DOCUMENT

ARTEMIS Announcement of Opportunity

European Space Agency
Agence spatiale européenne

APPROVAL

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Table of contents:

1 ACRONYMS

AMCF	ARTEMIS Mission Control Facility
AO	Announcement of Opportunity.
AOCC	ARTEMIS Operations Control Centre
ARTEMIS	Advanced Data Relay and Technology Mission
ASCII	American Standard Code for Information Interchange
ATV	Automated Transfer Vehicle
AVP	ARTEMIS Availability Plan
BAFO	Best and Final Offer
CMS	Control and Monitoring System
CET	Central Earth Terminal
CNES	Centre National d'Etudes Spatiales
COS	Combined Operations Schedule
DAP	ARTEMIS Detailed Assignment Plan
DRS	Data Relay Satellite
DRTM	Data Relay and Technology Mission
DSR	Detailed Service Request
DTS	Detailed Telecommand Schedule
EC	European Commission
EGNOS	European Geostationary Navigation Overlay Service
ESRIN	European Space Research Institute
ESSP	Earth System Science Partnership
FD	Flight Dynamics
FES	Fixed Earth Station
GEO	Geostationary Earth Orbit
GHz	GigaHertz
GTO	Geosyncronous Transfer Orbit
HEX	Hexadecimal
ICD	Interface Control Document
ICS	Interface de Communication Standard
IOL	Inter-Orbit Link
IOT	In-Orbit Test
IOTE	In-Orbit Test and Experimentation
IP	Inter-Pass
ISS	International Space Station
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
LEO	Low Earth Orbit
LLM	L band Land Mobile
MIB	MCF Information Base
MP	Master Plan
MPS	Mission Planning System
MUT	Mobile User Terminal
MVM	Microvibration Monitor

OBT	On-Board Time
ODR	Optical Data Relay
OGS	Optical Ground Station
OPALE	Optical Payload for ARTEMIS Link Experiment (GEO Passenger)
ORB	Orbit Prediction Messages
ORM	Operators Review Meeting
OSM	Operations Status/Scheduling Message
OUP	Outline Utilisation Plan
PFOS	Platform Operations Schedule
PLOS	Payload Operations Schedule
PO	Programme Office
PTL	Payload Test Laboratory
SCC	Satellite Control Center
SDM	Service Data Message
SILEX	Semiconductor Laser Inter-orbit Link Experiment
SIR	Service Incident Report
SKDR	S-Band/Ka-Band Data Relay
SLA	Service Level Agreement
SR	Elementary Services Request
STDM	Spacecraft Trajectory Data Message
TBC	To Be Confirmed
TBD	To Be Defined
TC	Telecommand
TDRSS	Tracking and Data Relay Satellite System
TM	Telemetry
TMS	Test and Monitoring Stations
TTC	Telemetry, Tracking and Command
UCI	User Communication Interface
UCO	User Coordination Offices
UET	User Earth Terminal
USCC	User Spacecraft Control Centre
USC	User Spacecraft
USP	User Service Profile
UST	User Space Terminal
USV	Unmanned Space Vehicle
UTC	Universal Time Coordinated

2 REFERENCE DOCUMENTATION

No reference documentation

3 BACKGROUND

ARTEMIS has successfully completed more than 10 years in orbit, since its launch in July 2001.

All the on-board payloads have operated with level of performances that exceeded the initial design goals. Some of the technologies on board, and in particular the electric propulsion, have also proved fundamental to rescue the satellite after the launch failure and to allow the completion of the mission.

Since July 2011, the ARTEMIS mission has been extended beyond its design lifetime on a "best effort" basis in the attempt to satisfy the operational needs of the users until March 2013. A mission completion plan has been presented to ESA Council including the plan for the ramp down of operations, the de-orbiting of the Satellite and the end of the programme. Before proceeding to the execution of the mission completion plan, ESA issues this Announcement of Opportunity aimed at European Satellite Operators for taking full ownership of the ARTEMIS satellite, assuming full liability for the operations of the satellite as well as benefiting from the rights and obligations of the corresponding satellite ITU frequency filings.

4 INTRODUCTION

This document presents the ESA ARTEMIS Announcement of Opportunity including:

- Description of the opportunity
- Conditions of the ESA ARTEMIS Announcement of Opportunity
- Selection process
- Evaluation Criteria
- Proposal guidelines

Four annexes provide the Bidders information regarding:

- Appendix A: Template for Notice of intent.
- Appendix B: ARTEMIS Technical description
- Appendix C: ARTEMIS Operation description
- Appendix D: ARTEMIS frequency filings

5 DESCRIPTION OF THE OPPORTUNITY

5.1 Main principles of the opportunity

This Announcement provides an opportunity for a European Operator to obtain the full ownership of the ARTEMIS satellite as well as the rights and obligations associated to the corresponding ITU frequency filing. In return the Operator shall offer a concrete plan that will support/generate activities benefiting the European Space Telecom Industry. These activities do not have to be directly related to the exploitation of the ARTEMIS satellite. It is therefore left to the Bidding Operators to define and propose the nature of these activities. The Operator shall also become solely responsible for the operations and the de-orbiting of the ARTEMIS satellite at its end of life. The Operator shall assume full responsibility for liabilities arising from the operation of ARTEMIS.

This Announcement describes the conditions for the transfer (in section 6) and the selection process for the Operator (in section 7). The final decision on the transfer of ownership of the ARTEMIS satellite is subject to ESA Council agreement.

5.2 ARTEMIS mission description

The long list of ARTEMIS mission achievements starts on 12 July 2001, after the separation from Ariane 5 in an orbit that was half way from the target GTO. Since then, ARTEMIS has managed to claim an outstanding number of world premières and mission goals.

The orbit recovery was realised through the combination of the first major reprogramming of a telecommunications satellite in orbit and the first orbital transfer to geostationary orbit using electrical propulsion.

The ARTEMIS satellite design lifetime was 10 years and the mission has been declared completed on April 2012. Since then ARTEMIS is operated on the best effort basis under request of its institutional users.

5.2.1 SILEX mission

The ARTEMIS part of the Silex, the OPALE, has performed well during the entire mission. In conjunction with its LEO counterpart embarked on SPOT-4, the first optical inter-satellite link was performed in December 2001, while ARTEMIS was still en-route to its final GEO slot.

The optical inter-satellite link with SPOT-4 was operated at the rate of 1 session per day, until January 2008, when the service had to be suspended due to an unrecoverable failure on the PASTEL terminal on-board SPOT-4. In total 1789 communication sessions were successfully completed for a total of 378 cumulated hours of transmissions with a success rate in excess of 96%.

The OPALE terminal has also been successfully utilised for experimental data transmission with the JAXA satellite Kirari. The experimental phase lasted 12 months, between December 2005 and 2006. During this period 108 optical links were successfully completed for an overall duration of 24 hours and a success rate above 98%. The optical terminal embarked on Kirari had been developed by JAXA on the base of ICD information exchanged between the two agencies.

More results in the optical data relay domain were realised between 2006 and 2007 when ARTEMIS established successful bi-directional links with an airplane flying over the southern coast of France with a remarkable reliability.

During the mission, the OPALE terminal has also been used for experiments with Optical ground Stations in Tenerife and in Kiev. These latter tests confirmed that the terminal is still in good health.

5.2.2 SK Data Relay mission

5.2.2.1 Ka-band mission

The Ka-band mission has progressively grown over the ARTEMIS operational life to become a crucial pillar in the ENVISAT operational set-up. From the first image transferred in June 2003, ENVISAT then utilised 14 to 15 links a day (one 100 Mbit/sec and one 50 Mbit/sec channel) for a total of approximately 7 hours of transmission per day. In total almost 2/3 of the 217 GB of data that ENVISAT sends back to Earth every day was relayed through ARTEMIS.
In total, since April 2003, the ENVISAT Ka-band data relay mission has cumulated over 20'240 hours of transmission with a success rate of more than 99%.

The Ka-band mission was also successfully tested with the JAXA satellite ADEOS.

After the end of ENVISAT mission in April 2012, the Ka-band facilities are used only for testing purposes.

5.2.2.2 S-band mission

The S-band mission has been used in an operational scenario in conjunction with the Automated Transfer vehicle (ATV) mission to the International Space Station.

The typical service configuration for ATV is two telemetry channels (at 8 and 64 kbps) and one telecommand channel (at 1 kbps) during the various phases of the mission. ARTEMIS S-band data relay service is hot back-up to the TDRSS during the rendez-vous phase and becomes primary service during the docked phase to the ISS. ATV and ENVISAT operations were interleaved and, due to the different geometry of the orbits on ENVISAT and ATV, require an uninterrupted activity of the SKDR tracking antennae on board ARTEMIS.

Three full ATV missions were supported (Jules Vernes and Johannes Kepler) in 2009 and 2011 respectively for an aggregate duration of 11 months. In total over 2000 hours of communications have been completed, with a success rate of 99%. Support to ATV 3 (Edoardo Amaldi) was provided from March till September 2012.

Two additional ATV missions (ATV 4 and 5) could also be supported through ARTEMIS respectively in 2013 and 2014 should the selected Bidder choose to include this service into its answer to this AO.

In 2007 ARTEMIS also demonstrated successfully bidirectional links in S-band with the Unmanned Space Vehicle (USV), an unmanned drone dropped from an altitude of 21 Km off the eastern coast of Sardinia. For both missions (USV-1 and USV-2) telemetries and telecommands were exchanged with the drone body mounted omnidirectional antennae during the free fall at speeds in excess of Mach 1.

Experiments of S-band data relay have also been performed successfully during both JAXA mission, Kirari (OICETS) and ADEOS II.

5.2.3 Navigation mission

The NAV payload has been used in the context of EGNOS space segment based on two GEO satellites in Operation and on one GEO satellite in TEST configuration.

From 2003 to 2005 ARTEMIS was used by Industry for system qualification testing, together with Inmarsat's 3F2 and 3F5. In 2005 ARTEMIS entered the initial operations phase in the TEST configuration, shared between Industry and ESSP for operations qualification and training. At that time Inmarsat 3F2 & 3F5 provided the operational signal.

In February 2009 ARTEMIS entered the Operational configuration in replacement of Inmarsat-3F5. Since then, it broadcasts 24x7 the EGNOS Signal-in-Space on PRN124. As such the NAV payload has played an essential role for EGNOS to deploy its services:

- October 2009: Open Service declared by EC
- March 2nd, 2011: Safety-of-Life Service declared by EC.

EGNOS reconfigured the space segment and utilise ARTEMIS in TEST mode in Q2/2012. In this function the NAV payload is used to achieve the qualification of the EGNOS System release V2.3.2. EGNOS will utilise ARTEMIS until 31/12/2013 should the selected Bidder decide to include this service into its answer to this AO.

The NAV payload has operated reliably during the above period with an overall availability figure of 99.92%. The outages were due to the well-known spurious events that randomly affect the ARTEMIS platform services.

5.2.4 LLM Mission

With an L-band mission on-board, ARTEMIS has access to an L-band allocation of 2. 1 MHz obtained through the coordination with the other L-band operators.

Telespazio is the largest L-band capacity user on ARTEMIS via a direct contract with ESA. Telespazio uplink their L-band traffic from their Ground Station in Lario (Como, Italy).

The LLM services have been continuously available to the Users with the exceptions of a limited number of short outages related to ARTEMIS spurious events that affect the availability of the satellite platform services. The overall service availability figure is 99.89% over the period April 2003-December 2011.

The contractual rights and obligations arising from the agreement between ESA and Telespazio will expire at the latest when the selected Operator takes over the full responsibility of ARTEMIS operations. Bidders envisaging to continue with the provision of the L band capacity to Telespazio are invited to negotiate the terms and conditions for such provision directly with Telespazio.

5.3 ARTEMIS ITU filings

The ARTEMIS ITU filing for the orbital position 21.5 E is composed of 3 separate filings:

- ARTEMIS-21.5E-DR (AR11/C/2507), covering the Data Relay functions and the TT&C
- ARTEMIS-21.5E-LM (AR11/C/2512), covering the L-band mobile function
- ARTEMIS-21.5E-NAV (AR11/C/3688), covering the EGNOS navigation function

These filings were generated in the mid-90’s for the Artemis launch in 2001.

The details of these filings can be found in the ITU database. Appendix D simply summarizes their main characteristics, to allow the Bidders to make a first-level assessment of the potential interest of reusing the filing for a future satellite in the same orbital position. The full details of the ARTEMIS filings can be found in the ITU SNS database.

Some bi-lateral coordination agreements further restricted the use of the frequencies indicated in the filing. The details of those constraints will be provided to the Bidders having indicated their interest according to section 7.1.1.

The L- band allowed usage (assignment) for ARTEMIS allocation is subject to revision on an annual basis at the Operators Review Meeting (ORM) to reflect the actual and forecasted utilisation needs of the different operators. The current ARTEMIS assignment for 2013 is 1.984 MHz.

6 CONDITIONS OF THE ESA ARTEMIS ANNOUNCEMENT OF OPPORTUNITY

6.1 Transfer of ownership of ARTEMIS asset

The ownership of the satellite as detailed in Appendix B will be transferred to the selected operator upon approval by the ESA Member States represented in the ESA Council. ESA cannot guarantee the outcome of this process and declines, as a result, any responsibility arising from the pre-contractual stage.
The ownership of the ground segment will not be transferred to the selected operator.

6.2 Transfer of rights and obligation of the corresponding ITU filings

The right of use of the frequency filings detailed in section 5.3, which is ancillary to ARTEMIS satellite, will be transferred to the selected Operator.

Subject to the approval by the regulatory authorities of the ESA Member States, the selected Operator is responsible for undertaking all the necessary steps with the national administration of his choice in order to register the filing in ITU.

The filing for the ARTEMIS satellite is administered by France and it is registered in the name of “FR-ESA”. Given that ESA is not a member of the ITU, the national frequencies authorities of the ESA Member States will be requested to give their consent to amend the filings from ESA to merely one ESA Member State that will become the filing authority for ARTEMIS once the transfer of ownership takes place. The Council will record this consent that will have to be previously communicated by the ESA delegations.

6.3 ARTEMIS operation

Upon the transfer of ownership of the ARTEMIS satellite, the satellite operations are under the responsibility of the selected Operator. The Operator is free to choose the means to undertake this task.

Currently, ARTEMIS is operated using the facilities at the Satellite Control Centre and Mission Control Centre in Fucino and Redu respectively. Appendix C describes the ARTEMIS operational set-up.

At present, ESA has a contract each with TAS-I (subcontractor Telespazio) and with RSS for the provision of ARTEMIS operations. ESA will organise in February 2013 (on a date to be announced in January 2013) visits both to Fucino and Redu to allow the Bidders (having provided the Notice of Intent) to evaluate the ARTEMIS operational environment.

ESA is taking all the necessary steps to close those contracts upon the transfer of ownership of the ARTEMIS satellite. Nevertheless, Bidders may, at their discretion, enter into negotiations with the incumbent contractors in order to continue ARTEMIS operations and/or to ensure a smooth transition of the ARTEMIS satellite, to familiarise themselves with the particularities and technical features of the ARTEMIS satellite and its operation as well as to avoid any undesired interruption in the provision of the technical services necessary for operating the ARTEMIS satellite.

6.4 ARTEMIS de-orbiting

The ARTEMIS satellite shall be de-orbited at the end of its usage. Upon the transfer of ownership, ARTEMIS de-orbiting is under the full responsibility of the selected Operator.

6.5 Expected benefit for ESA from this AO

ESA is expecting the Bidder to provide an activity plan that will benefit the European Space Telecom Industry. The nature of these activities is left for the Bidder to define. A list of possible schemes is provided here as examples. This list is only indicative and it is not exhaustive:

- Commitment from the Bidder to support European industry to introduce innovation in their operational environment.
- Commitment for the Utilisation of ARTEMIS satellite for experimental/proof of concept purposes:
    - Optical communications space to space / space to ground
    - UAV link,
    - Aeronautical Services,
    - Inter-satellite links,
    - M2M services,
    - Interference mitigation,
    - Etc.
- Committed embarkation and use of identified European innovative Telecom technologies on board future Satellites of the Bidder,
- Committed free of charge satellite real estate for future ESA proposed hosted payload opportunities on board future Satellites of the Bidder,
- Commitment for the re-use (not necessarily related to ARTEMIS operation) of the ARTEMIS ground segment, including ARTEMIS IOT facilities in Ku and Ka-bands, in ESA Redu Centre and/or Fucino.

In addition to this, ESA considers ARTEMIS as the current baseline for the provision of ATV-4 and ATV-5 services. Therefore, the Bidding Operator may decide to provide an offer for the provision of those services.

The same principle as explained for the ATV services applies for the provision of EGNOS test services till 31/12/2013.

The benefits offered to ESA in exchange for the transfer of ownership do not need to take the form of a monetary compensation. However this is not excluded and such compensation could be considered as part of the benefits for ESA.

6.6 Contractual conditions

This section highlights the main legal and contractual principles and requirements related to the intended transfer of ownership of the ARTEMIS satellite and the associated regulatory filings, which shall form part of the contract to be concluded between ESA and the selected Operator.

- The operator to be selected as a result of the present AO shall become the owner of the ARTEMIS satellite as described in Appendix B.
- Property and risk of the ARTEMIS satellite shall pass to the selected Operator upon signature of the contract with ESA resulting from this Announcement of Opportunity. At the same time, possession of the ARTEMIS satellite shall be deemed to have passed to the selected Operator.
- The Agency transfers the ARTEMIS satellite in the condition "as is"; no representations, warranties or guarantees shall apply to its technical condition, performance or fitness for any particular purpose. The Agency shall not be liable for any latent defects that may emerge post-transfer due to the continued degradation of the technical condition of the ARTEMIS satellite, nor for any direct, indirect, incidental or consequential damage such as but not limited to loss of data, profit, frequency filings and business interruption.
- The selected Operator shall be liable to pay any compensation for damage caused by the ARTEMIS satellite on the surface of the Earth or to aircraft, and for damage due to its faults in space. This will also cover the payment of any damages and involvement of ESA in any proceedings in the latter's capacity of a launching state according to the UN Outer Space Treaty and the Liability Convention.
- The Agency does not intend to transfer the property of any equipment of the ARTEMIS ground segment as described in Appendix C or to put such equipment at the disposal of the selected operator in any other way. It is the selected operator's responsibility to carry out on his own or to procure the satellite operation services currently provided through the ARTEMIS ground segment (see also section 6.3 of the present document).
- The selected Operator shall be responsible for the safe de-orbiting of the ARTEMIS satellite and bear all costs related to the de-orbiting.
- The specific undertakings of the selected Operator (see 6.5) shall also be laid down in this contract.
- The selected Operator may make a proposal for the provisions of data relay services for ATV 4 and 5 and EGNOS. In this case, the commercial, financial and legal conditions under which such services would be provided shall be defined.

- The orbital slot associated to the ARTEMIS satellite, which is currently registered as "F/ESA" and administered by France, will have to be re-registered with the national administration chosen by the selected operator. The selected Operator is responsible for undertaking all the necessary steps with the national administration of his choice in order to register the filing in ITU. The Agency shall not be responsible for obtaining the support of any national frequency administration and shall not be obliged to support the selected operator in its negotiations or proceedings with national frequency administration(s). This is the exclusive responsibility of the selected Operator.

- The selected Operator will also be responsible for taking all necessary steps required by the applicable national administrations of those jurisdictions to which the ARTEMIS satellite may provide coverage, as may be necessary or appropriate to secure and maintain its rights to utilize the orbital slot. In this respect all required activities related to frequency licensing and coordination with other national administrations and satellite Operators for frequencies shall be performed by the selected operator according to the requirements of the applicable national legislation.

7 SELECTION PROCEDURE AND EVALUATION CRITERIA

7.1 Selection procedure

The selection procedure will follow the steps further described below.

Step 1: Notice of Intent
Step 2: Dialogue phase
Step 3: Proposal submission
Step 4: Final selection
Step 5: Contract signature

7.1.1 Step 1: Notice of Intent

Following the issuing of this Announcement of Opportunity, interested parties are requested to submit a Notice of Intent indicating their firm intention to submit a proposal and providing a first set of information as defined in the template provided in Appendix A. There will be no pre-selection done among the Bidders on the basis of content of the Notice of Intent. The completed Notice of Intent shall be submitted by e-mail to the address indicated in the cover letter.

Please note that further communications (provision of more detailed data, further questions, broadcast of general-interest Q&A and dedicated dialogue sessions) will only be done with Bidders having submitted a Notice of Intent duly signed by the deadline defined in section 7.2.

7.1.2 Step 2: Dialogue phase

Additional information regarding the services currently provided by ARTEMIS, the satellite operational status and the frequency filing coordination status will be provided to the Bidders with confirmed interest (by means of the Notice of Intent defined in Step 1) subject to the signature of a mutually agreed NDA.

It is recognised that some interactions with the Bidders may be required during the Bidding phase. ESA therefore offers support to Bidders in providing further clarifications (including needed information from TAS-I/Telespazio and RSS aimed at better shaping the Bidder's offer).

Questions shall be addressed via e-mail to the address stated in the cover letter. Questions will be collected during this period and will be answered on an individual basis as soon as possible. Dialogue sessions may be organised individually with each Bidder during this phase on the Bidder's request. However, the results of such dialogue sessions shall never be interpreted as changing the terms and conditions of the present Announcement of Opportunity.

Bidders may also contact TAS-I/Telespazio, currently in charge of the ARTEMIS SCC function, and perform the related due diligence. In that case, the outcome of this due diligence shall be presented as part of the proposal. ESA shall be informed of any discussion/meeting organised between the Bidder and TAS-I/Telespazio and shall be granted the right to attend.

The same approach applies with Redu Space Services RSS currently providing the ARTEMIS Mission Control Facility function.

7.1.3 Step 3: Proposal submission

By the defined deadline (see calendar in section 7.2) a full proposal will need to be submitted, with the content defined in section 8).

7.1.4 Step 4: Final selection

An evaluation of the submitted proposal will be done that may result in a down selection. Initial negotiations may be undertaken with one or several Bidders to allow them to propose a best and final offer at the end of this process. The criteria as defined in section 7.3 will be used to rank the proposals.

7.2 AO process schedule

The schedule associated to the AO is defined in the following table:

Step	Event	Date/duration
1	Notice of Intent	31st January 12h00 (CET)
2	Technical + Contractual dialogue	1st February to 14th March
3	Proposal submission	1st April
4	Final selection	30th May

Table 1: AO process schedule

7.3 Evaluation criteria

Through this Announcement of opportunity the Agency is looking to obtaining maximum benefits for the Agency and the European space telecom industry. For the final selection, the following evaluation criteria will be used:

1. Consortium experience in Satellite Operation and Service provision;
2. Credibility of the operation and deorbiting plans of the ARTEMIS satellite proposed to be executed by the Bidder after taking ownership of ARTEMIS;
3. Credibility and Benefits for ESA and European Space Telecom Industry of the Bidder plan of activities.
4. Compliance with contractual and legal conditions.

8 PROPOSAL GUIDELINES

8.1 General tender conditions

The proposal and all correspondence relating to it shall be in English.

The proposal shall specifically state a period of validity of 4 months from the closing date for the receipt of tenders.

Any document submitted in reply to the AO shall become the property of the Agency. The Agency will use commercially sensitive or proprietary information solely for the purpose of the evaluation of the proposal and the selection.

Expenses incurred in the preparation and dispatch of the proposal will not be reimbursed. This includes any expenses connected with the dialogue with TAS-I/Telespazio and/or RSS and to the visits organised by ESA to the SCC and MCC facilities.

The AO does not bind the Agency in any way to place a contract.

The Agency reserves the right to issue amendments to the AO.

Prior to submitting the proposal, the Bidder is requested to complete and send a Notice of Intent form no later than the date indicated in section 7.2. The template for this document is provided in Appendix A.

8.2 Proposal content

The Bidder shall include at least the following content (any additional relevant information deemed necessary by the Bidder may be included in its proposal). Some of those sections may not be relevant depending on the intended re-use of ARTEMIS proposed by the Bidder. In case a section is not considered to be relevant, the Bidder is invited to indicate so.

1. **Signed Cover Letter including:**

    - A summary of the intended use of the ARTEMIS satellite and frequency filing(s) and of the proposed activity plan benefiting the European Satellite Telecom Industry;
    - The name, telephone / fax number and e-mail address of the bidder's contact person to whom all communications relating to its proposal should be addressed;
    - The contact details of the persons responsible for technical and contractual matters;
    - The name and function of the legal representative that would sign the contract on behalf of the bidder;
    - The name of the author(s) of the proposal.

2. Detailed description of the intended operations of the ARTEMIS satellite including:
- Operational concept;
- Identification and description of the ground entities (companies and physical premises) involved and their respective functions;
  NB: the Bidder is invited to report the results of the due diligence with TAS-I and RSS and indicate if the operations of the ARTEMIS satellite will be continued with those entities or if the Bidder will take over this role by other means;
- Intended orbital relocation;
- Service(s) to be provided through the use of ARTEMIS satellite including types of services, frequency band used, coverage, etc.;
- Intended service duration;
- Satellite replacement strategy;
- De-orbiting plan.

3. Intended use of the ARTEMIS filings including:
- Identification of the Filing(s) to be re-used;
- Evidence from a selected National Frequency Administration agreeing to become the administrator of the relevant ARTEMIS filing.

4. Provision of ATV and EGNOS services proposal including (at Bidder's discretion):
- Operational concept;
- Service fees;
- ATV and EGNOS Service Level Agreement status of compliance.

5. Proposal for activities benefiting European Satellite Telecom Industry:
- The proposal should include concrete evidence of the execution of this plan.

6. Management and contractual proposal including:
- Industrial organisation (entities and their role);
- Relevant Background information on the entities involved (in particular for satellite operation and service provision).

7. Statement of compliance with the contractual conditions set forth in chapter 6.6 of the present AO.

APPENDIX A   NOTICE OF INTENT FORM

<u>SUMMARY PAGE</u>

Name of the Bidder company:

Contract manager name:

Mailing address:
Tel.:
Fax:
E-mail:

Technical manager name:

Mailing address:
Tel.:
Fax:
E-mail:

Statement of firm intention to submit a proposal signed by an authorised representative of the bidder.

Description of the intended use of the ARTEMIS satellite:

If this section is relevant, please include at least:
- a description of the service/utilisation of the ARTEMIS satellite;
- the expected duration of the use of ARTEMIS satellite;
- if orbital re-location is required, state to which location;

Description of the intended used of the ARTEMIS filings:

If this section is relevant please include at least:
- Which bands in the three filings are intended to be exploited;
- Whether a replacement satellite is planned;
- Which National Frequency Administration would be selected to become the administrator of the ARTEMIS filing(s);

Description of the planned activities benefiting European Space Telecom Industry:

Provide as much details as possible on the planned activities.

ATV/EGNOS services:

Indicate if the Bidder is considering providing ATV/EGNOS services.

Note: this document should be approximately 10 pages long.

APPENDIX B ARTEMIS TECHNICAL DESCRIPTION

At this stage of the AO, the information provided here below is also available in the public domain. More detailed technical information will be provided to the Bidders who have returned a completed and duly signed Notice of Intent (Appendix A).

Satellite

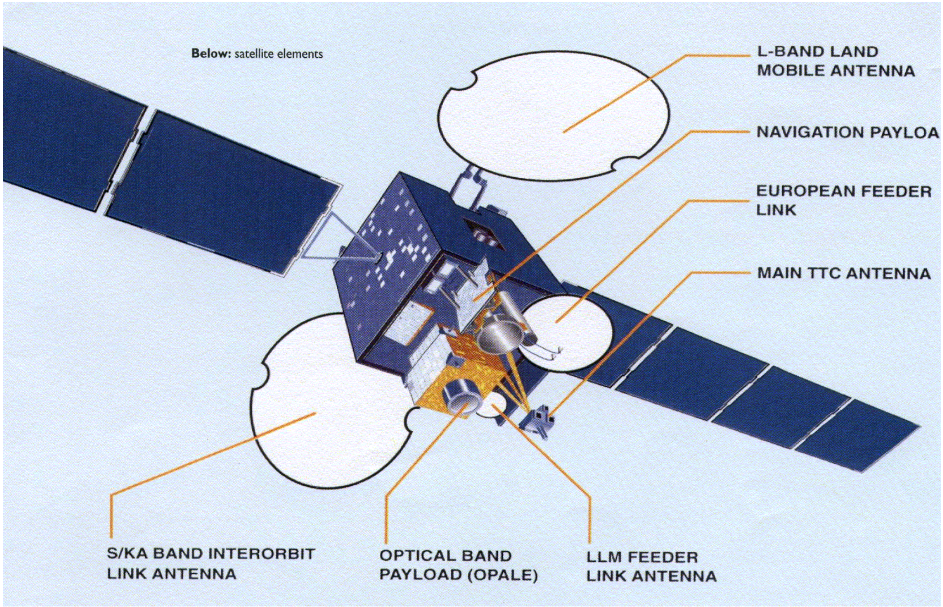


Figure 1: ARTEMIS satellite

The S/C structure consists of a box-shaped three-axis bus of Italsat heritage (Alenia Spazio bus family). The primary structure consists of the central cylinder (aluminum honeycomb skinned with carbon fiber), the main platform, the propulsion platform, and four shear panels. The secondary structure is made up of the N/S radiators, the E/W panels, and the Earth-facing panel. The central propulsion module houses the propellant tanks, LAE (Liquid Apogee Engine), the East panel with the L-band antenna feed, the West panel with the IOL (Inter Orbit Link) antenna. The two antenna reflectors (2.85 m diameter) for IOL support are dominant features of the S/C structure.

S/C attitude is measured by Earth/sun sensors and gyros. Reaction wheels serve as actuators. Thrusters of an RCS (Reaction Control System) are used for wheel off-loading. The UPS (Unified Propulsion System) employs a bi-propellant system of a single 400 N LAE for insertion into GEO. The propellants are stored in two Cassini-type 700 liter tanks. E/W positioning is maintained by a 10 N RCS (Reaction Control System) engine. N/S positioning is maintained by electric ion thrusters. The IPS (Ion Propulsion System) comprises two thruster assemblies, RIT (RF Ion Thruster) and EIT (Electro-bombardment

Ion Thruster). Each is powered and monitored separately, but a common propellant supply is used (40 kg of xenon), 600 W of input power is needed for operation..

S/C electric power of 2.8 kW (at equinox after ten years to a 42.5 VDC bus) is provided by two solar wings (span of 25 m). BSR (Back Surface Reflecting) solar cells are mounted on each of the two solar wings. Two NiH2 batteries provide energy of 60 Ah for eclipse protection. A S/C design life of 10 years is provided. The S/C launch mass is 3100 kg (550 kg payload, 1538 kg propellant).

At the platform level, ARTEMIS combines all the tasks classically associated with the data handling and attitude and orbit control subsystems into one subsystem, the ICDS (Integrated Control and Data System). The ICDS in turn is comprised of the following elements (all units have a redundancy):

- OBCU (On Board Computer Unit)
- IRES (InfraRed Earth Sensor)
- RIGA (Rate Integrating Gyro Assembly)
- PSSA (Precision Sun Sensor Assembly)
- MWA (Momentum Wheel Assembly)
- RU-A (Remote Unit A), RU-B (Remote Unit B)
- OBDH (On Board Data Handling) bus (ESA standard). The OBDH bus provides the communications media between the OBCU, and all platform and payload units.

The attitude and orbit control functions within ICDS make use of additional actuators which are not part of the ICDS, namely the RCS, the LAE, and the ion thrusters plus their alignment platform (ITAM).

Spacecraft Characteristics	
Mass at launch, power	3100 kg, 2.5 kW
S/C size: height, length, width	4.8 m, 25 m (solar array tip-to-tip), 8 m (antennas deployed)
Design life	10 years
Orbital position	21.5º E (GEO)
Communications: Data Relay Payload	
Coverage	Approximately 65% of orbits up to 1000 km altitude
Feeder/downlink coverage	Western Europe
Inter-orbit link (S-band 2 GHz)	Up to 1 Mbit/s in the forward direction (i.e. ARTEMIS to low altitude spacecraft). Up to 3 Mbit/s in the return direction (i.e. low altitude spacecraft to ARTEMIS)
Ka-band (23/26 GHz)	10 Mbit/s in the forward direction 3 x 150 Mbit/s in the return direction
Optical link (800 nm)	2 Mbit/s in the forward direction 50 Mbit/s in the return direction
LLM (L-band Land Mobile) Payload	
Coverage	Europe, North Africa & Middle East (one European beam and three spot beams)
Frequency bands	1.5 GHz (L-band) to/from mobiles 12/14 GHz (Ku-band) to/from fixed earth stations
Voice channels	Up to 662 bi-directional
Mobile terminal antenna	20 cm x 40 cm
Navigation Payload EGNOS	
Coverage	Global (specifically Europe)
Mass, power	25 kg, 110 W
Antenna	L-band to user: 45 cm diameter horn antenna
Frequency bands	Downlink: 1.575 GHz (L-band, L1 GPS) & 12.748 GHz (Ku-band) Uplink: 13.875 GHz (Ku-band)

Table 2: ARTEMIS satellite main characteristics

SILEX (Semiconductor Intersatellite Link Experiment) payload

SILEX is an ESA laser experiment built by MMS, France (now Astrium Satellites SAS). SILEX consists of two optical terminals, namely OPALE (Optical Payload for Intersatellite Link Experiment) located on ARTEMIS, and PASTEL (PAssager SPOT de Técommunication Laser) on-board SPOT-4. The objective is to beam data at rates of 50 Mbit/s (bit error rate of <10-6) from the transmitter terminal on SPOT-4 in LEO - to the receiver (OPALE) on ARTEMIS for subsequent relay via feeder link to the SPOT ground segment in Toulouse. The SILEX terminal on-board ARTEMIS is also being used to support a second LEO experiment, namely an IOL between ARTEMIS and OICETS (Optical Inter-orbit Communications Engineering Test Satellite) of NASDA.

PASTEL (Passager SPOT de Técommunication Laser). A joint ESA/CNES passenger demonstration experiment. PASTEL is a prototype high data-rate intersatellite transmission system based on laser technology. The objective is to transmit imaging data from SPOT-4 to ARTEMIS. The aim of the experiment is to validate the PASTEL concept design in an operational environment. PASTEL is a gimbal-mounted assembly consisting of a telescope, an optical bench with a fine pointing system, communication detectors with avalanche photodiodes, a thermal control system for precision temperature control, a two-axis gimbal mechanism, and the launch locking mechanisms needed during the launch phase. The telescope mirrors and main structural elements are made of Zerodur. The acquisition and tracking sensors use CCD detectors. The laser diodes are of the GaAlAs type. The SPOT-4 - ARTEMIS optical links operate at wavelengths of 830 nm. The peak output power is 160 mW (60 mW continuous operation), the beamwidth is 0.0004°. Data to be transmitted include: HRVIR image data, pseudo-noise (PN) code, PASTEL telemetry.

OPALE (Optical Payload for Intersatellite Link Experiment) terminal, mounted on the geostationary satellite ARTEMIS (a GEO terminal). The receiver employs Si-APD (Silicon Avalanche Photodiode) detectors and a low-noise trans-impedance amplifier of 1.5 nW useful receiver power.

SKDR Payload (S/Ka-band Data Relay)

The objective of the IOL antennas (2.85 m diameter) is to track a LEO user satellite via either loaded table values and/or error signals - and to receive up to 450 Mbit/s of data in the Ka-band, or up to 3 Mbit/s in S-band for relay via the feeder link to Earth (return link operation). Up to 10 Mbit/s in Ka-band and 300 kbit/s in S-band may be transmitted by ARTEMIS to the LEO satellite (forward link operation). In addition, ARTEMIS broadcasts a 23.540 GHz beacon to help the LEO satellite to track it.

A single Ka-band transponder (plus one backup) provides return/forward frequencies of 25.25 - 27.5/23.2 - 23.5 GHz links in Rx/Tx, adjustable EIRP (Effective Isotropic Radiated Power) of 45-61 dBW, G/T of 22.3 dB/K, up to 150 Mbit/s each of the three channels LEO to ARTEMIS (return link), and up to 10 Mbit/s from ARTEMIS to LEO (forward link). RH/LHCP on command.

One S-band transponder (plus one backup) provides return/forward frequencies of 2.200-2.290/2.025-2.110 GHz links in Rx/Tx, adjustable EIRP 25-45 dBW, G/T of 6.8 dB/K. The bandwidth is 15 MHz. Up to 3 Mbit/s of data can be transmitted in a single channel from LEO to ARTEMIS (return link), and up to 300 kbit/s can be transmitted from ARTEMIS to LEO (forward link). RH/LHCP on command.

Feeder link of SILEX and SKDR: Three transponders (plus one backup) act as ground-ARTEMIS links for SILEX and SKDR. The feeder Ka-band frequencies are: 27.5-30/18.1-20.2 GHz for Rx/Tx. The EIRP is 43 dBW, G/T of 0 dB/K, use of 234 MHz bandwidth, linear vertical polarization.

NAV Payload

The objective is to provide enhanced navigation performance in terms of accuracy and integrity (with the required levels of availability and continuity) over the ECAC (European Civil Aviation Conference) region. The ECAC coverage area is from 30° W to 45° E and from 25° N to 75° N.

The EGNOS payload on ARTEMIS uses the Ku-band in the uplink and downlink (for S/C - fixed user communication in the ground segment). The uplink frequency is allocated at 13.875 GHz, and separate from the LLM feeder link frequency, while the downlink of the navigation payload is shared with the LLM channels (12.748 GHz). The transmitted EGNOS wide-area service signal is the GPS L1 frequency at 1575.42 MHz (L-band).

The total mass of the navigation payload, including structure, thermal control hardware and the DC harness, is 25 kg. Its total power consumption is about 110 W.

Receive frequency	13.875 GHz (Ku-band)
Transmit frequencies	12.748 GHz (Ku-band), 1575.42 MHz (L-band)
Useful bandwidth	4 MHz
G/T [(receiver) Gain / (noise) Temperature]	>-2.3 dB/K
EIRP (Effective Isotropic Radiated Power)	>17 dBW for Ku-band; >27 dBW for L-band
Polarization	LP for Ku-band, RHCP for L-band
Frequency stability	$2x\ 10^{-12}$ (10s); 10^{-9} (24 h); 2×10^{-7} (life)

Table 3: ARTEMIS NAV payload sCharacteristics

LLM Payload

The objective of the communications payload is to permit two-way communications, via satellite, between fixed Earth stations and land mobiles, such as trucks, trains or cars, anywhere in Europe and North Africa. The LLM receives the signals transmitted by the fixed users in Ku-band (14.2 GHz) and transmits them at L-band (1550 MHz) to the mobile users (forward link). The return link establishes the connection from the mobile user at L-band (1650 MHz) to the S/C, and at Ku-band (12.75 GHz) from the S/C to the fixed user in the ground segment. About 400 bi-directional user links can be established simultaneously.

ARTEMIS carries two antennas of 2.85 m diameter and a multiple element feed for pan-European coverage and three European spot beams. Three 1 MHz plus three 4 MHz SSPA (Solid-State Power Amplifier) channels, provide 400 2-way circuits with an EIRP>19 dBW. The on-board L-band transmits to terminals (users) in the ground segment at 1550 MHz and receives data at 1650 MHz. A Ku-band feeder link at 14.2/12.75 GHz Rx/Tx transmits the data to the home stations. All channels are fully tunable and most commandable for LH/RHCP support.

Ground Segment

The ARTEMIS Programme element also included the development of the Ground Segment Infrastructure including both the Mission Control Centre (AMCF: ARTEMIS Mission Control Facility, in Redu) and the Satellite Control Centre in Fucino. More details is provided in the Appendix C

APPENDIX C ARTEMIS OPERATIONS DESCRIPTION

ARTEMIS operations in geostationary orbit are unconventional due to the need of preserving the feeder link coverage in the lack of North South station keeping. The harmonic bias compensation is therefore active for the vast majority (exceptionally disabled by spurious events) of the time and the satellite inclination has been growing steadily.

An overview, including all Users' interfaces for current and past missions, is provided in the following scheme.

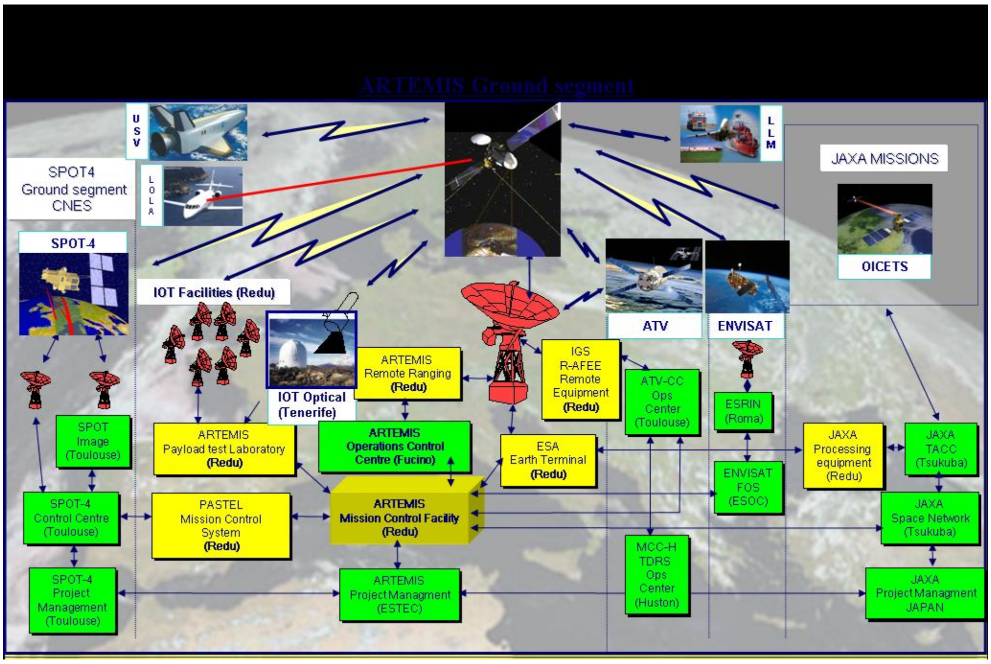


Figure 2: ARTEMIS user interface scheme

Hereafter the main capabilities of the Satellite Control Centre and of the Mission Control centre are listed.

ARTEMIS Satellite Control Centre (Fucino)

- Controls and monitors the ARTEMIS satellite operating through the Ka-band TTC station or the S-band back-up TTC station in Fucino.
- Responsible for the execution of all satellite operations.
- Responsible for all satellite operations needed to configure the payload according to the payload operation schedule received from the AMCF.
- AOCC is manned 24 hours per day continuously.
- No operational contact between the Users and the AOCC.

ARTEMIS mission control centre (Redu)

- Responsible for the detailed scheduling of ARTEMIS payload utilisation
- Interfacing with the ARTEMIS Control center in Fucino for payload configuration request.
- Receiving the service requests from the Users.
- Managing the conflicts between Users for service attribution.
- Interfacing with the Users for the day to day operations.
- Producing the planning products for the users as the Detailed Assignment Plan.
- Exchanging ancillary data such as orbit predictions with users.
- Managing emergency service requests
- Coordinating with users anomaly investigations and fault isolation.
- Manned 8 hours per day, 5 days per week during normal working periods, can be extended to meet the requirements of the users for critical operations.

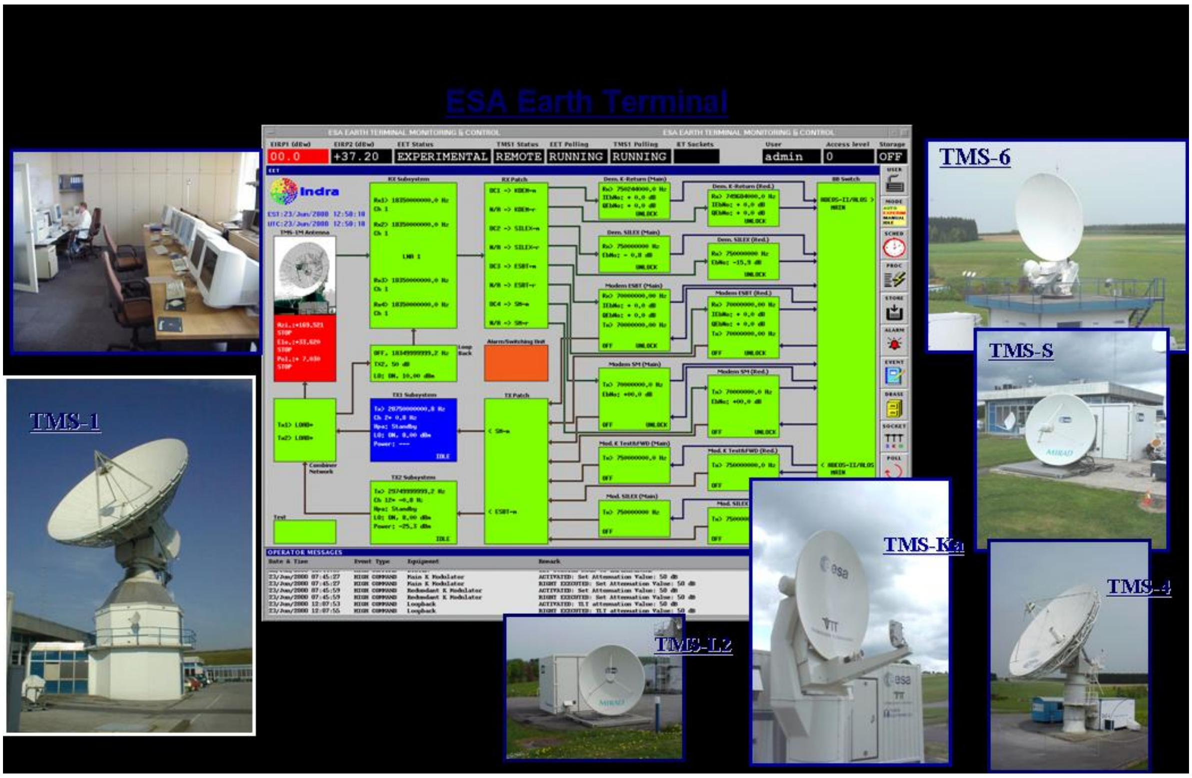


Figure 3: ARTEMIS MCC at Redu

Users interfaces

In case of anomaly, AMCF issues an Operations Status Message (OSM) and unavailability reports and provides statistics on the utilization of the payload.
AMCF manages also the database with the Users characteristics and the ARTEMIS payload configuration details for each user.
The TC for payload configurations are generated automatically at the AOCC based on the payload schedule received from AMCF generated once per week and divided by the AOCC in slice of 8 hours of on-board schedule.
ICD documents are produced for each User which includes the requirements for the mission management and operations of the ARTEMIS services.

ESA Earth Terminal and IOT facilities (Redu)

- Real time monitoring of the payload operations.
- Forward and return link data transmission and acquisition via a feeder station
- Satellite in orbit payload testing.
- Monitor in real time correct data transmission and receiving the ARTEMIS telemetry.
- Acting as a feeder link station with up to two forward channels and up to 4 simultaneous return channels.
- The In Orbit Tests facilities include several antennae operating in all data relay frequency bands simulating LEO satellite.

TMS1-M (RED-2)

Antenna

Figure 4:Redu 2 13.5m antenna (TMS-1M)

The Redu 2 (TMS-1M) is a 13.5m Ka-band full monition antenna and is part of the EET facility, which simultaneously supports Data relay and Ranging functions.

The antenna system has the following capabilities: -

- Provides two simultaneous channels data relay forward feeder link at 30 GHz converted from 750 or 70 MHz.
- Provides four simultaneous channels data relay return feeder link at 20 GHz converted to 750 or 70 MHz.
- Provide data relay test loop by means of a synthesised TLT in order to verify transmit and receive function of any single transmit and receive channel.
- Provide a receive and a transmit port (20 and 30 GHZ) respectively) interfacing to the RRT.
- Receive the satellite pilot and provide it to the EET.

The EET comprises the TMS-1M antenna system, the modems, fiber optic switch, the test equipment's (BER, Spectrum Analyser, Pilot Frequency Counter) EET Data Patch and the M&C computer.

Description

Tracking

The tracking subsystem is a monopulse type. The tracking chain is part of TMS-1M antenna system and is composed of the following items:

- A mode generator and combining network
- A low noise amplifier for the error signal
- Two dual channel tracking down converters
- A dual channel tracking receiver
- The antenna control unit
- The Az and El antenna servos

Transmit Chains

The TMS-1M transmit s/s has two complete chains (HPA+U/C) that can feed the antenna TX port simultaneously (frequency combined) or can be operated transmitting only one of them (with a EIRP 3.5dB higher than when combined).
Each HPA is a 100W TWTA with an internal SSPA. The associated U/C has incorporated a PIN attenuator to provide EIRP adjustment of at least 20dB from maximum and in steps lower than 1 dB.

Receive Chains

The TMS-1M and RRT have receiver chains with a common part (from the feed RX port up to the divider after the LNA) and an individual part (from the Ka band down converter input up to the IF port). These common elements are included in the TMS-1M
The 20GHz section comprises of the following elements (starting from the feed port): -

- A waveguide coupler to inject the receive chain the TLT output (either from TMS-1M or RRT).
- Two WG switches to select LNA1 or LNA2.
- Two LNA's with 1.5dB noise figure.
- A wave guide coupler to pick-up a sample of the received pilot signal in order to provide the sum signal to the auto-track s/s.
- Three rotary joints that allow the azimuth, elevation and polarisation movements of the rigid waveguide path to connect with the 2-way divider located in the first floor.

After that one 4-way divider provides two outputs for the RRT Down Converter as well as one SHF test output; the other 4-way divider drive the four Ka-band Down Converters of the TMS-1M.

Calibration

This subsystem contains two different parts: the TX power measurement arrangement and a test loop translator. The first is devoted to measure the EIRP of the transmitted carried and the second one to operate the station in a closed loop via the TLT (to verify any transmit/receive channel function of TMS-1M).

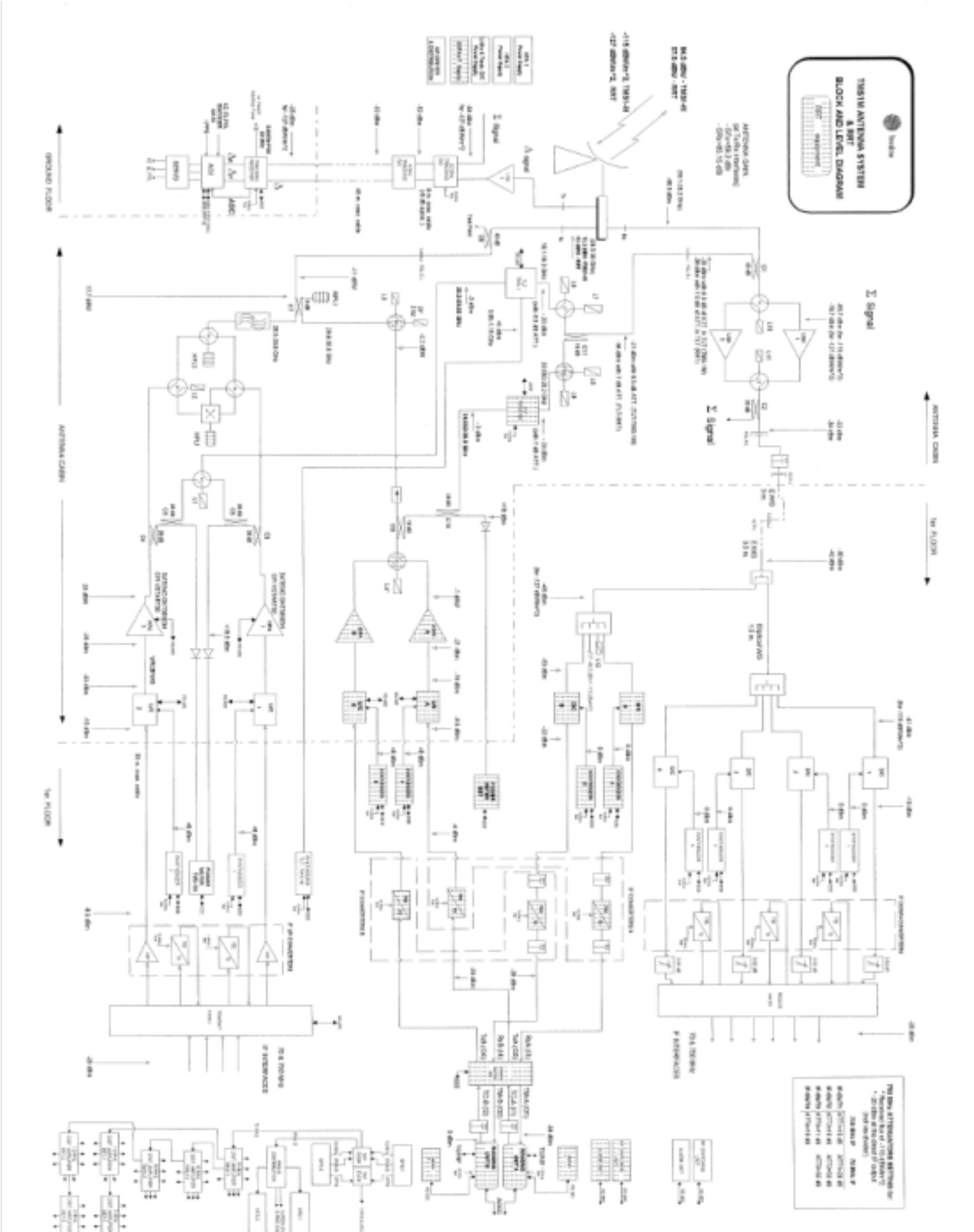


Figure 5 : Redu-2 Block Diagram (TMS-1M)

TMS-4

TMS-4 measures the performance of geostationary satellites in the 12 to 14 GHz band (Ku-Band), with the support of the 9.3 m antenna, which can transmit in dual linear polarisation and in two frequency bands (12.96 to 13.29 GHz and 13.96 to 14.30 GHz); in addition, it is able to receive the 12.46 to 12.79 GHz range, also in dual linear polarisation (X and Y). TMS-4 is remotely controlled from the Test Monitoring Room (TMR).

Antenna

Figure 6: TMS4 Antenna

TMS-4 has a Cassegrain 9.3m antenna with a 92cm sub-reflector. It has a gain at interface RX IOT point of 59.6 dBi at 12.75 GHz and of 61.7 dBi at interface TX IOT point at 14.5 GHz. The pointing range is 90°-270° in azimuth, 0°-90° in elevation and 360° in polarisation.
It has three pointing modes: Program track, slaved to TMS5 and slaved to TMS6.

Description

Each HPA can work in fixed gain mode (FGM) or in automatic level control mode (ALC). Some switches act as attenuators at the HPA's output to output a fairly high power from the HPA's in order to minimise their noise contribution when low EIRP is required for up-link to the satellite.

An HP-UX workstation is located in the antenna shelter. This computer controls and monitors all the station equipment via HP-IB buses or LAN.

Characteristics

Transmit:

- Transmit frequency bands:
  12.96-13.29 GHz and 13.96-14.3 in TX/RX mode, using up-converters.
  12.75-14.5 GHz in TX only mode, using SHF synthesisers.
- Number of simultaneous carriers:

two, one on each polarisation or both on one polarisation after high power combining.

- Maximum EIRP:

> 84 dBW each carrier
> 81 dBW when combined

- EIRP range: maximum to 80 dB down spread over 4 ranges involving two high power attenuators
- EIRP control: fast ALC loop or gain control
- EIRP accuracy: ± 0.5 dB
- TWTA output power: 500 W
- HPA intermodulation: 27 dBc at 10 dB output backoff
- HPA AM/PM conversion: 4°/dB at 500 Watts
- HPA noise density: -75dBW/4kHz
- Power measurement accuracy: ± 0.2 dB
- Power versus frequency:
  ± 0.2 dB/80 MHz in ALC mode
  ±1.25 dB/full band in gain mode
- IF frequency and bandwidth: 750 MHz ± 80 MHz when using up-converters
- Frequency stability: derived from HP8662 or R/S SMP SHF synthesiser (5.10-10/day)

Receive:

- Receive frequency band: 12.46-12.79 GHz in TX/RX mode only
- G/T (clear sky, 30° elevation): > 31.0 dB/K
- Flux measurement range: -115 dBW/m2 to –165 dBW/m2
- Flux measurement accuracy: ± 0.4 dB
- Pilot power accuracy: ± 0.3 dB
- Band flatness: ± 0.5 dB over 80 MHz
- Group delay overall: ± 3 nS over 80 MHz
- IF frequency and bandwidth: 750 MHz ± 80 MHz
- Frequency stability: derived from HP8662 synthesiser (5.10^{-10}/day)

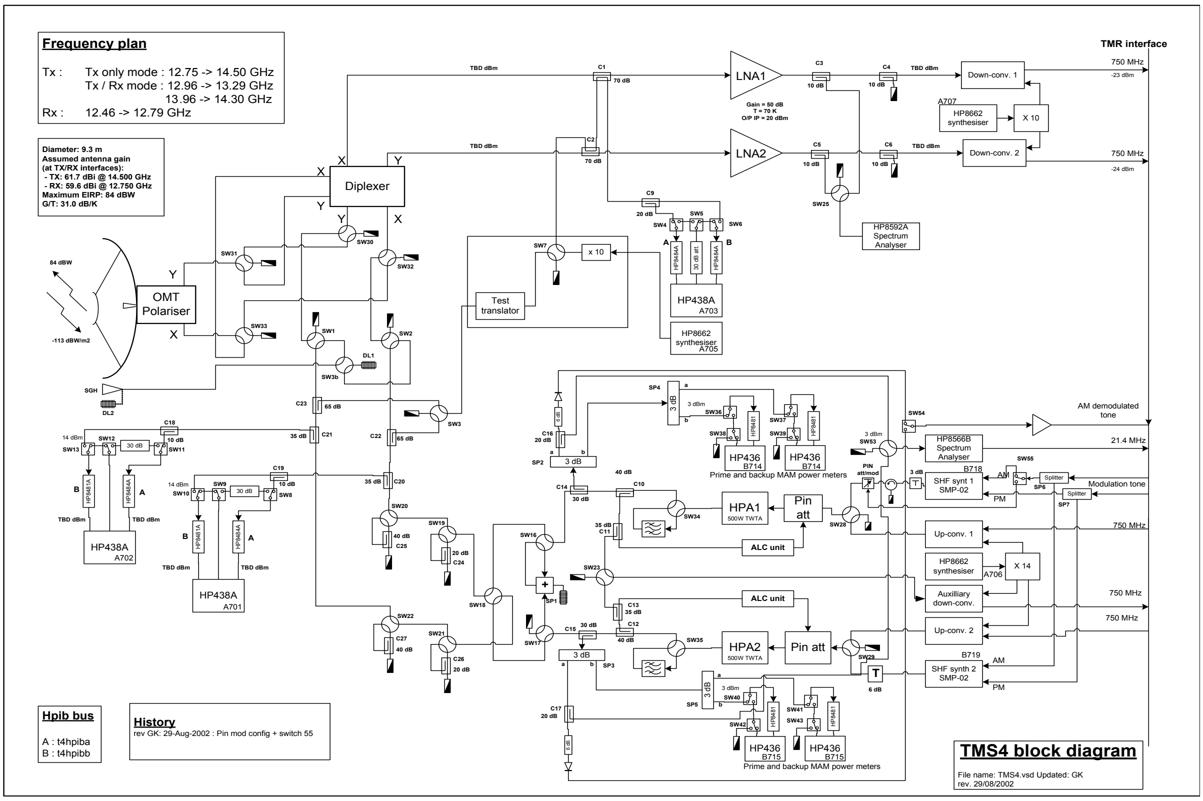


Figure 7 : TMS4 schema

TMS-5

The 9.3 m antenna can transmit in dual circular polarisation on six selectable channels with 80 MHz bandwidth, spread over the 17.3 to 18.1 GHz band; in addition it can receive in dual circular polarisation in the 11.7 to 12.5 GHz band.

Antenna

Figure 8 : TMS-5 antenna

TMS-5 has a Cassegrain 9.3m antenna with a 92cm sub-reflector. It has a gain at interface RX IOT point of 58.8 dBi at 12.75 GHz and of 61.3 dBi at interface TX IOT point at 17.5 GHz. The pointing range is 90°-270° in azimuth, 0°-88° in elevation and ±50° in polarisation.

Description

Each HPA can work in fixed gain mode (FGM) or in automatic level control mode (ALC). Some switches act as attenuators at the HPA's output to output a fairly high power from the HPA's in order to minimise their noise contribution when low EIRP is required for up-link to the satellite.
An HP-UX workstation is located in the antenna shelter. This computer controls and monitors all the station equipment via HP-IB buses or LAN.

Characteristics

Transmit:

- Transmit frequency bands:
  17.3-18.4 GHz (Linear Pol.)
  17.3-18.1 GHz (Circular Pol.)
- Number of simultaneous carriers: two, one on each polarisation or both on one polarisation after high power combining
- Maximum EIRP:
  > 82 dBW each carrier
  > 79 dBW when combined
- EIRP range: maximum to 80 dB down spread over 4 ranges involving two high power attenuators
- EIRP control: fast ALC loop or gain modes
- EIRP accuracy: ± 0.5 dB
- TWTA output power: 300 W
- HPA intermodulation: > 27 dBc at 30 Watts output
- Power measurement accuracy: ± 0.2 dB
- Power versus frequency:
  ± 0.2 dB/80 MHz in ALC mode
  ± 1.25 dB/full band in gain mode
- IF frequency and bandwidth: 750 MHz ± 80 MHz

Receive:

- Receive frequency band: 10.70-12.75 GHz
- G/T (clear sky, 30° elevation): > 34 dB/K
- Flux measurement range: -115 dBW/m2 to –165 dBW/m2
- Flux measurement accuracy: ± 0.4 dB
- Pilot power accuracy: ± 0.3 dB
- Band flatness: ± 0.5 dB over 80 MHz
- Group delay overall: ± 0.5 nS over 100 MHz
- IF frequency and bandwidth: 750 MHz ± 80 MHz

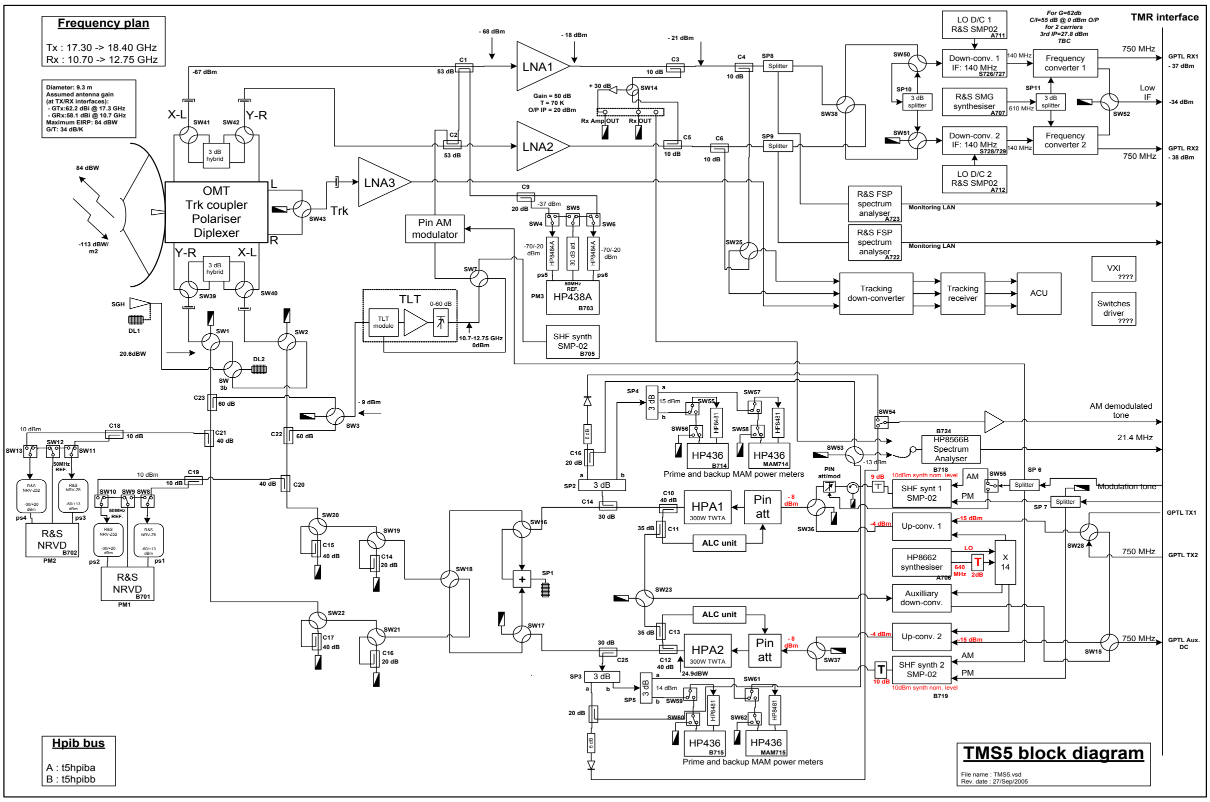


Figure 9 : TMS-5 schema

TMS-6

The TMS-6 test and monitoring antenna complements TMS-4 & 5, it has two transmit chains operating in the 27.5 to 30 GHz range, and three reception chains operating in the 18.1 to 20.2 GHz band.

Antenna

Figure 10: TMS-6 Antenna

TMS-6 has a Gregorian 4m antenna with a 1m sub-reflector. It has a gain at interface RX IOT point of 53.2 dBi at 18.1 GHz and of 59.5 dBi at interface TX IOT point at 28.5 GHz. The pointing range is 90°-270° in azimuth, 1°-44° in elevation and ±90° in polarisation. The antenna control system can be set to autotrack mode. In this mode, the antenna is continuously pointed, in azimuth and elevation, to the satellite beacon or signal source.

Description

The system is capable of simultaneous RX and TX on dual orthogonal linear polarisation (X and Y) and circular polarisation (LHCP and RHCP). At LNA input, the received level for a nominal –110 dBW/m² flux is –71 dBm. This signal is amplified by the LNA, which has a noise figure of 2.6 dB and a gain of 40 dB, giving an output signal of –31 dBm. The TX subsystem can provide an EIRP of 79 dBW on each carrier.

The HPAs can be operated in Automatic Level Control (ALC), Fixed Gain (FG) or ASSC mode. An HP-UX workstation is located in the antenna shelter. This computer controls and monitors all the station equipment via HP-IB buses or LAN.

Characteristics

Transmit:

- Transmit frequency bands: 27.5-30.0 GHz (at antenna interface)
  28.5-30.0 GHz (U/C instantaneous BW)
- Number of simultaneous carriers: two, one on each polarisation or both on one polarisation after high power combining
- Maximum EIRP:
  79 dBW each carrier in linear or 75.5 dBW when combined
  76 dBW each carrier in circular or 72.5 dBW when combined
- EIRP range: maximum to 40 dB down spread over 2 ranges involving one high power attenuator per chain
- EIRP control: fast ALC loop or gain control
- EIRP stability: ± 0.4 dB
- TWTA output power: 250 W
- HPA bandwidth: 2500 MHz
- HPA C/I3 intermodulation: -15 dBc at 3 dB output backoff
  -21 dBc at 6 dB output backoff
- HPA AM/PM conversion: 5.5°/dB at 0 dB output backoff
  3°/dB at 10 dB output backoff
- Power measurement accuracy: ± 0.2 dB
- Power versus frequency: ± 0.2 dB/80 MHz in ALC mode up to 29.4 GHz
  ± 1.25 dB/full band in fixed gain mode up to 29.4 GHz
- Group delay response: 2 ns over 80 MHz
- Power stability: ± 0.4 dB max.
- IF frequency and bandwidth: 750 MHz±80 MHz
- Frequency stability: / day (Redu-1 Cesium oscillator)
- Phase noise: derived from R&S SME-03E synthesiser
  Reference frequency (10MHz)+20*log(N)-4 (N : mult. factor).

Receive:

- Receive frequency band: 18.1-20.2 GHz
- G/T (clear sky, 30° elevation): 29.3 dB/K
- System noise temperature: 25.8 dBK at LNA input
- RX chain overall gain: 60 dB
- LNA gain : 40 dB
- LNA noise figure: 2.6 dB at 23°C
- Flux measurement range: -110 dBW/m2 to –160 dBW/m2
- Flux measurement accuracy: better than 0.6 dB
- Pilot power accuracy: better than 0.4 dB
- Band flatness: < 1.5 dBp-p over 200 MHz
- Group delay overall: < 3 ns over 200 MHz
- IF frequency and bandwidth: 750 MHz ± 125 MHz
- Frequency stability: 2×10^{-11} / day (Redu-1 Cesium oscillator)
- Phase noise: ref. freq(10MHz)+20*log(N)-4 (N: multiplication factor).

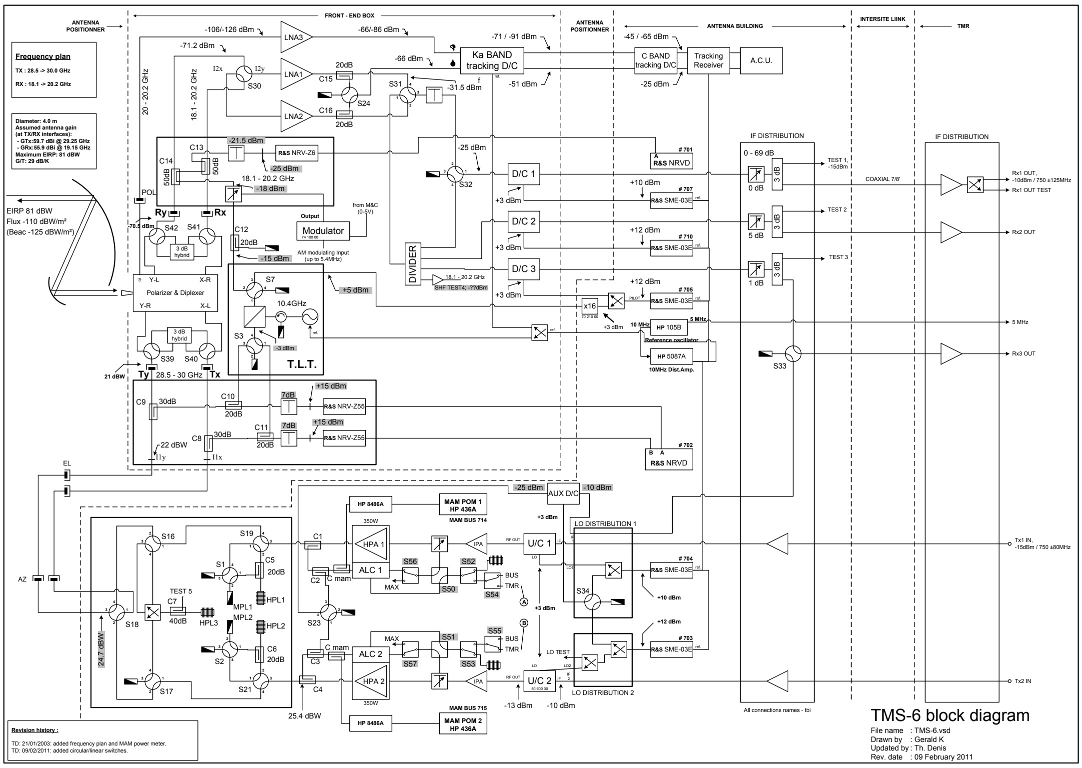


Figure 11 : TMS-6 Schema

TMS-L

Three transportable stations TMS-L2 and TMS-L3 allow to carry out spot beam measurements. They can be sited at different locations. The station includes a set of instrumentation located in the shelter close to the antenna, but is also connected to the L-band payload test laboratory where a complete set of instruments is available. The main purpose of this L-band station is to measure in-orbit satellite payload performances.

Figure 12 : TMS-L antenna

Antenna

TMS-L2 as well as L3 is a parabolic 2.4-metre antenna that can be oriented from 88-272 degrees in Azimuth, 1-66 degrees in elevation. The feed includes an orthomode transducer to generate dual circular polarisation (RHCP and LHCP). TMS-L2 antenna can work in transmit and receive mode via a classical diplexer (OMT), whereas TMS-L3 can only receive.
The TMS-L2 antenna control system can be operated in local or remotely controlled and provides only position-preset mode. The antenna can be slaved to TMS-6 by means of locally developed software, supporting program track and autotrack modes.
TMS-L3 is not equipped with any antenna control unit and therefore can only be moved by hand.

Description

There are two independent transmit chains to generate signal in each polarisation, or to combine two signals in one polarisation only. The antenna shelter is equipped with two R&S SMHU signals generators. The received signals, separated from transmitted signal by a diplexer, are presented to the LHC and RHC antenna inputs and then delivered to the first stage of the LNA's via isolators.

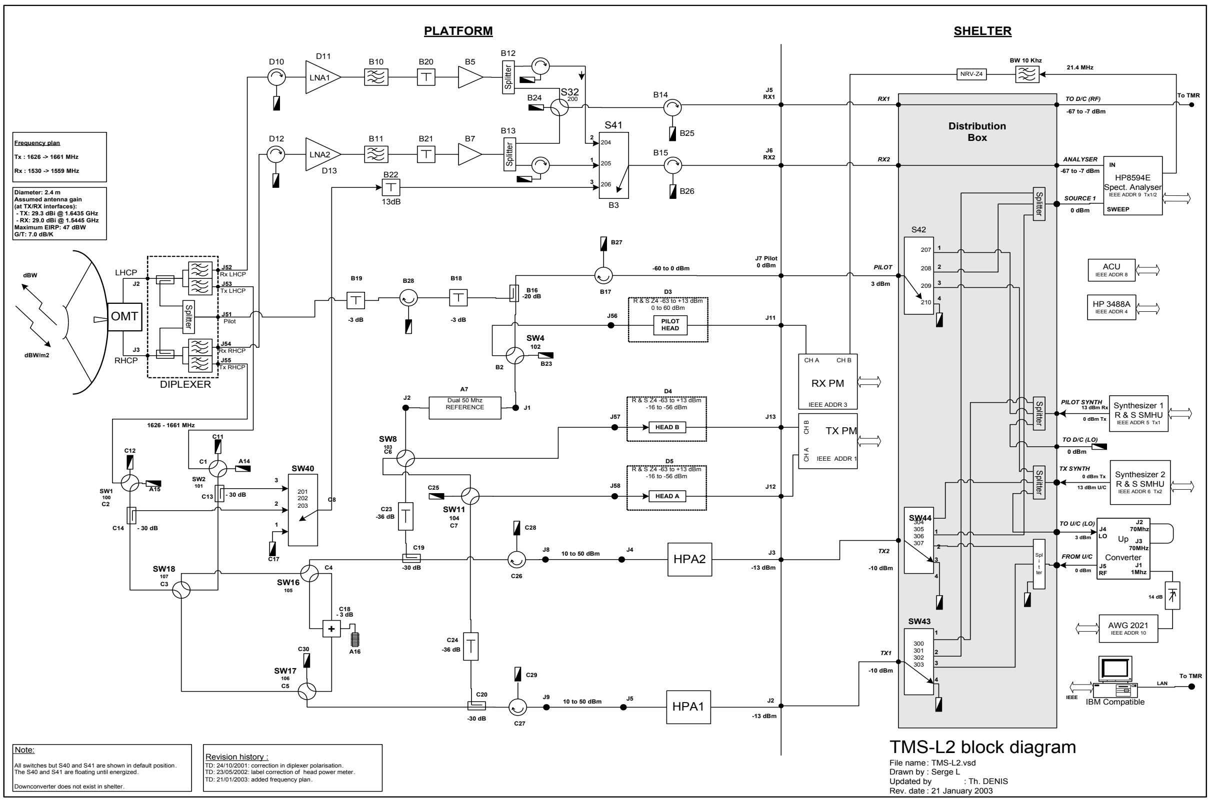


Figure 13: TMS-L2 schema

Characteristics

<u>Transmit (TMS-L2):</u>

- Transmit frequency bands: 1.626 to 1.661 GHz
- Number of simultaneous carriers:
  two, one on each polarisation or both on one polarisation after high power combining
- Maximum EIRP:
  47 dBW single carrier operation
  44 dBW per carrier when combined
- EIRP range: maximum to 40 dB down
- EIRP accuracy: ± 0.5 dB over the entire frequency range
- SSPA output power: 100 W
- HPA C/I3 intercept point: +56.5 dBm
- Power measurement accuracy: 0.1 dB
- Power versus frequency:
  ≤ 1 dB over full band
  ≤ 0.2 dB over any 4 MHz
- AM to PM conversion: 2 deg/dB
- Group delay response: ≤ 4 ns over full band
- Power stability: ≤ ± 1 dB over 24 hours at 10°C

- Frequency stability:

< 1x10-9 over 24 hours after 30 days operation (according to R&S SMHU specifications)

- •SSB Phase noise:

< -124 dBc(1Hz) at 2000 MHz and 20 kHz offset(according to R&S SMHU specifications)

- Input VSWR (J8/J9 ports): 1.22:1
- Output VSWR (J2/J3 ports): 1.22:1

<u>Receive:</u>

- Receive frequency band: 1.53 to 1.559 GHz
- Overall Gain: 70 dB
- Noise figure: 1.4 dB
- G/T (clear sky, 30° elevation): > 7 dB/K
- Power measurement range: -130 dBm to –60 dBm
- Flux measurement accuracy: ± 0.1 dB
- Pilot measurement accuracy: ± 0.1 dB
- Gain ripple:

± 2 dBpp over full frequency range
± 0.3 dBpp over any 4 MHz

- Gain stability: ± 1 dB over 24 hours
- Group delay overall:

±7 nspp over full frequency range
±1 nspp over any 4 MHz

- C/I3 Intercept. Point: +18 dBm
- Input VSWR (J2/J3 ports): 1.17:1
- Output VSWR (J5/J6 ports): 1.17:1

TMS-S

The UHF S-band transportable station, TMS-S, is part of the overall REDU IOT facility. This antenna is capable of simulating the payload of a low orbiting spacecraft. It is connected to the main Payload Test Laboratory (PTL) by low-loss coaxial cables operating directly at the RF frequency.

Antenna

Figure 14: TMS-S Antenna

TMS-S is a parabolic 2.4-metre antenna that can be oriented from 87-273 degrees in Azimuth, -1-74 degrees in elevation. The feed includes an orthomode transducer to generate dual circular polarisation (RHCP and LHCP). The antenna can work in transmit and receive mode via a classical diplexer (OMT).
The TMS-S antenna control system can be operated in local or remotely controlled and provides only position-preset mode. The antenna can be slaved to TMS-6 by means of a locally developed software, supporting program track and autotrack modes.

Description

There are two independent transmit chains to generate signal in each polarisation, or to combine two signals in one polarisation only. The received signals, left and right polarisation separated by the orthomode transducer, are presented to the LHC and RHC antenna ports (diplexer's input) and then delivered to the first stage of the LNA's via isolators.

Characteristics

Transmit:

- Transmit frequency bands: 2200 to 2290 MHz
- SSPA output power: 60 W
- Number of simultaneous carriers:

two, one on each polarisation or both on one polarisation after high power combining

- Maximum EIRP:
  50 dBW single carrier operation
  47 dBW per carrier when combined
- EIRP range:

maximum to 40 dB down spread over 2 ranges involving one high power attenuator per chain

- HPA C/I3 intercept. point: +54.5 dBm
- Gain variation:

≤ 0.5 dBpp over full band
≤ 0.05 dBpp over any 4 MHz

- Gain stability: ≤ ± 1 dB over 24 hours at 10°C
- AM to PM conversion: 2 deg/dB at –1dB gain compression point
- Power measurement accuracy: 0.1 dB
- Input VSWR (J8/J9 ports): 1.17:1
- Output VSWR (J2/J3 ports): 1.17:1

Receive:

- Receive frequency band: 2025 to 2110 MHz
- Overall Gain: 75 dB
- Noise figure: 1.4 dB
- G/T (clear sky, 30° elevation): > 9 dB/K
- Power measurement range: -130 dBm to –60 dBm
- Flux measurement accuracy: ± 0.1 dB
- Pilot measurement accuracy: ± 0.1 dB
- Gain ripple:
  ± 2 dBpp over full frequency range
  ± 0.3 dBpp over any 4 MHz
- Gain stability: ± 1 dB over 24 hours
- Group delay overall:
  ± 7 nspp over full frequency range
  ± 1 nspp over any 4 MHz
- C/I3 intercept point: +21 dBm
- Input VSWR (J2/J3 ports): 1.17:1
- Output VSWR (J5/J6 ports): 1.17:1

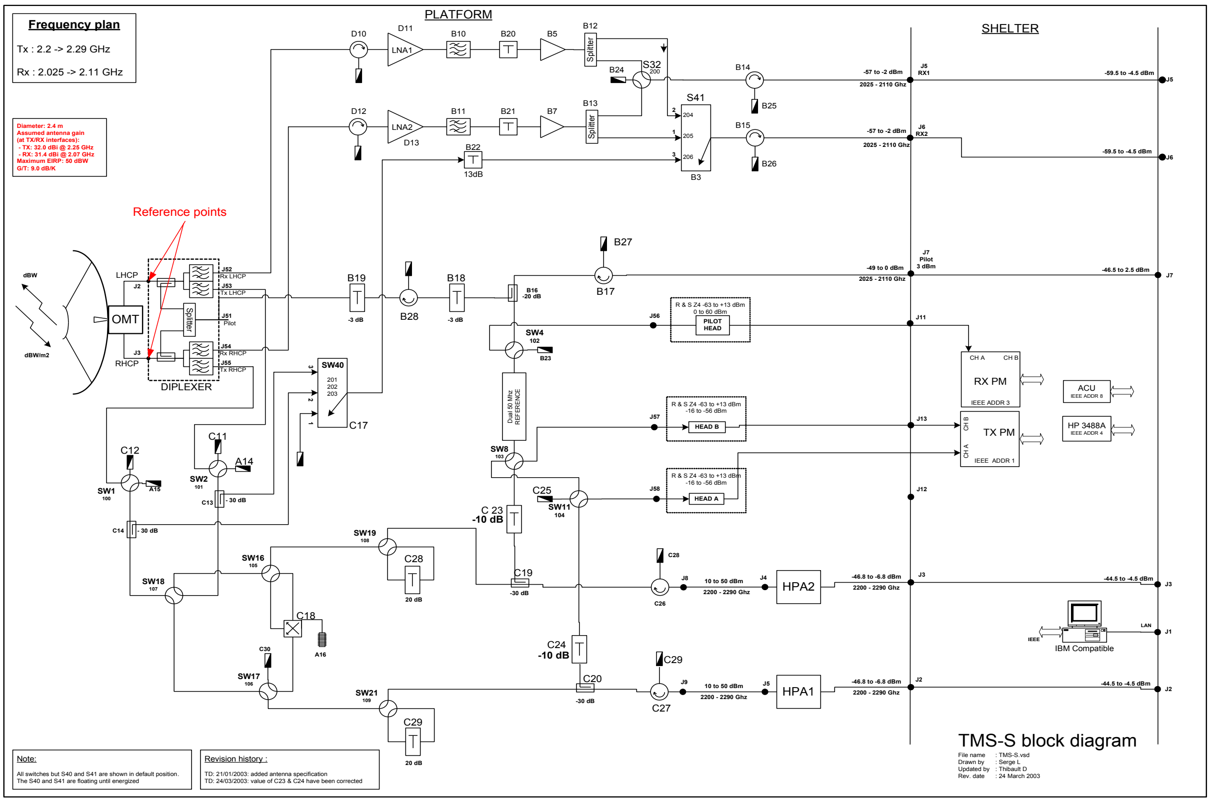


Figure 15 : TMS-S Schema

TMS-Ka

The Ka-band station, TMS-Ka, is part of the overall REDU IOT facility and was designed in the frame of the ARTEMIS project. The frequency bands were tailored to simulate a Ka-Band LEO user spacecraft for the data relay payload of ARTEMIS.
The station is connected to the main Payload Test Laboratory (PTL) by low-loss coaxial cables operating at an intermediate frequency centred on 750 MHz.

Antenna

Figure 16 : TMS-Ka Antenna

The TMS-Ka antenna is a dual offset 1.8-metres parabolic reflector. The feed horn and the aluminium subreflector are installed on a specific support. The antenna is circularly polarised and has four ports: two receive ports (LHCP and RHCP) and two transmit ports (LHCP and RHCP). The receive antenna gain at 23.33 GHz is 50.9 dBi and the transmit gain at 26.41 GHz is 51.8 dBi. The structure of the antenna pedestal allows an azimuth angle range of 105-255 degrees and an elevation range of 1-70 degrees.
The TMS-Ka antenna can be operated in local using the user interface or remotely controlled via IEEE-488 interface bus. The system has four operation modes: preset, program track, speed control and stand-by. The antenna can be slaved to TMS-6 antenna by means of a locally developed software.

Description

The TMS-Ka transmit system consists of two independent and identical transmit chains able to generate signals in each polarisation or to be combined in one polarisation only. A TX auxiliary down-converter is also part of the transmit subsystem. The two receive chains consist of a LNA, down-converter and gain/frequency response equaliser. An HP-UX workstation is located in the antenna shelter. This computer controls and monitors all the station equipment via HP-IB buses.

Characteristics

Transmit:

- Transmit frequency band: 25250-27500 MHz
- Instantaneous bandwidth: 250 MHz
- Frequency stability: 1.0e-9 per day (R&S SMGU synthesiser)
- Number of simultaneous carriers:

two, one on each polarisation or both on one polarisation after high power combining

- TWTA max. output power: 40W
- EIRP range:

maximum to 60 dB down spread over 2 ranges involving one 17.5dB high power attenuator

- EIRP control: ALC loop or fixed-gain
- EIRP accuracy: ≤0.4 dB RSS
- EIRP stability: ≤ 0.2 dB/24h (ALC mode)
- Transmit chain gain flatness :
  TX1 : < 5 dB over the whole SHF band
  TX2 : < 3.7 dB over the whole SHF band
- TWT Gain flatness : < 1 dB in any 250MHz band
- AM/PM conversion2: < 6°/dB
- Third order Intermodulation2: ≤-29 dBc, 2 carriers at 10MHz, 10 dB O.B.O.
- Group delay: ≤ 4 nspp in any 250 MHz band
- Phase noise:
  -42 dBc/Hz at 10 Hz
  -65 dBc/Hz at 100Hz
  -90 dBc/Hz at 1kHz
  -98 dBc/Hz at 10kHz

Receive:

- Receive frequency band: 23120-23550 MHz
- Instantaneous bandwidth: 250 MHz
- G/T (clear sky, 30° elevation): 23 dB/K
- Flux measurement range: -90 to –130 dBW/m²
- Flux measurement accuracy: ≤0.4 dB RSS
- Pilot measurement accuracy: ≤0.14 dB (R&S power meter spec.)
- Gain flatness at 750 MHz interf.: 1 dBpp
- Gain stability: 0.33 dB over 24 hours
- Group delay at 750 MHz interf.: 1.35 nspp
- AM to PM conversion: ± 1°/dB
- Third order intermodulation: ≤-40 dBc, 2 carriers at 10MHz

- Frequency stability: 1.0e-9 per day (R&S SMGU synthesiser)
- Phase noise:
  -35 dBc/Hz at 10 Hz
  -73 dBc/Hz at 100 Hz
  -78 dBc/Hz at 1 kHz
  -91 dBc/Hz at 10 kHz

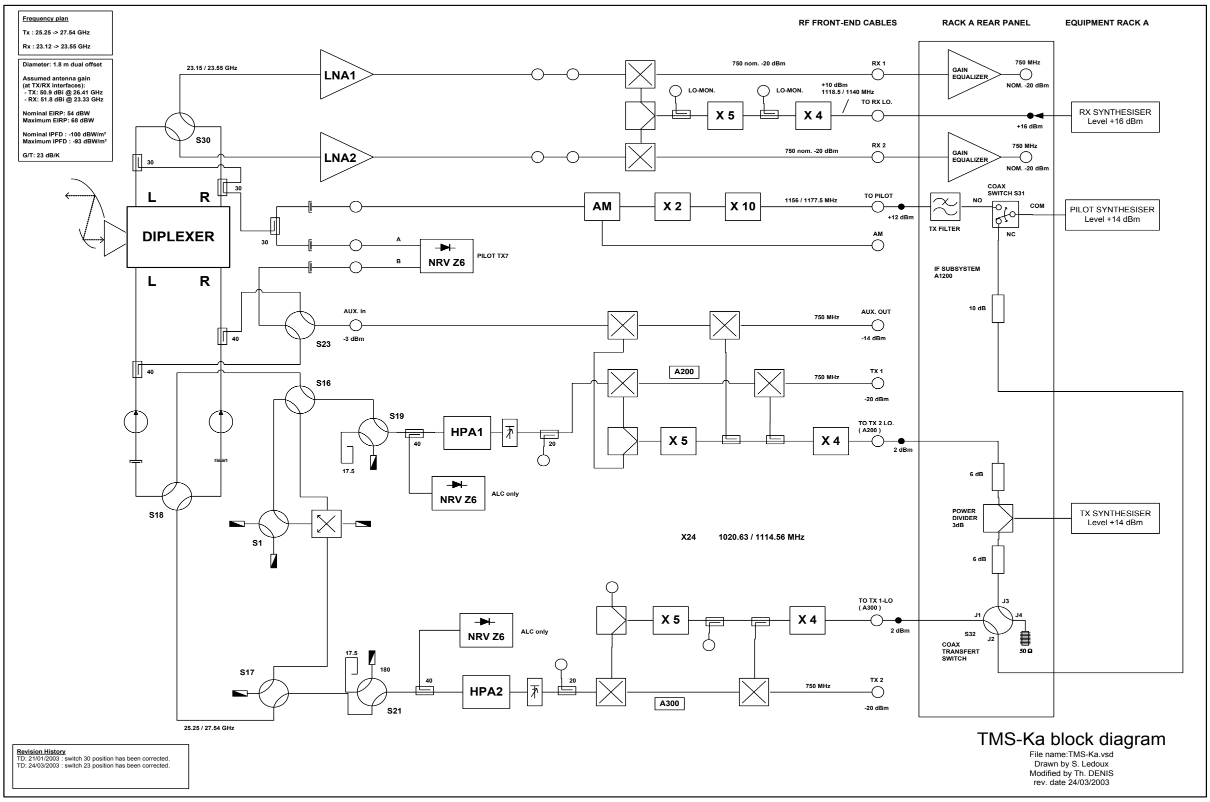


Figure 17: TMS-Ka schema

Payload Test Laboratory

The Payload Test Laboratory (PTL) provides the interface to the IOT and ESVA facilities and is the location where IOT and ESVA operations are carried out. The room is mainly equipped with computer consoles.

A full set of instruments complete the IOT capabilities deployed in Redu.

APPENDIX D ARTEMIS FILINGS

ARTEMIS-21.5E-DR

This filing covers:
- TT&C links in S-band
- Feeder links and TT&C nominal links in Ka-band
- Ka-band intersatellite links for data relay function
- S-band intersatellite links for data relay functions

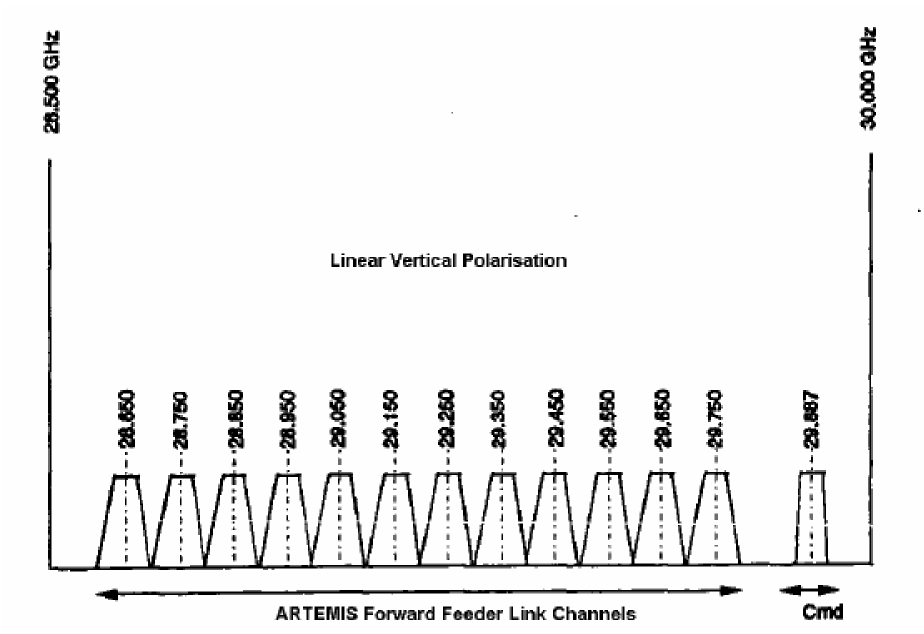
TT&C links in S-band

Uplink: 500 kHz centred around 2026.754 MHz. Earth station: any Estrack station or station with similar parameters

Downlink: 500 kHz centred around 2201 MHz. Earth station: any Estrack station or station with similar parameters

Feeder links and TT&C nominal links in Ka-band

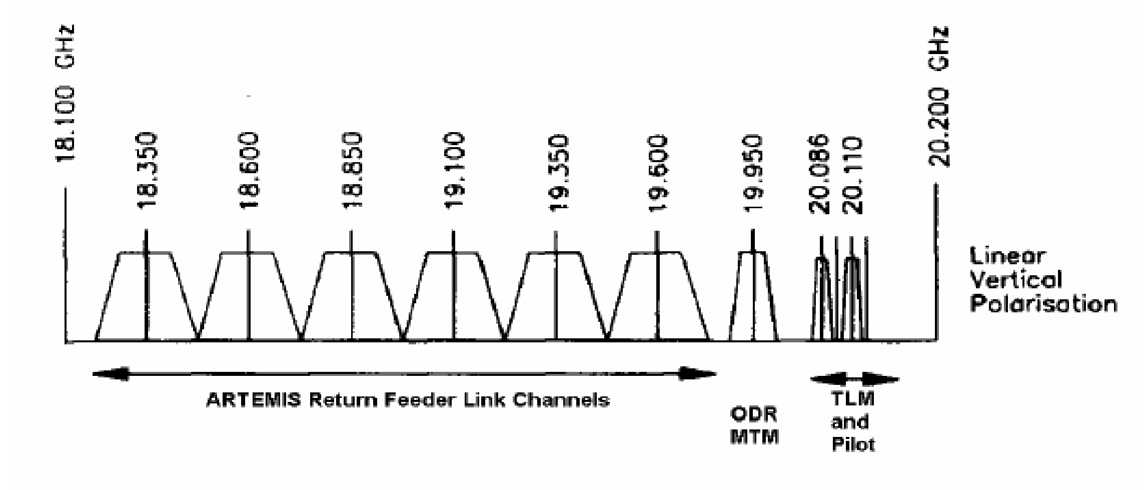
a) Feeder Up-link (29-30 GHz)



AR11/C/2507

Frequency	GHz	28.65, 28.75, 28.85, 28.95, 29.05, 29.15.				28.65, 28.75, 28.85, 28.95, 29.05, 29.15.			
		29.25, 29.35, 29.45, 29.55, 29.65, 29.75				29.25, 29.35, 29.45, 29.55, 29.65, 29.75			
Carrier Type		Comms	Comms	Comms		Comms	Comms	Comms	Comms
Assigned Frequency Band	kHz	100000	100000	100000		100000	100000	100000	100000
Carrier designation		6M00G7DDC	2M00G7DBT	1M00G7DBT		10M0G7DBT	6M00G7DDC	2M00G7DBT	100KG7DBT
Filter Bandwidth	kHz	6000	2000	1000		10000	6000	2000	100
Max power	dBW								
Max peak power	dBW	18.4	22	15.2		20.1	8.4	12	5.2
Max power density	dBW/Hz	-46.4	-38	-44.8		-49.9	-56.4	-48	-54.8
Min Power	dBW	15.4	19	12.2		17.1	5.4	9	2.2
Min power density	dBW/Hz	-49.4	-41	-47.8		-52.9	-59.4	-51	-57.8
Satellite Beam Designation		FDU	FDU	FDU		FDU	FDU	FDU	FDU
Satellite Antenna gain	dBi	40.1	40.1	40.1		40.1	40.1	40.1	40.1
ES Name		TERM1	TERM1	TERM1		TERM2	TERM2	TERM2	TERM2
ES antenna gain	dB	57.6	57.6	57.6		67.6	67.6	67.6	67.6
ES pattern		Rec. 465	Rec. 465	Rec. 465		Rec. 465	Rec. 465	Rec. 465	Rec. 465
Polarization		Linear, 97 deg	Linear, 97 deg	Linear, 97 deg		Linear, 97 deg	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg
Tnoise	K	1305	1305	1305		1305	1305	1305	1305
C/Nreq	dB	16.8	16.7	16.6		16.8	16.7	16.6	16.5
C/Ireq	dB	29	28.9	28.8		29	28.9	28.8	28.7
ES location		Redu	Redu	Redu		Redu	Redu	Redu	Redu
ES location		Fucino	Fucino	Fucino		Fucino	Fucino	Fucino	Fucino

b) Down-link transponder plan (18-20 GHz)



AR11/C/2507

Frequency	18.35 - 18.6 - 18.85 - 19.1 - 19.35 - 19.6			18.35 - 18.6 - 18.85 - 19.1 - 19.35 - 19.6				
Carrier Type	Comms	Comms	Comms	Comms	Comms	Comms	Comms	Comms
Assigned Frequency Band	250000	250000	250000	250000	250000	250000	250000	250000
Carrier designation	50M0G1DDT	20M0G1DDT	6M00G1DDT	150M0G1DDT	100M0G1DDT	50M0G1DDT	20M0G1DDT	6M00G1DDT
Filter Bandwidth	50000	20000	6000	50000	100000	50000	20000	6000
Max power								
Max peak power	9	9.7	-12.9	9.8	9.7	9	9.7	-12.9
Max power density	-68	-63.3	-77.7	-72	-70.3	-68	-63.3	-77.7
Min Power	6	6.7	-15.9	6.8	6.7	6	6.7	-15.9
Min power density	-71	-66.3	-80.7	-75	-73.3	-71	-66.3	-80.7
Satellite Beam Designation	FDE	FDE	FDE	FDE	FDE	FDE	FDE	FDE
Satellite Antenna gain	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2
ES Name	TERM1	TERM1	TERM1	TERM2	TERM2	TERM2	TERM2	TERM2
ES antenna gain	54	54	54	63.9	63.9	63.9	63.9	63.9
ES pattern	Rec. 465	Rec. 465	Rec. 465	Rec. 465	Rec. 465	Rec. 465	Rec. 465	Rec. 465
Polarization	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg	Linear, 97 deg
Tnoise	484	484	484	484	484	484	484	484
C/Nreq	13.8	13.3	25.7	12.4	14.1	13.9	13.3	25.7
C/Ireq	26	25.5	37.9	24.6	26.3	26.1	25.5	37.9
ES location	Redu	Redu	Redu	Redu	Redu	Redu	Redu	Redu
	Fucino	Fucino	Fucino	Fucino	Fucino	Fucino	Fucino	Fucino
	Frascati	Frascati	Frascati	Frascati	Frascati	Frascati	Frascati	Frascati

Ka-band inter-satellite links for data relay function

Return link (User spacecraft to ARTEMIS direction): satellite to ARTEMIS. 8 ranges of 250 MHz as per table below. Possible channel sizes: 150, 100 and 20 MHz.

Forward link (ARTEMIS to User spacecraft direction) : ARTEMIS to satellite. 6 ranges of 60 MHz as per table below. Possible channel sizes: 10, 2 and 1 MHz

Centre freq MHz	Bandwidth MHz
25600.00000	250
25850.00000	250
26100.00000	250
26350.00000	250
26600.00000	250
26850.00000	250
27100.00000	250
27350.00000	250

RTN link

Centre freq MHz	Bandwidth MHz
23205.00000	60
23265.00000	60
23325.00000	60
23385.00000	60
23445.00000	60
23505.00000	60

FWD link

Beacon: ARTEMIS to satellite. 2 ranges of 500 kHz for a beacon size of 10 kHz

Centre freq (MHz)	Bandwidth (kHz)
23540.00000	500
23545.00000	500

S-band intersatellite links for data relay functions

1 channel for return transmission from Envisat: centre freq 2255 MHz, size 6 MHz

1 channel for forward transmission to Envisat: centre freq 2076.48 MHz, size 6 MHz

1 channel for return transmission from ATV: centre freq 2287.5 MHz, size 5 MHz

1 channel for forward transmission to ATV: centre freq 2106.4 MHz, size 6 MHz

ARTEMIS-21.5E-LM

Feeder links

Uplink in Ku-band: Centre frequency 14240 MHz, bandwidth 20 MHz.

Note: the channels defined (450 kHz and 1 MHz) are not the ones actually used for the current L-band applications by Telespazio.

Downlink in Ku-band: Centre frequency 12740 MHz, bandwidth 20 MHz.

Same note as above for the channels actually used on Artemis.

L-band user links

Four different types of beams (MLA, MLB, MLC, MLE) with different coverage areas.

Note: the actual usability of these frequencies is determined by the ORM output.

Uplink

Beam	Centre freq MHz	Bandwidth (kHz)
MLA	1633.00000	3000
MLA	1640.00000	11000
MLA	1651.50000	10000
MLA	1658.50000	4000
MLB	1633.00000	3000
MLB	1640.00000	11000
MLB	1651.50000	10000
MLB	1658.50000	4000
MLC	1633.00000	3000
MLC	1640.00000	11000
MLC	1651.50000	10000
MLC	1658.50000	4000
MLE	1633.00000	3000
MLE	1640.00000	11000
MLE	1651.50000	10000
MLE	1658.50000	4000

Downlink

Beam	Centre freq MHz	Bandwidth (kHz)
MLA	1531.50000	3000
MLA	1538.50000	5500
MLA	1550.00000	10000
MLA	1557.00000	4000
MLB	1531.50000	3000
MLB	1538.50000	5500
MLB	1550.00000	10000

ARTEMIS-21.5E-NAV

Feeder links

Uplink in Ku-band: Centre frequency 13875 MHz, bandwidth 4 MHz

Downlink in Ku-band: Centre frequency 13875 MHz, bandwidth 4 MHz

Users link

Downlink signal (EGNOS radionavigation): Centre frequency 1575.42 MHz, bandwidth 4 MHz