X-WING SATCOM ANTENNA

Construction Guide — Functional replica of the L3Harris 12006-9001-01 antenna using 3D printed parts

Figure 1: Assembly Model 1 with base plate, enclosure with socket, Ø32 mm tube, and head_v2 with aluminum strip elements.

> **Overview:** Crossed dipole (turnstile) antenna for the UHF SATCOM band, designed for a center frequency of 280 MHz.

1 Description and Variants

The antenna consists of two crossed half-wave dipoles (4 horizontal arms forming an X-shape) mounted on a Ø32 mm tube above the ground, which acts as a reflector. The design is based on the L3Harris 12006-9001-01 vehicle antenna (225–400 MHz, max. height 28.7 cm, tip-to-tip wing span 48.8 cm).

The STL model set provides two base options and two head options:

Assembly	Parts	Purpose / Description
Model 1 — Portable	`base_square` + `base_square_top` + `head_v1` / `head_v2`	Standalone base with an enclosure containing a BNC connector and space for phasing. The base plate features pockets for neodymium magnets, suitable for mounting on a vehicle hood.
Model 2 — Flanged	`base_flange` + `head_v1` / `head_v2`	A Ø100 mm flange to be screwed directly to a mounting surface. Features a set screw to lock the tube; the cable passes through a hole without a connector.

The heads are interchangeable: `head_v1` is designed for elements made from a 25 mm wide steel tape measure (thin curved slot, 0.4 mm thickness), while `head_v2` is designed for flat aluminum strips (slot width approx. 24 mm, thickness approx. 1.6 mm, such as door threshold profiles from a hardware store).

2 Printed Parts — Main Dimensions

Part	Dimensions (mm)	Notes
base_square	160 × 110 × 15	Base plate; 4 feet Ø20 × 5; 4 pockets (15 × 15 mm) for neodymium magnets (accessible from top).
base_square_top	127 × 77 × 60	Enclosure with 3 mm wall thickness and a tube socket (Ø32.2 hole, 57 mm depth); 4 corner holes Ø6 with a spacing of 111 × 61 mm; side hole Ø12.7 mm for BNC connector.
base_flange	Ø100 × 5, collar h. 40	Through-hole Ø32.2; 4 × Ø4 holes on a Ø70 mm pitch circle for surface anchoring; radial Ø6 hole for tube locking; radial Ø8 hole for cable pass-through without a connector.
head_v1	Ø80 × 31	Socket for Ø32 mm tube (insertion depth approx. 30 mm); 4 curved slots for 25 mm tape measure strips; each arm contains a Ø4.1 hole with a Ø8.2 counterbore from the bottom (M4 nut + bolt).
head_v2	Ø90 × 33	Socket for Ø32 mm tube (insertion depth approx. 28 mm); 4 slots for aluminum strips; each arm has 2 holes with a Ø7.1 counterbore from the top and a Ø3.1 pilot hole for plastic screws.

3 Electrical Design for 280 MHz

Wavelength $\lambda = 299.79 / 280\ MHz = 1071\ mm$.

The arms are quarter-wave elements with a velocity/shortening factor of ~ 0.95 due to the wide, flat geometry of the elements.

Since the elements do not extend completely to the central axis of the head, and the support tube is inserted deep into the base socket, the values below are approximate. The critical parameters are the total tip-to-tip span and the height of the elements above the ground reflector, which should be verified on the actual printed assembly.

Parameter	Value (approx.)	Note
Dipole span (tip-to-tip)	505 mm	Critical dimension. Cut elements with a margin (approx. 260 mm each) and shorten symmetrically after assembly to match the target span and optimize SWR.
Length of one element	≈ 255 – 265 mm	Total length of the tape/strip including the section inside the head slot; adapt to the printed head.
Element material (head_v2)	Al strip ~24 × 1.5 mm	4 pieces; flat, mounted horizontally.
Element material (head_v1)	Tape measure 25 mm	4 pieces; spring steel, mounted horizontally.
Element height above ground ($h = \lambda/4$)	≈ 270 mm	Maximum radiation towards the zenith — corresponds to the original (28.7 cm) when mounted on a vehicle roof.
Element height above ground ($h = \lambda/2$)	≈ 540 mm	Maximum radiation at ~30° elevation — ideal for geostationary UHF satellites received from Central Europe (elevation 25–35°).
Ø32 mm Tube — Total Length	≈ 250 – 300 mm / ≈ 500 – 550 mm	Depending on the selected height h; calculate based on actual assembly (base insertion approx. 57 mm, head insertion approx. 28–30 mm, plus base height).

4 Circular Polarization (RHCP) — Phasing

The two crossed dipoles must be fed with a $90°$ phase shift. Two reliable methods can be used:

- **Variant A — $\lambda/4$ Phasing Line:** Both dipoles are cut to the exact same length. The second dipole is connected through an electrical quarter-wavelength section of coaxial cable (RG-58, velocity factor 0.66). The phasing line length is 177 mm; the span of both dipoles is ≈505 mm.
- **Variant B — Self-Phased Turnstile:** Eliminates the phasing line by making one dipole ~5% longer (inductive) and the other ~5% shorter (capacitive). They are connected in parallel directly at the head or enclosure. The span of the longer dipole is ≈530 mm, and the shorter is ≈480 mm.

The impedance of the crossed dipole is approximately 36 Ω, typically resulting in an SWR below 1.5 when matched to a 50 Ω system, which is excellent for monitoring and experimental purposes. The polarization sense (RHCP/LHCP) depends on which dipole the phasing line is connected to; if the polarization is inverted, simply swap the connections to one of the dipoles.

5 Bill of Materials — Model 1 (Portable)

Item	Description	Qty	Notes
1	3D Printed parts: `base_square`, `base_square_top`, `head_v2` (or `head_v1`)	3	PETG or ASA recommended for outdoor longevity.
2	Ø32 mm Tube (Aluminum 32×2 or rigid PVC/conduit)	1	Total length approx. 250–300 mm ($h \approx \lambda/4$) or 500–550 mm ($h \approx \lambda/2$) — measure to fit.
3	Element material: Al strip ~24 × 1.5 mm, length ≈260 mm	4	For `head_v1`, use 25 mm steel tape measure instead. Target final span ≈505 mm.
4	Plastic screw 3 × 10 mm (max head Ø7 mm)	8	2 pcs per arm (for `head_v2`); drill Ø3.5 mm holes in the strips matching the head.
5	M4 × 12 Bolt + M4 Nut (for `head_v1`)	4+4	Nut fits into the Ø8.2 mm pocket under the arm; drill Ø4.5 mm holes in the tape.
6	Screw/Bolt for corner enclosure holes (Ø6 mm)	4	E.g., 4 × 40 mm screws; verify length based on the printed enclosure.
7	Panel-mount BNC female connector (for Ø12.7 mm hole)	1	Mounted on the side wall of the enclosure.
8	RG-58 Coaxial cable for phasing section (Var. A)	~0.3 m	Electrical $\lambda/4 = 177$ mm (Velocity Factor 0.66).
9	Neodymium magnets 15 × 15 mm	4	Optional, fits into the base plate pockets.
10	Consumables: wires, heat-shrink tubing, cable lugs, cyanoacrylate glue	-	As required for wiring and assembly.

6 Bill of Materials — Model 2 (Flanged)

Item	Description	Qty	Notes
1	3D Printed parts: `base_flange` + `head_v1` or `head_v2`	2	PETG or ASA recommended.
2	Ø32 mm Tube, length according to desired height	1	Through-hole design allows the tube to extend down to the mounting substrate.
3	M4 Anchoring screw/bolt	4	For mounting the flange (4 × Ø4 holes on a Ø70 mm pitch circle). Flange thickness is 5 mm.
4	Locking screw/bolt for radial Ø6 mm hole	1	Secures the tube against rotation and sliding.
5	Elements and fasteners	4	See items 3–5 from the Model 1 Bill of Materials.
6	Coaxial cable feed	-	Direct output through the radial Ø8 mm hole without a connector (or using a grommet).

7 Assembly Procedure

1. **Print the components:** Print the parts for your chosen configuration. Ensure that the Ø32 mm tube fits into the base socket and head with slight resistance; lightly sand or file the printed openings if necessary.
2. **Prepare the elements:** Cut the elements to approximately 260 mm (for Variant B: cut two to ~273 mm and two to ~248 mm). Insert them fully into the head slots, then mark and pre-drill the mounting holes through the printed guides: `head_v2` → Ø3.5 mm (2 holes per element), `head_v1` → Ø4.5 mm (1 hole per element).
3. **Mount the elements:** For `head_v2`, secure the aluminum strips using 3 × 10 mm screws. For `head_v1`, use M4 × 12 bolts with nuts seated in the bottom pockets. The mounting hardware also provides electrical contact — ensure the mating surfaces are completely clean and free of oxidation.
4. **Wiring:** Connect opposite arms together to form two separate dipoles, and connect the phasing assembly as described in Section 4. Route the feedlines down through the center of the tube into the enclosure (Model 1) or out through the Ø8 mm collar hole (Model 2).
5. **Base assembly:**
    - *Model 1:* Install the BNC connector into the side wall. Secure the enclosure to the base plate using 4 screws. Optionally, glue the neodymium magnets into the feet pockets, paying careful attention to keep the magnetic poles oriented identically.
    - *Model 2:* Secure the flange to the mounting surface using 4 × M4 screws and lock the tube in place using the radial set screw.

- **Final adjustments:** Push the tube fully into the base socket and the antenna head. Set the element height above the ground plane according to Section 3 (***≈270 mm*** for overhead zenith optimization, ***≈540 mm*** for a ***~30°*** elevation angle).
- **Tuning:** Measure the SWR in your target frequency range. Symmetrically trim the ends of the elements by approx. 5 mm at a time until the final tip-to-tip span is ≈505 mm. Because flat, wide elements inherently feature a wide bandwidth, fine-tuning is highly forgiving.

8 Notes

- All specified lengths for elements and tubes are approximate overall dimensions. The 3D models do not extend the elements fully to the center axis, and the tube occupies space inside the sockets. Always verify and tailor dimensions on your specific physical build.
- The UHF SATCOM band (downlink 243–270 MHz) is highly popular in Central Europe for monitoring and experimental reception. Transmission is strictly limited to the bands and conditions authorized by your local telecommunications authority (e.g., ČTÚ).
- The original commercial antenna features arms slightly canted downwards to achieve a broader circular polarization pattern and improved impedance matching. This simplified DIY design maintains horizontal elements, which performs excellently for fixed, permanent stations.
- Dimensions of the printed components were verified directly from the STL files. Electrical design optimized for 280 MHz. Reference specifications taken from the L3Harris 12006-9001-01 technical datasheet.