The Helios Mission

by

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Helios-mini-Workshop
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Note that some of the information used is not available

in written documentation any more and I had to rely on

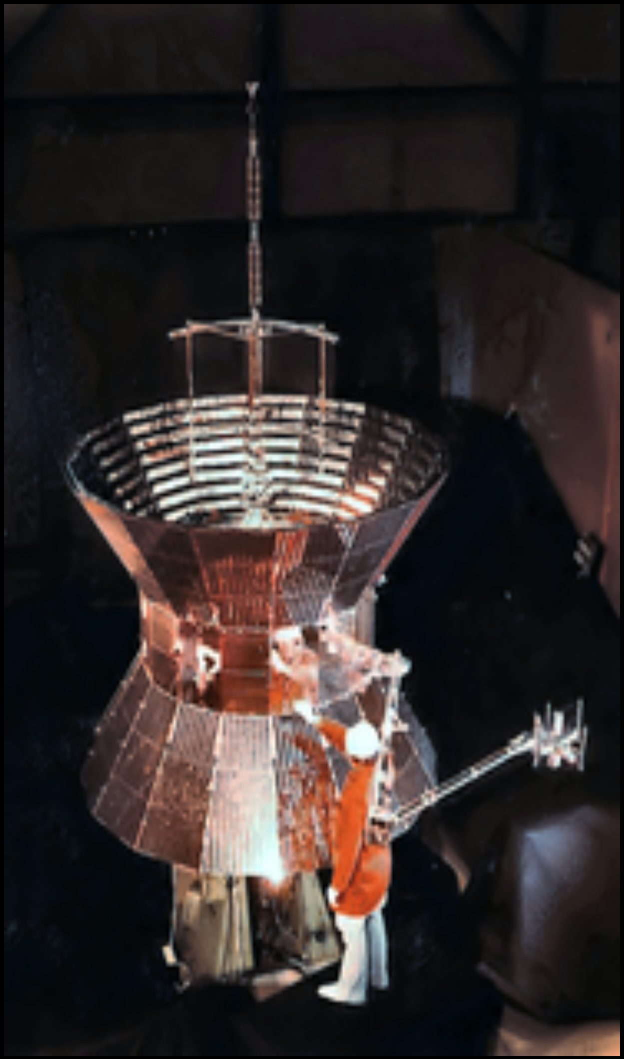
my memory and sometimes of others .

Experiment in Space Archaeology

Köln , June 27- 29 , 2016

Agenda of Talk

- Historical remarks
- Scientific objectives – Experiments
- Orbital information
- Spacecraft
  - Overall description
  - Thermal design
  - Magnetic cleanliness
  - Telemetry features
- Conclusions



The Helios mission: A little history

- The idea of an "ambitious" US-German mission was initiated in 1966 during negotiations between US-President Lyndon B. Johnson and German Chancellor Ludwig Erhard. Choice between "Solar probe" and "Jovian probe" to be made later after detailed discussions.
- There was soon a tendency favoring the " Solar probe" eventually leading to a " Memorandum of Understanding" signed in 1969:
- It involved two space probes (Helios A and B renamed Helios 1 and 2 after launch) approaching the sun in the ecliptic down to approximately 0.3 AU.

Note: During the initial design, considerations even a perihelion down to 0.16 AU was briefly discussed based on launch vehicle performance.

The Helios mission: A little history (cont'd)

- **Later a follow-on mission Helios C was** discussed for some time as an Out-of-ecliptic mission or a cometary mission (e.g. comet P/Encke)
- The potential Helios C spacecraft can now be admired in the museum for science and technology (Deutsches Museum) in Munich !

Helios mission

Scientific objectives	Experiment	PI
Solar wind ions and electrons	E1	Rosenbauer
Interplanetary magnetic field	**E2**, E3, **E4**	Neubauer, Mariani, Neubauer
plasma waves,electric fields	E5a,b,c	Gurnett , Kellogg , Stone
energetic particles	E6,E7,E8	Kunow , Trainor , Kepler
zodiacal light	E9	Leinert
dust particles	E10	Fechtig
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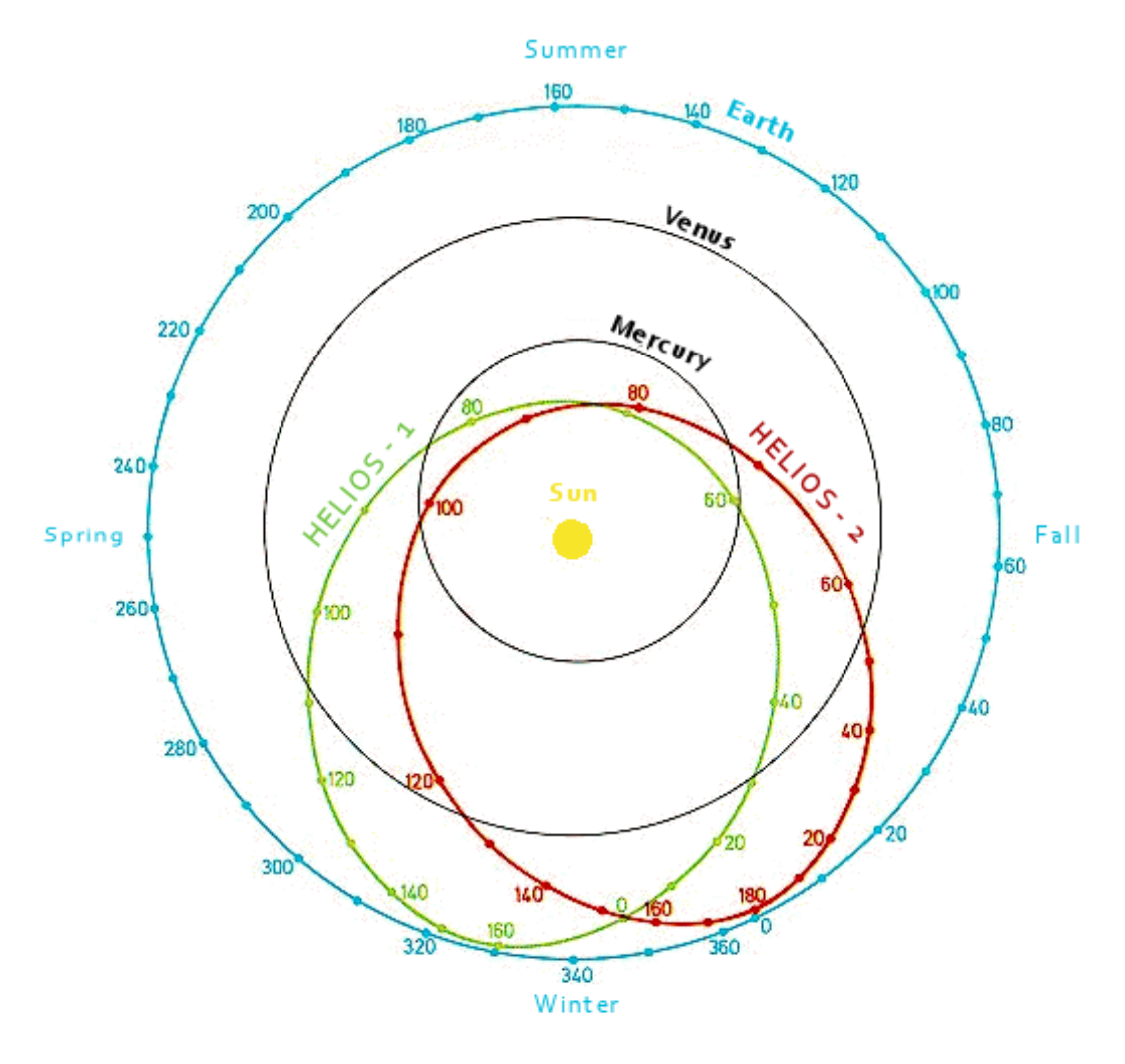
celestial mechanics	E11	Kundt
Faraday rotation and wave prop.	E12,E13	Volland , Edenhofer

Helios mission(cont'd)

Orbits



Helios mission(cont‘d)

- Orbital Information

	Helios 1	Helios 2
launch date	December 10 , 1974	January 15 , 1976
perihelion distance	0.309 AU	0.290 AU
orbital period	190.15 d	185.8 d

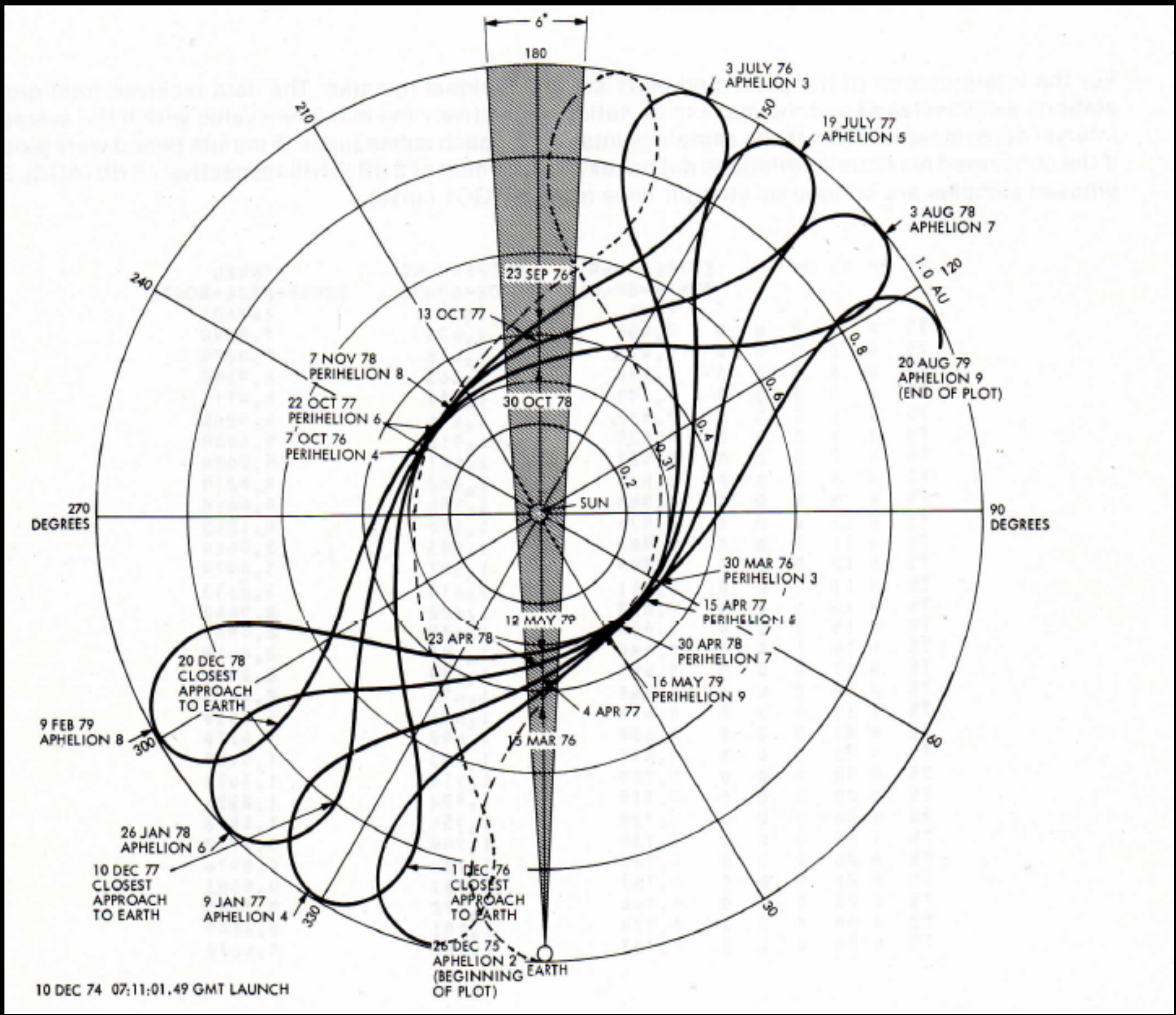
both orbits in the ecliptic

heliographic latitude between -7° 25‘ and + 7° 25‘

primary mission: first 120 days each

Helios-2: Fastest ever spacecraft with respect to sun:70.2 km/s

Helios mission(cont'd)
Helios 1 orbits in Sun-Earth system



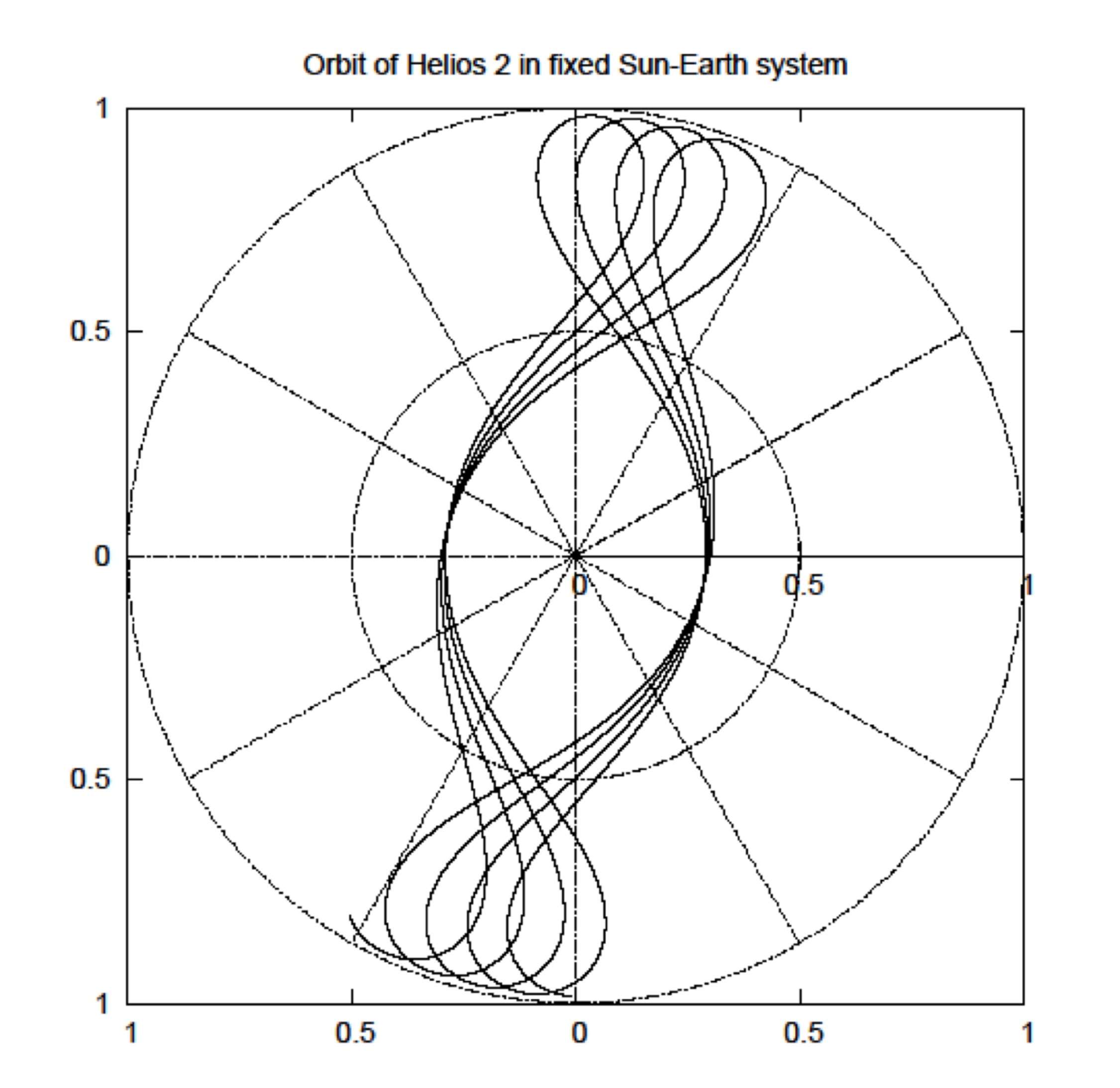
Orbit presentation in fixed Sun-Earth system

1. Telemetry impossible cone

2. Solar-terrestrial relationships

Helios mission(cont'd)

Helios 2 orbits in Sun-Earth system



Note less orbit rotation

because of orbital period

closer to ½ Earth year

Helios mission(cont‘d)

Spacecraft

•“Reel of thread“-shape

height:2.12 m diameter: 2.77 m

• Mantles of cones covered by solar cells

• Three antennas:

Important for science data:

high gain antenna with despun

reflector (60 rpm)

•Two magnetometer booms

• Electric field antennas 32m end to end

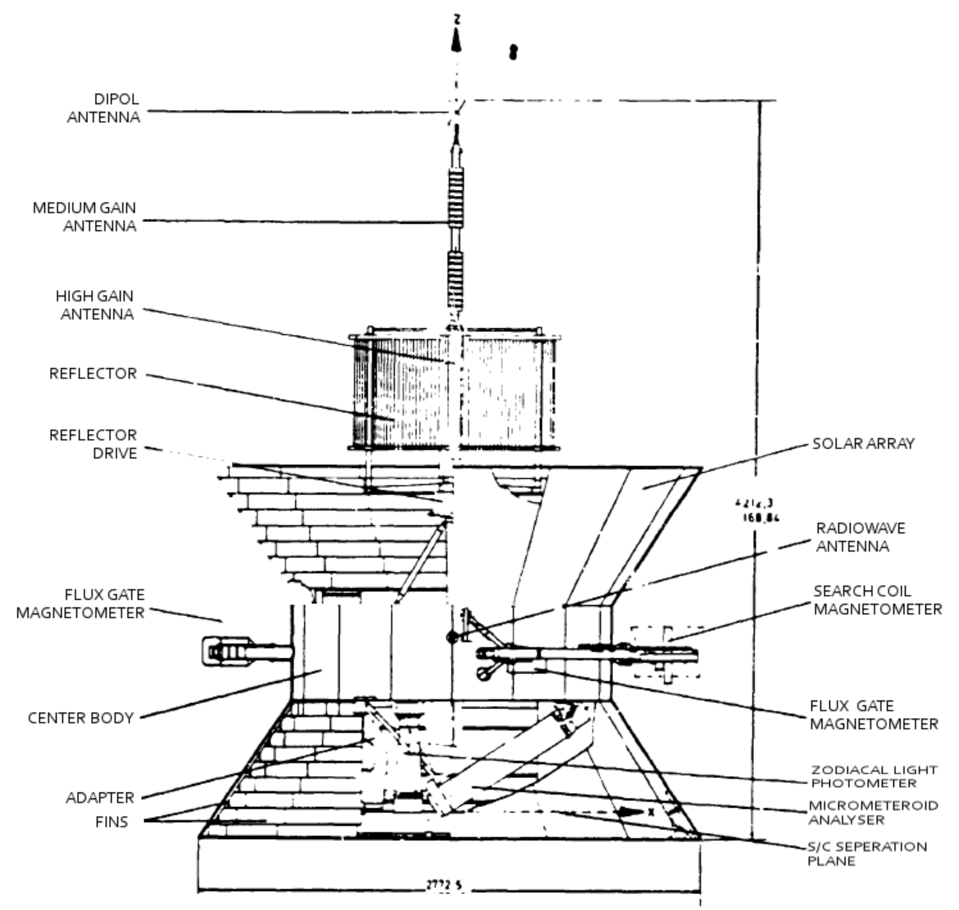


Figure 1 Spacecraft Launch Configuration

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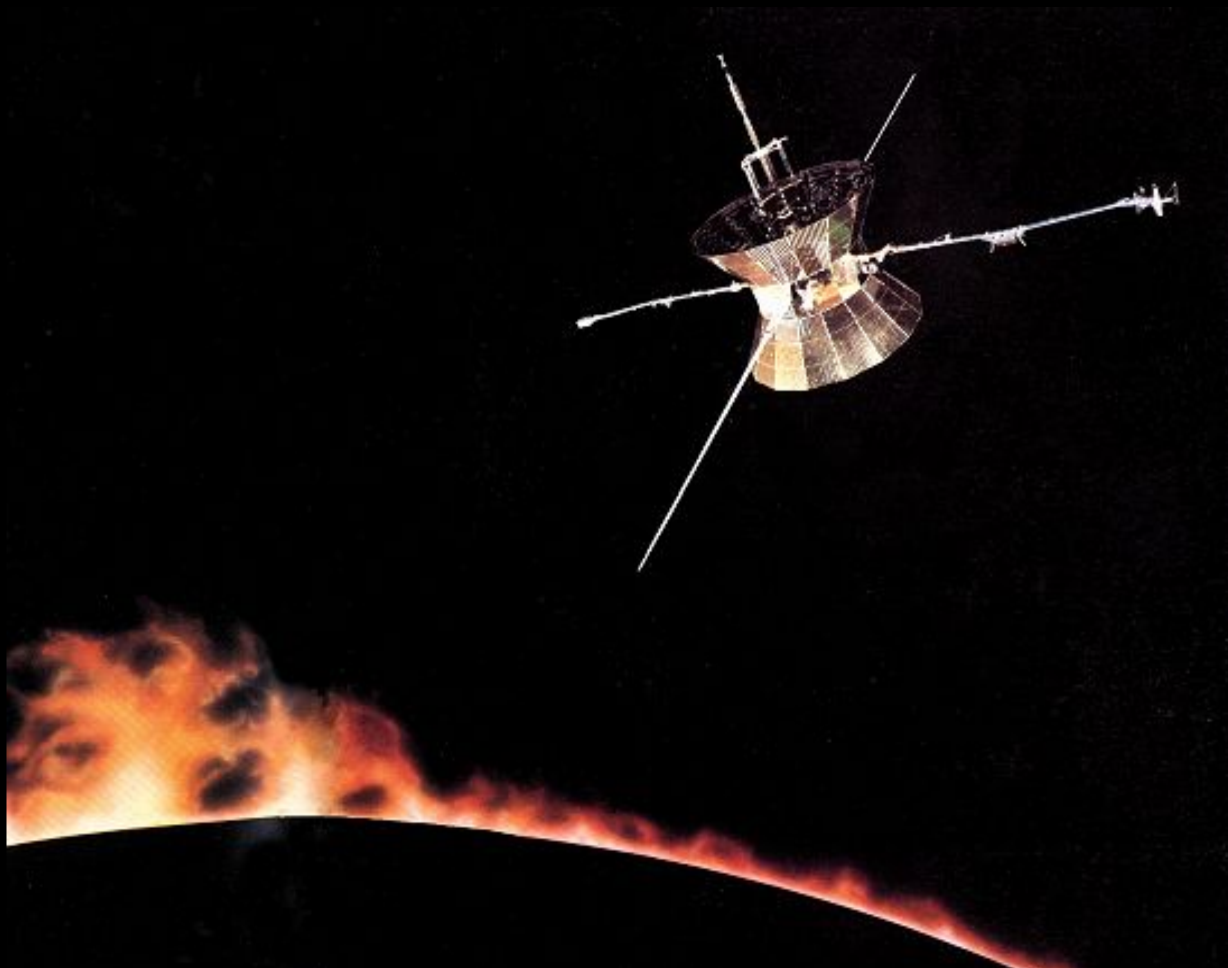
Helios mission(cont‘d)

Spacecraft characteristics

- Mass 370 kg
- Ten hardware experiments (E1 – E10)
- Nominal spin frequency 60 rpm
- Spin axis nominally perpendicular to ecliptic plane
- Two magnetometer booms 4.62 m each

Helios mission(cont‘d)

Artist‘s view of Helios with magnetometer booms and radio wave antennas



Helios mission(cont'd)

Thermal design

- Objective: To develop a system which guarantees all the time temperatures at given locations in the spacecraft in a safe temperature range

- Implementation:

  + Passive approach:

    SC shape, rotation

    control of insolation by second surface mirrors

    super insulation mats

  + Active approach:

    bi-metal spring activated louvers

    heating resistors at cold spots

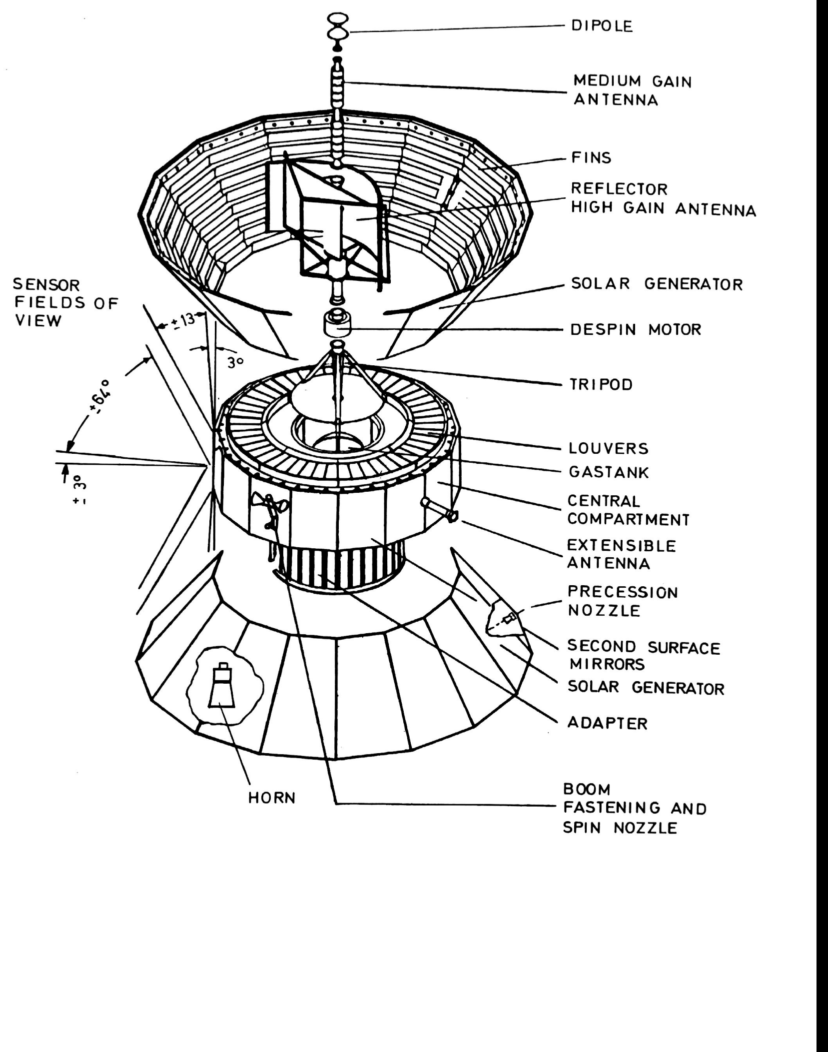


Figure 7.0-1: HELIOS S/C Configuration

Helios mission(cont‘d)

Thermal design(cont’d)

Performance of Helios thermal design:

Generally good results for central SC compartment, surfaces etc

Poor results for boom-mounted systems like sensor boxes of E2 and to a lesser extent E4 .

Thermal design was the project’s responsibility!

Helios mission(cont‘d)

Thermal design(cont’d)

Detailed thermal history

✓Far too hot for boom mounted Helios 1 systems particularly for E2 near perihelion.The thermal design was changed for Helios 2 by adding further super insulation mats leading to too low temperatures for boom mounted Helios 2 systems.

✓Because of deterioration of insulation mats maximum temperatures were increasing from perihelion to perihelion for both spacecraft.

✓Because of the deterioration of solar cells available power was decreasing as time progressed. Hence heating resistors for maintaining sufficiently high temperatures at aphelion had to be switched off leading to excessively low temperatures at aphelion: - 80° C !

Helios mission(cont‘d)

Thermal design(cont’d)

Consequences of thermal design problems:

- ✓ Severe negative effects on inflight calibration by partial loss of mechanical flipper mechanism on E2 !
- ✓ Hence for parts of the mission the magnetometer zero-offsets were affected in their accuracy (see E2 description!)!
- ✓ In later parts of the mission E4 noise levels were increasing from perihelion to perihelion

Helios mission(cont'd)

Magnetic cleanliness:

- For the magnetic field measurements in the interplanetary medium the largest error sources are the zero-offsets of the instrument sensors (E2) plus the SC disturbance fields due to SC currents and permanent and induced fields due to magnetic materials (E2 and E4). The SC disturbance fields are summarized under the topic "magnetic cleanliness".
- An effective magnetic cleanliness program was carried out on Helios. This consisted of establishing design rules to be followed in the design of SC and experiment electronics, its surveillance and control by accurate measurements in zero-field coil facilities supervised by the project.
- Finally the disturbance fields were greatly reduced by the boom mounting at large distances from the SC for Helios E2,E3 and E4

Helios mission(cont'd)

Telemetry system

- Six formats in SC data system: Format 1 - Format 6
- Ten total SC bitrates for real-time data transmission
  - ✓ 8 , 16 , 32 , 64 , 128 , 256 , 512 , 1024 , 2048,4096 bps
  - ✓ Memory modes: **SC 500kb magnetic core memory** was used for short but high time-solution shock mode events or filling of long gaps at very low time resolution
- Ground based antenna systems:
  - ✓ DSN stations: Goldstone, Canberra, Madrid
  - ✓ GSOC station Weilheim
  - ✓ MPI für Radioastronomie Effelsberg radiotelescope

Helios mission(cont'd)

Conclusions mainly from magnetometer's viewpoint:

- The Helios mission has provided in-situ measurements in the inner heliosphere down to 0.3 AU at heliographic latitudes of + - 7° 25', which are still unique today.
- Mariner 2 to Venus in 1962 suffered from huge SC magnetic disturbance fields , therefore hardly useful for Helios planning purposes in the late sixties!
- Mariner-Venus-Mercury 73 suffered from loss of ion plasma experiment but provided very useful magnetic field data.
- The recent Messenger mission to Mercury has provided very useful data during cruise to Mercury between 0.31 and 0.47 AU.
- Venus missions too far from sun (a=0.723 AU)

Helios mission(cont‘d)

Conclusions (cont’d)

- Technically, the mission has been mostly successful except for thermal problems with the boom mounted systems, deployment of E5 antennas etc.
- Scientifically ,it has been very successful!
- It provides a good starting point for future missions like SO and SPPlus.