha[2], Jim Lovell[3], Dave Jauncey[4] ([1]ICRAR/Curtin University, [2]NVI, Inc./USNO, [3]University of Tasmania, [4]ATNF) and the ASKAP VAST Collaboration

VLBI observations of intraday variable (IDV) quasars found in the MASIV (Micro-Arcsecond Scintillation-Induced Variability) 5 GHz VLA Survey of 500 flat-spectrum sources in the northern sky have shown that these sources are extremely compact, often unresolved, on milliarcsecond scales, and more core-dominated than their non-IDV counterparts. VAST: an ASKAP Survey for Variables and Slow Transients proposes to observe 10,000 square degrees of southern sky daily for two years in the VAST-Wide survey component. This is expected to reveal of order 30,000 compact sources brighter than 10 mJy showing refractive interstellar scintillation (the cause of centimeter-wavelength IDV) at the survey frequency of about 1.4 GHz. Many of these sources may be suitable astrometric calibrators at higher frequencies.

S4-P05 The Tropospheric Products of the International VLBI Service for Geodesy and Astrometry

Christian Schwatke, Robert Heinkelmann (DGFI Munich)

The IVS runs two tropospheric products: the "IVS tropospheric parameter rapid combination" monitors the zenith wet delay (ZWD) and zenith total delay (ZTD) of the rapid turn-around sessions R1 and R4. Goal of the combination is to identify and to exclude outliers by comparison and to assess the precision of current VLBI solutions in terms of tropospheric parameters. The rapid combination is done on a weekly basis four weeks after the observation files are released on the IVS Data Centers. Since tropospheric parameters and geodetic parameters, such as vertical station components, are significantly correlated, the consistency of the ZTD can be a measure of the consistency of the underlying TRF as well. The ZWD rely very much on accurate atmospheric pressure data. Thus, besides estimation techniques, modeling and analytical noise, ZWD reflects differences in the atmospheric pressure data applied to the VLBI analyses. The other product, called "tropospheric parameter long-term combination", aims for an accurate determination of climatological signals, such as trends of the atmospheric water vapor observed by VLBI. Therefore, for this product the long-term homogeneity of atmospheric pressure data plays a crucial role. The poster reviews the methods applied and results achieved so far and depicts the new maintenance through DGFI.

S4-P06 Station Positions Intraday Variations

Elena Skurikhina (Institute of Applied Astronomy)

Station positions with intraday resolutions have been obtained from CONT campaigns. A comparison with some intraday effects such as antenna thermal deformations, atmospheric pressure loadings, and oceanic solid Earth tides was made.

S4-P07 Simulation of Local Tie Accuracy on VLBI Antennas

Ulla Kallio, Markku Poutanen (Finnish Geodetic Institute)

We describe a new mathematical model to compute the centering parameters of a VLBI antenna. These include the coordinates of the reference point, axis offset, orientation and non-perpendicularity of the axes. Using the simulation we have tested the expected accuracy and robustness of the method. In our simulations we varied placements and number of targets in indirect observation method, number of VLBI antenna positions and the achievable accuracy of the coordinates of target points and accuracy of the angle readings of the VLBI antenna. We tested the model on some different types of telescopes by simulating coordinate observations of the targets with normally distributed random errors. We have also applied the model to the Metsahovi VLBI telescope using real data. We show that it is possible to achieve a sub-millimeter formal accuracy for the coordinates of the reference point and the antenna offset by increasing the number of VLBI antenna positions, even if the accuracy of target points is on the cm level. The systematic errors are neglected. Based on the simulation we can give some recommendations and practices to control the accuracy and reliability of the local ties at the VLBI sites.

S4-P08 Sub-diurnal EOP Variations from the Analysis of the CONT Campaigns

Rüdiger Haas (Chalmers University of Technology)

Atmospheric and oceanic angular momentum exchange is believed to cause EOP variations with sub-diurnal periods. The VLBI CONT campaigns are excellent data sets to study such sub-diurnal EOP variations. Results from the CONT campaigns are analyzed and compared to model predictions. In particular the origin of the mysterious ter-diurnal signals observed in polar motion results from some of the CONT campaigns is addressed.

S4-P09 VLBI and GPS-based Time Transfer Using CONT08 Data

Carsten Rieck[1], Rüdiger Haas[2], Kenneth Jaldehag[2], Jan Johansson[1] ([1]SP Technical Research Institute, [2]Chalmers University of Technology)

A necessary prerequisite for geodetic VLBI stations are highly stable frequency standards (e.g., hydrogen masers). This makes VLBI stations interesting for studies of time and frequency transfer techniques. Most VLBI stations that participate in the IVS also host equipment for GNSS and contribute observation data to the IGS. Often the same hydrogen maser is used as the frequency and time reference for both VLBI and GNSS observations, which makes a direct comparison between the two techniques possible. In this paper we present a comparison of VLBI and GPS Carrier Phase (GPSCP) relative time transfer based on the data of the two week long CONT08 VLBI campaign.

Previous studies [Takiguchi et al., "VLBI Measurements for Time and Frequency Transfer", EFTF2008, Toulouse Space Show 08] concerning the use of the VLBI technique for precise time transfer showed promising results on short baselines. However, the temporal resolution of data from the IVS network is usually not good enough for use in practical time applications. Consecutive IVS campaigns like CONT08 are therefore a good opportunity to study the timing capabilities of VLBI on long baselines. CONT08 was a 15 days long campaign that involved 11 VLBI stations on different continents. Different methods of GPSCP time transfer are used to assess the results from the VLBI data analysis. Furthermore, we estimate the time link stability between two stations by using the intrinsic stability of the station clocks. For differential GPSCP techniques the link frequency stability is better than 2E-14 at 1000 s on baselines up to 1000 km. Time links using VLBI are expected to perform similar or better.

Even though the calculus for both VLBI and GNSS are very similar, relative time comparisons using VLBI can be seen as an independent technique and thus, in the future, can be an alternative option for international time transfer. The development of the next generation VLBI system, called VLBI2010, might allow making VLBI time transfer operational. Both GNSS (GPS) and TWSTFT are heavily dependent on active third parties that are not necessarily dependable in the long term. These two satellite-based techniques are today the backbone of international time metrology and are used for the formation of the international time scale UTC, Universal Time Coordinated, where the used techniques can fast become outdated due to economical or political reasons. A passive method based on VLBI technology could become a major time transfer technique if the development of small footprint equipment is forced.

Session 5: Progress in Technology Development

S5-T01 The Mark 5C VLBI Data System

Alan Whitney[1], Chester Ruszczyk[1], Jon Romney[2], Ken Owens[3] ([1]MIT Haystack Observatory, [2]NRAO, [3]Conduant Corp.)

The Mark 5C disk-based VLBI data system is being developed as the third-generation Mark 5 disk-based system, increasing the sustained data-recording rate capability to 4 Gbps. It is built on the same basic platform as the Mark 5A, Mark 5B, and Mark 5B+ systems, and will use the same 8-disk modules as earlier Mark 5 systems, though two 8-disk modules will be necessary to support the 4 Gbps rate. Unlike its earlier brethren, which use proprietary data interfaces, the Mark 5C will accept data from a standard 10 Gigabit Ethernet connection and be compatible with the new VLBI Data Interchange Format (VDIF) standard. Data sources for the Mark 5C system will be based on new digital backends now being developed, specifically the RDBE in the U.S. and the dBBC in Europe, as well as others. The Mark 5C system is being planned for use with the VLBI2010 system, and will also be used by NRAO as part of the VLBA sensitivity-upgrade program; it will also be available to the global VLBI community from Conduant. Mark 5C system specification and development is supported by Haystack Observatory, NRAO, and Conduant Corporation. Prototype Mark 5C systems are expected in early 2010.

S5-T02 Cryogenic Integration of 2-14 GHz Eleven Feed in Wideband Receiver for VLBI2010

Miroslav Pantaleev[1], Jian Yang[1], Yogesh Karadikar[1], Leif Helldner[1], Benjamin Klein[2], Rüdiger Haas[1], Ashraf Zaman[1], Mojtaba Zamani[1], Per-Simon Kildal[1] ([1]Chalmers University of Technology, [2]Hartebeesthoek Radio Astronomy Observatory)

The next generation VLBI system requires the design of a wideband receiver covering the 2−14GHz range. Key component of the receiver system is the wideband feed. Here we present the advance of the development during 2009 of a cryogenic 2−14 GHz Eleven feed for reflector radio telescope antennas and its integration in a cryogenic receiver. The Eleven feed is designed for dual linear polarization and is built up by four pieces of log-periodic folded dipole array. Each pair of array is fed by a differential two-wire transmission line connected either to balun or differential LNA. We present design, simulation data, and comparison of a large quantity of measurements done at several independent laboratories. The measurement results show that the feed has very high polarization efficiency, the beam width is nearly constant over the operational bandwidth, the reflection coefficient is below −10 dB and the location of the phase center is constant. An extensive design study was done to evaluate Aeff/Tsys and the expected noise performance of the cryogenic receiver based on an Eleven feed and also to estimate the advantages of different feeding structures. Moreover in the article we present the development of a cryogenic receiver for the Eleven feed and the results of investigating several feeds in the receiver to examine the mechanical and cryogenic performance of the design and evaluate the reliability of the manufacturing and assembly. By the time of the meeting we will present data about the feed electrical parameters in cryogenic conditions and measurement of the receiver noise temperature.

S5-T03 Next Generation A/D Sampler ADS3000+ for VLBI2010

Kazuhiro Takefuji[1], Hiroshi Takeuchi[2], Masanori Tsutsumi[1], Yasuhiro Koyama[1] ([1]NICT Japan, [2]JAXA/ISAS)

In VLBI2010, four 1-GHz sub-band sampling is required in the 2-14 GHz radio frequency range. A total data rate would become 8 Gbps at maximum. In this requirement, we are developing a next-generation A/D sampler, which is called the ADS3000+. The ADS3000+ can sample analog signal up to 4 Gsps (Giga samples per second), 2 Gsps x 2 channels, 1 Gsps x 4 channels with 8 bits quantization. In addition, after digitized analog signal, signal processing such as real-time DBBC (Digital Base Band Conversion) or simple suppressing RFI signals (CW) are possible with FPGA techniques. The ADS3000+ will combine VSI system (VLBI Standard Interface), it is possible to control via the Web, transfer to the network with versatile Linux PC. Already first fringes at 4 Gsps mode have been successfully obtained in early 2009. In the presentation, we will report more detail results and current status of the ADS3000+.

S5-T04 e-control: First Public Release of Remote Control Software for VLBI Telescopes

Alexander Neidhardt[1], Martin Ettl[1], Helge Rottmann[2], Christian Plötz[3], Matthias Mühlbauer[3], Hayo Hase[3], Walter Alef[2], Sergio Sobarzo[4], Cristian Herrera[4], Ed Himwich[5] ([1]FESG Wettzell, [2]MPIfR Bonn, [3]BKG Wettzell, [4]Universidad de Concepción, [5]NVI, Inc./NASA GSFC)

Highly automated and remotely controlled observations become more and more important for future operations in a Global Geodetic Observing System (GGOS). At the Geodetic Observatory Wettzell a software extension to the existing NASA Field System is developed for remote control in cooperation with the Max-Planck-Institute for Radio Astronomy in Bonn. It uses the principle of a remotely accessible, autonomous process cell as server extension for the Field System. The communication is realized also for low transfer rates on the basis of Remote Procedure Calls (RPC) and uses generative programming with the interface software generator "idl2rpc.pl" developed at Wettzell. The user interacts with this system over a modern graphical user interface realized with wxWidgets. For security reasons the communication is automatically tunneled through a Secure Shell (SSH) session to the telescope. After successful test observations with the telescopes at O'Higgins, Concepción, and Wettzell and while it is already regularly used at Wettzell, the first public release of the software, which will also be useful for other telescopes, is now available.

S5-T05 The Wettzell System Monitoring Concept and First Realizations

Martin Ettl[1], Alexander Neidhardt[1], Matthias Mühlbauer[2], Christian Plötz[2] ([1]FESG Wettzell, [2]BKG Wettzell)

Automated monitoring of operational parameters of measuring systems of the geodetic space techniques become more and more important in order to improve the geodetic data and to ensure safety and stability for automatic or remote controlled observations. Therefore the Wettzell group develops the system monitoring "SysMon" based on a reliable, remotely controllable hard-/software realization. A multi-layered data logging system on a van-less, robust industrial PC with an internal database system is used to collect data from several, external, serial-, bus-, or PCI-based sensors. The internal communication is realized with Remote Procedure Calls (RPC) and uses generative programming with the interface software generator "idl2rpc.pl" developed at Wettzell. Each data monitoring stream can be configured individually via configuration files to define the logging rates or analog-digital-conversion parameters. A first realization is currently installed at the new laser ranging system at Wettzell for safety issues and at the VLBI station O'Higgins as meteorological data logger. A concept to setup the monitoring for the Wettzell radio telescope should be realized in the near future.

S5-T06 Lunar, Martian, and Jovian Geodesy and Science Mission Using VLBI and Astrometrical Technology

Takahiro Iwata[1], Hideo Hanada[2], Hirotomo Noda[2], Fuyuhiko Kikuchi[2], Seiichi Tazawa[2], Hiroo Kunimori[3], Koji Matsumoto[2], Kazumasa Imai[4], Yoshiaki Ishihara[2], Yuji Harada[2], Sho Sasaki[2] ([1]JAXA, [2]NAOJ Japan, [3]NICT Japan, [4]Kochi National College of Technology)

We will report on the observation planning using VLBI and astrometrical technology for Japanese future lunar and Martian explorers. The candidate instruments are ILOM (In situ Lunar Orientation Measurement), LLR (Lunar Laser Ranging), iVLBI (Inverse VLBI), and LLFAST (Lunar Low Frequency Astronomy Telescope) for SELENE series. Areodesy measurements using ranging and VLBI methods are also candidate experiments for Martian landing mission.

S5-T07 The Development of VLBI Technologies at SHAO

Xiuzhong Zhang (Shanghai Astronomical Observatory)

VLBI technology development at SHAO showed significant progress in the last few years. We will report on the new VLBI techniques such as DBBC, software and FPGA based correlator, a new VLBI antenna, and new VLBI applications.

S5-T08 The Progress of CDAS

Renjie Zhu, Ying Xiang, Yajun Wu (Shanghai Astronomical Observatory)

The Chinese Data Acquisition System (CDAS), based on FPGA technology, has been developed for the purpose of replacing the traditional analog baseband convertors. It has a 1024 Mbps sample rate for 512 MHz bandwidth input and up to 16 channels (both USB and LSB) output with VSI compatible interface. The instrument has a flexible design and can be easily updated. We will report on the construction, performance, and experiment results and give an outlook into the future work.

S5-P01 Development of a Compact Eleven Feed Cryostat for the Patriot 12-m Antenna

Christopher Beaudoin[1], Per-Simon Kildal[2], Jian Yang[2], Miroslav Pantaleev[2] ([1]MIT Haystack Observatory, [2]Chalmers University of Technology)

The feed efficiencies of the Eleven antenna in free space have been shown to be quite good. It is equally important that these efficiencies not be degraded significantly by installing the feed in a cryostat. The MIT Haystack Observatory, with guidance from Onsala Space Observatory and Chalmers University, has been working to integrate the Eleven antenna into a compact cryostat suitable for the Patriot 12-m antenna. The practical considerations made to develop such a cryostat as well as simulations and possibly measurements of the feed/cryostat efficiency will be presented.

S5-P02 Radio Telescope Focal Container for the Russian VLBI Network of New Generation

Alexander Ipatov[1], Vyacheslav Mardyshkin[1], Andrey Cherepanov[2] ([1]Institute of Applied Astronomy, [2]SPbSPU)

This article is dedicated to considerations of developing structure of receivers for Russian radio telescopes. The development of these radio telescopes takes place under project for creating a Russian small-antenna-based radio interferometer of new generation. For small antennas (10−12 meter) the principal unit, which provides the best SNR, is the so-called focal container placed at primary focus. It includes the primary feed, HEMT LNA, and cryogenic cooling system down to 20°K. A new multi-band feed based on traveling wave resonators is used. This feed has small dimensions, low weight, and allows working with circular polarizations. Thus it can be placed into focal container and cooled together with the LNA. We will present a block diagram of the multi-band receiver with traveling-wave-resonator feed, a sketch of the focal container, and calculations of the expected parameters of the multi-band receiver.

S5-P03 Digital Backend for JPL VLBI Data Acquisition Terminal

Robert Navarro (Jet Propulsion Laboratory)

JPL currently uses thirty-year-old equipment to down-convert, channelize and record VLBI data to disk for later correlation. This equipment is based on designs from Haystack Observatory. Currently, both Haystack and the National Radio Astronomy Observatory are working on new modern equipment based on digital backends to replace older analog backend down-conversion and channelization hardware. This poster will describe how JPL will use pieces of the Haystack and NRAO hardware to build a VLBI system that meets the specific requirements of JPL VLBI processing at the DSN stations. An overview will be given of the customizations that JPL intends to implement.

S5-P04 DBBC2 Backend: Status and Development Plan

Gino Tuccari[1], Walter Alef[2], Alessandra Bertarini[3], Salvatore Buttaccio[1], Gianni Comoretto[4], David Graham[2], Alexander Neidhardt[5], Pier Raffaele Platania[1], Alan Roy[2], Michael Wunderlich[2], Reinhard Zeitlhöfler[6] ([1]Istituto di Radioastronomia/INAF, [2]MPIfR Bonn, [3]University of Bonn, [4]Osservatorio Astrofisico di Arcetri/INAF, [5]FESG Munich, [6]BKG Wettzell)

The DBBC2 system is in a mature phase now and the deployment is continuing. A review of the backend is shown and the new functionalities in development are reported.

S5-P05 RDBE – A Second-Generation Digital Backend System

Alan Whitney[1], Shephard Doeleman[1], Alan Hinton[1], Russell McWhirter[1], Arthur Niell[1], Chester Ruszczyk[1], Michael Taveniku[1], Miguel Guerra[2], Matthew Luce[2] ([1]MIT Haystack Observatory, [2]NRAO)

A first-generation polyphase-filter-bank (PFB) digital-backend system, dubbed 'DBE1', and developed at Haystack Observatory based on the Berkeley-developed iBoB board, has been in regular use for more than two years, supporting both VLBI2010 development efforts as well as millimeter-wavelength astronomy observations of the galactic center. The DBE1 supports two 500-MHz-wide IF inputs, with output to a pair of VSI-H interfaces, each at a data rate of 2 Gbps, compatible with a pair of Mark 5B data-recording systems. A second-generation system, dubbed 'RDBE', is currently under development, based on the second-generation iBoB-type board, dubbed 'ROACH', developed at Berkeley in collaboration with NRAO and South Africa. Haystack is developing FPGA code for the ROACH board to support two 500-MHz-wide IFs with output to a 10 Gbps Ethernet port compatible with the Mark 5C data-recording system. A prototype of the RDBE subsystem is projected to be ready in early 2010. NRAO is developing a flexible digital-down-converter FPGA module which can be substituted for the Haystack-developed PFB module on the ROACH board, which NRAO is planning to use in the VLBA upgrade project. Ultimately, we hope to extend the RDBE to support two 1-GHz-wide IFs with an 8 Gbps output data rate for use in the VLBI2010 system.

S5-P06 The Digital Data Acquisition System for the Russian VLBI Network of New Generation

Leonid Fedotov, Eugene Nosov, Sergey Grenkov (Institute of Applied Astronomy)

The digital DAS system consists of some identical channels of 1024 MHz bandwidth in each. In each channel the RF band is frequency-translated to the intermediate frequency range 1–2 GHz. Each channel consists of two parts: the digitizer and Mark 5C recorder. The digitizer is placed on the antenna near the corresponding Low-Noise Amplifier output and consists of the analog frequency converter, ADC, and a device for digital signal processing using FPGA. In the digitizer the sub-digitization on frequency of 2048 MHz is used. For producing of narrow-band channels and interface to existing data acquisition systems a polyphase filtering in FPGA can be used. Digital signals are re-quantized to 2-bits in the FPGA and are transferred to an input of Mark 5C through the Fiber Line. Now the breadboard model of a digitizer is tested and the data acquisition system is being designed.

S5-P07 Round Trip System Available to Measure Path Length Variation in Korean VLBI System for Geodesy

Hongjong Oh[1], Tetsuro Kondo[1,2], Tuhwan Kim[1], Sangoh Yi[1], Myungho Kim[3], Suchul Kim[3], Jinsik Park[3], Hyunhee Ju[3] ([1]Ajou University, [2]NICT Japan, [3]NGII Korea)

A project for construction of a Korean geodetic VLBI system was officially started in October 2008. The construction of all systems will be completed by the end of 2011. The project was named Korea VLBI system for Geodesy (KVG), and its main purpose is to maintain the Korean Geodetic Datum. In the case of the KVG system the observation room, where an H-maser frequency standard is located, is in a building separated from the antenna by several tens of meters. Therefore, the KVG system will adopt a so-called round-trip system to transmit reference signals to the antenna with reducing the effect of path length variations. KVG's round-trip system is designed to not only use available metal or optical fiber cables, but also to measure the path length variations directly. We will present this unique round trip system for KVG.

S5-P08 Experiment of Injecting Phase Cal ahead of the Feed: First Results

Dmitrij Ivanov, Anatolij Maslenikov, Alexander Vytnov (Institute of Applied Astronomy)

For developing the Russian VLBI network of new generation few experiments of injecting phase calibration signal ahead of the feed are carried out. In the experiments an external broadband phase

calibration signal is emitted through a special feed to a receiver horn directly. Prototypes of the feed for a frequency range of 2−18 GHz are created. The first experiments on injection phase cal ahead of the feed are carried out at the Svetloe observatory of the QUASAR VLBI network. The phase cal signal is emitted by the broadband feed installed on the roof of a mirror cabin, reflected by the sub-reflector, and received by the horn of the receiving system. The results of these experiments are considered.

S5-P09 First Phase Development of Korea-Japan Joint VLBI Correlator and its Current Progress

Se-Jin Oh[1], Duk-Gyoo Roh[1], Jae-Hwan Yeom[1], Hideyuki Kobayashi[2], Noriyuki Kawaguchi[2] ([1]KASI, [2]NAOJ Japan)

The first phase of the Korea-Japan Joint VLBI Correlator (KJJVC) development has been completed and installed to correlate the observed data from KVN (Korean VLBI Network) and VERA (VLBI Exploration of Radio Astrometry) in October 2009. KJJVC is able to process 16 stations, a maximum of 8 Gbps/station, and 8,192 output channels for VLBI data. The system configuration and the experimental results would be introduced in this paper.

S5-P10 Development of an e-VLBI Data Transport Software Suite with VDIF

Mamoru Sekido[1], Kazuhiro Takefuji[1], Moritaka Kimura[1], Takuya Shinno[2], Fujinobu Takahashi[2] ([1]NICT Japan, [2]Yokohama University)

A class library for manipulating VLBI data has been developed. This library is not only for reading/writing of data files, but also for transmitting/receiving over the network. The architecture of task is resolved into multiple layers such as a transport/network layer (FILE IO, SUDP/IP), a presentation layer (VLBI data format: VDIF, K5, Mark 5), and an application layer (sender, receiver, reader, writer) by interpretation with OSI model. By separating the tasks at each layer, a variety of VLBI data formats can be handled. Since the newly defined VDIF (VLBI Data Interchange Format) is designed with the scope of network data transmission, the VDIF was used for the common data format on the network. A sender module converts the data from particular data form (K5/VSSP, Mk5B, VDIF) to small chunks of data in VDIF format, then a header of SUDP (Simple UDP protocol) is attached and fed continuously as a stream into network. The receiver module gets each packet and assembles them to form a data file in a particular data format such as K5/VSSP, Mark 5B, or VDIF. This software package is coded with C++ and it will be open to the public for free use. An application of this software package will be used for real-time data transmission of Mark 5B data from Wettzell to Tsukuba for Intensive UT1 observation.

S5-P11 The Progress of the Hardware Correlator Development at SHAO

Zhijun Xu, Xiuzhong Zhang, Renjie Zhu, Ying Xiang, Yajun Wu (Shanghai Astronomical Observatory)

We will report on the progress of a new hardware correlator development at Shanghai Astronomical Observatory (SHAO). The correlator will replace the Mark IV hardware correlator that was used for the Chinese VLBI Network (CVN) in the past three years.

S5-P12 The Impact of Radio Frequency Interference (RFI) on VLBI2010

Bill Petrachenko (Natural Resources Canada)

A significant motivation for the development of a next generation system for geodetic VLBI is to address growing problems related to RFI, especially at S-band. In this regard, the broadband 2−14 GHz frequency range proposed for VLBI2010 has advantages and disadvantages. It has the advantage of flexible allocation of bands anywhere in the full range of 2−14 GHz and hence the ability to place bands away from the worst RFI. However, the receiver LNA is at the same time vulnerable to saturation from RFI anywhere in the whole range. A number of RFI examples are considered to better understand their impacts on the VLBI2010 system, followed by a discussion of strategies to reduce those impacts.

Public lecture

Creating a Radio Telescope the Diameter of the Earth

Alan Whitney (MIT Haystack Observatory)

Ever since radio astronomy was accidentally invented in 1931, scientists have dreamed of larger and more sensitive telescopes to dig deeper into the mysteries of the universe. It was not long before they realized that multiple radio-telescopes connected together could realize many of the benefits of a single very-large (and impossibly expensive to build!) telescope; many of these so-called ‘connected-element arrays’ have been built since the 1960s, with many still operating today. Still not satisfied, scientists began to explore the possibilities of removing the wire connections which limited these arrays to relatively small geographic areas, allowing the individual telescopes to spread out over very large distances, a step first successfully demonstrated in 1967. Since then, the practice of Very Long Baseline Interferometry (or ‘VLBI’, as it has become to be known) has progressed to include Earth-size telescope arrays doing amazing work, such as making the most detailed images of some of the most distant objects in the universe, determining the positions of distant extragalactic radio objects to extraordinary precision, determining the size of the black hole at the center of our galaxy, directly measuring continental drift, and exquisitely measuring the wiggles and wobbles of the Earth as it moves through space. We will explore the world of VLBI and its many aspects, including a pre-view of exciting instruments planned to be built in Australia and elsewhere.

Maps

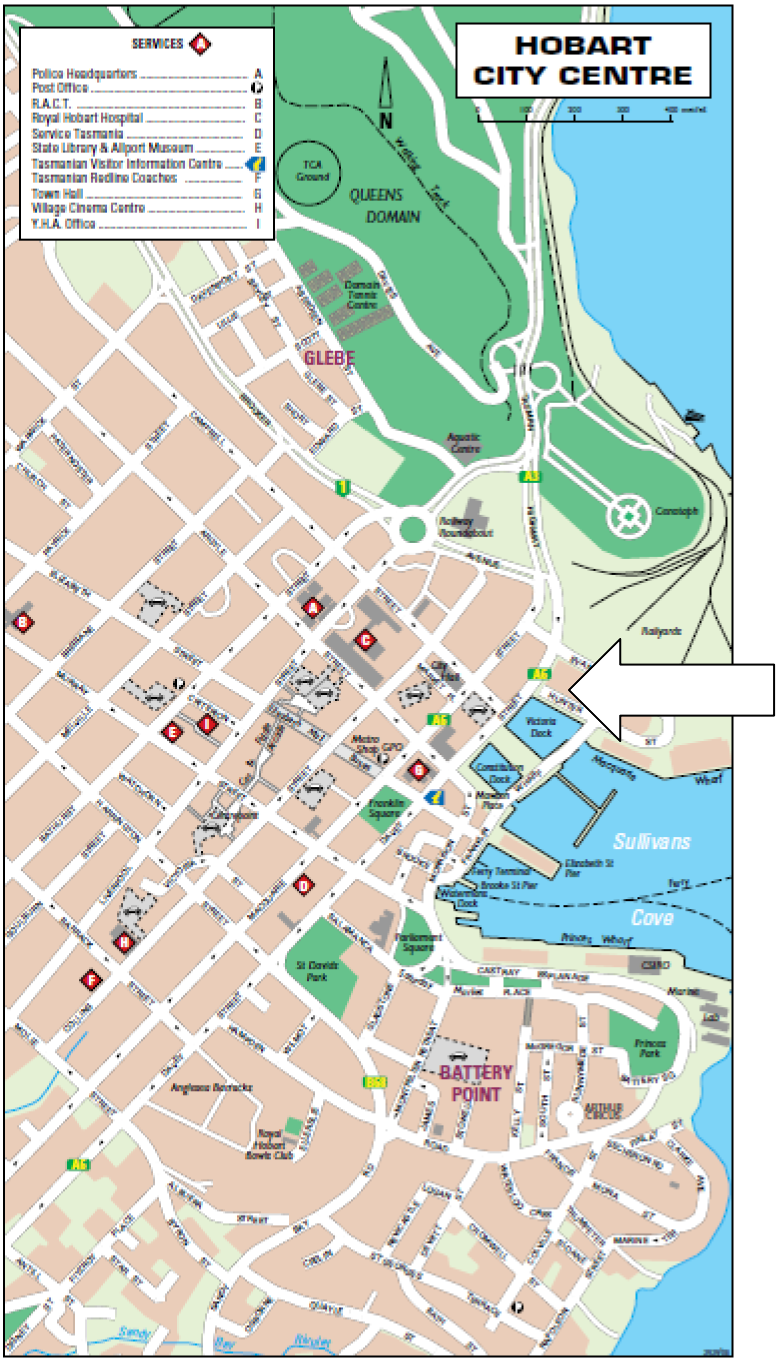
Hobart overview:

A general view of Hobart on the Derwent River.

The venue of the 6th IVS General Meeting is located in Sandy Bay in the south of Hobart. Please check the campus map for the exact location of the venue. The icebreaker reception is planned as a cocktail party at Zero Penthouse of Zero Davey. Zero Davey is located in Sullivans Cove on Hobart's waterfront. Please see the city centre map for a detailed view.

Hobart city centre:

A view of Hobart's city centre.



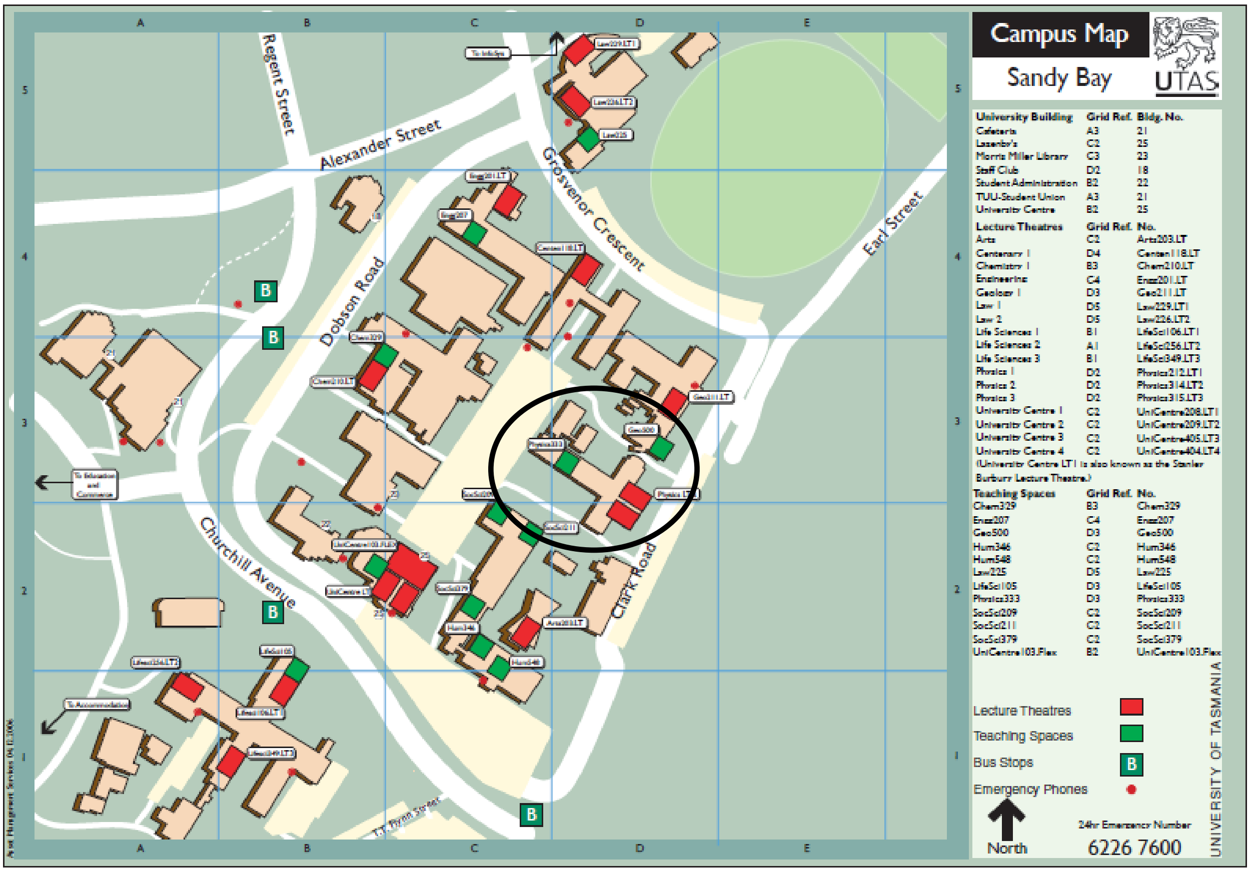
The icebreaker reception will be held as a cocktail party at Zero Penthouse of Zero Davey. Zero Davey is on 15 Hunter Street in Sullivans Cove. The location is marked with an arrow in the city centre map.

Zero Davey
(15 Hunter Street)

From the Sandy Bay campus of the University of Tasmania it is about a 45-min walk to Zero Davey. Alternatively, you can hire a cab that will bring you there in 10-15 min.

University of Tasmania, Sandy Bay campus:

The venue of the General Meeting is the **Physics Building** of the University of Tasmania. The Physics Building is circled in the campus map and aerial view.



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