THE CELESTIAL SYSTEM OF THE INTERNATIONAL EARTH ROTATION SERVICE

E.F. ARIAS
Central Bureau of IERS, Paris, France
and La Plata Observatory/CONICET, Argentina

M. FEISSEL
Central Bureau of IERS - Observatoire de Paris/URA 1125 du CNRS
Observatoire de Paris - 61, avenue de l'Observatoire, F-75014 Paris, France

ABSTRACT. The celestial system of the International Earth Rotation Service (IERS) is materialized by the J2000.0 positions of more than 250 extragalactic compact radio sources observed by VLBI. The source coordinates are evaluated from the combination of individual celestial frames obtained by the Goddard Space Flight Center, the Jet Propulsion Laboratory and the U.S. National Geodetic Survey.

The combination model and the maintenance algorithm are described. To free the IERS celestial frame from inconsistencies due to the inaccuracy of the IAU conventional models for precession and nutation, it is implemented on individual frames which have been obtained in parallel to the adjustment of corrections to the direction of the celestial pole.

The IERS celestial reference frame is consistent with FK5 at a few milliarcsecond level. To be made denser and more accessible for astronomical uses, it will be related to the HIPPARCOS stellar frame.

Introduction

Between 1978 and 1980, several multibaseline VLBI observation programs were initiated for space navigation, geophysics and astronomy; the Deep Space Network (DSN) is operated by the Jet Propulsion Laboratory (JPL), the Crustal Dynamics Project (CDP) is operated by NASA, and the International Radio-Interferometric Surveying (IRIS) program is operated by agencies in the United States and other countries. A common requirement for the scientific use of these observations is the establishment of an accurate celestial reference system, materialized by a reference frame, *i.e.*, a catalog of positions of extragalactic radio sources and a set of astronomical and geophysical models (Ma, 1989).

The current practice in the analysis of VLBI observations consists of a global adjustment of the terrestrial coordinates of the observing stations, the celestial coordinates of the radio sources and the series of the Earth Orientation Parameters (EOP) which relate the terrestrial to the celestial frame as a function of time. These adjustments are performed over the complete period of observations.

The International Earth Rotation Service (IERS) was established in 1987 by the IAU and the IUGG and it started operation on 1988 January 1st (IAG, 1988). It replaces the International Polar Motion Service (IPMS) and the earth-rotation section of the Bureau International de l'Heure (BIH). IERS is a member of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS). It

J. H. Lieske and V. K. Abalakin (eds.), Inertial Coordinate System on the Sky, 119–128.

is responsible for defining and maintaining a conventional terrestrial reference system based on observing stations that use the high-precision techniques in space geodesy; defining and maintaining a conventional celestial reference system based on extragalactic radio sources, and relating it to other celestial reference systems; and determining the Earth orientation parameters connecting these systems, *i.e.*, the terrestrial and celestial coordinates of the pole and universal time.

Several laboratories contribute to the work of IERS by analysing the above mentioned VLBI observations on the basis of common models and constants. The Central Bureau of IERS performs a global combination of these results with similar ones obtained by laser ranging to the Moon (LLR) and to artificial satellites (SLR). By the nature of the observing techniques, the celestial frame realized in this global analysis is based solely on VLBI, while the terrestrial frame and the EOP include a large contribution of satellite geodesy (IERS, 1989).

This paper first describes the IERS System in some detail. The implementation by the Central Bureau of the system maintenance process is then outlined, with application to the most recent realization of the celestial frame. Finally the link to FK5 and the future extension to the HIPPARCOS stellar frame are discussed.

The IERS Reference System

The IERS Reference System is composed of several parts: the IERS standards, the IERS reference frames, and the corresponding series of the Earth Orientation Parameters, which are consistent with one another at a few milliarcsecond level.

IERS Standards

The IERS standards used in 1988 are the MERIT Standards (Melbourne et *al.*, 1983) including *Update No 1*; the IERS Standards (1989) are under preparation (McCarthy, 1989). They consist of a set of constants and models used by the IERS Analysis Centres for VLBI, LLR and SLR, and by the Central Bureau in the combination of results. The values of the constants are adopted from recent analyses; in some cases they differ from the current IAU and IAG conventional ones. The models represent, in general, the state of the art in the field concerned.

IERS Reference Frames

The IERS reference frames consist of the IERS Terrestrial Reference Frame (ITRF) and IERS Celestial Reference Frame (ICRF); both frames are realized through lists of coordinates of fiducial points: terrestrial sites or compact extragalactic radio sources.

Terrestrial frame. The origin of the ITRF is located at the center of mass of the Earth, with an uncertainty of 10cm. The length unit is the metre (SI). The IERS Reference Pole and Reference Meridian are consistent with the corresponding directions in the BIH Terrestrial System (BTS) within 0\".003. The BIH reference pole was adjusted to the Conventional International Origin (CIO) in 1967; it was then kept stable independently until 1987. The uncertainty of the tie of the BIH reference pole with the CIO was 0\".03 (Boucher and Feissel, 1984).

Celestial frame. Guinot (1979) proposed that the definition of the celestial reference frame be attached to the directions of extragalactic sources. The maintenance of the frame would then be based

https://doi.org/10.1017/S0074180900086472 Published online by Cambridge University Press

on the stability of the set of the selected objects, no attempt being made to re-adjust the origins of the frame. The recommendations of the IAU/IUGG Working group MERIT (Wilkins and Mueller, 1986), endorsed by the IAU in 1985, follow the same lines. The analyses of the Central Bureau of IERS implement these recommendations.

The origin of the ICRF is at the barycentre of the solar system. The direction of the polar axis is the one given for epoch J2000.0 by the IAU 1976 Precession and the IAU 1980 Theory of Nutation. The origin of right ascensions is such that the right ascension of 3C 273 is $12^h\,29^m\,6\overset{s}{.}6997$. The initial definition was based on 23 radio sources available in three VLBI reference frames derived by the Goddard Space Flight Center (GSFC), JPL and the U.S. National Geodesy Survey (NGS) from observations from 1978 through 1987; it is described by Arias *et al.* (1988).

THE EARTH ORIENTATION PARAMETERS

The IERS Earth Orientation Parameters (EOP) are the parameters which describe the rotation of the ITRF to the ICRF as a function of time, in conjunction with the conventional precession and nutation models. They model the unpredictable part of the Earth's motion. They consist of five parameters: the coordinates of the terrestrial pole (x, y) ; universal time (UT1), related to the Greenwich mean sidereal time (GMST) by a conventional relationship (Aoki *et al.*, 1982); the offsets in longitude and in obliquity ($d\psi$, $d\varepsilon$) of the celestial pole with respect to its position defined by the conventional IAU precession/nutation models.

Shortly after the adoption of the IAU 1980 Theory of Nutation, (Seidelmann, 1982), the VLBI observations started to show evidence of inaccuracies in some of its components, reaching $0\overset{''}{.}01$ in the principal term, $0\overset{''}{.}005$ in the annual term and $0\overset{''}{.}001$ in several other terms in longitude; some of the obliquity components also have inaccuracies of $0\overset{''}{.}001$ - $0\overset{''}{.}002$; in addition, the precession constant might require a correction of about $0\overset{''}{.}003$ per year (Herring *et al*; 1986). In the analysis of observations, these model deficiencies would propagate unevenly in the source positions, giving rise to local systematic errors and to misorientation of the frame, both at the level of several milliarcseconds. To avoid these effects, the VLBI analyses in the framework of IERS include the estimation of $d\psi$, $d\varepsilon$, for each session. Such solutions entail fixing *a priori* the values of $d\psi$ and $d\varepsilon$ for one date; the numerical values chosen reflect themselves in the orientation of the derived celestial frame (an alternative procedure is the direct adjustment of corrections to some of the terms of the models).

Maintenance of the IERS Celestial Reference Frame

The initial realization of the IERS Celestial Reference Frame, RSC (IERS) 88 C 01, (Arias *et al.*, 1988) included a total of 228 extragalactic radio sources.

In the normal process of IERS global analyses, the ICRF can be re-evaluated whenever new information is available. This is a maintenance process, in which strict rules are applied, with the aim of insuring the consistency of the direction of axes with the initial definition, while improving the accuracy of the existing sources and extending the frame to new sources. The practical implementation which led to RSC (IERS) 89 C 01, published in the IERS Annual Report for 1988, is described below.

The adjustment of the celestial reference frame is one part in a process which also embodies the terrestrial frame and the series of EOP over several years. This approach makes it possible to compare the corresponding elements in the various solutions, thus providing an external check of the consistency of the models used. In the case of the celestial frames, the model for comparisons is a three-angle rotation (see below). The consistency checks are based on a comparison of rotation angles between frames with systematic differences between time series of universal time and of the celestial pole offsets (Altamimi *et al.* 1989). The results of the comparisons characterize the link of the individual systems with the IERS System.

CLASSIFICATION OF CONTRIBUTING CATALOGS

The individual frames which are to contribute to the *maintenance* of axes are selected according to the consistency of their link to the IERS System, and to their density and precision. Another class of frames, still dense and precise but less consistent with the IERS System, is used to *densify* the combined frame when it contains additional sources. Finally, the less dense and consistent frames are only *compared* to the combined one. The individual frames available for the 1989 analysis are described in Table 1.

CLASSIFICATION OF SOURCES

The individual catalogues include well observed pointlike sources, with small uncertainties in their coordinates, and other sources, less observed or having sizeable structure, with coordinates of greater uncertainty. It is therefore necessary to select carefully the *primary sources* to be used in the maintenance of the frame. The 23 primary sources in the initial definition of the IERS frame were

Table 1 - Individual reference frames: number of sources (n), rms formal uncertainty (σ) and declination interval (δ). Unit for σ : 0.″001. (*1*)

Frame		Total n	Primary n	Primary σ	Secondary n	Secondary σ	Complem. n	Complem. σ	declination limits (°)
Maintenance									
RSC (GSFC)	89 R 01	64	20	0.2	36	0.6	8	0.8	–30,+81
RSC (JPL)	89 R 02	189	16	2.5	173	2.7	-	-	–45,+85
RSC (NGS)	89 R 01	50	20	0.2	30	0.7	-	-	–30,+79
Densification									
RSC (JPL)	89 R 03	195	-	-	173	4.2	4	15.0	–45,+85
Comparison									
RSC (NAOMZ) (2)	89 R 01	20	10	-	10	-	-	-	–4,+79
RSC (SHA) (*3*)	89 R 01	14	6	-	8	-	-	-	0,+79

(*1*) The classification of sources is explained in the text.
(2) NAOMZ : National Astronomical Observatory, Mizuzawa (Japan)
(*3*) SHA : Shanghai Observatory (China).

selected on the basis of structure, sky coverage, time stability and number of observations (Carter, 1987).

Radio sources common to at least two of the frames used for the maintenance or densification, but not in the primary list, are defined as *secondary sources*, while those belonging to only one individual frame are the *complementary sources*. Neither secondary nor complementary sources are used to define the directions of axes of the combined frame; only their positions relative to it are evaluated.

For the implementation of RSC(IERS) 89 C 01, the list of primary sources was re-examined. For this purpose, a preliminary combined frame was calculated with axes aligned on the initial definition by use of the 23 initial primary sources; then the differences in coordinates in the two frames 88 C 01 and 89 C 01 for all common sources were compared to their standard errors derived from the combination. Former primary sources were kept in this category only if their change in coordinates was smaller than twice their standard error; former secondary sources with a change in coordinates less than their standard error were upgraded to the primary status.

Following these criteria, four radio sources were deleted from the primary list: 0212+735, 0454–234, 1034–293 and 1803+784, and a new one was included: 1749+096. The sources 0212+735 and 1803+784 showed right ascension differences of 2.9σ and 3.5σ respectively, confirmed by structure in right ascension observed in their maps (Charlot, 1989).

The combination model

The differences between catalogs are expressed in a direct trirectangle coordinate system with the x-axis and z-axis in the respective directions to the origin of right ascensions and pole of the IERS celestial frame. The model currently used considers a three-angle rotation matrix, assuming no systematic local deformation; the validity of the latter assumption is a part of the examination of the results.

Let A_1 (i), A_2 (i), A_3 (i) be the rotation angles between the combined reference frame and the individual frame i ; α_{ij}, δ_{ij} are the coordinates of the source j in the frame i, and α_{cj}, δ_{cj} its coordinates in the combined celestial reference frame. The respective equations of observation in right ascension and declination are :

$$
\begin{aligned}
+ A_1(i)\ \tan\delta_{ij}\cos\alpha_{ij} + A_2(i)\ \tan\delta_{ij}\sin\alpha_{ij} - A_3(i) + \alpha_{cj} &= \alpha_{ij} \\
- A_1(i)\sin\alpha_{ij} + A_2(i)\cos\alpha_{ij} + \delta_{cj} &= \delta_{ij}
\end{aligned}
\qquad (1)
$$

The combination is performed in three steps.

1- Using only the three frames selected for the maintenance of the system, the coordinates of the primary sources in the combined frame and the relative orientations A_1(i), A_2(i), A_3(i) between it and the three individual frames are evaluated in a weighted least squares fit. The directions of axes of the combined frame are constrained to be aligned with the axes of RSC (IERS) 88 C 01.

2- The orientation of the densification frame relative to the combined frame is evaluated on the basis of the primary radio sources available in it.

3- The coordinates of secondary and complementary sources in the combined frame are obtained by applying to the individual frames the rotation angles derived in steps (1) and (2).

In the three steps, the equations of observation are weighted according to the formal uncertainties of the individual coordinates; the formal uncertainties in the individual source positions below 0.″00025 have been set to this value.

RSC (IERS) 89 C 01

The combination described above led to the positions of 209 compact extragalactic radio sources of which 20 are primary, 177 secondary and 12 complementary. The formal uncertainties of the primary sources are in the range 0.″0002 to 0.″0004, which is consistent with the formal uncertainties in the individual frames. They agree well with the respective values for RSC (IERS) 88 C 01 given in the BIH Annual Report for 1987. For the secondary sources belonging only to JPL frames, we have adopted as formal uncertainty the largest value in the individual frames; for the other secondary sources, the consistency between coordinates in the individual frames ranges from 0.″0003 to 0.″02.

57 addditional extragalactic sources had coordinates in RSC (IERS) 88 C 01, whereas they were not present in the frames of Table 1; they can be considered as a complement of the new realization. The 266 sources of RSC (IERS) 89 C 01, including this complementary list, are plotted in Figure 1. Its extension south of its present limit, –45°, on the basis of recent observations (Ma, 1989), is planned.

The rotation angles of the frames of Table 1 to RSC (IERS) 89 C 01 are given in Table 2. The major part in these angles reflects the fact that the *a priori* fixing of the values of dψ and dε for one of the observing sessions is made independently in the various analyses. After taking out the corresponding biases, the disagreement of the maintenance frames axes with the IERS one is under 0.″0005, except for still unexplained discrepancies in the celestial pole offsets in longitude angles at the level of 0.″005.

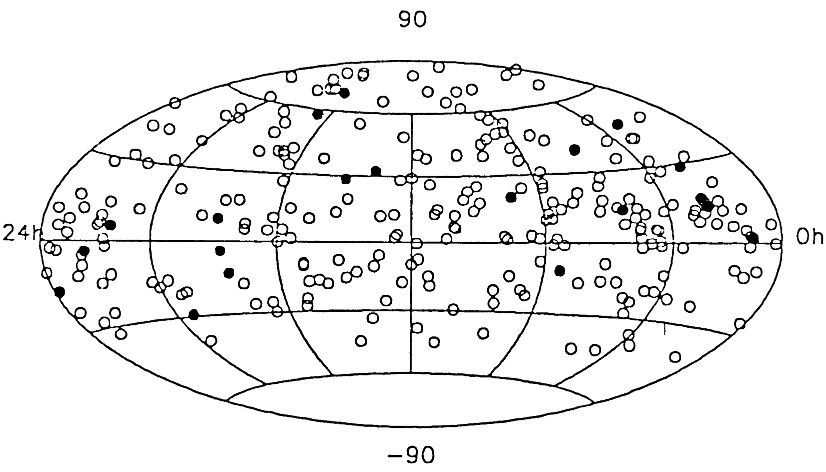

Figure 1. Sky distribution of the 266 radio sources of RSC (IERS) 89 C 01. Dark circles represent the primary sources.

https://doi.org/10.1017/S0074180900086472 Published online by Cambridge University Press

Comparisons between the individual frames, and between them and the combined one, show that local systematic deformations of the IERS celestial frames can be expected to be lower than 0."002 (Arias and Lestrade, 1989).

Table 2 - Relative orientation between the individual frames and RSC (IERS) 89 C 01. The rotation angles A_1, A_2, A_3 transform the coordinates from the individual VLBI frames to the combined frame. N is the number of common radio sources. Unit : 0."001.

Individual frame		N	A_1	A_2	A_3
Maintenance					
RSC (GSFC)	89 R 01	64	+1.28 ± 0.09	+2.46 ± 0.10	–0.15 ± 0.07
RSC (JPL)	89 R 02	162	–0.04 ± 0.06	–1.15 ± 0.07	+0.07 ± 0.04
RSC (NGS)	89 R 01	50	+0.31 ± 0.10	–0.07 ± 0.10	–0.24 ± 0.08
Densification					
RSC (JPL)	89 R 03	176	+0.76 ± 0.08	–3.03 ± 0.08	+0.72 ± 0.24
Comparison					
RSC (NAOMZ)	89 R 01	20	–1.30 ± 0.37	–2.08 ± 0.37	–0.19 ± 4.06
RSC (SHA)	89 R 01	14	–1.85 ± 0.41	–5.19 ± 0.38	–1.63 ± 4.33

Extension of the IERS Celestial Reference Frame to galactic frames

The densest VLBI reference frames presently available contain a few hundreds of sources. The extragalactic frame is considered the best realization of a quasi-inertial reference frame because of its properties: it is kinematically stable (nuclei of galaxies and quasars being at cosmological distances, their apparent proper motions can be considered nonexistent), and its precision is at the milliarcsecond level. Nevertheless, it has two disadvantages relative to the stellar frames :

a) it does not supply a large number of fiducial points (200-300 sources), and
b) extragalactic radio sources are very faint objects (m > 13) which are not optically observable, thus it is accessible only with the VLBI technique.

The observations of the astrometric satellite HIPPARCOS will contribute to the densification and accessibility of the extragalactic frame, if the satellite can accomplish its *nominal* mission. On the other hand, the astrometric qualities of the HIPPARCOS frame will be exploited only if it is linked to a quasi-inertial frame of similar precision. The HIPPARCOS reconstructed sphere will be affected by the galactic rotation at a rate of about 0.007"/year (Lestrade *et al.* 1985). Being derived from a space telescope, its reference system will not be linked to the terrestrial equator and the ecliptic. For stars brighter than m = 9, the expected mean precision is 0".002 in the positions and 0.002"/year in the proper motions. It will observe about 120 000 stars brighter than m = 13.

Several possibilities have been envisaged to make the HIPPARCOS reference frame inertial (Mignard, 1989) :

- To link it to the VLBI frame by radio stars. Radio stars are members of our galaxy. Most are quite bright optically. The satellite HIPPARCOS has over one thousand of them in its observational program. They provide a direct link between the radio and optical frames.

- The Hubble Space Telescope (HST) will determine relative positions between extragalactic objects and nearby HIPPARCOS stars. There are 92 extragalactic objects for the HST and 173 HIPPARCOS "Super High priority" stars at small angular distances to link them. 52 radio sources in RSC (IERS) 89 C 01 had already been selected for the HIPPARCOS / ST proposal, giving prospect for a good link by this route (Argue, 1989).

Until the HIPPARCOS stellar frame becomes available, the IERS celestial frame can be made accessible by considering the rotation angles between it and the FK5 stellar frame (Fricke *et al.* 1988). The uncertainty of individual positions is evaluated to ±0".05 for the present epoch by Ma *et al.* (1989), and Morrison *et al.* (1989) have shown that regional systematic errors are present in the FK5 at the level of 0".05-0".10. A preliminary evaluation, based on a comparison of 28 quasar positions brought to the FK5 frame through the AGK3RN catalog (Ma *et al.*, 1989) with the IERS ones, indicates that the rotation angle of the IERS celestial frame to the FK5 frame in the equator is –0".005 and that the polar axes of the two frames are consistent within 0".04, with an uncertainty of about 0".02 due to the noise in the optical positions of quasars.

Summary

The current realization of the IERS Celestial Reference Frame contains 266 extragalactic sources of which 76 have position uncertainties smaller than 0".001 and 117 sources are between 0".001 and 0".003. The algorithm by which it is maintained insures the consistency of the successive versions at the best level achievable with the existing data (0.1 mas in 1989). It allows the continuous improvement of the accuracy and distribution of the frame as new data become available.

Through the global IERS analysis, the IERS Celestial Reference Frame is indirectly related to the dynamical celestial reference frames used in satellite geodesy and Lunar Laser Ranging, and it is related directly to the IERS Terrestrial Reference Frame at the milliarcsecond level.

The IERS Celestial Reference Frame is the realization of a quasi-inertial frame at the level of 0".002 in the individual source positions. The FK5 is another realization at the level of 0".05-0".10. The axes of the two frames are in agreement within 0".04. Future connection with the HIPPARCOS stellar frame through VLBI observations of radio stars and/or Hubble Space Telescope observations of quasars should extend the accessibility of the IERS celestial frame to optical observation of stars at the level of 0".002, if the nominal HIPPARCOS mission is achieved.

Acknowledgment. We are grateful to Chopo Ma and J.G. Williams for enlightening discussion of our work. This work was carried out during a stay of the first author at Paris Observatory and Bureau des Longitudes.

References

ALTAMIMI, Z., ARIAS, E.F., BOUCHER, C., FEISSEL, M., 1989 : Earth Orientation determinations : some tests of consistency. *IAG Symposium 105*. Wilkins (ed.).

AOKI, S., GUINOT, B., KAPLAN, G.H., KINOSHITA, H., McCARTHY, D.D., SEIDELMANN, P.K.:1982 : The new definition of Universal Time. *Astron.and Astrophys.* **105,** 359.

ARIAS, E.F., FEISSEL, M., LESTRADE, J.-F.: 1988. An extragalactic celestial reference frame consistent with the BIH Terrestrial System (1987). *BIH Annual Report for 1987*, p.D-113. Observatoire de Paris.

ARIAS, E.F., and LESTRADE, J.-F., 1989 : Extended astrometric comparisons between two dense VLBI extragalactic reference frames elaborated at the GSFC and the JPL. Submitted to *Astron. and Astrophys.*

ARGUE, N., 1989 : The strategy adopted for linking HIPPARCOS to an extragalactic reference frame. *This volume.*

BOUCHER, C., and FEISSEL, M., 1984 : Realization of the BIH Terrestrial System. *Proc. Internat. Symp. on Space Techniques for Geodynamics,* Somogyi and Reigber (eds). Res. Inst. of the Hungarian Acad. of Sci. (Sopron, Hungary), Vol. **1,** 235.

CARTER, W.E., 1987 : IERS memorandum, 1 December 1987.

CHARLOT, P., 1989 : 14 extragalactic radio sources mapped at 2.3 and 8.4 GHz with a 24 hour Crustal Dynamics Program VLBI experiment. *Astron.and Astrophys.* (in press).

FRICKE, W., SCHWAN, H. and LEDERLE, T., 1988 : *Fifth Fundamental Catalogue (FK5),* Part 1, Veröffentlichungen ARI, Heidelberg.

GUINOT, B., 1979 : Basic problems in the kinematics of the rotation of the Earth, *IAU Symposium 82,* McCarthy and Pilkington (eds.), Reidel.

HERRING, T.A., GWINN, C.R., and SHAPIRO, I.I., 1986 : Geodesy by radio interferometry : study of the forced nutation of the Earth, 1, Data analysis. *J. Geophys Res.* **91,** 4745.

IAG, 1988 : *Geodesist's Handbook,* Bull. Géod., **62,** 337.

IERS, 1989 : *Annual Report for 1988,* Observatoire de Paris.

LESTRADE, J.-F., PRESTON, R.A., MUTEL, R.L., NIELL, A.E. and PHILLIPS, R.B., 1988 : Linking the HIPPARCOS Catalog to the VLBI Inertial Reference System, high angular resolution structures and VLBI positions of 10 radio stars, *The Second F.A.S.T. Thinkshop,* J. Kovalevsky (ed).

MA, C., SHAFFER, D.B., DE VEGT, C., JOHNSTON, K.J., and RUSSELL, J., 1989 : Precise radio source positions determined by Mark III VLBI : observations from 1979 to 1988 and a tie to the FK5, *Astron. J.* (in press).

MA, C., 1989 : The realization of an inertial reference frame from VLBI. *This volume.*

McCARTHY (ed.), 1989 : IERS Standards. *IERS Technical Note No 3,* Observatoire de Paris.

MELBOURNE,W. (ed.), 1983 : Project MERIT Standards. *USNO Circular 167.*

MIGNARD, F., 1989 : HIPPARCOS and reference frames. *This volume.*

MORRISON, L.V., GIBBS, P., HELMER, L., FABRICIUS, C., REQUIEME, Y., RAPAPORT, M., 1989: *Proc. IAU Colloquium 100*, Reidel, *in press.*

SEIDELMANN, P.K.,1982 : IAU 1980 Theory of nutation: the final report of IAU working group on nutation. *Celest. Mech.* **27**, 79.

WILKINS, G.A., and MUELLER, I.I., 1986 : Joint summary report of the IAU/IUGG Working Groups MERIT and COTES, *Bull. Geod.* **60,** 85.

Discussion

HUGHES: For how many sources, especially primary sources, have you maps ?

ARIAS: In addition to the two sources mentioned, the Charlot (1989) paper includes maps of 0229+131, 0234+285, 0528+134, 0552+398, 0851+202, 1404+286, all of them being primary sources.

ARGUE: I have examined the IERS Catalogue. I do not have the actual figures with me, but my recollection is that there are some 50-60 sources on the Hubble Space Telescope selected for linking to HIPPARCOS.

ARIAS: There are 52 radio sources in the IERS Celestial Reference Frame which have been selected for the HIPPARCOS/Hubble Space Telescope link.

WESTERHOUT: Are you planning to introduce a new version of the celestial reference frame each year?

ARIAS: The analysis will be done every year, but a new version will be computed only when justified by the expected improvement in quality or entension of the frame.

WALTER: You process several independent observation catalogues. To which extent have these catalogues been reduced in compliance with the current IAU conventions of astronomical constants ?

ARIAS: The most questionable part of IAU conventions in this work is the precession and nutation models. While these models are used in the individual data analyses to refer the frames to the J2000.0 System, the selected individual frames had been obtained by adjusting for each session the celestial pole offsets, which frees the frames from related systematic errors.