Minutes of the Eighth Meeting

of the

HIPPARCOS SCIENCE TEAM

ESTEC, 3 - 4 November, 1983

Attendance:

HST:	Dr. M.A.C. Perryman, Chairman
	Dr. M. Crézé
	Dr. A.M. Cruise
	Professor F. Donati
	Dr. M. Grenon
	Professor M. Grewing
	Dr. E. Hog
	Professor J. Kovalevsky
	Dr. L. Lindegren
	Mr. C.A. Murray
	Mr. R.S. Le Poole
	Dr. C. Turon
	Professor C.G. Wynne
ESA:	Mr. L. Emiliani (part time)
	Mr. R. Bonnefoy (part time)
	Dr. K. Clausen (part time)
	Mr. M. Schuyer (part time)
	Dr. S. Vaghi
	Dr. R.D. Wills
ESOC:	Mr. P. de Broeck
	Mr. H. Laue
MATRA;	Mr. E. Zeis

Professor A. Blaauw, Dr. D.E. Page, Dr. B.G. Taylor and other members of the HIPPARCOS Project Team attended the Input Catalogue Consortium report.

Adoption of the Agenda

The agenda as shown in Annex I was adopted.

1. Report by Project Manager

Emiliani explained that the C/D proposal from MATRA was under review by the Project Team and that Phase C/D would commence early in 1984 subject to a successful negotiation of certain items with MATRA and subject to approval by the Science Programme Committee (SPC) and Industrial Policy Committee (IPC).

Emiliani confirmed that termination of the Science Advisory Group (SAG) had been requested. Hog and Kovalevsky considered that direct and less formal contact with MATRA engineers was valuable for the project. Emiliani would consider whether specialist meetings, in place of the SAG, could be held in ESTEC - perhaps preceeding or following HST meetings.

2. Distribution of Software

Vaghi distributed the software inventory (October 1983 update) ESA-HIP-3747 to the four consortia leaders, and stressed that documented ESA/MESH programmes could be requested from him by the consortia. Copies of the ESA SOS software and the associated documentation (see also Item 12), and copies of the MATRA/LOGICA ILS software and the associated documentation (see also Item 17) were distributed to NDAC and FAST. A copy of the SOS software was also given to INCA, and a copy was requested by TDAC.

3. DCN 15

Copies of DCN 15 had been distributed to the HST members, and the change in the requirement on the gradient of the field-to-grid transformation (MAT-HIP-5894 distributed to NDAC and FAST) was discussed and approved.

4. Revised Overall System Specification

Wills gave a presentation of the changes to be found in Issue 3, Rev. 1 of the Overall System Specification (see Annex II). Updates of the Overall and Payload System Specifications would be sent to HST members in due course.

5. Grid Report

(a) THD Alternative Grid. ESTEC had awarded a contract to THD. Due to electrostatic cleanliness a flat grid (due date October 1) will not be available before November 15. A curved grid is due December 1, but present indications are that this date will also slip.

(b) CEH Grid. Wills presented the rms error induced at frame level by 'other error sources' derived from MAT-HIP-4803 and from the TNO/TPD commitment respectively (see Annex III). Le Poole and other HST members expressed concern at the situation which presently existed for on-ground calibration. Bonnefoy felt that the current TPD commitment might be conservative, and that updated values might be available before the end of B2. Cruise expressed concern at the limited number of measurements that had been made to arrive at the present performance predictions, and stressed the importance of automatic measurements to increase their number. Zeis confirmed that automatic measurements were foreseen for early C/D. Kovalevsky expressed concern at how the in-flight calibration would be performed, and stated that some investigations into the problem would be carried out within FAST.

(c) Stitching Error. Copies of 'Attenuation Factor for a Perfect Saw Tooth Profile' (MAT-HIP-6087) and 'Effect of Scanning Velocity and Scanfield Size on the Attenuation of Regular Stitching Errors' (ESA-HIP-3634) were distributed to all HST members. Wills presented the results of the simulations described in the latter note.

6. Veiling Glare

Lindegren presented the results of his assessment of the MATRA notes 'Detection Thresholds for Parasitic Stars' (MAT-HIP-5791) and 'Revision of the IFOV profile local model' (MAT-HIP-5953) in view of the analysis methods that are foreseen by NDAC (see Annex IV).

The principal conclusions were:

- the approach was considered reasonable and consistent with the data reduction methods foreseen.

- the evaluation of σ^2 in MAT-HIP-5791 was relevant to a specific configuration and should perhaps be ~ 3 x larger.

- the evaluation of C is probably optimistic, the a priori value of σ^2 being determinable with possibly only a 20 per cent precision.

The acceptability of the approach was endorsed by Kovalevsky.

Zeis commented that a revision of the veiling glare analysis will be undertaken by MATRA using a more realistic value of C, which would decrease the affected dead-time and increase the associated error variance.

Bonnefoy stated that a modified IDT should be delivered by 15 November, and the measurements of the IFOV profile for the new tube were foreseen for 15 December.

7. Chromaticity Calibration Proposal

Kovalevsky introduced LA.FA.24, 'A Proposal for the In-Flight Calibration of the Chromaticity', and identified concerns related to the present approach for chromaticity calibration. The use of the two IDTs, and the variation of geometry (attitude and FOV position) between successive great circles were of particular concern.

Bonnefoy and Zeis considered the proposal worthy of further study.

8. Relay Lens Design

(a) Ghost Images. Wynne repeated his concerns about ghost images in the present proposed relay lens design. Even if state-of-the-art anti-reflective coatings were applied to all surfaces, the present specification of the magnitude of the ghost images would probably be impossible to achieve.

(b) Complexity of the Present Design. Wynne requested that a justification of the present design should be provided by ESA/MATRA. Perryman noted that the specifications on transversal coma (6.8 μm) and lateral chromaticity (3 μm) should be clarified.

Bonnefoy proposed a meeting to be organised between ESA, Wynne, Lindegren and MATRA engineers to review the design specifications and to allow Wynne to provide more specific comments on the present design.

9. Choice of Tycho Photomultipliers

MAT-HIP-6488 was distributed ('TYCHO Optimisation'). Lindegren presented his estimates of the TYCHO limiting magnitude for $\sigma = 0.5$ mag:

B-V	BT	VT(bialkali)	VT (S20)
0	11.56	10.87	10.68
0.7	11.57	10.63	10.62
1.5	11.64	10.45	10.70

Thus if there are more red than blue stars at B = 11 mag, S20 is marginally better.

Furthermore the sensitivity to sky background is:

-	gain for 0.5 * sky	0.31	0.29	0.13 respectively
-	loss for 2 * sky	0.34	0.33	0.20 respectively

Finally the separation in BT and VT effective wavelengths is 106 nm (bialkali-bialkali) and 160 nm (bialkali - S20).

In view of the above performances, the HST strongly recommended the choice of bialkali-S20, even though the bialkali-bialkali performance met the SRD specifications and would thus be considered acceptable.

A final decision will be made by the Agency when the cost of the bialkali-S20 option has been assessed and when the programmatic aspects of such a choice have been examined.

10. Star Distribution Models/IRS for RTAD

Results of the MATRA simulations on the two RTAD star distribution options given in ESA/MAT-HIP-3951 were not yet available. A note was expected from MATRA in the near future and would be distributed when available.

The acceptability of using the option of uplinking IRS stars for RTAD only was confirmed by Hog and Kovalevsky. Both consortia would, in this case, request SM records for RTAD stars as well as programme stars for attitude reconstitution purposes.

Turon presented results of a study of the contents of the first iteration of the Input Catalogue, which confirmed earlier speculation that some 20 000 IRS stars would probably not be contained in the Input Catalogue.

Laue questioned whether a 20 per cent increase in the uplink data rate could be accommodated given the present design of the ground segment.

11. INCA Activity Report

Turon gave a detailed account of the present status of the Input Catalogue Consortium work. Professor A. Blaauw, Chairman of the Proposal Selection Committee, and members of the ESA Space Science Department and HIPPARCOS Project Team attended the presentation. A second meeting of the Selection Committee was foreseen for early 1984.

Because of the minimal time that could be devoted to these important reports during the present meeting, Perryman proposed to include both subjects in the next HST meeting.

15. Meridian Observations

Hog distributed a note on the possibility of using the La Palma meridian circle (expected to be operational at the end of 1984, limiting magnitude = 13 mag) or Tokyo or Perth circles. Turon would contact the responsible persons if such observation were considered desirable for the work of the Input Catalogue Consortium.

16. Absolute Time Requirements

Murray distributed a note on the absolute time requirements - 1 msec would be required and would be adequate for the data analysis.

Clausen described the method of datation of the scientific data (see Annex VIII).

Laue stated that the uncertainty on the orbital determination was dominated by the uncertainty in the determination of the azimuth angle. Orbital parameters would be referred to a geocentric inertial frame.

17. Simulated Data Exchange

NDAC and FAST would supply their requirements on data to be generated by ESTEC. Vaghi would review the request and assess whether such data could be generated by the ILS software.

18. ESOC Data Formats

Comments on the ESOC paper had been provided by NDAC and FAST. Schuyer and Laue foresaw no problems in agreeing with the proposals. Details of the block/tape structures would need to be reviewed, however.

19. Memorandum of Understanding

The MoU, now referred to as an 'Agreement', had been distributed to all HST members, and some comments had been received by Hog. HST members were requested to submit any further comments on the first draft by December 15. Grewing confirmed that, although the production of a TYCHO Input Catalogue is not listed in the commitments of TDAC, such a catalogue is anticipated to be available in time from the ST institute. Methods of data reductions for TYCHO which are presently considered assume the existence of an input catalogue.

20. Publicity Brochure

This is now planned for early 1984.

21. Next Meeting

A list of possible dates would be circulated with the minutes.

M.A.C. Perryman
7th November, 1983

esa estec

HIPPARCOS

MEETING HIPPARCOS

PLACE ESTEC

REF. HST 8

DATE NOV 3-4 1983

PAGE

ACTION No	DESCRIPTION (not more than 4 lines)	CLOSING DATE	ACTIONNEE Person/firm	INITIATOR Person/firm
1	Distribute updated System Specifications (System and Payload) to HST when available.	AS AVAILABLE	PERRYMAN	HST
2	MATRA to update veiling glare analysis in line with HST recommendations.	~~AS AVAILABLE~~ 30 NOV	MATRA/ZEIS	SCHUYER
3.	MATRA to comment on LA.FA. 24 proposal for chromaticity calibration	As relevant	MATRA/ZEIS	BONNEFOY
4.	ESA to arrange meeting on Relay Lens		BONNEFOY	WYNNE
5	NDAC and FAST to communicate proposed contents & format of simulated data to be supplied by ESTEC.	15 December	CRUISE/FALIN	VAGHI
6	HST to supply first round of comments on the draft 'Agreement'	15 December	HST members	PERRYMAN

Signatures

ANNEX I

Eighth Meeting
of the
HIPPARCOS SCIENCE TEAM
3-4 November 1983

AGENDA

1. Status Report (L. Emiliani/M. Perryman)

2. Distribution of Software information, documentation, etc.

3. DCN No. 15, & Grid-to-Field Coordinate Gradient Requirement

4. Revised Overall System Specification (R. Wills)

5. Grid Report: - THD Alternative Grid (R. Bonnefoy)
   - CEH/TPD Error Budget (R. Wills)

6. Veiling Glare - comments on MATRA revised approach (L. Lindegren)

7. Calibration - chromaticity proposal (R. Bonnefoy)

8. Relay Lens Design

9. Choice of TYCHO Photomultipliers

10. Star Distribution Models/IRS for RTAD/RTAD Simulations

11. INCA Activity Report (C. Turon)

12. Observing Strategy Report (S. Vaghi)

13. INCA Simulation Report & Global Observing Strategy (M. Creze)

14. Photometric Standards (M. Grenon/E. Hog)

15. Meridian Observations (E. Hog)

16. Absolute Time Requirements (C.A. Murray)

17. Simulated Data Exchange

18. ESOC Data Format

19. Memorandum of Understanding (M. Schuyer)

20. HIPPARCOS Publicity Brochure

21. Next meeting of the HST (date/objectives)

22. Any other business

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

ANNEX II

REVISION 1 TO OVERALL SYSTEM SPECIFICATION ISSUE 3

- EDITORIAL CHANGES AND CORRECTIONS, INCLUDING ALIGNMENT WITH P/L SPECIFICATION
- REVISED (CLEARER) DIAGRAMS WITHOUT DIMENSIONS
- CORRECTIONS TO S/C SUBSYSTEM REQUIREMENTS
- SOME SECTIONS REDUCED TO REFERENCES TO ICD's OR SUPPORT SPECIFICATIONS
- G R M CALIBRATION EVERY 24 HR. (WAS TBD)
- NEW SECTION (§5.2.2.5.3) ON LIGHT TIGHTNESS
- POSITIVE SPIN SENSE IN TO AND NSO
- DELETION OF VILLAFRANCA AND ASSOCIATED STATION LONGITUDE
- INCREASED MASS ALLOCATION
- UPDATES TO ACCURACY AND CALIBRATION REQUIREMENTS, ASSUMPTIONS AND ALLOCATIONS.

Verif n: 00074

B	NUMBER OF PROGRAMME STARS	COLOUR DISTRIBUTION			COMPLE-TENESS (%)	OBS.TIME PER STAR (SEC)	% OF TOTAL OBS. TIME (%)
		B-V =-0.25 %	B-V = 0.5 %	B-V = 1.25 %			
-1 - 0	2	59	28	13	100	270 ~~210~~	1
0 - 1	6						
1 - 2	19						
2 - 3	77						
3 - 4	218						
4 - 5	647						
5 - 6	2031						
6 - 7	5400	48	35	17	100	310	3
7 - 8	14800	37	46	17	100	390	9
8 - 9	40800	32	51	17	100	530	33
9 - 10	16000	21	52	27	15	730	18
10 - 11	12000	10	49	41	4	990	18
11 - 12	6000	4	38	58	0.8	1330	12
12 - 13	2000	5	41	54	0.1	1780	6
TOTAL	100000					$6.5\ 10^7$	100

Figure 5.1/1a : HIPPARCOS STAR MODEL (Uniform Distribution over sky) (PROGRAMME STARS)

B magnitude	Stellar density (deg^{-2})
- 1 - 0.	6.06×10^{-5}
0 - 1	1.98×10^{-4}
1 - 2	6.35×10^{-4}
2 - 3	1.99×10^{-3}
3 - 4	6.09×10^{-3}
4 - 5	1.82×10^{-2}
5 - 6	5.31×10^{-2}
6 - 7	1.51×10^{-1}
7 - 8	4.20×10^{-1}
8 - 9	1.14
9 - 10	3.03
10 - 11	7.89
11 - 12	20.1
12 - 13	50.3
13 - 14	123.9
14 - 15	300.3
15 - 16	718.4
16 - 17	1190.0

Figure 5.1.1/b : <u>PARASITIC STAR MODEL</u>

5.1.1.4 - Star Models for Attitude Determination

5.1.1.4.1 - Reference Stars

* Definition

The reference stars are those stars which can be used for Real Time Attitude Determination through Star Mapper observations.

N/A

00079

Reference stars will be assumed to meet the following requirements :

- Their magnitude and colour distribution is as per Figure 5.1/2-a ; they are scattered according to a uniform random distribution over the whole sky for each magnitude interval and each colour index.
- The a-priori knowledge on their position as a function of their magnitude shall be as follows :

B(mag)	Number of stors	rms error (arcsec)
5-6	500	0.14
6-7	1000	0.14
7-8	3700	0.30
8-9	15000	0.30

All other stars (to complete average by density of 1.4 star deg^{-2}) shall have an rms error of 1 arcsec.

- Their distribution over the sky is such that the maximum angular distance between 2 reference stars for any great circle scanned is 1.7° conside-ring a transverse Field of View of 40 arcmin.

B	NUMBER OF REFERENCE STARS	COLOUR DISTRIBUTION		
		B-V=0 %	B-V=0.7 %	B-V=1.5 %
5 - 6	2000	72	22	6
6 - 7	5400	62	29	9
7 - 8	14800	52	39	9
8 - 9	29800	49	41	10
9 - 10	5800	33	49	18

5.1/2-a : RTAD STARS (Reference stars)

00079

5.1.1.5 - Secondary Photometric standard Stars

Secondary photometric standard stars are those stars which shall be used for the in-orbit photometric calibration as specified under sectin 5.2.7.

Secondary photometric standard stars shall be assumed to meet the following requirements :

- Their magnitude and colour distribution is as per figure 5.1/3. 00 081
- They are scattered over the whole sky according to a uniform random distribution for each magnitude interval and each colour index. 00 082
- Their Hipparcos as well as B_T & V_T magnitudes are known a-priori with an r.m.s. error as per figure 5.1/3. 00 083

B	NUMBER OF SECONDARY PHOTOMETRIC STANDARD STARS	COLOUR DISTRIBUTION			A-PRIORI r.m.s. ERRORS		
		B-V=0 %	B-V=0.7 %	B-V=1.5 %	H	B_T	V_T
			TBD				

Figure 5.1/3 : SECONDARY PHOTOMETRIC STANDARD STAR MODEL

5.1.3.1 - Definition of Error Sources

The field coordinate error variance shall take into account the following errors :

- Photonstatistical Error

00088

. This error includes the following contributing terms :

a) photon noise.
b) Sky background.
c) Straylight.
d) Detector dark current.
e) Aliasing effect.
f) Sample loss (when moving IFOV from one star to another).
g) Coding error
h) Degradation of photometric properties induced by IFOV pointing error.
i) Presence of a 3rd harmonic in the modulated IDT signal.

. The Cramer Rac bound shall be used for evaluation of the photon statistical error - including error terms a) to e) - which is defined for 1 s of observation time.

. Other error terms add as multiplicative degradation factors to be applied to the Cramer Rac bound.

- Veiling Glare Error

00089

. This error, induced by IDT veiling glare, depends on the observed star neighbourhood. Measurements for which veiling glare detection threshold is exceeded shall be disregarded and therefore treated as additional dead time for the given star.

- Attitude Jitter Error

00090

. This error is associated with the non-simultaneity of observations and is induced by non measurable motions of the instrument optical axis.

. This error is defined for one frame of the observing sequence (refer to 5.2.3 : observation strategy) for a star which receives approximately the average observation time.

. This error shall be computed using the window function associated to the observation strategy and specified under section 5.2.5.2.

- Error from Other Sources

00091

. This error includes contribution from all other identified sources, as listed below, to the field coordinate RMS error for one frame of the observing sequence :

a) Calibration residuals from grid to field coordinate transformation.
b) Photocathode inhomogeneity.
c) Clock jitter.
d) Phase distorsion due to IFOV pointing error.

5.1.3.2 - Hipparcos Error Apportionment

The HIPPARCOS error apportionment, performed according to the assumptions of section 5.1.1 shall be as shown on figure 5.1/6.

All figures are expressed in milliarcsec or milliarcsec/year (proper motion).

The system margin appearing in this figure - under the form of a multiplicative factor acting on the Cramer Rao bound - corresponds to the simplifying assumptions which had to be made in order to derive the error apportionment.

	B = 9		B = 12		
	B-V = 0.5	B-V -0.25 or 1.25	B-V = 0.5	B-V -0.25 or 1.25	
PHOTON NOISE					
- cramer Rao bound	7.1 mas	12.2 mas	39.6 mas	53.0 mas	00089
- multiplicative factors					
* sample loss	5 %	5 %	5 %	5 %	
* 1FOV depointing	12 %	12 %	12 %	12 %	
* 3rd harmonic	2 %	2 %	2 %	2 %	
- System margin	5 %	5 %	5 %	5 %	
JITTER	2 mas	2 mas	2 mas	2 mas	00090
OTHERS	3 mas	3 mas	3 mas	3 mas	00091
CHROMATICITY					
- constant		2.7 mas		2.7 mas	00092
- variable		1.5 mas		1.5 mas	

Figure 5.1/6 : HIPPARCOS ERROR APPORTIONMENT

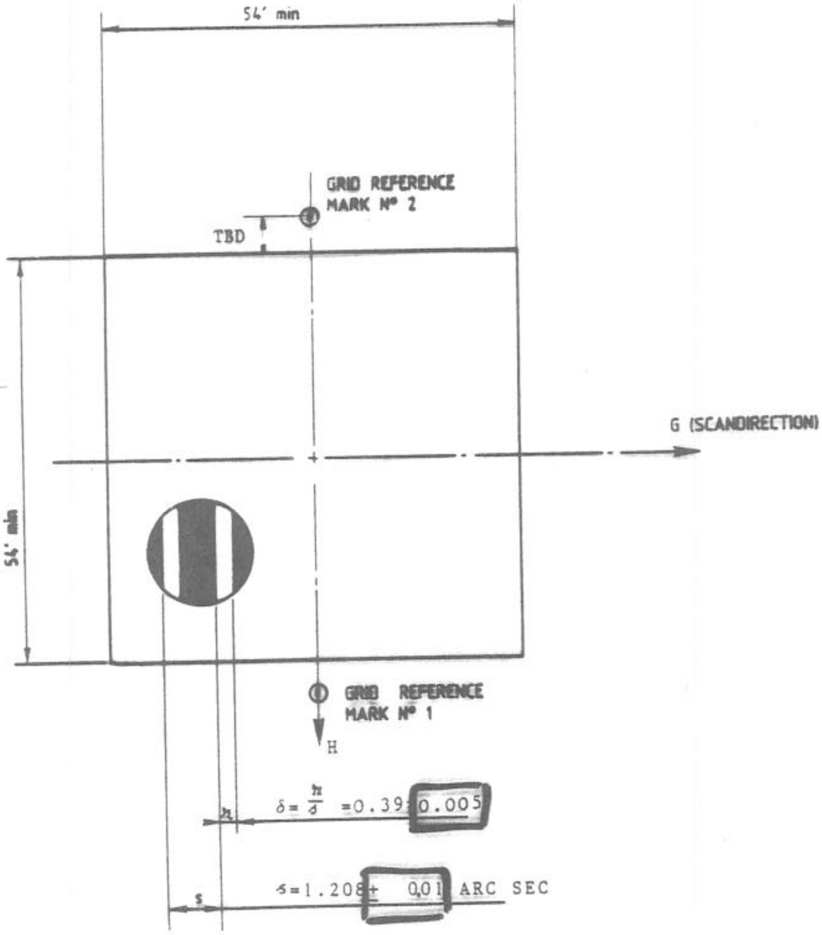


FIGURE 5.2/3-a- MAIN GRID PARAMETRES

00109

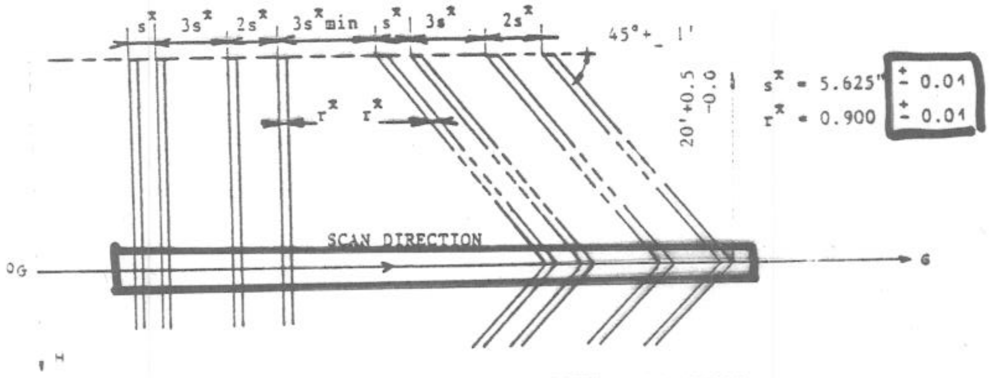


Fig. 5.2/3b-STAR MAPPER GRID GEOMETRY & PARAMETRES

00110

Figure 5.2/3 : GEOMETRY OF THE GRID

described by a matrix of at most 100 X 100 calibration points per viewing direction, per detection chain and per frequency. One parameter per calibration point shall describe the mean contribution to this component from a zone surrounding the calibration point, these zones being equal and covering the field of view. 00117

- Residuals of the transformations not described by the contributions specified above shall be compatible with the "other error sources" allocation as specified, under section 5.1.3.1. 00118
- The large scale contribution to the transformation shall be stable to better than 0.001 arcsec RMS over the FOV during any period of 24 hours for each FOV and for the two first frequencies of the grid. 00119
- The gradients of the (LSC + Nominal distorsion) along the scan direction and perpendicular to it shall not exceed 5 milliarcsec/arcsec. 00120
- The medium scale contribution to the transformation shall be stable to better than 0.001 arcsec RMS throughout the operational lifetime. This requirement applies to each FOV, each frequency and each channel. 00121

verif. nb:

- The transverse component of the transformation shall be known throughout the mission to an accuracy of 25 mas. RMS. 00122

5.2.2.7.2 - Star Mapper Field-of-View

- The transformation from grid coordinates to field coordinates shall comply with the following requirements for a star of B - V = 0.5 magnitude : 00123
  - the longitudinal and transverse components of the transformation shall be described by the algebraïc sum of a large and a medium scale contribution,
  - the large scale contribution shall be extrapolated from the large scale analytic function used for the primary field-of-view,
  - the medium scale contribution is the detailed map of local distorsions due to the grid itself,
  - the total error on the transformation from grid to field coordinate shall be less than 25 mas RMS.

This total error includes :

- extrapolation error from primary FOV-LSC analytic function,
- calibration/stability error from primary FOV-LSC,
- calibration/stability error from the medium scale contribution.
- difference in grid coordinates as sensed by the primary FOV and SM detector chains.

5.2.3 - Observation Strategy

Since one star only can be observed at a time, the available observing time combined FOV during the frame period, while still remaining in the combined FOV for a minimum of 3 T_3's during that frame period, and if its blue magnitude B is smaller than or equal to 9.

5.2.3.2 - Observation Sequence Generation Criteria

The observation sequence shall be generated on-board to share the observation time between up to 10 stars for each new frame period.

The elaboration of the observation sequence shall comply with the following criteria :

- The determination of those stars which are fully/partially observable is made according to the programme star positions and magnitudes as uplinked in the PSF.
- The Fully Observable Stars (FOS) are selected on the basis of their current selection index ; this index is generated from a basic selection index as uplinked in the PSF and from the star estimated position in the combined FOV at the frame period central time.
- The number of FOS's corresponding to one viewing direction must be as close as possible to the number of FOS's corresponding to the other viewing direction.
- Each FOS must receive a minimum observing time per interlacing period, as uplinked in the PSF.
- A maximum of 2 POS's (one entering the combined FOV during the frame duration and the other one leaving the combined FOV during the frame duration) can be included in the observation sequence.
- The POS's are selected on the basis of their magnitude as uplinked in the PSF.
- Each POS is observed during a dwell period of 2 T2's during each of the interlacing periods where it is present in the combined FOV.

When there is no FOS present in the field, the full observing time is allocated to POS present, without restriction in their magnitudes.

- The basic interlacing period structure is set up assuming that all POS's are in the combined FOV throughout the frame duration ; any actual interlacing period will deviate from the basic structure only for what concern the attribution of the dwell periods corresponding to the POS's.
- The dwell period corresponding to a given POS must be attributed to a FOS in all those interlacing periods where the POS is not within the combined FOV.
- In any interlacing period, the observing time devoted to a given star cannot be split into several segments.
- The allocation of observing time to the FOS's, beyond their minimum observing time, is to be made in accordance with their target observing time as uplinked in the PSF.

ERROR	DEFINITION	ALLOCATION	
	<u>Star position knowledge error</u>		
ΔAPP	A-priori knowledge of star position in the sky	1.67	
ΔMOT	Star motion in the IFOV	0.32 2.15	
ΔATT	RTAD	1.32	00136
	<u>IFOV piloting error</u>		
ΔCAL	IDT calibration error	3.0	
ΔOPT	Transformation from grid to photocathode		00130
ΔIDT	Transformation from photocathode to deflection current		
	<u>IFOV pointing error</u>	3.7	00129

All figures are in arcsec RMS

Figure 5.2/7 : <u>IFOV POINTING ERROR APPORTIONMENT</u>

- The supplementary error terms which degrade the exploitation of the transit time information shall be assumed as follows : 000135
  . 25 mas r.m.s. for grid to field transformation.
  . 25 mas r.m.s for chromaticity affects for stars of extreme colours (B - V = 0/1.5).

5.2.5.2 - <u>Attitude Reconstitution Requirements</u>

* <u>RTAD</u>

To allow adequate IFOV piloting :

- the absolute directions of the 2 optical axes shall be known in real-time at all instants to an accuracy better than 1.0 arcsec RMS (error cone semi-angle). 00136
- the error angles rates $\dot{\Phi}$, $\dot{\Theta}$ and $\dot{\Psi}$ shall be known in real-time at all instants to an accuracy better than 0.1 arcsec/s rms.

* <u>OGAR</u>

The Satellite attitude about each of the 3 axes shall be determinable a posteriori to an accuracy better than 0.10 arcsec RMS averaged over one great circle. 00137

MAGNITUDE (B+V)/2 COLOUR INDEX (B-V)		≤ 7.15	8.15	9.15
B-V = 0	Vertical	0.030	0.050	0.100
	Inclined	0.040	0.075	0.130
B-V = 0.7	Vertical	0.035	0.070	0.125
	Inclined	0.045	0.090	0.185
B-V = 1.5	Vertical	0.045	0.080	0.170
	Inclined	0.060	0.105	0.240

5.2/8-a : RTAD Requirements (Vertical slits and Inclined Slits) 00131

MAGNITUDE $\frac{B+V}{2}$ COLOUR INDEX B-V		≤ 7.15	8.15	9.15
B-V = 0	Vertical	0.020	0.035	0.060
	Inclined	0.025	0.040	0.075
B-V = 0.7	Vertical	0.025	0.035	0.070
	Inclined	0.030	0.045	0.090
B-V = 1.5	Vertical	0.025	0.040	0.075
	Inclined	0.030	0.050	0.095

5.2/8-b : OGAR Requirements (Vertical slits and Inclined Slits) 00134

All figures are r.m.s. errors in arcsec

Figure 5.2/8 : ACCURACY REQUIREMENTS ON TRANSIT TIME DATATION

5.2.7 - Calibration Requirements

5.2.7.1 - Primary Field-of-View Geometric Calibration

5.2.7.1.1 - Basic Angle

The basic angle (as specified under section 5.2.2.1) shall be known with the following accuracy :

. before launch	5 arc sec (3 sigma)	00144
. end of on-orbit commissionning	0.5 arc sec (3 sigma)	00145
. stability	Refer to 5.2.2.1	

5.2.7.1.2 - Large Scale Contribution

The large-scale contribution to the grid to field coordinates transformation (as specified under section 5.2.2.7) shall be known with the following accuracy :

. before launch	N/A	
. end of on-orbit commissioning	0.050 arc sec RMS	00146
. stability	Refer to 5.2.2.7.1	

- Starting from the above specified values, the large scale component of the transformation shall be assumed to be determined on a 24 h basis from the scientific data processing with an accuracy of 1.7 milliarsec RMS. 0014

5.2.7.1.3 - The medium scale contribution

The medium scale contribution to the grid-to-field cordinates transformation (as specified under section 5.2.2.7) shall be known with the following accuracy :

. before launch	5 milli arcsec RMS	0014
. end of in-orbit commissioning	3 milli arcsec RMS	0014
. stability	Refer to 5.2.2.7.1	

5.2.7.1.4 - IDT Piloting Matrix Calibration

- The transformation from grid coordinates to deflection current shall be calibrated through a matrix of at most 30 X 30 to an accuracy compatible with the IFOV piloting budget as specified under section 5.2.4. 0015

5.2.7.2 - Star Mapper Field-of-View Geometric Calibration

The transformation from grid-to-field coordinates at any point of the star mapper FOV shall be known with the following accuracy :

. before launch	2 arcsec RMS	0015
. end of in-orbit commissioning	25 mas RMS	0015
. Stability	Refer to 5.2.2.7.2	

5.2.7.3 - Photometric Calibration

This section applies to both primary field-of-view and star mapper field-of-view since the requirements are nearly identical.

5.2.7.3.1 - Absolute Photometric Response

The absolute photometric response of the payload for one wavelength and averaged over each FOV shall be known with the following accuracy :

. before launch	5 % RMS	00153
. end of in-orbit commissioning	5 % RMS	00154
. stability	1 % over any period of 24 hours	

This applies to one wavelength for each of the two redundant channels in each of the 3 fields (main field, star mapper field BT, star mapper field VT). Absolute photometric response shall be interpreted as :

- I_0 I_{BK} M_1 M_2 for the primary FOV.
- I_0 I_{BK} and single slit response for star mapper FOV.

5.2.7.3.2 - Intensity Transfer Function

The intensity transfer function (defined as the relative photon events response to different light intensity levels) shall be known with an accuracy of :

- before launch	3 % RMS	00155
- end of in-orbit commissioning	1 % RMS	00156
- stability	N/A	

5.2.7.3.3 - Spatial Variations of the Photometric Response

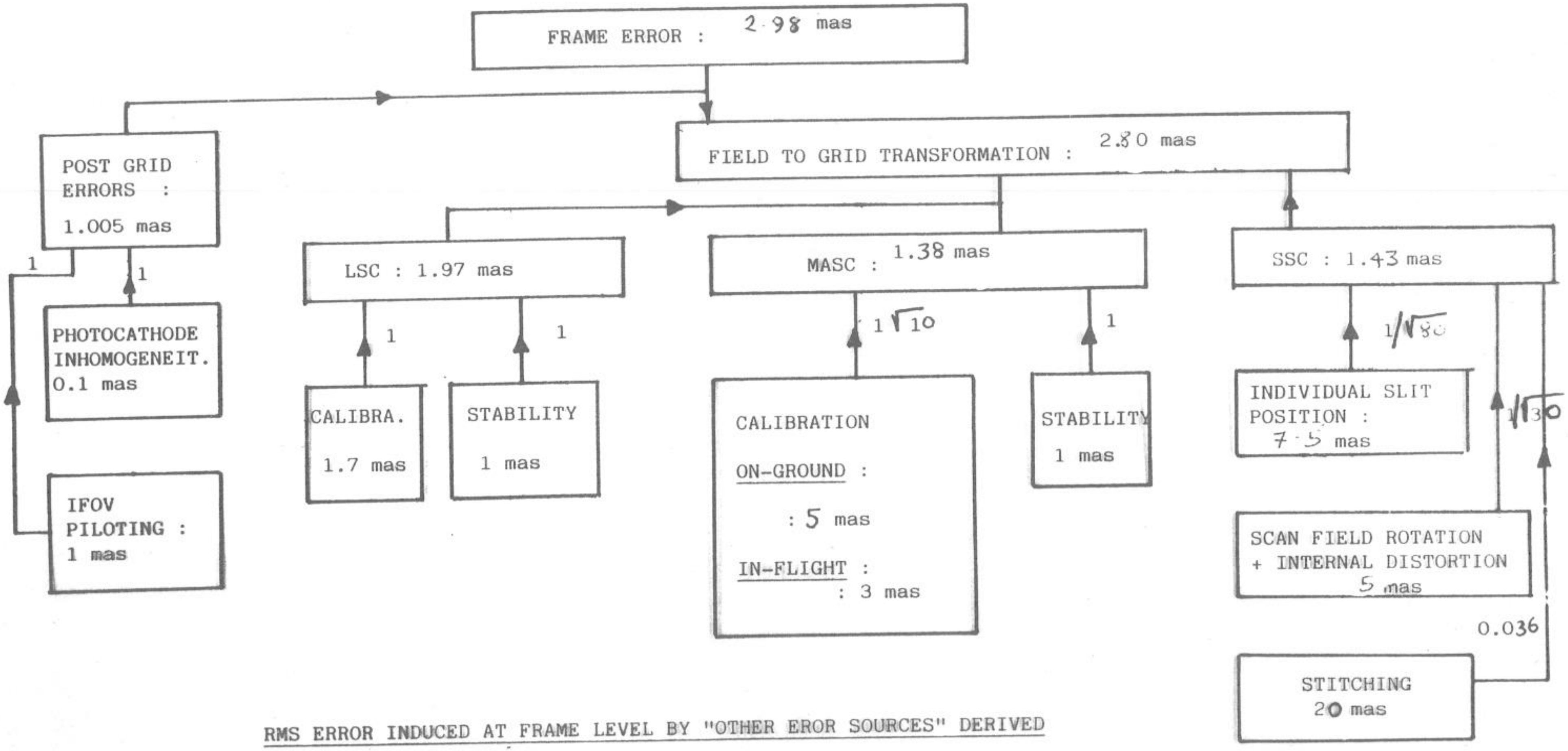
Primary FOV : on a mesh 11 x 11 the P/L sensitivity in 3 wavelength ranges of $\Delta\lambda = 50$ nm centered on 425-550-650 nm respectively shall be known with an accuracy of :

. before launch	5 % RMS	00157
. end of in orbit commissioning	5 % RMS	00158
. stability	1 % over any period of 24 hours	

Star mapper FOV : on a mesh 5 points per slit system the Tycho photometric response at the central wavelength of each channel shall be known with an accuracy of :

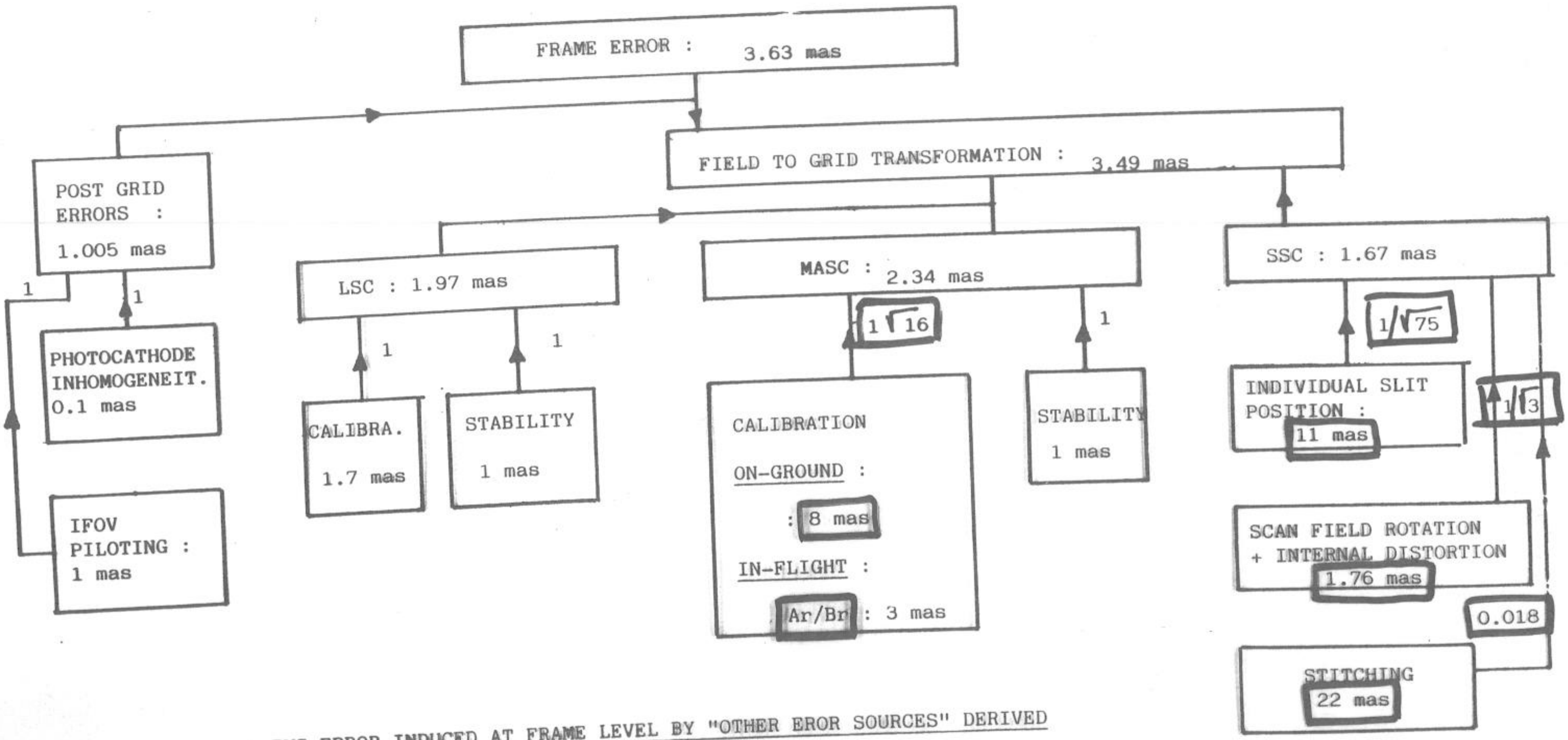
. before launch	2 % RMS	00159
. end of in-orbit commissioning	2% RMS	00160
. stability	1 % over any period of 24 hours	

ANNEX III



RMS ERROR INDUCED AT FRAME LEVEL BY "OTHER EROR SOURCES" DERIVED

FROM MAT-HIP-04803

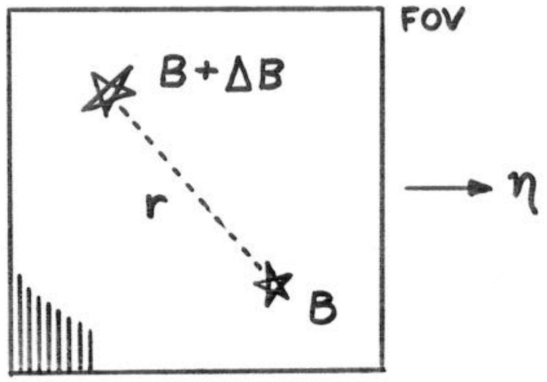


RMS ERROR INDUCED AT FRAME LEVEL BY "OTHER EROR SOURCES" DERIVED

FROM TNO/TPD COMMITTMENT

ANNEX IV

VEILING GLARE - IFOV PROFILE



ERROR IN η-COORDINATE: $b(\Delta B, r, \Delta\phi)$

$$|b| \leq (160\,\text{mas}) \cdot 10^{-0.4\Delta B}\, \zeta(r)$$

$$b_{rms} \simeq (94\,\text{mas}) \cdot 10^{-0.4\Delta B}\, \zeta(r)$$

MODELLING

WITHOUT VG, EACH FOV CROSSING

$$i = 1, 2, \ldots, n$$

IS AN INDEPENDENT OBSERVATION OF η WITH VARIANCE σ^2.

δ_i = RESIDUALS AFTER GLOBAL SOLUTION

$s^2 = n^{-1} \Sigma_i \delta_i^2$ = SAMPLE VARIANCE

— IN ABSENCE OF VG:

$$\delta_i \sim N(0, \sigma^2) \quad \Rightarrow \quad E(s^2) = \sigma^2$$

— WITH VG:

$$\delta_i \sim N(b_i, Y\sigma^2) \qquad (Y \geq 1)$$

-- DISTURBING STAR IN SAME FOV:

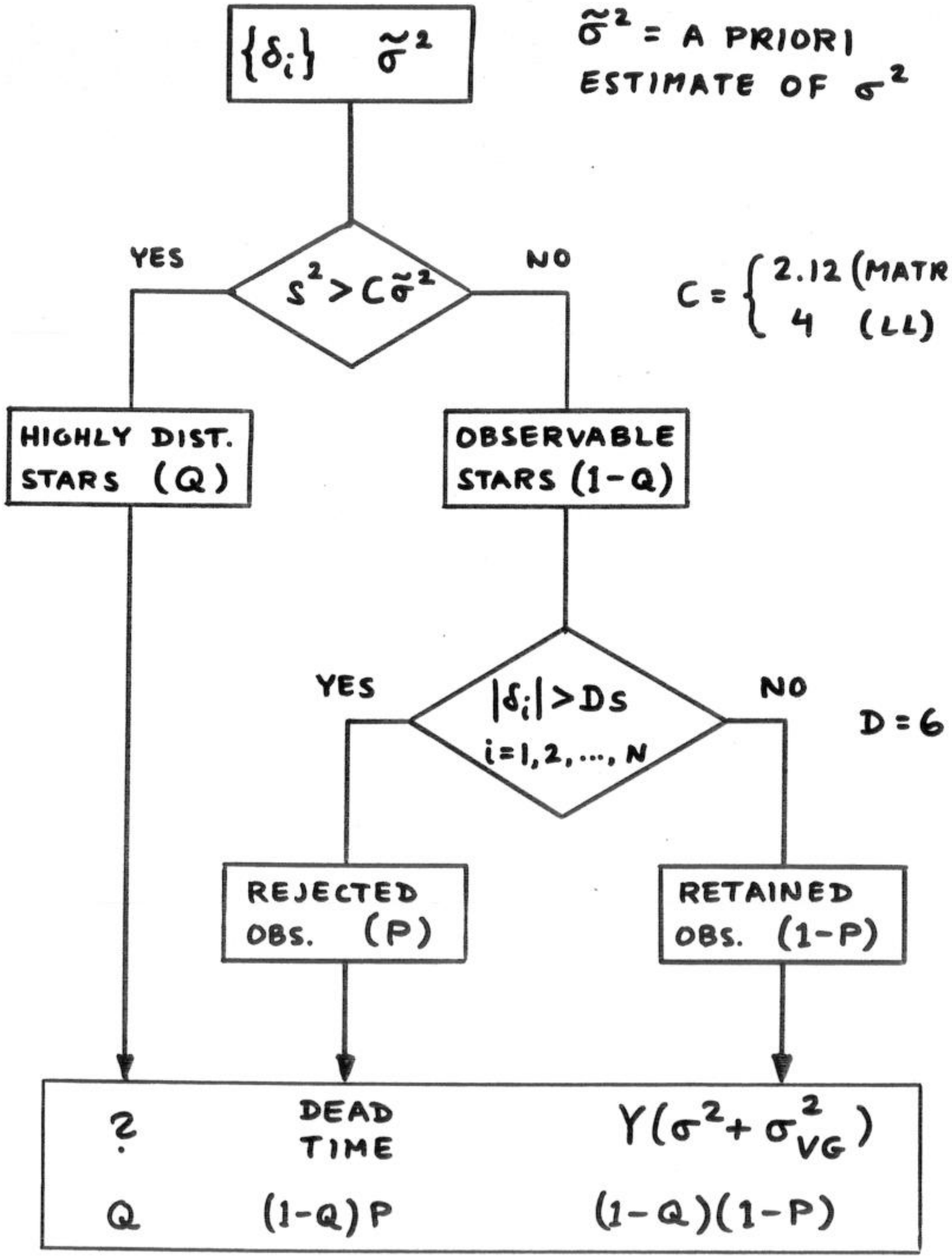
$$b_i \sim N(0, b_{rms}^2) \Rightarrow E(s^2) = Y\sigma^2 + b_{rms}^2$$

-- DIST. STAR IN OTHER FOV:

$b_i \sim 0$ EXCEPT FOR SOME i

$\Rightarrow E(s^2) \simeq \sigma^2$, SOME $|\delta_i| >> s$

TESTING



$\tilde{\sigma}^2$ = A PRIORI ESTIMATE OF σ^2

$$C = \begin{cases} 2.12 & (\text{MATRA}) \\ 4 & (\text{LL}) \end{cases}$$

$D=6$

CRITICISM

- APPROACH REASONABLE AND CONSISTENT WITH DATA REDUCTIONS (?)
- EVALUATION OF σ^2 INCORRECT IN MAT-HIP-5791, SHOULD BE ~ 3 x HIGHER
- EVALUATION OF C MAY BE OPTIMISTIC

$$C = \frac{1+3R_1}{1-3R_2}$$

R_1 = REL. S.D. OF s^2

R_2 = REL. S.D. OF $\tilde{\sigma}^2$

MATRA : $R_1 = R_2 = \sqrt{\frac{2}{n}} \simeq 0.12 \Rightarrow C = 2.12$

PERHAPS RATHER $R_2 \simeq 0.2 \Rightarrow C = 3.4$

ANNEX V

INCA APPROACH
of
GLOBAL and LOCAL
OBSERVING STRATEGY

1 OUTLINES

We do not consider existing tables giving total observing times and numbers of stars as a function of magnitudes as a rigid framework, but only as a first average estimation of what would be a reasonable achievement of Hipparcos objectives.

Our limiting conditions are (without hierarchy)

- → Selection Comittee priorities
- Completeness up to TBD limiting magnitude
- Adequacy to technical requirements
  including regular occurence of bright "primary stars" - and Star mapper stars -
- Smooth distribution over the whole sky
- Controle of Veiling Glare effects (limited to aspects within INCA capabilities) -
- Scanning law and adopted observing strategy per frame -

Our degrees of freedom

- compromise between number of stars selected and time allocation per star
- magnitude / observing time relation and coefficients driving the observing strategy.
- modulation of above quantities according to latitude, star density in the program, star density in the sky

- modulation of same quantities with time all along the mission (star density per field superposition, veiling glare, priority conflicts, position on great circles.

- specific processing for peculiar cases: very important stars, stars required for proper motions only.

Since optimisation of so many free parameters through so many constraints is far from trivial we must use some kind of a perturbation method: we start with the most straightforward assumptions and keep them until simulation results forces to change parameters or catalogue.

Three processes are developped in parallel

1 Static Approach: Starting from a compilation of all Candidate stars ~~and using a standard global observing strategy,~~ : evaluate the observing time request per unit area on the sky (without field superposition). this will point out and remove major ~~it will point out and remove~~ major irealistic features from the sky distribution of candidate stars.

différence
par champ
entre 1
2

2 Global Simulations: will tentatively allocate observing time to stars all along the mission, check that those allocations can lead to satisfactory mission achievement and suggest changes in the catalogue.

3 Detailed Simulations: are performed to test most efficient policy for driving the observing strategy all along the mission.

2 STATIC APPROACH

At this stage, we do not take into account the effect of field superposition. So we adopt very high inclusion phrase par level thresholds and force inclusion of stars contributing to the survey. Note that in this approach, the ~~survey limit~~ limiting magnitude of the survey is not an a priori decision, but a result of the simulation. The resulting limit depends of course of the level of priority on which the survey is introduced. Various levels can be tried and the subsequent degradation of other programs can be tested.

The following steps are identified

1°- collect all stars from selected programs, flag their peculiarities (very Important Star, star requiring high accuracy, Star requested for proper motion only ...)

2°- Add bright stars up to the highest expectable survey limit ($m_V \leq 9$?) variable avec b

3°- Allocate "Standard" target times

3.1 $m_H \rightarrow T_0$ global target time. Any other criterion can define T_0 if specific accuracy requested.

3.2 $\beta \rightarrow N(\beta)$ mean scanning frequency from nominal scanning law

3.3 $y_0 = \frac{T_0}{2 \times N(\beta) \times (1-D)}$ target time per field crossing D is the % dead time -

4°: Divide in cells (0.9 × 0.9 d°) or larger)

~~[illegible]~~

or examine the neighbourhood of each star -

5°: Flag veiling glare from bright stars.

6°: Sort stars in each cell according to the following rule. (use magnitude in each class).

6.1 To Be Kept P = 1
6.2 High Priority Reservoir P = 2
6.3 Brighter than Lower Survey Limit (8.2?) P=
6.4 Medium Priority Reservoir P = 4
6.5 Brighter than Higher Survey Limit (9.0?) P=5
6.6 Low Priority Reservoir P = 6
6.7 Veiling Glare affected P = 7
6.8 others

7°: In each cell, following above hierarchy, Increment

N : number of observable stars
Σy : sum of observing time requests.

until $N > 10$ <u>or</u> $\Sigma y > 19.2$ (crossing time for 0.9 × 0.9° ce

Stars not ~~still~~ yet included when those rejection thresholds are reached will be flaged "tentatively rejected".

8°: Make statistics

- Distribution of tentatively rejected stars according to magnitudes, according to priorities (same for tentatively included,
- Histogram of the number of rejected stars per cell
- Map of cells where this number exceeds a certain value (choosen after histogram).
- Map of cells where N and Σy_i do not reach a lower threshold.
- Map of completeness to a given limiting magnitude.

Maps will help in deciding final exclusions so that they will not depend critically on cell's width nor on the actual cell's pattern.

9°: Come back to selected programs.

3 GLOBAL SIMULATION

This Task aims at reducing to reduce the input Catalogue to an actually realistic density Level. So it implies includes a simulation run including the scanning Law with fields superposition and a rough algorithm of time allocation.

Simulations should be run~~ned~~ over a long period (six months in order to ~~[illegible]~~ produce all situations of field superposition. ~~[illegible]~~ As above, it is planned to use post simulation statistics to drive modifications of the Catalogue - The Scenario is very similar to §.2.

1° allocate to each star standard target time per field crossing y_0

2° simulate scanning and dispatch available observing time according to y_0, field crowding and priorities.

(?) Test veiling glare (field superposition) and frequency of star mapper stars and primary stars -

3° define a post simulation performance index per star: $r = \frac{\text{Allocated time}}{M(\beta) \times y_0}$

4° Make statistics:

Histogram of r: global, per m, per y_0, per Priority Class, per β, per ~~[illegible]~~ region on the sky.

Map of cells where a certain threshold in r is systematically over or underpassed. List of those cell, list of stars poorly observed

5° back to selected Programs

A first realistic estimation of feasibility Conflicts between programs will be obtained at this stage -

Presently the corresponding software is being tested and implemented on simulated Catalogues -

4) DETAILED SIMULATIONS

The observing strategy per frame uses three coefficients: x_o minimum time, y_o target time, b_o selection index. The aim of this ~~se~~ third part of INCA simulation software is to derive guidelines for assigning x_o, y_o, b_o to each star and ~~de~~ for driving variations of those coefficients all along the mission.

Simulations have yet been performed by S. Vaghi but they remain at the great circle time scale and do not evaluate cumulative effects of the observing strategy for one star all along the mission.

We want to learn how to manage observing strategy.

4.1 The following questions should be clarified:

- efficiency of forcing large y_o ?
- " " " x_o ?
- " " " b_o ?

- efficiency of modulating x_o, y_o, b_o
  - according to field crowding ?
  - " observational history ?
  - " scientific targets ?
  - " veiling glare ~~by~~ field superposition.
  - " position on great circles. ?

- Does observing strategy efficiency degrade and how does it when
  - too many stars in the program
  - too many stars with high minimum time

4.2 Answers to those questions imply ~~simulations~~ ~~with~~ observing strategy - oriented simulations with quite different caracteristics :

- whole mission
- exact observing strategy per frame
- restriction to small test regions and their associated coronas (so as to allow large number of trials). Test regions are chosen at various β.
- more specific performances indices

we use three indices (not independent from each other).

$$\frac{\Sigma \tau}{T_0} = \frac{\text{total allocated observing time}}{\text{global target time}}$$

$$\frac{C_\pi}{C_{\pi_0}} = \frac{\text{Improvement coefficient for parallaxe}}{\text{~~target~~ mean target coefficient}}$$

$\frac{C_\mu}{C_{\mu_0}}$ same as above for proper motion in ecliptic latitude

- Time dependent performances indices are derived too. they measure the growth of accuracy acquisition compared to ideal growth.

$$\frac{C_\mu(t)}{C_{\mu_0}(t)} \quad , \quad \frac{C_\pi(t)}{C_{\pi_0}(t)} \quad , \quad \frac{\Sigma\tau(t)}{T_0(t)}$$

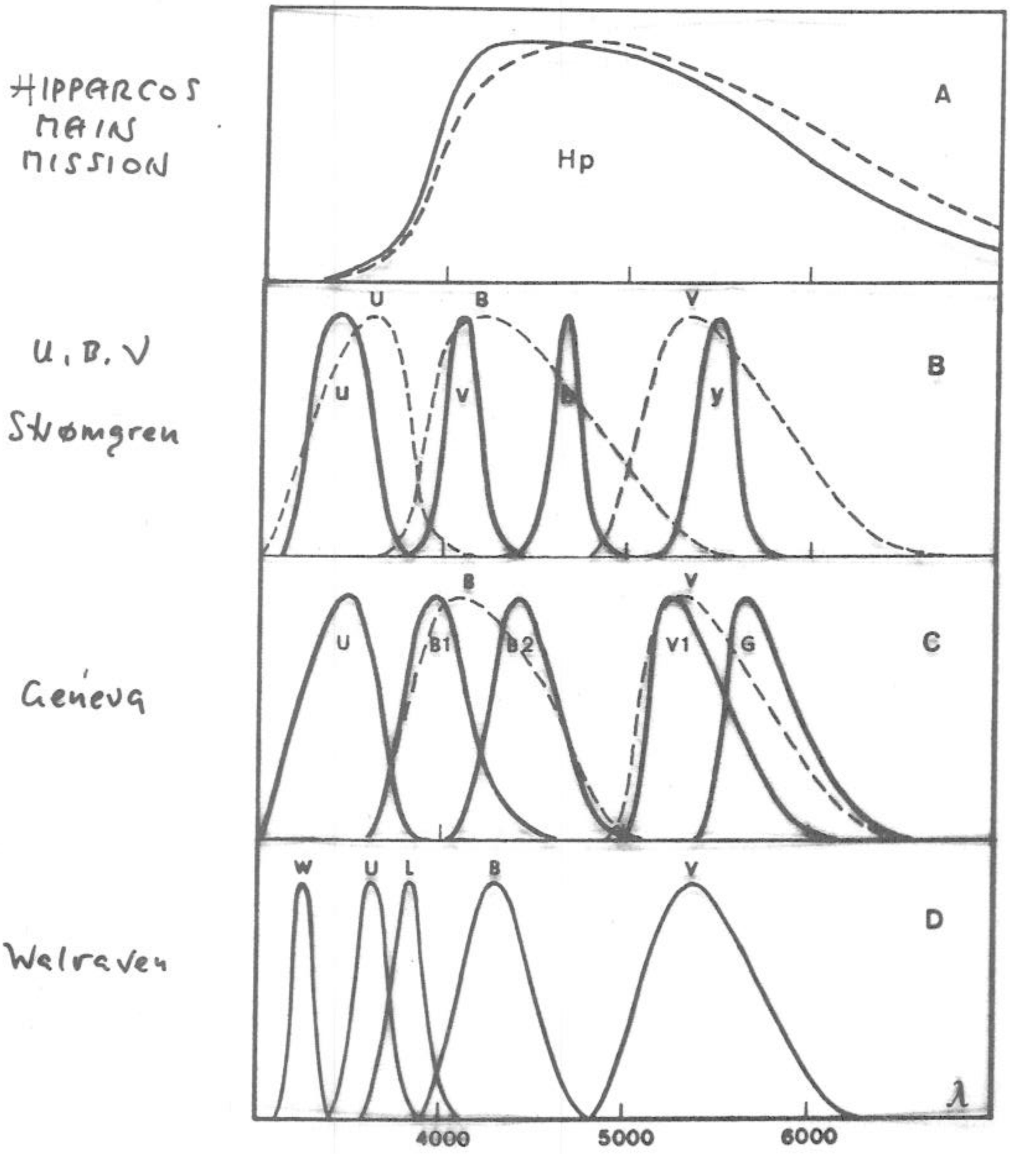
4.3 Post simulation Statistics

Include mean, standard deviation and histogram of performance indices per ~~[illegible]~~ test region, per priority, per m, per y_0, x_0, b_0 -

Trials should be performed ~~in the~~ following items 4.1 -

~~[illegible]~~

ANNEX VI



Hp band : —— Quantum efficiency

---- Equienergetic response

* λ_{eff} Hp = λ_{eff} V for (B-V) = 0.90 - 1.00

THE m_{Hp} COMPUTATION

1st iteration: Integration of & observed (Straizys) predicted (Kurucz models) fluxes ≤ A0

with Hp band &
UBV
uvby
Geneva
Walraven filters

~ 100 E, distributions

TRANSFORMATION EQUATIONS

(H−V) function of indices, for a given φ system:

$$(H-V) = \sum_i a_i (F_i - V) + \sum_i b_i (F_i - V)^2 + c$$

or of parameters & indices:

$$(H-y) = \alpha (b-y) + \beta (b-y)^2 + \gamma \cdot c_1 + \delta \cdot m_1 + \varepsilon$$

Coefficients optimized by LSQ for selected luminosity classes. (Dwarfs: OBAFG V-IV KM III)

Several coefficients may be = 0

COMPLICATED RELATIONS BECAUSE REAL STAR E(λ) DEVIATED SENSIBLY FROM B.B. E(λ).

2nd iteration: Use of provisional tr. equations for computing m_{Hp} from the various φ systems A, B, C, D, E

Homogeneization (Reduction to system A)

$$m_{Hp_A} = m_{Hp_B} + F(\text{indices}_B)$$

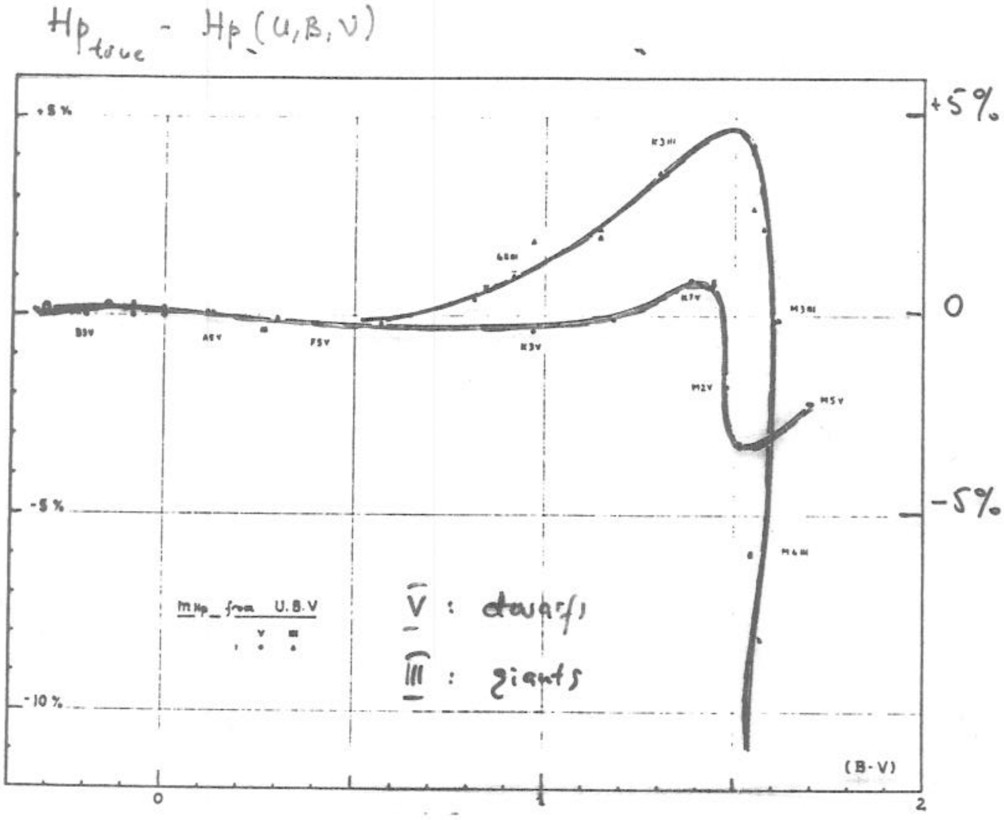
→ Improved Tr. Equations

based on several 10^3 * in common

THE RESIDUALS ARE FUNCTION OF:

- gravity, [M/H], e, E_{B-V}, discrete absorption (i.e. TiO).

RESIDUAL ERRORS ON MHp
estimated from p.e. data



The errors & their amplitude depend on the number of available filters within Hp band

ε = f (gravity , E_{B-V}, [M/H], TiO, discrete e or absorption features)

- ERRORS ON M_{Hp} due to small effects may be neglected for the computation of observing time per star
- MUST BE CONSIDERED FOR THE DEFINITION OF A STANDARD FOR THE PAYLOAD CALIBRATION

NB : THE STARS FOR WHICH Hp IS DIFFICULT TO PREDICT ACCURATELY ARE MOSTLY NON CONSTANT & NOT SUITABLE AS STANDARDS

THE STELLAR VARIABILITY

- According to σ_V, stars may be considered as:
  - Constants $\sigma_V < .014$ (.010)
  - μ- Var. $\sigma_V \in .014 - .030$
  - Variables $\sigma_V > .030$

  (Geneva definition)

- Many stars have only one observation or unaccurate photometry

- STABILITY CRITERION

T 1) If at least 3 measurements have been made over more than 1 year, in one Φ. system

2) & if $\sigma_V < \sigma_0$ (e.g. .010 mag).

the star is a highly probable non-variable

- or: if M_{Hp} obtained from distinct photom. systems coincide within .02 mag.

- If a star belong to a non variable category it is with a few % exceptions (e.g: EB, close SB)

a probable non variable

UNSTABLE STARS

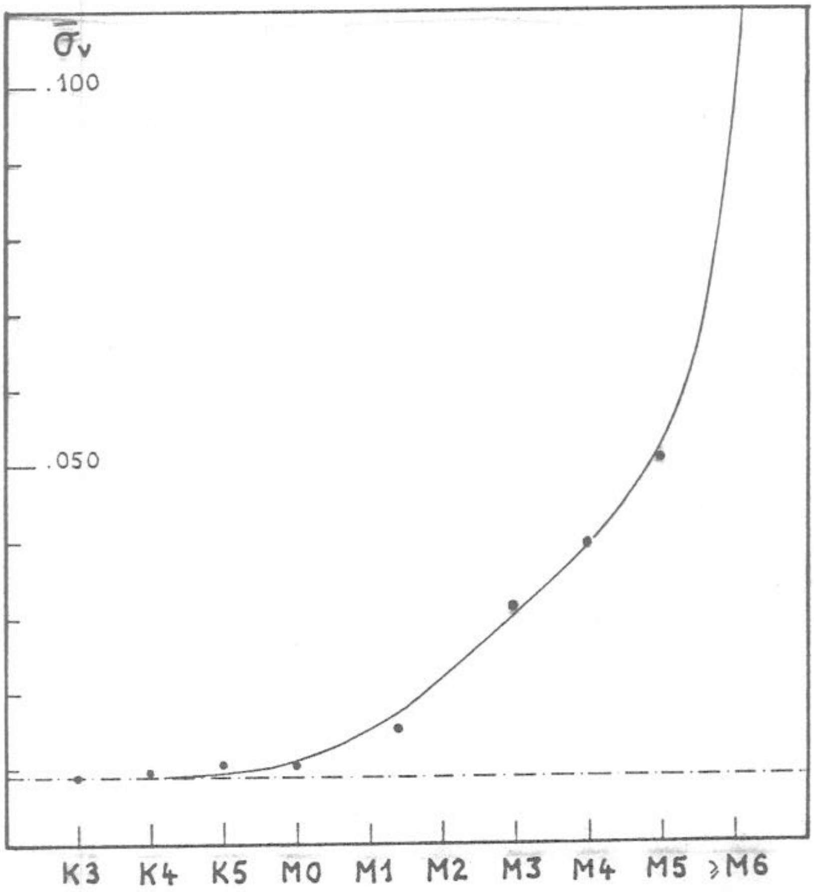
- all very luminous *
- Of, WN, WR
- O, Be, OBAFG

Ia : $\bar{A}$	.066	K Ia -	M0a	.43
Iab	.043	Iab	.066	.21
Ib	.036	Ib	.027	.11

- BHB
- Ap, Bp
- F0 - F2 V - III (δ Scuti)
- dKe - dMe spotted *, BY Dra, UV Cet
- M, S, C, ... giants or Pop II equivalents.
- short P binaries

These stars are to be rejected even if the variability is not confirmed

THE VARIABILITY OF RED GIANTS



Mean $\bar{\sigma}_v$ for class $\underline{III}$ red giants

$\sigma_v = 0.009$ mag = typical s.e. for non variable stars measured in Geneva photometry

VISUAL MAGNITUDE AMPLITUDE

peak to peak $A = 3.3 \cdot \bar{\sigma}_{v_i}$

K3 III	K4 III	K5-M0 III	M1-M2 III	M3 III	M4 III	M5 III
.00	.01	.02	.04	.10	.13	.17

→ GIANTS EARLIER THAN M1 MAY BE USED AS CONSTANT STANDARDS $(B-V)_0 < 1.55$

→ M1 - M5 III MAY BE CONSIDERED AS CONSTANT OVER A 12 HOURS PERIOD

THE ON - ORBIT CALIBRATION

The real payload sensitivity response will be probably different during the commissioning phase and during the mission from that estimated before launch

CHANGES OF QE Tycho & M.Mission Smooth

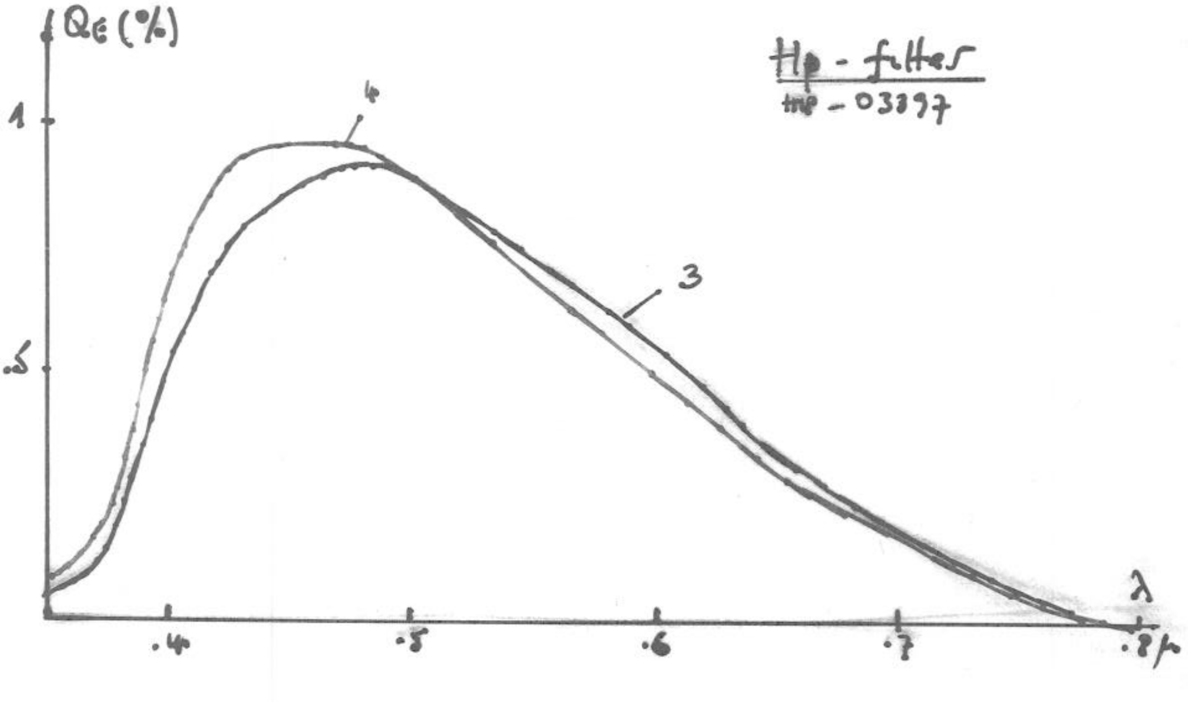
→ Simplified relations probably sufficient

$$m_{Hp}(t) = m_{Hp_0} + c(t) + s(t)\cdot(B-V) + p(t)(B-V)^2$$

$$B_T(t) = B_{0_T} + \dots$$

$$V_T(t) = V_{0_T} + \dots$$

NO NECESSITY OF USING THE ORIGINAL TRANSFORMATION EQUATIONS



Simulation of a change of QE :
Expression of $m_{Hp_3} = f(m_{Hp_4})$

MAIN - MISSION

STATISTICS ON THE P.E. DATA

1. - STARS INCLUDED IN THE INPUT CATALOGUE
2. - IDENTIFIED IN CSI
3. - ESA PRIORITY ≤ 3

$\left.\right\}$ 70712 *

NB : These * are the brightest of I.C.

59575 * with HD number
8006 * " DM "

& 1917 * in open clusters

INTERSECTION WITH THE LAUSANNE PHOTOMETRIC DATA BASIS (Mermilliod)

→ $\boxed{24\,075\ *}$

& 1294 systems (2-3-)

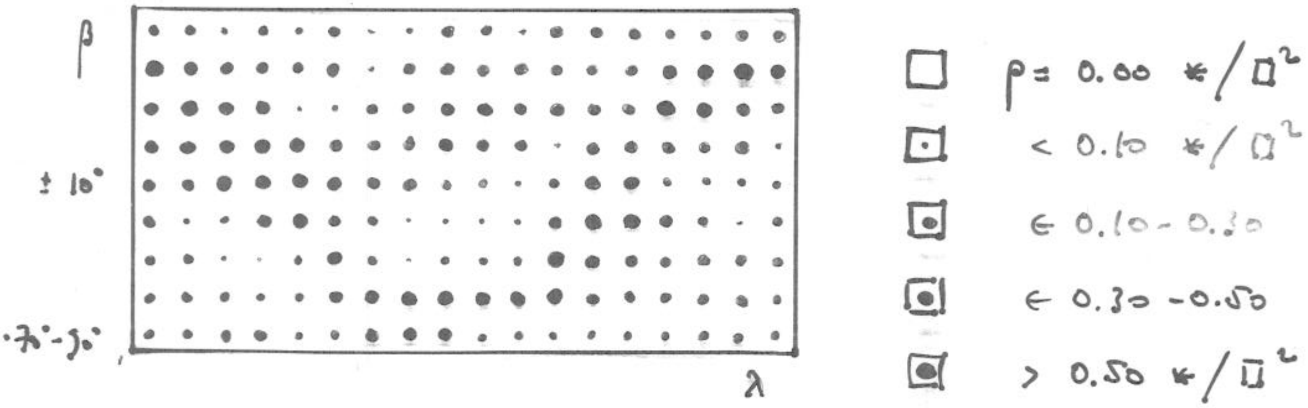
have pe data from UBV, UBV_c, Strömgren or Geneva systems.

MAIN - MISSION

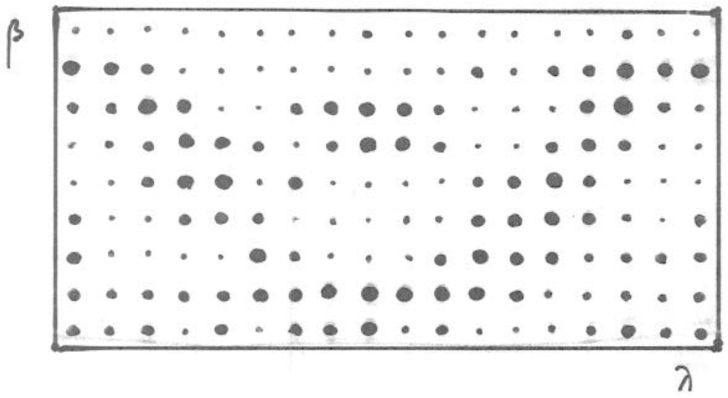
DENSITY OF STARS WITH PHOTOMETRIC MEASUREMENTS IN UBV GENEVA OR STRÖMGREN SYSTEMS, AND ESA PRIORITY P ≤ 3.

22-II sept. 83 L.W

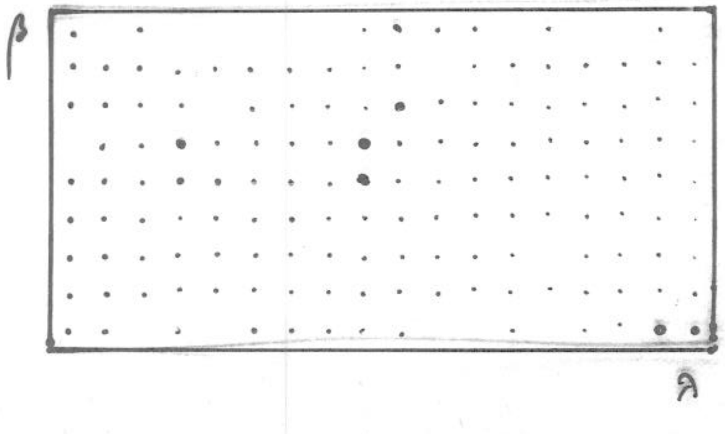
$m_V \in 6.0 - 8.0$



$m_V \in 8.0 - 10.0$



$m_V \in 10.0 - 12.0$



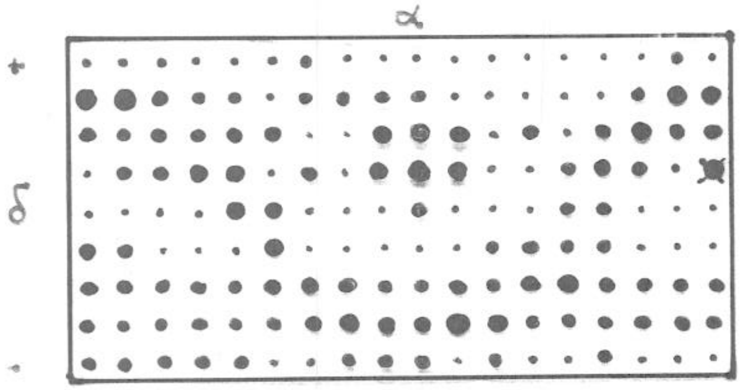
OUTSIDE FROM NGP :

$$\bar{\rho} = \frac{900 \ast}{41257}$$

$$= 0.022 \ast/\square^2$$

STAR DENSITY OF I.S. WITH ESA PRIORITY ≤ 3
AND WITH P.G. DATA FROM UBV, uvby or GEN.

$m_V \in 8.0 - 10.0$



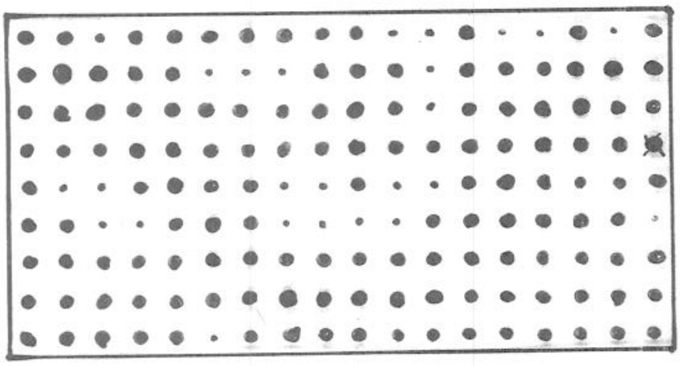
$\rho < 0.10 * / \square^2$

$0.10 , 0.30$

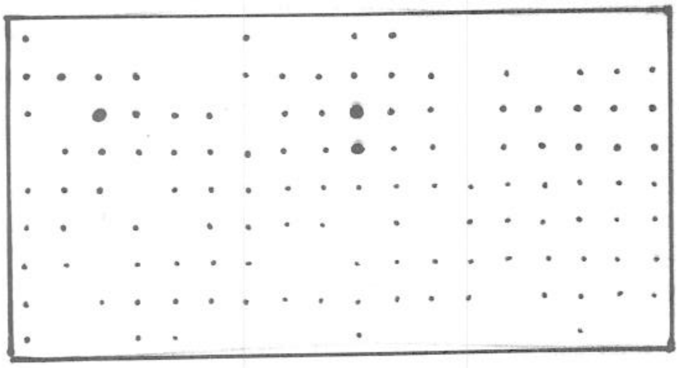
$0.30 , 0.50$

$\rho > 0.50 * / \square^2$

$m_V \in 6.0 - 8.0$



$m_V \in 10.0 - 12.0$



$\square \equiv \rho = 0.00$

MAIN - MISSION

- DISTRIBUTION ACCORDING TO PHOTOM. SYSTEM

UBV Johnson	17826 *
UBV Cape	4548 *
Strömgren	> 10224 *
Geneva	11396 *

- NUMBER OF STARS IN COMMON

Geneva - UBV Johns.	8116 *
Geneva - UBV Cape	3436 *
Geneva - Strömgren	5478 *

- → THE RELATIONS BETWEEN m_{Hp} AND THE VARIOUS PH. DATA MAY BE PRECISELY ESTABLISHED AND HOMOGENEIZED

- → A LARGER NUMBER OF STARS MAY BE CONFIRMED AS CONSTANT.

- COLOUR DISTRIBUTION

Geneva System

B-V	(B2-V1)	N *	
<.10	<-.075	3073	Blue
.10, .80	.075, .500	4919	Yellow
.80, 1.400	.500, 1.015	2526	Red
>1.400	> 1.015	707	Very Red

MAIN - MISSION

COLOUR & QUALITY DISTRIBUTIONS

UBV Johnson Nicolet 1978

(B-V)	Q = 1	2	3	4	Σ
< .10	229	341	2836	1972	5378
.10 , .80	667	805	2234	3098	6804
.80 , 1.40	245	264	1801	1539	3849
> 1.40	134	108	697	163	1102
	1275	1518	7568	6772	17133 *

THESE FIGURES ARE LOWER LIMITS. THE * PUBLISHED AFTER 1977 HAVE NO Q ESTIMATES

Q = 1 $\Leftrightarrow$ $\sigma_{V, B-V, U-B} > .06$ mag

Q = 2 $\in .03 , .06$

Q = 3 $\in .015 , .03$

Q = 4 $< .015$ mag

- Q=4 STARS MAY BE USED AS STANDARDS FOR ON-ORBIT CALIBRATION
- OTHER STARS WITH B-V < 1.40 MAY BE USED AS CONSTANT STARS (IN PART)
- MORE STARS HAVE UBV PHOTOMETRY
- FAINT STARS AND SURVEY STARS NOT YET INCLUDED IN L2 - Σ.

PHOTOMETRIC STANDARDS
FOR THE ON-ORBIT
PAYLOAD CALIBRATION

Secondary photometric standards needed because the stars with known accurate spectrophotometry are: too bright & too few

---

A STAR WITH P.E. DATA MAY BE RETAINED AS STANDARD FOR HIPPARCOS OR TYCHO IF:

1) m Hp may be predicted with $\sigma_{m_{Hp}} \leq .02$ or better from multicolour data

true if:

a) photometry sufficiently accurate

b) transformation equations valid

c) star is a long term non-variable

$$\bar{m}_{Hp}(1990) \equiv \bar{m}_{Hp}(1960-1985)$$

d) the short term amplitude of microvariations is less than

A: peak to peak $\tilde{<}$ 0.02 mag.

2) non-visual double

3) located in uncrowded area (e.g. non cluster member)

TYCHO

STANDARD STARS FROM GENEVA PHOTOMETRY

June 83 status : 18347 * measured

i.e. 7439 BS
14865 HD
16770 DM

number of measurements 131582

annual rate : ~ 15000 (3 mes/*)

Magnitude distribution :

3-4	342 *	9-10	2554
4-5	1016	10-11	1581
5-6	2863	11-12	732
6-7	3861	12-13	348
7-8	2084	13-14	74
8-9	2709	14-15	13

Standard deviations on colours & magnitude V

	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13
σ_c	.004	.004	.004	.004	.005	.005	.007	.011	.015
σ_V	.006	.007	.006	.007	.008	.009	.010	.011	.018:

- NUMBER OF CONSTANT STARS :

cst if $Q \geq 3$ ie more than 2 measures over more than one years

and $\sigma_V \leq .010$

about 5000 * are confirmed as non-variables

and have $\sigma_V \leq \frac{.010}{\sqrt{Q}} = .006$ mag.

ANNEX VII

here always the same param. i.e. obj.-model as in solution.

Table 1 · Variation of the number of parameters.

S stars sky	2000	2000	2000	2000	2000	2000
C stars sky	8000	8000	8000	8000	8000	0
Span of photo set (h)	12	12	12	12	12	12
S stars in photo set	30	30	30	30	30	30
C stars in photo set	120	120	120	120	120	0
No. of zero point terms	0	0	0	2	2	2
No. of colour terms	0	1	2	1	2	2
Total no. of parameters	9	10	11	12	13	13
F ratio for S stars:						
6^m	1.10	2.16	2.72	2.40	2.75	2.79
8^m	1.03	1.10	1.16	1.21	1.34	1.38
10^m	1.00	1.03	1.05	1.04	1.06	1.06
12^m	1.00	1.01	1.01	1.01	1.02	1.02
average	1.02	1.13	1.20	1.20	1.28	1.30
F ratio for C stars:						
6^m	1.12	1.46	1.74	1.75	1.98	
8^m	1.03	1.16	1.24	1.26	1.35	
10^m	1.01	1.02	1.03	1.05	1.08	
12^m	1.00	1.01	1.02	1.02	1.03	
average	1.03	1.14	1.22	1.24	1.31	
F average for S+C stars	1.03	1.14	1.22	1.23	1.31	1.30

Table 2 Variation of the span of the photo set

S stars sky C stars sky	2000 8000	2000 8000	2000 8000	2000 8000
span of photoset(h)	12	24	48	48
S stars in photo set C stars in photo set	30 120	54 214	96 384	96 384
No. of time terms total no. of parameters.	2 13	2 13	2 13	③ 14
F ratio for S stars				
6^m 8^m 10^m 12^m	2.75 1.34 1.06 1.02	2.00 1.22 1.06 1.00	1.52 1.13 1.04 1.01	1.53 1.13 1.04 1.01
average	1.28	1.24	1.12	1.12
F ratio for C stars				
6^m 8^m 10^m 12^m	1.98 1.35 1.08 1.03	1.78 1.23 1.10 1.02	1.68 1.19 1.06 1.02	1.64 1.20 1.06 1.02
average	1.31	1.26	1.19	1.19
F ratio for S+C stars	1.31	1.25	1.17	1.18

Table 3: Variation of the ratio between S- and C stars, m.e. of S catalogue, variability

S stars sky	20000	5000	10000	10000	18000	10000
C stars sky	20000	17000	12000	12000	12000	12000
per cent of variables	0	0	0	5	0	0
Span of photo set	12	12	12	12	12	12
S stars in photo set	30	75	150	150	150	150
C stars in photo set	329	284	209	209	209	209
No. of parameters	13	13	13	13	13	13
m.e. of S star catalogue	$0^{m}.02$	$0^{m}.02$	$0^{m}.02$	$0^{m}.02$	$0^{m}.03$	$0^{m}.04$
F ratio of S stars						
6^m	2.75	1.81	1.32	1.35	1.53	1.76
8^m	1.33	1.15	1.08	1.08	1.16	1.24
10^m	1.05	1.02	1.01	1.02	1.02	1.04
12^m	1.02	1.00	1.00	1.00	1.01	1.01
average	1.28	1.14	1.08	1.11	1.14	1.22
F ratio of C stars						
6^m	2.07	1.57	1.40	1.26	1.64	1.90
8^m	1.34	1.17	1.09	1.09	1.16	1.24
10^m	1.11	1.05	1.03	1.02	1.05	1.08
12^m	1.03	1.01	1.01	1.01	1.01	1.02
average	1.29	1.15	1.09	1.08	1.14	1.21
F average for S+C stars	1.29	1.15	1.08	1.09	1.14	1.21

2000 S   8000 C

```
FILE =IDT1      THSET= 12.0  NSTAR= 200  BWIDTH= 3.00
U1 =   .50-006   V1 =   .60-006 OMEGA1=   .82-203    0
SIMULATION: MS=13 MEAN SDBVS= .020  MEAN SDMS= .020
             :     MEAN SDBVC= .040  MEAN SDMC= .040
REDUCTION  : MREDUC=13 NSTAR= 150 NSTD=  32 NVAR=  0

STELLAR DISTRIBUTION D3      COUNT RATE C1        10000 * SKY
2 ZERO-POINT,  2 TIME,    7 FIELD,    AND 2 (B-V) PARAMETERS


RESULTING S-STAR DISTRIBUTION:

  MH=    6.00  8.00 10.00 12.00 S.D.:(B-V) M
B-V -----------------------------------------
1.37       1     1     1     2      .020  .020
1.00       0     3     1     1      .020  .020
 .50       0     6     1     1      .020  .020
 .00       1     3     4     4      .020  .020
-----------------------------------------------

RESULTING C-STAR DISTRIBUTION:

  MH=    6.00  8.00 10.00 12.00 S.D.:(B-V) M
B-V -----------------------------------------
1.37       2     4     1     5      .040  .040
1.00       2     8     5    10      .040  .040
 .50       5    14    11     7      .040  .040
 .00      11    18     5    12      .040  .040
-----------------------------------------------

AVERAGE S-TABLE OF F AT POINTS (MH,B-V):

  MH=      6.00      8.00      10.00      12.00
B-V -------------------------------------------
1.37       3.79      1.57      1.23       1.05
1.00        .00      1.25      1.02       1.01
 .50        .00      1.36      1.00       1.01
 .00       1.72      1.29      1.03       1.00
- - - - - - - - - - - - - - - - - - - - - - - -
           2.75      1.34      1.06       1.02
-----------------------------------------------

AVERAGE C-TABLE OF F AT POINTS (MH,B-V):

  MH=      6.00      8.00      10.00      12.00
B-V -------------------------------------------
1.37       2.92      2.07      1.06       1.07
1.00       2.55      1.44      1.07       1.02
 .50       1.74      1.24      1.08       1.02
 .00       1.82      1.24      1.08       1.02
- - - - - - - - - - - - - - - - - - - - - - - -
           1.98      1.35      1.08       1.03
-----------------------------------------------
```

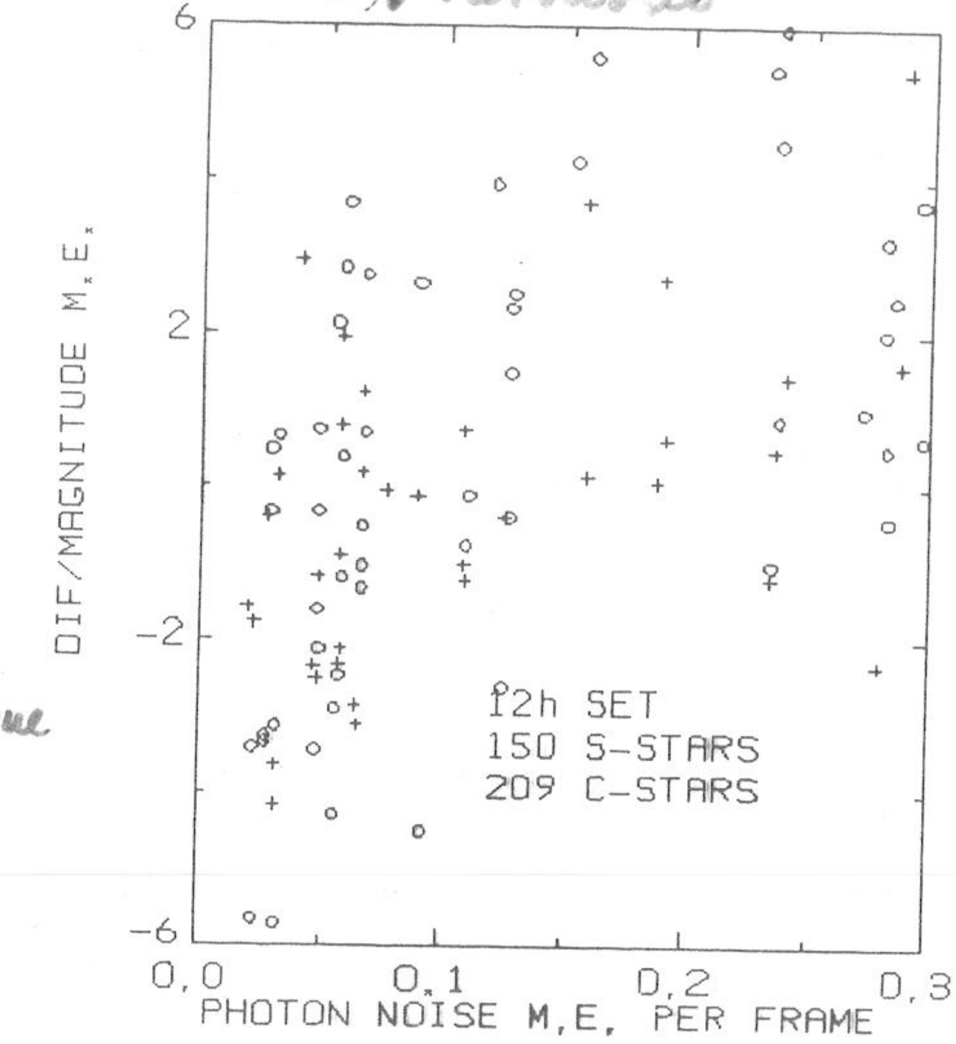
2000 S   8000 C   12 hours

```
FILE =IDT1      THSET= 12.0  NSTAR= 260  BWIDTH= 3.00
U1 =     .50-006  V1 =     .60-006 OMEGA1=    .82-003  0
SIMULATION: MS=13 MEAN SDBVS= .020  MEAN SDMS= .020
                : MEAN SDBVC= .040  MEAN SDMC= .040
REDUCTION  : MREDUC=13 NSTAR= 150 NSTD=  30 NVAR=  0

STELLAR DISTRIBUTION D3      COUNT RATE C1      10000 * SKY
2 ZERO-POINT,  2 TIME,   7 FIELD,   AND 2 (B-V) PARAMETERS


INSTRUMENTAL PARAMETERS:
       ↓
NO  TERM  . . . . . . . .YTRUE. . . . .YSOL. . . . RATIO . .DIF         S.D..       CIF/S.D. MAG-EFFECT
--------------------------------------------------------------------------------------------------------
 1 →ZERO-POINT(MAG)     .500+000    .519+000     1.038    .188-001    .754-002      2.49    .0075
 2  DIF ZERO-POINT      .100+000    .992-001      .992  -.792-003    .714-003     -1.11    .0007
 3  TIME  T    (HOUR)   .330-002    .312-002      .946  -.179-003    .368-003      -.49    .0022
 4  TIME  T**2          .550-003    .718-003     1.305    .168-003    .846-004      1.98    .0030
 6  ETA        (MRAD)   .250-002    .297-002     1.189    .471-003    .202-003      2.33    .0016

 7  ZETA       (MRAD)   .250-002    .276-002     1.106    .265-003    .215-003      1.23    .0017
 8  ETA**2              .320-003    .611-004      .191  -.259-003    .488-004     -5.31    .0030
 9  ETA*ZETA            .320-003    .514-003     1.605    .194-003    .378-004      5.12    .0023
10  ZETA**2             .320-003    .207-003      .647  -.113-003    .427-004     -2.64    .0026
12 →(B-V)       (MAG)   .500-001    .251-001      .502  -.249-001    .116-001     -2.15    .0116

13 →(B-V)**2            .500-001    .837-001     1.674    .337-001    .223-001      1.51    .0223
14  ETA*(B-V)           .640-002    .567-002      .886  -.731-003    .335-003     -2.18    .0026
15  ZETA*(B-V)          .640-002....614-002      .959  -.261-003    .388-003      -.67    .0030
--------------------------------------------------------------------------------------------------------
```

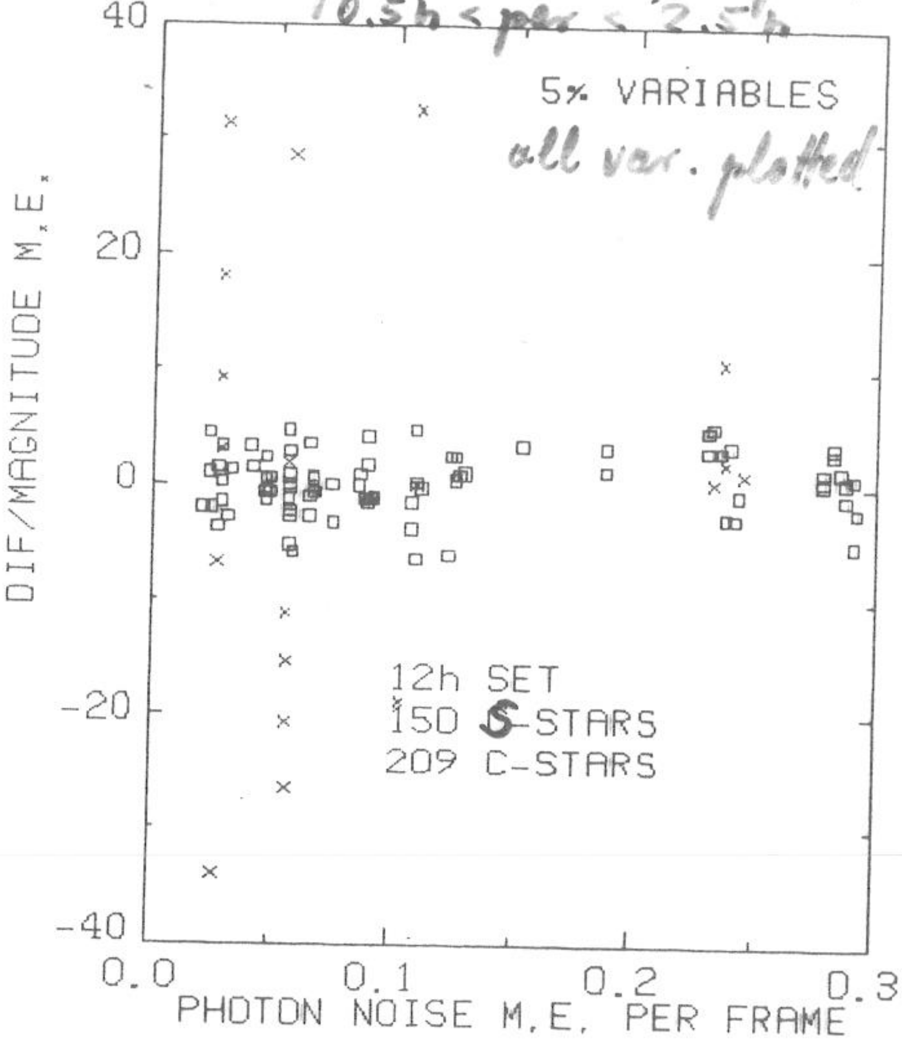
ESA: constancy of param. in ~50h ?
true values ! "

stim-true

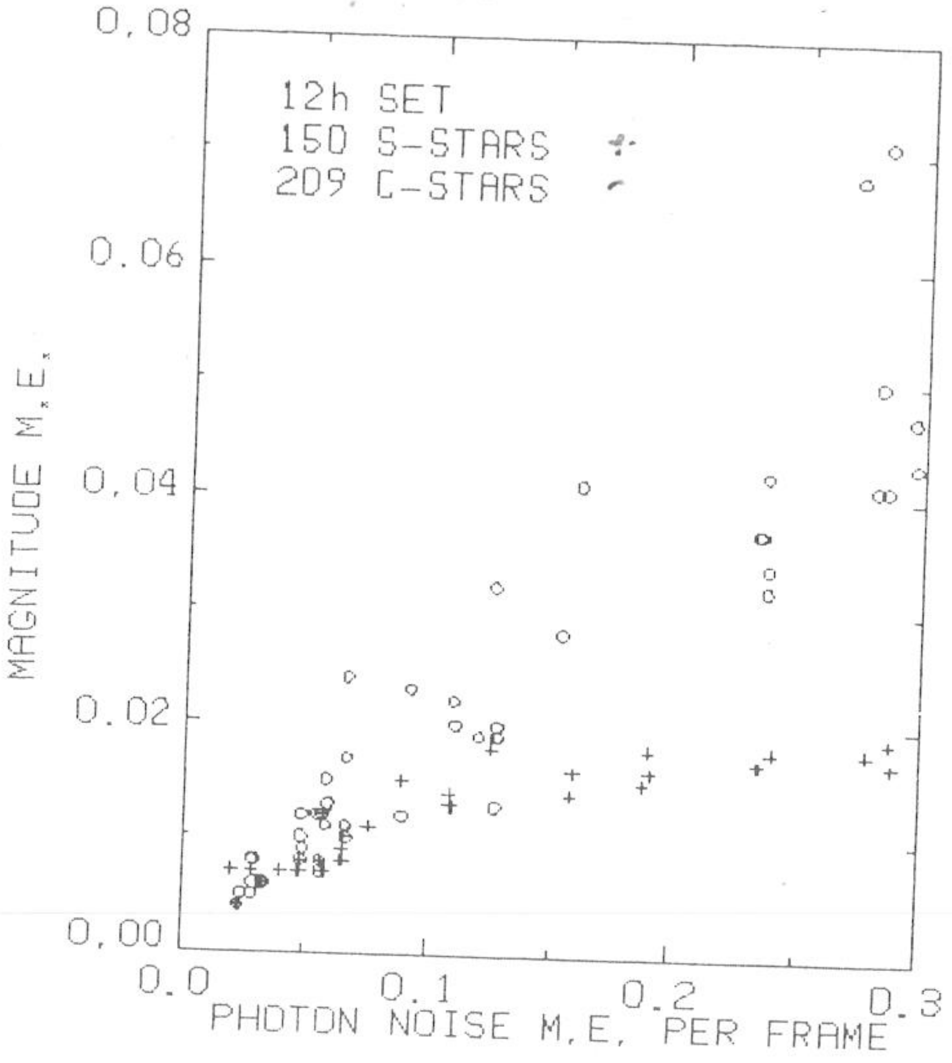
0% variables

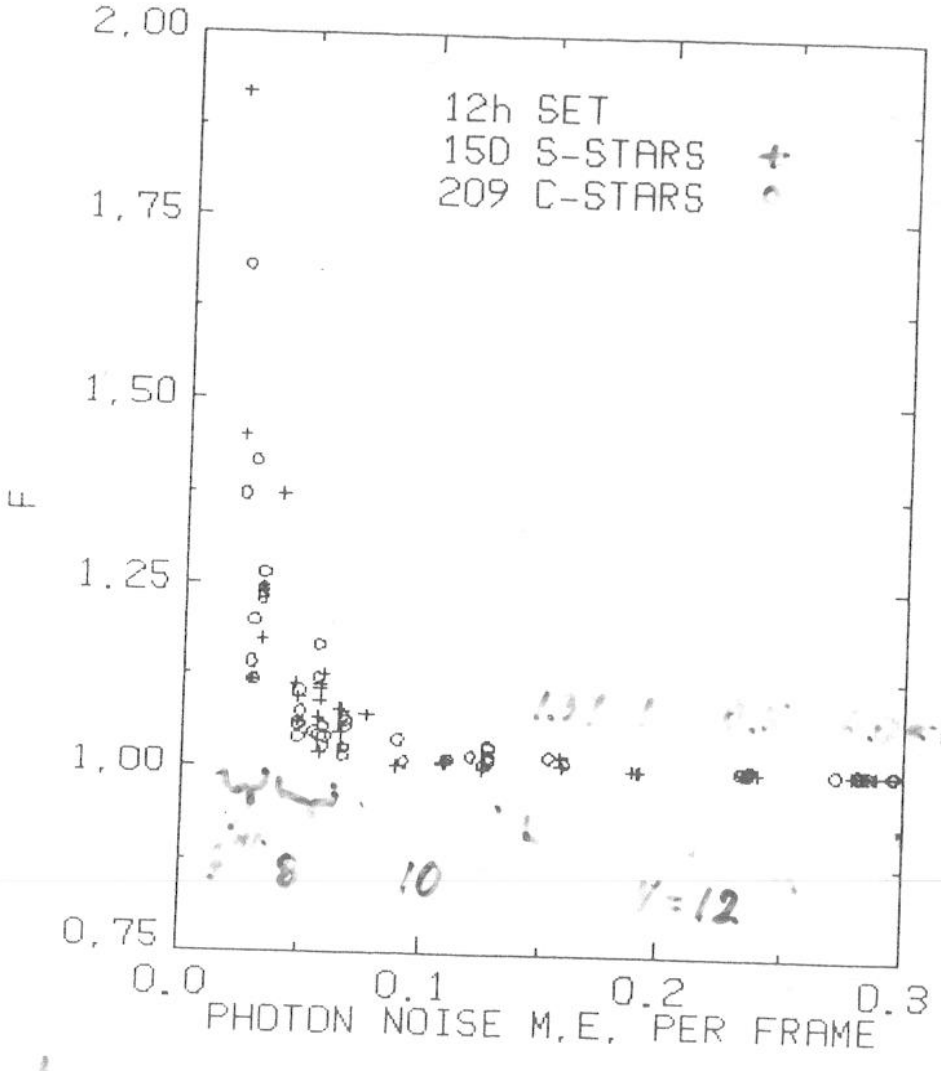


5% of all C and S var.
all ~~in~~ B-V=0.5, ampl 0.5,
0.5h < per < 2.5h



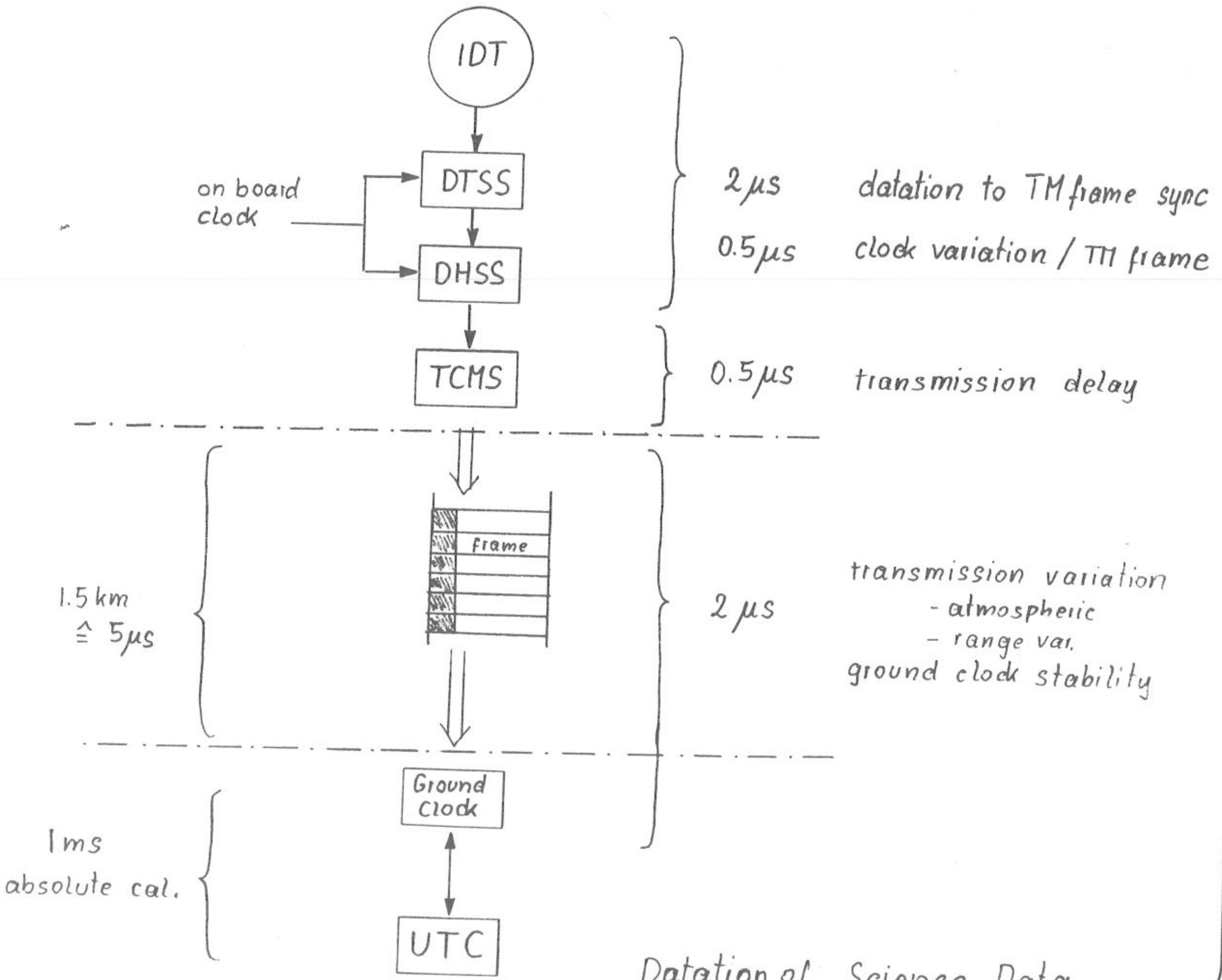
all var. plotted


12h SET
150 S-STARS +
209 C-STARS ○
MAGNITUDE M.E.
0.00
0.02
0.04
0.06
0.08
0.0
0.1
0.2
0.3
PHOTON NOISE M.E. PER FRAME


12h SET
150 S-STARS +
209 C-STARS ○
F
0.75
1.00
1.25
1.50
1.75
2.00
0.0
0.1
0.2
0.3
PHOTON NOISE M.E. PER FRAME
8
10
V=12

Date 3.11.83 K.C.

ANNEX VIII



Datation of Science Data