

APPENDIX E

THE HIPPARCOS MISSION COSTS

Project Costs

The following table summarises the costs of the Hipparcos mission to the European Space Agency, since the time of the project's acceptance within the Agency's mandatory scientific programme in 1980. These costs cover industrial development and management, satellite manufacture and testing, manpower, 'overhead charges', computer, travel, test facilities (ESTEC and external), launch, satellite operations, and all post-operation costs.

Item	Cost mixed (kAU) (1)	Cost 82 EC (MAU) (2)	Updated Cost 90 EC (MAU) (3)	Updated Cost 95 EC (MAU) (4)
A. Satellite development	225 221	177.6	259.6	337.0
B. ESA internal costs	49 506	39.0	57.0	74.1
C. Launch	41 391	32.6	47.7	62.0
D. Satellite operations	70 590	55.7	81.3	105.7
E. Science operations	817	0.6	0.9	1.2
Total	387 525	305.5	446.5	580.0

Economic Conditions

In the table, 'cost' refers to the 'cost at completion' in ESA terminology, with figures calculated in 'accounting units' (or AU; in 1990 and 1995, 1 AU = 1 ECU) according to specific economic conditions (EC). The columns having the following meanings:

- (1) cost to completion in 'mixed economic conditions'. Basically the cumulative costs reflect the actual prices in the year for which the costs were incurred, up to 1995. These costs, therefore, ignore the effects of inflation. Since these costs were directly accountable, they are presented at the level of kAU.
- (2) the formally backdated cost at '1982 economic conditions', using a backdating index of 0.7882. Backdated costs must be taken as indicative, since the actual costs were not tracked on this basis (columns 2-4 are therefore presented only at the level of MAU).

- (3) the backdated cost at 1982 economic conditions (column 2) updated to 1990 economic conditions, using the Wiesbaden indices for the total ESA scientific programme. These combine the weighted price variation and the weighted conversion rate variation of the AU, together resulting in an updating index of 1.4616. Costs in 1990 economic conditions can be transformed to national currencies using the relevant exchange rates (for example, average 1990 conversion rates were 6.926 FF, 2.059 DM, 0.715 GBP, or 1.223 \$ per AU).
- (4) as column 3, but updated to 1995 economic conditions, resulting in an updating index of 1.8989. Costs in 1995 economic conditions can be transformed to national currencies using the relevant exchange rates (for example, average 1995 conversion rates were 6.545 FF, 1.865 DM, 0.835 GBP, or 1.331 \$ per AU).

Columns (1–4) include the additional contributions to the operations costs incurred as a result of the non-nominal orbit. These costs, which were met from outside of the scientific programme (4700 kAU in 1990, 7227 kAU in 1991, and 6941 kAU in 1992) amounted to 18 868 kAU (mixed economic conditions) or 12 162 kAU (backdated to 1982 economic conditions). Without these additional costs, the cost at completion in 1982 economic conditions was 293 302 kAU, to be compared with a target envelope cost of 243 750 kAU at the time of the project's acceptance, again in 1982 economic conditions, a cost over-run of 20 per cent over the 15 year project duration. Part of these cost over-runs were attributed to the launch delay of almost one year resulting from Ariane launch delays. A small part, approximately 2 MAU, was attributed to the inclusion of the Tycho experiment in 1981. The target envelope cost updated to 1990 or 1995 economic conditions would be 356.3 MAU or 462.9 MAU respectively.

Breakdown of Project Costs

The figures in the table cover the following items:

- (A) Satellite development: these costs include the industrial costs during the project definition phase (Phase B) (9%); and the industrial cost for the development of the satellite (including spacecraft, payload, and all sub-systems), i.e. Phase C/D, as well as the industrial support for launch preparations (91%). [Phase A studies were funded outside the scientific programme.]
- (B) ESA internal costs: these costs include the cost for ESA project management (67%), technical support within ESTEC (9%), and the utilisation of test facilities (24%). [These are further broken down as follows. The principal contributions to the costs for ESA project management comprised the salary of permanent ESA staff associated with the project (37%); missions (travel) of ESA staff during the project lifetime (8%); and ESA internal overheads (50%). The remaining costs (5%) were incurred for local and part-time staff, young graduates, packing and freight, public relations and international affairs, rental of internal ESTEC facilities, technical consumables and spare parts, 'experts and consultants' including the Hipparcos Science Team, software development, costs of the ESA team at the launch range, and mission specific launch services. The costs for technical support covered ESTEC manpower (50%) and ESA internal overheads (50%). The cost for test facilities comprises the cost for utilising ESTEC and coordinated test facilities (95%), and ESA internal overheads (5%).]
- (C) Launch: this was the cost to ESA of the shared Ariane 4 launch of the Hipparcos satellite (dual launch with TV-SAT2).

- (D) Satellite operations: this covered the total cost for the satellite operations, broken down into the cost for development of the Mission Operations Centre at ESOC (15%), operational costs at ESOC (60%), and ESA internal overheads (25%). The spacecraft operations costs covered permanent staff and contractual manpower at ESOC, computers and associated equipment, and the operation of all four ground stations, including industrial manpower, dedicated equipment, data communications, and tracking, telemetry and ranging. The cost figure includes the additional costs incurred by the non-nominal orbit (see above) which were funded by a Council contribution outside the 'science level' of the ESA scientific programme.
- (E) Science operations: the total cost to ESA of the three-year post operational phase, including external contracts, and 'experts and consultants' including the Hipparcos Science Team costs, covering the costs of coordinating and supervising the catalogue completion, publication, and archival on ASCII CD-ROM. The printed catalogue publication costs do not appear under this heading, since they are intended to be fully covered by catalogue sales.

These figures are finally supplemented by the cost of the ESA Project Scientist (one ESA staff member for 16 years), and approximately one man-year of contractual support related to the preparation of the final mission products financed from within the ESA Space Science Department.

Costs of the European Scientific Participation in the Mission

Detailed estimates of the additional costs of the mission incurred through the participation of the scientific consortia, as funded directly by participating nations, are less easy to quantify than the ESA project costs, due to the different accounting procedures, charging policies, and incompleteness of detailed records. The total involvement of nearly 200 scientists within the four scientific consortia, would probably correspond to some 60 man-years per year averaged over the 16 year lifetime of the project (INCA 25; NDAC 7; TDAC 8, FAST 20), supplemented by the appropriate computer, infrastructure, and travel costs. An indicative cost of around 80 MAU (1990 economic conditions) would probably be a realistic estimate, but this figure must be viewed as somewhat dependent on the charges for overheads, computer resources, etc.

