esa

european space agency
european space research and technology centre

05683

MINUTES OF THE NINTH MEETING OF THE

HIPPARCOS SCIENCE TEAM

ESTEC, 23 - 24 May, 1984

Attendance:

HST:
Dr. M. Crézé
Dr. M. Grenon
Professor M. Grewing
Dr. E. Hog
Professor J. Kovalevsky
Dr. L. Lindegren
Mr. C.A. Murray
Dr. C. Turon

ESA:
Dr. M.A.C. Perryman (Chairman)
Mr. M. Schuyer
Dr. S. Vaghi
Mr. L. Emiliani (part-time)
Mr. R. Bonnefoy (part-time)
Dr. R. Wills (part-time)
Mr. K. van Katwijk (part-time)
Mr. H. Eggel (part-time)
Mr. G. Ratier (part-time)

ESOC: Mr. J. van der Ha

MATRA: Mr. E. Zeis

Drs. Cruise, Donati, Le Poole and Wynne were unable to attend.

1. Agenda

The agenda given in Annex I was adopted.

2. Status Report (Emiliani)

Emiliani described the events that had taken place since the start of Phase C/D in January, and gave a description of the model philosophy and associated schedule of activities and reviews until launch (Annex II). HST would be invited to participate in the next major review, the System Critical Design Review, at the end of 1985.

3. Status Report (Perryman

Perryman reviewed the status of major issues discussed at the previous HST meeting, the documents distributed to HST members since that meeting and those foreseen to be distributed in the near future (Annex III).

The following Consortia and related meetings had taken place since the November meeting: FAST (Utrecht 25-26 April), INCA (Paris 1-2 March), TDAC (Tubingen 28-29 March) and Proposal Selection Committee (Paris 26-27 March). Future meetings foreseen are TDAC (ESTEC 25 May) and INCA (Geneva 25-27 June).

4. Payload Status Report

(a) The Payload Section gave a detailed report covering overall status (Bonnefoy), Performances (van Katwijk), Optics/Grid (Ratier) and Detection (Eggel). These presentations are attached as Annex IV to the minutes.

Bonnefoy described the LAS experimental arrangements (telescope, relay lens, and moving grid) to verify the results of HIPOPTIC with encouraging results (e.g. oversizing factor and modulation coefficients were well reproduced).

van Katwijk noted that the MTF degradation may be somewhat better than the 7.4% system allocation to M1 since the refocussing step size has been reduced from 5 μm to 3 μm (nominal).

Ratier noted the following points of relevance to the HST:

- the chromaticity calibration device proposed by Le Gall was now baselined by MATRA

- a meeting had been held in ESTEC between the Project, MATRA, and Drs. Wynne and Lindegren to discuss the IDT relay lens design. A double gaussian design had been explicitly considered subsequently, and attempts had been made to reduce the evident complexity of the design. Bonnefoy stressed that a simplification was in the interest of all parties, and had been sought, but that the mechanical constraints had prevented major improvements. Perryman considered that the concerns expressed by Professor Wynne in particular had been examined as far as possible by the Project Team and MATRA, and that in the absence of any alternative proposal the present design should be approved.

- the PMT relay lens design was being re-examined in view of the proximity of the grid image to the dichroic filter

- no further details of the THD 'alternative grid' were available

(b) Wills summarized the present values of Io, M1 and M2 derived by MATRA (PNE budget, issue 4) and by Le Gall (LA-FA-28) as given in Annex V.

Wills noted that removing the degradation factors included in th PNE budget (line 2) brought the 'nominal instrument' (line 3) into better agreement with the results of LA-FA-28 (line 4). The remaining discrepancy between the values of M1 and M2 was identified by Zeis as arising from the fact that FASTGRID does not account for the sampling at 1200 Hzwhich leads to further degradations of 0.978 on M1 and 0.912 on M2, correctly accounted for by HIPOPTIC. ESA considers that the discrepancies between the MATRA and Le Gall values of M1 and M2 have therefore been removed. Kovalevsky would ask Le Gall to check his values of Io (i.e. star flux model and other assumptions) and let Perryman know the results (Action 3).

(c) Hog drew attention to discrepancies between MAT-HIP-06488 and results obtained by Yoshizawa on TYCHO. The NDAC simulations are more pessimistic than MATRA's, and for the photometric aspects NDAC do not agree with the MATRA Cramer-Rao bound. ESTEC would investigate further (Action 4).

(d) Hog requested the Project to assess whether the sun stray light level can be significantly lower than the specifications given in the SRD, since this could affect the limiting magnitude of the TIC (Action 5).

5. <u>ESOC Status</u>

van der Ha presented an overview of present ESOC activities (Annex VI). The MIP (Mission Implementation Plan) would be drafted in the last half of 1984, and Schuyer confirmed that HST members would have the opportunity to comment on its contents before it was frozen.

van der Ha presented details of the data that would be provided for orbit determination. Details are given in Annex VII.

6. <u>Calibration</u>

(a) <u>OOCR</u>. Wills reviewed the status of the calibration activities. An On-Orbit Report (OOCR) is due 20 July, 1984, which will include details of special scanning laws, SOS, etc. if needed. This would be distributed to HST for their comments, and a dedicated meeting between interested parties set up as necessary. An On-Orbit Calibration Manual would be produced in early 1985 including inputs from these comments.

(b) <u>Grid Calibration</u>

TPD presently commit to an on-ground calibration accuracy of 8 m arcsec for the MSC. A revised issue of the Grid Calibration Plan would be provided by TPD at the end of May. R. Le Poole had proposed to use the Leiden 'astroscan' to reach 5 m arcsec or even less on ground, although this approach was not presently under consideration by TPD.

Zeis presented MATRA's present approach to the problem of In-Orbit MSC Calibration (MAT-HIP-07960). Lindegren questioned whether one parameter per stitching row would allow separation of effects such as scan velocity and large scale effects (Action 6).

(c) SM Distortion

A new paper would be produced by Vivier based on a comparison of SM/main grid observables, an approach thought by Zeis to provide a better prospect of calibrating the SM geometric distortion. Hog favoured an in-orbit verification of the inclined slit geometry, although no obvious way of performing this had been identified by MATRA. Kovalevsky suggested that a calibration would be possible after a sphere reconstitution (yielding accurate positions and attitudes).

(d) Photometric standard stars

Grenon expected to provide inputs on the availability of photometric standard stars (on the basis of the next version of INCA's L2) by the end of July. Since the energy distributions of standard stars have been given in functions of B-V, Zeis stated that for the assessment of photometric calibration MATRA would like to assume that B and B-V would be known with a precision of 0.02 mag. Grenon said it would be no problem to provide this information together with H, BT and VT to the same accuracy as already committed. The change will be reflected in the next revision of the Overall System Specification.

(e) M1, M2 Calibration

Kovalevsky accepted the requirements on the determination of M1 (1%) and M2 (5%), although these requirements were not consistent, and a better calibration of M1/M2 was required (for double star detection) and would be performed by FAST.

(f) SM Dichroic Optimisation

Zeis presented the current situation - a separation of 117 nm between B_T and V_T effective wavelengths could be achieved, but with the insertion of blocking filters leading to a loss of photons of $\sim$20% (average for both channels) and the following count rates (for B + V = 19.3).

B-V	BT	VT
0.0	3800	1500
0.7	2400	1800
1.5	1500	2300

The HST recommendations were unanimously:

- to maximise the number of photons by removing the blocking filters, possibly leading to a separation of 100 nm between BT and VT;

- to balance the number of photons in BT and VT at B-V = 0.7, since the number of stars at B+V = 19.3 peaks at this colour.

  This optimisation would be performed by MATRA.

7. <u>In-Orbit Activities</u>

(a) Quick Look Monitoring

Wills presented the results of the ESA assessment of the ESOC requirements (ESA-HIP-03631), suggesting that checks at the level of photon counts (possibly with some phase extraction analysis) should be sufficient. Lindegren noted that, in any case, a marcsec GCR would be very difficult to implement. Kovalevsky recalled that FAST will use a quick look analysis at Utrecht, and that if ESA could provide data directly to Utrecht a turn-around time of 1 week may be expected. ESA would clarify their requirements.

(b) Commissioning

Schuyer presented the Project Team's current ideas on the possible involvement of FAST and NDAC in the commissioning activities (Annex VIII). Hog confirmed that NDAC would not wish to participate in these responsibilities, so that ESA should continue its dialogue with FAST alone. Kovalevsky would consider FAST's involvement in such activities if specific requests were made by ESA. Manpower, desired reaction time, location of s/w (ESOC or Utrecht) as well as availability and suitability of any required software would need to be considered.

8. <u>Dynamical Smoothing Specification</u>

Schuyer presented the proposed revised specification. This would be acceptable to all parties with the inclusion of the condition that the model should not require terms of frequency higher than, for example, 0.1 Hz (Lindegren). Such a condition would be included in MATRA's specification.

9. <u>Attitude Control (Donati) Law</u>

The detailed reasons why Donati's proposal had not been considered further by ESA were presented by Perryman, and no objection was expressed by HST members. Perryman would provide full details in a written reply to Kovalevsky.

10. <u>Logica Simulations</u>

Schuyer and Zeis presented details of the recent Logica work:

- the effect of the third harmonic had been assessed by simulations to give a maximum degradation of 2-3% in the frame error at 0° phase difference with respect to the first harmonic

- the SOS software developed in ESTEC will be incorporated into the Logica simulation program.

An accuracy report is due in June.

11. SOS Status Report

(a) The SOS Users Manual had been distributed to NDAC, FAST, INCA and Crézé. Vaghi distributed to HST members the paper "The Star Observation Strategy for HIPPARCOS" which provides a summary of the SOS algorithm. The SOS was now frozen, having received the full support of Crézé and Kovalevsky. The alternating priority concept was baselined. There was insufficient time at the meeting for Crézé to present his assessment of the PSF ground preparation requirements on ESOC. Preliminary ideas would be communicated by Crézé to Perryman following the meeting.

(b) Global Observing Programme (GOP). On the basis of the current contents of the Input Catalogue Version L2 IV, MATRA had produced a note (MAT-HIP-8874) on the "Impact of GOP on GCR Performances" suggesting that an increased number of stars could be contained in the Input Catalogue at the expense of only limited degradation at $B \lesssim 9$ mag. due to increased rigidity of the CGR solution.
Lindegren suggested that it could be imprudent to assess the GOP on the basis of the MATRA GCR software alone, since rigidity would be improved in any case by the consideration of RGC's rather than individual great circles. In this case the overall effect of introducing more stars would be to decrease the final achievable precision. It would be more realistic to vary the GOP on the assumption of a fixed rigidity. The effect of dynamical smoothing should also be considered. Lindegren had produced a note on results of his own assessments of the GOP considered by MATRA illustrating these points.
Studies of the GOP were considered to be timely by Perryman. Studies would be initiated by Schuyer within the Project Team.

12. Software Inventory/Data Exchange

(a) Vaghi distributed to Consortia Leaders the May issue of the S/W inventory.

(b) IDT Simulated Data: Murray will request data from FAST, which should satisfy their immediate needs. Vaghi will continue development of the necessary modifications to the GCR software in ESTEC so that the Project Team is ready to provide data to both consortia when requested later in the year. Vaghi foresaw availability of ESTEC simulated data around October.

(c) SM Simulated Data: MATRA have RTAD and TYCHO software packages, which could in principal be modified to provide pseudo-SM data, although this has not been foreseen (note that SM Software Users Manual is available in ESTEC, but due to its bulky nature will not be distributed to consortia leaders at this time). Kovalevsky said that SM simulation software was under development by FAST.

(d) Kovalevsky expressed an interest in receiving NDAC's sphere reconstitution simulated data.

13. Conventions

(a) Scanning Law

A note by Lindegren (1984 April 17) was distributed. It was considered that this note should form the basis for the nominal sun position and the nominal scanning law. Kovalevsky would review FAST's current assumptions.

(b) Ecliptic/Equatorial Coordinate System

It emerged that FAST were working in ecliptic coordinates, whereas NDAC (and INCA) were using equatorial coordinates. The form of the final catalogue is to be defined, but if equatorial coordinates are used Kovalevsky noted that error estimates would need to be treated properly (expected to be symmetrical in ecliptic coordinates).

(c) Weighting of Phases

A full discussion of this topic would be made at the next HST meeting.

14. Data Formats

The following requests related to ESA-HIP-05375 (24.4.84) were made by DRC;

- B_T and V_T should be together within a star identifier, along with the FOV identifier and slit type.

- 60 arcsec per slit crossing was considered satisfactory for the RTAD SM records.

- references to UT should be replaced by TAI or, failing that possibility, UTC.

- a file length of less than 720 formats would be preferred by both consortia, for example in the range 150-250 (e.g. 200). This length should be shortened in the event of occultations.

- the IDT/SM file lengths should be synchronised (720/722 in the present text, to take account of RTAD star crossings, is not necessary for the DRC).

- the SOS report (p.26) needs to take account of POS - how this is foreseen is not clear.

- 'additional data' should be accessible in the same time blocks as the main data.

- the additional data file should contain (amongst other items) the coordinates of the spin axes and their time derivatives, together with the times at which thruster actuations occurred.

van der Ha noted that ESOC will need to assess computer availability etc. before committing to the precise formats to be adopted. Since the ESOC view of GRTAD has evolved, ESA now proposed to distribute RTAD data to the consortia, without further attitude determinations derived on ground (see Action # 9). ESOC intends to provide further details of the telemetry content, indicating expected data volume, and whether the data is likely to be (a) useful, (b) possibly useful, or (c) not useful to the DRC.

The Project Team will produce a new version of the document taking the results of the discussion into account. An opportunity for a meeting between Consortia members and ESA coud be foreseen later in the year.

15. Agreement

The revised version was discussed. Several detailed comments were received. Main concerns were on the subject of data rights. Perryman was of the opinion that any data compiled or collected under the auspices of the Input Catalogue should be distributed in the manner described in the draft text. After some discussion it was agreed that Perryman would draft a further version of the section "Distribution of the Data within the Consortia" based on the use of a short "internal proposal," since there remained some controversy on how data should be distributed within each Consortium.

16. Publicity Brochure

The following inputs would be submitted in addition to detailed comments:

- Turon: details of INCA work
- Kovalevsky: details of data reduction work
- Lindegren: details of the analysis chain

17. Date of Next Meeting

The next meeting of the HST was provisionally arranged for 2-3 October. At this meeting FAST and NDAC would give presentations of the details and current status of their Step 1 tasks.

M.A.C. Perryman
30th May, 1984

25 x 687

ACTIONS

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ANNEXES

I - VIII

esa estec

HIPPARCOS

MEETING HIPPARCOS HST #9

PLACE

REF.

DATE

PAGE 1

ACTION No	DESCRIPTION (not more than 4 lines)	CLOSING DATE	ACTIONNEE Person/firm	INITIATOR Person/firm
1	Perryman to send the following tech. notes:		PERRYMAN	HST
	– MAT-HIP-03426 (Chanot) ✓ to C. TURON	asap ✓		
	– LAS report on simulations to NDAC×2, FAST×2, TDAC	asap ✓		
	– MAT-HIP-03952 (28/2/83, Zeis) on SOS to Crézé	asap ✓		
	– On-Orbit Calibration Report	as available ✓		
	– MAT-HIP-07960 (MSC Calibration) to NDAC, FAST	asap ✓		
	– MTF deg. budget (MAT-HIP-4435 Iss. 3) to NDAC, FAST	asap ✓		
	– FPA defocus budget (MAT-HIP-6803 Iss. 1) —— " ——	asap ✓		
	– PNE Budget (Issue 5) to NDAC, FAST, INCA	asap ✓		
2	MATRA to provide ESA (will forward to C. TURON) advanced information on P/L IFOV profile,		E. ZEIS	ESA/ PERRYMAN
3	KOVALEVSKY / LE GALL to check star flux model and other assumptions relevant to the determination of I_0		KOVALEVSKY / LE GAL	ESA/ PERRYMAN
4	Resolve discrepancy between NDAC / MATRA derivations of TYCHO astrometric and photometric Cramer-Rao bound and simulations (cf Yoshizawa) (see also #19)		SCHUYER	HØG

Signatures

esa estec

HIPPARCOS

MEETING HIPPARCOS HST #9

PLACE

REF.

DATE

ACTION No	DESCRIPTION (not more than 4 lines)	CLOSING DATE	ACTIONNEE Person/firm	INITIATOR Person/firm
5	Assess whether sun straylight can be significantly lower than the SRA specifications		BONNEFOY	HØG
6	(a) Assess validity of MATRA's approach to in-orbit MSC calibration in view of scan velocity / large scale effects.		SCHUYER	—
	(b) Assess ability of SOS to cope with associated observing requirements, and if such requirements impact on the ground PSF preparation.		SCHUYER	—
7	Provide details of availability of photometric standards	31 JULY	GRENON	PERRYMAN
8	Perform re-optimisation of TYCHO dichroic on the basis of HST recommendations		MATRA / ZEIS	—
9	Inform ESA whether GRTAD results with higher precision are necessary for them, or whether RTAD is sufficient	8 JUNE	HØG / KOVALEVSKY	PERRYMAN
10	Inform ESA whether a need for routine GCR at ESOC can be identified or whether checks at photon count level is ok.	8 JUNE	HØG / KOVALEVSKY	PERRYMAN
11	Provide information on the effects of solar flares on IDT / SM detectors, in view of solar maximum		BONNEFOY	GREWING
12	ESA to specify quick-look / commissioning requirements to FAST for their consideration		SCHUYER	—

Signatures

esa estec

HIPPARCOS

MEETING HIPPARCOS HST #9

PLACE

REF.

DATE

PAGE 3

ACTION No	DESCRIPTION (not more than 4 lines)	CLOSING DATE	ACTIONNEE Person/firm	INITIATOR Person/firm
13	MATRA/ESA to include specification of permissible frequency content in Dynamical Smoothing Spec.		Schuyer/Zeis	—
14	Crézé to provide note on preliminary PSF preparation requirements at ESOC.		Crézé	Perryman
15	Carry out studies of GOP in ESTEC		Schuyer	—
16	ESOC to provide telemetry details for data interface documents showing whether useful/possibly useful/not useful		van der Ha	Schuyer
17	ESA to produce specification of data interface		Schuyer	—
18	HST to submit inputs to Publicity Brochure	8 JUNE	HST	Perryman
19	(see also #4) Høg to check TYCHO simulations with MATRA's filter and compare with NDAC results		Høg	—

Signatures

ANNEX I

Ninth Meeting

of the

HIPPARCOS SCIENCE TEAM

23-24 May 1984

AGENDA

1. Status Report (Emiliani)

2. Status Report (Perryman)

3. Review of Past/Future Meetings (FAST, NDAC, INCA, TDAC, Proposal Selection)

4. Payload Status Report:
   - Performances (van Katwijk)
   - Optics/Grid (Ratier)
   - Detection (Eggel)
   - Modulation Coefficients - MATRA v. Le Gall (Kovalevsky/Wills)

5. ESOC Status (MIRD, MIP, OAD 263, orbital reconstitution) (van der Ha)

6. Calibration:
   - Calibration status (Wills)
   - Grid Calibration (Ratier (on ground); Zeis (in orbit))
   - SM Distortion & Calibration
   - C stars, M1/M2, etc.

7. In-orbit activities:
   - Quick Look Monitoring (ESA-HIP-03631, Wills)
   - Commissioning Tasks (Schuyer)

8. Dynamic Smoothing Specification (Schuyer)

9. Attitude Control Law - Donati proposal (Donati/Kovalevsky)

10. Report on LOGICA Simulation Results (Schuyer)

11. SOS Status Report:
    - SOS Users Manual
    - Global Observing Programme & GCR S/W (Perryman)
    - Ground PSF Preparation (Creze)

12. Software Inventory & Simulated Data Exchange (Vaghi)

13. Conventions:
    - Scanning Law (Lindegren)
    - Use of Ecliptic/Equatorial Coordinate System (Kovalevsky)
    - Weighting of Phases (Kovalevsky)

14. Data Formats (ESA-HIP-05375)

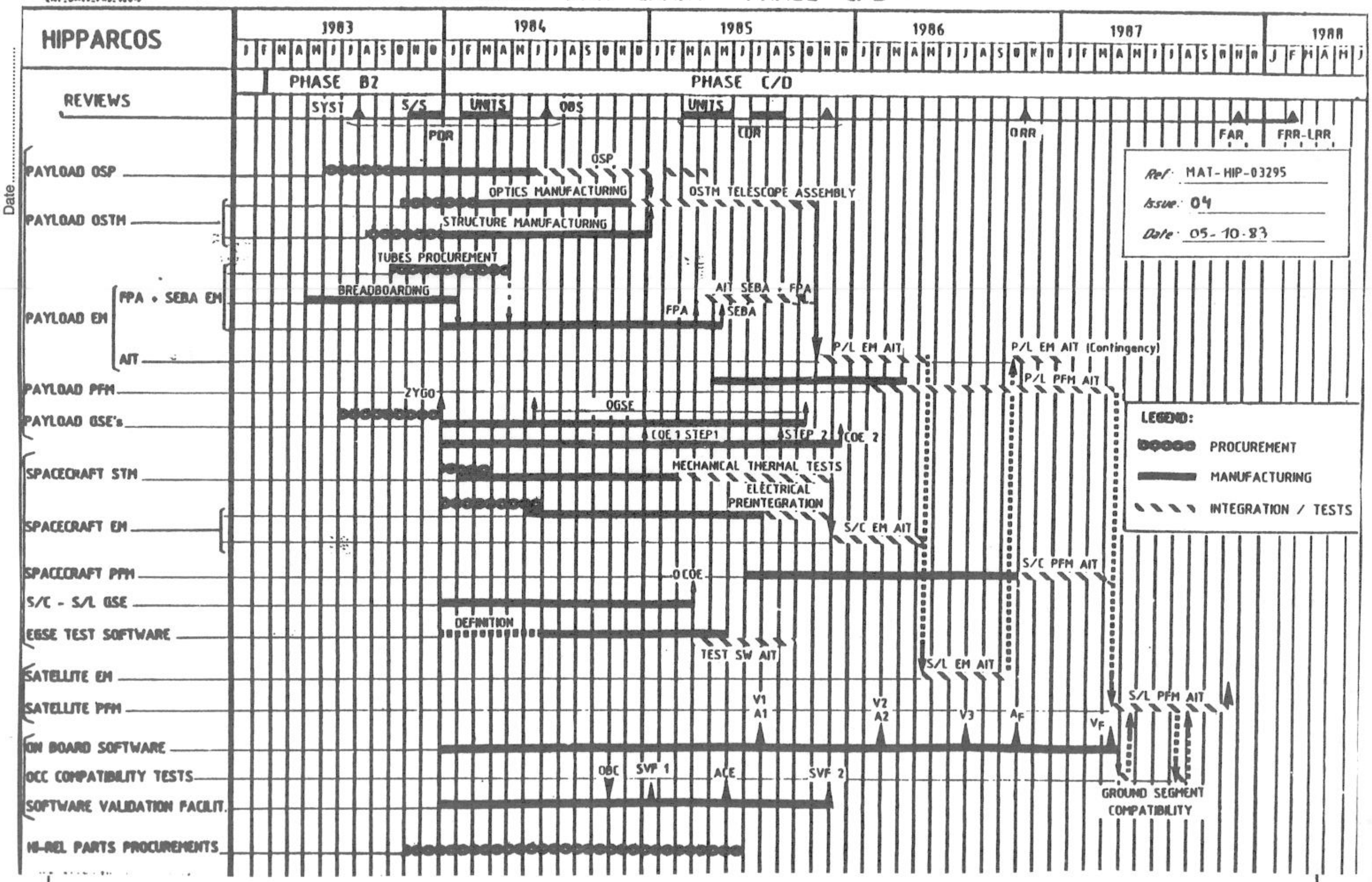
15. Agreement

16. Publicity Brochure

17. Any Other Business, Next Meeting, etc. To include:
    - ST Calibration
    - JPL involvement

Annex II

SU..IARY BAR CHART PHASE C/D



ANNEX III

NOVEMBER HST

Issue:	Status
GRID	see P/L status report
CHROMATICITY CALIB^{N}	accepted, — " —
RELAY LENS DESIGN	December meeting in ESTEC, — " —
PM tubes	bialkali/bialkali chosen, see 'status' letter
IDT APERTURE SIZE	increased to 110 μm, — " —
ABSOLUTE TIME REQ^{T}	incorporated in specs.
SOS	frozen in CBSS spec, with 'alternating priority'
RTAD	relaxation of req^{ts} on INCA to 1.5 arcsec rms.

- DATA FORMATS / MoU / PUBLICITY (discussed separately).

DOCUMENTS DISTRIBUTED

- DCN #16
- OSS (Iss. 3 Rev. 4 + Rev. 3)
- P/L SS (unsigned)
- CBSS, OSS Section only
- Satellite/GSE Ground Segment ICD
- P/L Status Report (Fade 7606)
- Status of P/L parameters (Vivier 6076)
- P/L IFOV estimation (Chanot 3426)
  (NDAC, FAST, Le Gall, Schrijver)
- Ghost image analysis of IDT relay lens (ZO-HIP-003.84) (Wynne)
- Third harmonic (Vivier 7571)
- SM distortion & chromaticity budget (Vivier 7697
- SSR for SM slits (LA-HIP 52/53) NDAC, FAST, TDI
- SOS Users Manual (NDAC, FAST, INCA, Crézé
- ABM free materials (Flandrin 7420)
- GOS (Zeis/Gardelle 8874)
- Quick Look Monitoring (ESA-HIP-3631)
- Data Interface/Formats (ESA-HIP-5375)
  (also to Pieplu)
- Agreement
- Publicity Brochure (also to ESOC, MATRA)

ANNEX IV (A)

H I P P A R C O S

SCIENCE TEAM MEETING

25 MAY 1984

PAYLOAD STATUS REPORT

PRESENTED BY:

R. BONNEFOY
K.V. KATWIJK
G. RATIER
H. EGGEL

Date..............................

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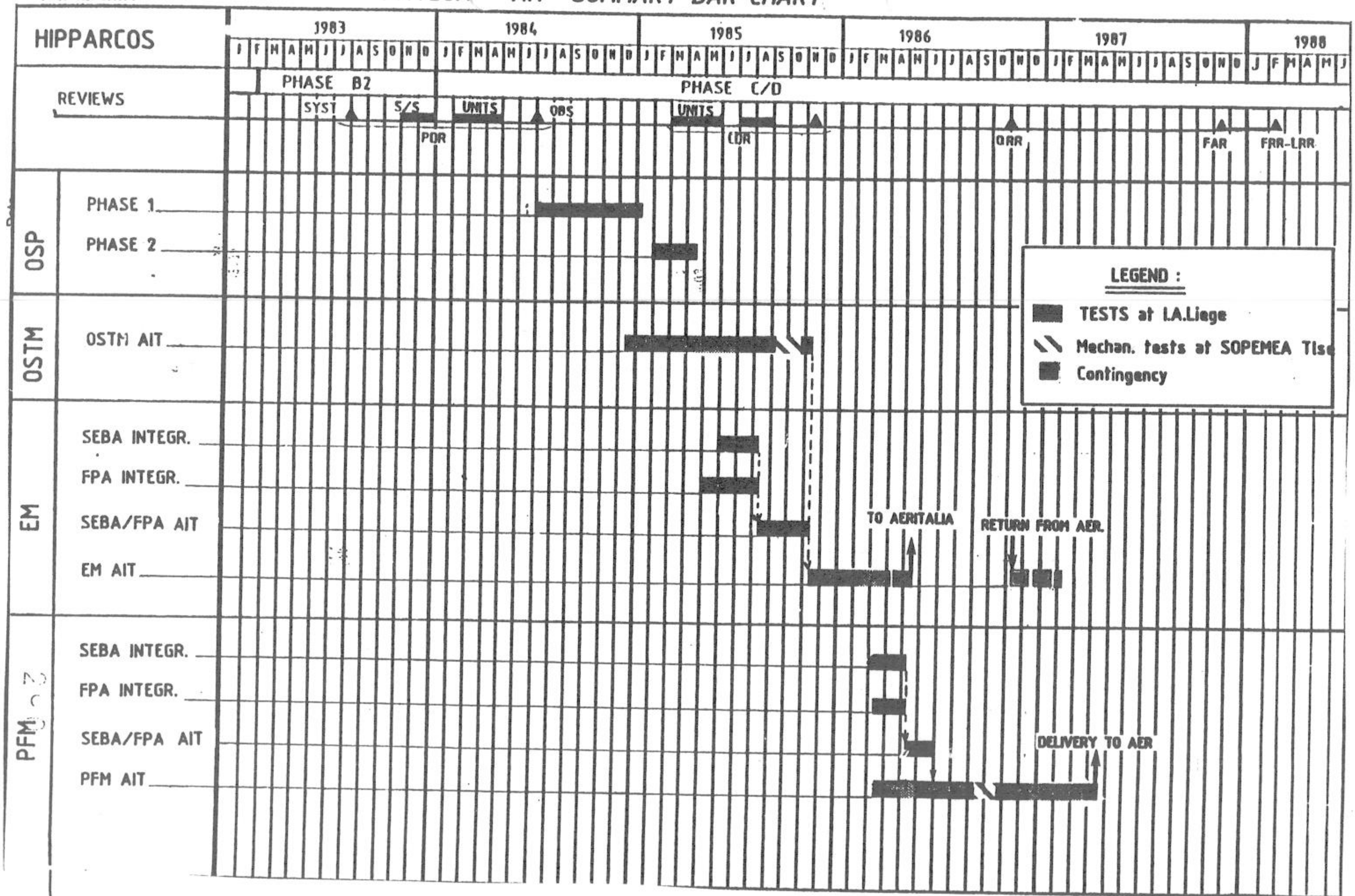


R. BONNEFOY

PAYLOAD OVERALL VIEW

(1) MAJOR EVENTS SINCE LAST HST

A) SCIENTIFIC PERFORMANCES

- UPDATING OF P/L PERFORMANCE BUDGETS
- HARDWARE MODIFICATIONS (E.G. SIZE OF IDT DISSECTING APERTURE CHROMATICITY DEVICE)

B) HARDWARE DEVELOPMENT

CONTINUATION OF ADVANCED ACTIVITIES ON HIGH TECHNOLOGY ITEMS (BEAM COMBINER, GRID) OR NEW DEVELOPMENT (DETECTION, STRUCTURE)

C) DOCUMENTATION

- SYSTEM LEVEL : PAYLOAD SYSTEM SPECIFICATION (IS.3 REV.3) ISSUED IN JANUARY
  NEXT UPDATE FOR MAY 30TH 1984
- SUBSYSTEM LEVEL : ALL SUBSYSTEM SPECIFICATIONS UPDATED IN THE 1ST QUARTER OF 84 AND NEGOTIATED WITH THE VARIOUS PAYLOAD SUBCONTRACTORS (TOTAL 14 SUBCONTRACTORS).

(2) PRESENT SITUATION

- PREDICTED PERFORMANCES SATISFACTORY
- GROUND TESTING CONSIDERED TO BE CRITICAL (HIGH PERFORMANCE TEST EQUIPMENT)
- PLANNING TIGHT DUE TO 1) "TEETHING" PROBLEMS FOR SOME CRITICAL ITEMS
  2) "MAKE WORK" CHANGES (E.G. DETECTION GROUNDING)
- MODIFICATIONS TO BE AVOIDED AS MUCH AS POSSIBLE TO MAINTAIN PRESENT SCHEDULE.

Date ....

ANNEX IV (B)

KvK Date 22/5/84 (1)

K. van KATWIJK

PAYLOAD PERFORMANCES

1. Performance budget approach
2. Typical performance budget
3. Definition of status of telescope optics
4. Status of payload budget reports per 16/5/84
5. Present Payload performances overview

1. PERFORMANCE BUDGET APPROACH

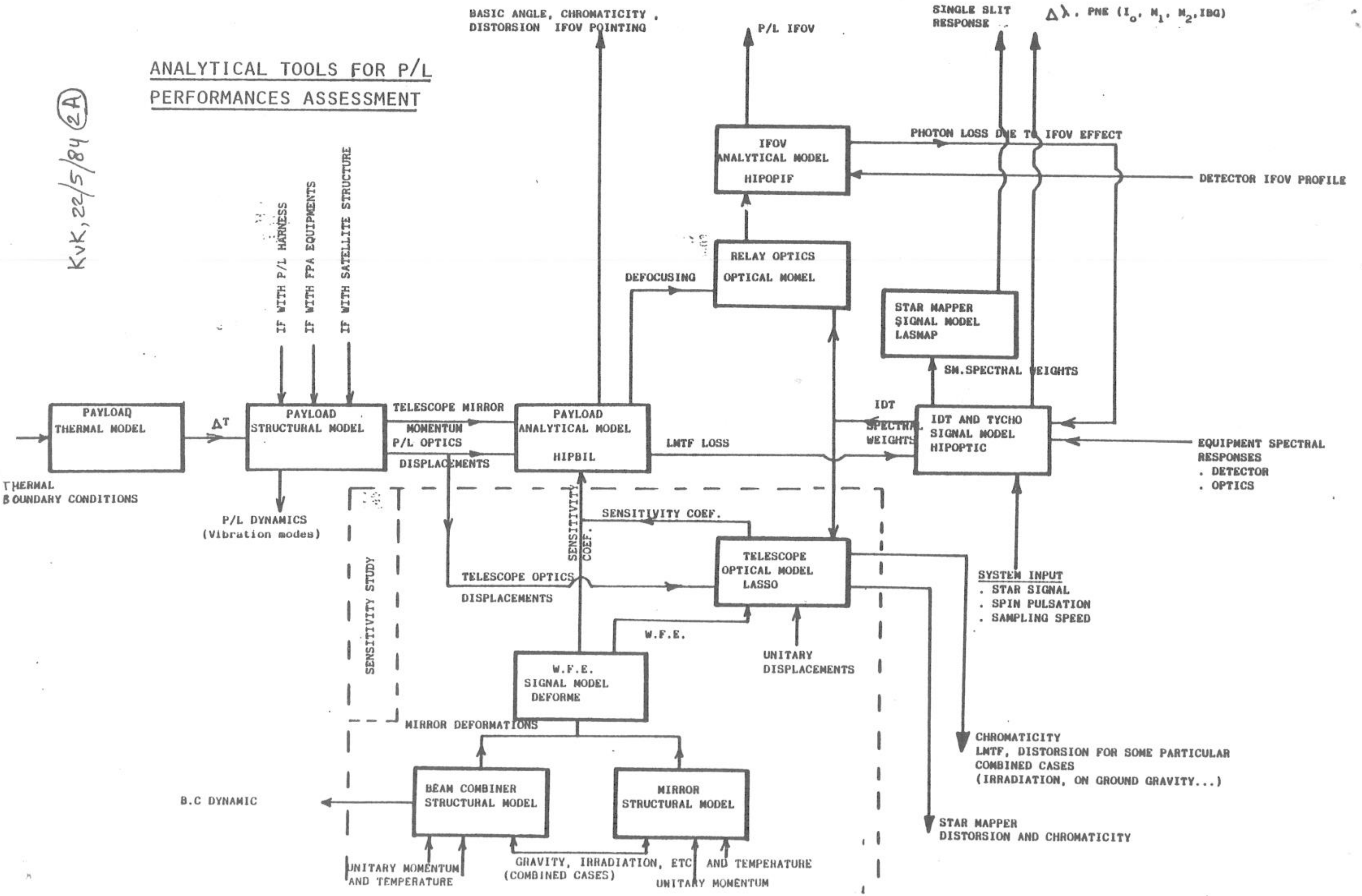
- Payload performance parameters are those which
  - have a direct impact on mission performances, e.g: PNE, basic angle stability, distortion and chromaticity, ...
  - are affected by various subsystems (optics/structure/-) e.g: IFOV pointing, MTF degradation, FPA defocus, ...

- Performance parameters are controlled through Performance Budgets, which integrate a large numer of elementary data ie displacements and deformations of mirrors, transmission of optics, etc, through appropriate S/W tools like HIPOPTIC, HIPDIS, HIPOPIF, etc and an overall S/W HIPBIL. Assessment of modifications will be done via sensitivity analyses.

- Performance budgets, first issued in phase B2 will be regularly updated in phase C/D (every 6 months) to monitor the status of Payload performances and to derive corrective actions if required.

KvK, 22/5/84 (2A)

ANALYTICAL TOOLS FOR P/L PERFORMANCES ASSESSMENT



2. TYPICAL PERFORMANCE BUDGET

- Example: Basic angle stability (BAS)
- Inputs: Sensitivity analyses wrt optics displacements and deformations + telescope deformation status analyses wrt thermal control, moisture release, launch effects, etc
- Affected Subsystems: Optics, Structure, Thermal control, Refocassy, Harness, Integration/alignment, etc.
- Allocation to Subsystems: Iterative process, involving feasability, mutual interaction and engineering assessment, supported by sensitivity analyses.
- Resulting performances
  - Required at System level 1 mas
  - Specified to Subsystems 0,95 mas
  - Present status, best estimate 0,64 mas

KvK Date 22/5/84 (4)

3. DEFINITION OF STATUS OF TELESCOPE OPTICS

- Sensitivity analyses (~24 "loadcases" defined to LAS)
  - Rigid body movements of optics (BC/FM/SM) and grid (G)
  - Mirror deformations due to loads, gravity, temperature, irradiation.
  - Polishing errors: coma, astigmatism (simple surfaces)
- Typical cases (~14 "loadcases" defined to LAS)
  - Combinations of "simple" cases used in sensitivity analyses
  - Definition of "nominal" and "degraded" telescope performances

KuK, 22/5/84 (4A)

Definition of "loadcases" (sensitivity analysis)

1.1	$\Delta XSM = 100\,\mu m$		rigid body movement
1.2	$\Delta ZG = 1\,\mu m$		" " "
1.3	$\Delta \Theta XG = 36$ as		" " "
1.4	SM	$3\ 10^{-12}(x^3 + xy^2)$	polishing error ($\lambda/50$) RMS
1.5	SM	$10^{-13}\, x^3 y$ (all mm)	chromaticity analysis
1.6	SM	$10^{-12}\, x y^3$	" "
1.7	SM	$10^{-8}\, xy$	" "
1.8	$\Delta \Theta YG = 0{,}01$ degr		rigid body movement
1.9	$\Delta \Theta ZG = 0{,}01$ degr		" " "
1.10	$\Delta XG = 10\,\mu m$		" " "
1.11	$\Delta YG = 10\,\mu m$		" " "
1.12	SM	$MR3 = 1$ Nm	invalid, see 1.14
1.13	SM	$DTX = 1\,^{\circ}C$	"
1.14	SM	$MR3 = 1$ Nm	radial moment
1.15	SM	$DTZ = 1\,^{\circ}C$	thermal gradient
1.16	BC	$0{,}5625\ 10^{-11}(x^3 + xy^2)$	polishing error ($\lambda/60$) RMS
1.17	BC	$0{,}6893\ 10^{-9}(x^2 - y^2)$	" " " "
1.18	SM	$0{,}25\ 10^{-11}(x^3 + xy^2)$	polishing error ($\lambda/60$) RMS
1.19	SM	$0{,}4105\ 10^{-9}(x^2 - y^2)$	" " " "
1.20	SM	$0{,}4105\ 10^{-9}\, xy$	" " " "
1.21	BC	?	effect of BC cutting
1.22	BC	$0{,}5625\ 10^{-11}(x^2 y + y^3)$	polishing error ($\lambda/60$) RMS
1.23	SM	$0{,}25\ 10^{-11}(x^2 y + y^3)$	polishing error ($\lambda/60$) RMS
1.24	$\Delta ZG = 50\,\mu m$		rigid body movement

KvK, 22/5/84 (4B)

Definition of "loadcases" (combinations)

2.1	(1.1)+(1.2)+(1.3)+(1.9)+(1.11)	+(1.16) typical after launch
2.2	(1.1)+(1.2)+(1.3)+(1.10)+(?)	" " "
2.3	(1.1)+(1.2)+(1.3)+(1.9)	short term, distortion
2.4	(1.1)+(1.2)+(1.3)+(1.9)+(?)	" " "
2.5	(1.1)+(1.2)+(1.3)+(1.8)+(1.10)	+(?)
2.6	invalid	
2.7	invalid	
2.8	invalid	
2.9	(1.1)+(1.2)+(1.3)+(1.9)	short term
2.10	(1.1)+(1.2)+(1.3)+(1.10)	
2.11	BC/FM/SM deformed	1g gravity
2.12	BC/FM/SM deformed	EOL irradiation
2.13	(1.3)+(1.9)	SM-distortion
3.1	grid tilt	SM-distortion

KvK Date 22/5/84 (5)

Status of P/L budget reports per 16.5.84

Primary budget reports	MAT-HIP	Issue	Update
PNE	3486(5)	23.03.84	-
Basic angle stability	3571(3)	24.04.84	-
Distortion	3567(2)	12.04.83	June '84
Chromaticity	3617(2)	11.04.83	June '84
P/L IFOV profile	3426(2)	07.02.84	Sept '84
IFOV pointing accuracy	4948(2)	03.01.84	Sept '84
Third harmonic	7571(1)	12.01.84	Sept '84
Tycho performances	6488(1)	02.11.83	June '84
SM distortion + chromaticity	7697(1)	25.01.84	Sept '84
Grid geometry + calibration	4803(2)	22.04.83	?

Intermediate budget reports	MAT-HIP	Issue	Update
Optical transmittance	4184(5)	20.04.84	-
MTF degradation	4435(3)	20.01.84	Sept '84
FPA defocus	6803(1)	22.11.83	July '84

Sensitivity analyses	MAT-HIP	Issue	Update
Due to mirror deformations	3553(2)	16.02.83	May '84
Due to optics displacements	3554(2)	22.02.83	May '84
Telescope deformations	3559(1)	27.10.82	July '84

KvK Date 22/5/84 (6)

5. PRESENT PAYLOAD PERFORMANCES OVERVIEW

Primary budgets		System requ't	Subsystem requ't	Present status	Comments
Photon noise error	mas	7,10	7,14	6,69 – 7,04	dependent on procurement policy; improvement due to grid diffraction measurements introduced
Basic angle stability	mas	1,00	0,95	0,64	
Distortion stability	mas	1,00	0,90	–	to be updated
Chromaticity C_c	mas	3,00	2,20	–	to be updated
C_v	mas	1,77	0,90	–	to be updated
P/L-IFOV-profile	–				IFOV-size now 36" (110 µm) no improved veiling glare present profile within spec
IFOV pointing	as	3	2	–	
Third harmonic M_3	%	5	–	–	spec change/relaxation proposed for M_3, φ_3 by MA
φ_3	degr	5	–	–	
TYCHO + SM	–				LA-HIP-52/53/61 can be used but dichroics to be optimised

Photon Noise Error

	PNE	System accuracy
P/L-spec (for B=9 ; B-V=0,5)	7,10 mas	2,00 mas
IDT-spec + Optics-spec	7,14 mas	2,01 mas
IDT-spec + Optics-typical	7,04 mas	1,98 mas
IDT-typical + Optics-typical	6,69 mas	1,88 mas
	σ = 0,25 mas (10 tubes)	

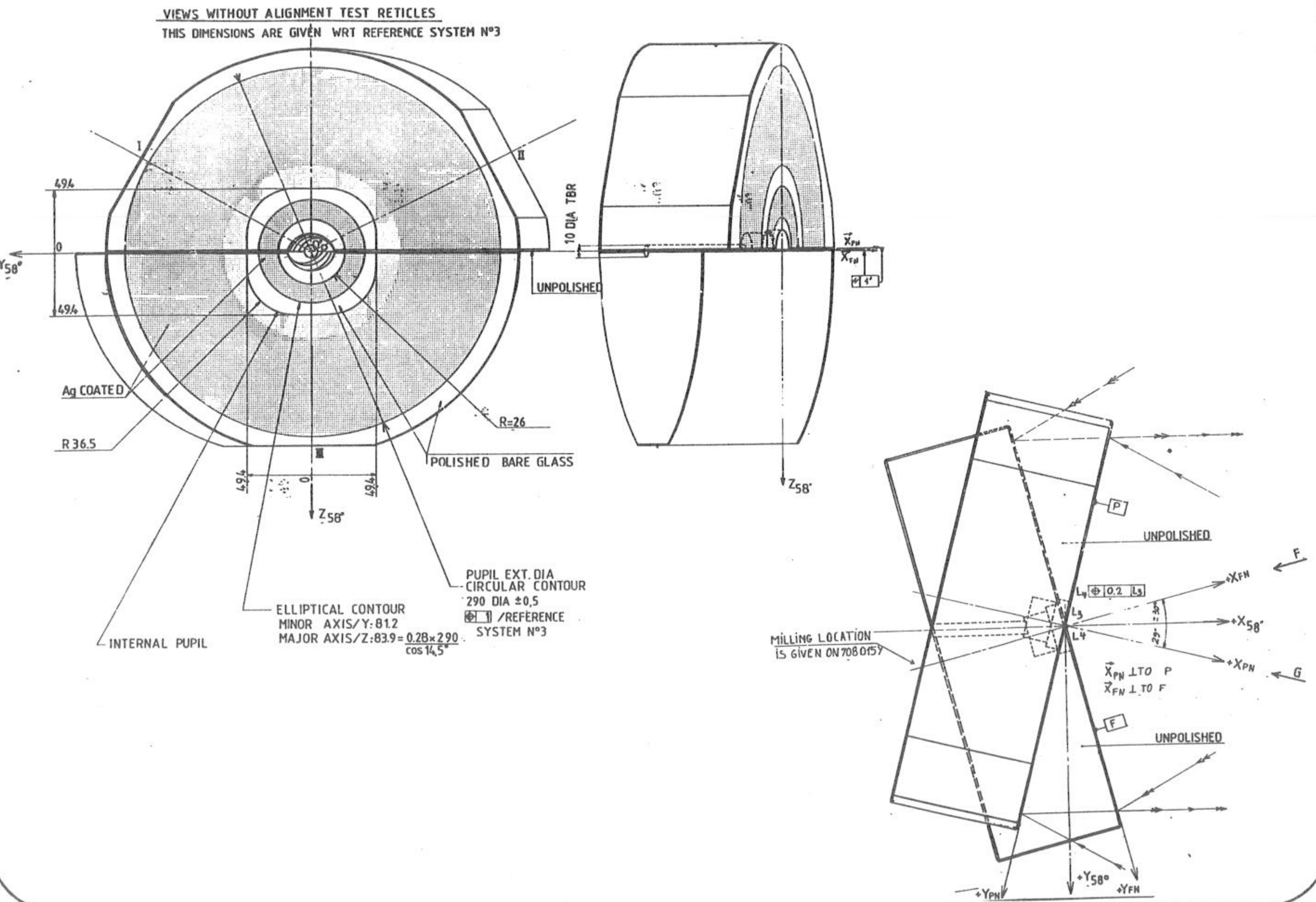
5. CONT'D

Intermediate budgets		System requ't	Subsystem requ't	Present status	Comments
Optical transmittance	1	—			present spectra within spec
MTF degradation	%	7,4 on M_1	7,3 on M_1	—	reduced refocmech stepsize not yet considered BC polishing error $\lambda/37$ (iso $\lambda/60$) → 0,8 % to be added quadratically → ΔMTF = 7,4 %

ANNEX IV ©

G. RATIER

BEAM COMBINER



Date ....

BEAM COMBINER (CONT'D)

MAJOR REQUIREMENTS

- EXTERNAL DIAMETER Ø = 326MM - THICKNESS = 100 MM
- LIGHTWEIGHTED (M ≤ 12.9 KG) - WEDGEANGLE = 29° ± 0.5′
- SURFACE = ASPHERICAL (KERBER PROFILE) DECENTERED BY 4MM
- WAVEFRONT ERROR (FROM NOMINAL)
  - λ/60 RMS
  - SYMMETRY SUCH AS INDUCED CHROMATICITY LESS THAN 1 MAS
- CENTRAL HOLE WITH B.C. DECENTER SENSOR

Date..........................

Date..........................

BEAM COMBINER DEVELOPMENT TESTS

1) - FLAT BREADBOARD MODEL

- MAINLY DESIGNED TO STUDY IMPACT OF CUTTING PROCEDURE AFTER POLISHING
- SURFACE = FLAT (MEDIUM QUALITY POLISHING, BUT WITH GOOD REGULARITY)
- CUTTING DONE = BEGINNING APRIL 84 (DELAY DUE TO TEST S/W PROBLEMS)
- AFTER CUTTING: - WAVEFRONT ERROR HAS VARIED BY $\lambda/37$ RMS
  - SYMMETRY REMAINS IN TOLERANCE (0.87 MAS)
- CORRECTIVE ACTIONS : - EDGE POLISHING - CHEMICAL TREATMENT
  - BETTER UNDERSTANDING OF STRESSES PHENOMENA
- REQUESTED DELIVERY DATE = 31.03.1984
- PENDING RESULTS OF CORRECTIVE ACTIONS, PLANNING DELAYS ON EM MODEL MIGHT OCCUR.

2) - ASPHERICAL MODEL

- DESIGNED TO DEMONSTRATE FEASBILITY OF ASPHERICAL PROFILE BY CONVENTIONAL POLISHING ($\lambda/60$ RMS)
- USED FOR VALIDATION OF WAVEFRONT ERRORS TEST METHODS
- MIGHT BE TRANSFORMED IN A FLIGHT REPRESENTATIVE MODEL (LIGHTWEIGHTING EXCEPTED) FOR USE IN THE "OPTICAL SUPPORT PROGRAM"
- DELIVERY DATE = 6 NOV 84 (POLISHING PRESENTLY IN PROGRESS)

./....

Date.....................

BEAM COMBINER DEVELOPMENT TESTS (CONT'D)

3) - MECHANICAL MODEL

- USED FOR VALIDATION OF THE MECHANICAL BEHAVIOUR OF THE BEAM COMBINER (ASSEMBLY & PADS BONDING PROCESS) - TESTED IN VIBRATIONS.
- FULL SIZE - LIGHTWEIGHTED - UNPOLISHED
- DELIVERY DATE = 31.03.84
- STATUS = LIGHTWEIGHTED
  - ° CUTTING AND BONDING DELAYED AT MATRA's REQUEST
  - ° EXPECTED DELIVERY DATE AUGUST 84

4) - BONDING SAMPLES

- DESIGNED TO STUDY BONDING PROCEDURES
- NO MAJOR PROBLEMS - TEST REPORT TO BE ISSUED
- UNBONDING PROCEDURE TO BE INVESTIGATED

Date ....

THE 3 BEAM COMBINER MODELS

1) O.S.P.
- WEDGE ANGLE = 10′ (WITH BONDED AREA REPRESENTATIVE OF THE 29° WEDGE)
- COATING = ALUMINIUM - SURFACE = FLAT ($\lambda/8$ PTV)
- MAINLY DESIGN TO VALIDATE LIGHTWEIGHTING PROCESS
- WILL BE USED EXTENSIVELY DURING THE "OPTICAL SUPPORT PROGRAM" AND THE TEST SEQUENCE ON P/L OPTICAL STRUCTURAL MODEL (OSTM) - DURING THIS TEST "BASIC ANGLE" STABILITY WILL BE CHECKED (1 MAS)
- STATUS = LIGHTWEIGHTING/STRESS RELEASE ALREADY DONE - POLISHING IN PROGRESS
- PLANNED DELIVERY DATE = 19 JUNE 84

2) E.M.
- WEDGE ANGLE = 29°
- HIGH EFFICIENCY COATING
- STATUS = LIGHTWEIGHTING AND STRESS RELEASE (SCHOTT) ALREADY DONE
- PLANNED DELIVERY DATE = 3 MAY 85

3) P.F.M.
- WEDGE ANGLE = 29°
- WORK HAS NOT YET STARTED
- PLANNED DELIVERY DATE = 24 FEB 86

./....

Date..................................

TELESCOPE OPTICS - MAJOR REQUIREMENTS

- SPHERICAL MIRROR (SM) =
  - -EXTERNAL DIAMETER Ø=393MM THICKNESS = 66MM
  - -LIGHTWEIGHTED (MASS 12.1 KG) - ZERODUR
  - -RADIUS OF CURVATURE R=2800MM
  - -OPTICAL QUALITY =
    - WFE = $\lambda/60$ RMS
    - SYMMETRY = SUCH AS INDUCED CHROMATICITY LESS THAN 1 MAS
  - -FOR ON-GROUND TESTING, A "BEAM ~~COMBINER~~ CONVERGER" IS BONDED ON REAR SIDE

- FLAT FOLDING MIRROR (FM)
  - -EXTERNAL DIAMETER Ø = 356 MM THICKNESS = 60MM
  - -LIGHTWEIGHTED (MASS 9.3 KG) - ZERODUR
  - -CONICAL CENTRAL HOLE (Ø = 69 MM)
  - OPTICAL QUALITY =
    - RADIUS OF CURVATURE ≫ 100 KM
    - WFE = $\lambda/60$ RMS
    - SYMMETRY = SUCH AS INDUCED CHROMATICITY LESS THAN 1 MAS

Date..........................

TELESCOPE OPTICS - DEVELOPMENT STATUS

1) SPHERICAL MIRROR DEVELOPMENT MODEL - INITIATED BY ZEISS TO CHECK POLISHING PROCEDURE AND TO ENABLE FFM TESTING

   - WORK COMPLETED - REPORT NOT YET AVAILABLE.

2) O.S.P. = - AT FLIGHT STANDARD EXCEPT THAT HIGH EFFICIENCY COATING IS REPLACED BY ALUMINIUM COATING.

   - USED TO DEBUG ALL MANUFACTURING PROCESSES (LIGHTWEIGHTING, POLISHING WFE TESTING)
   - USED DURING THE "OPTICAL SUPPORT PROGRAM".

- SPHERICAL MIRROR
  - UNDER POLISHING (PRESENTLY $\lambda/20$ RMS)
  - TEST SOFTWARE COMPLETED, BUT NOT ACCEPTED YET
  - REQUESTED DELIVERY DATE = 19 JUNE 84 - EARLIEST DELIVERY DATE - 6 JULY 84 (MAINLY DELAYED BY DEBUGGING OF LIGHTWEIGHTING PROCEDURE)
  - NEXT MILESTONES = WFE TEST - VIBRATION TEST

- FLAT FOLDING MIRROR
  - POLISHING NOW STOPPED
  - WFE TESTING PRESENTLY IN PROGRESS IN A DEDICATED "THERMAL SHIELDED" CHAMBER
  - REQUESTED DELIVERY DATE = 9 MAY 84 - EARLIEST DELIVERY DATE - 20 JUNE 84
  - NEXT MILESTONES = VIBRATION TESTING IN IABG (6 JUNE 84)
    = ACCEPTANCE TESTING (12 JUNE 84)

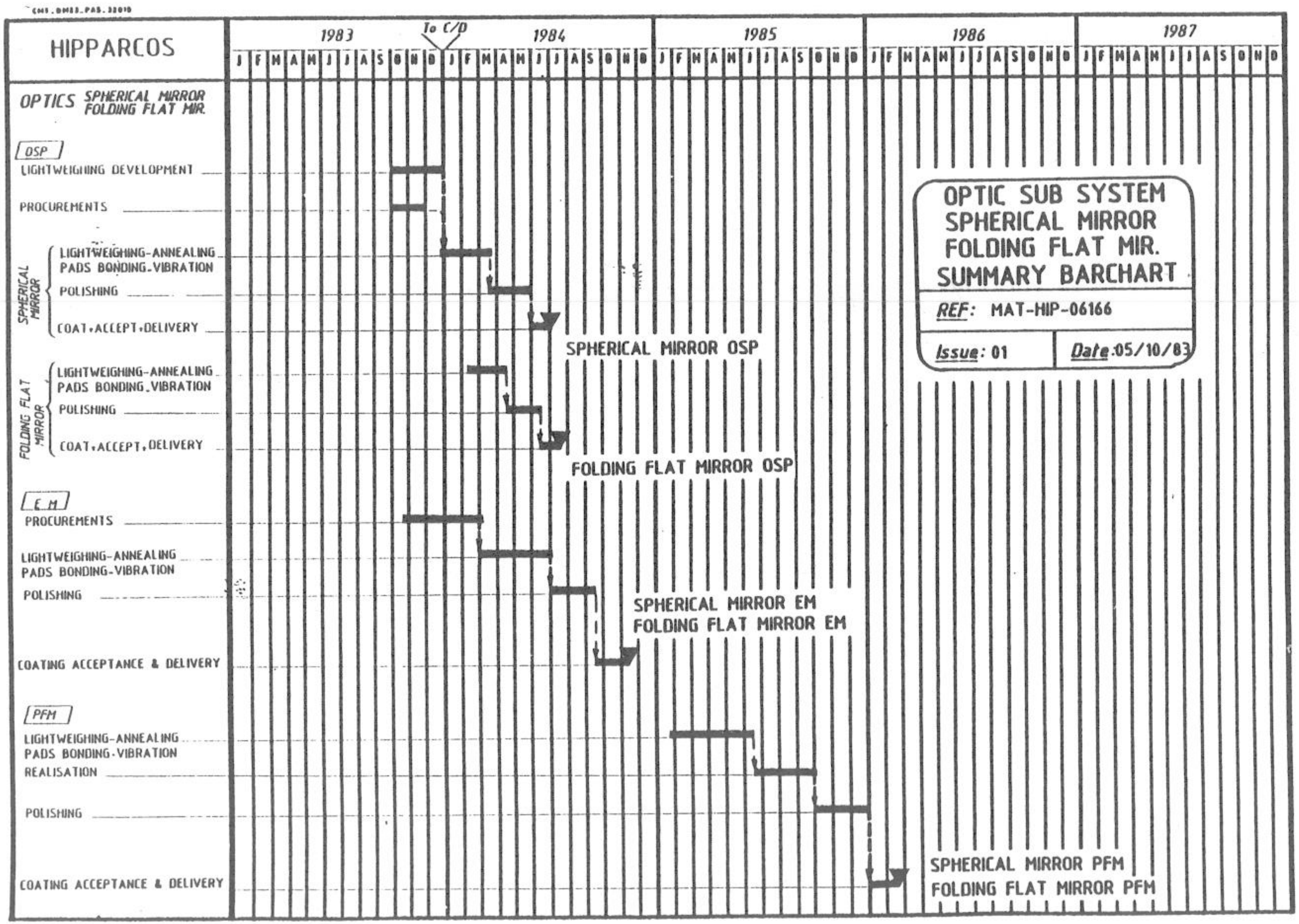
./......

Date..................

TELESCOPE OPTICS - DEVELOPMENT STATUS (CONT'D)

3) E.M.
- ZERODUR PROCUREMENT DONE FOR BOTH MIRRORS
- LIGHTWEIGHTING OF S.M. SHOULD BE COMPLETED
- DESIGN OF VACUUM CHAMBER (FOR WFE TESTS) NEARLY COMPLETED
- REQUESTED DELIVERY DATE = NOVEMBER 84

4) P.F.M.
- NOT YET INITIALISED
- REQUESTED DELIVERY DATE = JANUARY 86.


CMS.DMSS.PAS.32010
HIPPARCOS
1983
To C/D
1984
1985
1986
1987
J F M A M J J A S O N D
OPTICS SPHERICAL MIRROR FOLDING FLAT MIR.
OSP
LIGHTWEIGHING DEVELOPMENT
PROCUREMENTS
SPHERICAL MIRROR
LIGHTWEIGHING-ANNEALING PADS BONDING.VIBRATION
POLISHING
COAT.ACCEPT.DELIVERY
FOLDING FLAT MIRROR
LIGHTWEIGHING-ANNEALING PADS BONDING.VIBRATION
POLISHING
COAT.ACCEPT.DELIVERY
E.M
PROCUREMENTS
LIGHTWEIGHING-ANNEALING PADS BONDING-VIBRATION
POLISHING
COATING ACCEPTANCE & DELIVERY
PFM
LIGHTWEIGHING-ANNEALING PADS BONDING-VIBRATION
REALISATION
POLISHING
COATING ACCEPTANCE & DELIVERY
SPHERICAL MIRROR OSP
FOLDING FLAT MIRROR OSP
SPHERICAL MIRROR EM
FOLDING FLAT MIRROR EM
SPHERICAL MIRROR PFM
FOLDING FLAT MIRROR PFM
OPTIC SUB SYSTEM
SPHERICAL MIRROR
FOLDING FLAT MIR.
SUMMARY BARCHART
REF: MAT-HIP-06166
Issue: 01
Date: 05/10/83

Date ....

GRID REQUIREMENTS

° MAINFIELD - 2688 SLITS (PERIOD = 8.20 MICRONS SLIT WIDTH = 3.20 MICRONS)

- GRID IS A MATRIX OF 168 x 46 SCANFIELDS (EACH SCANFIELD IS 480 MICRONS LONG AND COVERS 16 SLITS)
- DETAILED SPECIFICATION IS GIVEN IN EQ.4.06.2 ISSUE 1 REV. 3
- ALL MANUFACTURING REQUIREMENTS HAVE BEEN ACCEPTED BY T.P.D..

SUCH AS - STITCHING:

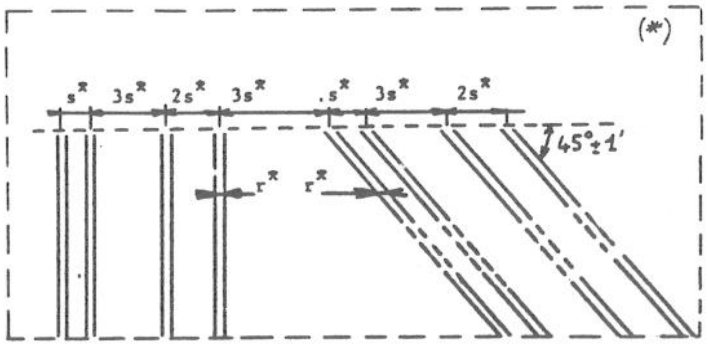
* REGULAR "SAW TOOTH STEP" < 0.12 MICRONS MAX
* IRREGULAR "SAW TOOTH STEP" < 0.03 MICRONS RMS

- SCANFIELD ORIENTATION ERROR

DGMAX < 0.034 MICRONS OR 0.012 MICRONS DEPENDING ON POSSIBLE CORRELATION.

° STAR MAPPERS

- DEFINED IN EQ.4.06.2



WITH $s^* = 38.2\ \mu m \pm 0.17\ \mu m$ (max), $r^* = 6.2\ \mu m \pm 0.17\ \mu m$ (max) } AVERAGED OVER THE PATTERN

MAX, TOLERANCE ON PATTERN GEOMETRY $\pm$ 0.17 μm

Date ....

Date ....

GRID REQUIREMENTS (CONT'D)

- TPD HAS ACCEPTED ALL REQUIREMENTS EXCEPT THE SLITWIDTH TOLERANCE ± 0.17 MICRONS - THIS POINT WILL BE CLARIFIED FOR 15 JUNE 84

° AUXILIARY EQUIPMENT

- GRID REFERENCE MARKS (FOR IDT PILOTING)
- AUTO COLLIMATION SLIT (FOR ON-GROUND TEST SEQUENCE)

Date............................

GRID DEVELOPMENT/STATUS

A) EBPG TECHNOLOGY

- IN 1983, FLAT AND "FLAT TILTED" SAMPLES HAVE BEEN WRITTEN BY C.E.H. TO SELECT THE BEST WRITING STRATEGY
- A "CONCAVE GRID" HAS BEEN WRITTEN WITH THE SELECTED STRATEGY
  - MEASUREMENTS ARE IN PROGRESS IN T.P.D./PHILIPS ON E.B.P.G. MACHINE
  - DELAY OCCURED DURING MANUFACTURING DUE TO POOR QUALITY OF ANTI-REFLECTION COATING
  - A FIRST BATCH OF 10 SUBSTRATES (PILOT SERIES) ARE UNDER PROCESSING

    OUTCOME WILL BE:

    - 1 O.M. GRID (USED FOR ALIGNMENT) DELIVERED BY CEH: END MAY 84
    - 1 GRID (P5) FOR VALIDATION OF PHILIPS " " " : JULY 84 CALIBRATION PROCEDURE
    - 1 E.M. - DELIVERY TO MATRA REQUESTED FOR MARCH 85 (INCLUDING REFOCUSSING ASSEMBLY MECHANISM AND PRECALIBRATION REPORT)
  - A SECOND BATCH OF 7 SUBSTRATES IS FORESEEN TO MANUFACTURE =
    - 1 FLIGHT MODEL
    - 1 FLIGHT SPARE MODEL

    REQUESTED DELIVERY DATE IS JANUARY 86 (INCLUDING MECHANISM AND FULL CALIBRATION REPORT).

./....

Date..............................

GRID DEVELOPMENT/STATUS (CONT'D)

B) PR LE POOLE TECHNOLOGY

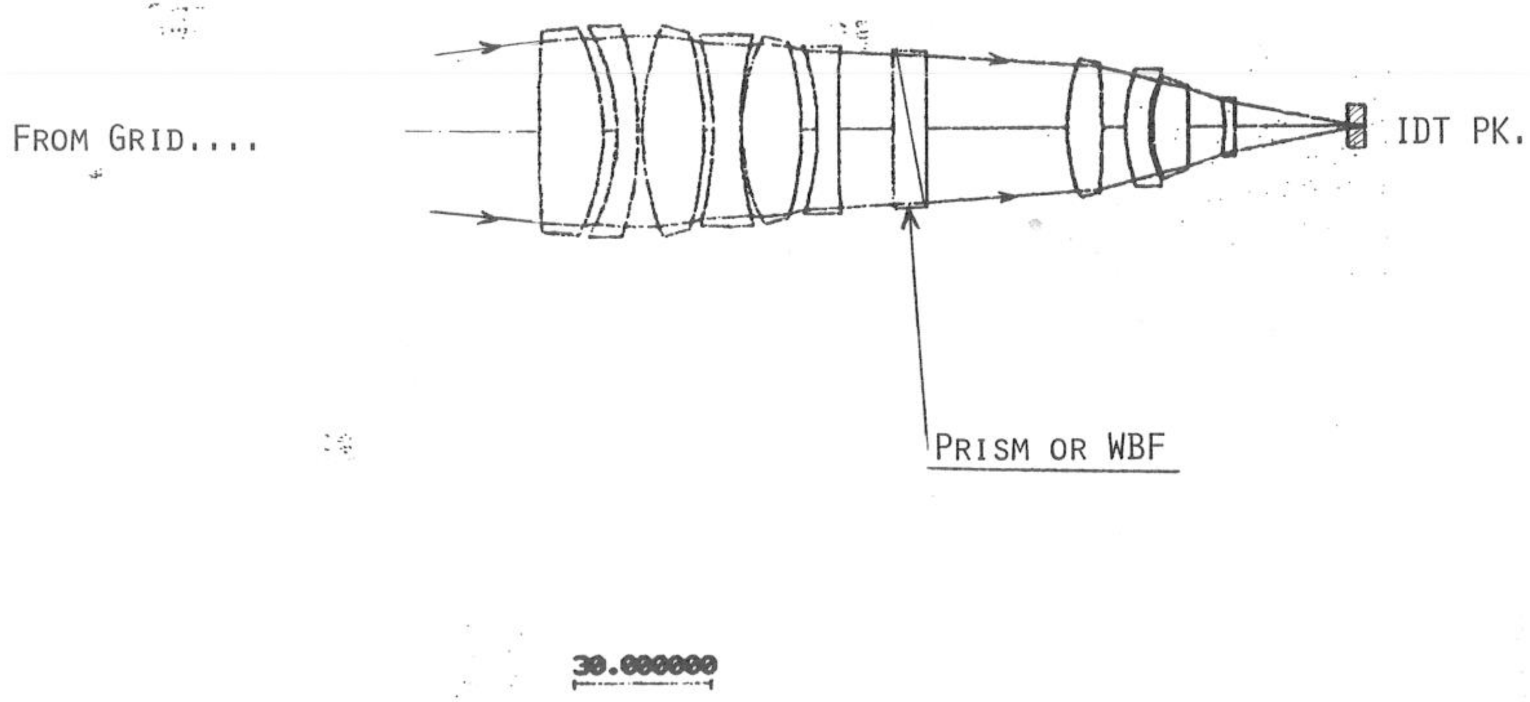
- CURVED TEST SAMPLES HAVE BEEN WRITTEN, BUT CLEANLINESS APPEARED TO BE THE MAJOR DRAWBACK AT THE PRESENT TIME.
- ORIGINAL DELIVERY DATE DECEMBER COULD NOT BE MET
- TODAY NO FULL CURVED GRID HAS BEEN WRITTEN
- EXPECTED DELIVERY DATE : NOT KNOWN.

Date..........................

GRID CALIBRATION (ON-GROUND)

- THIS CALIBRATION COVERS "MEDIUM SCALE IRREGULARITIES"
- A FIRST ISSUE OF THE "GRID CALIBRATION PLAN" BASED ON A EBPG MACHINE (REF TPD-GRI-35-35-INF-101) HAS BEEN EXTENSIVELY DISCUSSED WITH MATRA/TPD.
- HOWEVER CONTENT OF THIS PLAN IS NOT FULLY AGREED BETWEEN ESA/MATRA/TPD
- A REVISED ISSUE IS EXPECTED FROM TPD FOR END MAY 84.
- OPEN POINT
  - PRESENT COMMITMENT FROM TPD, BASED ON AN AUTOMATED ROUTINE DEVELOPED BY PHILIPS FOR AN EBPG MACHINE, IS 8 MAS - (SEE TPD-GRI-35-35-INF-107) (ESA REQUIREMENT IS 5 MAS FOR ON-GROUND CALIBRATION)
  - HOWEVER MATRA HAS COMMITTED THEMSELVES TO REACH 3 MAS DURING IN-ORBIT COMMISSIONING.
  - SITUATION WILL BE REVIEWED END OF AUGUST 84, IN LIGHT OF RESULTS OBTAINED ON PILOT SERIES P5.
  - AN ALTERNATE METHOD HAS BEEN PROPOSED BY PR. LE POOLE, BUT HAS NOT BEEN RETAINED FOR THE BASELINE BY TPD.

I.D.T. RELAY LENS DESIGN



Date ....

Date..........................

IDT RELAY OPTICS

- OPTICAL DESIGN
  - AFTER MEETING HELD AT ESTEC BETWEEN PR. WYNNE, DR. LINDEGREN, MATRA AND ESA, VARIOUS SOLUTIONS HAVE BEEN INVESTIGATED (DOUBLE GAUSS, REDUCTION OF NUMBER OF LENS, DELETION OF WBF ....)
  - DESIGN HAS BEEN REVIEWED TO ACCOMMODATE PRISM FOR CHROMATICITY CALIBRATION.
  - RADIUS OF CURVATURE OF FIELD LENS (GRID ASSY) HAS BEEN MODIFIED.
  - OPTIMIZATION HAS BEEN PERFORMED BY ZEISS.
  - GHOST IMAGES HAVE BEEN EVALUATED BY ZEISS
    (T.N. ZO-HIP-003.84)
    AND HAVE A MINOR IMPACT
- MECHANICAL DESIGN:
  - RATHER DIFFICULT (DUE TO NUMEROUS CONSTRAINTS ON FOCAL PLANE ASSEMBLY INTERFACES)
- REQUESTED DELIVERY DATES
  - EM = 12 MAR 85
  - PFM = 16 JAN 86

CHROMATICITY CALIBRATION

-PRINCIPLE HAS BEEN GIVEN DURING LAST H.S.T. (SEE T.N. LA.FA.24)

-THIS PRISM IS NOW PART OF MATRA BASELINE
(SEE T.N. MAT HIP 7336 & 7852)

-DEFINITION IS NOT COMPLETLY FROZEN;MAIN FEATURES ARE:

- -PRISM MADE OF TIF6 & PSK 53 (THICKNESS :8MM)
- -DISTANCE BETWEEN BLUE (λ =425 NM) AND RED (λ =625NM)IMAGES IS 215 MICRONS IN IDT PHOTOCATHODE PLANE.
- -SPECTRAL SEPARATION ACHIEVED BY A "BAND BLOCKING" FILTER
- -FILTER MECHANISM HAS BEEN MODIFIED (NEW COUNTERWEIGHT)
- -OPTICAL & MECHANICAL DESIGN OF IDT RELAY LENS HAS BEEN UPDATED.

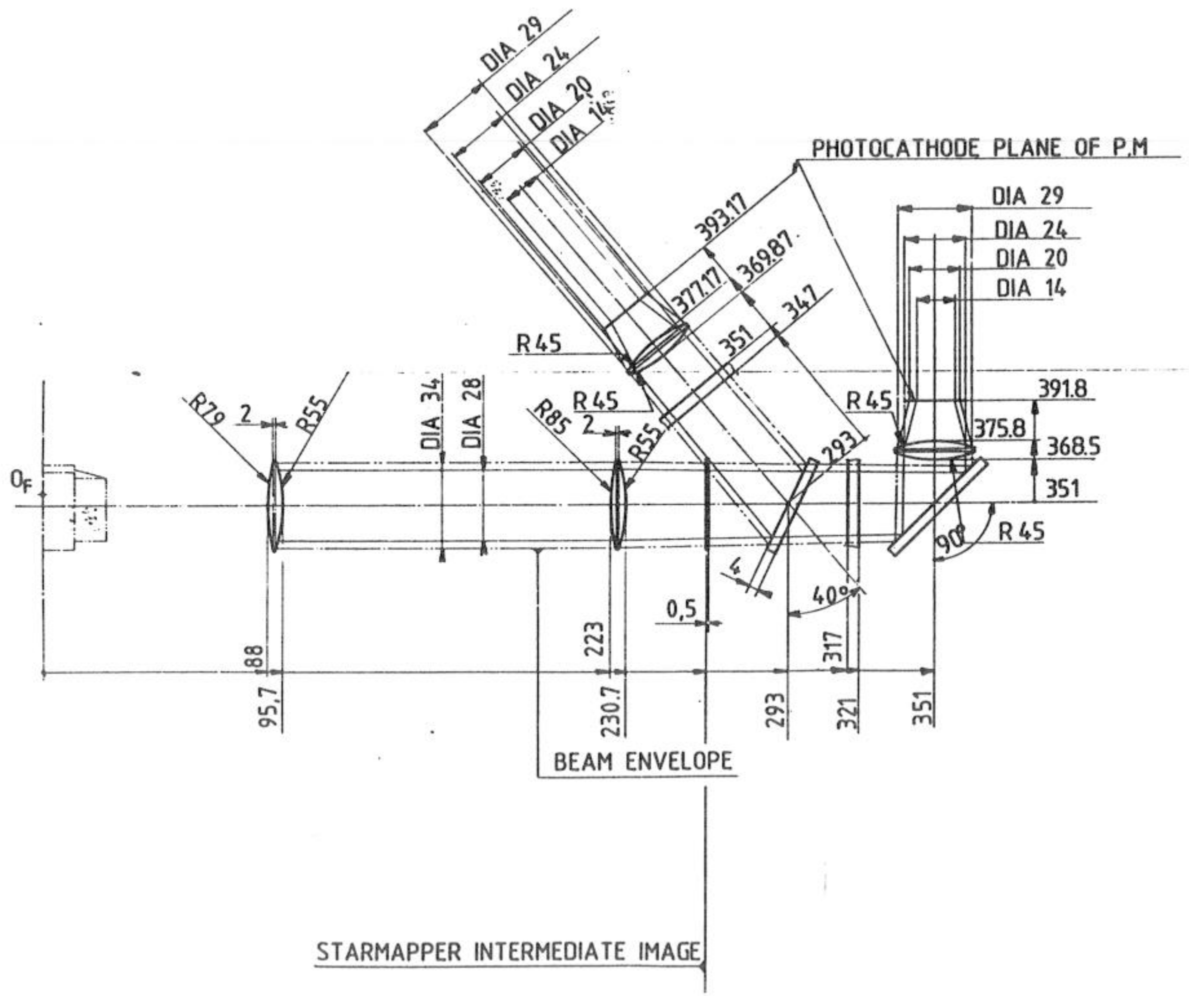
-CONSEQUENTLY,ON-GROUND TEST EQUIPMENT FOR P/L PERFORMANCES VERIFICATION HAS BEEN SIMPLIFIED.

-OPEN POINT:

- -SPECIFICATION FOR THIS DEVICE NOT AVAILABLE.

Date ....

P.M.T. RELAY LENS DESIGN



Date..............................

Date....................

PMT RELAYS OPTICS

OPTICAL DESIGN :

- BASIC DESIGN SHOWN ON PREVIOUS VIEWGRAPH HAS BEEN REVIEWED TO INCORPORATE CHANGES ON GRID ASSY.
- OPTIMIZATION HAS BEEN PERFORMED BY ZEISS.

MECHANICAL DESIGN :

- INTERFACES WITH FOCAL PLANE ASSEMBLY HAVE BEEN STUDIED.

OPEN POINTS :

- LOCATION OF STAR MAPPER IMAGE CLOSE TO DICHROIC PLATE (UNDER REVIEW)
- FOR ONE SIDE, INTERMEDIATE STOP FALLS IN THE SHUTTER AREA
- REQUIREMENTS FOR OPTICAL QUALITY WILL BE UPDATED

REQUESTED DELIVERY DATES:

- EM = 12 MAR 85
- PFM = 16 JAN 86

H. EGGEL

ANNEX IV (1)

Date..........

DTSS PERFORMANCES (S/S SPEC. SS-4-04-0) 3 REV. 4

OPEN POINT : LONG TERM PILOTING STABILITY - ENGINEERING PROBLEM

TUBE PERFORMANCE EVALUATION IS FINALIZED, NO PROBLEMS

TESTS PERFORMED SINCE LAST HST MEETING :

1) MEASUREMENT OF "IMPROVED VEILING GLARE" TUBE
2) PILOTING VERIFICATION WITH MULTIHOLE MASK PILOTING FROM 1 MM PITCH PATTERN IS FEASIBLE WITH σ = 2 μM, LINEAR INTERPOLATION
3) OVEREXPOSURE MEASUREMENTS (earth equivalent for 1 hour - nominal performance is achieved again within 1 hour)
4) SENSITIVITY TO EXTERNAL MAGNETIC FIELDS

TUBE PROCUREMENT STATUS:

IDT : OCT 83 : MATRA PROPOSED TO CHANGE THE ACCELERATION MESH TO OBTAIN HIGHER TRANSPARENCY

END 83 : ESA CANNOT ACCEPT THE PROGRAMMATIC RISKS INVOLVED AND SUGGESTS TO SELECT THE BEST TUBES FROM THE STANDARD PRODUCTION (BASED ON TUBE DATA FOR EXOSAT/IPS)

JAN 84 : MATRA ADOPT THE PHILOSOPHY OF TUBE SELECTION.

EM TUBE DELIVERY (3) : JUNE/JULY 84, FIRST BENCHTEST RESULTS ARE PROMISING

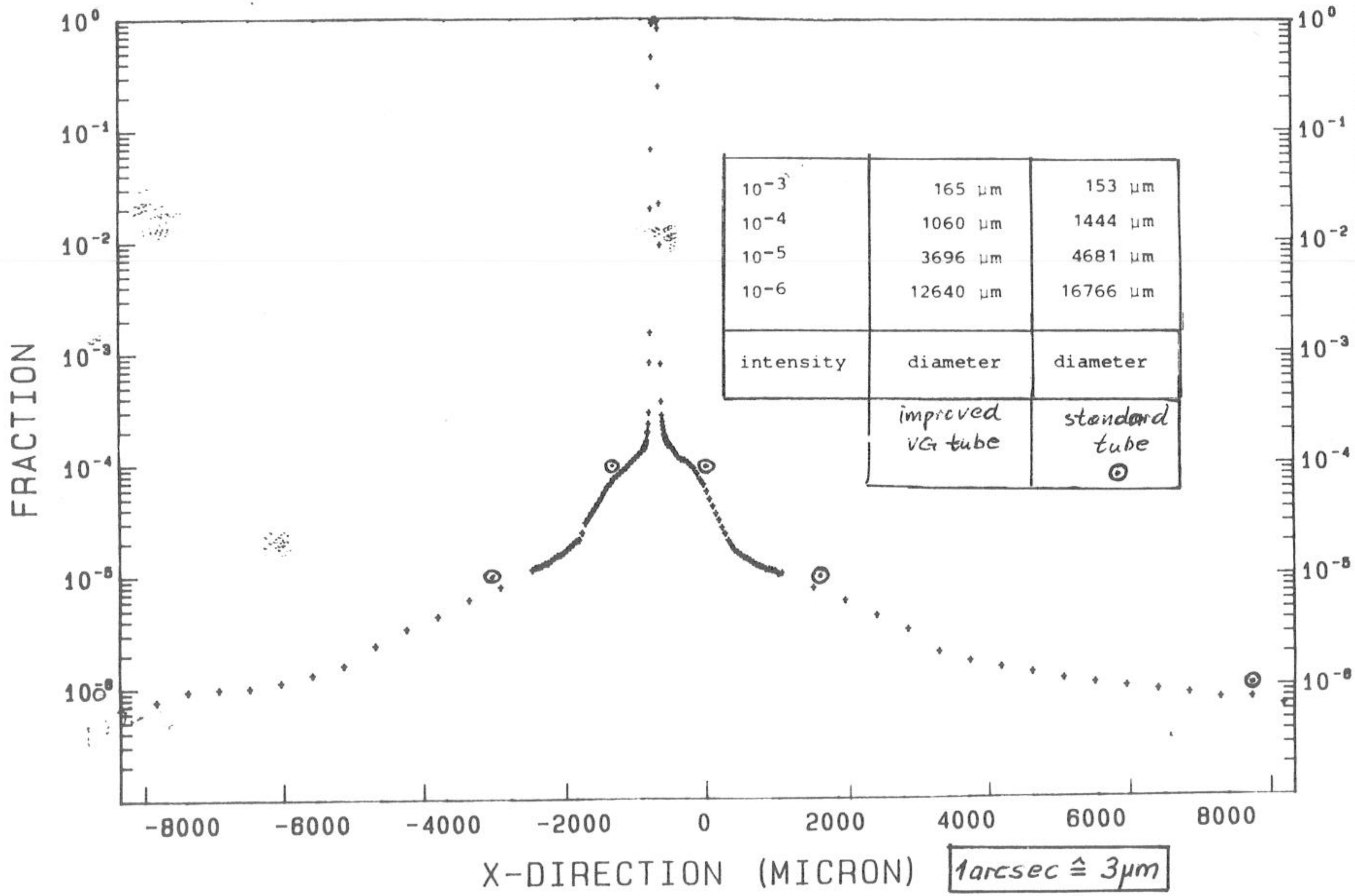
FM TUBE DELIVERY (5) : JAN 85; FIRST BENCHTEST RESULTS EXPECTED SEPT/OCTOBER

IF THE PERFORMANCE OF THE FIRST FM BATCH WOULD INDICATE THE NEED, A SECOND BATCH OF TUBES COULD BE ORDERED.

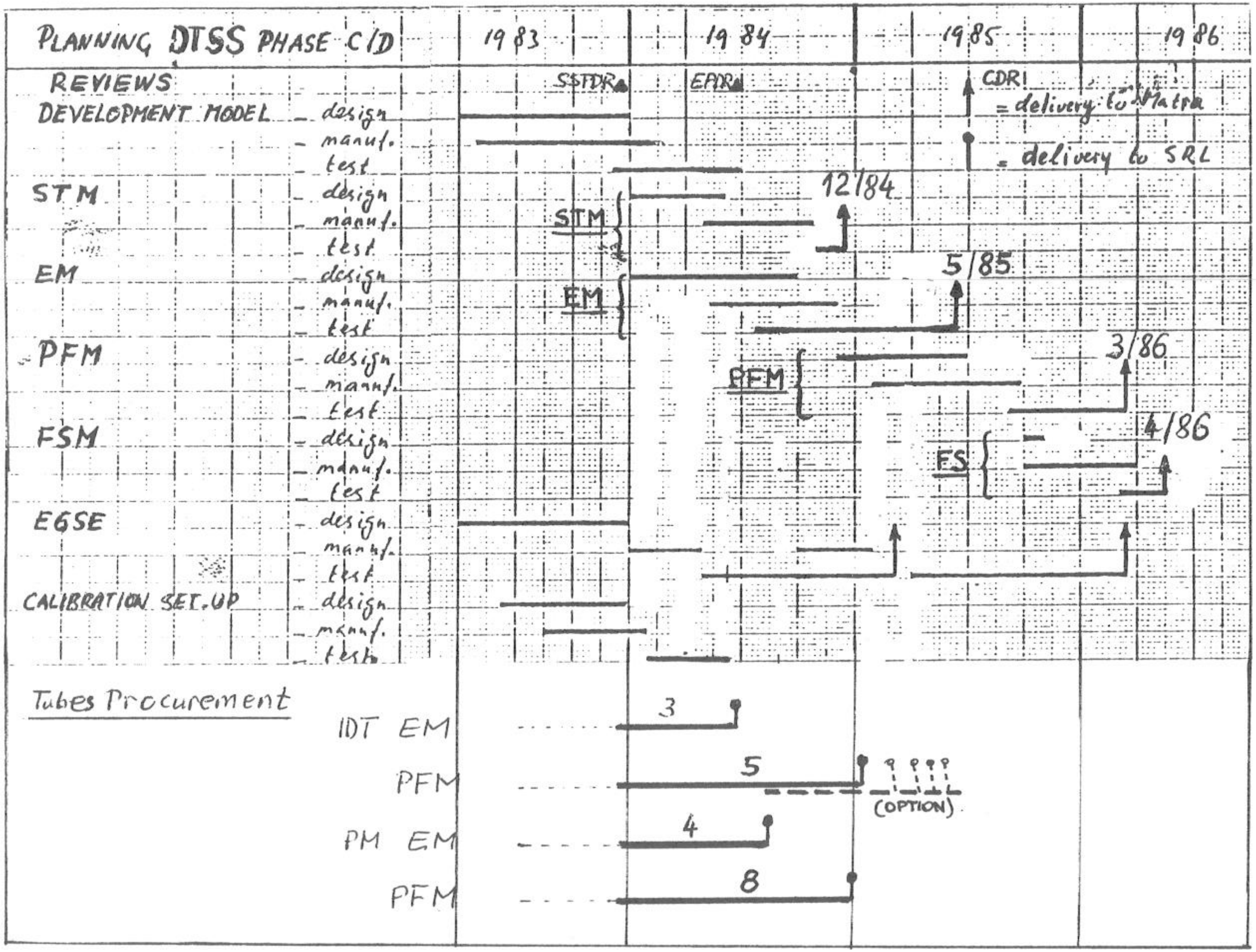
PMT : TUBES ON ORDER FROM EMI (ALL BIALKALI)

Date..........

Date 25/05/84



intensity	diameter	diameter
10^{-3}	165 μm	153 μm
10^{-4}	1060 μm	1444 μm
10^{-5}	3696 μm	4681 μm
10^{-6}	12640 μm	16766 μm
	improved VG tube	standard tube ⊙


PLANNING DTSS PHASE C/D
1983
1984
1985
1986
REVIEWS
SSTDR
EPDR
CDR
= delivery to Matra
= delivery to SRL
DEVELOPMENT MODEL
design
manuf.
test
STM
design
manuf.
test
EM
design
manuf.
test
PFM
design
manuf.
test
FSM
design
manuf.
test
EGSE
design
manuf.
test
CALIBRATION SET.UP
design
manuf.
test
STM
EM
PFM
FS
12/84
5/85
3/86
4/86
Tubes Procurement
IDT EM
PFM
PM EM
PFM
3
5
4
8
(OPTION)

Date

ANNEX V

B = 9 B − V = 0·5

	I_0	M_1	M_2
MATRA pre budget Issue 4	2139	0·689	0·248
Degradation factors	0·93	0·85	0·85
"Nominal Instrument"	2300	0·811	0·292
LA-FA-28	2011	0·829	0·320
ESA(RDW) pre budget	2110	0·671	0·247
" (undegraded)	2260	0·790	0·291

ANNEX VI /

ESOC PRESENT ACTIVITIES

* FUNCTIONAL SUPPORT TASKS DEFINITION

- o LEOP
- o INITIALISATION (SPR & GRTAD)
- o COMMISSIONING CALIBRATION
- o NORMAL MODE
  - PAYLOAD MONITORING
  - RTAM
  - ROUTINE CALIBRATIONS
  - DATA ROUTING & STORAGE
- o EMERGENCIES

ANNEX VI

* **Computer Configuration Definition**

o RELIABILITY OF DATA ACQUISITION & PSF UPLINK

o INTERFERENCES WITH OTHER PROJECTS

o INSTALLATION AND OPERATING COST

o DATA PROCESSING REQT'S

o CONTENTS & STRUCTURE OF DATA DELIVERY TO DRC's

o OFF-LINE & ON-LINE SEPARATION

* **Operations Preparation**

o SIMULATOR AND OPERATIONS SOFTWARE REQT'S

o USER MANUAL CONTENTS

o OBS INTERFACES

INITIALISATION PHASE

* INITIAL STAR PATTERN RECOGNITION

o SUN POINTING MODE

o REFOC ON BASIS OF SM PMT OUTPUTS

o SAS & GYRO-CONTROL DISABLE

o SEPARATION OF STARS FROM BOTH FOV'S

o MAPPING ONTO REFERENCE CATALOGUE

o CONFIRMATION OR CORRECTION OF MAPPING

* GYRO CALIBRATION

o MONITORING GYRO OUTPUTS

o COMPARISON WITH DRIFTS IN STAR PATTERN

* GRTAD

o GC SCANNING UNDER GYRO CONTROL
o ON-GROUND ATTITUDE DETERMINATION VIA SM OUTPUTS AND ON-GROUND PSF
o UPLINK OF ATTITUDE ANGLES AND RATES FOR CONTROL

* RTAD INITIALISATION

o UPLINK OF PSF (REFERENCE STARS ONLY)
o UPLINK OF INITIAL ATTITUDE OFFSETS & GYRO DRIFTS FOR RTAD
o MONITORING OF RTAD AND COMPARISON WITH GRTAD OUTPUTS
o SWITCH-OVER TO CLOSED-LOOP CONTROL ON BASIS OF RTAD RESULTS

* IDT INITIALISATION

o UPLINK OF COMPLETE PSF

ACQUISITION PHASE

* 43^{0} MANOEUVRE

o STOP SCANNING

o SLEW UNDER GYRO CONTROL (ACCURACY $\sim 0.5^{0}$)

o GC SCANNING UNDER GYRO CONTROL

* FINAL STAR PATTERN RECOGNITION

o USE A PRIORI PHASE KNOWLEDGE

o TOUCH-UP MANOEUVRE (GYRO CONTROL) TO $\zeta = 43^{0}$ $\pm$ 10 ARCMIN

o GC SCANNING UNDER GYRO CONTROL

* **RTAD REINITIALISATION**

- o GRTAD REIMPLEMENTATION
- o UPLINK OF PSF
- o RTAD MONITORING
- o CLOSED-LOOP CONTROL VIA RTAD

CALIBRATION SUPPORT

* PRELIMINARY DEFINITION IN OAD 263

* OPEN QUESTIONS

  - EXTENT AND NATURE OF SOFTWARE TRANSFER FROM MESH
  - REQUIREMENT OF GCR SOFTWARE AT ESOC
  - DIVISION OF TASKS BETWEEN ESOC & DRC'S
  - COMMISSIONING DURING SUN-POINTING OR IN NSL
  - NON-NOMINAL SCANNING REQT'S
  - NON-NOMINAL PILOTING REQT'S
  - INCLUSION OF DUMMY STARS IN PSF
  - PRECISE FREQUENCY OF CALIBRATION TASKS IN ROUTINE PHASE

Annex VII

ORBIT DATA INTERFACE

* RANGING & ANTENNA ANGLES (ODW) EVERY 3 - 4 HRS

* ACCURACY:

o ALTITUDE ~ 200 M
o LONGITUDE/LATITUDE ~ 1.0 KM
o VELOCITY ~ 13 CM/SEC

} POSITION ~ 1.5 KM

* ORBIT DETERMINATION ONCE A WEEK

o T_0, $\underline{X}_0$, $\dot{\underline{X}}_0$
IN MEAN-EQUINOX OF DATE FRAME

* FOURIER FIT OVER EVERY HALF DAY

o 10 PARAMETERS FOR EACH POSITION/VELOCITY COMPONENT
o ACCURACY OF FIT: ~ 1 M; ~1 MM/SEC

* **DATA VOLUME**

  o 2*6*10 = 120 PARAMETERS/DAY

  o LESS THAN 4 KBYTE/WEEK

  o IN CASE OF MANOEUVRES: 2 SETS OF DATA

* **PROPOSED DELIVERY**

  o IN 'ADDITIONAL' DATA FILE ONCE PER WEEK

  o SUBROUTINES FOR CONVERSIONS CAN BE PROVIDED

4.3 Approximation of State Vectors

4.3.1 Sychronous Orbit Parameters

The approximation of the state vectors (position, velocity) are used primarily in the near synchronous and synchronous phases as already mentioned. Typical orbit parameters for these two phases are:

semi-major	42 164 km
eccentricity	< 0.002
inclination	< 5°

Assuming an eccentricity of 0.002 the following heights are derived

height of perigee	35 702 km
height of apogee	35 870 km

The orbits will be almost circular, resulting in a uniform movement with a periodicity of about 1 day. The uniform angular velocity offers a representation of the parameters/components versus time, which facilitates the running of the retrieval program with respect to CPU time and subsequent core allocation. In the case of a larger eccentricity the parameters should be represented as a function of the anomaly, for example.

The perturbations (Ref. 27) for this type of orbit are significantly smaller compared with the large J_2 perturbations for the transfer orbit. The short periodic perturbations are caused mainly by luni-solar gravitation and are roughly of the following magnitude:

semi-major axis	< 2000m
eccentricity	< $0.5\ 10^{-4}$

Ref. 27 - W. Flury: Station Keeping of a Geostationary Satellite ESOC Internal Note 114 March 1973

Because of the relatively small variations in the orbit parameters, the osculating elements/state vector can be approximated direct.

4.3.2 Representation of State Vectors

As already stated, the movement of the satellite is very uniform due to the low eccentricity, and the short periodic perturbations are small for the above-mentioned type of orbit. Because of these conditions the state vector (position and velocity quoted in the inertial equatorial geocentric coordinate system) versus time can be approximated direct using the truncated Fourier expansion (Ref. 28):

Given a sequence of state vectors x(t) referring to the time t, this is approximated in the form

$$x(t) = a + b\,(t-t_o) + \sum_{n=o}^{m} (C_n \cos M(t) + a_n \sin M(t))$$

where

$M(t) = n_o\,(t-t_o)$, in which

n_o = mean motion and t_o = epoch (reference time).

The numerical tests have shown that 10 coefficients (i.e. m=3) are sufficient in order to have an approximation error of less than 10 m in position and 10 mm/s in velocity using an approximation time interval of 0.5 days.

The computation is fairly simple, i.e.

1) Input state vectors referring to the approximation time interval, select reference time t_o and compute the mean motion n_o .

Ref. 28 - J.M. Dow: Approximate Representations of the Elements of Highly Eccentric Orbits
ESOC/OAD Working Paper No. 16
April 1975

2) Set up the equations

$$x(t) = a + b(t-t_o) + \sum_{n=o}^{3} \cdot \{C_n \cos M(t) + d_n \sin M(t)\}$$

$$y = (a, b, c_o, \ldots, d_3) \quad .$$

3) The matrix equation is obtained by the least squares approach.

$$y = (A^T A)^{-1} A^T X.$$

The inversion of the matrix $(A^T A)$ is computed by the Cholesky method.

Unlike the transfer orbit representation with less stringent position accuracy requirements, the near synchronous and the synchronous orbits must be determined accurately. The required position accuracy is of the order of 1-2 km. The inherent approximation error should therefore be at least one order of magnitude smaller, which can easily be achieved under normal circumstances. The manoeuvre case, however, needs further consideration. Again two possibilities exist, i.e.

- a constant time interval (defined for the whole phase), and
- a variable time interval.

In both cases the discontinuity in some components of the state vector (velocity only) due to manoeuvres is taken into account by adjusting the sequence for the approximation. The variable time interval should be used in order to minimise the approximation errors.

The sequence of the retrieval program for computation of the state vector in the inertial coordinate system is very simple i.e. given t_o, n_o for a selected set of coefficients for a given time t

compute $M(t) = n_o(t-t_o)$ and

evaluate

$$x(t) = a + b(t-t_o) + \sum_{n=o}^{3} \{ C_n \cos M(t) + d_n \sin M(t)\} \quad ,$$

and finally check whether the velocity components should be adjusted for the influence of an orbit/attitude manoeuvre.

4.3.3 Numerical Results

The numerical performance depends greatly on the uniform movement of the satellite, i.e. it depends on the value of the eccentricity The smaller the eccentricity, the smaller the approximation error. In this case the approximation of the state vector was ascertained for an orbit with

semi-major axis	42 164 km
inclination	2°

The approximation time interval is 0.5 days with no manoeuvres. The performance (position and velocity error) is shown versus the eccentricity.

Eccentricity	Difference between apogee height and perigee height (km)	Position error (km)	Velocity error (m/s)
0.05	4 210	< 0.005	< 0.005
0.10	8 430	0.030	0.010
0.20	16 860	0.83	0.38

4.4 Sequential Storing of Orbit Parameters

Contrary to the two methods described above, which are intended for use in the operational environment, this third possibility is provided for off-line computations, of which the following are considered to be typical:

- visibility studies for future spacecraft
- evaluation purposes.

Although integration of the orbit is performed in cartesian coordinates, the orbit parameters are stored on a file, which is primarily for reasons of compatibility with existing programs.

ANNEX VIII

NOTE: DUE TO LIMITED OVERALL DURATION OF COMMISSIONING, ALL CALIBRATIONS ARE TIME-CRITICAL DURING THIS PHASE.

HIPPARCOS ON-ORBIT CALIBRATIONS

1. GEOMETRIC CALIBRATIONS

IDENT.[N]	TYPE	USE	BY-PRODUCT OF DATA RED.[N]	TIMING CRITICALITY	ESOC COST IMPACT	PREFERRED IMPLEM.[N] AT ESOC
1.1	LONGIT.[L] LSC	C	YES	NO	YES	NO
1.2	MSC	C	NO	NO	YES	NO (1.1,1.2 CAN'T BE DISSOCIATED)
1.3	SCC	NA	-	-	-	-
1.4	TRANSV. COMP.[T]	V	YES	NO	NO	NO (AS 1.2)
1.5	SM TRANSFORM.[N]	C	YES	NO	NO?	YES
1.6	BASIC ANGLE	C	YES	NO	YES	NO (AS 1.2)
1.7	IDT (ISPA)	O	NO	YES	YES	YES
1.8	IDT (GRM)	O	NO	YES	YES	YES
1.9	MAIN FOV CHROMAT.[Y]	C	NO	NO	YES	YES
1.10	SM CHROMAT.[Y]	C	NO	NO	YES	YES
1.11	ATT. JITTER	V	NO	NO	YES	YES

CODE
- C — CALIBRATION, INPUT TO DATA REDUCTION CONSORTIA
- O — FUNCTIONAL CALIBRATION
- V — VERIFICATION OF PERFORMANCE ONLY

2. PHOTOMETRIC (AND STRAYLIGHT) CALIBRATIONS

IDENT.[N]	TYPE	USE	BY-PRODUCT OF DATA RED.[N]	TIMING CRITICALITY	ESOC COST IMPACT	PREFERRED IMPLEM.[N] AT ESOC
2.1	LARGE SCALE SENSIT.VARIAT.[NS]	C	NO	NO	YES	YES
2.2	PL IFOV PROFILE	C	NO	NO	YES	YES
2.3	REL. SPECTRAL RESPONSE	C	NO	NO	YES	YES
2.4	ABSOL. PHOTOM. RESPONSE	O/C	NO(I_o),YES(M_1,M_2)	YES(M_1),NO(I_o,M_2)	YES	YES
2.5	ITF MAIN FIELD	C	NO	NO	YES	YES
2.6	SM SENSIT. VARIAT.[NS]	C	YES	NO	YES	NO
2.7	SM SPECTRAL RESPONSE	C	YES	NO	YES	NO
2.8	SM ABSOL. RESPONSE	C	NO(SSR),YES(I_o)	YES(SSR),NO(I_o)	YES	YES
2.9	SM ITF	C	YES	NO	YES	NO
3.1	SUN STRAYLIGHT/LIGHT TIGHTNESS	V	NO	YES	NO	YES
3.2	EARTH/MOON STRAYLIGHT	C	NO	NO	NO	YES

NOTE CALIBRATIONS DURING IN-ORBIT COMMISSIONING ARE TIME-CRITICAL (SEE TABLE 1 NOTE)