CEOS CAL/VAL NEWSLETTER issue 2

Committee on Earth Observations Satellites
Working Group on Cal/Val

Contents:

This is the second issue of the bi-annual Newsletter of the Working Group on Calibration and Validation (WGCV) of the Committee on Earth Observations Satellites (CEOS).

Recent activities of the WGCV have included the very successful sixth and the seventh meetings of the WGCV, hosted by INPE in Sao José dos Campos, Brazil from November 23 to 25 1992, and by the Commission of the European Communities at the Joint Research Centre, Ispra, Italy from 2 to 4 June 1993 respectively, and the first meetings of the WGCV Subgroups on Infrared and Visible Optical Sensors (IVOS) and Terrain Mapping.

THE CAL/VAL DOSSIER

At the WGCV6 meeting the need for a cal/val dossier to contain all the available information on calibration and validation sites, facilities and activities of the WGCV members was agreed. Additionally the need for the cal/val dossier to be updated on a regular basis was recognised. It was considered that the update information would be readily available from the members reports to WGCV.

The main benefits of the cal/val dossier in bringing together the complete set of information on cal/val activities would be:

1) its potential use as a reference by members wishing to know what cal/val work is current or planned on a particular area of interest. This will allow smaller members to be able to concentrate on areas of cal/val which are not being addressed.

2) its potential to act as a mechanism by which collaboration between members on common cal/val topics can be increased. Additionally its existence may hopefully avoid duplication or wasted effort on cal/val.

A recommendation from the WGCV was made to the CEOS Plenary in December 1992 to request the commissioning of a first draft of the cal/val dossier.

This recommendation and the other recommendations from the WGCV were well received and well discussed by the Plenary. However the Plenary requested that the WGCV should undertake further work in defining the content of the cal/val dossier and should provide a detailed outline to the next Plenary meeting which is to be held in Tokyo in November 1993.

At WGCV7 the UK offered to complete a 'pilot' version of the cal/val dossier. This offer was accepted by the meeting. The 'pilot' cal/val dossier will be prepared by Smith System Engineering Ltd. and Defence Research Agency with inputs and reviews by the WGCV members. It is intended that the 'pilot' cal/val dossier will cover as a minimum the ERS-1 SAR and ATSR instruments. It is hoped that the submission of the 'pilot' cal/val dossier to the November CEOS Plenary meeting will lead to the commissioning of the first issue of the cal/val dossier during 1994.

WGCV SUBGROUP MEETINGS:

IVOS
Ian Barton(email barton@larry.dar.csiro.au, fax +61-3 586 7600).

During 1992 the WGCV established a subgroup on the cal/val of infrared and visible sensors (IVOS). Ian Barton of CISRO, Australia agreed to act as the first chairman of this subgroup which has now met twice to establish the terms of reference and initial activities.

The first meeting was hosted by NOAA and held at their Science Centre in Camp Springs during November 1992. At this meeting the following terms of reference were discussed and agreed.

1. To identify and agree on calibration and validation requirements and standard specifications for IVOS, including on-board systems.

2. To promote international and national collaboration in the calibration and validation of all infra-red and visible optical sensors and thus assist in the improved application of data from satellite instruments.

3. To include all sensors (ground based, airborne and satellite) where there is a direct link to the cal/val of satellite sensors.

4. To identify test sites and encourage continuing observations and inter-comparisons of data from these sites.

5. To encourage the timely and unencumbered release of data relating to cal/val activities, including details of pre-launch and in-flight calibration parameters.

These terms of reference have since been ratified by the WGCV at the June 1993 meeting at JRC, Ispra.

The IVOS also identified two initial activities:

i) Test sites - IVOS members to develop a database for selected test sites and to investigate a means of easy exchange of data.
ii) Inter-comparison of solar diffusers and on-board calibration techniques.

The first meeting of IVOS also formulated the following recommendations which were presented to the 1992 CEOS Plenary.

- Recognising that accurate and long term calibration is crucial for the use of satellite data in climate and global change applications, the IVOS recommends that CEOS members support the identification, characterisation and maintenance of ground test sites for the verification of on-board calibration systems, the in flight calibration of infrared and visible sensors, and subsequent cross calibration of satellite sensors.

- That, as a matter of urgency, CEOS supports the establishment of a comprehensive database on selected test sites for the future in-flight calibration of infra red and visible sensors.

- IVOS congratulates NOAA/NASA on the implementation of the 'Pathfinder' activities and encourages the produces and users of satellite data to support similar activities for other satellite systems.

These recommendations have resulted in the CEOS Plenary placing the following action on the WGCV

'to provide specifications and costs on proposed ground test sites for calibration and validation'. This action is currently being responded to by the various subgroups of the WGCV.

SAR CALIBRATION

Mark Hutchins, Defence Research Agency, Farnborough, Hants., UK. (email markh@raespa-mod.farn.uk fax. +44 252 522959).

The fourth meeting of the SAR calibration subgroup was held in Ottawa, Canada during the week of September 21 to 25, 1992. The meeting was co-hosted by the Canadian Space Agency and the Canadian Centre for Remote Sensing. The meeting was attended by approximately 100 participants. At the meeting over 40 presentations were made in total which covered

the topics: science requirements, radiometric calibration, polarimetric calibration, geometric calibration, calibration devices, interferometric calibration, processor calibration, and spaceborne SAR calibration. Selected papers from the meeting are to be published in a special issue of the Canadian Journal of Remote Sensing.

Minutes of meeting can be obtained from the subgroup chairman, Tony Freeman, using the contact numbers below.

The next meeting of the SAR calibration subgroup is to be hosted by the ESA at ESTEC, The Netherlands, on 20 to 24 September 1993.

Attendance at the meeting is open to all interested in SAR calibration. Further information can be obtained from Tony Freeman (Chairman), (Tel +01 818 354 1887 fax +01 818 393 6943) or Y-L Desnos (Workshop Organiser), (Tel +31 1719 84927 fax +31 1719 84596).

Selected full length papers will be published as ESA WPP-48 (Guest Editor E Attema) in November 1993.

TERRAIN MAPPING

Ian Dowman(email idowman@ps.ucl.ac.uk fax +44-71 380 0453).

The first meeting of the Terrain Mapping Subgroup, chaired by Dr Tony Freeman, was held at the Jet Propulsion Laboratory, Pasadena, California, U.S.A. on 7-9th December 1992. The second meeting of the subgroup was held from 31 May to 1 June 1993 at JRC, Ispra prior to WGCV7 under the chairmanship of Prof. Ian Dowman on behalf of the BNSC/UK. The meetings were attended by people from different groups including users of terrain data, cartographers, software designers for optical and microwave systems and system designers. The meetings comprised technical presentations and detailed discussion leading to some specific actions and recommendations

At the meetings the subgroup:

- formulated a general statement on the accuracy requirements (5m horizontal and 1.5m vertical) to allow most applications to be met.

- identified the need for controlled test sites with the following characteristics to permit the validation of spaceborne systems
  - easy access
  - long term availability
  - size of the order of 80Km^2
  - coarse grid of reference points for the entire site
  - smaller denser grids in a few locations
  - control point determination to $\pm$0.5m in position and elevation
  - frequent coverage

  Death Valley and Marseilles were identified as primary sites and group members will collect data on these and other sites.

- recognised that in order to fulfil the user requirements, mixed satellite technologies (e.g. optical/radar) should be used

- noted that future satellites sensors will be able to produce DEMs with an accuracy of 1-2 m from optical sensors and missions designed for SAR interferometry and recommend that space agencies support the establishment and maintenance of test sites and make data available free of charge.

- discussed the ERS-2 mission and urged ESA to put ERS-2 into a tandem orbit to ERS-1 with a 30 minute separation to give optimum conditions for repeat track SAR interferometry.

The Terrain Mapping sub-group is now well established and doing useful work. Any input from groups interested in setting up or using test sites will be welcome and people are encouraged to contact Ian Dowman on these topics.

PASSIVE MICROWAVE

Bruce Guenther, NASA, GSFC, Greenbelt, Maryland, USA. (fax +01 818 393 5285).

The WGCV is sponsoring a Passive Microwave cal/val meeting to be held near Boston, Massachusettes, in the United States in early October, 1993. The objective of this meeting is to determine if there is appropriate interest and work to establish a Passive Microwave subgroup of WGCV. Additional information can be obtained from the meeting convenor, Jim Shiue, of NASA GSFC by telephone on +01 301 286 6716 or by fax +01 301 286 4661 or by email at JCSHIUE/GSFCMAIL.

ESA CALIBRATION/VALIDATION ACTIVITIES

Evert Attema, ESA, ESTEC, Noordwijk, The Netherlands.

(email attema@estwm0.dnet.estec.esa.nl fax. +31-1719 85617).

The calibration and validation activities of the European Space Agency (ESA) currently include data evaluation and algorithm development for ERS-1, new initiatives in support of future spaceborne missions and airborne simulation campaigns.

ERS-1 Calibration and Validation

ERS-1 instruments and platform performance continue to be stable. Update of the scatterometer wind retrieval model improved the quality of the fast delivery wind product and removed the 'granularity' in the wind direction. During a recent intermediate review the geophysical performances of ERS-1 data products given in Table 1 were reported.

New Initiatives

ESA working groups are currently in the process of defining the calibration and validation strategies for future satellite missions. These include ERS-2 (SAR, Scatterometer, Radar Altimeter, GOME), ENVISAT-1 (ASAR, RA-2, MERIS, MIPAS, GOMOS) and METOP-1 (MIMR, ASCATT).

ESA Simulation Campaigns

Presentations of the first results of the MAC Europe campaign took place at a special session of the ERIM conference in Graz, Austria. This campaign was a collaboration between NASA, ESA, the Joint Research Centre of the EC and national remote sensing institutes. Over 60 investigators presented their work.

The proceedings of the final workshop of the European Lidar Airborne Campaign have been published (ESA WPP-49, March 1993). Follow-on activities include an airborne Doppler lidar campaign in 1993/94. The European LIDAR community also expressed interest to participate in the NASA 'LITE' mission .

The first results of ERS-1 SAR observations in support of the HAPEX-SAHEL project, notably soil moisture mappings, were reported at the principle investigators meeting in Toulouse on 12th –14th May 1993.

ESA is currently seeking collaboration with CEOS members in a new initiative, the joint ESA/JRC European Multi-sensor Airborne Campaign (EMAC 94/95), involving airborne SAR, airborne imaging spectromerty and airborne microwave radiometry. A preliminary announcement of opportunity has resulted in over 90 letters of interest being received which are currently being

Data Product	Range	Accuracy (Bias/s.d.)	Instrument
Wind Field			
.Velocity	0.5-30 m/s	0.3/2.2 m/s	AMI Wind Mode
		0.02/2.2 m/s	Radar Altimeter
.Direction	0-360 deg.	0.8/22 deg.	AMI Wind Mode
Wave Field			
.Significant Wave Height	1-20 m	0.05/0.48 m 'similar to RA'	Radar Altimeter Wave Mode
.Wave Direction	0-360 deg.	15 deg.	AMI Wave Mode
.Wavelength	50-1000 m	20%	AMI Wave Mode
Earth Surface Imaging .Land .Ice .Coastal Zones	100 km Swath Width	Radiometric Acc. Bias/s.d. : 0.13/0.4 dB Geometric Res. 25*22 m Radiometric Res. 2 dB	AMI Image Mode
Altitude			
.Over Ocean	745-825 km	Bias/s.d. -0.41/0.05 m	Radar Altimeter
Sea Surface	500 km	0.5 K	ATSR

Temperature	Swath Width		
Water Vapour	25 km Spot	0.5g/cm2	Microwave Sounder

Table 1 Proven Geophysical Measurement Performance of ERS-1 Data Products

evaluated.

ESA plays a co-ordinating role in the experiment SEMAPHORE, led by French investigators and in the European portion of the Canadian initiative GLOBESAR.

SEMAPHORE is mainly concerned with the study of mesoscale heat fluxes at the air/sea interface. The interest for ESA in this experiment lies mainly in the investigation and stimulation of the use of satellite data in this area of climate research. GLOBESAR is an airborne SAR campaign with the Canadian Centre for Remote Sensing IRIS system. The objectives of the campaign include SAR application development and RADARSAT simulation.

US-NASA EARTH OBSERVING SYSTEM (EOS) CALIBRATION NEWS

Bruce Guenther, NASA, GSFC, Greenbelt, Maryland, USA. (fax. +1 301 286 1616).

The NASA EOS Project has established Calibration Peer Reviews as an essential part of the process for providing high quality calibrated and earth located (Level 1) data sets to the science community for each of its instruments.

To date the EOS Project has held Peer Reviews at the time of the engineering review of the preliminary instrument design for four instruments. In June 1992, the CERES (Clouds and the Earth's Radiant Energy System) review was held in Los Angeles, California, U.S.A.; in September 1992, the MODIS (MODerate resolution Imaging Spectroradiometer) review was held in Santa Barbara, California; in March 1993, the ASTER (Advanced Spaceborne Thermal Emission and Reflection radiometer) review was held in Tsukuba, Ibaraki, Japan; and in May 1993, the MISR (Multi-angle Imaging SpectroRadiometer) review was held in Pasadena, California.

The first MOPITT (Measurement Of Pollution in The Troposphere) Calibration Peer Review is tentatively scheduled for November 1993, in Canada. In addition to these Calibration Peer Reviews, a Calibration Workshop on thermal infrared radiation measurement was held jointly with the Utah State University, Space Dynamics Laboratory, Logan, Utah, USA in 1992.

For the Sea-viewing Wide Field Scanner sensor (SeaWiFS), an EOS precursor flight mission, a round-robin laboratory comparison was held in July 1992, at San Diego State University, San Diego, California, and a second comparison is scheduled for June 1993 at the same location. This comparison yielded differences of 10 per cent or greater. The EOS Calibration Panel held a Cross-calibration Workshop at the US National Institute of Standards and Technology, Gaithersburg, Maryland, U.S.A. on 18 May 1993.

Other organisations that wish to participate in these programs through joint field measurements and laboratory comparisons are invited to participate. Specific or additional information on these is available from Bruce Guenther, EOS Project Scientist for Calibration (telephone +01-301 286 5202).

HEIGHT CALIBRATION OF THE ERS-1 AND ERS-2 RADAR ALTIMETERS

Mark Hutchins, Defence Research Agency, Farnborough, Hants., UK. (email markh@raespa-mod.farn.uk fax. +44 252 522959).

At the ERS-1 Radar Altimeter Height Bias Calibration Meeting held on 11-12 May 1993 at Instituto per lo Studio della Dinamica delle Grandi Masse of the Italian Consiglio Nazaionalle della Richerche (ISDGM-CNR), Venice, Italy, ESA presented its final results on the height bias calibration for the ERS-1 Radar Altimeter (RA) obtained from the Venice Campaign.

The Venice Calibration Campaign

The design of the ERS-1 RA allows it to make height measurements with a stability at the

millimetre level with a noise level of about 2.5 cm. However before the launch of ERS-1 it was not possible to measure the height bias to an equivalent accuracy, the residual error was estimated at about 0.5 m.

The measurement of the height bias was achieved by a dedicated calibration campaign during which the ERS-1 overflew the 'Acqua Alta' Oceanographic Research Tower, off the coast of Venice, once every 3 days in the commissioning phase orbit. Surveys to determine the 3-dimensional positions of all reference points and the local geoid were completed during 1990 and 1991. During the period of the campaign (31 July to 17 September 1992) measurements of the sea level (tide) at the 'Acqua Alta' tower together with all the relevant environmental properties (tropospheric and ionospheric corrections, winds, waves, etc.) were made and ERS-1 was tracked by a network of European satellite laser ranging (SLR) stations.

The calibration procedure can be simply stated as follows: measure the altimetric height of the satellite above the sea surface, determine the satellite's altitude from an orbit computation based on tracking data, and simultaneously measure the sea level height by a tide gauge, the position of which is accurately known. The comparison of the difference of the first two values with the latter yields the altimeter bias. The achievement of this calibration procedure in practise has taken a considerable amount of effort from nearly twenty 'expert' institutes across Europe.

The static errors affecting the orbit determination, the altimeter measurement and the tidal sea surface measurement combined by root sum of squares is $\pm$3.2 cm. An altimeter bias obtained from a weighted average of ten single pass bias estimates is -41.5 $\pm$2.0 cm. This results in a final bias estimation and total uncertainty of -41.5 $\pm$5.2 cm.

ESA have completed a very comprehensive calibration campaign to determine the height bias to the ERS-1 RA. This calibration has effectively met the 1988 ESA goal for an overall accuracy of 5 cm for the RA height measurement. The result from the campaign is supported by the current measurements to the ERS-2 RA. These measurements suggest that an error of 3 ns was made in the measurement of the delay time outside of the internal calibration loop for the ERS-1 RA.

A comprehensive final report covering the Venice calibration campaign has been issued by the ESA ('The Calibration of the ERS-1 Radar Altimeter: The Venice Calibration Campaign', ref. ER-RP-ESA-RA-0257, issue 2.0, dated 1 March 1993).

ERS-2 RA Calibration

From the results of the Venice calibration campaign it is understood that it is not possible to significantly improve on the accuracy achieved for the absolute height calibration. To fully exploit the millimetre stability of the RA height measurements between ERS-1 and ERS-2 it is suggested by ESA that a relative calibration with millimetre accuracy should be undertaken. It is proposed that this relative calibration can be achieved by the use of a global solution procedure.

ESA also propose a repeat of the Venice Campaign for ERS-2 if the relative calibration is not successful to the required accuracy. However this would require shifting the ERS-2 orbit into a 3-day repeat cycle, from the 35-day repeat launch orbit, in order to acquire sufficient passes over the Venice site in a short period of time. An absolute height bias calibration of the ERS-2 RA could be achieved in the 35-day orbit by the use of the transponders. This could potentially avoid the need for a repeat of the Venice calibration campaign.

DRA FARNBOROUGH ERS-1 SAR CALIBRATION ACTIVITIES

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A calibration site containing a number of large (47 dBsm) precision corner reflectors was established at Romney Marsh, Kent for the ERS-1 commissioning phase. The RCS of the reflectors was measured to an accuracy of ± 0.3 dB and were found to have a stability of approximately the same order. Subsequently the site has been in continuous use, which has allowed assessment of the stability of the ERS-1 SAR and the targets over a period of nearly two years. Preliminary results show a small long-term drift in the instrument performance see figure 1. However results from ESA's analysis using data from one of the ESA transponders, figure 2, does not appear to show a long term trend.

Investigation of a Goretex radome cover has also continued at the Romney site during this period. Comparisons with open reflectors have confirmed the 0.3 dB radome attenuation found during the commissioning phase. A decrease in the stability of the radome covered reflectors has been found during the winter months, which is thought to be related to weather conditions. A new rigid radome has been designed and should be installed by the end of July 1993.

The cross swath radiometric calibration has been measured from June 1992 onwards using a further set of precision targets deployed across a site in East Anglia. Measurements of the target signatures in images processed at the UK-PAF revealed variations between targets of approximately 1.5 dB. Subsequent analysis of the mean cross-swath intensity for these images revealed a 1.5 dB “ripple”. These results led to the discovery that the errors were due to the incorrect application of the antenna gain correction during processing. The East Anglia targets were also used in support of a crop monitoring experiment, which set out to investigate the feasibility of using spaceborne SAR for crop discrimination.

Two new precision reflectors have been manufactured having a 360 deg. of azimuth rotation capability and hydraulic elevation control over a range of 15 - 50 deg. of incidence angle. These will be deployed at the Romney site in June 1993 and then possibly transferred to the ESTEC calibration site at Flevoland for comparison with the ESA transponders. The use of these targets at Flevoland in support of the calibration of SIR-C is being considered. Additionally, DRA are developing a low cost transponder with a 30 - 60 dBsm RCS capability, which will be pre-programmed with RCS and pointing data for at least 10 passes. The battery power source will be re-charged during the sleep mode by either wind or solar power. The peak received power will also be recorded.

ATSR CALIBRATION AND VALIDATION

David Llewellyn-Jones.

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VALIDATION OF ATSR ON ERS-1

Validation campaigns continue to be run in many different parts of the world. In the last six months alone there have been campaigns run in the mid-Pacific, in the Atlantic from the UK to the Antarctic, the Tyrrhenian Sea, the East China Sea, the Adriatic, Lake Malawi and Mutsu Bay in Japan.

All groups working on ATSR validation are now preparing papers on their results and in addition they have all been invited to contribute to a joint paper summarising their work and giving a global view of the validation results.
A series of meetings has been held for everyone working in the field of ATSR validation. The most recent was held at RAL on 30 March 1993, attended by about 25 people. At the meeting there was a general view that work needed to be done on the development of new radiometers, all of the present designs having faults that made them difficult or expensive to use at sea. In some areas of the world airborne radiometers can be more cost effective than shipborne ones because they take measurements along a significant part of the ATSR swath rather than being restricted to just one point. They can also move quickly to cloud free areas of the swath. RAL agreed to set up a workshop to provide recommendations for further radiometer development in three areas:-

1) An improved shipborne radiometer

2) A low cost radiometer for use on ships of convenience

3) An airborne SST radiometer.

PRE-LAUNCH CALIBRATION OF THE ATSR-2

On 10 May 1993 the ATSR-2 flight model radiometer, designed to continue the ATSR data set of precise sea surface temperature, was delivered to the European Space Agency for integration upon the ERS-2 satellite, which is due for launch in early 1995. The delivery of ATSR-2 was the culmination of an intensive 5-month calibration period at Oxford University, where the instrument underwent an exhaustive series of

functional tests followed by careful measurement of the instrument's field of view and radiometric response.

All the parameters measured showed levels of performance well within specifications and in many cases significantly better than the corresponding parameters for ATSR-1.

On the basis of this exercise, which was a co-operative effort between Oxford University, Rutherford Appleton Laboratory and the industrial prime contractor, British Aerospace, the project team at RAL now have confidence that ATSR-2 will continue the high quality of infrared imagery and global sea surface temperature measurements that are now being produced by the ATSR-1 instrument on ERS-1.

The ATSR-2 also contains visible wavelength channels with a novel on board visible wavelength calibration system, which will enable ATSR-2 to extend its mission objectives towards the area of land remote sensing.

ON-BOARD CALIBRATION OF IRS LISS CAMERAS

A S Kiran Kumar, G Mangalam and Kurian Mathew.
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The Indian Remote Sensing Satellites, IRS-1A and IRS-1B, became operational in March 1988 and August 1991 respectively and since then have been sending good quality images of the Indian subcontinent. The remote sensing payloads of both satellites are identical and consists of three solid state, push-broom cameras; LISS1, LISS2A and LISS2B. Each camera consists of four spectral bands: band1 (0.45-0.52µm), band2 (0.52-0.59µm), band3 (0.62-0.68µm) and band4 (0.77-0.86µm). The cameras have a modular structure with separate optics as well as detectors for each band. The detector of each LISS band consists of a 2K element CCD array (Fairchild CCD143A).

LISS payloads are provided with a unique on-board calibration facility to monitor variation of the detector sensitivity. The calibration facility consists of two light emitting diodes (LEDs) in each band which directly illuminate the CCD array. The LEDs are positioned on either side of the detector, tilted at 60 degrees to the optical axis. The LEDs are operated in pulsed mode and the exposure level (intensity*time) is varied by adjusting pulse duration. Since the detector integrates the light energy falling on it, the output count will be proportional to the exposure level.

A special scheme adopted for the LED-operation enables the generation of calibration data for 13 exposure levels (including one zero level). This is achieved by selecting different combinations of pulse duration and intensity levels. The LEDs can be operated with four pulse duration (W, 2W, 3W and 4W) whereas three intensity levels (I_1, I_2, I_1+ I_2) are realised by switching on either one of the LEDs or both the LEDs together.

On-board calibration is carried out once in every orbit repeat cycle (22 days) of the satellite during the night time passes. Any variation in the detector calibration/sensitivity is estimated by comparing the on-board data with a reference data generated during the prelaunch period under simulated thermovac conditions of the orbit. Various performance parameters of the payload and the device which are monitored through on-board calibration data are:-

1) System noise (standard deviation)
2) Variations in video chain offset
3) Variations in the 'odd-even channel difference'
4) Response variations of the CCD element and
5) Response linearity of the CCD element.

Table 2 gives the performance of the IRS-1A LISS payloads during the last five years (March 1987 - March 1993) estimated from the analysis of the on-board calibration

Parameters Estimated	LISS 1				LISS 2A				LISS 2B			
	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4
System noise dev. Mean value	0.43	0.44	0.34	0.26	0.50	0.34	0.44	0.34	0.44	0.39	0.28	0.29
System noise dev., worst case value (counts)	1.00	0.90	0.60	0.60	0.90	0.60	0.60	0.60	1.20	0.70	0.60	1.00

Video offest change (counts)	3.2	2.3	1.0	1.6	2.7	1.5	1.1	1.4	3.0	0.9	1.2	1.5
Response variation (counts)	±1	±1	±2	±2	±2	±1	±1	±1	±2	±2	±2	±2
Variation in 'odd-even channel difference' <(%)	1	1	1	1	1	1	1	1	1	1	1	1
Response nonlinearity <(%)	1	1	1	1	1	1	2	1	1	1	3	1
LED stability <(%)	1.0	1.7	1.4	1.5	1.0	1.5	1.7	2.5	1.8	1.3	2.3	2.5

Table 2 On-board calibration of IRS-1A LISS cameras. Summary results for the 5 year period (March 1988 to March 1993)

Parameters Estimated	LISS 1				LISS 2A				LISS 2B			
	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4
System noise dev. Mean value	0.28	0.28	0.30	0.26	0.35	0.35	0.37	0.28	0.34	0.40	0.37	0.35
System noise dev., worst case value (counts)	1.00	1.00	0.80	0.60	0.80	0.60	0.70	0.60	1.00	0.80	1.00	1.00
Video offest change (counts)	3.2	2.3	1.0	1.6	2.7	1.5	1.1	1.4	3.0	0.9	1.2	0.20
Response variation (counts)	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2
Variation in 'odd-even channel difference' <(%)	0.12	0.12	0.12	0.12	0.3	0.3	0.3	0.3	0.22	0.22	0.22	0.22
Response nonlinearity <(%)	1	1	1	1	1	1	2	1	1	1	1	1
LED stability <(%)	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0

Table 3 On-board calibration of IRS-1B LISS cameras. Summary results for the 1 year period (August 1991 to August 1992)

data. Table 3 gives the in-orbit performance of IRS-1B LISS payloads over a period of one year (August 1991 - August 1992).

The large volume of calibration data collected over the years by the 24 spectral channels of (six) IRS-LISS cameras, corresponds to 72 device years of on-board experience. The analysis of these data clearly demonstrate variations of the payload performance. As for an example, it is found that since its launch, the dark current in all IRS-1A bands has been increasing in a regular fashion. Further studies carried out showed that this is due to the effect of particle radiation environment in the orbit. Currently, the on-board calibration facilities of both IRS-1A and IRS-1B are functioning well and providing valuable information about the payload performance.

SAR CALIBRATION DEVICES SURVEY

At the 1992 SAR calibration subgroup meeting a joint action was accepted by Helmutt Kietzman (DLR) and Derek Kenward (DRA) to circulate a questionnaire and from the responses compile an inventory of SAR calibration devices. Of the 36 questionnaires sent out few returns have so far been received.

To complete the inventory please return the outstanding questionnaires to Derek Kenward, CSC1, Q134 Building, DRA Farnborough, Hants, GU14 6TD, UK (Fax +44 252 372982).

FUTURE MEETING DATES

WGCV8: 21-25 February 1994, venue TBC.
WGCV9: November 1994, venue TBC.
SAR Calibration: 20 - 24 September 1993, ESTEC, The Netherlands.
Passive Microwave: October 1993, venue TBC.

REMINDER

Issue 3 of the CVWG Newsletter is intended to be completed in December 1993. Contributions for inclusion in the next issue should be submitted to the Newsletter editor Mark Hutchins preferably by email to markh@raespa-mod.farn.uk or by fax. to +44 252 522959 by 15 November 1993.

It is intended that amongst the articles in the next the next issue will be:

- The calibration of JERS-1
- AVHRR Calibration
- SAR calibration subgroup meeting report
- CEOS Plenary response to the 'pilot' cal/val dossier and the test site survey

CVWG BULLETIN BOARD

The WGCV maintains a bulletin board on OMNET (CEOS.WGCV.NEWS/OMNET). Information for inclusion on the bulletin board should be provided to your country WGCV representative.

TEST SITE SURVEYS TEST SITE SURVEYS TEST SITE SURVEYS TEST SITE SURVEYS

The sub-groups of WGCV are undertaking surveys on test sites and on-board visible calibration. Survey forms will be circulated to all CEOS members and an early response is requested. The information will be collated by WGCV will be used as input to the CEOS cal/val dossier discussed in the leading article to this newsletter. For further information please contact the subgroup chairmen:

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