第57回宇宙科学技術連合講演会

20-13 複数GNSS対応高精度軌道時刻推定ツール MADOCAの開発

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Overview



<u>Multi-GNSS Advanced Demonstration tool</u> for <u>Orbit and Clock Analysis</u>

- For real-time PPP service via QZSS LEX
 - Many (potential) applications over global area
- Precise orbit/clock for multi-GNSS constellation
 - Key-technology for future cm-class positioning
- Brand-new codes developed from scratch
 - Optimized multi-threading design for recent CPU
 - As basis of future model improvements

Real-Time PPP via QZSS



MADOCA Architecture



Models and Algorithms

Models

Satellite Orbit Models

- EGM 2008+solid earth tide+FES2004
- Sun, Moon, Venus and Jupiter with JPL DE421
- Empirical SRP model, ...
- Measurement Models
 - ZD Iono-free phase+ pseudorange, 2nd-order-iono
 - ZTD+gradient estimation with GPT+GMF/VMF1
 - IERS DEHANTIDEINEL+FES2004+pole tide+CMC

• ECI-ECEF Coordinates Transformation

- IAU 2000A/2006 by IAU SOFA

Empirical SRP Model





 $a_{srp} = S ((D_0 + D_C \cos f + D_S \sin f) e_D + (B_0 + B_C \cos f + B_S \sin f) e_B + (Y_0 + Y_C \cos f + Y_S \sin f) e_Y) \times 10^{-9} (m/s^2)$



D(

Do

Ds

Bc

Bs

Yc

Parameter Adjustment

	Offline	Real-Time			
Algorithm	Iterated Weighted LSQ	Dual-Cycle-EKF			
Estimated Parameters	Orbit, SRP/Emp-Acc, Clock, Position, ZTD/Grad, Ambiguity, Bias, EOP				
Measurements	ZD Carrier-Phase and Peudo-range				
Numerical Solver	NEQ by Cholesky Factorization	Numerical Stable EKF			
Clock Estimation	Parameter Elimination in NEQ	State as White-Noise or Random-Walk			
Integer Ambiguity Resolution	Network AR (Ge., 2005)	Real-Time Network AR			

Iterated Weighted LSQ



Parameter Elimination in NEQ



Network AR

- Dynamic baseline selection to convert ZD to DD
- WL and NL DD ambiguities by rounding
- Validation by confidence function and FCB
- For GPS, QZSS and Galileo (no GLONASS) AR-OFF AR-ON



Dual-Cycle-EKF



Numerically Stable EKF

Measurement Update of EKF $\boldsymbol{K} = \boldsymbol{P}^{-}\boldsymbol{H}^{T} (\boldsymbol{H}\boldsymbol{P}^{-}\boldsymbol{H}^{T} + \boldsymbol{R})^{-1}$ $x^{+} = x^{-} + K(y - h(x^{-}))$ $\boldsymbol{P}^+ = (\boldsymbol{I} - \boldsymbol{K}\boldsymbol{H})\boldsymbol{P}^-$ (1) v = y - h(x), H, R (2) $\mathbf{D} = \mathbf{P} \mathbf{H}^{\mathsf{T}}$ (sparse) (3) $\mathbf{S} = \mathbf{H} \mathbf{D} + \mathbf{R}$ (sparse) (A) = chol(S) DPOTRE

(4)
$$U = chol(S)$$
 DPOTRI
(5) $E = D U^{-1}$ DTRSM
(6) $K = E U^{-1}$ DTRSM

$$(7) \mathbf{x} = \mathbf{x} + \mathbf{K} \mathbf{v} \qquad \text{DGEM}$$

(8) $P = P - E E^{T}$ **DSYRK**

Standard EKF

(1)

(2)

(3)

(4)

(5)

(6)

[7)

Numerically Stable EKF

$\mathbf{v} = \mathbf{y} - \mathbf{h}(\mathbf{x}), \mathbf{H},$	R
$\mathbf{D} = \mathbf{P} \mathbf{H}^{T}$	(sparse)
S = H D + R	(sparse)
U = chol(S)	DPOTRF
$\mathbf{K} = (\mathbf{D} \ \mathbf{U}^{-1}) \ \mathbf{U}^{-T}$	DTRSM
$\mathbf{x} = \mathbf{x} + \mathbf{K} \mathbf{v}$	DGEMV
$\mathbf{P} = \mathbf{P} - \mathbf{K} \ \mathbf{D}^{T}$	DGEMM

Evaluation

Offline GPS/GLO Orbit



GPS Orbit vs. IGS AC

IGS AC	Analysis Softwara	# of Stas	GPS Orbit RMS (cm)				Clock (ns)	
	Analysis Software		R	Α	С	3D	STD	RMS
	MADOCA 0.3.0	77	0.89	1.10	1.12	1.81	0.109	0.131
ESA	NAPEOS 3.5	110	0.97	1.33	1.09	1.98	0.116	0.183
CODE	Bernese 5.1	231	1.01	1.36	1.14	2.04	0.075	0.089
NGS	arc, orb, pages, gpscom	199	0.95	1.46	1.41	2.24	-	-
GFZ	EPOS.P.V2	191	1.15	1.64	1.59	2.56	0.146	0.169
MIT	GAMIT 10.33, GLOBK 5.16	263	1.37	2.12	1.39	2.88	0.277	0.316
NRCan	GIPSY/OASIS-II 5.0	91	2.58	1.72	1.77	3.57	0.128	0.148
JPL	GIPSY/OASIS-II 5.0	142	2.62	1.67	1.98	3.68	0.168	0.226
SIO	GAMIT 10.20, GLOBK 5.08	258	2.42	2.26	1.77	3.75	-	-
GRG	GINS, DYNAMO	134	2.47	2.80	1.74	4.12	0.172	0.212

2011/01/01 -2011/12/31 (365 days), wrt IGS Final

Offline QZSS Orbit

QZSS-1 Michibiki J01



2011/06/04 - 2011/11/03 (153 days), 24 H-overlap

Offline Galileo Orbit



Galileo Orbit vs. TUM/GRM



Large Network Solution

Single NEQ + Network AR

- GEONET (1244) + IGS (7)
- Position (24h static), Clock,
 ZTD/Grad and Ambiguity



# E	stimations		# Parai	# Parameters		CPU Resource	
Sat	Sta	EP	CMN	EP	RAM	File	Time
31	307	288	28,770	97,632	9.1 GB	21.2 GB	15m
31	604	288	57,099	183,168	29.2 GB	78.8 GB	1h 40m
31	904	288	86,659	269,568	62.8 GB	173.9 GB	5h 27m
31	1,251	288	119,090	369,216	113.3 GB	380.4 GB	14h 05m

Xeon E5-2687W x 2 (16 core), RAM 128 GB, HDD 8TB, SSD 480GB

Real-Time PPP Test



IGS/MGEX (21)

Reference Station Network

STATION POSITION



Test Snapshots

Control and Monitor Console of MADOCA MGRTE

Real-time PPP by RTKLIB 2.4.2

MADOCA Control and Monitor	AADOCA Control and Monitor	MADOCA Control and Monitor		
PREALTIME ESTIMATOR STATUS	2013/05/21 02:23:15: MADDCA ver.0.6.2 CONTROL AND MONITOR	2013/05/21 02:23:15: WADDCA ver.0.6.2 CONTROL AND MONETOR	ZOLSY KSJEL KOLEKNOL (UPS) I UPS I U	Latton Height • RoverL1
2. TIME START 2013/05/19 09:22:51.1	NO. STA. FORMAT INP_BITES INP_BPS 5 LOG_BITES 5 MS6_STR / MS6_LOG	NO. FORMAT OUT_EVIES OUT_EPS LOG_BYTES MS6_STR / MS6_LOG	Solutioe: PPP	Solution: PPP
4: EPOCH 2013/05/21 02:23:12.0	2: IIN2 JAVAD 284090755 18039 C 284090755 C caster.ntrip.mgm.met/IIN2	2: M9K5 20544578 12914 C 0 -	N: 35° 52' 22.7625"	N: 35° 52' 22.7629"
6. CYCLE TIME 0.007 S	4: NK02 JAVAD 312570266 16290 C 312570266 C caster.strip-mgm.met/NK02	101AL 433/0101 H018 H32/07	E: 138° 23' 22.8114"	E: 138° 23' 22.8105" w
7: # DF CFLLES 147622 8: # DF EPOCHS 147622	5. NUKL JAVAU 3/4/0495/ 15090 L 3/2/045/ C Catter.htrip-mgm.met/UKL 6. 0602 JAVAD 329784741 16090 C 329784741 C caster.htrip-mgm.met/0602	AU: TYPE #001 SEN #ESSNES(#) 1: SSR1 4821 1057(4781) 1246(2444)	He: 1003.915 m	He: 1005810 m
10: # 0F 005LERS 2048 (0.1%)	7: SMA2 JAVAU 323375384 15874 C 323375384 C caster.ntrip-mgm.met/3Mk2 8: ATH2 JAVAU 327278691 14835 C 327278691 C caster.ntrip-mgm.met/ATH2	1: 5382 4921 1058(4781) 1247(2444) 1: 5583 4921	Age: 0.0 s Ratio: 0.0 # of Sat: 8	Age: 0.0 x Batto: 0.0 7 of Set 8
11: HMS RESIDUALS 0.0865 m 12: NORM-RMS RES 0.0660	9: ALMA 61NEX 160058691 4/02 C 160058691 C caster.ntrip-mgm.met/4LMA 10: STK2 81NEX 117294512 6853 C 117294512 C caster.ntrip-mgm.met/STK2	1: 5595 4921 1051(4781) 1250(2444) 1: 5596 147622 1052(143210) 1251(73393)	D (3) rtigs.org.0001 (2. 7	C (3) 292.168.0.203
13: 198EA0 EK0 -885680464 14: 198EA0 BGF 0	11: UCJ2 BINEK 111942548 3854 C 111942548 C caster.ntrip-mgm.met/UCJ2 12: TSK2 BINEK 116764401 6733 C 116764401 C caster.ntrip-mgm.met/TSK2	2: 081 4921 2: CLX 147622	Start Step Plot Options Exit	Start Spo Bot Options Duit
#DATA FEEDER STATUS	15: GDFBH JAVAD 268167564 14688 C 268167564 C caster.mtrip-mgm.met/GDFBH 14: DLF2 JAVAD 275638616 14688 C 275638616 C caster.mtrip-mgm.met/DLF2	2: RCLK 4921 2: TBOP 4921	RDRIAVI vec2.4.2 (4)	RTKNAVI ver.2.4.2 (2)
1: STATE RUNING 2: TIME START 2015/05/19 09:22.51.1	15: ABMG JAVAD 329399868 18889 C 329899860 C caster.ntrip-mgm.met/ABMG 16: DAE2 JAVAD 284951526 13960 C 284951526 C caster.ntrip-mgm.met/DAE2	2: A46 4921 2: B49 4921	2013/05/21 03:20:39.0 GPST I	2013/05/21 03:20:39.0 0917 I I I I I I I I I I I I I I I I I I I
5: TIME CUBRENT 2015/05/21 02:23:15.0 4: RUN TIME 147624.8 5	17: PFHR JAVAD 251755258 14669 C 231755258 C caster.mtrip-mgm.met/PFHR 18: BNLA 81NEX 125388488 9111 C 125288488 C caster.mtrip-mgm.met/VICPOS_BNLA	[1]: UDI IDD URA 13/05/21 D0-A D0-C D0-R D1-A D1-C D1-R C-0 C-1 C-2 C-RR	Lat,Lon,Vieight • Rover SVAR (dSViz) • •	Latton Height • Rover L1
5: # OF INPUTS 40 6: # OF MESSAGES 12944553	19: KRMG BINEX 122404832 BT91 C 122404852 C caster.mtrip-mgm.met/VICPOS_KRMG 20: MMGD BINEX BB747199 6601 C 80747199 C caster.mtrip-mgm.met/VICPOS_MMGD	G81 : 50 55 12 02:23:00 -1.299 -0.563 0.045 -0.125 0.174 0.040 5.693 0.000 0.000 -0.019 G82 : 50 106 13 02:23:00 -0.054 1.170 -0.229 -0.385 0.327 -0.377 5.383 0.000 0.000 -0.018	Solution: PPP 3	Solution: PPP
7: TOTAL INPUTS -455505892 BYTES 8: TOTAL RATE 452570 BP5	21: UNSX2 JAVAD 447261527 22228 C 447261527 C caster.ntrip-mgm.met/UNSX2 22: MAHOD JAVAD 478312899 27068 C 478312899 C caster.ntrip-mgm.met/MAHOD	G83 : 30 66 12 02:23:00 -0.986 -1.986 -0.653 0.044 -0.295 0.110 5.127 0.000 0.000 -0.012 G84 : 30 60 13 02:23:00 -0.887 1.121 -0.031 -0.298 0.046 -0.392 5.269 0.000 0.000 -0.005	F: 139° 47 32.5434"	E: 139.79237315 °
9: CPU LOAD 0.0 % 10: THREAD -876693760	25: SING0 JAVAD 404330051 24970 C 404330051 C caster.mtrip-mgm.met/SING0 24: HRAG0 JAVAD 290660635 19193 C 290660635 C caster.mtrip-mgm.met/HRAG0	685 : 30 82 12 02:23:80 0.121 0.494 -0.306 -0.172 0.281 0.180 5.030 0.000 0.000 -0.025 686 : 30 84 12 02:23:80 -0.783 -1.213 -0.100 -0.009 -0.394 0.283 4.561 0.000 0.000 -0.004	He: 59.434 m	He: 59.408 m
NO: USER LEVEL LOGIN(S) REMOTE_ADDRESS	25: PERT2 81NEX 79977822 6397 C 79977822 C caster.mtrip-mpm.met/PERT2 26: K2N2 RTCN5 173268462 9204 C 173268462 C mpex.igs-ip.met/K2N27	607 : 30 94 15 02:23:00 0.190 0.155 -0.507 -0.183 -0.064 0.361 4.768 0.000 0.000 -0.018 608 : 50 23 14 02:23:00 -0.585 -0.745 -1.674 -0.090 -0.125 0.399 4.603 0.000 0.000 -0.005	N: 0.121 E: 0.107 U: 0.257 m Age: 0.0 s Ratio: 0.0 F of 5at 3	E: 0.020 N: 0.020 U: 0.041 m Age: 0.0 s Tatio: 0.0 F of Sat. 5
1: edmin 1 541.4 192.168.8.6 2: edmin 1 474.9 192.168.8.6	27: HARB RTCHS 127199456 7581 C 127199456 C mpex.ig=-ip.met/HARB7 28: LMRE RTCHS 144220454 9258 C 144220454 C mpex.ig=-ip.met/LMRE7	649 : 58 78 12 02:23:80 -0.863 0.100 -1.007 -0.238 0.228 0.415 4.002 0.000 0.000 -0.012 610 : 38 79 13 02:23:80 -0.882 -0.525 -0.269 -0.051 0.316 -0.056 1.869 0.800 0.000 -0.033		< + + = # of Set: 9 (2009:2.3)
5. admin 1 504.6 192.158.0.6 4. admin 1 204.2 192.168.0.6	29: SCR2 RTCHS 73751961 8 C 73751961 C mpex.igs-ip.met/SCR27 38: KDM5 RTCHS 185302078 8520 C 183302078 C mpex.igs-ip.met/KDM57	611 : 30 67 13 02.23.80 -1.701 8.496 0.168 -0.217 8.258 8.259 6.836 0.608 0.608 -0.018 612 : 30 18 12 02.23.80 -0.879 8.110 0.114 -0.186 -0.048 -0.127 5.180 0.400 0.000 -0.028	(1) 49-212.82.183(TUN0 (3) rt.igs.org/00001 (2 7)	(1) 49.212.82.183(7).N0 (3) 192.168.0.103
5: admin T 192.5 192.168.0.6	31: NBME RTONS 127417758 8685 C 127417758 C mgex.igs-ip.met/NBM67 52: ULAB RTONS 26255840 6433 C 26255840 C mgex.igs-ip.met/ULAB7	615 3 58 41 15 07 35 40 -1 529 -8 362 0.175 -0.126 -4.052 0.022 5.442 0.000 0.000 -0.006 614 39 68 12 02 23 80 -1.664 -0.578 0.261 -0.088 0.085 -0.221 0.745 0.000 0.000 -0.006	ware stage PSL. Option. Dat	And Andrew Parkers Contract Dat
ND: EXTERNAL DATA FILE_PATH 1: P1C1 BIASES /pro1/madoca/data/dcb/P1C11201.0CB	33: TASH RTONS 196557502 8362 C 196557502 C mgex.igt-ip.met/TASH7 34: W/A2 RTONS 145535138 8199 C 145535138 C mgex.igt-ip.met/W/A27	615 : 30 82 12 02:23:80 0.151 -0.957 -0.904 -0.838 0.054 0.193 4.780 0.600 0.008 -0.048 616 : 50 34 13 02:23:80 -1.700 -0.739 0.858 -0.100 -0.340 0.285 5.981 0.600 0.000 -0.015	Cla Dig View Help	RTRNAVI ver.2.4.2 : RTRPLOT
2: P2C2 BEASES /proj/madocs/dats/dcb/P2C21101.0C8 4: OREIT PARAMETERS /proj/madocs/dats/obtorm.mdby.tst	35: KR66 RT0K5 96745843 4844 C 96745843 C mgex.ips-ip.net/R8667 36: 5082 RT0K5 26411777 1239 C 26411777 C mmm.ips-ip.net/K5020	617 : 30 187 12 02:23:00 0.815 0.342 0.540 -0.172 -0.034 -0.331 5.335 0.000 0.000 -0.016 618 : 50 183 11 02:23:00 -1.584 0.510 -0.717 -0.211 0.192 0.399 6.126 0.000 0.000 -0.011	• 1 2 :: Paster • 244 • 1 • H 1 8 + + • • 18 × • • •	• 1 2 :: Postor • CAL • + • H I 0+ + • • H × # 0
9: SINEX POSTION out/out909/obt17406.stx 13: FOP /mcsi/deta jers/sec2.dat	37: DAV1 RTOHE 58651758 3784 C 50651758 C www.igs-ig.net/DAV10 38: DAM2 RTOHE 56629418 3262 C 56629418 C www.igs-ig.net/DIMD8	619 : 30 51 12 02:23:00 0.035 -0.455 -0.405 -0.112 -0.244 0.049 5.519 0.000 0.000 -0.000 628 : 30 75 12 02:33:00 -1.589 0.459 0.115 -0.246 -0.043 -0.354 6.132 0.000 0.000 -0.025	1.0 CRi+ 35.872989402 ¹ 138.389669232 ¹ 1005.9223m	1.0 E-W (m) CR(= 35.872889401' 138.589680232' 1005.9223m
15: ANTENNA PARAMETERS /proj/medoca/deta/igs88.ets 16: STATION INFO	39: COC0 RTCHS 54298448 2094 C 54288480 C www.ips-ip.net/COC00 48: CON2 RTCHS 44808549 2278 C 44908184 C www.ips-ip.net/CON20	621 : 50 72 11 02:23:80 -1.831 8.545 8.410 -0.296 8.730 8.650 6.142 8.608 8.000 -0.018 622 : 50 54 13 02:23:80 8.200 -0.150 -0.544 -0.155 8.144 8.126 6.814 8.000 8.000 -0.018	0.5	0.5
17: OCEAN TIDE LOADING /proj/madoca/data/FES2004.BLQ	41: RI02 RTOHS 11429199 4419 C 11429199 C www.igs-ip.net/RI020 42: TVTT RTOHS 40509779 1023 C 40509779 C www.igs-ip.net/RI020	623 : 30 23 13 02:25:00 0.006 0.683 0.719 -0.276 0.110 -0.189 5.349 0.000 0.000 -0.028	0.0	0.0
21: SUMMARY REPORT out/out989/obt17412.res	45: BRAZ RTCH5 73919774 5040 C 75919774 C www.igs-ig.net/BRAZ0 46 REW RTCH5 73919774 5040 C 75919774 C www.igs-ig.net/BRAZ0	625 : 50 24 11 02:25:00 -1.571 0.144 0.435 -0.259 -0.311 -0.251 6.256 0.000 0.000 -0.021 515 - 50 55 11 02:25:00 -1.571 0.144 0.435 -0.259 -0.311 -0.251 6.256 0.000 0.000 -0.021	-0.5	-0.5
	45: NKLG RTCHS 50065516 2097 C 50065516 C www.igs-ip.net/NKLG0	627 50 8 8 11115:80 8.000 8.000 8.000 8.000 8.000 8.000 8.000 8.000 8.000 8.000 8.000	-1.0 AVE-0.0166m STD+0.0255m EME+0.0280m	-1.0 AVE-0.0255m TDu0.0118m BMI-0.0281m
MADOCA Control and Monitor	T01aL 3839461404 452570 3839461404	629 : 50 43 12 02:23:00 -0.235 2:193 -0.598 -0.411 0.066 0.086 5.444 0.000 -0.020	0.5	0.5
ifile-pleph +4P/deta/trxp1900p2053.421	NO: STA 13/05/21 LATENCY 40.25 40.50 40.75 41.00 41.25 41.50 41.75 42.00 42.25 42.50 42.75 43.00 53.00	631 : 30 65 12 02:23:40 0.045 1.097 -0.613 -0.324 -0.085 -0.234 5.045 0.000 0.000 -0.002 617 : 30 65 12 02:23:40 1.102 1.104 -0.102 -0.013 -0.324 -0.085 -0.245 0.000 0.000 -0.002	0.0	0.0
ifile-obt -W/data/obtprm_adby.txt	2: 1182 02:13:14 1.38 0 0 0 0 17758 71607 25095 169 96 135 148 55 305	381 : 30 161 17 02:23:00 -3.471 7.936 25.736 -0.358 -0.587 0.266 5.488 0.000 0.000 -0.009	-0.5	-4.5
ifile-sta =%(MADDCA_DIR)/data/sta/sta_mgmmet.txt	4: NK22 02:23:14 1.00 0 0 0 0 74178 71785 241 99 141 176 116 54 425 5: NK22 02:23:14 1.00 0 0 0 0 74178 71785 241 99 141 176 116 54 425		-1.0	-1.0
ifile-stainf -out/out909/obt17406.snx	5: 0502 02:23:14 1.47 0 0 0 0 0 54613 89583 2020 95 118 158 144 59 499	MADOCA Control and Monitor	0-0 (m) AVE-0.0034m STD-0.0001m RMS-0.000m 0.3	0.5 AVE=0.0751m STD=0.0827m RMS=0.0979m
ifile-tie =	8: ATH2 02:23:14 1.35 0 0 0 0 0 40956 91148 5095 100 95 164 154 59 444	5 2 [2013/05/21 02:00:22:00] 2013/05/21 02:00:10 623 maw eph 100E= 22-> 23 10E=2013/05/21 04:00:00	as we all here the production of the production	0.0
ifile-pos2 =	9. ALTR 42.15.15 0.74 0 0 44510 50420 55460 22000 0275 95 00 75 100 45 510 10: 51K2 02:23:14 1.10 0 0 4 27096 76115 32344 10014 100 80 76 100 49 418	5 2 [2013/05/21 42:00:24.57] 2013/05/21 02:00:20 019 MM eph 2006 30-7 51 106-2013/03/21 04:00:00 5 2 [2013/05/21 42:00:24.57] 2013/05/21 02:00:21 020 mew eph 1006= 74-7 75 106-2013/05/21 04:00:00		45
ifile-ent +V/dets/sps80.ats	12: TSK2 02:25:15 0.49 60399 85633 362 85 89 88 105 49 55 73 76 18 281	3 2 [2013/05/21 42:00:26.13] 2013/05/21 02:00:25 R02 new eph 100E= 31 > 33 10E-2013/05/21 02:15:16 3 2 [2013/05/21 02:00:26.44] 2013/05/21 02:00:25 R02 new eph 100E= 31 > 33 10E-2013/05/21 02:15:16	10	
stile-entr +4P/dets/ent_b4L_QCS.etx ifile-pic1 +4P/dets/dcb/P1C11201.DC8	13: 09750 92:25:14 1.33 0 0 0 0 0 0 26046 99832 20047 400 99 90 111 52 809 14: 0.72 02:23:14 1.31 0 0 0 0 0 26046 91571 28741 93 09 85 101 50 306 15: 040 0.12 1.12 1.12 0 0 0 0 0 0 26046 1571 28741 93 09 85 101 50 306	5 2 [2013/05/21 02/00/20:05] 2015/05/21 02/00/23 810 088 E01 200e 31-2 35 00e+4015/05/21 02/05/21 02/05/21 02/05 3 2 [2013/05/21 02:06/27:30] 2015/05/21 02/06/24 814 new eph 100e 19-2 21 106/2015/21 02/05/21 02/05/21 02/05/21 3 2 [2013/05/21 02:06/27 35] 0015/05/21 02/06/24 814 0.00 000 100/2015/21 02/05/21	00:90 01:00 01:00 01:00 02:00 02:00 02:00 03:00	R(2013)(05:00 01:00 01:00 02:00 02:00 03:00 R(2013)(05:21:03:20:40.00 GPST : E= 0.0313m N= 0.0333m U= 0.1127m Q= 6;099
ifile-dcb =	16: DAE2 02:23:14 1.43 0 0 0 0 060476 76622 235 82 87 83 101 320 322 452 17: press 02:73:14 1.34 0 0 0 0 060476 76622 235 82 87 83 101 50 397	3 2 [2013/05/21 02:00:27.39] 2013/05/21 02:00:24 810 mem eph 2006 179 21 105/2013/05/21 02:15:16 3 2 [2013/05/21 02:00:27.39] 2013/05/21 02:00:24 810 mem eph 2006 19-> 21 105/2013/05/21 02:15:16 3 2 [2013/05/21 02:00:27.30] 2013/05/21 02:00:24 810 mem eph 2006 19-> 21 105/2013/05/21 02:15:16	🕷 RTKNAVI ver.2.4.2 (4) : RTKPLOT 😄 🕮 🔯	🙀 RTKNAVI ver.2.4.2 (2) : RTKPLOT 💿 🖾 🖾
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ifile-tec . ifile-ren	28. MIGO 02.23:15 0.70 4 51668 49609 398 120 24452 28122 128 88 96 87 44 335 21: MISCO 02.23:88 6.80 0 8 0 0 8 0 0 120 24452 281051 27128 22911 4840 347 96 83188	3 2 (2013/05/21 02.00.27.09) 2013/05/21 02.00.24 811 new eph 100E= 10-> 21 10E=2013/05/21 02.15.16 3 2 (2013/05/21 02.00.27.04) 2013/05/21 02.00.24 810 new eph 100E= 10-> 21 10E=2013/05/21 02.15.16	•••••••••••••••••••••••••••••••••	• 1 2 - Poston • ALL • + • H I 8 + + • S H × • 0
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ofile-clog +4P/str_VVekdb.log	28: LMMF 02:23:14 1.07 0 2 1574 10152 22500 40613 28270 9509 5774 5129 4194 3605 9674 30: CFR2 21:36:16 0.01 0 16 1677 10201 0711 10101 5100 1670 15101 15101 15101	3 2 [2013/05/21 02:00:29.04] 2013/05/21 02:00:26 023 new eph 100E+ 19-> 21 10E+2013/05/21 02:15:16 7 2 [2013/05/21 02:00:20 041 2013/05/21 02:00:26 042 new eph 100E+ 19-> 21 10E+2013/05/21 02:15:16		
start start realtime estimator *	30, 1006 02,23,14 1.09 0 0 33 1234 5889 2020 28735 16421 11697 10935 15410 6884 19909	3 2 [2013/05/21 42:40:29.04] 20:5/05/21 02:00:26 R04 mem eph 100E= 31-> 33 T0E+2013/05/21 02:15:16	N-S (m) AVE=-0.0103m STD=0.0243m RMS=0.0265m	N-5 (m) AVE=0.0052m STD=0.0129m RMS=0.0139m
restart [opts] restart realtime estimator *	31, 100% 92,133,14 1,57 0 3 1135 9657 23422 41052 20057 11509 7064 5341 4401 3972 9524 32: ULAB 92:23:12 2,78 0 0 0 0 2 201 880 1678 2753 4606 15313	3 2 [2013/05/21 42:00:25.37] 2013/05/21 02:00:28 807 new eph 2005x 19-5 21 105x2013/05/21 02:15:16 3 2 [2013/05/21 02:00:31.88] 2013/05/21 02:00:28 807 new eph 2005x 19-5 21 105x2013/05/21 02:15:16	0.5	03
shutdown shutdown realtime estimator *	32: HAIM VEL25: 15 1:93 0 0 0 0 0 0 9 5959 21888 40455 55615 10025 6008 22515 34: WYA2 02:23:15 2:22 0 0 0 0 0 0 0 17 4138 24359 44766 5426 6424 6536 23852	5 2 (2013/05/21 02:00.31.00) (015/05/21 02:00.20 K20 new eph 100Ev 19-2 21 10E-2015/05/21 02:15:16 5 2 (2013/05/21 02:00.31.00) 2015/05/21 02:00.20 K21 new eph 100Ev 19-2 21 10E-2015/05/21 02:15:16	0.0	0.0
checkput [opts] save checkpoint to external file " log [opts] show log file	35. MNRL 92.25.13 2.33 0 0 0 12 385 5402 21299 27805 188149 20085 10161 25511 36. SCR2 02.25.14 1.05 0 0 0 801 45254 50710 5026 19605 21709 3419 288 110 515	5 2 [umi3/05/21 02:02:05/05/21 02:02:25 E19 new eph ICOL+ 42-> 45 TOE+2015/05/21 01:08:00 5 2 [2015/05/21 02:02:25.19] 2015/05/21 02:02:22 E19 new eph ICOL+ 43-> 45 TOE+2015/05/21 01:54:00	-0.5	-0.5
status[stat [opts] show status of realtime estimator report[rep [opts] show summary report	57: DANT 02:25:13 1.36 0 0 0 56 20121 20501 9245 54522 37575 15937 362 110 669 38: DAND 02:23:14 0.95 0 0 3467 31313 11858 46029 45634 9808 355 180 115 44 474	5 2 [2013/05/21 02:11:20.77] 2015/05/21 02:11:23 E19 new eph DODE=45> 44 102=2013/05/21 02:00:00 5 2 [2013/05/21 02:11:54.54] 2013/05/21 02:11:31 E20 new eph DODE=488>440 105=2013/05/21 01:50:00	-1.0 U-D (m) AVE-0.0070m STD-0.0558m RMS-0.0562m	-1.0 U-D (m) AVE=-0.0306m STD=-0.0542m RMS=0.0622m
dump [opts] dump internal parameters input[in [opts] show input stream status	95: LULU W2:25:14 1.20 8 8 8 19 15888 55575 18658 57457 52568 18559 588 229 827 40: CON2 02:23:15 8.60 8 58 36206 40122 765 26023 31598 108 202 268 221 131 748	5 2 [2015/05/21 02:11:40.55] 2015/05/21 02:11:57 E19 new eph 100E= 44-> 44 T0E=2015/05/21 02:00:00 2 4 [2015/05/21 02:14:14.49] console login : user=admin addr=192.160.0.6	0.5	0.5
sutput[out [opts] show output stream status ====================================	41: RED2 02:23:12 2.85 0 0 0 0 0 136 3533 3081 2978 5537 4295 3637 42: THTL 02:23:15 0.77 0 317 50169 61747 1817 15421 16167 573 191 146 159 74 400	3 2 [2013/05/21 02:15:19.13] 2013/05/21 02:15:16 J01 new eph IODE+168->161 10E+2013/05/21 03:15:12 2 4 [2013/05/21 02:15:20.99] console login : user+atmin addr=192.168.0.6	as and a stand where the stand of the stand	0.0
[command external command logout[bys logout control and monitor console	43: BRAZ 02:23:14 0.95 0 120 1744 26041 26075 25015 36388 26993 2796 380 289 89 529 44: REUN 02:23:14 1.51 0 4 1067 20748 42792 27428 21317 23159 7149 837 493 483 822	2.4 [2013/05/21 02:16:51.30] console login : uservadmin eddr=192.168.0.6 2.4 [2013/05/21 02:18:21.60] console login : uservadmin eddr=192.168.0.6	-0.5	45
help? show help (* restricted for administrator users)	45: M0.6 02:23:15 0.61 0 50 53876 47222 548 26552 18278 76 66 71 91 41 136 46: DRAD 02:23:15 0.89 0 11 17482 79227 31104 3365 11048 3860 201 152 166 59 402	2 4 [2013/05/21 02:20:03.23] console login : uservadmin eddr=192.168.0.6 3 2 [2013/05/21 02:21:26.35] 2013/05/21 02:21:23 E19 mem eph IODE= 44-> 45 TDE=2013/05/21 02:10:00	-1.0 00 10 01 00 01 10 02 00 02 04 04 00	-1.0 00:00 01:00 01:00 02:00 00:00
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		3 2 (2013/05/21 02:22:10.20) 2013/05/21 02:22:07 E19 mem eph 100E+ 45-> 45 10E+2013/05/21 02:10:00 *	R12013/05/21 03/20:39:00 GPST : E = 0.098 2H N= 0.0573H U= 0.029 2H O= 6/HP	R02013/05/21 03:20:39:00 GPST : E = 0.0975in N = 0.0949in U = 0.0030in C = 6/99

Real-Time PPP Test Results



Real-Time Experiment



LEX Data Format

LEX Data Format (MT12)

■メッセージタイプ :JAXA実験用信号としてメッセージタイプ 12 で放送予定

 メッセージフォーマット: PPPユーザ向けのRTCM^(*1) SSR(State Space Representation)フォーマットに基づき、 MADOCAにより生成したプロダクトを格納する。 LEXメッセージのデータ部には、RTCMメッセージの"Variable Length Data Message"のみを先 頭から詰めて格納する。 LEXメッセージとRTCMメッセージの関係は、下記のとおり。 (*1)RTCM (Radio Technical Commission for Maritime services)



Conclusion

MADOCA

- Precise orbit/clock for multi-GNSS constellation
- Offline and real-time estimation engine
- Optimized for both of performance and accuracy
- RT-PPP accuracy: < 5 cm HRMS, < 10 cm VRMS</p>
- QZSS LEX Experiment for RT-PPP (2013/4 ~)
- Evaluation of long-term stability of RT-orbit/clock

Future Plan

- Evaluate and add RT-GLONASS orbit/clock
- Enhancement for PPP-AR and BeiDou