MANUAL

for handling of the

CONSERT

Orbiter Antenna

STM

RO-OCN-TN-3019

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Content

Content of the CONSERT orbiter antenna TRANSPORTATION CONTAINER.

Packing List:

1) antenna with pyro; antenna is folded and bolted to transport panel;
2) 100 cm pyro wire with cable assembly;
3) safety harness.
4) accessories
5) general tools
6) white gloves
7) four pieces of string, each about four meters long;
8) 'deployment bracket';
9) two 'holding bracket's;
10) balloon(s);
11) counter-weight;
12) ‘string attachment’;
13) Ohm-meter;
14) three pieces of string, each of about 50 cm length;
15) ADP;
16) logbook;
17) helium bottle attachments;
18) prepared pyro wires.

CONSERT orbiter antenna system level activities for integration and deployment tests of STM

1.0 Introduction

In this section a qualitative description of the Consert orbiter antenna is given. A quantitative description is in the MICD.

The basic requirements and ideas for the mechanical design are,

1) the antenna is deployed by a single command to a pyro-device to cut a wire (or during ground test this wire can be cut by hand with a wire-cutter). This pyro-wire fixes the antenna in the folded position (launch position). After the wire has been cut the antenna deploys automatically in a controlled manner;

2) once released, the deploying forces acting on the antenna are 'much larger' than the opposing friction forces; but small enough to avoid a collision of the antenna with the spacecraft during deployment;

3) deployment forces are provided by spring forces; no motors are involved;

4) two deployment indicators signals the successful deployment;

5) once deployed the antenna structure will lock-on, such as to be unaffected by forces associated with orbiter maneuvers.

Two masts support the antenna elements. The masts are of carbon fiber material covered by plasmocer treated aluminum foil. The springs that deploy the masts are Carpenter-Springs. One Carpenter Spring connects the two masts, and another spring connects the end of one mast to an antenna foot, that is bolted to the spacecraft. In folded position the masts are parallel and placed along a spacecraft edge. When the antenna is released the Carpenter Springs go into action. The Carpenter Spring, when straightened out, is in an equilibrium position, where quite a large force is needed to bend the spring. This provides for stability of the deployed antenna. The stability is further enhanced by the manchets ,which are pushed across the Carpenter Springs to lock against the support structure.

The antenna- and reflector elements are aluminum rods with a surface of plasmocer. Each dipole element is connected to one of the masts with a spring. Similarly each reflector element is connected to the other mast with a spring. When the antenna is in the folded position, then each dipole- and reflector element is folded back along the mast to which it is attached, and kept in place by a 'manchet'.When the antenna deploys the manchets are pushed back to release the elements, which are deployed each by the spring. Each of these springs has the form of a coil. Inside each springs is a pin, which locks-on when the spring has straightened out, thereby fixing the elements in the wanted position.

The antenna is kept in launch position (folded position) by three supports and is lashed to the central support with a wire. The wire is cut by a pyro-device to deploy the antenna. During ground tests the wire can also be cut by hand using the wire-cutter.

An initial push to the masts to deploy is provided by springs located on the central of the above mentioned three supports. Each spring is placed in a Al-tube. One tube is located above the pyro (”top-spring-tube”, see section 4.1.2), and one below the pyro.

The controlled deployment of antenna- and ground elements is provided by spring action.

Each carpenter-spring is supplied with an Ohmic resistor (R) which acts as adeployment indicator:
Folded antenna: R < 50 Ohm;
Deployed antenna: R > 1 MOhm;
These resistances are measured on Connector JA4.

Figure 1 illustrates how the folded antenna is placed on the spacecraft. The X-, Y-, and Z- axis of the coordinate system shown in the figure represents the URF coordinate system for the antenna and also the spacecraft coordinate system (only the origin of the shown system is not correct).

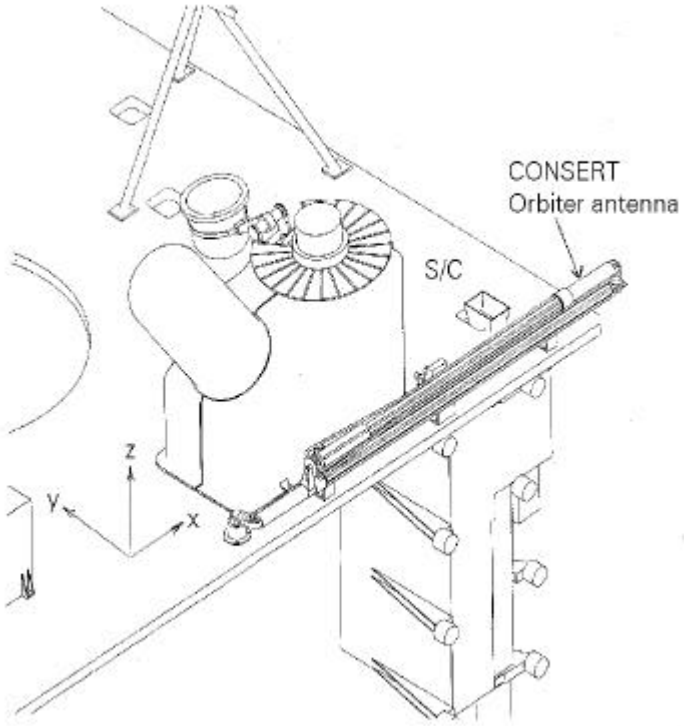

Figure 1: The CONSERT orbiter antenna on the spacecraft. The antenna is shown in the folded position. Note the two masts and several thin rods (the dipole- and reflector elements), which all are folded parallel to each other. Note also the four supports which fixes the antenna to the spacecraft, and serves to keep the folded antenna in position.

Figure 2 is a schematic drawing of the antenna in folded position (launch position). The different parts of the antenna are labelled with the names, which are used in this report. Figure 2 is a fold-out at the back of this report.

Figure 3 illustrates the deployed antenna. The different parts of the antenna are labelled with their names. Figure 3 is a fold-out at the back of this report.

The STM will be cleaned and delivered to ESA in folded position. All four supports (Support-1, Support-2, Support-3, and Support-4) are bolted to a transport panel with four bolts each. The antenna is bolted to Support-1 with one bolt, and is lashed to Support-3 with the pyro wire. The pyro with safety plugs is inserted in Support-3. The antenna will be cleaned in a 1000 class environment and placed in a clean bag.

The antenna will be packed in an aluminum transport container with dimensions 120x80x51 cm. The container is ATA300 compatible, cleared for air transportation. The total weight of the container with

antenna will be about 25 kg (TBC). The container is provided with handles, and can be carried by two persons. In addition to the antenna the container will hold 100 cm pyro wire, to be used to fold the antenna again following the three deployments foreseen for the STM. The container will also hold a 'red flagged' safety harness (see Section 6), which can be placed on the folded antenna to prevent an unintentioned deployment (which may occur by an act of God).

Items in antenna transportation container:
- antenna with pyro; the antenna is folded and bolted to transport panel;
- 100 cm pyro wire, with cable assembly (see section 5);
- safety harness;

2. Integration of the antenna on the spacecraft.

In order to integrate the antenna on the spacecraft, to deploy it, and to re-fold it after deployment, a certain free space is needed around the location where the antenna is mounted on the spacecraft. The free space is required partly to ensure that the deploying and deployed antenna will not collide with or touch any obstruction, and partly in order to allow all works on the antenna to be carried out (integration, deploying, and folding). Two persons must be able to reach any point inside the free space defined in Figure 4. The two persons must stand securely so as to have free hands for handling the antenna.

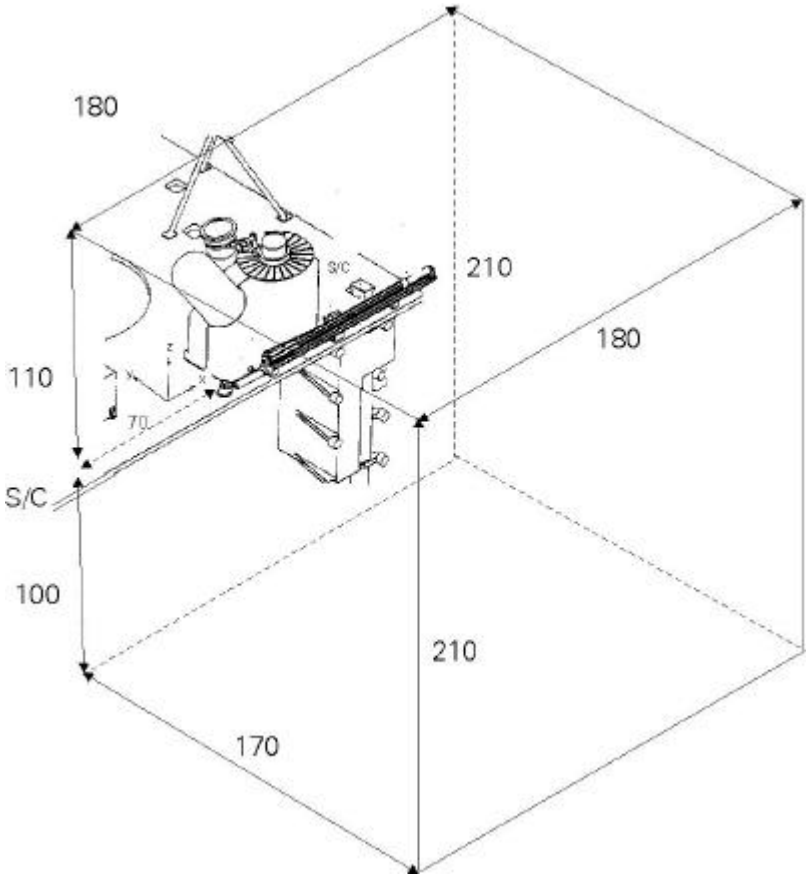

Figure 4: Shown is the part of the spacecraft on which the antenna is located. The part of space which must be free of obstacles during deployment of the antenna is defined by the cube. The cube's location is given relative to Support-1. All dimensions are in centimeters.

A further requirement to ensure a correct deployment of the antenna is that the side of the spacecraft on which the antenna is mounted (the +Z panel) shall be horizontal to an accuracy better than 5 millimeter over one meter. The reason for this requirement will be clear in the section describing the deployment procedure.

It is further assumed that the MLI at the areas where the 4 Supports will be mounted, have been folded back to allow the Supports to be mounted on the spacecraft.

Only general tools are required for the mechanical works. The general tools will be parts of the content of the transport container.

The antenna will arrive in the transportation container in the lock to the hall (clean area) where the spacecraft is located. The actual procedure for bringing the antenna to the location where the antenna will be mounted on the spacecraft will, of course, depend on the actual facilities available on the spot:
- how high over the floor is the mounting surface located?
- how is it accessible? (stairs, latter, elevator, cherry-picker)?

The transportation container is opened in the lock. The antenna - folded and bolted to the transport panel - is removed, brought into the hall where it is carried or lifted to the mounting area.

Step-by-step procedure to integrate the antenna on the spacecraft (with reference to Figure 2):

1) Support-2 and Support-4 are removed from the transport panel, and mounted with four bolts each to the spacecraft (standard torque);

2) The four bolts holding Support-1 to the transport panel are removed, and Carpenter-Spring-1 carefully released;

3) Support-3 (with the whole antenna structure and Support-1 attached) is removed from the transport panel, and mounted with four bolts to the spacecraft (standard torque);

4) Manchet-1 is pushed back from Carpenter-Spring-1 (it is to be controlled that the ends of the reflector elements end up inside Manchet-1, and that the pin at the head of Mast-2 is placed in the corresponding hole in Manchet-1). Then the Carpenter-Spring-1 is bend, and Support-1 is bolted with four bolts to the spacecraft (standard torque);

5) cable from S/C is connected to JA4 on Support-1 (connector for 'deployment indicators');

6) cable from CONSERT e-box is connected to JA1 (HF signal coaxial cable), which is located on Support-1;

The pyro is at this point not connected to the system; the safety plugs remain in place;

The system may now deploy the spacecraft MLI to cover the lower parts of the antenna supports. The MLI is allowed to cover the supports to a height of 20 to 30 mm.

Items in antenna transportation container:
- accessories;
- general tools.

3. Deployment Ground Support Equipment (GSE).

The antenna is designed for deployment in space, i.e. in the absence of gravity. To deploy the antenna on the ground special measures therefore have to be observed to compensate for gravity. Partly for the deployment to complete, and partly to ensure that the antenna can stay deployed without breaking.

The deployment of the antenna consists fundamentally of the movements of two parts: the horizontal deployment of Mast-1, and of the vertical deployment of Mast-2 (see Figure 2 and Figure 3).

The deployment of Mast-1 is a rotation about a vertical axis through Support-1. The far point of Mast-1 describes a horizontal circle with center in Support-1 (it is for this reason that Support-1 has to be mounted with an accuracy of better then 5mm over 1m in the horizontal plane; see Section 2). Compensation for gravity is accomplished by a piece of string going from the far point of Mast-1 to a Point vertically above Support-1. At this Point the string will be fastened to a crane-hook located at least 2.5 meters above Support-1.

However, the string will not go diagonally from the end of Mast-1 to the crane-hook, because the string in that case would interfere with the vertical deployment of Mast-2. Instead the string will be lead from the end of Mast-1 vertically up about 1.2 m, and then it will be lead across to the crane-hook. In order to guide the string in this manner a 'deployment-bracket' is required. The T-shaped 'deployment-bracket' together with the folded antenna, crane-hook and string is illustrated in Figure 5a.

The 'deployment-bracket' consists of two perpendicular hollow aluminum tubes. One vertical tube is placed between Support-1 and the crane-hook, and kept in place by a string running inside the tube and connecting Support-1 and the crane-hook. At Support-1 the string is connected at the point where the Carpenter-Spring-1 is attached to Support-1. The other tube is horizontal and is placed perpendicular to the first tube at a distance of 1.2 m above Support-1. The string connecting the horizontal tube to the end of Mast-1, is .fastend to the ‘string attachment’ mounted on the end of Mast-1. The ‘string attachment’ is a short rod that is screwed to the end of Mast-1. This short extension of Mast-1 is necessary in order to ensure that the string connecting this point to the ‘deployment-.bracket’ will not be in the way of the deploying Mast-2.

For the vertical deployment of Mast-2 work has to be done against gravity. This work will be done by a balloon fastened to the far end of Mast-2, where the dipoles are located (see Figure 5a). The balloon string is attached to the end of Mast-2. The string is attached at the top of Mast-2 just below the points where the dipole elements are attached to the mast.

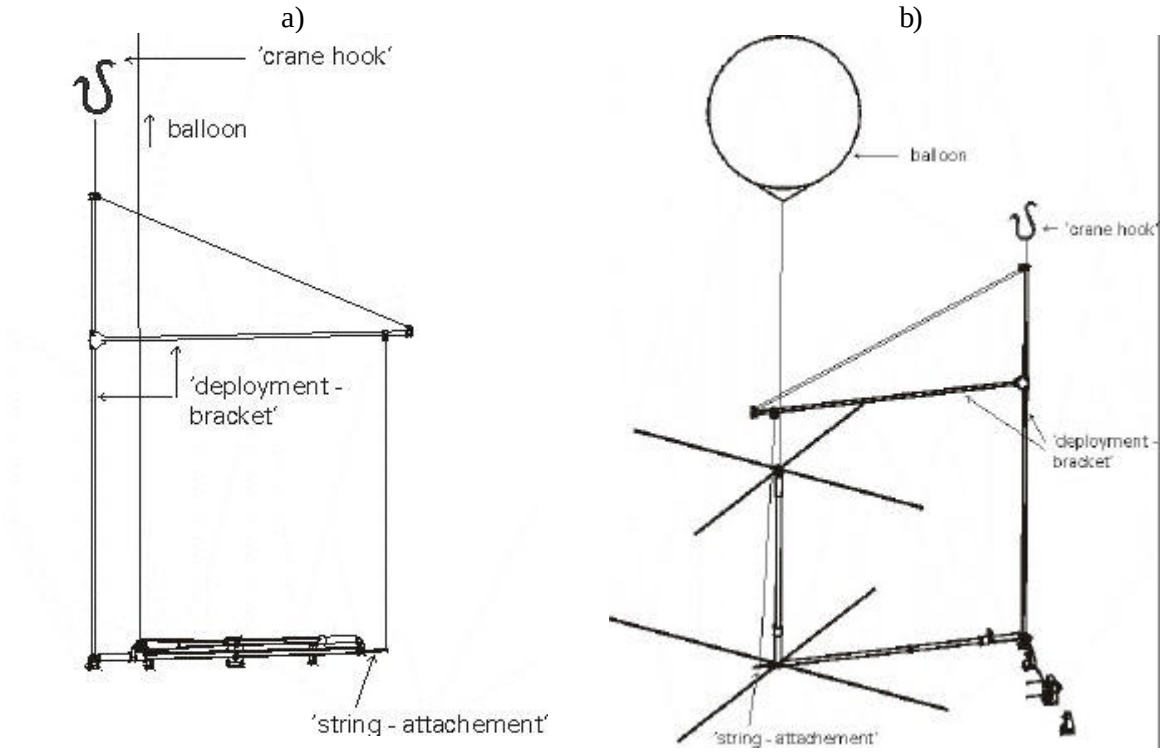

Figure 5: The antenna connected to 'deployment bracket' and crane-hook for the purpose of testing the deployment mechanism using gravity assist. The 'string attachment' is mounted at the end of Mast-1.
Panel a) The folded antenna ready to be deployed. Mast-1 will deploy horizontally kept in place against gravity by the 'deployment-bracket' and the crane-hook. Mast-2 will deploy vertically assisted by the balloon against gravity.
Panel b) The antenna after deployment. The antenna is supported against gravity jointly by the 'deployment -bracket', crane-hook and balloon.

When the pyro wire is cut two springs on Support-3 give the antenna an initial push. Then Carpenter-Spring-1 take over the horizontal deployment of Mast-1 supported by the 'deployment-bracket', crane-hook and string, while the balloon together with Carpenter-Spring-2 performs the vertical deployment of Mast-2. The dipole- and reflector elements are deployed by the springs with which they are connected to the antenna support structure (to Mast-1 and Mast-2). The sequence of events during deployment is

a) cut pyro wire
b) release of Mast-1; activation of Carpenter-Spring-1;
c) release of Mast-2; activation of Carpenter-Spring-2;
d) release of reflectors;
e) release of dipoles

Once the deployment is completed the antenna locks automatically in place: the Manchets-1 and -2 are pushed back over the Carpenter-Springs-1 and -2, and the pins inside the dipole- and reflector elements springs are pushed to lock. Figure 5b shows the antenna after deployment still with the gravity assist equipment attached.

The Carpenter-Springs are not designed to hold the antenna against gravity. Thus, if no gravity assist equipment is in place each Carpenter-Spring must be bridged-over with a 'holding-bracket'. One 'holding-bracket' connects Mast-1 to Support-1 across Carpenter-Spring-1, and the other 'holding-bracket' connects Mast-1 to Mast-2 across Carpenter-Spring-2. These 'holding-bracket's are illustrated in Figure 6. The two 'holding-brackets' are of electrically non-conductive materials, such that the

brackets will have a negligible influence on the antenna's electrical performance. Each end of a ‘holding-bracket‘ is connecting to a Mast or to Support-1 with a clamp and 2 screws.

The above mentioned balloon is filled with helium. Thus, a helium bottle with a capacity of TBD must be available in the integration hall. To ensure satisfactory operation of the balloon it must have a vertical pull of 270 g (TBC). The pull of the balloon will be balanced with a counter-weight, which is part of the equipment in the transport container. Since Helium leaks out of the balloon, thus, this pull will only be sustained for 4 hours (TBD). After that time the balloon has to be re-pressurized with helium. Thus, a deployment test has to be carried out less than 4 hours after the balloon has been pressurized.

The GSE consist of:
- four pieces of string, each about four meters long;
- 'deployment bracket';
- two 'holding bracket's;
- balloon;
- counter-weight;
- ‘string attachment’

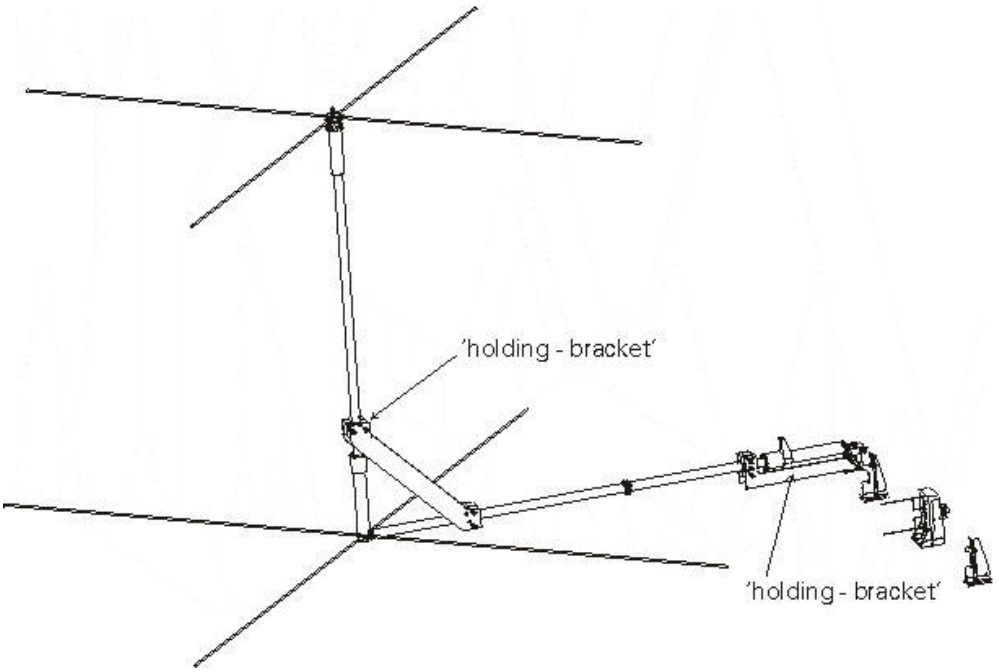

Figure 6:The two 'holding-brackets' placed on the deployed antenna to prevent it collapsing under the action of gravity. The exact form of the 'holding-brackets' are still TBD.

4. Deployment tests.

When the pyro wire is cut the antenna will deploy automatically.

Before and after deployment the ‘deployment indicators’ are checked with an Ohm-meter (connector JA4 on Support-1) to verify that the Ohmic resistance changes from a small value to a very large value.

The antenna may be deployed for different reasons to tests different aspects of the antenna. For example,

- to test deployment in space using gravity assist measures; here one may cut the pyro wire by hand with a wire cutter, or by firing the pyro;
- to use the deployed antenna for EMC tests; here the deployment may be done by hand without gravity assist.

4.1 Deployment with gravity assist.

Step-by-step procedures to deploy the antenna on the spacecraft with gravity assist.

4.1.1 Mount 'deployment-bracket' , 'string attachment' and balloon:

1)The 'string attachment' is mounted on the end of Mast-1.

2) two strings each four meters long are fastened by one end to the crane-hook;

3) one string three meters long with a weight attached to one end, is fastened in one end to the crane-hook such that there is about 2.5 meters from the crane-hook to the weight;

4) the crane-hook is placed vertically over the center of the Support-1 at an altitude of about 2.5 to m; this is done by move the crane-hook until the weight (see point#2) is located exactly over the center of Support-1;

5) the end of one of the four meter strings, which were fastened to the crane-hook (see point#2), is passed through the hollow tube of the 'deployment bracket', and is fastened to Support-1; at the point where the Carpenter-Spring-1 is attached to Support-1.

6) the other four meter string, which were fastened to Support-1 (see point#1), is passed to the end of the horizontal tube of the 'deployment bracket' where it is fastened, and then lead to the end of Mast-1 where the string is fastened to the 'string attachment'; make sure the string is taught enough to hold the antenna horizontal;

7) a balloon is filled with helium to produce a vertical pull of 270 g (TBC) measured with the vertical-pull meter; the bottle of helium (volume...)is provided by the system. The project will provide equipment to pass helium into the balloon.

8) the string on the balloon is tied to the top of Mast-2; the string on the balloon is placed under the springs attached to the dipole elements;

The antenna is now ready to be deployed with gravity assist. The deployment can be initiated in two different ways, manually or with pyro.

4.1.2 Manual deployment with gravity assist.

In this case the pyro-wire is cut manually with the wire cutter.

To allow manual deployment the pyro must first be removed. This is done in the following steps:
– remove the top-spring-tube;
– remove the 2 screws holding the pyro;
– remove the pyro;
– reinstall the top-spring-tube.

It is now important to ensure that the person cutting the wire is not in the way of the deploying antenna. It is assumed that it is not possible for a person to climb on to the spacecraft, and so place himself

behind the deploying antenna. Thus, the person cutting the wire must be placed in the half hemisphere into which the antenna deploys. The following procedure should be used: One person place himself in the -X direction from the antenna, about 0.2m from Support-1. In his left hand he holds a wire cutter. He now leans forward towards Support-3, and cuts the pyro wire. He remains in this position until the deployment has finished, and the antenna has locked on.

Once the antenna has deployed the antenna must either be secured against gravity with the two 'holding-bracket's, or the antenna must be re-folded. This has to be done before removing the 'deployment bracket' and the balloon.

4.1.3 Pyro deployment with gravity assist.

In this case the pyro wire is cut by the pyro. Check that the pyro is installed. If missing install the pyro. The mechanical construction is such, that the pyro is guided to the exactly right position relative to the pyro wire. While handling the pyro make sure the safety plugs are in place.

Installation of the pyro is done in the following steps:
– remove the top-spring-tube;
– place pyro in Support-3;
– insert and tighten the 2 screws holding the pyro;
– reinstall the top-spring-tube.

The spacecraft system is then connected to the pyro connectors JA2 and JA3. The pyro is fired by the spacecraft system.

Once the antenna has deployed the antenna must either be secured against gravity with the two 'holding-bracket's, or the antenna must be re-folded. This has to be done before removing the 'deployment bracket' and the balloon.

4.2 Manual deployment without gravity assist.

During system tests, for example EMC test, it may be required that the antenna is in its deployed position. In such a case there may be no demand for testing the deployment mechanism. The starting position of the antenna before deploying it for system test, is the integrated folded antenna (see Section 2).

Step-by-step procedure for deploying the antenna on the spacecraft for system test purposes:

1) the four dipoles are secured with a string to the Mast-2; place the string 10 to 15 cm above the manchet;

2) the four reflectors are secured with a string to the Mast-1; place the string 10 to 15 cm above the manchet;

3) the two masts are secured to each other with a string; place the string near the impedance matching unit;

4) hold the antenna by hand, and remove (loosen) the lower end of the pyro wire from Support-3 and remove the wire, or alternatively cut the pyro-wire with the wire cutter (in the latter case the pyro must first be removed, see section 4.12);

5) let Mast-1 (with Mast-2 tied to it) slowly deploy; keep supporting the antenna by hand;

6) remove the string that hold the two masts together, and let Mast-2 deploy; keep supporting the whole antenna structure by hand;

7) remove the string that hold the reflectors, and let them deploy until they lock-in;

8) place the 'holding-bracket' that bridge the Carpenter-Spring-1; the bracket connects Support-1 to Mast-1;

9) remove the string that hold the dipoles, and let them deploy until they lock-in;

10) place the 'holding-bracket' that bridge the Carpenter-Spring-2; the bracket connects Mast-1 to Mast-2.

For this procedure we require the following:
- three pieces of string, each of about 50 cm length

5. Folding the deployed antenna

The starting position of the antenna before folding, is the deployed antenna with or without 'holding-bracket's, or balloon and 'deployment-bracket'.

Before starting to fold the antenna a new pyro wire must be availabe. Alternatively, prepare a pyro wire as follows:
– Cut a piece of pyro wire of length 250mm;
– Mount a cable assembly on one end of the wire;
– Mount a cable assembly on the other end of the wire so that the (inner) distance between the cable assemblies is 217mm;
– Remove the pyro;

Step-by-step procedure for folding the antenna on the spacecraft:

1) if the pyro has been used then disconnect the spacecraft system from the pyro connectors JA2 and JA3;

2) if needed remove the 'holding-bracket's that bridge Carpenter-Spring-1 and Carpenter-Spring-2 between the two masts; support the antenna by hand;

3) fold the reflector elements along the Mast-1, and secure the elements with a string placed about 15 cm above the manchet .
To fold the reflector elements: pull the locking string at the end of the reflector carefully to unlock the reflector (unlock the pin); keep pulling while the folding of the reflector;

4) Carpenter-Spring-1 at Support-1 is bend, and the antenna placed (hold by hand) against the Support-2, -3, and –4. Make sure the tip of the reflector elements are placed inside Manchet-1.

5) fold the dipole elements along Mast-2, and secure the elements with a string placed about 15 cm above the manchet.
To fold the dipole elements: pull the locking string at the end of the dipole carefully to unlock the dipole (unlock the pin); keep pulling while the folding of the dipole;

6) fold Carpenter-Spring-2 between the two masts, and place the two masts parallel together; keep supporting the whole antenna structure by hand. Make sure the tip of the dipole elements are placed

inside Manchet-2. Also, make sure that the pin at the top of Mast-2 is placed in the corresponding hole in Manchet-1.

7) secure the two masts together with a string; keep supporting the whole antenna structure by hand;

8) the pyro-wire is inserted and fastened. Starting from the top-hole on Support-3 threat the prepared pyro wire in place; where the cable assembly emerges from the lower-hole on Support-3, place the pyro wire with assembly in the tigthening-unit, and pre-tension the tightening-unit;

9) the string holding the folded antenna together is removed, and the antenna with dipole- and reflector elements placed (by hand) in the correct positions, and the pyro wire is tightened;

10) the strings that hold the dipole- and reflector elements are removed;

11) after making sure that the antenna is placed correctly, the pyro wire is tightened with the tightening-unit to the nominal pull of 45N;

12) remove ‘string attachment’ if no longer used;

13) the pyro may be left out or re-installed (with safety plugs) (see section 4.1.2) according to future plans.

14) install the safety harness.

For this procedure we require the following:
– 10 prepared pyro wires.

6. Safety aspects.

Safety has to be observed in two aspects of the antenna:
– pyro;
– unintentioned deployment (for example through a 'break' of the pyro wire);
– Mishandling: one or several elements “escape” from hands.

6.1 Pyro

It must be assured that the explosives in the pyro only are activated when wanted. When there is no intend to use the pyro, the cable from the spacecraft to antenna connectors JA2 and JA3 should be disconnected.

6.2 Safety harness

When the antenna is not being operated in any way, it should be in the folded position, and in addition be secured with a safety harness against the possibility of an unintended deployment. This safety harness will have the form of 2 strings attaching the masts to Support-2 and Support-4. Each string will have a 'red tag'.

Figure captions

Figure 1: The CONSERT orbiter antenna on the spacecraft. The antenna is shown in the folded position. Note the two masts and several thin rods (the dipole- and reflector elements), which all are folded parallel to each other. Note also the four supports which fixes the antenna to the spacecraft, and serves to keep the folded antenna in position.

Figure 2: The folded antenna with the major parts named.

Figure 3: The deployed antenna fastened to Support-1 with the major parts named. The Carpenter Springs are not visible because they are covered by the Manchets.

Figure 4: Shown is the part of the spacecraft on which the antenna is located. The part of space which must be free of obstacles during deployment of the antenna is defined by the cube. The cube's location is given relative to Support-1. All dimensions are in centimeters.

Figure 5: The antenna connected to 'deployment bracket' and crane-hook for the purpose of testing the deployment mechanism using gravity assist. The ‘string attachment’ is mounted at the end of Mast-1.
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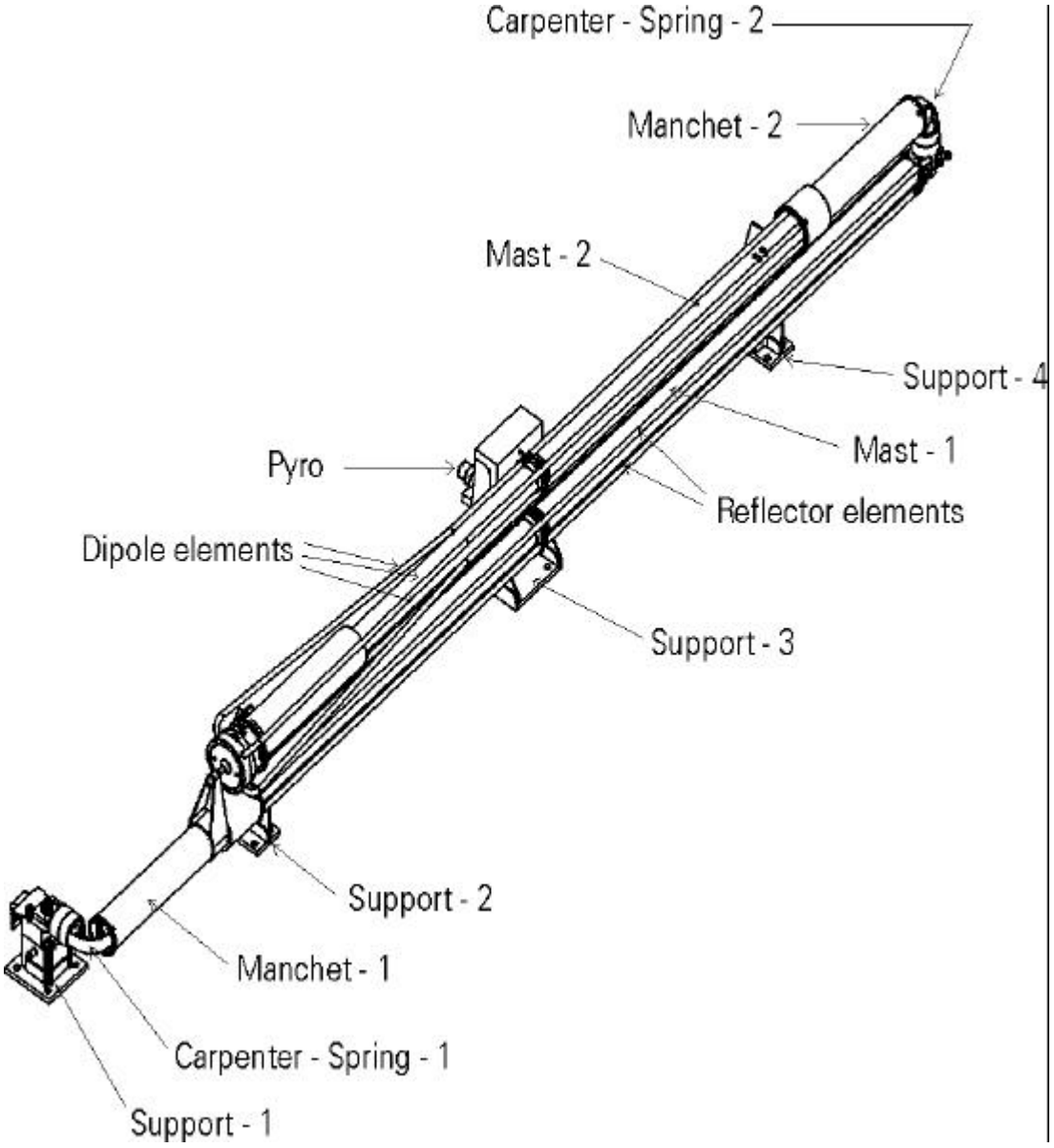

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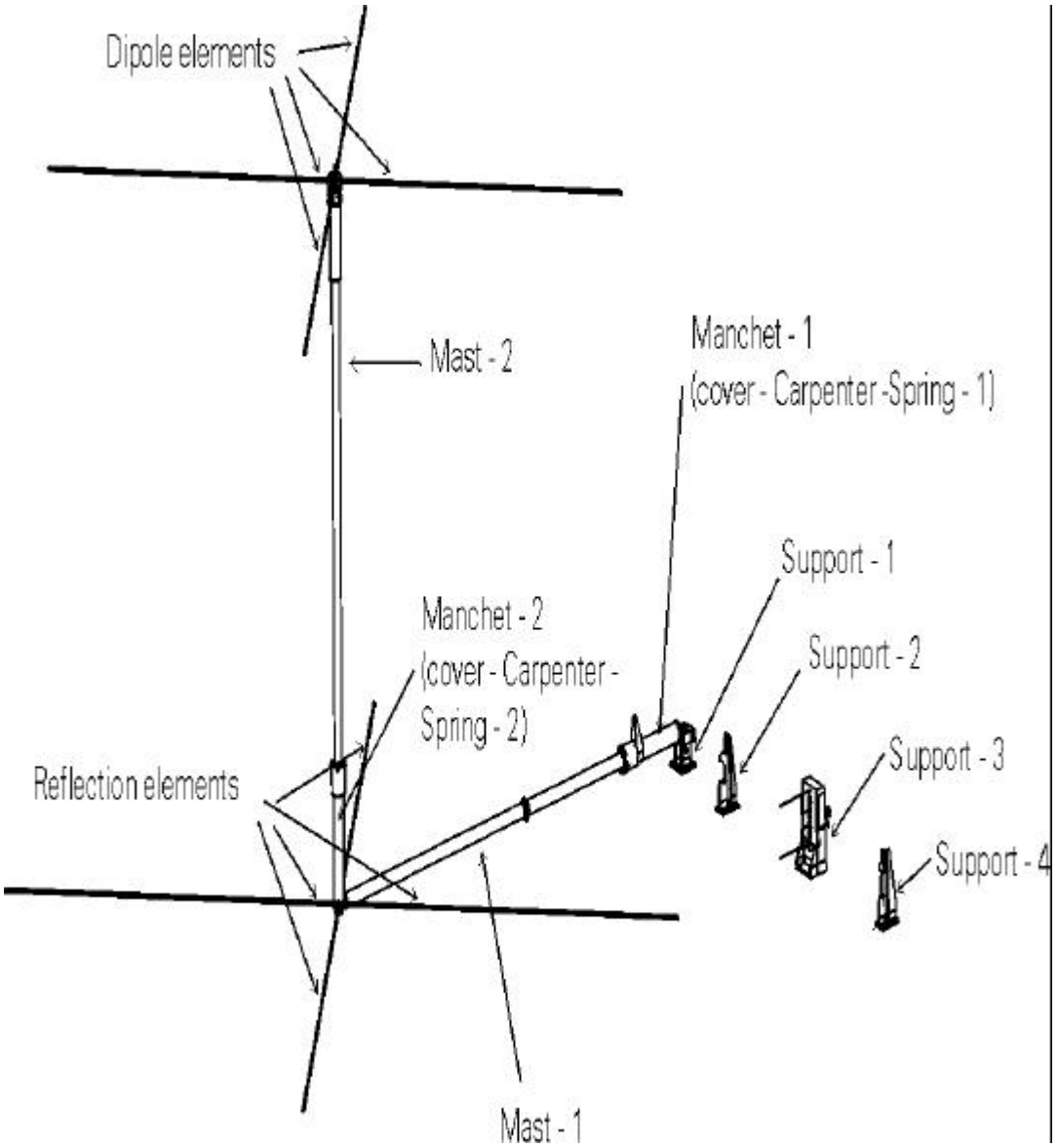

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