Twentieth Meeting of the Hipparcos Science Team

ESTEC, 15–16 February 1989

Attendance:

HST: Dr M. Crézé, Prof. F. Donati, Dr. M. Grenon, Prof. M. Grewing (second day only), Prof. E. Høg, Prof. J. Kovalevsky, Dr L. Lindegren, Ir H. van der Marel, Mr C.A. Murray, Mr R.S. Le Poole, Dr C. Turon.

ESTEC: M.A.C. Perryman, S. Vaghi, R.D. Wills (first day)

T. Batut, K. van Katwijk, K. Clausen, H. Hassan (part time)

ESOC: J. van der Ha; A. Schütz

Dr F. van Leeuwen was unable to attend.

1. Agenda

The Agenda given in Annex I was adopted.

2. Project Status Report

Hassan announced that launch was likely to be either end-June or early July. The satellite had been re-activated, compatibility tests were on-going, and the satellite will go to Intespace for a low-level vibration test after box replacements, then to Matra, and hence to Kourou. Technically, the decision to move the IDT's would be made on 20 February. The baffle deployment hardware was now fixed, and the gyros were performing correctly after an accidental switch on. Hassan invited HST members for an HST meeting at Kourou at the time of launch (covering an interval of about 3 days). Medical requirements are attached (Annex XIII). Professors Blaauw and Lacroute would be invited at ESA expense as VIP's (Perryman explained the restrictions on numbers of VIP's and the reasons why certain VIP's would not be VIP's, and vice versa).

Hassan agreed to include up to 12 consortia scientists, selected by the team leaders, who would go to Kourou at their own expense. Administrative arrangements could nevertheless be made by the project team. Consortia leaders were requested to let Perryman have the names of those persons in this category (Action 4). Good coverage would be given by ESOC; scientists could also attend at Arianespace (Evry) or ESA Paris or ESTEC (if ESA organizes launch coverage). Names of all persons in this category to be with Perryman one month before launch (Action 5).

3. Payload Aspects

(a) Batut gave a report on the Tycho calibration status and the main field photometric anomaly (Annex II). The calibration data on the magnetic tapes, distributed previously, was unaffected, updated diskettes (main chain only) were distributed at the meeting (Kovalevsky, Schrijver, Grenon, van Leeuwen) and the updated calibration report was also distributed (Høg, Grenon, Schutz, Kovalevsky, Lindegren, van Leeuwen, Turon, Schrijver).

For the Tycho chain, the main conclusions were that (a) the SRU q.e. measurements were too optimistic by 10-20%; (b) the corrected results are about 30% lower than predictions; (c) there was no indication of incipient failures—in 6 weeks in vacuum no changes were observed (Batut); (d) photometric calibration may require different responses for the two FOV's (Grenon); (e) on-ground calibration equipment set-up may still be partly to blame (Batut). Lindegren noted that since the photomultipliers are imaging different parts of the photocathode for the different FOV's, some FOV discrepancy may not be unexpected. The photometric and astrometric performances of Tycho were still much better than specification (Annex II). 400 000 stars was still be taken as the projected Tycho catalogue size (Høg).

For the main FOV, the main concern was about the effect of the consequent phase errors assuming that the explanation given in Annex II is correct (IDT defocus combined with relay optic misalignment on IDT2). With this expanation there was also concern about degraded veiling glare performance, and chromatic effect on photometric calibration. Lindegren agreed to run further simulations of effects of telescope and IDT defocus. Results would be discussed with project on 20 February when a decision whether or not to refocus the IDT's would be made. (In air, the focus was considered good to $\pm 50\mu$m. The shift in vacuum was expected to be 200μm, hence both IDT's might need to be adjusted. It was also noted that this effect should show up as a strong difference on the payload IFOV profile in air and vacuum). The satellite schedule was tight, and Hassan only advocated adjusting the IDT's of the simulations showed that this was mandatory. Le Poole noted that grid refocussing would also affect the IDT best focus.

[Note added after the meeting: it was subsequently decided to move both IDT's, and this has now been done.]

(b) van Katwijk reported on the usage of detection chains 1 and 2 (Annex III). Any combinations of SM and IDT could be made in orbit, with a preference for using the same DEB if possible for reliability reasons.

4. INCA Aspects

(a) Turon reported on the INCA schedule. The past months had been spent improving colours, and information on multiple systems. INCA were finalising the list on which the simulations would be made. IC5 would be available in the interval end March/end April, depending on problems encountered. The production of ESOC test tape 5 was agreed (Kovalevsky , van Leeuwen, Bastian) to be based on IC5. ESOC expected to distribute test tape 5 about 2 weeks after the availability of IC5. (Concerning test tape 5, van der Ha agreed to send the subset of the 1500 or so stars used for the Tycho data stream simulations to Bastian at the same time as the data tape. It would contain abstracts of the main catalogue only—not the double or variable star annexes—and this proposal was acceptable to Turon, since it avoided the need to send the entire IC5 to Heidelberg).

(b) Input Catalogue publication: there was general agreement to include (less precise) 1950 coordinates as well as J 2000, and to minimise the amount of information given in Annexes. Murray had investigated the table settling program (TOPS) used by the Nautical Almanac/HMSO; the information and correspondence was passed to Perryman and Turon.

(c) Kovalevsky presented results of his investigations (with Bec-Borsenberger) into the observability of minor planets (Annex IV) based on the magnitudes and frequency of observability. The conclusion was to include the 12 group 6 objects, the 4 group 5 objects and Bellona and Nemausa from group 4 (48 objects in total). The selection criteria and magnitude limit of observability could, in any case (especially for the marginal case of Nemausa) be re-assessed after launch.

(d) Grenon presented his proposal for objects to be included in the INCA finding charts (Annex V). HST members would investigate whether they could find students who might be willing to spend 4 months or so at Baltimore to complete the work. Grenon felt that this work should start as soon as possible. Once names were identified, Perryman would make further contact with the GSSS team to arrange logistics. Further work on the selection of charts to be included would also be needed.

(e) Europa/Titan: the situation regarding ephemerides was confusing. Turon would request Arlot to send his new theoretical code to Lindegren, and to make a proposal for the necessary convergence of activities.

5. ESOC Aspects

(a) DDID outstanding issues: these are now essentially closed (Annexes VI and VII). Some aspects of IDT datation were still unconfirmed, but it was believed that these should have no impacts on the DRC. Van der Ha would distribute updated pages of the DDID on his return to ESOC (Action 6).

(b) NSL timing: Clausen presented the problem posed by the spacecraft clock instability. It was eventually agreed that the NSL would be formulated in terms of the spacecraft clock. An explanatory note would be included in the DDID (Action 6).

(c) Utrecht (Schrijver) were experiencing problems with the funding of the planned 6250 bpi tape drive. Van der Ha would write a letter explaining the difficulties of switching delivery to 1600 bpi, and Vaghi would investigate loan of OGSE drive if available (Action 7). Utrecht's present software would not allow them to assess B_T and V_T responses separately; this was considered desirable by the project both for performance confirmation, and for contractual incentive (Action 8).

(d) Use of B/V for RTAD: Wills had completed studies of the RTAD performance using the B and V channels. As a result, the B channel would be baselined, but ESOC would have the capability of switching to the V channel, if required.

(e) Solar monitoring: ESOC were already in receipt of solar activity information (Annex VIV). Turon would investigate, with F. Crifo, if this was adequate and advise Perryman (and/or Lantos) if the Meudon data was not needed throughout the mission (Action 9).

(f) Test tape 5: van der Ha confirmed that the test tape would be fully representative, cover some 4 hours of data, and include a Tycho tape (Annex IX). The schedule was now tied to the completion of IC5 by INCA (see item 4a above).

(g) Orbit determination errors: van der Ha presented the main results of the errors on the orbit determination (Annex X). A report was handed to Kovalevsky. Residuals had a sidereal day period. Optical position determinations were not mandatory, but still might be attempted by CERGA and CUO.

(h) A very preliminary time-line for commissioning activities was presented by van der Ha (Annex XI).

6. Book status

Version 3 was handed to HST members at the meeting, and had been sent by post to other 'participants' on 10 February. Final (inflexible) deadline for comments was 17 March. In view of the assistance provided, Turon was invited as assistant editor to the INCA Volume, and Lindegren and Murray to the DRC volume.

The following changes had been made and approved by the HST: H_p for Hipparcos magnitude (in place of H or m_H) as suggested by Grenon, and 'sphere solution' in the place of 'sphere reconstitution' as proposed by Lindegren. For the final version it was proposed to rename 'attitude reconstitution' as 'attitude determination'.

For final reviewing, names were assigned to the INCA and DRC chapters. In addition Murray was invited to review the notation, glossary, and abstracts for the DRC volume, Turon and Grenon to review the INCA glossary, and van der Marel to review aspects of the DRC general notation.

7. Data Reduction Aspects

(a) FAST/NDAC/TDAC Status: for FAST, Kovalevsky reported that all software had been received by CNES, although not yet accepted. Completion was due end May beginning June. CNUCE were undertaking studies of the global sphere solution. Frascati (Badiali, Cardini) were dealing with double stars (with Mignard, Walter and Bernstein).

For NDAC, Høg reported that the Copenhagen great-circle data management system was not yet available. Photometry software was also not yet available. Lindegren reported that the double star software was not yet completed, but was not needed until at least a year after launch.

For TDAC, Høg reported that updated test reports and documentation was expected by mid-April. All TIC input data was now available in Strasbourg, and a real TIC was expected to be available April/May. To facilitate and promote links between INCA and TDAC, Høg reported that Turon had been proposed as a consultant to TIC production, and Bec-Borsenberger as consultant to minor planet prediction.

(b) IDT/SM attitude/GCR comparisons: there was no progress to report on IDT/SM comparisons (van Leeuwen). For attitude comparisons, van der Marel did not consider that further work could be done in the Netherlands. Donati, however, reported that the necessary comparison software had nearly been completed in CSS. The following related actions were agreed upon: (i) FAST (Kovalevsky) will provide to CSS a test tape in TDAC (= FAST external) format in early March from CERGA/CNES; (ii) Høg will send to CSS a test tape in NDAC format, along with a specification of the format from Copenhagen at end February; (iii) Donati will assess the specifications, readability, etc. to confirm if the formats are suitable, or to propose alternatives, if necessary in conjunction with Bastian (who has already agreed to provide reading/transformation facilities from NDAC to TDAC format). Donati noted that they were waiting for ASI approval to run the comparisons during the mission, but that in any case, some comparisons would be done in Torino.

For the GCR comparisons, van der Marel presented a status report (Annex XII) and a description of test results obtained so far. He reported that the comparison software would be written at Delft, the GCR for comparisons should be selected by Schrijver, and the comparisons will be run once per month at Leiden under the supervision of Le Poole.

8. Miscellaneous

(a) Nature paper: HST gave their comments on the 'Nature' paper drafted by Perryman. The following names were added to the list of task leaders: Galligani, van Daalen (FAST), Lederle (INCA), Snijders, Murray, Cruise, Lund (NDAC).

(b) the film would be availabe in one week or so. Modifications had been made following HST comments, and Le Poole would participate in the final editing.

(c) COSPAR 1990: Kovalevsky reported that the organisation was proceeding. Lindegren was now on the organising committee, and that COSPAR will confirm the symposium after their meeting of 7-8 March.

(d) Aeritalia Press Conference: Høg, Donati and Grenon would attend, the latter two making short presentations.

(e) Workshops: the UK RAL workshop was mentioned, as was a possible ESOC lecture by Yatskiv on 16/17 August, 1989 (on the project for space astrometry in the USSR).

(f) Bulletin Board: Vaghi distributed notes on the use of and access to, the Hipparcos bulletin boards (SPAN and EARN) set up in ESTEC.

(g) HST after launch: following HST proposals it was suggested to augment the HST after launch by inviting P.L. Bernacca to join the present composition. A technical committee could be composed of the present HST (perhaps without Bernacca, Crézé, Grenon and Murray) but complemented by Bastian, Schrijver, Mignard and Petersen. The former would meet, say, twice per year, the latter 4 times per year with working group meetings run by panel chairmen, perhaps as follows: Donati (attitude), van Leeuwen (star mapper), Lindegren (IDT and sphere), van der Marel (GCR), Mignard (double stars and photometry) and Schrijver (instrument calibration). In any case all persons would be able to participate in both meetings, if so desired.

9. Future Meetings

INCA (6-7 March, Paris), NDAC (3-5 April, Cambridge), TDAC (1-2 June, Strasbourg), FAST (8-9 June, Milan). A future HST and/or DDID was not necessarily foreseen, but if needed the following two dates (one-day meeting) were set aside: 13 June (assuming launch at end June/early July) or 27 June (assuming delayed launch), probably at ESOC.

M.A.C. Perryman

20 February 1989

esa estec

HIPPARCOS

MEETING HIPPARCOS

PLACE ESTEC

REF. 20th HST

DATE 15-16/2/89

PAGE

ACTION No	DESCRIPTION (not more than 4 lines)	CLOSING DATE	ACTIONNEE Person/firm	INITIATOR Person/firm
1	Update format for IDT/SM comparisons	overdue	F. van Leeuwen	
2	Complete software readiness review form / Point Comparison	—	J. Kovalevsky	
3	Turon to request Arlot to clarify ephemerides situation of Europa/Titan	end March	C. Turon	
4	Submit names of persons from INCA/NDAC/FAST/TDAC at own expense	15 March	Kovalevsky/Høg/Turon	
5	—— " —— attending ESOC/ESA/ESTEC/Arianespace	end May	—— " ——	
6	Distribute update pages of DDID, covering closed issues and NSL	end February	J. van der Ha	
7	a) Write to Schrijver/Lemmon about inability to switch to 1600 bpi b) Investigate 6250 bpi drive (OGSE) loan possibility	— " — "	J. v. der Ha S. Vaghi	
8	Investigate running s/w for B_T and V_T response determination	end March	H. Schrijver	
9	Investigate suitability of ESOC solar monitoring data	end March	C. Turon	

Signatures

Annex I

Twentieth Meeting

of the

HIPPARCOS SCIENCE TEAM

ESTEC (Room 16133), 15-16 February 1989

(Start of meeting: 09:30 on Wednesday 15 February)

PROVISIONAL AGENDA

1. Project/Korou/satellite status (09.30-09.45) (Hassan)

2. Action Item Review closed issues (09.45-10.00)

3. Payload aspects (10.00-10.30):
   - Tycho Calibration status (Batut)

4. INCA aspects (10.30-12.00):
   - status of INCA/ESOC interface and INCA schedule (Turon/Schutz)
   - proposed format for Input Catalogue publication + RGO (HST)
   - observability of minor planets, HST19.1 (Kovalevsky)
   - finding charts (Grenon) and GSSS (Perryman)

5. ESOC aspects (12.00-16.30):
   - DDID open issues: IDT datation, coil currents (van der Ha)
   - NSL timing (van der Ha/Schutz)
   - Utrecht tapes (van der Ha to request of Schrijver)
   - use of B/V for RTAD (Wills)
   - solar monitoring (van der Ha)
   - status of test tape 5, contents, and use for TDAC (van der Ha)
   - orbit determination (optical) + error report (Pallaschke 19.19)
   - time line for commissioning (van der Ha)

6. 'Book' status (16.30-18.00)

Thursday 16 February

7. Data Reduction aspects (9.00-12.00):
   - status/problems within FAST, NDAC and TDAC (Kovalevsky/Hoeg)
   - IDT/SM/GCR/attitude comparison (FvL 19.9, FD/HvdM 19.10)
   - 'point comparison' and SRR (Kovalevsky, 19.11)

8. Miscellaneous (12.00-13.00)
   - Nature paper (HST comments)
   - film status (Perryman)
   - COSPAR 1990 (Kovalevsky)
   - Aeritalia press visit
   - HST after launch (HST views and conclusions)

9. Any other business, future Hipparcos meetings, next HST meeting

Distribution: Hipparcos Science Team
ESTEC: H.Hassan, S.Vaghi, R.D.Wills, K.Clausen, O.Pace, K.van Katwijk, T.Batut
ESOC: J. van der Ha, A. Schutz

NOAUP

P/L ASPECTS

TYCHO CALIBRATION STATUS

MAIN FIELD PHOTOMETRIC ANOMALY

THIERRY BATUT

15th FEB. 89

ANNEX II

1 - TYCHO CALIBRATION STATUS

11 - STATUS IN OCTOBER 88

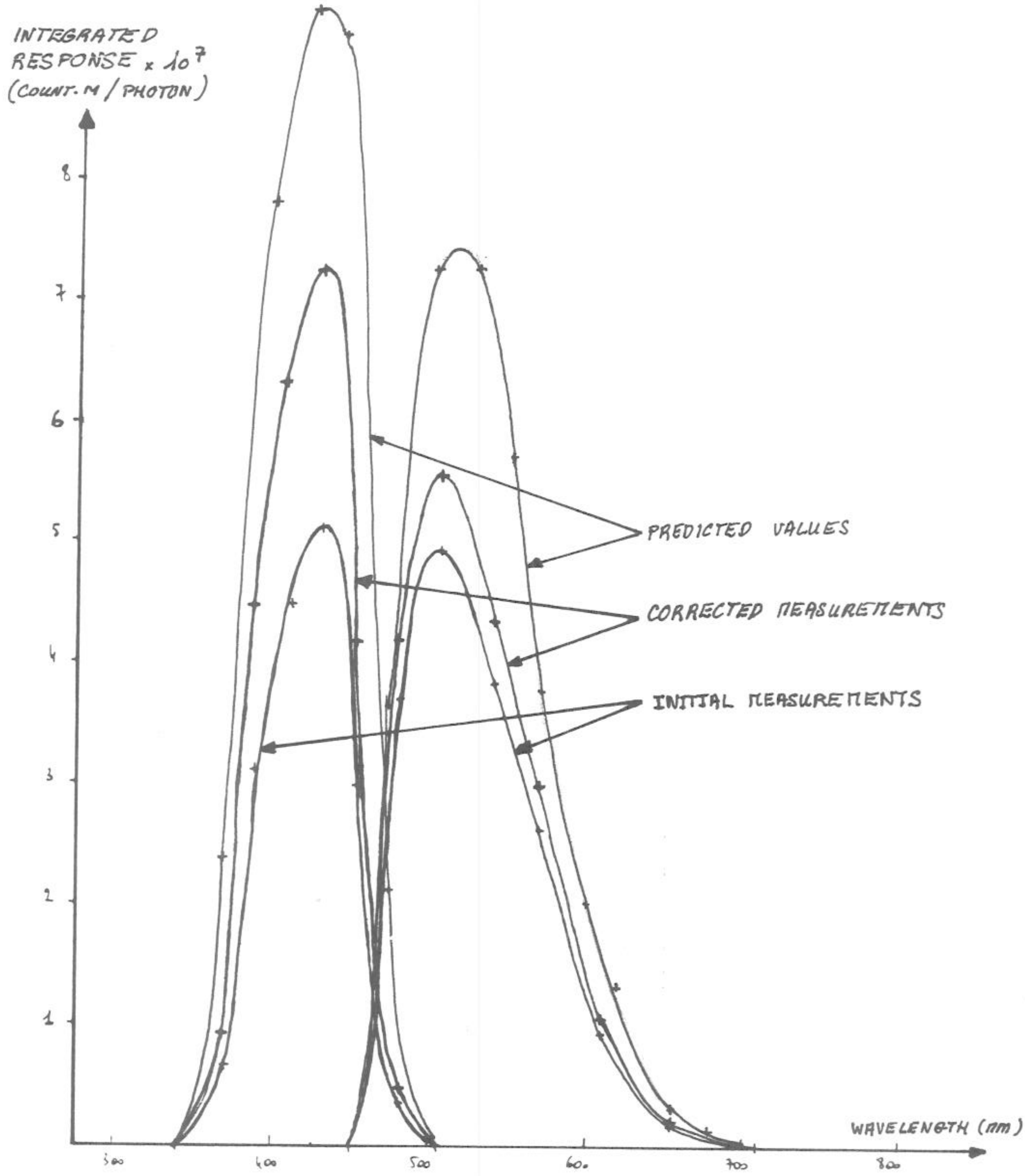
- MEASURED PERFORMANCES ABOUT HALF OF PREDICTIONS
- IMBALANCE BETWEEN BLUE AND VISIBLE SIGNALS FOR B-V = 0.7

12 - EVOLUTION SINCE LAST HST

121 - IMPROVEMENT OF PERFORMANCES

- MISTAKE FOUND IN POST-CALIBRATION PROCESSING WHICH AFFECTS ONLY ABSOLUTE PHOTOMETRIC MEASUREMENTS
- CALIBRATION REPORT UPDATED ACCORDINGLY
- CORRECTED RESULTS STILL ABOUT 30 % LOWER THAN PREDICTIONS
- DIFFERENCES BETWEEN MEASUREMENTS AND PREDICTIONS CAN BE EXPLAINED BY A NUMBER OF INACCURACIES ON BUDGET INPUTS AND CALIBRATED PARAMETER.

TYCHO PERFORMANCES IMPROVEMENT



DTSS 1 - AVERAGE FOV1 / FOV2
VERTICAL SLITS

TYCHO PERFORMANCES IMPROVEMENT

PHOTOMETRIC PERFORMANCES	B_T σ_{B_T} (mag)	V_T σ_{V_T} (mag)	SPEC σ_m (mag)
$(B+V)/2 = 9.65$			
$B-V = 0$	0.124 (0.154)	0.154 (0.164)	0.375
$B-V = 0.7$	0.174 (0.219)	0.139 (0.149)	0.250
$B-V = 1.5$	0.254 (0.327)	0.115 (0.123)	0.375
ASTROMETRIC	**σ_A (ARCSEC)**	**SPEC (ARCSEC)**	
$(B+V)/2 = 9.65$			
$B-V = 0$	0.070 (0.072)	0.150	
$B-V = 0.7$	0.080 (0.091)	0.100	
$B-V = 1.5$	0.075 (0.083)	0.150	

PARAMETERS RESPONSIBLE FOR POSSIBLE DIFFERENCES BETWEEN PREDICTED AND MEASURED TYCHO INTEGRATED RESPONSES :

CONTRIBUTORS		ATTACHED OVERESTIMATION
INTERPOLATION BETWEEN BUDGETED VALUES		3%
MODEL FOR GRID AND MIRROR REFLECTIVITY		2%
SLIT WIDTH ESTIMATION		3%
ACCURACY ON SSR		5%
ACCURACY ON DICHROIC FILTER TRANSMISSION		1%
ACCURACY ON DETECTION EFFICIENCY		10% *
	TOTAL	24%
INTEGRATED RESPONSE MEASUREMENT ACCURACY		5%
	TOTAL	29%

* SOME DOUBTS CAST ON AVAILABLE MEASUREMENTS ARE NOT REFLECTED IN THE QUOTED NUMBER -

122 - SLIGHTLY DEGRADED PERFORMANCES ON FOV1

- CORRECTION OF TYCHO CALIBRATION RESULTS REVEALED LOWER PERFORMANCES ON FOV1

	B_T		V_T	
	NOM. DTSS 1	RED. DTSS 2	NOM. DTSS 1	RED. DTSS 2
FOV 1	0.85	0.80	0.85	0.76
FOV 2	0.96	1.00 (REF.)	1.00	1.00 (REF.)

- PHOTOMETRIC LOSSES ON TYCHO CHAIN IS LIKELY TO HAVE A DIFFERENT ORIGIN THAN THAT ON THE MAIN CHAIN (GRM COUNTS, VARIATIONS BETWEEN AMBIANT AND VACUUM)

- IN PARTICULAR, THE ANOMALY DOES NOT SEEM TO BE EXPLANABLE BY THE DIFFERENCE BETWEEN REFRACTION INDEXES OF AIR AND VACUUM

13 - FUTURE OUTLOOK

- CONTINUE INVESTIGATION, BUT NO ACTIVITY FORESEEN ON HARDWARE.

2- MAIN FIELD PHOTOMETRIC ANOMALY

21- STATUS IN OCTOBER 88

- PHOTOMETRIC PERFORMANCES DECREASE BY 5% ON ALL FOV/IDT CONFIGURATIONS DUE TO VACUUM. 15% ADDITIONAL UNEXPLAINED LOSS ON FOV1 / IDT2 (ALSO IN CHROMATICITY MODE).
- TEST PERFORMED ON FLIGHT DETECTOR GIVES MORE CONFIDENCE OF STABLE SITUATION

- P/L PERFORMANCES IN SPECIFICATIONS.

22 - EVOLUTION SINCE LAST HST

- MISTAKE FOUND IN CALIBRATION POST-PROCESSING ENHANCED ABSOLUTE VALUE OF DETECTION EFFICIENCY BY A FEW PERCENTS.

- ALL INVESTIGATIONS DONE SO FAR AGAIN THOROUGHLY REVIEWED

- EARLY COMPUTATIONS THAT CONCLUDED TO A VIGNETTING EFFECT WERE INVALIDATED. EVIDENCE IS BROUGHT INSTEAD THAT NO LOSS OF LIGHT OCCUR BUT THAT IT IS SPREAD ON THE PHOTOCATHODE.

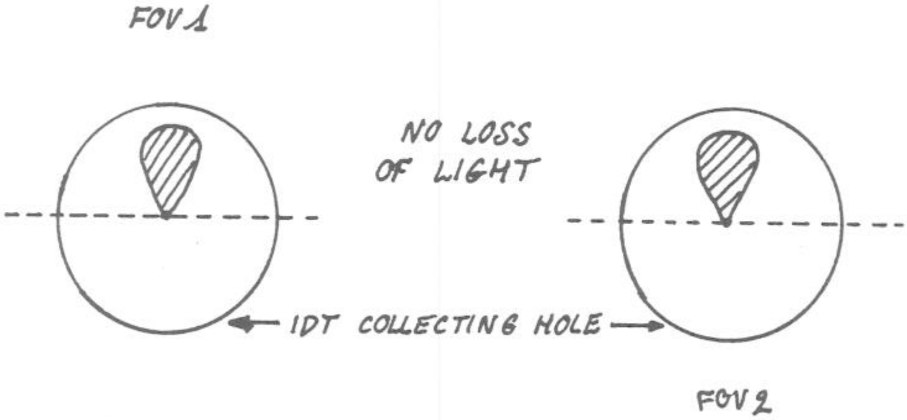
23 - POSSIBLE EXPLANATION OF THE ANOMALY

- VARIATION OF INDEX OF REFRACTION BETWEEN AMBIANT AND VACUUM CREATES A DEFOCUS OF 200 μm IN VACUUM.

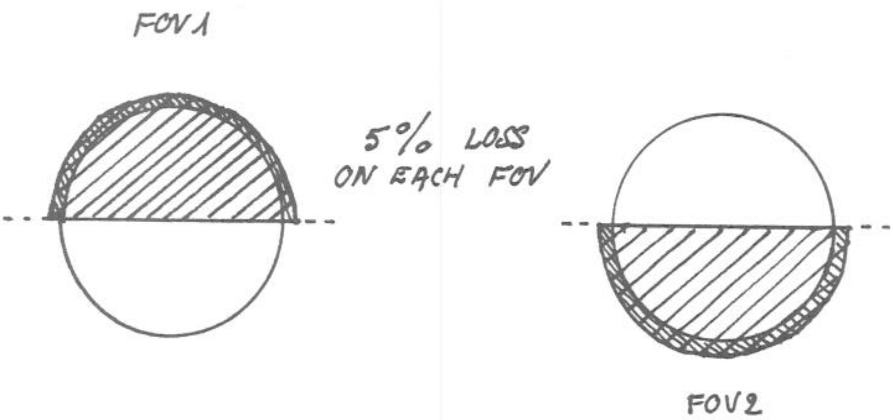
- THIS CAN LEAD TO A 5% LOSS ON BOTH IDTS AND FOVS

- IF THE DEFOCUS IS COMBINED WITH A RELAY OPTICS MISALIGNMENT ON IDT2 IT IS POSSIBLE TO RECONSTRUCT AN ADDITIONAL 15% LOSS ON FOV1 ONLY DUE TO OPTICAL ABERRATIONS.

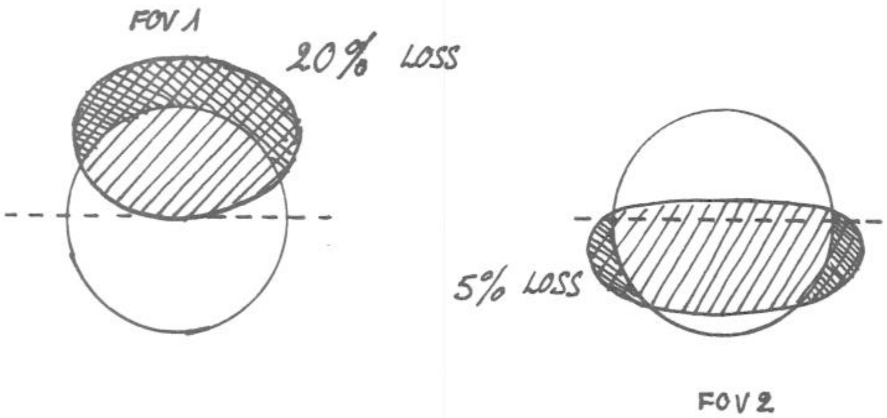
EFFECT OF DECENTERING ALONE :



EFFECT OF DEFOCUS DUE TO VACUUM ALONE:



COMBINED EFFECT :



- THIS SITUATION DOES NOT WORSEN IN ORBIT
- IT HAS TO BE CONFIRMED THAT THIS SCENARIO CAN EXPLAIN ALL OBSERVATIONS.

24 - FUTURE ACTIVITIES

- VALIDATION OF PROPOSED SCENARIO REQUIRES ACCESS TO THE INSIDE OF FPA. GLASS WINDOWS COULD BE USED TO SIMULATE AN IDT DEFOCUS AT AMBIANT.
- CORRECTIVE ACTION CONSIST IN PUSHING IDT 2 BY 200 μm.
- VALIDATION OF REPAIR COULD BE PERFORMED BY MEASURING THE PHOTOMETRIC DEGRADATION DUE TO DEFOCUS, BUT NOT THE IMPROVEMENT ITSELF.

DECISION TO PERFORM CORRECTIVE ACTION WILL BE TAKEN WHEN IMPACT ON

- CALIBRATION VALIDITY
- OVERALL PERFORMANCES (INCLUDING PHASE ERROR)

IS ASSESSED

CONCLUSIONS :

- PHOTOMETRIC PERFORMANCES ON TYCHO MISSION ARE SIGNIFICANTLY IMPROVED AND RESIDUAL DEVIATION WRT PREDICTIONS ARE UNDERSTOOD

- THE IDT PHOTOMETRIC ANOMALY IS LIKELY TO BE DUE TO A COMBINATION OF EFFECT OF PRESSURE ON THE AIR REFRACTIVE INDEX AND OF OPTICS MISALIGNMENT.

- IMPACT OF REALIGNMENT TO BE ASSESSED BEFORE 27^{th}-2 BEFORE ACTIVITIES ARE UNDERTAKEN.

HIPPARCOS PAYLOAD

A. USAGE OF DETECTION CHAINS 1 ∧ 2

- PAYLOAD SPEC : ANY COMBINATION POSSIBLE — see B
- DETECTION DESIGN : GROUPED NOMINAL/REDUNDANT — see C
- RELIABILITY ASPECT : DEGRADED BY ~FACTOR 2 — see D
- THERMAL DESIGN (NOT ANALYSED) {DEB1 + MDA1 / DEB2 + SDA2; DEB2 + MDA2 / DEB1 + SDA1} — see E
- PREFERENCE : DEB1 + MDA1 + SDA1
or DEB2 + MDA2 + SDA2

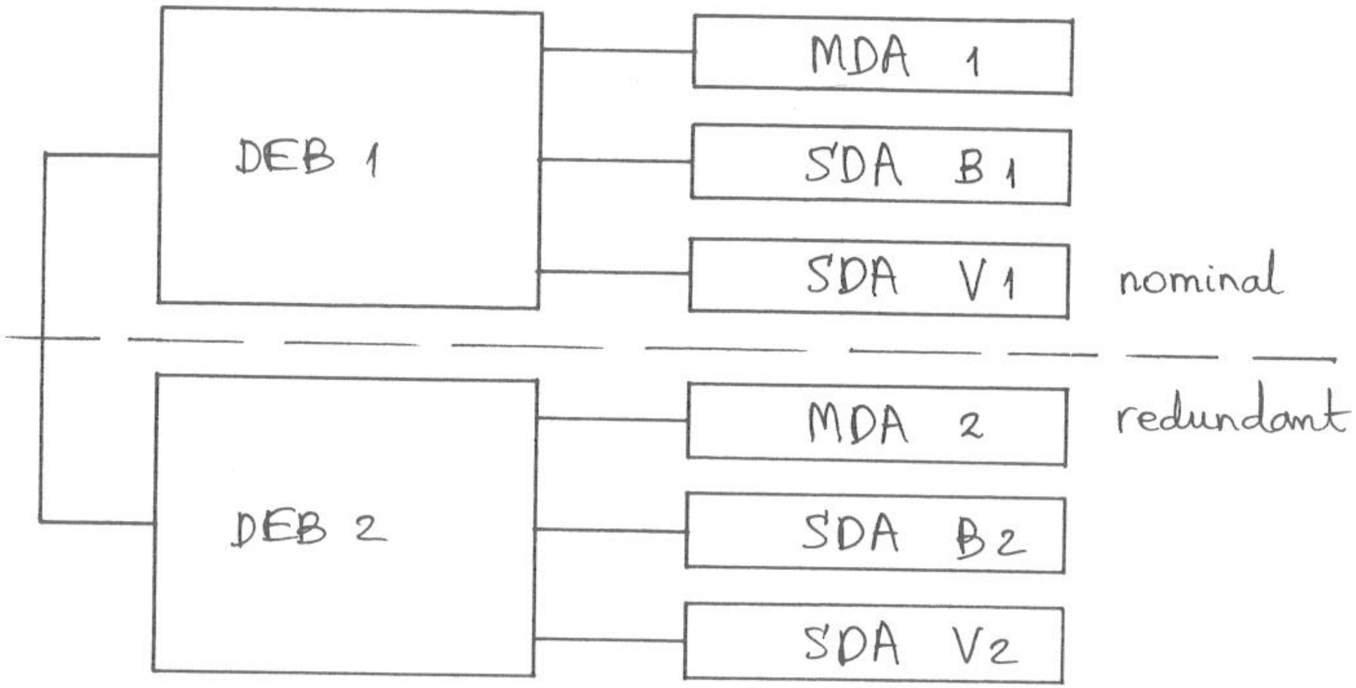
KvK 14/2/89 (2)

B. PAYLOAD SPEC : MDA + SDA COMBINATIONS

DETECTION CHAIN MODES	P1	P2	B_T1	V_T1	B_T2	V_T2
NORMAL REDUNDANT MODES (R = COLD REDUNDANCY)	ON	R	ON	ON	R	R
	ON	R	R	R	ON	ON
	R	ON	ON	ON	R	R
	R	ON	R	R	ON	ON
OFF	OFF	OFF	OFF	OFF	OFF	OFF
PARTICULAR MODES	ON	OFF	OFF	OFF	OFF	OFF
	OFF	ON	OFF	OFF	OFF	OFF
	OFF	OFF	ON	ON	OFF	OFF
	OFF	OFF	OFF	OFF	ON	ON

KvK [redacted] 14/2/89 (3)

C. Detection chains block diagram



KvK [redacted] 14/2/89(4)

D. Reliability assessment of DEB1 + DEB2 usage

component	t (hrs)	DEB1=on DEB2=off CDR analysis		DEB1=on DEB2=on estimate (TBC)	
		1−R	λ*(FIT)	λ(FIT)	1−R
stage 1	480	0,00010	208,34	416,69	0,00020
stage 2	23000	0,02029	891,25	1782,49	0,04017
overall	23480	0,02030	873,46	1746,92	0,04019
target		0,05000	2184,55		0,05000

λ* calculated from $\lambda = -\ln R / t$ $(R = \exp(-\lambda t))$

KvK 14/2/89 (5)

E. DEB temperatures (°C)

configuration DEB1 = off DEB2 = on

condition	SAA	DEB1(−Y)		DEB2(+Y)	
		cold	hot	cold	hot
sunpointing mode	0	−20	−16	0	5
normal mode	43	−14	−4	5	14
uncertainty	—	−7	7	−7	7
acceptance level	—	−25	40	−25	40

configuration DEB1 = on DEB2 = on

condition	SAA	DEB1(−Y)		DEB2(+Y)	
		cold	hot	cold	hot
sunpointing mode	0	?	?	?	?
normal mode	43				
uncertainty	—	−7	7	−7	7
acceptance level	—	−25	40	−25	40

MINOR PLANET OBSERVABILITY

GROUP 5	Nb Obs H<12	Nb Obs 12.0<H≤12.2	Nb Obs 12.2<H<12.5
30 URANIA	4	4	9 (0)
63 AUSONIA	8	6 (6)	0
115 THYRA	4	4	16 (16)
192 NAUSICAA	5	3	4 (0)

GROUP 4			
17 THETIS	0	0	15 (6)
<u>28 BELLONA</u>	10	0	21 (21)
51 NEMAUSA	0	8 (8)	22 (14)
89 JULIA	0	0	12 (0)
			12.8 ≳ H<12.5

GROUP 3 21, 24, 45, 52, 97	0	N (N)	N'
GROUP 2 46, 65, 68, 423	0	0	0 Few
GROUP 1 49, 171, 337, 433	0	0	0 No

STARS REQUIRING Identification Charts from GSC

1. Stars without BD or CpD designations & with BD, CpD but $m_{Hp} \gtrsim 10$
2. Stars with CoD designation but fainter than m_v 9.5 (CoD)
3. All stars in clusters < 1000 *
4. All stars in LMC, SMC ~ 105 *

~ 15000 * fainter than $Hp = 10$

CHARTS NOT NECESSARY for :

1. Stars with G, GD, GR numbers (Lowell Obs.)

   4788 G-numbers *
   3664 without redundancy with LHS
   > 2774 * in I. Catalogue (8th Vers.)

2. Stars with LHS number & Chart

   1379 LHS
   1339 without redundancy
   1174 * in I Catalogue (8th Vers.)

Σ > 4223 faint * with Charts

ANNEX IV

ANNEX V

ANNEX VI

2.0 DDID STATUS

2.1 *UPDATE PAGES RELEASED:*

- Standard Label is 2
- Detailed definition of CATHKMS (mechanisms microswitches)
- Explanation of bit 5 of Overall Quality Flags
- Definition of Dummy Star Flags
- Precise Datation of AOCS Telemetry
- Inclusion of NSL Heliotropic Angle in AOCS Data
- Correction of IDT Monitoring File Length
- Valid CCCM File Always Available on Tape
- Update of Numbering of Planets and Minor Planets
- A Number of Outstanding Minor Updates and Corrections

2.2 *REMAINING OPEN ITEMS:*

- CCCM eta0 and zeta0
- IDT Datation (MATRA inputs not yet available)
- Coil Currents (MATRA inputs not yet digested)
- Spacecraft Clock Stability Effects (if any)

4.0 NSL DATATION

4.1 TWO OPTIONS:

- NSL Referred to GMT (Baseline)
- NSL Referred to Spacecraft Clock

4.2 ASPECTS OF OPTION 1:

- Already Embedded in DRC Software
- Adverse Effects due to Spacecraft Clock Performance
- Errors in Nominal Star Crossings may be Unacceptable
- Errors may be Reduced Somewhat by ESOC Software Support

4.3 ASPECTS OF OPTION 2:

- NSL Nominal Star Transits Accurately Determined (A Posteriori)
- Appears to be 'Catastrophic' for DRC Software
- Introduces Difficulties Also in ESOC Software Support

4.4 Spacecraft Clock Drift Characteristics:

- Initial Frequency Error Below 10 ** -5 : almost one sec per day
- Short-Term Stability Below 2 10 ** -6 : 2 microsec per sec
- Ageing: Below 5 **10 -6 over one year
- Environment: Below 2 ** 10 -5 over Temperature Range and Life

4.5 Ground Station Clock Characteristics:

- Drift Below 10 ** -12 : almost 0.1 microsec per day
- Resolution of 0.2 microsec
- Absolute Datation of Order of 1 microsec by Loran-C Resets

ANNEX VII

SUMMARY OF HIPPARCOS ON-GROUND TELEMETRY DATATION

89-02-14

Jozef C. Van der Ha
ESA / European Space Operations Centre
Darmstadt, FRG

Table of Contents

1.0 INTRODUCTION **2**

2.0 NSL AND PSF DATATION **3**

3.0 ON-BOARD DATATION **4**
3.1 Timing for Telemetry Datation 4
3.2 On-Board Telemetry Datation 4
3.3 Spacecraft Clock Characteristics 4

4.0 ON-GROUND DATATION **6**
4.1 On-Ground Datation of Spacecraft Clock 6
4.2 Ground Station Clock Characteristics 6
4.3 Error sources in on-ground datation 7

5.0 REFERENCES **8**

1.0 INTRODUCTION

There are quite a number of different aspects related to the datation of the scientific telemetry data downlinked by the HIPPARCOS satellite. For the purpose of simplification, the datation aspects are categorised as follows:

1. NSL and PSF Datation
2. On-board Telemetry Datation
3. On-ground Telemetry Datation

A short overview of the main characteristics of each of the two first points is given below.

The main purpose of the present Note will be to provide an overview of the essential aspects of the last point.

2.0 NSL AND PSF DATATION

The first point refers to the datation of the nominal star transits based on the NSL and is addressed in detail in Schuetz' note (Ref. 1). There are basically two options, i.e.

1. NSL time referred to GMT (baseline assumed up to now)

2. NSL time referred to spacecraft clock

The main advantage of the latter option would be the fact that the datation of the NSL and associated nominal star crossings can be performed with extremely good precision. This datation is done a posteriori by time-tagging of the spacecraft clock time by the ground station for every telemetry frame. There are also a number of disadvantages, mainly the fact that it introduces complicated modifications in the DRC software at this late stage. Also ESOC software would need modifications, particularly in those areas where use is made of a satellite phase angle.

In the case that the first option prevails, there is no impact on the DRC's as their software has been built on this basis. However, ESOC will have to make adaptations to the PSF preparation and/or uplink software in order to minimise the effect of on-board clock drift on the accuracy of the nominal star transits.

The following suggestions should be considered and evaluated:

- The history of the on-board clock drift using the ground station datation can be determined. The drift history may then be extrapolated into a model (of the 'running' type) where parameters are adjusted at daily or hourly intervals depending on most recent spacecraft clock correlations performed by the ground station clock (or, in fact, the computer clock).

- The nominal star transit times could be corrected using the clock correlation model established above. This correction should take account of the expected clock offset at the nominal transit time of the star and should preferably be done at the latest possible time before uplink.

Technically, however, it appears that the on-board clock performance is such that even with these provisions, errors in the NSL nominal transits of the order of a number of arcsec may occur.

3.0 ON-BOARD DATATION

3.1 Timing for Telemetry Datation

The on-board time representation used in the datation of the telemetry data is described in MATRA documentation, e.g. IF.3.00.4, page 71 (Ref. 2). The essential principle is that events can be timed relative to the start of telemetry frames and formats which are specific instants defined by the spacecraft clock. In the case of the AOCS telemetry data, a detailed definition of the precise datation of each of the telemetry entries has been established recently, see Ref. 3.

On the precise datation of the IDT and SM data, inputs from MATRA are still outstanding at the present time.

3.2 On-Board Telemetry Datation

The spacecraft clock provides a time-tag to the start of each telemetry frame, i.e. $(t_n)_{SC}$ for frame number n. Due to the drift of the spacecraft clock, the intervals between the telemetry frames are not exactly identical. These intervals, however, will be determined with good precision by the ground station clock datation. Therefore, the link between the on-board datation of a particular event and the more accurate on-ground datation of the same event is provided by the datation of each frame startsby the ground station clock.

3.3 Spacecraft Clock Characteristics

The spacecraft clock has the following performance characteristics (see IF.3.00.4, page 76):

- Initial error in clock frequency of less than 10 ** -5 whcih leads to a constant error of almost one sec per day
- Short time stability of less than 2 10 ** -6 over a 10 sec interval
- Ageing of less than 5 10 ** -6 over one year
- Environmental effects of less than 2 10 ** -5 over full temperature range at any point in time

After calibration of the initial error, the remaining drift is of the order of 10 ** -5 or about 1 sec per day. This results in a maximum error of 7 arcsec after one hour. In the case of a full on-board PSF buffer of about 2.5 hours, the error in the nominal crossing time could amount to almost 20 arcsec (which is un-acceptably large), even when a clock correlation is performed shortly before uplink of the PSF data. Furthermore, any interruption in PSF uplinks would result in instantaneous jumps in the reference NSL attitude and would disrupt the RTAD performance.

4.0 ON-GROUND DATATION

The principal aspects of on-ground datation of telemetry data and associated error sources will be addressed now.

4.1 On-Ground Datation of Spacecraft Clock

The timing provided by the spacecraft clock on-board is 'reproduced' on-ground by datation of the start of each telemetry frame immediately on arrival at the ground station. This time (i.e. in UTC units) is available on the DRC tapes (see Ref.4, page 35) and is expected to have an absolute accuracy of the order of 1 microsec. In order to be able to keep track of datation fluctuations down to the telemetry frame level, the frame datation information will be provided on the DRC tapes in the AOCS data file.

The following functional relationship between the two datations by spacecraft clock (SC) and ground station clock (GC) is valid:

$$(t_n)_{GC} = (t_n)_{SC} + (\delta_n)_{SC} + PD , \qquad (1)$$

where δ represents the drift of the spacecraft clock relative to the ground station clock and PD is the signal propagation delay induced by the distance between the satellite and the ground station.

The spacecraft frame datation $(t_n)_{SC}$ is available in the downlinked telemetry and the propagation delay can be estimated from the available orbit data and known ground station position. Therefore, Eq, (1) provides us in principle with the instantaneous clock drift at the start of each frame, i.e. the satellite 'time' as a function of UTC.

4.2 Ground Station Clock Characteristics

The datation by the satellite ground station cesium clock is extremely accurate as seen from following characteristics:

- Drift below 10 ** -12 (sec per sec)
- Resolution of 0.2 microsec
- Absolute datation better than 1 microsec (under weekly drift updates using LORAN-C signals)

4.3 Error sources in on-ground datation

The on-ground datation does not take account of the propagation delay due to the distance spacecraft-ground station. In order to find the corresponding time of the start of the telemetry frame on-board, the propagation delay must be calculated from the orbital data provided by ESOC and subsequently subpracted from result in (1). The maximum error in the calculation of the propagation delay due to ionospheric effects is 0.15 microsec and due to orbit determination errors is below 0.2 microsec. In addition, effects due to ground station equipment delays must be taken into account; these are expected to be of the order of 0.1 microsec.

A more detailed breakdown of absolute and relative errors in the datation budget is given in Ref. 5.

5.0 REFERENCES

1. A. Schuetz, HIPPARCOS PSF Timing, PROFS Note 88347ESC0026 of 12.12.88.
2. Satellite and GSE/Ground Segment Interface Control Document, IF.3.00.4, Issue 6. 30.7.87.
3. J. Van der Ha, Precise Datation of AOCS Telemetry, DDID Update, 22.12.88.
4. DDID Issue 5, September 1988.
5. J. Van der Ha, On-Ground Datation Errors of Telemetry Data, OPS/SPSD/PMD(870331)6.

ANNEX VIII

ZCZC 640287 32I284 IT4510

+
1150 RUNDSEN D
4197193 ION D (10.02 07.38)

TELEX-NR. 04/10

FROM IONOSPHAERE DARMSTADT

TO

1. ESOC DARMSTADT
   ATTN: MR WILKINS, DR FLURY, MR MAERTENS, MR KOUWENBERG

2. RFE/RL, BOX 85

3. SESAT LUXEMBOURG

SDF NUMBER 040
JOINT USAF/NOAA REPORT OF SOLAR AND GEOPHYSICAL ACTIVITY.
ISSUED 2200Z 09 FEB 1989
IA. ANALYSIS OF SOLAR ACTIVE REGIONS AND ACTIVITY FROM 08/2100Z TO 09/2100Z: SOLAR ACTIVITY WAS HIGH. REGIONS 5354 (N30E15) AND 5355 (N24E32) COMBINED EFFORTS TO KEEP THE ACTIVITY LEVEL HIGH BY PRODUCING AN X3 X-RAY FLARE AT 09/1301Z. THIS FLARE WAS OPTICALLY 1B IN REGION 5354 AND 2B IN REGION 5355. REGION 5354 REMAINS THE MOST COMPLEX REGION ON THE DISK. NEW REGION 5358 (S29W07) WAS NUMBERED TODAY.
IB. SOLAR ACTIVITY FORECAST: SOLAR ACTIVITY IS EXPECTED TO BE MODERATE TO HIGH. MAJOR FLARES ARE POSSIBLE FROM REGIONS 5354/5355. C-CLASS ACTIVITY IS POSSIBLE FROM REGION 5347 (N17W23).
IIA. GEOPHYSICAL ACTIVITY SUMMARY FROM 08/2100Z TO 09/2100Z: THE GEOMAGNETIC FIELD WAS QUIET TO ACTIVE.
IIB. GEOPHYSICAL ACTIVITY FORECAST: THE GEOMAGNETIC FIELD IS EXPECTED TO BE MOSTLY UNSETTLED THE FIRST DAY OF THE FORECAST. THE FIELD IS EXPECTED TO BE MOSTLY ACTIVE THE LAST TWO DAYS AS A RESULT OF THE RECENT FLARE ACTIVITY.
III. EVENT PROBABILITIES 10 FEB-12 FEB
CLASS M   90/90/90
CLASS X   40/40/30
PROTON   25/25/25
PCAF   YELLOW
IV. OTTAWA 10.7 CM FLUX
OBSERVED   09 FEB 277
PREDICTED   10 FEB-12 FEB 300/310/310
90 DAY MEAN   09 FEB 205
V. GEOMAGNETIC A INDICES
OBSERVED AFR/AP 08 FEB 010/012
ESTIMATED AFR/AP 09 FEB 014/015

ANNEX IX

3.0 TEST TAPE 5

3.1 CONTENTS:

- Two Intervals of at least 2.15 Hrs
- SM Data (first time)
- Representative HK Data (first time)
- CCCM Data (first time)
- Payload Monitoring File (first time)
- Consistent Orbit and Eclipse Files

3.2 FURTHER CHANGES:

- Different Tapes for FAST/NDAC and TDAC
- Latest DDID Changes Included
- Errors Identified in Tape 4 Corrected (if Possible)
- Star Catalogue: IC-5 (if Available)
- Nominal Star Mapper Used

3.3 IDT & SM ERROR SOURCES INCLUDED:

- Field-to-Grid Transformation (IDT and SM)
- Photon Noise (Already in Tape 4)
- MTF Variation (in polynomial form)
- Constant Background
- Realistic SSR Model
- Photometric Model Based on Simulations Reports

3.4 SCHEDULE:

TAPE IS FORESEEN TO BE READY BY EASTER

Annex IX

HIPPARCOS ORBIT DETERMINATION ERRORS

Orbit determination errors are caused by

- measurement inaccuracy

  RMS angles .02°

  RMS range 10 m

- model inadequacy

  solar radiation pressure as example

- poor observability

  location of ground station used, longitude separation, geometry

Orbit determination errors

- eccentricity error .85 10^{-5}

  amplitude radial (a e) .4 km

  longitude (2e) .7 km

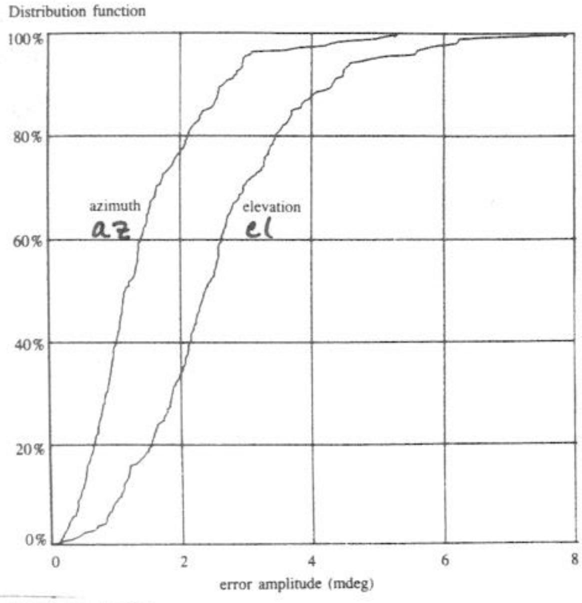
- inclination error .004°

  amplitude latitude 2.8 km

- mean longitude error .002°

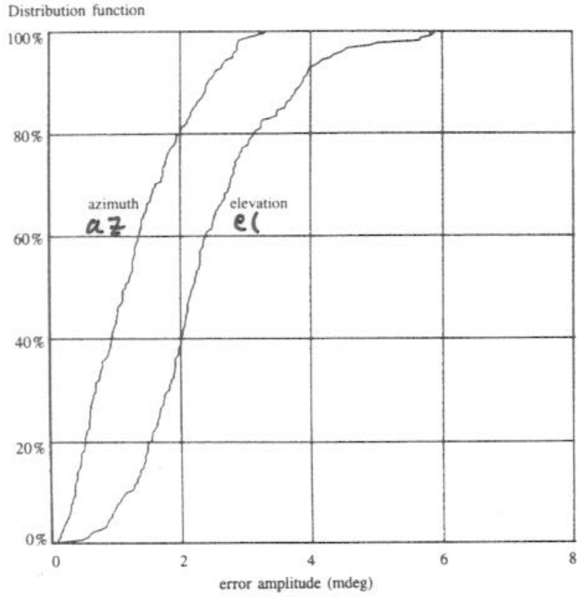
  1.5 km

1 year of TMS-1 antenna angle residuals for ECS-1.

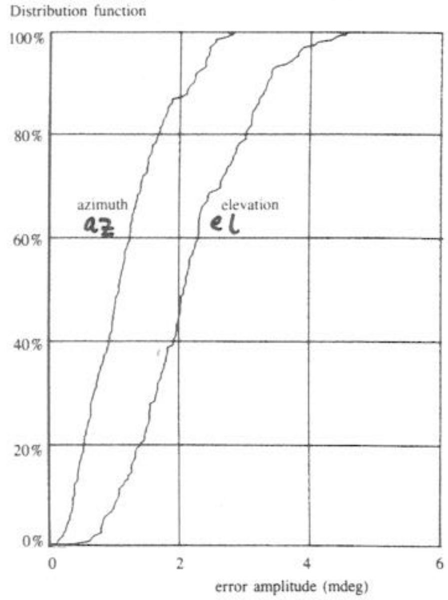


2 days

→ amplitude of sinusoidal residuals

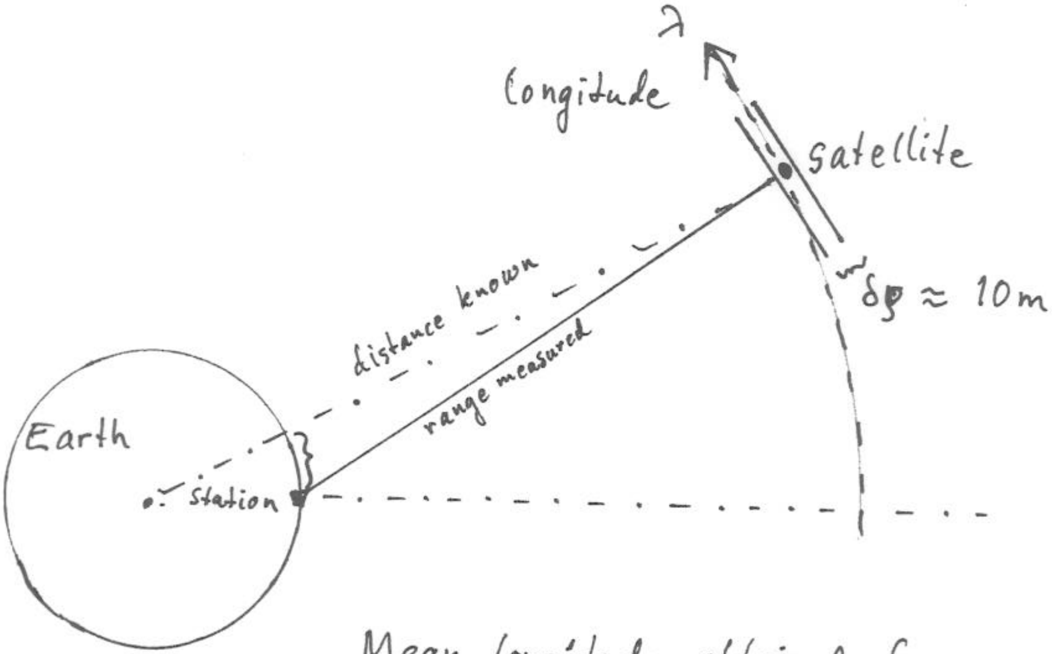


4 days

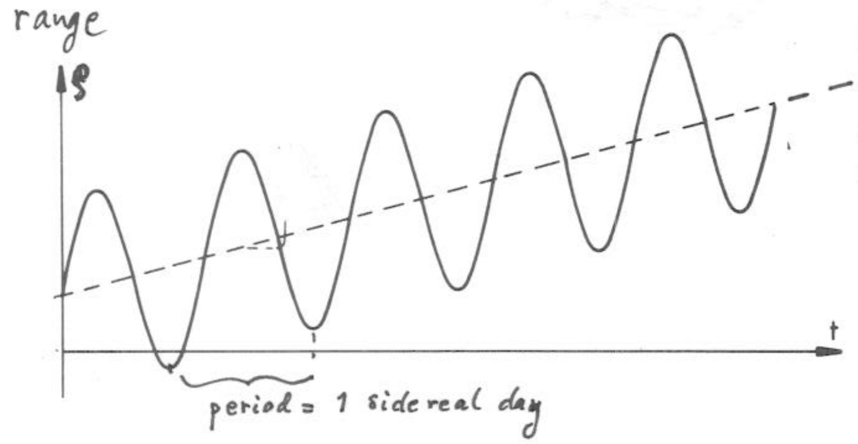


8 days tracking interval

(HIP antenna is ~ 10× worse)



Mean longitude obtained from ranging.

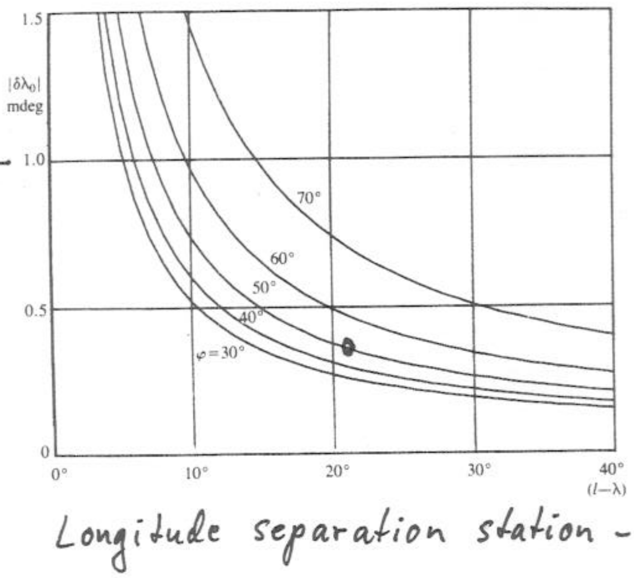


Slope ⇒ longitude drift ⇒ semi-major axis ⇒ distance satellite – earth.

Distance & range ⇒ mean satellite longitude

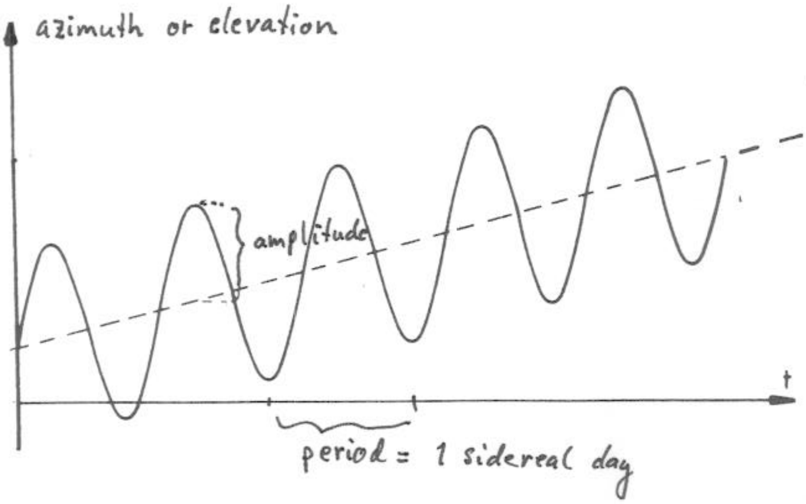
Error in mean longitude.

0.001° = 0.75 km

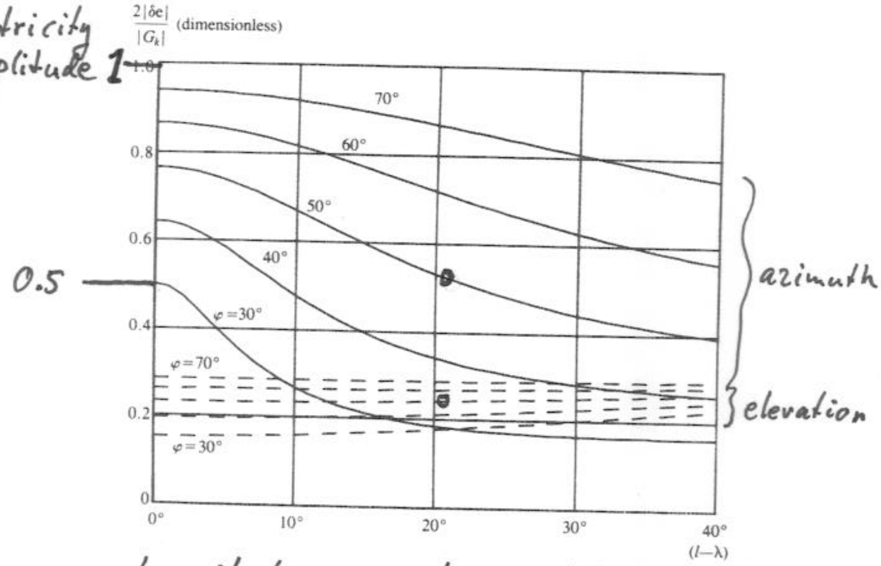


Longitude separation station - satellite

o HIP

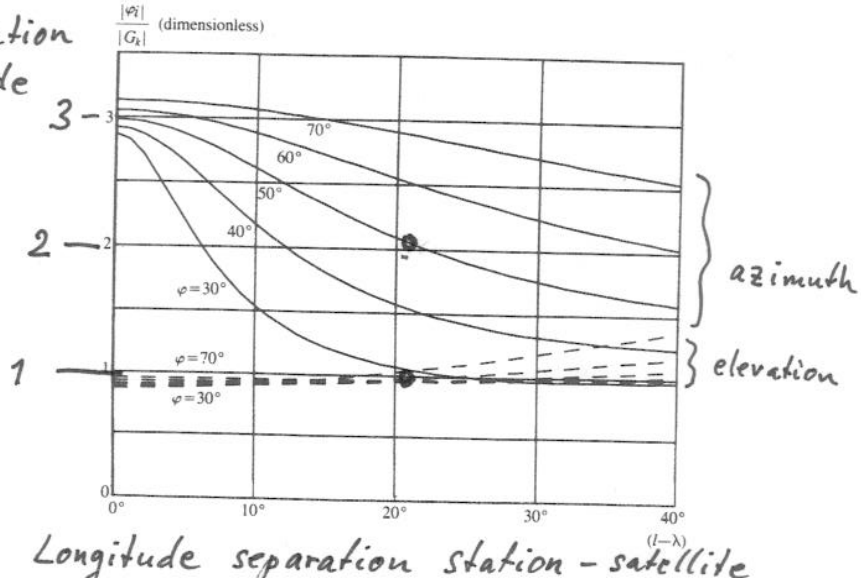


Error in longitude caused by eccentricity librations / amplitude



Longitude separation station – satellite

Error in inclination vector / amplitude



Longitude separation station – satellite

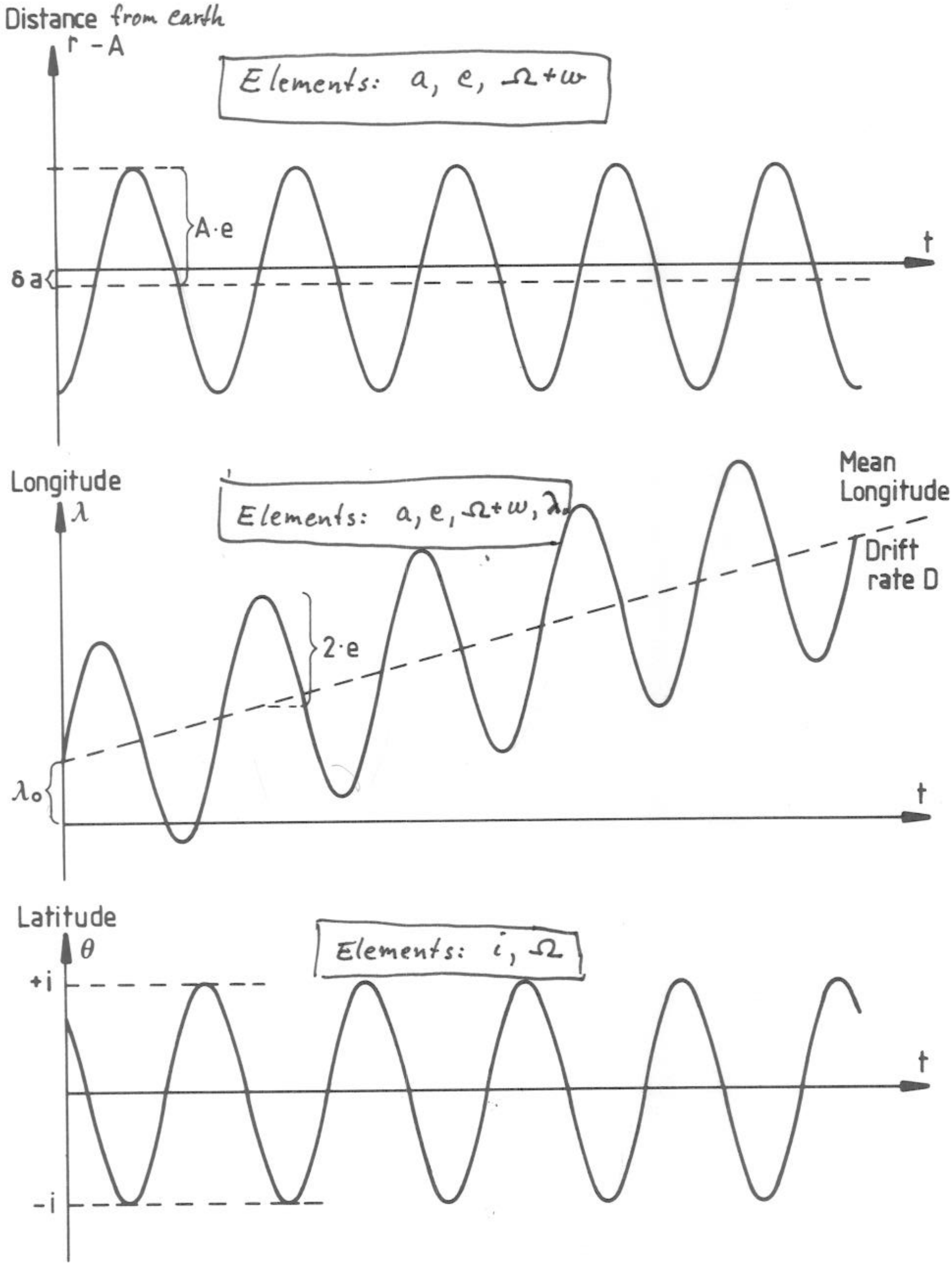


Figure 9. Linearised unperturbed spacecraft motion, given as distance (r), longitude (λ) and latitude (θ). The sinusoidal libration of each component has the period of one sidereal day.

ANNEX XI

Day	PAR	Calibration Task	DC Time	DP Delay	UP	CRI	IDT	SM	PL	PSF	Notes
1		ISPA & GRM Trans Offset	0.25 2.25	2.0 4.0	X X	X X	2 2	2 2	X X		
2		GRM Refocussing	0.0 6.0	1.0 24	X X		2 2	2 2	X X		
3	 X X X X X	GRM SSR Large Scale SM Photomet. SM Chromatic. Large Stabil.	0.0 3.8 10.7 24.0 5.0 24.0	1.0 4.0 DRC DRC DRC 24	X X X		2 2 2 2 2 2	2 2 2 2 2 2	X	(X)	
4		GRM Chromaticity Photometric	0.0 1.1 12.0	1.0 24 DRC	X		2 2 2	2 2 2	X X	X	
5-8		GRM IFOV Profile	0.0 47.0	1.0 48	X		2 2	2 2	X X		
9		GRM Medium Scale	0.0 6.5	1.0 DRC	X		2 2	2 2	X X	X	
10	 X X X	Switch IDT/SM ISPA & GRM SSR SM Photomet. Large Scale	0.0 0.25 3.8 24.0 10.7	1.0 2.0 4.0 DRC DRC	 X X X	X X	2 1 1 1 1	2 1 1 1 1	X X	(X)	
11		GRM Photometric	0.0 12.0	1.0 DRC	X		1 1	1 1	X		
12		GRM Large Scale	0.0 10.7	1.0 DRC	X X		1 1	1 1	X	X	
13-16		GRM IFOV Profile	0.0 47.0	1.0 48	X		1 1	1 1	X X		
17		GRM Jitter	0.0 2.0	1.0 24	X		1 1	1 1	X X	X	
18		GRM Large Scale	0.0 10.7	1.0 DRC	X X		1 1	1 1	X	X	
Event		Stray	0.1				-	-			
Event		Ba. Ang. Sta.	2.5				-	-		X	

DRAFT

Table 3.6.2 Calibration Schedule

Table 3.6.2 has been derived as a first attempt at producing a calibration plan on a day-by-day basis. It is based on current understanding of the calibration tasks and was constructed using the schedule given in Ref. 1 §6 and utilising the possible parallel data collection identified in table 3.6.1. The column headings have the following meaning:

PAR: An 'X' in this column indicates that data for this task will be collected in parallel with other tasks marked 'X' for the given day.

DC Time:
Data collection time in hours.

DP delay:
Acceptable delay in data processing in hours. DRC indicates the delay will be long due to the DRCs performing the required processing.

UP: An 'X' indicates that results will need uplinking.

CRI: An 'X' indicates that the task is critical i.e. the schedule cannot continue until the processing for the critical task is complete.

IDT: Number of the IDT in use.

SM: Number of the Star Mapper in use.

PL: An 'X' indicates payload or CBS in a non-nominal mode.

PSF: An 'X' indicates a non-nominal PSF will be used.

v.d. Marel → program
ANNEX XII

Status of the GCR comparison

DUT(Ge)/HvdM

February 1989

- Data exchange formats (see [1])

  * At most four files (abscissae, instrument and attitude, and possibly l.s. residuals), one per RGC for each consortium.
  * Reference values (errorless data) are given on the same files (if available).
  * Attitude file has the same format as for the OGAR comparison.

  * s/w to generate these comparison files is available in Copenhagen and Delft (Delft s/w will be installed by CNES also)

- Comparison s/w (Delft)

  * A first version of the comparison s/w is completed (comparison of abscissae)

  o The comparison s/w for the along scan attitude will be similar to the s/w for the abscissae.

- Level 1 comparisons

  * Lund data (LOSIM3) reduced by Copenhagen and Delft
  * exchange of formatted files with results (typically first treatment data)
  * comparison in Delft

- Level 2 comparisons

  * Data has been simulated by CERGA (RGC 1000) and distributed to CSS, DUT(Ge) and RGO
  o status data reduction: CSS (Ready), DUT (Busy), RGO (?), CUO (?).
  o Exchange of formatted files (DUT and CUO) with results.

  o Level 2 comparison on the operational s/w chains ?

- Level 3 comparisons

  o once per month (baseline) on real data (produced by CNES and CUO), the RGC's are selected by SRL Utrecht (H. Schrijver)
  o comparison will be done in Leiden (R. Lepoole) with s/w developed in Delft.

References:

[1] H. v.d. Marel, Comparison of Great-Circle reduction results between FAST and NDAC, issue No. 2, November 1987.

ANNEX XIII

Kourou

		Valid	at least
Yellow fever	inj.	10 years	10 days before departure (mandatory)
D.T.P. (Diphteria, Polio, Tetanus)	inj.	5 years	---
Vivotif (Typhus)	caps.	3 years	3 weeks before departure
Gamma globuline (Hepatitis A, general infections)	inj.	3 months	---
Paludrine (Malaria)	tabl.	--	---
Nivaquine (Malaria)	tabl.	--	---

Paludrine: start the day of departure
take one tablet per day (after meal)
continue 4 weeks after return.

Nivaquine: start the day of departure
(=chloroquine) take 3 tablets in once, once per week (after meal)
continue 4 weeks after return.