Activities of the IERS Working Group on Prediction (WGP)

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IERS WG on Prediction

- **Tasked to**
  - **Determine what prediction products are useful to the user community**
  - **Make a detailed examination of the fundamental properties of the different input data sets and algorithms**
- **IERS RS/PC concerns**
  - **Continued relevance of current products**
  - **New accuracy requirements**
  - **Impact of new data sets**
  - **Viable new prediction methodologies**
- **Builds on the foundation laid by the Prediction Comparison Campaign (PCC) and the Combination Pilot Project**
- **Creates the potential for new improved EOP products**

WGP Members

- William Wooden (USA), Chair
- Wieslaw Kosek (Poland), Algorithms Sub-group Chair
- Tonie Van Dam (Luxemburg), Data Sub-group Chair
- Jianli Chen (USA)
- Olivier De Viron (France)
- Daniel Gambis (France)
- Richard Gross (USA)
- Maciej Kalarus (Poland)
- Hansjoerg Kutterer (Germany)
- Sebastien Lambert (France)
- Brian Luzum (USA)
- Zinovy Malkin (Russia)
- Tomasz Niedzielski (Poland)
- Waldemar Popinski (Poland)
- Jim Ray (USA)
- Bernd Richter (Germany), ex officio
- Markus Rothacher (Germany), ex officio
- David Salstein (USA)
- Harald Schuh (Austria)

WGP Goals and Objectives

1) Determine the desired EOP products – what is needed by the user community

2) Determine the importance of the input data – what new data sets are available, are data sets interchangeable, are some inherently better

3) Determine which types of input data create an optimal prediction – what is the noise of the series, what smoothing is best, what geophysical phenomena are being measured

4) Determine the strengths and weaknesses of the prediction algorithms – which algorithms perform best under what circumstances, how can problems be mitigated

5) Determine the interactions between series and algorithms that are beneficial or harmful – what qualities of certain data sets make them well suited or poorly suited for certain algorithms

IERS Rapid Service/Prediction Center

- **Provides EOPs on a rapid turnaround basis**
- **Primarily intended for real-time users (predictions) and others needing the highest quality EOP information (rapid service) sooner than is available in the IERS final series (*Bulletin B*)**
- **Current products**
  - **Bulletin A (weekly)**
  - **Daily data files**

RS/PC Prediction Accuracies

2005				2006				2007			
Days in Future	PM-X mas	PM-Y mas	UT1-UTC ms	Days in Future	PM-X mas	PM-Y mas	UT1-UTC ms	Days in Future	PM-X mas	PM-Y mas	UT1-UTC ms
1	.44	.37	.127	1	.42	.36	.147	1	.45	.38	.141
5	2.44	1.70	.380	5	2.33	1.51	.518	5	2.18	1.31	.439
10	4.13	2.77	.935	10	4.44	2.55	1.06	10	3.96	1.91	1.07
20	6.82	4.56	3.30	20	8.25	4.72	3.11	20	7.39	2.62	4.00
40	11.9	8.32	5.98	40	16.3	9.14	6.88	40	14.0	4.88	9.38
90	25.2	18.9	7.61	90	33.5	18.7	22.1	90	16.9	12.7	12.1

Current Status

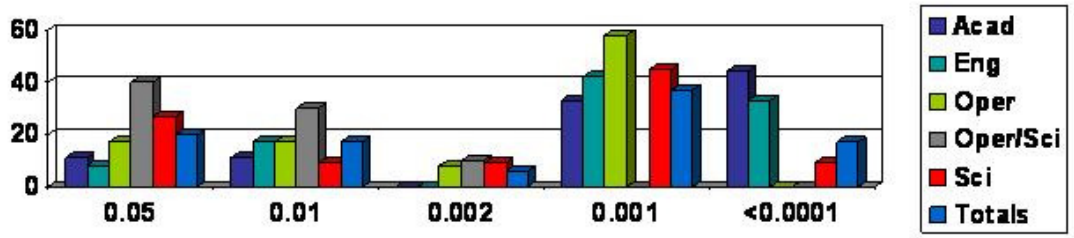
- User survey conducted
- Results analyzed
- Task to understand fundamental properties of input data sets and algorithms – in progress
  - Repository established at Univ. of Luxembourg
  - Data sets being identified and placed in repository
  - Algorithms identified
  - Comparison criteria being established

EOP User Survey

- Are the current IERS EOP prediction products, which were implemented more than 20 years ago, meeting the needs of the EOP user community?
- Given the multitude of modern high accuracy applications, what characteristics of EOP predictions (type, accuracy, data spacing, data span, form, etc.) are required?
- To understand the needs of current and potential users of EOP predictions and focus its effort, the Working Group developed a short user survey
- The link to the survey was distributed by the IERS Central Bureau and the IERS Rapid Service/Prediction Center with the request that it be completed by January 15, 2007
- Survey consisted of 9 short, check the box questions, and 1 question asking what prediction improvements would you like to see

User Survey Results

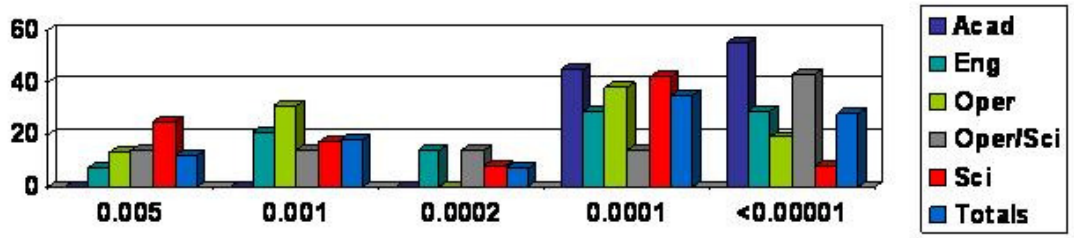
Polar Motion Accuracies (arcsec)



- Most users want accuracies of 1 milliarcsec or better
- Operational/Scientific users have the least stringent requirements
- Academic users are more interested in long term predictions

User Survey Results

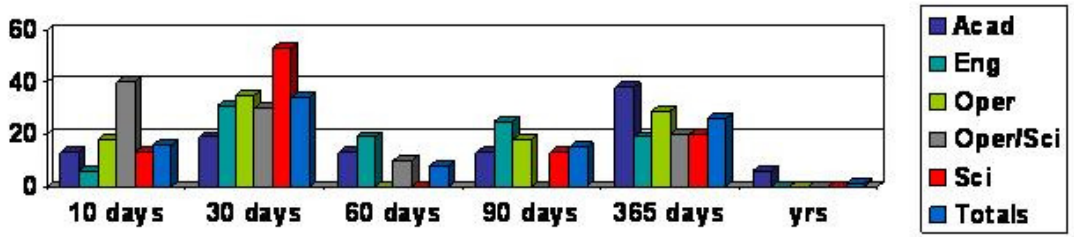
UT1-UTC Accuracies (sec)



- Almost two/thirds of all users want accuracies of 0.1 millisecond or better
- A few scientific and operational users have low accuracy requirements
- Academic users have the most stringent accuracy requirements

User Survey Results

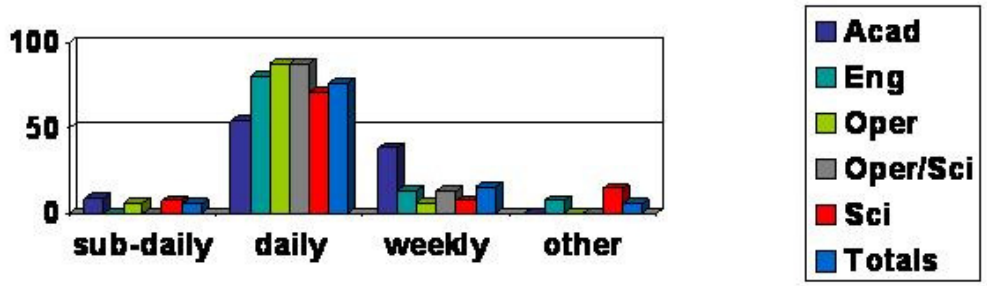
EOP Prediction Length



- Half of all users want predictions of 30 days or less
- There seem to be two classes of users: those who need predictions of less than 30 days and those who would like predictions of 1 year (~25%)
- Academic users are more interested in long term predictions

User Survey Results

EOP Data Spacing

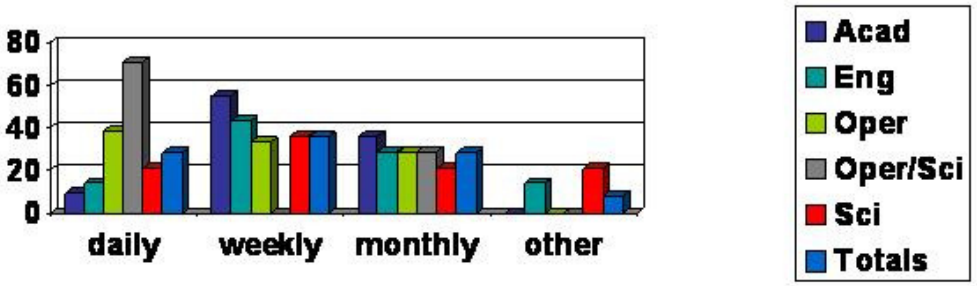


- Majority of users prefer data at 1-day intervals

- Some users have an emerging requirement for sub-daily prediction data

User Survey Results

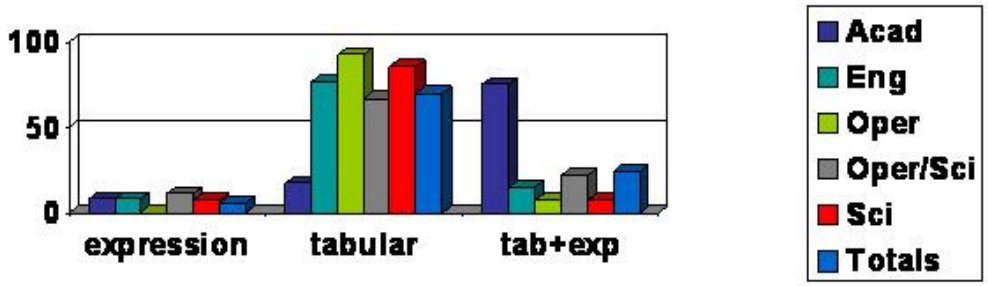
EOP Update Frequency



- Operational/Scientific users prefer predictions to be updated daily
- Academic users prefer weekly updates
- Almost two/thirds of all users would like daily or weekly updates

User Survey Results

EOP Data Formulation



- Majority of users prefer tabular data
- Academic users desire analytical expression in addition to tabular data

User Survey Conclusions

- Confirmed that a large class of operational users need daily predictions, tabular data, one-day spacing, and predictions up to 30 days
- Each of the different classes of users have different needs
- Terms of reference under which the IERS RS/PC operates has been reconfirmed by the survey results
- New requirement for increased accuracy and the WGP efforts to examine algorithms and incorporate potential new sources of data appears to address that need
- Growing interest in daily and sub-daily predictions exists which requires more timely measurements of EOP quantities and some increased processing capability

Input Data Considerations

- Exploit methods to minimize data latency; minimize extrapolation to current time
- Determine loss of information if all data sets have a common epoch
- Examine potential geophysical data sets from the IERS Global Geophysical Fluids Center
- Examine the geodetic technique services' combination data sets resulting from the IERS Combination Pilot Project
- Determine sensitivities of missing data sets to the prediction process
- Examine pathological data sets from Chandler and annual destructive interference time frame
- Determine the optimum combination of geophysical signals to create the best predictions
- Determine where research is needed to make future improvements in EOP prediction

Input Data

- Data placed in password-protected repository for retrieval and analysis
- Time series of geodetic data
  - GPS
  - SLR
  - VLBI
- Geophysical fluids data sets
  - AAM
  - OAM
  - HAM

Test Cases

- General test set 2000-2006
- Test set for polar motion loops
- Test set for large amplitude annual/Chandler polar motion
- Test set for radical UT1 changes
- Test set for minimal UT1 changes
- Test set for differences in smoothing
- Artificial test sets with noisier end points

Algorithm Considerations

- Maintain the integrity of effort, the group analyzing the predictions will be different from the group generating the predictions -- each group checks the other group's results
- Finalize the specific metric criteria for comparison
- Examine time dependency and/or frequency dependency issues with the results
- Provide definitive write-up on each algorithm -- characterize the advantages and shortcomings
- Determine what the state-of-the-art is in prediction techniques
- Determine how robust the algorithms are
- Determine suitability for operational setting
- Determine what research is needed for improvement

Algorithms

- EOP time series data consists of
  - Deterministic component; gives rise to trends, seasonal variations, and tidal variations
  - Stochastic component; causes statistical fluctuations with a short term correlation structure
- Best EOP prediction results when the deterministic components are predicted by the deterministic method and a stochastic prediction technique is applied to forecast the stochastic component
- Combining deterministic and stochastic terms improves the prediction accuracy in low and high frequency components

Prediction Methods

- **Least-squares extrapolation (deterministic prediction method)**
- **Least-squares collocation**
- **Kalman Filter**
- **Autoregressive**
- **Autoregressive (integrated) moving-average**
- **Auto covariance**
- **Neural networks**
- **Fuzzy Logic**
- **Multidimensional**

Future Plans

- Add more data sets to the repository at the University of Luxembourg
- Finalize criteria for algorithm comparisons
- Determine optimal parameters in combination prediction algorithms
- Investigate geophysical causes of prediction errors
- Investigate new forecast techniques

WGP Expectations

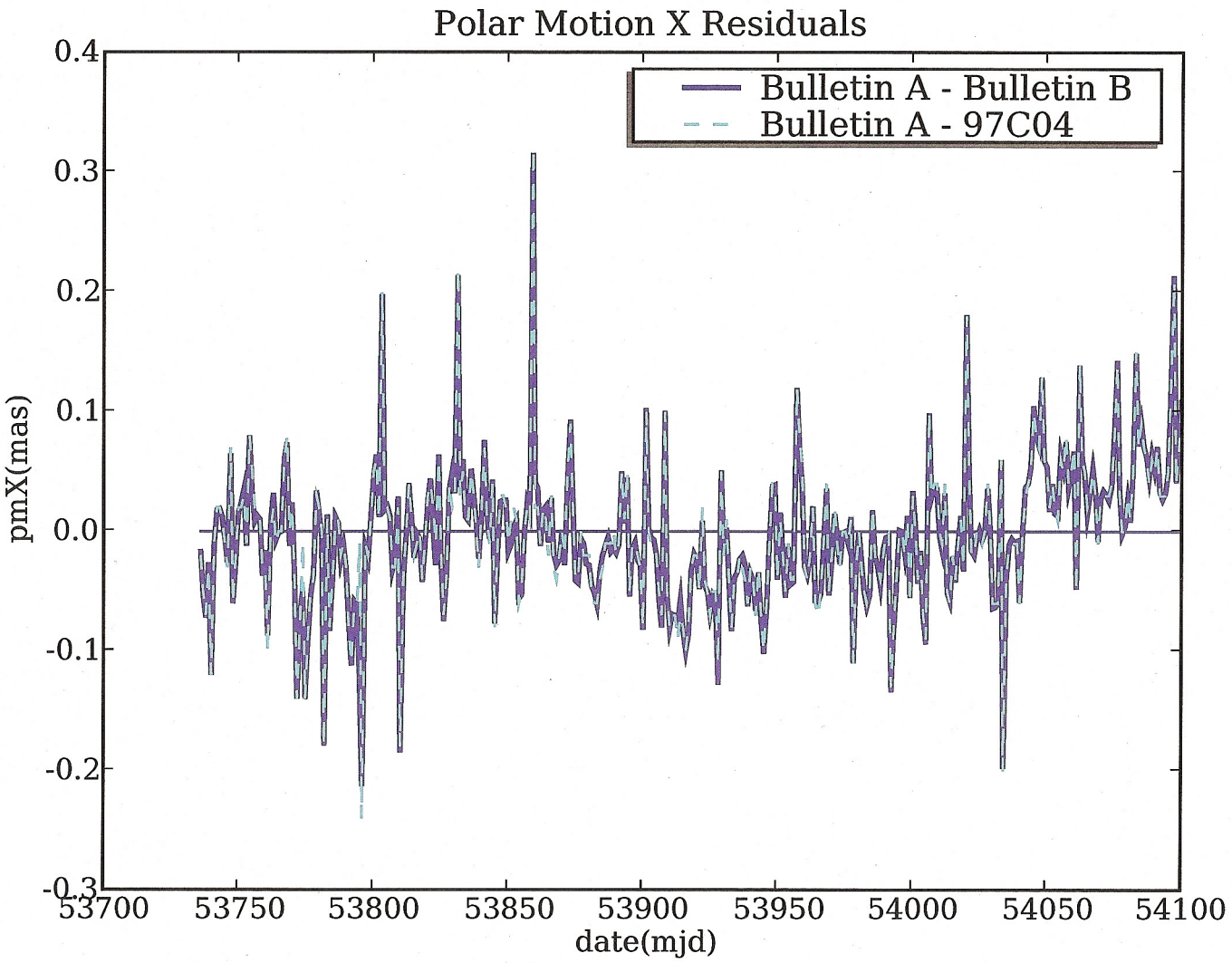
- Definitive user requirements
- Comprehensive look at prediction methods
- Comprehensive look at new data sets
- IERS Technical Note describing current state-of-the-art EOP prediction including requirements, methods, and data set information content

Want to Participate?

- If you are interested in participating in these activities, contact one of the following:
  - William Wooden (william.wooden@usno.navy.mil)
  - Wieslaw Kosek (kosek@cbk.waw.pl)
  - Tonie van Dam (tonie.vandam@uni.lu)

BACKUP

IERS Bulletin A Accuracies



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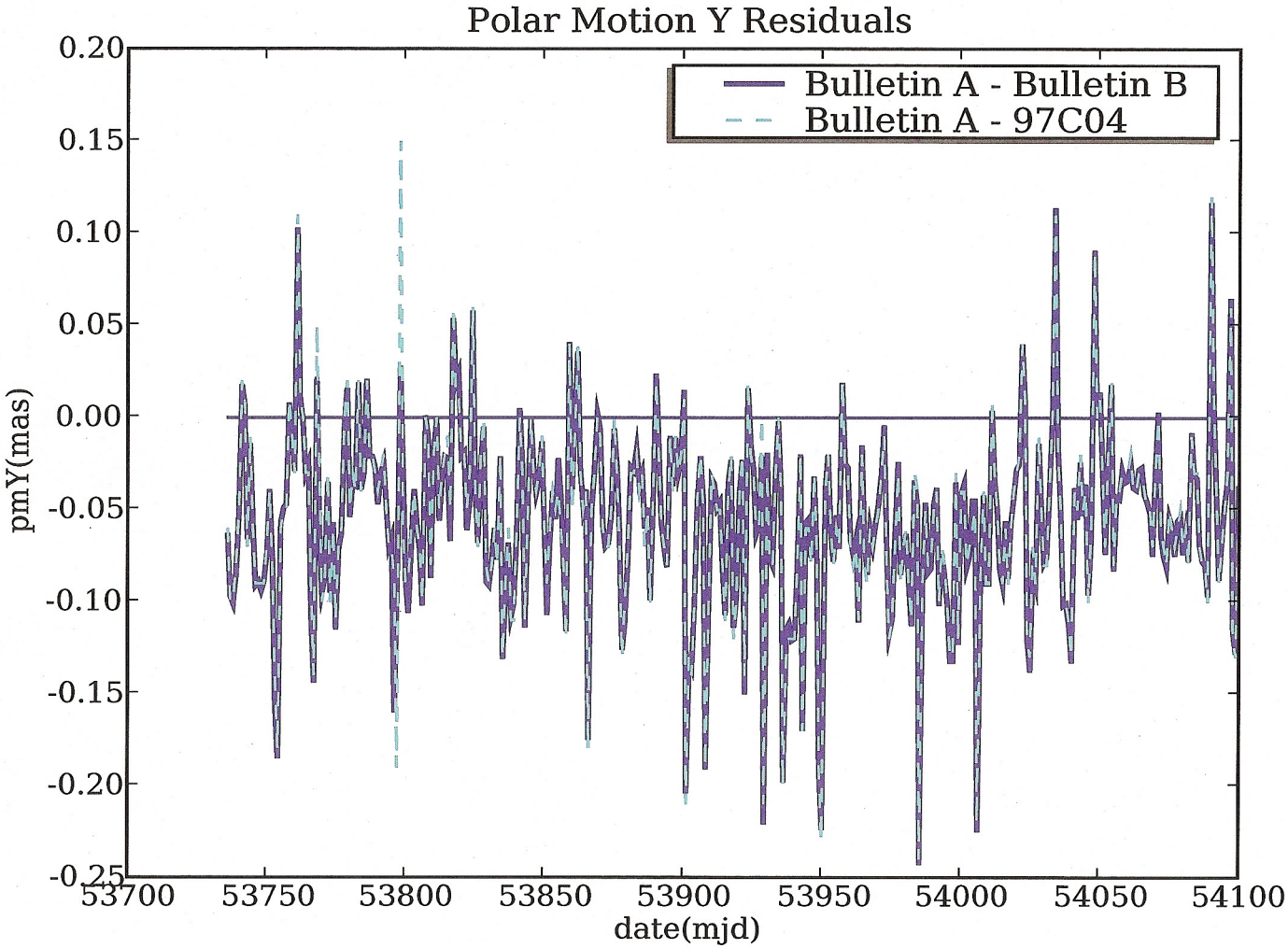

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