GENERAL DYNAMICS
SATCOM Technologies

ASSEMBLY, OPERATION
and
MAINTENANCE MANUAL
for

Model 8.1 and 9.0-Meter Standard Travel
Kingpost Satellite Earth Station Antenna

600-0045

Revision D
June 7, 2010

SATCOM Technologies
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REV.	DESCRIPTION	DATE	WRITER	CHK.	APPR.
D	EC 10-0596 Revised polarization gearbox requirements in Figure 3-4b	6/7/10	LRB	SPK	LJI
C	EC 10-0585 Revised gearbox oil requirements in Figure 3-4b	6/2/10	LRB	SPK	LJI
B	EC 10-0436	4/19/10	CMC	SPK	LJI
A	Revised to include 9.0M, 3.4, 3.5 and added fig. 3.4b	11/1/91	--	WCM	JP
N/C	Original release	9/10/91	--	DLP	JP

Use of *WARNINGS,* CAUTIONS, etc.

Warnings, Cautions and other notes are included throughout this document to provide necessary information. IGNORING WARNINGS, CAUTIONS AND OTHER NOTES MAY RESULT IN DAMAGE TO THE PRODUCT, INJURY, OR IN EXTREME CASES, DEATH. You should know the use of Warnings, Cautions and other markings. Definitions are:

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- Always tag all circuits noting that the power is OFF, the date and your name, prior to commencing any work on that system.

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The antenna limit switches and resolvers have been pre-set to allow for maximum antenna performance. Any subsequent adjustment may jeopardize antenna performance and/or result in damage to the antenna.

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ALWAYS WORK SAFELY!

TABLE OF CONTENTS

1.0 INTRODUCTION

The Satcom Technologies 8.1/9.0-meter kingpost antennas couple outstanding performance with mechanically superior rigid structural design. The Satcom Technologies 8.1 or 9.0-meter antenna is ideal for the broadcast industry's television and audio uplinks and downlinks and for private and corporate voice and data network earth stations. The Model 8.1 and 9.0-meter antennas feature all aluminum reflectors and a steel kingpost pedestals for adjustable positioning toward any visible satellite.

The purpose of this manual is to provide information for the operation and maintenance of the Model 8.1/9.0 kingpost basic antennas. Each basic antenna consists of the pedestal assembly, reflector assembly, elevation and azimuth drive assembly, and a feed system. Should any repair or maintenance problems arise which are not discussed within this manual, such problems should be referred to the equipment manufacturer:

General Dynamics SATCOM Technologies Customer Service Department
2600 N. Longview Street
Kilgore, Texas 75662
903-984-0555

A listing of antenna components and characteristics are included, followed by various operation and maintenance procedures and vendor catalogs, where applicable.

Refer to preceding Table of Contents to locate section(s) describing operational or maintenance information required.

2.0 ANTENNA COMPONENTS AND CHARACTERISTICS

2.1 General. This section lists a brief general description of the antenna system. More detailed operation and maintenance instructions are covered in subsequent sections. All pertinent antenna system drawings are with the print pack supplied at time of shipment.

2.2 Pedestal Assembly. A two-axis elevation-over-azimuth kingpost pedestal is used to accurately position the RF axis of the antenna.

2.3 Reflector Assembly. The 8.1 or 9.0-meter diameter modified paraboloid reflector is constructed from 16 high accuracy panels and is combined with a high performance cassegrain feed system to give maximum efficiency with low sidelobes.

2.4 Elevation Drive Assembly. Basic characteristics of the elevation drive assembly:

a. Worm gear screw jack: Joyce-Dayton Model AWJ820
   * Capacity: 20 Tons
   * Ratio: 16 revolutions of the input shaft for 1 inch of jack extension or retraction
   * Jack stroke: 59 inches with rod end and stop sleeve installed
   * Travel limits: External stop nut attached to end of jack screw

b. Gearmotor (Optional--Motorized)
   * Reference the Motorization System O&M manual for description.

2.5 Azimuth Drive Assembly. Basic characteristics of the azimuth drive assembly:

a. 8.1M-Worm gear screw jack: Joyce-Dayton Model AWJ 1125
   * Capacity: 25 tons

   9.0M-Worm gear screw jack: Joyce-Dayton Model AWJ 1135
   * Capacity: 35 tons

   8.1/9.0M
   * Ratio: 16 revolutions of the input shaft for 1 inch of jack extension or retraction
   * Jack stroke: 75 inches with rod end and stop sleeve installed
   * Travel limits: External stop nut attached to end of jack screw

b. Gearmotor (Optional--Motorized)
   * Reference the Motorization System O&M manual for description.

2.6 Reflector Backup Structure. The reflector backup structure is comprised of 16 aluminum radial rib trusses emanating from a center hub structure. Interconnecting hoop members are provided to furnish the structure with maximum stiffness capability. The truss work on the rear of the reflector is provided to eliminate surface distortion, which may result from dead weight deflections of the supporting members causing rotations at the panel supports.

2.7 Reflector Panels. Sixteen trapezoidal aluminum reflector panels are provided with each reflector. The panels are designed to meet the stiffness and load requirements for the overall specification. The panels will support, without permanent deformation of surface accuracy, a 300-pound(136 Kg) soft-bottom shoe load.

2.8 Subreflector Support Assembly. The subreflector support structure consists of four spars fastened together by an apex assembly to form a space truss protruding from the main reflector backup structure. The spars have been structurally optimized to minimize the R.F. blockage and relative displacements between the subreflector, feed launcher and main reflector axis. A factory-aligned mounting plate is provided as part of the apex assembly so that precise apex alignment is not required in the field. If necessary, subreflector alignment may be made by adjustments relative to this apex structure.

2.9 Material Finishes.

2.9.1 **Aluminum Structure.** The aluminum reflector structure portion of the Satcom Technologies satellite antenna includes the following components:

a. Panels

b. Radial trusses

c. Hub

d. Radial interconnect lacing

e. Torsional lacing

f. Subreflector apex mount and legs

The panels' top surface have been cleaned, painted to a thickness of 2.5-3.0 mils, and baked dry leaving an average thickness of 1.5 mils. Paint is Gillespie Flat White #707-701. The radials and hub have been cleaned and brightened.

Warning! *High or semi-gloss paint should never be used on panel faces or on the subreflector surface.*

The remainder of the aluminum structure has one coat of white semi-gloss to maintain the new appearance. This paint is Gillespie Semi-Gloss White #709.

2.9.2 **Steel Structure.** The steel structure of the Satcom Technologies Kingpost pedestal antenna includes the following:

a. Kingpost pedestal

b. Front support legs

c. Jack drive assemblies

d. Pivot bearing blocks

e. Jack pivot bearing blocks

f. Ladders and platforms (Optional)

With the exception of the optional ladders and platforms which are hot-dip galvanized, each of these structural components is normally sandblasted, primed with Gillespie Red Oxide #101, and given a final finish of Gillespie #13-587 General Dynamics SATCOM Technologies Gray. As an option, any of these components may be provided with hot-dip galvanized finish.

3.0 RECOMMENDED MAINTENANCE SCHEDULES AND PROCEDURES

3.1 Pedestal/Reflector Assembly Protective Finish. The pedestal/reflector assembly should be inspected on a regular basis and should be maintained as follows:

a. Accumulations of dirt and/or grease shall be removed using a solution of hot water and detergent. Following cleaning, rinse with clear water.

b. Damaged or deteriorated surface finishes shall be repaired as follows:

3.1.1 Reflector Backup Structure.

a. Clean thoroughly using a solvent for greasy areas; hot water and detergent for dirt accumulations.

b. Wire brush to remove oxides.

c. Wipe down area using clean rag and acetone (Exercise caution, as acetone is a dangerous substance).

d. Apply primer (See Section 2.9).

e. Apply semi-gloss white paint (See Section 2.9).

3.1.2 Reflector Surface Panels (Painted Aluminum).

a. Lightly sand damaged area.

b. Apply one coat of zinc-chromate primer (See Section 2.9.).

c. Apply two coats of flat white paint (See Section 2.9).

3.1.3 Miscellaneous Painted Steel Components.

a. Remove dirt, grease and/or rust.

b. Apply one coat of red oxide #101 (See Section 2.9.).

c. Apply two coats of #13-587 General Dynamics SATCOM Technologies Gray (See Section 2.9.).

3.2 Assembly Hardware. Assembly hardware shall be visually inspected. Frequency of inspection is optional. Any hardware which appears to be loose shall be tightened in accordance with AISC specification for structural joints.

3.3 Foundation Anchor Bolts (And Other Galvanized Steel). Deteriorated surface finish on protruding anchor bolts and other galvanized steel shall be repaired as follows:

a. Clean thoroughly using a solvent for greasy areas; hot water and detergent for dirt accumulations.

b. Wire brush to remove rust and oxides.

c. Apply a coat of a cold galvanizing type paint (either aerosol or liquid).

3.4 Lubrication Schedule. Table 3.4 identifies the items on the antenna, which require lubrication. Refer also to the installation assembly drawings and figure 3.4b for locations requiring lubrication.

Table 3-4. Lubrication Schedule

ITEM	FREQUENCY	LUBRICANT	REMARKS
1. Screw Jack Housing	Norm. Oper. Once per month. Severe Oper. Twice/month	Mobil SHC PM460 Grease	Grease fitting on head of jack--2 places. See Section 3.5 for additional remarks.
2. Elevation Bearings	Every 2 Months	Mobil SHC PM460 Grease	Grease fitting on pedestal elevation lug--1 place each side
3. Azimuth Bearings	Every 2 Months	Mobil SHC PM460 Grease	Grease fittings on azimuth axis bearing housing--2 each per upper and lower bearing
4. Azimuth Rod End Bearing	Every 2 Months	Mobil SHC PM460 Grease	Grease fitting on end of rod end
5. Elevation Rod End Bearing	Every 2 Months	Mobil SHC PM460 Grease	Grease fitting in hub jack lug
6. Jack Screws	Every 2 Months	Mobil SHC PM460 Grease	During periodic maintenance, jack screw boots are to be removed and the screws lubricated as described in Section 3.5.

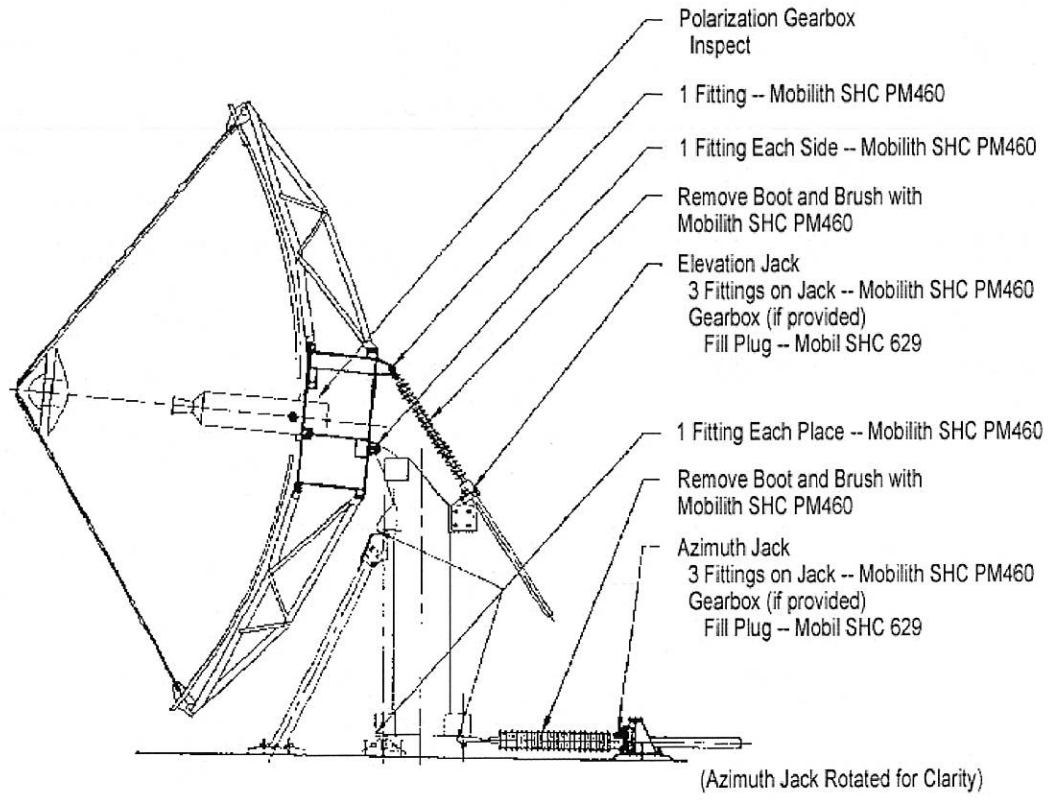

Figure 3-4b. Antenna Lubrication Points

3.5 Jacks And Gearboxes. The gearing in the machine screw jacks, Item 1, is lubricated with Mobil SHC PM460 grease. For normal operation, jacks should be greased at least once a month. Under severe use, (i.e. steptrack operation on one satellite or many changeovers between satellites daily) jacks should be greased twice a month. There are two (2) grease fitting locations on each wormscrew jack--one on the sleeve cap, and one on the worm shaft housing. Refer to the jack grease capacity chart in Section 3.4 for the proper amount of grease to use when relubricating the jacks. It is recommended that the worm screw be driven in and out of the jack housing (12") during lubrication to insure proper lubrication.

Table 3-5. Jack Grease Chart

JACK SIZE	APPLICATION	GREASE CAPACITY SHOTS	GREASE CAPACITY WEIGHT	* RELUBRICATION AMOUNT SHOTS	* RELUBRICATION AMOUNT WEIGHT
5 TON	3.5 METER	26 SHOTS	13 OZ.	3 SHOTS	1.5 Oz.
10 TON	4.6M/6.1M El.	50 SHOTS	25 Oz. or 1# 19 Oz.	5 SHOTS	2.5 Oz.
20 TON	6.1M Az./7.2M El. 8.1M El./9.0M El.	105 SHOTS	52.5 Oz. or 3# 4.5 Oz.	10 SHOTS	5 Oz.
25 TON	7.2M Az./8.1 Az.	140 SHOTS	70 Oz. or 4# 6 Oz.	10 SHOTS	5 Oz.
35 TON	9.0M Az./11M El.	140 SHOTS	70 Oz. or 4# 6 Oz.	10 SHOTS	5 Oz.
50 TON	11M Az./13M Az. & El.	275 SHOTS	137.5 Oz or 8# 9.5 Oz.	15 SHOTS	7.5 Oz.
75 TON	15M/18M	400 SHOTS	200 Oz. or 12# 8 Oz.	15 SHOTS	7.5 Oz.
100 TON	21M	800 SHOTS	400 Oz. or 25#	15 SHOTS	7.5 Oz.

*** Each grease fitting**

Warning! *Do not mix greases*

The exposed jack screw should be coated with a thin coating of the Mobil SHC PM460 grease. The grease should be thinned with a petroleum based solvent and painted on with a paint brush so that a film of at least .03 inches remains on all exposed surfaces of the jack screw. The gearmotor (if supplied) lubrication levels should be checked at least every two months and new lubricant should be added as necessary. See lubrication schedule, for proper lubricant for the gearmotor provided.

Jack Boot Lubrication:
The antenna drive jack boot life can be extended with a monthly coating of "ARMOR-ALL", a product of Armor-All Products Corporation, Viejo, Calif., or another vinyl protectant. It is available at most auto and large chain stores.

3.6 Bearing Lubrication. The following paragraphs describe the function, location, and lubrication of the remaining moving mechanisms of the antenna system, which requires lubrication.

The bearings used on the pedestal assembly are the elevation axis bearings (2), the azimuth axis bearings (2), and the elevation and azimuth drive jack rod end bearings (1 each assembly). Bearings should be lubricated at least every two months. Be sure that all dirt is cleaned off grease fittings and inject Mobil SHC PM460 grease, using a conventional pump-type grease gun.

3.7 Elevation Axis Bearings. The reflector is attached to the pedestal at the elevation axis through two self-aligning spherical bushings.

The elevation axis grease fittings are located on the elevation lugs protruding from the pedestal assembly. A drilled and tapped hole is provided on each lug, and each is fitted with a grease nipple.

3.8 Azimuth Axis Bearings. The azimuth axis of the antenna is defined by two bearings located in a vertical line on the front side of the pedestal. These are self-aligning spherical bushings similar to the two used for the elevation axis.

The azimuth axis bearing grease fittings are located on the sides of the azimuth axis bearing housing assemblies at the base and top of the pedestal steel tube.

3.9 Drive Assembly Bearings. A spherical bushing is used at the end of the elevation jack drive assembly to provide pivoting action at this point. A spherical bushing is used likewise at the end of the azimuth jack drive assembly.

The azimuth drive assembly bearing grease fitting is located on the end azimuth jack rod end. The elevation drive assembly bearing grease fitting is located on the hub jack lug.

3.10 Lightning Protection (Optional). When requested, lightning rods are provided on the subreflector apex assembly and the top radial beam. The elevation and azimuth axis bearings are protected by ground cables looped from reflector to pedestal and from pedestal to perimeter ground. The lightning rods, ground cables, and ground rods must be checked periodically to insure continuity of conductance (good metal-to-metal contact) to prevent damage to bearings during electrical storms.

4.0 VENDOR PUBLICATION

Contact General Dynamics SATCOM Technologies sales department for information regarding purchase, replacement and/or special servicing of OEM components.

4.1 Screw Jacks. The following is information for the screw jacks. The drive jacks of the elevation and azimuth axes have the following characteristics:

4.1.1 Elevation Axis:

a. Type--Worm gear, machine screw jack Joyce-Dayton Model AWJ820.

b. Rated Capacity--20 tons

c. Jack Ratio--16 turns of input shaft for one inch of jack extension or retraction

d. Stroke--59 inches with rod end and stop sleeve installed

e. Travel Limits--External stop nut attached to the end of the jack screw

4.1.2 Azimuth Axis:

a. 8.1M Type--Worm gear, machine screw Joyce-Dayton Model AWJ 1125.
9.0M Type--Worm gear, machine screw Joyce-Dayton Model AWJ 1135.

b. 8.1M Rated Capacity--25 tons
9.0M Rated Capacity--35 tons

c. Jack Ratio--16 turns of input shaft for one inch of jack extension or retraction

d. Stroke--75 inches with rod end and stop sleeve installed

e. Travel Limits--External stop nut attached to the end of the jack screw

5.0 WARRANTY

SATCOM Technologies warrants the items ordered hereunder at the time of shipment to be free from defects in material, workmanship, and to conform to the contract specification. SATCOM Technologies' liability under this Warranty shall terminate one (1) year after date of acceptance or eighteen (18) months from the date of shipment, whichever comes first. Some individual products include extended warranties as stated in brochure(s) and extended warranties may be purchased as requested and quoted. Written notice of any defects shall be given SATCOM Technologies upon discovery and SATCOM Technologies shall promptly correct such defects by repair or replacement, at its option, without charge, either FCA SATCOM Technologies' plant or service in the field.

IN NO EVENT SHALL SATCOM TECHNOLOGIES' LIABILITY UNDER THIS WARRANTY EXCEED THE COST OF REPAIR OR REPLACEMENT OF SUCH DEFECTIVE ITEM AND UNDER NO CIRCUMSTANCES SHALL SATCOM TECHNOLOGIES BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Specifically excluded from this Warranty are:

a. Defects or nonconformance caused by and resulting from improper operation, maintenance, or storage of the equipment.
b. Items of characteristically indeterminate life, such as bulbs, fuses, etc.

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6.0 ANTENNA SYSTEM DRAWINGS

See print pack.

GENERAL DYNAMICS
SATCOM Technologies

FIELD INSTALLATION SEQUENCE

6.1, 7.2, 8.1, 9.0-METER
KING POST ANTENNA

(120° AZIMUTH TRAVEL)

500-0300

Revision C
January 19, 2000

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C	ECR# 99-1046	1-19-2000	KAT	KAT	BBB
B	ECR# 98-1253	12.28.98	BBB	BBB	JAP
A	ORIGINAL RELEASE	09/27/96	H.L.A.	MLS	KDR
REV.	**DESCRIPTION**	**DATE**	**WRITER**	**CHECK**	**APPR**

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1.0 SCOPE

This procedure defines the sequence for assembly and erection of a General Dynamics SATCOM Technologies kingpost type antenna system. This installation sequence describes a logical procedure for the erection of the antenna. The sequence described assumes that adequate skilled laborers are available to perform some tasks in parallel and that the crane is capable of lifting the loads the required distances. The sequence described is not a rigid procedure and may be changed at the discretion of the field engineer or installation supervisor.

2.0 APPLICABLE DOCUMENTS & DRAWINGS

The following documents and drawings form a part of this specification:

500-0320	General Reflector Alignment Procedure
500-0231	Encoder Installation Alignment
300-2492	Procedure to Secure Couplings
300-1039	Reflector Panel Paint Specification
300-2436	Grout Installation Procedure
400-0429	Kingpost Pedestal Alignment Procedure
400-0430	Bolt Tightening Specification
400-0428	Panel Trim Procedure
500-0322	6.0, 7.2, 8.1, or 9.0 Tool List
900-0255	Antenna System Installation Checklist

Antenna System Drawings:
Antenna Assembly
Foundation Installation
Feed and LNA Installation
Control/Electrical Installation
Utility Electrical Installation
Azimuth Limit Switch Installation (if applicable)
Elevation Limit Switch Installation (if applicable)
Lightning Rod Installation (if applicable)
Azimuth Resolver and Vernier/Protractor Installation
Elevation Resolver and Vernier/Protractor Installation
Hub Assembly
Reflector Assembly
Ladder and Platform Installation
Elevation Drive Assembly
Azimuth Drive Assembly
Az Motorization Kit (if applicable)
El Motorization Kit (if applicable)

2.1 Calibration

INSTRUMENT / MODEL	SERIAL NUMBER	CAL. DATE	CERTIFICATE / BY	GOOD FOR

3.0 EQUIPMENT DESCRIPTION & WEIGHT SUMMARY

This section defines the special machinery, tools and instruments necessary to accomplish the field installation of the antenna. The equipment needs of the applicable procedures shall be determined and provided with the specific equipment needs of this Field Installation Sequence.

3.1 Equipment Needed. Cranes

TASK	6 METER		7 METER		8 METER		9 METER	
	SIZE	BOOM	SIZE	BOOM	SIZE	BOOM	SIZE	BOOM
OFFLOAD, BUILD PEDESTAL AND REFLECTOR	10 TON	45 FEET	7 TON	45 FEET	10 TON	45 FEET	10 TON	45 FEET
LIFT AND POSITION PEDESTAL	10 TON	45 FEET	7 TON	45 FEET	10 TON	45 FEET	10 TON	45 FEET
LIFT AND POSITION REFLECTOR	10 TON	65 FEET	10 TON	65 FEET	18 TON	70 FEET	18 TON	70 FEET
LIFT AND POSITION REFLECTOR (DEICED)	10 TON	65 FEET	12 TON	65 FEET	25 TON	70 FEET	25 TON	70 FEET
LIFT AND POSITION FEED	7 TON	45 FEET	7 TON	45 FEET	7 TON	45 FEET	7 TON	45 FEET
ADJUST SUBREFLECTOR	30' MANLIFT		30' MANLIFT		30' MANLIFT		30' MANLIFT	

The above table assumes unrestricted access to foundation on flat compacted surface. Any other condition will require on-site crane sizing.

3.2 Equipment.

3.2.1 General Dynamics SATCOM Technologies specification 500-0322 contains a general list of hand tools needed for assembling this antenna.

3.2.2 General Dynamics SATCOM Technologies General Reflector Alignment procedure 500-0320 contains the special reflector alignment tools and optical equipment necessary to assemble and align the reflector.

3.3 Major Component Weight Summary.

COMPONENT		UNIT WT. (LBS)
Reflector Assembly:	6.1M →	2,100
	7.2M →	2,880
	8.1M →	3,440
	9.0M →	4,260
Pedestal Assembly:	6.1M →	1,390
	7.2M →	1,390
	8.1M →	3,320
	9.0M →	3,320
Azimuth & Elevation Drive Assembly (Less Motor Drive):	10 Ton →	250
	20 Ton →	400
	25 Ton →	600
	35 Ton →	750

4.0 INSTALLATION SEQUENCE

4.1 Procedure. On site assembly of antenna equipment will involve the preassembly of some components or subassemblies at ground level. Preassembly may take place in any order prior to installation on the final assembly. The staging of subassemblies will be at the discretion of the Field Installation Supervisor. The following installation sequence will contain some instructions for ground assembly that must be accomplished before installation.

a. Inventory the parts against the shipping list, if shortages or damage exist, contact General Dynamics SATCOM Technologies with the information. While parts inventory is taking place, organize the antenna part storage on site for efficient accessibility as the antenna installation progresses. Make sure perishable items and small items are adequately stored to prevent loss and/or weather damage.

b. Construct the pedestal assembly.

NOTE: Verify actual anchor bolt layout to the foundation layout drawing.

c. Grease the pintle bearings.

4.1.1 Assemble And Install Legs.

a. Loosely fit all splice plates and hardware to each leg.

b. Mount leg assemblies to the concrete foundation anchor bolts in accordance with the Antenna Assembly drawing. Use the leveling screws with thrust plates to maintain a nominal 3" grout gap between the foundation surface and the bottom of the foot.

NOTE: On three-leg models the two rear legs may be leaned back away from the pintle position for ease of pedestal installation.

c. Install the pedestal assembly to the leg assemblies and the lower azimuth pintle anchor bolts. The pedestal should be lifted by placing a minimum of two wire slings around the upper pedestal. Use plywood between the slings and the pedestal to protect the finish of the pedestal. Use the leveling screws with thrust plates to maintain a nominal 3" grout gap between the foundation surface and the bottom of the lower pintle.

d. **For three-legged models:** Lean outside legs into place and secure to the upper pintle with the splice plates.
For two-legged models: Using splice plates, secure both legs to the upper pintle.

e. Through the use of jacking bolts and thrust plates in the lower pintle and the leg assemblies, rough level the pedestal in the vertical axis using a spirit level. The top of the pedestal relative to the bottom of the pedestal shall be perpendicular to the ground/horizontal plane within 0.125" or 0.03° or 0.006 inches per foot.

IMPORTANT: Verify that the pintle shaft has sufficient clearance per the installation drawing. *Final* align the pedestal *only* after the reflector has been installed.

f. Grout the lower pintle in accordance with General Dynamics SATCOM Technologies specification 300-2436. Be sure to apply a generous amount of bearing grease to the grout side of the leveling screws before grouting.

IMPORTANT: Do *not* grout the leg assemblies at this time.

4.1.2 Install the azimuth trunnion assembly to the foundation using the assembly drawing and adjust the leveling bolts to provide a nominal 3" space for grout. Do not grout at this time.

a. Install the azimuth drive assembly.
b. Assemble the azimuth drive to the trunnion in accordance with the assembly drawing. Install the motorized drive assembly (if applicable) to the azimuth drive assembly.

NOTE: Motorized drive may be left off at this point and jack can be manually driven.

c. Check the level of lubrication in the azimuth drive gear box. Next check for freedom of motion throughout the rotation angle of the trunnion.
d. Extend the lead screw to its fully extended length and verify proper travel.

CAUTION: Do not drive into the stop nut. Support extended shaft at all times when not connected to the deadman to prevent damage to the drive nut and/or shaft.

e. With a precision spirit level mounted on the lead screw, rough level the azimuth drive assembly within 0.06° or 0.0126 inches per foot. This leveling is accomplished by adjusting the jacking bolts of the trunnion assemblies.

NOTE: Final azimuth jack alignment will be made only after final pedestal alignment is performed.

4.1.3 Install the azimuth lead screw boot at this time per azimuth drive assembly to protect the shaft during assembly of pending structure.

4.1.4 Install the access platforms and ladders according to the ladder and platform drawing (if applicable).

a. Assemble the handrails to the platform assemblies at ground level.
b. Hoist the platform onto the pedestal assembly and fasten into place.
c. Assemble the ladders at ground level.
d. Hoist the ladders into position and fasten them to the platforms and pedestal per platform installation drawing.

4.1.5 Install the elevation drive assembly (6.1 & 7.2 only).

a. Assemble the elevation trunnion block to the elevation drive assembly.
b. Install the motorized drive assembly to the elevation drive assembly (if applicable).

NOTE: Motorized drive may be left off at this point and jack can be manually driven.

c. Install the elevation drive assembly onto pedestal assembly in accordance with the antenna installation drawing. Be sure to orient the worm/motor of the elevation drive assembly to be on the lower side of jack axis.

NOTE: Some models orient the jack with the rod-end connected to the pedestal.

d. Check the level of lubrication in the elevation drive gear box and for freedom of motion throughout the rotation angle of the connecting lugs.

4.1.6 Assembly of the hub and reflector

a. Build the hub/reflector assembly on a flat firm surface. Provide sufficient cribbing beneath the hub to allow the elevation axis clevis and jack bearing lugs to clear any ground obstacles. Arrange the cribbing to allow the measurement of the distance between the elevation axis clevis/lugs to be performed. Setup the hub with the feed opening face up. Measure the distance between the elevation clevis/lugs on the hub and verify with the distance between the elevation clevis/lugs on pedestal.

b. Assemble all the radial beams to the hub assembly in accordance with the reflector drawing. Mount the radial beams in a manner that will maintain balance to the reflector assembly during the entire radial beam assembly process. Torque the radial beam/hub attaching hardware to specification at this time.

NOTE: The backup structure may be assembled in the air.

c. Loosely attach all torsional and circumferential angle bracing to the radial beams as shown on the reflector drawing. Do not tighten any bracing hardware at this time.

d. Rough align radial beams per General Dynamics SATCOM Technologies Reflector Alignment procedure 500-0320.

e. Install the Lightning Protection System (if applicable) in accordance with the lightning rod installation drawing.

f. Attach all panel studs to the radial beam panel clips and the hub panel clips. Locate the studs in the center of the panel clip slots. Assemble all panel studs with (3) nuts and (2) washers. Set aside the remaining nuts and washers.

g. Install panels one at a time (starting with inner tier) on the previously installed panel studs. Loosely install bevel washers and nuts per installation drawing. Install another panel adjacent to the previous panel. After installation of each panel, rough align per General Reflector Alignment procedure 500-0320. Continue this process until all inner panels are installed. Install the next tier (if applicable) of panels one at a time with the in-board edge approximately 1/8" to ±1/16" away from the inner tier panel edge and rough align per alignment procedure 500-0320.

NOTE: The reflector may be rough aligned in the air or on the ground in the zenith position. The reflector will be final aligned only after being mounted on the pedestal at the primary elevation look angle.

SAFETY NOTE: Safety belts are required for any work inside the reflector back-up structure except during ground assembly.

4.1.7 Assemble the subreflector, apex and quad leg assembly and attach to the reflector according to the reflector assembly and antenna installation drawings.

a. Assemble (4) quadrapod leg assemblies to the apex assembly.

b. Assemble the apex lightning rod (if applicable)in accordance with lightning protection system drawing.

c. Hoist the subreflector assembly into position and assemble to the reflector.

d. Confirm the subreflector is in adjustable range by checking the dimension from the General Dynamics SATCOM Technologies of the reflector assembly to the face of the subreflector per the reflector assembly drawing.

4.1.8 Lift and install the reflector assembly onto the pedestal assembly as follows.

NOTE: This assembly must be hoisted on a calm day with winds not exceeding 20 mph. Attach whip lines to stabilize the reflector during pinning operations and have sufficient manpower available to control the motion.

a. Attach one nylon strap to each quad-leg radial at the quad-leg attachment point.

NOTE: Make certain the straps are long enough to clear subreflector.

b. Clean and lubricate the elevation axis bearings.

☞**IMPORTANT:** **The crane must be able to handle the load for the required distance and height.**

c. Lift the reflector and connect the elevation axis lugs to the pedestal per the assembly drawing. To connect the axis, insert a drift pin through the axis lugs on one side and install the axis pin through the other side. After one side is completely bolted and secure, remove the drift pin and insert the other axis pin completing the elevation axis joint.

d. Position the elevation jack to the lug on the reflector hub assembly and pin per the assembly drawing.

4.1.9 Final align the pedestal assembly per Kingpost Pedestal Final Alignment procedure 400-0429.

☞**CAUTION: Always use the jack to drive the antenna in case of sudden wind gust.**

4.1.10 Final level the azimuth jack with the precision level as in the previous section of this document.

a. Replace the lead screw boot of the azimuth drive assembly.
b. Apply a generous amount of bearing grease to the grout side of the leveling screws of the leg assemblies and azimuth drive assembly.
c. Grout the leg assemblies and the azimuth drive assembly in accordance with the assembly drawing and General Dynamics SATCOM Technologies specification 300-2436.

4.1.11 Perform the final alignment of the reflector panel surface in accordance with the General Reflector Alignment procedure 500-0320.

4.1.12 Perform the final alignment of the subreflector in accordance with 500-0320.

4.1.13 After the grout has cured for a minimum of three days tighten all the anchor bolts to installation drawing specifications.

4.1.14 Wash the reflector dish. Remove all dirt and scuff marks from the reflector panels. Apply gap tape if applicable. Paint the reflector on an as-needed basis.

4.1.15 Install the feed assembly to the feed support ring in accordance with the Feed Installation Drawing

4.1.16 Install RF system equipment per RF systems installation drawings and/or applicable procedures.

4.1.17 Install the azimuth limit switch.

4.1.18 Install the elevation limit switch.

4.1.19 Install the azimuth resolver and align in accordance with 500-0231, Encoder Installation Alignment.

4.1.20 Install the elevation azimuth resolver and align in accordance with 500-0231, Encoder Installation Alignment.

4.1.21 Install the antenna utility electrical per the utility electrical installation drawing for this system.

4.1.22 Install the antenna control electrical installation per the antenna control electrical installation drawing for this system.

4.1.23 Define and set the elevation and azimuth travel limits.

4.1.24 Make sure all customer and supervisor sign-offs have been completed.

INSERT 900-0255 ANTENNA
CHECKLIST HERE

6.0 APPENDIX

500-0320 General Reflector Alignment Procedure

500-0231 Encoder Alignment Procedure

300-2492 Procedure to Secure Couplings

300-1039 Reflector Panel Paint Specification (Flat White)

300-2436 Grout Installation Specification

400-0429 Kingpost Pedestal Final Alignment Procedure

400-0430 Bolt Tightening Specification

400-0428 Panel Trim Procedure

500-0322 Tool list

DOCUMENT 500-0320, General Reflector Alignment Procedure

IMPORTANT: In addition to this manual, the following manuals must be provided to ensure adequate information:

Document No.	Description
300-1027	Theodolite Correction Factor
400-0428	Panel Trim Procedure
400-0430	Bolt Tightening Specification

PLEASE DISCARD THIS PAGE BEFORE BINDING MANUAL

GENERAL DYNAMICS
SATCOM Technologies

GENERAL REFLECTOR ALIGNMENT PROCEDURE

KPC/KPK REFLECTOR

(Radials, Panels, and Subreflector)

500-0320

Rev. D
January 26, 2001

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Use of *WARNINGS,* CAUTIONS, etc.

Warnings, Cautions and other notes are included throughout this document to provide necessary information. IGNORING WARNINGS, CAUTIONS AND OTHER NOTES MAY RESULT IN DAMAGE TO THE PRODUCT, INJURY, OR IN EXTREME CASES, DEATH. You should know the use of Warnings, Cautions and other markings. Definitions are:

WARNING! ***HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN INJURY TO OR DEATH OF PERSONNEL.***

CAUTION! **HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO OR DESTRUCTION OF EQUIPMENT OR THE LOSS OF MISSION EFFECTIVENESS OR LONG TERM HEALTH HAZARDS TO PERSONNEL.**

Important: **Highlights an essential installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, will ensure efficiency and/or safety of said procedures.**

Note: *Highlights an installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, could enhance efficiency and/or safety of said procedures.*

ESD: **The Electrostatic Sensitive Device (ESD) appears at the beginning of any procedure or procedural step that includes the handling of equipment sensitive to damage from electrostatic discharge.**

General Warnings and Cautions are also provided at the front of the document. These Warnings and Cautions should be read by anyone who is involved with installation, has access to the equipment or is assigned to perform maintenance on the equipment.

CAUTIONARY NOTICE

Although SATCOM Technologies has attempted to detail in this document all areas of possible danger to personnel in connection with the use of this equipment, personnel should use caution when installing, operating and servicing this equipment. Care should be taken to avoid electrical shock, whether the hazard is caused by design or malfunction. SATCOM Technologies is specifically not liable for any damage or injury arising from a technician's failure to follow the instructions contained in this document or his failure to exercise due care and caution in the installation, operation and service of this equipment. SATCOM Technologies shall not be responsible for injury or damage resulting from improper procedures or from the use of improperly trained or inexperienced personnel performing such tasks.

This document is intended as a general guide for trained and qualified personnel who are aware of the dangers of handling potentially hazardous electrical and electronic circuits. This document is not intended to contain a complete statement of all safety precautions that should be observed by personnel in using this or other electronic equipment.

ELECTRICAL HAZARDS

The antenna and feed system supplied by SATCOM Technologies is designed to be integrated with various types of electronic equipment. This system, if integrated with high power amplifiers or traveling wave tubes, will be capable of transmitting microwave energy at varying power levels. If transmitting microwave power, SATCOM Technologies cautions the end-user to review all applicable local, federal and international regulations and to comply with all such regulations in the operation and maintenance of the integrated system.

The electrical currents and voltages associated with this equipment, whether supplied by SATCOM Technologies or others, are dangerous. Personnel must at all times observe safety regulations.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Always disconnect power before opening covers, doors, enclosures, gates, panels or shields.
- Always use grounding sticks and short out high voltage points before servicing.
- Do not remove, short-circuit or tamper with interlock switches on access covers, doors, enclosures, gates, panels or shields.
- Keep away from live circuits.
- Know your equipment and do not take risks.
- Always remove all power to the system prior to working on the antenna, the reflector assembly, the reflector backup assembly or the feed assembly.
- Always tag all circuits noting that the power is OFF, the date and your name, prior to commencing any work on that system.

In case of emergency, be sure that power is disconnected.

POTENTIAL DAMAGE TO ANTENNA

The antenna limit switches and resolvers have been pre-set to allow for maximum antenna performance. Any subsequent adjustment may jeopardize antenna performance and/or result in damage to the antenna.

SAFETY NOTICE

The following safety procedures are listed to remind those performing any work on the antenna system that safety rules must be observed. Failure to observe safety rules may result in serious injury or death. Always work safely and in accordance with established procedures.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Care shall be taken in all operations to safeguard other people as well as property and to comply with all local safety procedures as established by the customer's site representative, as well as local building codes and fire protection standards.
- All persons performing work on the antenna system shall also comply with the Occupational Safety and Health Act (OSHA) standards and all other federal state and local laws, ordinances, regulations and codes relating to designated work.
- Unless the customer's representative on site specifically designates an individual responsible for site safety, the SATCOM Technologies Site Supervisor shall be responsible for and establish a site safety program for the SATCOM Technologies installation work. The site safety program shall incorporate all SATCOM Technologies safety procedures and requirements
- Never make internal adjustments or perform maintenance or service when alone or fatigued.

ELECTROMAGNETIC RADIATION

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Do not stand in the direct path of the feed system when the system is transmitting!
- Do not work on the feed system when the system is on!

ALWAYS WORK SAFELY!

WARRANTY

SATCOM Technologies warrants the items ordered hereunder at the time of shipment to be free from defects in material, workmanship, and to conform to the contract specification. SATCOM Technologies' liability under this Warranty shall terminate one (1) year after date of acceptance or eighteen (18) months from the date of shipment, whichever comes first. Some individual products include extended warranties as stated in brochure(s) and extended warranties may be purchased as requested and quoted. Written notice of any defects shall be given SATCOM Technologies upon discovery and SATCOM Technologies shall promptly correct such defects by repair or replacement, at its option, without charge, either FCA SATCOM Technologies' plant or service in the field.

IN NO EVENT SHALL SATCOM TECHNOLOGIES' LIABILITY UNDER THIS WARRANTY EXCEED THE COST OF REPAIR OR REPLACEMENT OF SUCH DEFECTIVE ITEM AND UNDER NO CIRCUMSTANCES SHALL SATCOM TECHNOLOGIES BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Specifically excluded from this Warranty are:

a. Defects or nonconformance caused by and resulting from improper operation, maintenance, or storage of the equipment.
b. Items of characteristically indeterminate life, such as bulbs, fuses, etc.

THIS WARRANTY CONSTITUTES SATCOM TECHNOLOGIES' SOLE AND EXCLUSIVE LIABILITY HEREUNDER AND BUYER'S SOLE AND EXCLUSIVE REMEDY FOR DEFECTIVE OR NONCONFORMING ITEMS AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS IMPLIED OR STATUTORY (INCLUDING THE WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE).

TABLE OF CONTENTS

LIST OF FIGURES

1.0 SCOPE

This procedure defines the sequence and specifications for aligning a reflector. The sequence includes alignment of the radial beams, reflector panels, and subreflector assembly per specifications. This procedure is for a general alignment and not job specific.

2.0 REQUIREMENTS

For final alignment, the reflector must be installed on the pedestal, positioned at the specified look angle and aligned under no-wind conditions. Typically, the reflector shall be aligned so that the aligned surface error does not exceed 0.010 inches RMS (Root Means Square). Contact the General Dynamics SATCOM Technologies responsible project engineer for job specific requirements.

A General Dynamics SATCOM Technologies installation supervisor or crew must be available to guarantee the product performance specifications.

Important: *Some portions of this procedure are to be followed during hours of darkness only. Final alignment should not be started until after the temperature of the antenna and ambient air have stabilized, and not before two hours after sunset.*

3.0 EQUIPMENT

1 ea	Level
1 ea	One-second theodolite
	Recommended: Topcon ETL-1, Topcon DT101, Hilger-Watts ST210 "Top Loaded", Hilger-Watts ST200 "Top Loaded," Wild T2 P/N 308501, w/900001 Axis Modification
1 ea	Right-angle eyepiece
1 ea	Short focus lens 2 ft-3 ft
1 ea	Short focus lens 3 ft-6 ft
1 ea	Mounting Adapter Plate
1 ea	Theodolite Spindle Kit
1 ea	Alignment Drill Tape
1 ea	Sub-Alignment Mirror
1 ea	50-Foot Retractable Steel Tape
1 ea	1/4 Drill Motor
1 ea	Automatic Center Punch w/3/16" Shank
6 ea	3/16" Drill Bits
A/R	432613-01 Snap in Plastic Optical Target

96 each	6.1 Meter
128 each	7.2,8.0,9.0 Meter
228 each	11.1 Meter
276 each	13.1 Meter
372 each	15.2 Meter
384 each	18.1 Meter
512 each	21.0 Meter

4.0 APPLICABLE DOCUMENTS AND DRAWINGS

4.1 The following documents and drawings form a part of this specification:

Number	Description
300-1027	Theodolite Correction Factor
400-0428	Panel Trim Procedure
400-0430	Bolt Tightening Specification
	Antenna Installation Drawing
	Reflector Assembly Drawing

5.0 PROCEDURE

Refer to General Dynamics SATCOM Technologies Installation Manual for proper installation of reflector components. After installation and setup of theodolite instrument, the radial beams will be aligned, the panels will be rough aligned during their installation, and the subreflector will be installed and aligned at zenith before final panel alignment. Reflector will be rough aligned on the ground or on the pedestal at zenith and then final aligned at operational look angle.

As in any measuring system, the operator must be aware of the errors inherent in the system and how to compensate for them. The theodolite has a method for correcting a pointing error which is expressed as the angular difference between the LOS (line of sight) of the telescope and the reading of the optical micrometer. The correction of this error results in a correction angle which is applied to the required setting and is referred to as the "K-factor." The K-factor is a function of the elevation angle and distance of the target from the instrument, and therefore must be calculated for each target row. The methods for calculating and how to apply the K-factors are outlined in Procedure 300-1027.

5.1 Installation of Instrument

This section defines the procedure for installation and setup of the theodolite instrument into the hub center.

Important: *Theodolite must be operated by trained personnel only.*

5.1.1 After radials and lacing are soft mounted per installation manual, install interface plate to feed support ring.

5.1.2 Install theodolite spindle assembly to the top of the interface plate.

Note: *Gravity should be locked out on the instrument (while in a leveled position) prior to its installation.*

5.1.3 "Buck-in" the theodolite to the spindle by viewing target on theodolite alignment tool.

5.1.4 Verify the instrument is in the center of the hub. Using instrument, view any radial/hub clip edge, rotate theodolite 180 degrees and view opposite clip. Check two more clips 90 degrees or at a right angle to the first set. The point of interest on each clip should be within 1/16" of opposite clip.

5.1.5 Verify instrument is vertical to reflector surface. View radial tips to find an average height. Without moving instrument leveling screws, shim the feed ring until instrument is very closely perpendicular to radial tips plane.

5.1.6 Establish bench marks on the hub so the instrument can be precisely replaced back into this same position after removal. View four points at 90 degree increments and place a target at each point for later use. Insure that these points can be seen after panels are installed. Number and record each target location.

Caution! *Extreme caution shall be exercised throughout the alignment procedure to assure parts (nuts, bolts, C-clamps, subreflector mounting plate, etc.) are not dropped on the theodolite assembly. The theodolite shall be protected by a lens cap and cover when not in use.*

5.2 Radial Beam Alignment

This section defines the procedure for alignment of the radial beam members of the reflector backup structure.

5.2.1 Mark the center line of each radial by scribing or marking a line on the center of each panel clip.

5.2.2 Set the radial tip height of each radial per the alignment data sheet. The point of reference is established as a centerline point on the outer most panel clip between the stud slots. Once the radial is in position, torque the radial attachment hardware.

5.2.3 Straighten and tighten the reflector backup structure as described below. As the structure is straightened, torque the bolts to the required torque per Bolt Tightening Spec 400-0430.

5.2.3.1 Position the theodolite over the centerline of a radial at the hub/radial attachment clip and establish a reference point. Rotate precisely to the nearest radial having a diagonal support which attaches to the hub. Align this radial first.

5.2.3.2 Starting at the hub attachment point raise the LOS to each radial clip. Pull the radial beam in the direction necessary to center it on the LOS. Come-a-longs may be used for this positioning process.

5.2.3.3 Tighten the angle bracing members to the left or counter clockwise direction necessary to hold the radial in position. Tighten always to the left which is the unadjusted side until the first radial beam is straight. Index in a clockwise direction and straighten the next radial tightening all of the bolts on the angle brace members to the left of the radial being adjusted.

5.2.3.4 Once the second radial is straightened, move back one angular increment and inspect the straightness of the first radial. If this radial is straight, continue the straightening operation one radial at a time in a clockwise direction continuing to check back to be assured that all radials which have been aligned continue to be aligned so when the last radial is set, the angle between it and the first will be proper.

5.2.4 Following this straightening operation, inspect all connecting bolts for proper torque.

Note: *All angle bracing can be in place if the crane is available for placing reflector panels in the dish following the assembly of the structure. If this is not possible, it is permissible to leave out a few angle braces for hoisting panels from the ground.*

5.3 Rough Panel Alignment

This section defines the procedure for rough alignment of the aluminum reflector panels. Reflector alignment data will be supplied to supervisor at time of installation. When requesting alignment data from General Dynamics SATCOM Technologies, the following must be supplied:

1. Antenna Size:
2. Spindle Number:
3. Drill Tape Number:
4. Adapter Plate Number:
5. Theodolite Type:

5.3.1 Install the first inner tier panel assembly per installation drawing and procedure.

5.3.2 Install the drill tape and insert a snap-in plastic optical target (432613-01) in each hole of the drill tape. Verify the bottom edge of the tape intersects the vertex. This measurement will be given on datum sheet as the distance from the "line-of-sight" (LOS) to bottom of tape.

5.3.3 Adjust the radial placement of the panel to within ±1/16" of the specified distance from the vertex. This measurement may be made by holding a tape measure from the vertex or instrument center to the inner edge of the panel.

Note: *The initial in-board panel trim radius can be found on the reflector alignment data sheet.*

5.3.4 Adjust both edges of each panel to within 1/16" of the center line of the radial clip by sighting down each edge with the theodolite and snug just enough studs to hold this position. The panel may need to be shifted inward or outward slightly to reach this position.

5.3.5 Rough align the reflector surface by adjusting each panel stud as required per the alignment data to make the center dot of each target roughly coincident with the theodolite LOS. Be certain to check instrument "K" factor (See Document 300-1027). If the "K" factor is within ±10 arc-seconds, neglect this error during rough alignment.

Record “K Factor” Data in the provided space. Attach additional sheet/s as required.

Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
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Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________
Row # _______	K Factor_________	Row # _______	K Factor_________

5.3.6 As panels are installed, check that panels are installed in equal segments by setting theodolite in azimuth to (30° 00'00" for 12 radials, 15° 00'00" for 24 radials, or 11° 15'00" for 32 radials) multiples and sighting along panel edges. Panels should be offset by 1/16" on each side, creating a 1/8" gap between panels.

5.3.6.1 Inspect all panel gaps to be approximately 1/8" and that no interference exists. Gaps should be no less 1/16" and no more than 1/4" between panels. Verify that all panels are generally aligned to the same height as the panels surrounding them.

Note: *If panels do overlap because of uncontrollable circumstances trimming may be necessary. Trim panels only as required per Panel Trimming procedure 400-0428.*

Important: *The subreflector must be installed before final panel alignment is performed.*

5.4 Subreflector Alignment

This section defines the procedure to be used for installation and alignment of the subreflector assembly at the elevation look angle using a centering hole method. For the mirror crosshair method, refer to Appendix A. The subreflector assembly shall be aligned to the specified dimensions within the following tolerances:

Axial: Within ± 0.05 inch of specified location.
Radial: Concentric with parabolic axis within 0.05 inch.
Tilt: Perpendicular to parabolic axis within 0.1° (6 arc-minutes).

5.4.1 Check the theodolite. Re-buck instrument if required.

5.4.2 Set the theodolite at the instrument zenith look angle and locate the subreflector mounting plate on the apex assembly so that the "parabolic axis pierce point" coincides with the theodolite line-of-sight.

Caution! *Extreme caution shall be exercised throughout the alignment procedure to assure that parts (nuts, bolts, C-clamps, subreflector mounting plate, etc.) are not dropped on the theodolite assembly. The theodolite shall be protected by a lens cap and cover when not in use.*

5.4.3 Adjust the axial position of the subreflector assembly so that the distance between the lower surface of the subreflector and vertex is within 1/16" as specified on installation drawing.

5.4.4 With the instrument at zenith, focus on the centering hole (.0625 ∅). Adjust the subreflector radially to line up the instrument crosshairs with the centering hole.

5.4.5 From the machined edge of the subreflector, pull a tape measure straight and vertical in four places at approximately 90°. Adjust tilt until all four readings are within 1/32".

Note: *Instrument should be rotated about its azimuth axis in 90° increments to establish a correction factor.*

5.4.6 Repeat steps 5.4.3 and 5.4.4 until the crosshairs are aligned using both methods without moving the instrument.

5.4.7 Record error readings and subreflector distance below.

5.4.8 Subreflector alignment is finalized at RF performance testing where adjustments will be made to balance and focus the antenna system.

Note: *Theodolite LOS to vertex is the distance on the data sheet ± 1/16"*

RECORD: LOS to sub vertex _____
Four Vertical Readings (Tilt) _____
_____
_____
_____

5.5 Subreflector Alignment Acceptance

This is to certify that the requirements outlined in Subreflector Alignment Section have been met and verified. All settings are within tolerance and completed.

ACCEPTED BY:

General Dynamics SATCOM Technologies Representative:_____

Customer Field Representative:_____

5.6 Final Panel Alignment

This section defines the procedure for final alignment of the aluminum reflector panels. All components including radials, lacing, panels and subreflector must be in place before beginning final alignment. Generally the elevation will be placed at the operational angle before final alignment.

Important: *The following effort must be accomplished during hours of darkness. Final alignment should not be started until after the temperature of the antenna and the ambient air have stabilized, and not before two hours after the sun has set. Re-calculate instrument "K" factor for each target look angle. (See Document 300-1027).*

5.6.1 Using drill tape and 3/16" bit, drill through panel skin directly over adjustment stud for each target location.

Note: *On smaller reflectors the alternate "prick punch" method may be used over the drilled target.*

5.6.2 Install a plastic datum target in each hole and face it toward the vertex.

5.6.3 Using Final Alignment data, align the reflector by adjusting each reflector support as required to make the center dot of the target precisely coincident with the theodolite LOS.

5.6.4 After all targets have been adjusted to the specified LOS, make a quick survey for any targets which may have been inadvertently overlooked. Correct the setting of any target which is not within the center dot.

5.6.5 When the panel contour has been properly aligned, a final survey shall be conducted to verify the contour alignment. Set the theodolite to the theoretical datum target setting. View each target and record (in RMS data work sheet) the vertical up or down distance from the center of the target. Numbering of targets shall be as defined as in figure 1.

5.6.6 Compute RMS data and document the results. RMS can be calculated as follows.

5.6.6.1 Square all target error readings

5.6.6.2 Add the squares up

5.6.6.3 Divide by the total number of targets

5.6.6.3 Take the square root of this number

5.6.6.4 Example: Assume four targets are read.

1. = -0.010 3. = 0.005
2. = 0.000 4. = -0.015

1.) Square each of the readings.
1. = 0.0001 3. = 0.00003
2. = 0.000 4. = 0.00023

2.) Add up the squared readings.

0.0001+0.000+0.00003+0.00023 = 0.00036

3.) Divide sum by number of targets.

0.00036 / 4 = 0.00009

Important: *The 0.000 targets must be included.*

4.) Take the square root.

(0.0009) = 0.00949

This would round down and give a 0.009" RMS. This would be an acceptable RMS. If it had been greater than 0.010" the larger target error readings would need readjustments made and RMS recalculated.

5.7 Panel Alignment Acceptance

The General Dynamics SATCOM Technologies representative and the customer representative must sign the Panel Alignment Acceptance in this specification.

This is to certify that the requirements outlined in Panel Alignment Section have been met and verified. All settings are within tolerance and completed.

ACCEPTED BY:

General Dynamics SATCOM Technologies Representative:_____

Date:_____

Customer Field Representative:_____

Date:_____

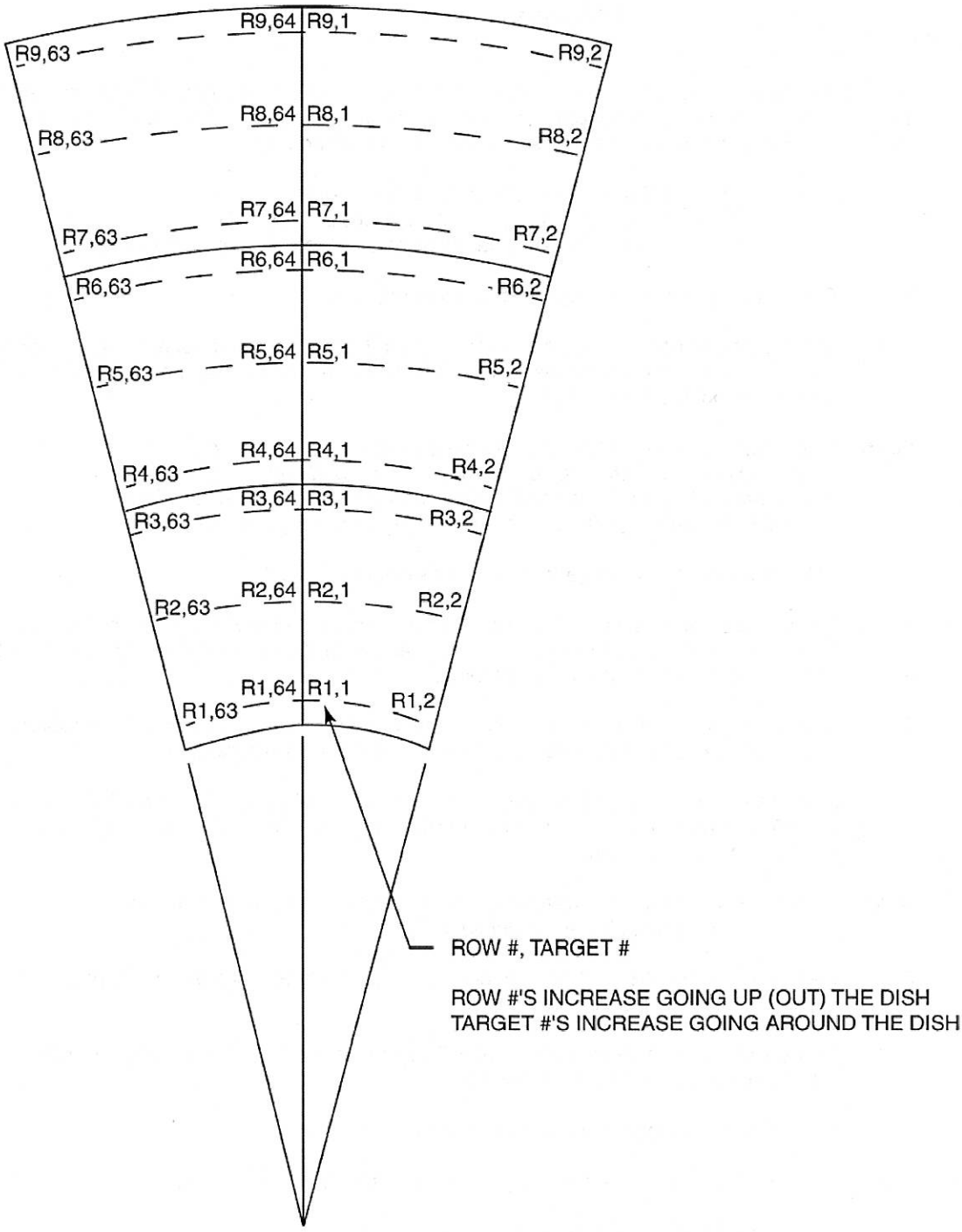

Figure 1. Panel –Target Numbering Sequence

APPENDIX A

Subreflector Alignment

This section defines the procedure to be used for installation and alignment of the subreflector assembly at the elevation look angle using a mirror crosshair method. The subreflector assembly shall be aligned to the specified dimensions within the following tolerances:

Axial:	Within ± 0.05 inch of specified location.
Radial:	Concentric with parabolic axis within 0.05 inch.
Tilt:	Perpendicular to parabolic axis within 0.1° (6 arc-minutes).

1. Check the theodolite. Re-buck instrument if required.

2. Set the theodolite at the instrument zenith look angle and locate the subreflector mounting plate on the apex assembly so that the "parabolic axis pierce point" coincides with the theodolite line-of-sight.

Caution! *Extreme caution shall be exercised throughout the alignment procedure to assure that parts (nuts, bolts, C-clamps, subreflector mounting plate, etc.) are not dropped on the theodolite assembly. The theodolite shall be protected by a lens cap and cover when not in use.*

3. Install the subreflector target mirror with hardware supplied.

4. Adjust the axial position of the subreflector assembly so that the distance between the lower surface of the subreflector and General Dynamics SATCOM Technologies is within 1/16" as specified on installation drawing.

5. With the instrument at zenith, focus on the mirror crosshairs. Adjust the subreflector radially to line up the instrument crosshairs with the mirror crosshairs.

6. Auto-reflect on the objective lens of the theodolite telescope and adjust the tilt of the subreflector assembly as required to position the hairlines on the center of the reflected image of the objective lens.

Note: *Instrument should be rotated about its azimuth axis in 90 degree increments to establish a correction factor.*

7. Repeat steps 5.7.3.5 and 5.7.3.6 until the crosshairs are aligned using both methods without moving the instrument.

8. Subreflector alignment is finalized at RF performance testing where adjustments will be made to balance and focus the antenna system.

9. Record error readings and subreflector distance below.

Note: *Theodolite LOS to Vertex is the distance on the data sheet ± 1/16"*

RECORD:

Axial readings	_____
Radial readings	_____
Tilt	_____
LOS to sub Vertex	_____

GENERAL DYNAMICS
SATCOM Technologies

PROCEDURE

FOR

THEODOLITE CORRECTION FACTOR

300-1027

Revision A
August 12, 1975

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SATCOM TECHNOLOGIES CONFIDENTIAL AND PROPRIETARY

A	Original release	8/12/75	Bill Anton	PGV	PGV
REV.	**DESCRIPTION**	**DATE**	**WRITER**	**CHK.**	**APPR.**

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1.0 SCOPE

There exists in all theodolites a collimation error which is due in part to the mechanical components of the instrument and the distance and angle of the line of sight to the target. This procedure outlines the methods which can be used to evaluate the size of the error and correct the instrument for setting targets at prescribed elevations.

2.0 PROCEDURE NUMBER ONE

1. It is assumed that the instrument, target tables, and linkages have been previously installed on the reflector.

2. A series of three circle left readings are taken at each target and recorded.

3. The instrument is now plunged and rotated and a series of three circle right readings are taken at each target and recorded.

4. Convert the circle right readings to equivalent first circle readings. (See Figure 1 and Table 1.)

5. Take an average of the circle left and circle right readings by adding each set and dividing by three. These averages will be used to find the correction factor for <u>each</u> target.

6. The following symbols will be used in the example which is typical for any vertical setting.

   K = Angular correction factor
   β = Circle left average
   α = Circle right average (Converted to equivalent first quadrant angle)
   Σ = Sum of β and α
   $\lambda = \Sigma / 2$ (true vertical angle)
   θ = Required angle
   Φ = Instrument angle

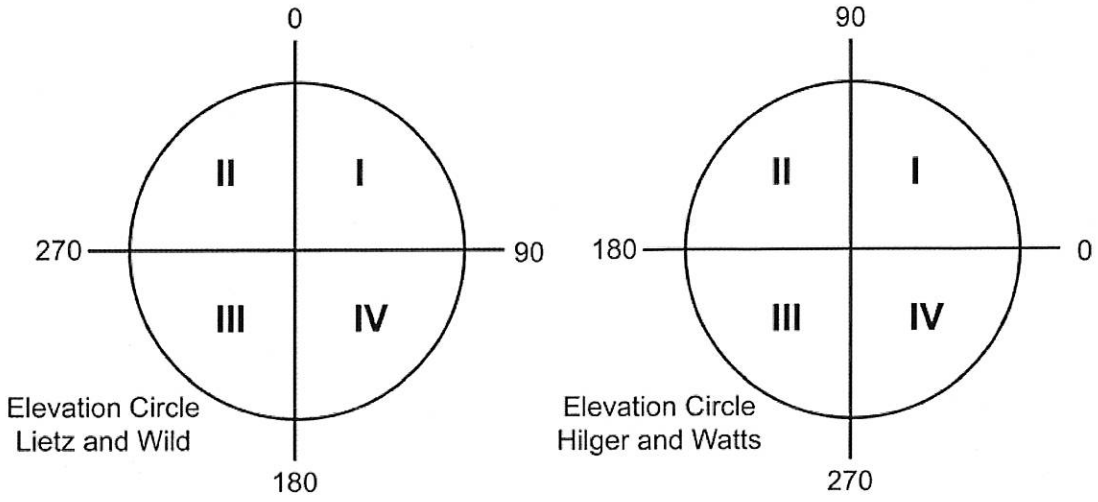


Figure 1. Elevation Circles

Table 1. Equivalent 1st Quadrant Angles

Elevation Reading	Quadrant	Numerical Value of Elevation or Depression	Position of Circle	Position of Telescope
Lietz TM-1A and Wild T2				
A	1st quadrant (0-90°)	90° – A	Left	Elevated
B	2nd quadrant (270°-360°)	B – 270°	Right	Elevated
C	3rd quadrant (180°-270°)	270° – C	Right	Depressed
D	4th quadrant (90°-180°)	180° – D	Left	Depressed
Hilger & Watts				
A	1st quadrant (0-90°)	A	Left	Elevated
B	2nd quadrant (90°-180°)	180° – B	Right	Elevated
C	3rd quadrant (180°-270°)	C – 180°	Right	Depressed
D	4th quadrant (270°-360°)	360° – D	Left	Depressed

2.1 Example 1: Positive K Factor (Lietz or Wild T2)

1. Circle left average reading = 88° 0' 04"

2. Circle right average reading = 271° 59' 48"

3. Convert above angles to 1st quadrant angles (see Figure 1 and Table 1)
   $\beta = 90° - 88° 0' 04" = 1° 59' 56"$
   $\alpha = 271° 59' 48" - 270° = 1° 59' 48"$

4. $$\begin{aligned} \beta &= 1° 59' 56" \\ +\ \alpha &= 1° 59' 48" \\ \Sigma &= 2° 118' 104" \end{aligned}$$

5. $\lambda = \Sigma / 2 = (2° 118' 104") / 2 = 1° 59' 52"$

6. $K = \beta - \lambda = 1° 59' 56" - 1° 59' 52" = 04"$

7. Therefore, if you wish to set a target at a required angle of $\theta = 1° 59' 50"$ then the instrument angle readout must be $\Phi = \theta + K$
   $\Phi = 1° 59' 50" + 04" = 1° 59' 54"$
   Physically, this means that the pointing angle is less than the readout.

8. Converting this angle back to 1st quadrant (circle left) for Lietz or Wild, we have a setting angle of $\Phi = 90° - 1° 59' 54" = 88° 0' 06"$

2.2 Example 2: Negative K Factor (Lietz or Wild T2)

1. Circle left average 88° 13' 30"

2. Circle right average 271° 46' 48"

3. Converting above angles to 1st quadrant angles:
   $\beta = 88° 13' 30" - 90° = 1° 46' 30"$
   $\alpha = 270° - 271° 46' 48" = 1° 46' 48"$

4.
$$\begin{array}{rr} & \beta = 1° 46' 30" \\ + & \alpha = 1° 46' 48" \\ \hline & \Sigma = 2° 92' 78" \end{array}$$

5. $\lambda = \Sigma / 2 = (2° 92' 78") / 2 = 1° 46' 39"$

6. $K = \beta - \lambda = 1° 46' 30" - 1° 46' 39" = -9"$

7. Therefore, if the required angle is $\theta = 1° 46' 24"$
   then the instrument angle $\Phi = \theta + K$
   $\Phi = 1° 46' 24" - 9" = 1° 46' 15"$

8. Converting this angle back to a circle left reading, the setting angle will be
   $\Phi = 88° 13' 45"$

3.0 PROCEDURE NUMBER TWO

1. This procedure is based on the fact that the sum of the reverse readings must equal 360°.

2. It is assumed that the first three steps of Procedure One have been accomplished.

Note: *Do not convert the angles to 1st quadrant angles.*

3.1 Example 1: Negative K Factor

1. Circle left average reading (β) = 88° 0' 04"

2. Circle right average reading (α) = 271° 59' 48"

3.
$$\begin{aligned} \beta &= 88^\circ\ 0'\ 04'' \\ +\ \alpha &= 271^\circ\ 59'\ 48'' \\ \Sigma &= 359^\circ\ 59'\ 52'' \end{aligned}$$

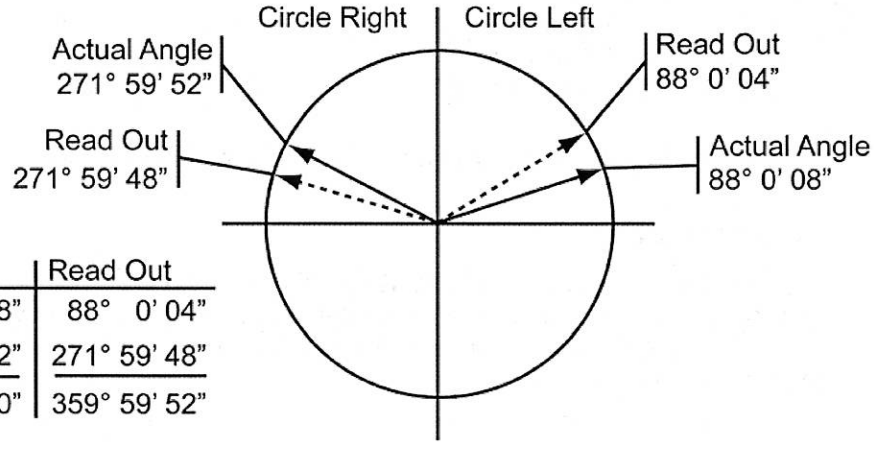
4. The difference Δ = 359° 59' 52" - 360° = -08"

5. The correction factor, K, is equal to half the difference
K = Δ / 2 = -08 / 2 = -04

6. Therefore, although the elevation readout indicates an angle of 88° 0' 04", the telescope is actually pointing at 88° 0' 08", an angle 4 seconds lower than indicated. (See Figure 2.)

7. If a look angle of θ = 88° 0' 10" is required then the setting angle Φ must be equal to Φ = θ + K = (88° 0' 10") + (-04) = 88° 0' 06"

8. Note that if the sum of the left and right readings is <u>less</u> than 360°, then the correction factor is <u>negative</u> and must be <u>subtracted</u> from the <u>circle left reading</u>.



	Actual	Read Out
CL	88° 0' 08"	88° 0' 04"
CR	271° 59' 52"	271° 59' 48"
	359° 59' 60"	359° 59' 52"

Figure 2. Illustration of Example 1 of Procedure Two

3.2 Example 2: Positive K Factor

1. Circle left average reading (β) = 88° 13' 30"

2. Circle right average reading (α) = 271° 46' 48"

3.
$$\begin{aligned} \beta &= 88^\circ\ 13'\ 30'' \\ +\ \alpha &= 271^\circ\ 46'\ 48'' \\ \Sigma &= 359^\circ\ 59'\ 78'' \end{aligned}$$

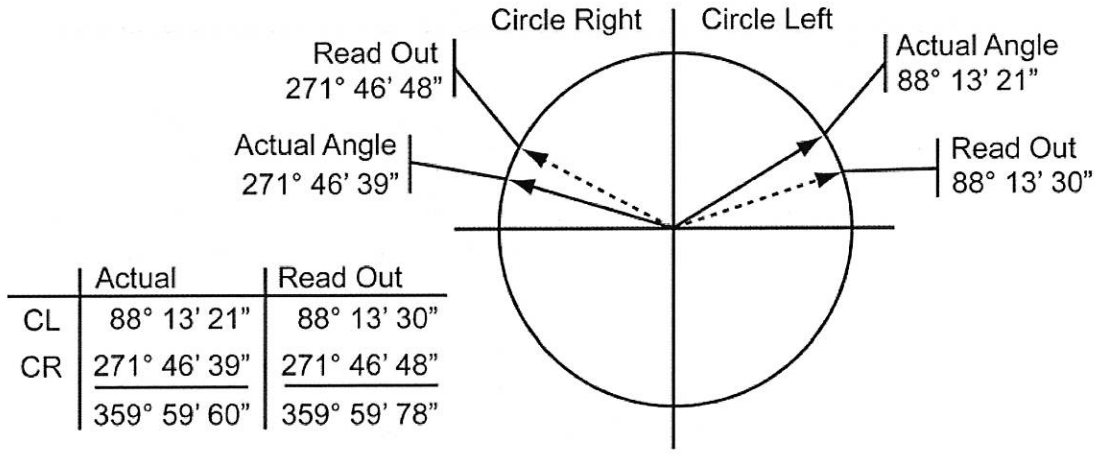
4. The difference Δ = 359° 59' 78" - 360° = +18"

5. K = Δ / 2 = 18 / 2 = +09"

6. In this case, the elevation reading indicates an angle of 88° 13' 30" while the telescope is actually pointing at 88° 13' 21", an angle 9 seconds higher than indicated. (See Figure 3.)

7. If the required angle θ is 88° 13' 36" then the setting angle Φ must be 9 seconds higher. Φ = θ + K = (88° 13' 36") + (09) = 88° 13' 45"

8. Note that if the sum of the left and right readings is greater than 360°, then the correction factor is positive and must be added to the circle left reading.



	Actual	Read Out
CL	88° 13' 21"	88° 13' 30"
CR	271° 46' 39"	271° 46' 48"
	359° 59' 60"	359° 59' 78"

Figure 3. Illustration of Example 2 of Procedure Two

4.0 CONCLUSION

It should be noted that the results using either method yield the same values, but careful observation is required to assure complete understanding of the physical situation. In actual practice, the correction factors differ from night to night and must be recalculated prior to each night's shooting.

GENERAL DYNAMICS
SATCOM Technologies

ALIGNMENT PROCEDURE
FOR
ANTENNA POSITION TRANSDUCER

(Programmable Calculator Method)

500-0231

Rev. B
December 5, 1996

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GENERAL DYNAMICS
SATCOM Technologies

B	New Alignment Process	12/05/96	CLS	HLA
A	Revised figures 2 & 4	12/18/92	WCM	PGV
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REV.	**DESCRIPTION**	**DATE**	**WRITER**	**APPR.**

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1.0 SCOPE

This method of alignment utilizes an angular rotation (clockwise or counter clockwise) for measurement of eccentricity and then provides a calculation for simpler and more accurate axial positioning of any position potentiometer, encoder or resolver that has been rough aligned. This procedure may also be used to document the actual resulting axial error in a new or existing transducer alignment. Graphical views are included to aid precise analytical alignments and for close approximate alignments without the need for analytical calculations.

2.0 EQUIPMENT

a. Two (2) dial indicators with at least 1/2" inch travel.

b. Two (2) flat dial indicator tips (approximately 3/16" diameter and 2" long).

c. Two (2) magnetic indicator stands with attachments for indicators.

d. One (1) inclinometer or protractor.

e. One (1) programmable scientific calculator or PC (optional); HP42S, HP32S or HP42.8 recommended.

f. Two- (2) 4" "C" clamps to secure indicator bases.

g. Plumb bob and tape measure.

3.0 SETUP

Step 1. After the fixed shaft has been rough aligned within 1/4" of the axis, mount the two dial indicators on the fixed pin as close to 90 degrees apart as possible (see figure 1).

Step 2. Label the indicators A and B **exactly** as oriented in figure 1 on next page.

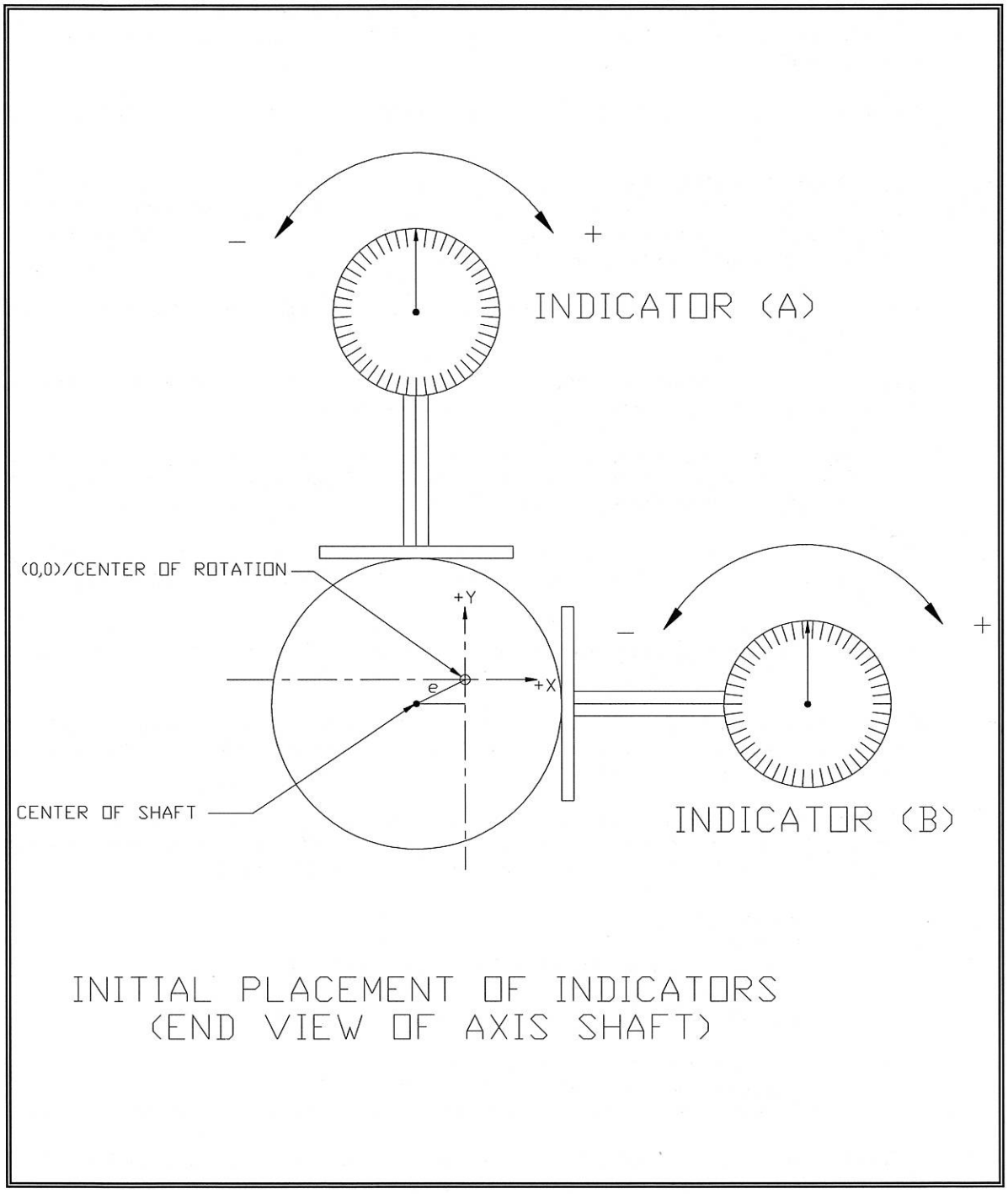
Note:*Indicator b must always orient 90 degree to the right of a.*

Step 3. Adjust indicators so that they both read zero.

Step 4. Make sure magnetic bases and all mounting hardware are tight (use clamps if necessary) and have sufficient clearance for at least 20° of rotation.

Step 5. For elevation, find a suitable location on the hub for the inclinometer or plumb line and plumb line combination. For azimuth, a cord length will be measured.

Important: *For this procedure the rotational directions are for the* ***shaft relative to the indicators.***



INITIAL PLACEMENT OF INDICATORS
(END VIEW OF AXIS SHAFT)

4.0 PROCEDURE

4.1 **Record the current position of the antenna axis.** An inclinometer works well for the elevation. If an inclinometer is not available a plumb line can be used with a protractor or with some trig calculations to get an angle. The azimuth angle can be calculated with a measurement of the radius and cord length or the use of the protractor.

Important: *Do not use the CW or CCW notation on the drive cabinet panel to determine direction of rotation.*

4.2 **Rotate the antenna.** Rotate the antenna either direction, whichever is convenient. Constantly view the indicators for a peak point; or in other words, a point where one of the dials starts rotating one direction, stops and begins to return. Try to rotate at least +/- 15° degrees. If a peak point is observed **stop rotation immediately** and go to step 3.

Note: ***The greater the angle of rotation the more precise the adjustments will be but do not exceed 90°.***

4.3 **Record the angular change in rotation.** Using inclinometer or protractor, record the new angle. Find the total angular change and record as "θ" in decimal degrees.

Note: *Measure the angular change of the shaft* ***relative*** *to the face of the indicators. For example in the positive CCW case, the edge of the shaft would move from indicator "B" to "A" and in the negative CW case, the edge of the shaft would move from indicator "A" to "B".*

4.3 **Record dial indicator values.** Note the change of each dial reading in writing (if the reading decreased, note this as a negative reading) and record this as "A" and "B" on the Work Sheet in Appendix C.

Important: *If one of the indicators reaches a peak point and goes beyond, the calculations may give the correct magnitude but possibly the wrong direction sign.*

4.4 **Hold position.** Hold the current position and plug the recorded values into the calculator program or equations listed in step 6. If a calculator or computer is unavailable skip to the "Alternate Method" for an accurate but less precise method.

4.5 **Calculate the X and Y distances to move pin.** Use figures 2 and 3 to determine the location of the shaft and adjust as calculated with calculator or with equations (1) thru (4). Use the "Work Sheet" in Appendix C and appropriate calculator instructions also found in the appendix.

A	=	Indicator A reading
B	=	Indicator B reading
X	=	Distance to move shaft in X direction (indicated on dial B)
Y	=	Distance to move shaft in Y direction (indicated on dial A)
θ	=	Angle of rotation (CCW=Positive or B to A, CW=Negative or A to B)

Note: *X and Y are distances in the after rotation position.*
Angles must be measured with respect to the shaft.
If a 90 degree rotation is possible, equations 1 through 3 may be used without a calculator.

Caution: *Watch how you use the negative and positive sign conventions! Example, if A is a -5 and B is a -2 then equation (1) is X = (-5-(-2))/2 = (-5+2)/2 = -3/2 = -1.5*

-90 DEGREE (CW) ROTATION ONLY:
X =(A - B) / 2 ..... (1)
Y =(-A - B) / 2 ..... (2)

90 DEGREE (CCW) ROTATION ONLY:
X =(-A - B) / 2(5) ..... (3)
Y =(-A + B) / 2 ..... (4)

4.6 **Zero the indicators.** Zero the dial indicators and use the X and Y values calculated to determine the amount and direction to move the shaft in each direction (see figures 1, 2 & 3).

Hint:*Set the dial indicators to the opposite value required and adjust pin until dials return to zero.*

4.7 **Adjust the shaft.** Adjust the shaft, taking care not to disturb the indicator mounts, and re-tighten all hardware.

4.8 **Re-zero the indicators and rotate antenna.** Reset the indicators to zero and continue to rotate the assembly or reverse back towards the initial position.

4.9 **Find total resulting axial error.** X and Y can be recalculated using methods in step 6. Using these new X and Y values, the resultant eccentricity can be calculated with the following equation;

$R = \sqrt{(X^2 + Y^2)}$ .... (5)

"R" must be less than or equal to the antenna specified axial tolerance (typically 0.010" but 0.002" is easily achievable). No large change should be noticed in either indicator. If a slight change is noticed and "R" is greater than tolerance, note this change and carefully readjust the shaft in the proper direction. If a large change is noticed something went wrong, see note below.

4.10 **Notice.** This step by step process may be repeated back and forth as needed; but if all readings and adjustments are made accurately, only one rotation is needed. If it takes more than two attempts something somewhere is moving, indicators are inaccurate or an error was made in data recording and/or calculations.

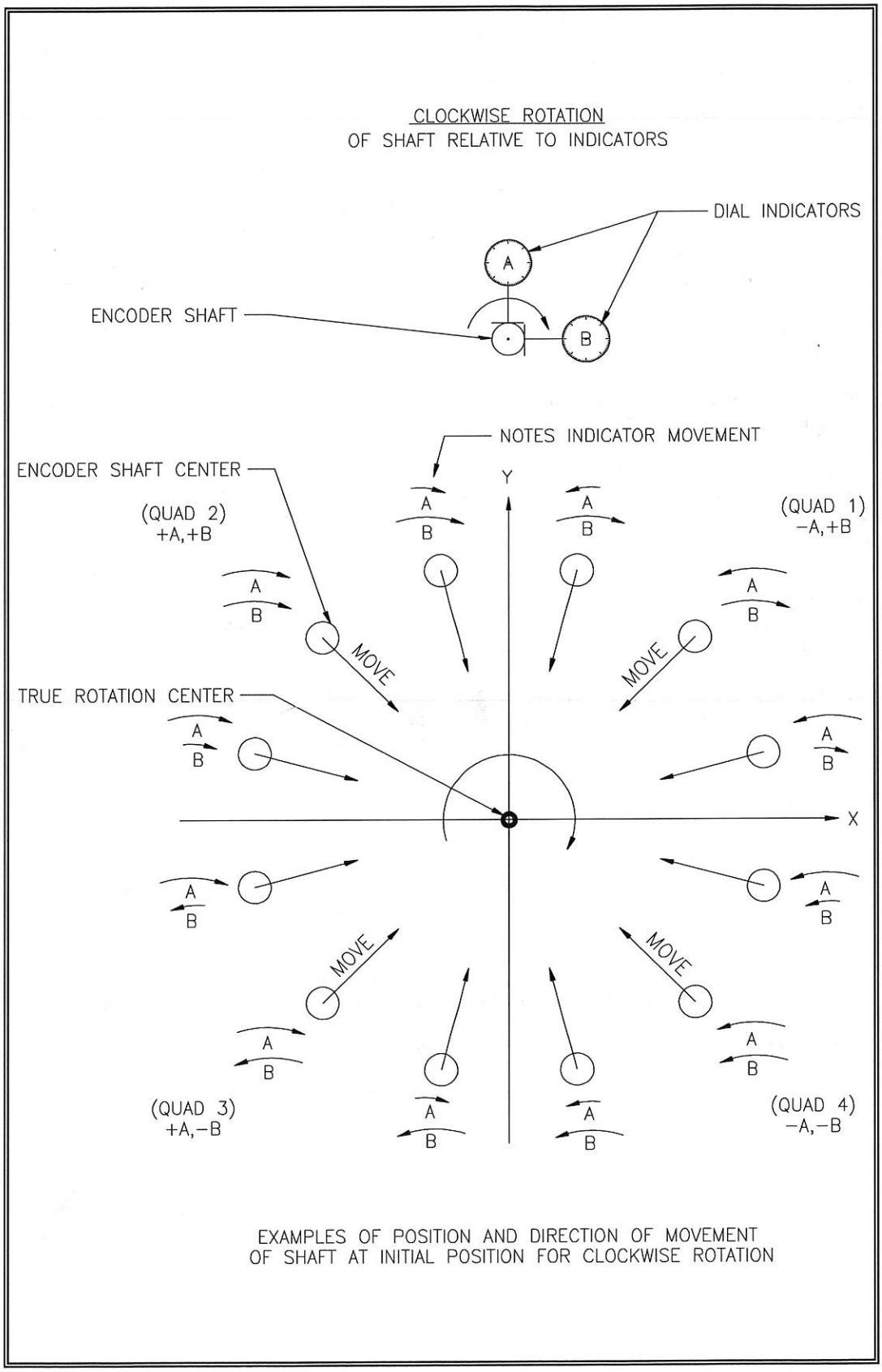
4.11 **Alternate Method.**

Step 1. Utilizing figures 2 and 3 (figure 2 is CW & figure 3 is CCW), sketch out the location of the shaft relative to the dial indicator positions. Notice the small arcs with an arrow and labeled A and/or B in the figures give a magnitude and direction of indicator movement in each quadrant.

Step 2. Make an approximate movement of the shaft in the appropriate direction. Be sure to keep track of all movements so if a mistake is made, the shaft can be returned to its initial position.

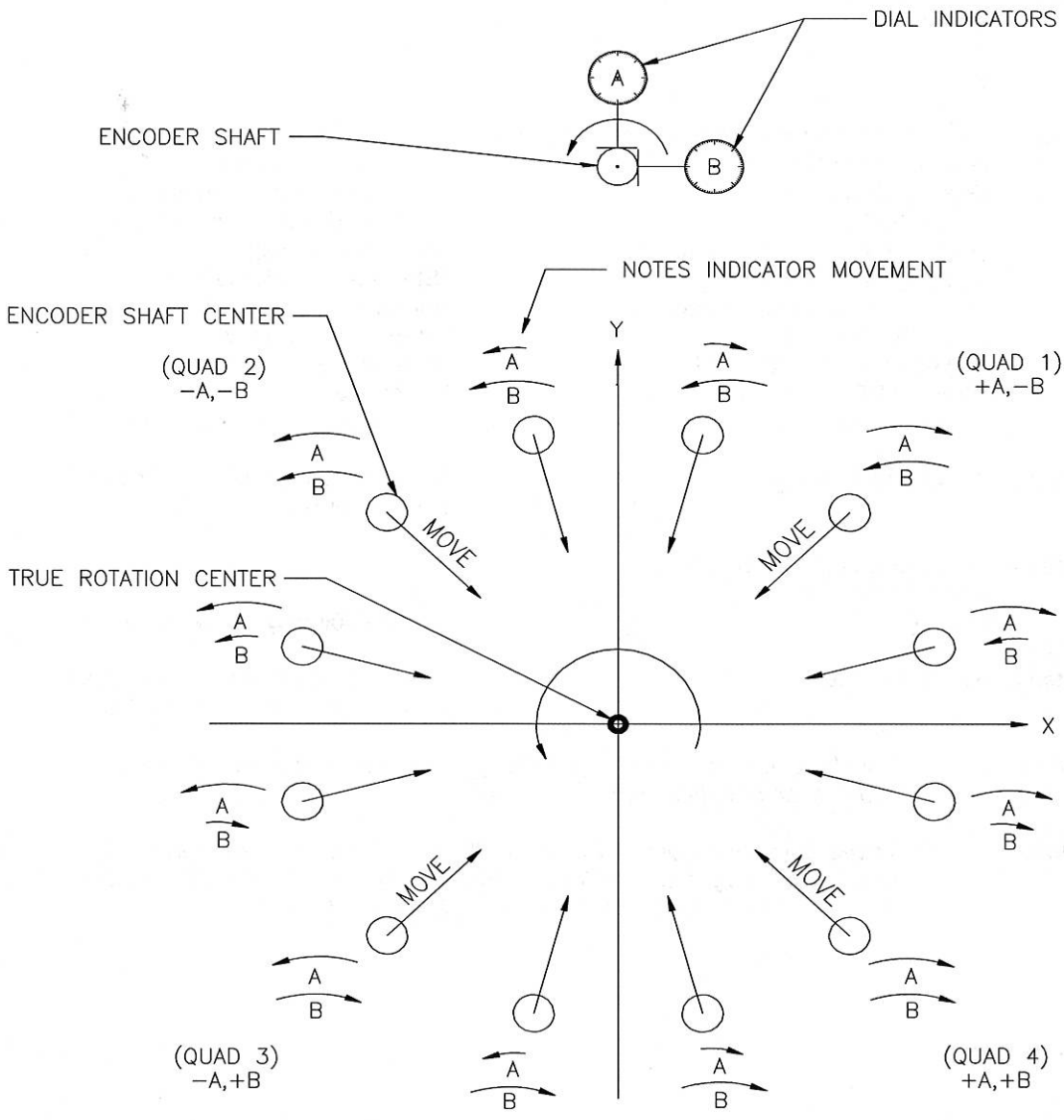
Step 3. Rotate the antenna and repeat this process.

Note:*The greater the rotation angle the more precise the adjustments will be. Do not exceed 90 degrees.*



EXAMPLES OF POSITION AND DIRECTION OF MOVEMENT
OF SHAFT AT INITIAL POSITION FOR CLOCKWISE ROTATION

COUNTER CLOCKWISE ROTATION
OF SHAFT RELATIVE TO INDICATORS



EXAMPLES OF POSITION AND DIRECTION OF MOVEMENT
OF SHAFT AT INITIAL POSITION FOR COUNTER CLOCKWISE ROTATION

5.0 APPENDIX

5.1 APPENDIX "A"

HP 42S Calculator Instructions
These instructions should be used in conjunction with the alignment procedure.

Step 1. Record angle change and the indicator values
θ = ANGL =
A =
B =

Step 2. Press the following sequence of buttons

-Press [ON] or [EXIT] two times	"Turns on and clears"
-Press [XEQ] button	"This starts program mode"
-Press {X.DIR}	"Use key directly below menu line"
-Type in the value for Indicator A =	"Include + or - sign"
-Press {A} in menu list	"Stores A indicator value"
-Type in the value for Indicator B =	"Include + or - sign"
-Press {B} in menu list	"Stores B indicator value"
-Type in the value for t = ANGL =	"Include + or - sign"
-Press {ANGL} in menu list	"Stores angle change value"
-Press [R/S] button	"Runs program and returns X value"

Step 3. Record the X.DIR = "Distance and direction to move pin in the X (or B indicator) direction"

Step 4. Press [ON] or [EXIT] button
Press [XEQ] button
Press {Y.DIR} "Use key directly below menu line"

Step 5. Record the Y.DIR = "Distance and direction to move pin in the Y (or A indicator) direction"

Important: *You do not need to input A, B, ANGL again since this will remain stored unless you change or delete them.*

Note: *To recall any of the output values (X.DIR or Y.DIR) or the input values (A, B, or ANGL), simply press the [ON] button then the recall button [RCL] and the corresponding menu key located directly below each name.*

5.2 APPENDIX "B"

HP 48G or GX Calculator Instructions

These instructions should be used in conjunction with the alignment procedure.

Step 1. Record angle change and the indicator values

θ = ANGL =	"A to B (or CW) is negative value" "B to A (or CCW) is positive value"
A =	"Include positive or negative sign"
B =	"Include positive or negative sign"

Step 2. Press the following sequence of buttons on calculator:

a.	-Press [ON] or two or more times	"Turns on and resets"
b.	-Press [←] [CLEAR] button	"Clears screen"
c.	-Press [→] [HOME] button	"Returns to home menu"
d.	-Press [VAR] button	"Opens variable menu"
e.	-Press {RESOL} in menu list	"Opens resolver directory"
f.	-Press {STRT} in menu list	"Starts program"
g.	-Type in the value for t = ANG =	
h.	-Press [+/-]	"Toggles to correct sign"
i.	-Press [ENTER]	"Enters angle"
j.	-Type in the value for Dial A =	
k.	-Press [+/-]	"Toggles to correct sign"
l.	-Press [▽]	"Moves cursor down to B"
m.	-Type in the value for Dial B =	
n.	-Press [+/-]	"Toggles to correct sign"

Note: *Press [▽] or [△] alternately to edit A or B if needed.*

o.	-Press [ENTER]	"Runs program"
p.	-Press {A.DIR} in menu list	"Displays value to move dial A"
q.	-Press {B.DIR} in menu list	"Displays value to move dial B"
r.	-Press {TOTAL} in menu list	"Displays total error"

Step 3. Record the A.DIR = "Distance and direction to move pin in the A indicator direction"

Step 4. Record the B.DIR = "Distance and direction to move pin in the B indicator direction"

Step 6. Record the TOTAL = "This is the total error that would be seen if pin was rotated 360°. Record this for final alignment documentation sign-off"

Important: *You may hit {STRT} in this current menu to run new numbers at any time or begin at step d. Remember you can clear the old numbers from screen if you do not want to reuse them.*

Note: *To recall any of the output values (A.DIR, B.DIR or TOTAL) simply press the corresponding menu key located directly below each name.*

5.3 APPENDIX "C"

WORK SHEET

TRIAL #1

BR = _____	(Angle Before Rotation)
AR = _____	(Angle After Rotation)
A = _____	(pos. or neg. indication of indicator "A")
B = _____	(pos. or neg. indication of indicator "B")
θ = _____	(Angular change in decimal degrees defined by the difference of BR and AR) Note: CW (A to B) = neg & CCW (B to A) = pos

AFTER CALCULATION

X = _____	(Distance to move indicated on dial "B")
Y = _____	(Distance to move indicated on dial "A")
R = _____	(Total resulting axial error)

TRIAL #2

BR = _____	(Angle Before Rotation)
AR = _____	(Angle After Rotation)
A = _____	(pos. or neg. indication of indicator "A")
B = _____	(pos. or neg. indication of indicator "B")
θ = _____	(Angular change in decimal degrees defined by the difference of BR and AR) Note: CW (A to B) = neg & CCW (B to A) = pos

AFTER CALCULATION

X = _____	(Distance to move indicated on dial "B")
Y = _____	(Distance to move indicated on dial "A")
R = _____	(Total resulting axial error)

GENERAL DYNAMICS
SATCOM Technologies

PROCEDURE
TO
SECURE 3-JAW COUPLINGS TO SHAFT

300-2492

Revision A
March 21, 1996

General Dynamics SATCOM Technologies
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SATCOM TECHNOLOGIES CONFIDENTIAL AND PROPRIETARY

A	ORIGINAL ISSUE	03/21/96	KDR	KDR	KDR
REV.	**DESCRIPTION**	**DATE**	**WRITER**	**CHECK**	**APPR.**

SCOPE: This procedure should be followed whenever installing 3-jaw couplings to prevent the couplings from backing off and disengaging.

PURPOSE: To set up a procedure to follow to prevent coupling slippage after installation.

PROCEDURE:

1.0 Install motor coupling cover on jack.

2.0 Install coupling half on motor and secure temporarily with set screw.

3.0 Install coupling half on jack and secure temporarily with set screw.

4.0 Install motor and check coupling alignment and seat. Ensure coupling halves have maximum 1/16" gap.

5.0 Remove motor, measure coupling to shaft, remove set screw and line drill through coupling into shaft. (see chart)

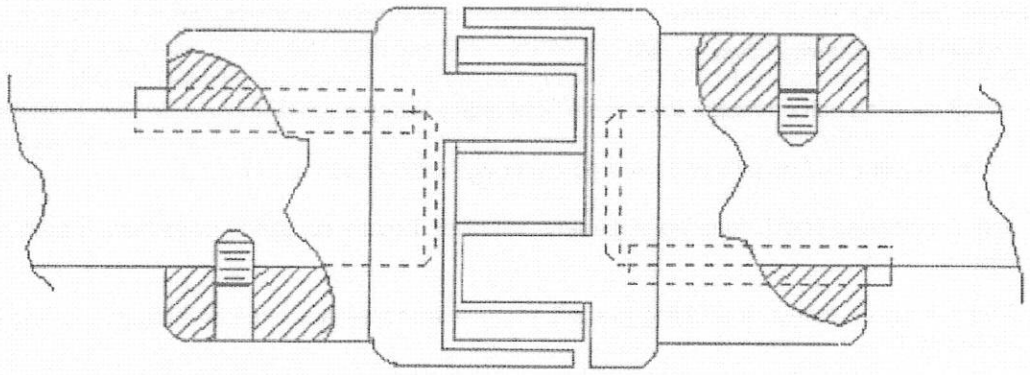
6.0 Clean out drill chips and run tap through coupling half and tap into motor shaft. Clean all chips. (Running tap in coupling assures alignmnet of threads.)

7.0 Install self-locking set screw (long enough to seat into shaft and coupling, approximately 1/2" longer than factory supplied screw).

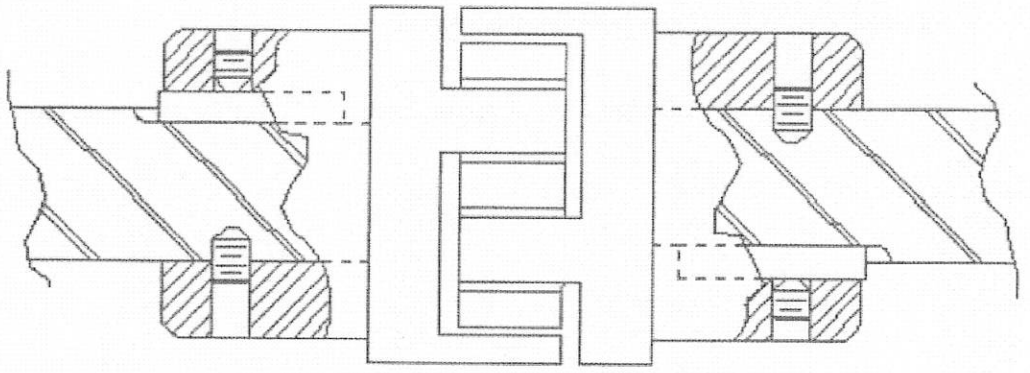
8.0 Repeat steps 5, 6, and 7 for coupling half on jack.

9.0 Reinstall motor, check clearances and lock all hardware.

Set Screw Size	Recess Drill Size	Recess Depth	Torque (+15%) In Lbs.
1/4-20	3/16	1/4	75
5/16-18	3/16	1/4	130
3/8-16	1/4	1/4	235
7/16-14	1/4	1/4	375
1/2-13	3/8	3/8	515
9/16-12	3/8	3/8	680
5/8-11	1/2	3/8	1110
3/4-10	9/16	3/8	1530



BOSTON GEAR TYPE COUPLING



MORSE, LOVEJOY TYPE COUPLING

GENERAL DYNAMICS
SATCOM Technologies

SPECIFICATION FOR PAINT FINISH ON ALUMINUM PANELS

300-1039

Revision F
September 12, 2000

General Dynamics SATCOM Technologies
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SATCOM TECHNOLOGIES CONFIDENTIAL AND PROPRIETARY

F		9/12/90			
REV.	**DESCRIPTION**	**DATE**	**WRITER**	**APPR.**	**PROJECT**

1.0 INTRODUCTION

This specification outlines two methods of applying a white finish to the aluminum panels. Panels may be painted using the air dry or oven-baked procedure.

2.0 AIR DRY PROCEDURE

2.1 Surface Preparation

a. Clean parts in accordance with material process #106.
b. Allow to dry two (2) hours minimum @ 65°F.
c. Wipe down surfaces with clean white rag dipped in acetone.

2.2 Primer. Apply even coat to clean dry surfaces TTP 1757 Yellow Primer (Cook Paints). Thickness of coat shall be 0.3-0.5 dry mils. Minimum temperature of 65°F.

2.3 Drying Time. Allow two (2) hours minimum @ 65°F.

2.4 Apply enamel white #13-701 (Flat) Gillespie Color #37925 per FED-STD-595. Minimum thickness of coat shall be 1.0 dry mil; maximum thickness of coat shall be 2.0 dry mils. Average film thickness per panel and for a whole panel set (per reflector) shall be 1.5 dry mils. Minimum temperature of 65°F.

3.0 OVEN-BAKED PROCEDURE

3.1 Surface Preparation.

a. Clean parts in accordance with MP-106.
b. Dry parts in oven at 150°F for 2-5 minutes, making certain all water has evaporated.

3.2 Finish Coat.

a. Apply enamel white #707-701 (Flat) Gillespie Coatings Color #37925 per FED-STD-595 or equivalent. Thickness of wet coat shall be 2.5 - 3.0 mils.
b. Bake dry at 300°F for 10 minutes. Thickness of dry film to be 1.0 mil, minimum; 2.0 mils maximum; 1.5 mils, average per panel and for whole panel set (per reflector).

4.0 FIELD PAINT

a. Wash reflector surface using detergent to remove all grease and dirt. Allow to dry.
b. Lightly sand damaged areas and apply one coat of TTP1757 yellow primer. Allow to dry 2 hours at minimum temperature of 65°F.
c. Apply one coat of Gillespie #13-701 flat white color #37925 per FED-STD-595 minimum temperature of 65°F.
d. Minimum dry film thickness to be 1.0 mils for field paint.

GENERAL DYNAMICS
SATCOM Technologies

HIGH STRENGTH GROUT SPECIFICATION AND GROUTING PROCESS PROCEDURE

VERTEXRSI SATELLITE EARTH STATION ANTENNA SYSTEMS

300-2436

Rev D
October 26, 2001

General Dynamics SATCOM Technologies
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GENERAL DYNAMICS
SATCOM Technologies

D	EC 02-0074	10/26/01	JRS	SPK	SPK
C	Revised Spec. & Added Procedure	08/14/96	CLS	JBJ	KDR
B	General Revision	08/31/93		MPH	KDR
A	Original Release	09/11/89			KDR
REV	**DESCRIPTION**	**DATE**	**WRITER**	**CHECK**	**APPR.**

1.0 INTRODUCTION

This document establishes the performance specifications for grouting material and the application process for grouted interfaces of VertexRSI antennas.

2.0 GROUT PRODUCT PERFORMANCE SPECIFICATION

The following performance specifications shall be met or exceeded.

2.1 **Typical Description**. Grouting material is a ready mix, durable non-shrink, non-metallic, highly fluid high strength compound used for shimming between a base plate and substrate.

2.2 **Minimum Compressive Strength for Grout**. Grout compressive strength shall be tested per industry standards. The grout product shall meet or exceed a 1 day compressive strength of 1,400 psi (9.65 MPa) and a 28 day compression strength of 7,000 psi (48 MPa).

2.3 **Non-Shrink Properties.** The grout product shall have an absolute non-shrink property or provide a positive expansion eliminating any shrinkage between material and base plate.

2.4 **Processing Temperatures.** The grout must be applicable in ambient temperatures between -45°F and +95°F. Grout application temperature to the extreme of this should be controllable with heated or chilled water.

2.5 **Packaging.** Grout shall be packaged in sturdy moisture resistant containers not to exceed 100 lbs.

3.0 GROUTING PROCESS PROCEDURE

The following process is specific to typical VertexRSI applications. Where performance may be affected the exact requirements of the specific grout manufacture must govern over this document.

3.1 **Grout Forming.** Create a form using available sturdy material such as wood. The forming shall be designed to provide a minimum grouting level of 1/4 inch above the bottom of the base plate. The forms should be caulked and/or water tight. Place the forms so that a minimum of 1 inches of space is provided between the form sides and base plate.

3.2 **Base Plates.** The base plates shall clean and free of grease. Any underside anchor nut not used for temporarily securing the base plate level or holding placement shall be backed down a minimum of 1 turn. A nominal 2-4" with a minimum of 1/2" should be between the base plate and substrate.

3.3 **Anchor Threads.** The anchor thread in the grout area shall be greased to prevent unwanted sticking of grout.

3.4 **Presoaking Concrete Substrate.** Presoak the substrate with water for a minimum of 1 hour. Remove standing water with air or other means but do not allow to fully dry.

3.5 **Mixing Grout.** Using mechanical paddle wheel or hand methods, mix grout to a fluid consistency removing all lumps per manufactures specifications. Cool or warm water may be required in extreme high or low temperatures. Consult manufactures specifications for these extreme temperatures pours.

3.6 **Placement of Grout.** Initially place grout in anchor holes or other voids which might be susceptible to air entrapment. Pour grout rapidly and continuously as possible from one side of the forms to minimize cold laps and air entrapment to the required level.

3.7 **Finishing.** If any special dressing is required the forming may be removed after final set (usually 1-2 hours) per the manufactures specifications otherwise leave the forms on for several hours to help retard surface cracking in hot weather.

3.8 **Curing.** Preferably and in dry and hot climates it will be necessary immediately after pour and finishing to cover the exposed grout with wet cloths or rags and covered with plastic to retain moisture. The covering may greatly minimize the common superficial surface cracking. Minimize any external vibration to protect the uncured grout from movement for several hours after pour.

3.9 **Torquing Bolts.** Anchor nuts may be tightly snugged or half torqued after 1 day if required and fully torqued after 3-4 days. See VertexRSI Bolt Tightening Procedure 400-0430.

GENERAL DYNAMICS
SATCOM Technologies

GENERAL PROCEDURE KINGPOST PEDESTAL FINAL ALIGNMENT

(Verticality / Azimuth Lean)

400-0429

Revision B
April 6, 2004

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REV	DESCRIPTION	DATE	WRITER	CHK.	APPR.
B	ECR 04-0322. Remove customer Representative from sign off. Convert to Microsoft Doc. Removed reference to customer sign-off: change 2.0 paragraph 1, Important; 5.4 step 5, 6; 6.0 title; 6.0 step 7. Change the numbering reference in 5.3 step 6	04/06/04	JMF	JLE	AP
A	Original Release	08/05/96	CLS	JPK	KDR

Use of *WARNINGS,* CAUTIONS, etc.

Warnings, Cautions and other notes are included throughout this document to provide necessary information. IGNORING WARNINGS, CAUTIONS AND OTHER NOTES MAY RESULT IN DAMAGE TO THE PRODUCT, INJURY, OR IN EXTREME CASES, DEATH. You should know the use of Warnings, Cautions and other markings. Definitions are:

WARNING! ***HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN INJURY TO OR DEATH OF PERSONNEL.***

CAUTION! **HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO OR DESTRUCTION OF EQUIPMENT OR THE LOSS OF MISSION EFFECTIVENESS OR LONG TERM HEALTH HAZARDS TO PERSONNEL.**

Important: **Highlights an essential installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, will ensure efficiency and/or safety of said procedures.**

Note: *Highlights an installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, could enhance efficiency and/or safety of said procedures.*

ESD: **The Electrostatic Sensitive Device (ESD) appears at the beginning of any procedure or procedural step that includes the handling of equipment sensitive to damage from electrostatic discharge.**

General Warnings and Cautions are also provided at the front of the document. These Warnings and Cautions should be read by anyone who is involved with installation, has access to the equipment or is assigned to perform maintenance on the equipment.

CAUTIONARY NOTICE

Although SATCOM Technologies has attempted to detail in this document all areas of possible danger to personnel in connection with the use of this equipment, personnel should use caution when installing, operating and servicing this equipment. Care should be taken to avoid electrical shock, whether the hazard is caused by design or malfunction. SATCOM Technologies is specifically not liable for any damage or injury arising from a technician's failure to follow the instructions contained in this document or his failure to exercise due care and caution in the installation, operation and service of this equipment. SATCOM Technologies shall not be responsible for injury or damage resulting from improper procedures or from the use of improperly trained or inexperienced personnel performing such tasks.

This document is intended as a general guide for trained and qualified personnel who are aware of the dangers of handling potentially hazardous electrical and electronic circuits. This document is not intended to contain a complete statement of all safety precautions that should be observed by personnel in using this or other electronic equipment.

ELECTRICAL HAZARDS

The antenna and feed system supplied by SATCOM Technologies is designed to be integrated with various types of electronic equipment. This system, if integrated with high power amplifiers or traveling wave tubes, will be capable of transmitting microwave energy at varying power levels. If transmitting microwave power, SATCOM Technologies cautions the end-user to review all applicable local, federal and international regulations and to comply with all such regulations in the operation and maintenance of the integrated system.

The electrical currents and voltages associated with this equipment, whether supplied by SATCOM Technologies or others, are dangerous. Personnel must at all times observe safety regulations.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Always disconnect power before opening covers, doors, enclosures, gates, panels or shields.
- Always use grounding sticks and short out high voltage points before servicing.
- Do not remove, short-circuit or tamper with interlock switches on access covers, doors, enclosures, gates, panels or shields.
- Keep away from live circuits.
- Know your equipment and do not take risks.
- Always remove all power to the system prior to working on the antenna, the reflector assembly, the reflector backup assembly or the feed assembly.
- Always tag all circuits noting that the power is OFF, the date and your name, prior to commencing any work on that system.

In case of emergency, be sure that power is disconnected.

POTENTIAL DAMAGE TO ANTENNA

The antenna limit switches and resolvers have been pre-set to allow for maximum antenna performance. Any subsequent adjustment may jeopardize antenna performance and/or result in damage to the antenna.

SAFETY NOTICE

The following safety procedures are listed to remind those performing any work on the antenna system that safety rules must be observed. Failure to observe safety rules may result in serious injury or death. Always work safely and in accordance with established procedures.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Care shall be taken in all operations to safeguard other people as well as property and to comply with all local safety procedures as established by the customer's site representative, as well as local building codes and fire protection standards.
- All persons performing work on the antenna system shall also comply with the Occupational Safety and Health Act (OSHA) standards and all other federal state and local laws, ordinances, regulations and codes relating to designated work.
- Unless the customer's representative on site specifically designates an individual responsible for site safety, the SATCOM Technologies Site Supervisor shall be responsible for and establish a site safety program for the SATCOM Technologies installation work. The site safety program shall incorporate all SATCOM Technologies safety procedures and requirements
- Never make internal adjustments or perform maintenance or service when alone or fatigued.

ELECTROMAGNETIC RADIATION

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Do not stand in the direct path of the feed system when the system is transmitting!
- Do not work on the feed system when the system is on!

ALWAYS WORK SAFELY!

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LIST OF FIGURES

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1.0 SCOPE

This document defines a procedure for the vertical alignment of a kingpost pedestal. This procedure assumes the pedestal and reflector have previously been installed and the pedestal verticality has been rough aligned with a spirit level. This document provides data record for the final verticality alignment.

2.0 PREREQUISITES

Prior to starting this procedure, the following installations and alignments must have been completed and checked. If they have not been accomplished, they must be completed before beginning the final pedestal alignment per this specification. Final alignment readings shall not be recorded until the structure is thermally stable, preferably at night. Do not grout the pedestal legs until this sheet has been signed.

Step 1 The pedestal has been installed according to the appropriate assembly drawing.

Step 2 The pedestal has a rough verticality alignment within 30 arc minutes (0.5°).

Step 3 The grout clearances are nominal as required per the installation drawing.

Step 4 Anchor nuts have several threads above the full nut engagement allowing ample adjustment during final alignment.

Step 5 The lower azimuth pintle has been leveled and grouted per installation drawing.

Step 6 The gap on three leg pedestals between the upper pintle and bearing must have been rough set per the drawing.

Step 7 The full weight of the reflector has been installed on the pedestal and can be driven to the operational look angle, at least manually.

3.0 APPLICABLE DOCUMENTS AND DRAWINGS

Contact General Dynamics SATCOM Technologies document control if the following documents are not part of the documentation package.

300-2436 High Strength Grout Preparation, Mixing, Placement

400-430 Bolt Tightening Procedure

4.0 EQUIPMENT

1. Theodolite with 3 way base

   Recommended: Topcon ETL-1
   Hilger-Watts ST210 "Top loaded"
   Hilger-Watts ST200 "Top loaded"
   Wild T2 P/N 308501

2. Theodolite Tri-pod
3. ½" wide linear scale with an incremental resolution of 1/64" (0.010") or better.
4. Starrett Level

5.0 PROCEDURE

5.1 Pedestal Preparation.

Final alignment of the pedestal should not be started until after the full deadweight of the reflector has been installed. Measurements should be made only after dark to allow the structure to become thermally stable.

Step 1 Verify the pedestal has been rough leveled in 2 directions using a spirit level on the vertical pedestal tube.

Step 2 Verify that all anchor nuts and push bolts are snug and push bolts are greased. The grease should help prevent galling of the threads.

Step 3 Level and grout the lower azimuth pintle base only at this time. Allow grout to cure overnight before proceeding with verticality alignment.

5.2 Instrumentation Setup

Step 1 Position the antenna in azimuth at pos.1 (see figure 5-1)(i.e. the center of rotation).

Step 2 Place the scale on the opposite sie of the pedestal from the pintle near the jack pivot point as shown (figure 1). Verify the scale is secure and will not move relative to the pedestal during rotation. A magnetic base works well to secure this scale.

Note: *The further the scale is placed from the azimuth axis the more precise the measurements will be. A stable extension placing the scale at least 60 inches from the azimuth axis is highly recommended.*

Step 3 Place the theodolite on a tripod no less than 6 Ft. from the scale directly in front of the pedestal to insure total viewing of the scale during rotation. Locating the scale and theodolite in this position should allow the scale to be viewed as the pedestal is rotated through approximately ±90°.

Note: *A few kingpost pedestal designs may only have a ±60° capability. In this case 60°will be sufficient.*

Important: *The theodolite should be operated by trained personnel only.*

Step 4 Lock gravity mode into the theodolite.

Step 5 Verify the theodolite is securely mounted and leveled to gravity. It may be necessary to grout the tripod legs in soft soil conditions.

5.3 Pedestal Alignment Measurement

Step 1 With the antenna at its center of rotation pos.1 (figure 5-1), set the scale at a 45° angle (figure 5-2) and read the scale with the theodolite. Record reading in table 6-1.

Step 2 After reading at pos. 1 rotate the antenna to pos. 2. Record the scale reading.

Step 3 Rotate the antenna to pos. 1, and rotate the scale 45° in the other direction being careful not to change the vertical reading of the scale. Verify the scale reading is identical as before rotation.

Step 4 Rotate the antenna to pos. 3 and record the reading.

Step 5 Determine the amount of change between positions 1 and 2, between positions 1 and 3, and between positions 2 and 3. Record these differences in Table 6-1.

Step 6 Record the max peak error of the differences calculated in Step 5 above in the last column of table 6-1.

Step 7 Return the pedestal to the center position 1 and adjust the pedestal verticality as needed per section 5.4.

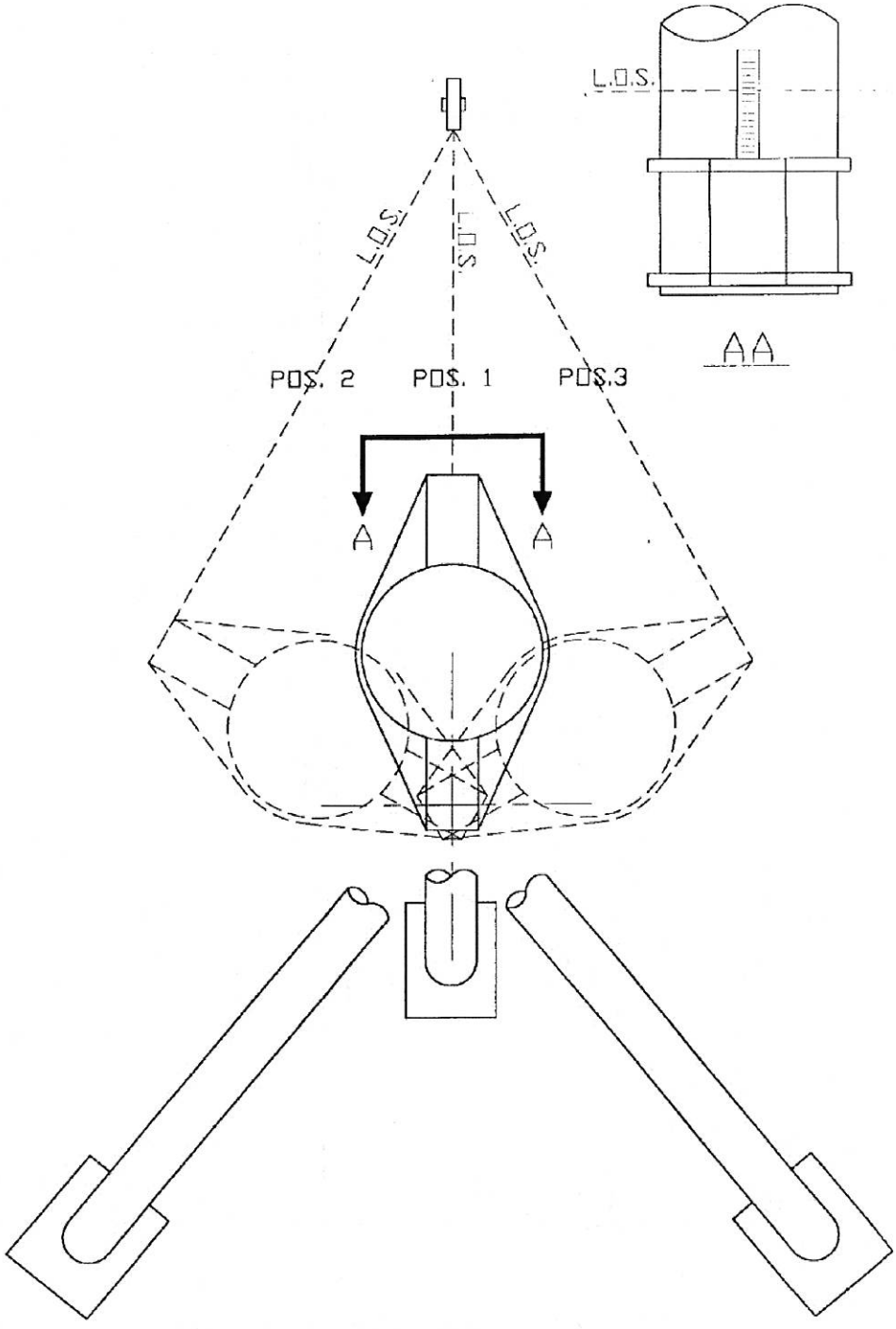

Figure 5 - 1. Instrument and Scale Setup

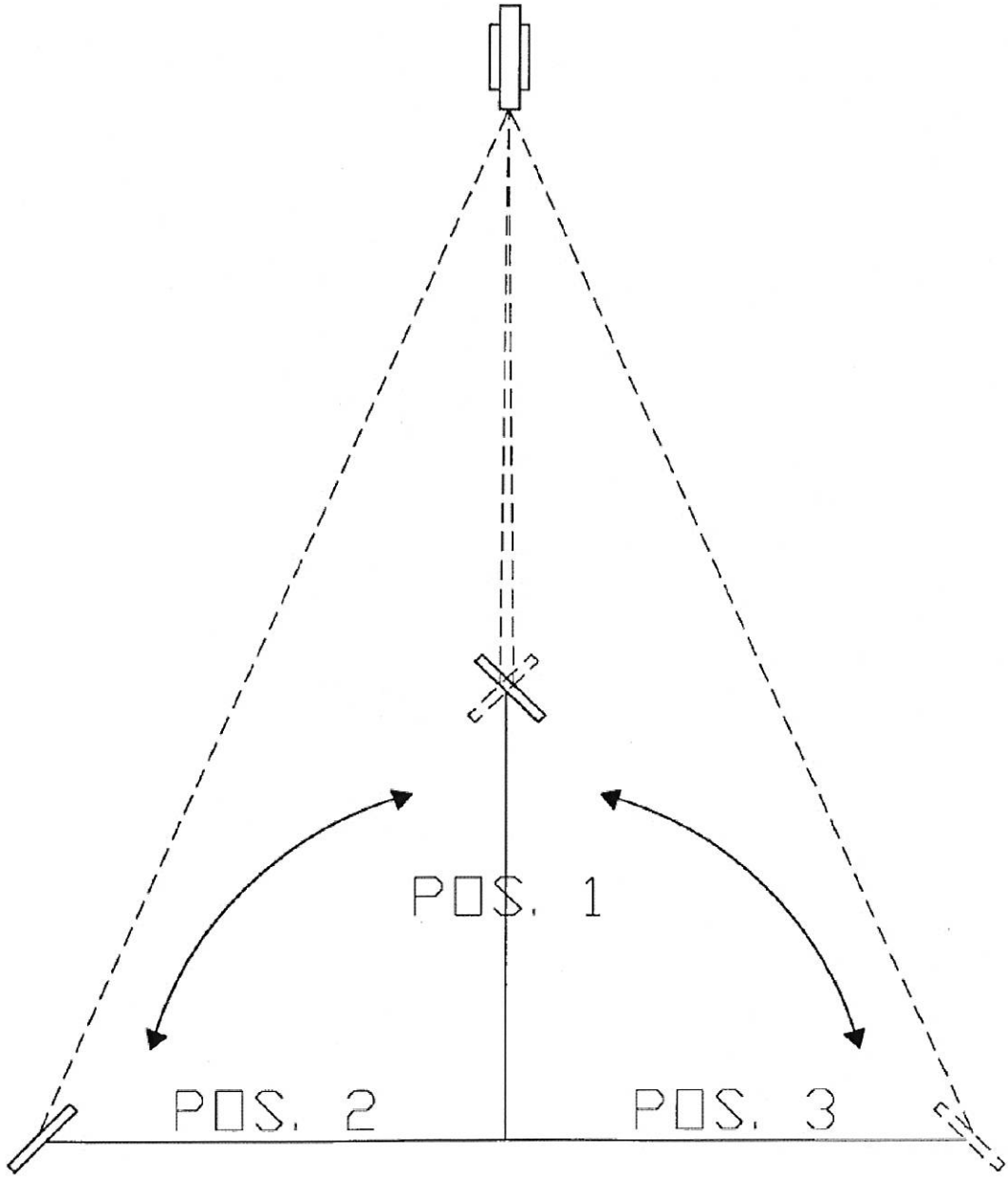

Figure 5 - 2 Scale Rotational Location

5.4 Pedestal Alignment Adjustment

The pedestal verticality will be adjusted using vertical movements of the support legs anchor nuts an push bolts. The difference between the maximum and minimum peak readings is used to calculate the verticality of the pedestal. Typical maximum allowable lean for a standard kingpost at operating elevation look angle is 0.030° from the vertical or 0.0005 inches per inch (see example below). For critical or special alignments (i.e. TT&C site) the maximum allowable lean at the operating elevation look angle is reduced to 0.010° from the vertical or 0.00018 inches per inch (see example below). If the measurements exceed specifications, adjust the pedestal legs per this section to correct the alignment.

Example: If the horizontal radial distance measured from the azimuth pintle center (AZ axis) to the scale is 50 inches, then 50 times 0.0005 equals 0.025 inches. This 0.025 inches corresponds to the vertical L.O.S. reading on the scale.

Therefore, 0.025" reading on the scale would be the max peak error for a standard pedestal.

Example: (scale reading) / (radius to scale) X 57.3 = Angle in Degrees
(0.025") / (50") X 57.3 = 0.029°

Step 1 Adjust the pedestal legs to align pedestal verticality. With the antenna facing the center (position 1), the legs are adjusted up and down by alternately turning the anchor nuts and push bolts until each side has moved the appropriate distance. The following rules of movement apply:

Important: *The pedestal must be rotated to the center position before making any adjustments.*

a. If position 1 is below both end positions, both legs moved down to correct the error.
b. If position 1 is above both end positions both legs move up to correct the error.
c. If position 1 is between the end positions, the leg on the low end moves up and the leg on the high end moved down.

Note: *If the scale reading is low the leg opposite that side goes up and vis-versa for a high reading*

IMPORTANT: ON 3 LEGGED DESIGNS MAKE SURE THE UPPER PINTLE BEARING IS FULLY SEATED AROUND THE PINTLE SHAFT. CHECK FOR PROPER CLEARANCE BETWEEN THE PINTLE BASE AND THE BEARING BLOCK.

Step 2 When each adjustment is completed, verify both the anchor nuts and push bolts are snug.

Step 3 Re-read and record the measurements for each of the three positions as in section 5.3.

Step 4 Repeat the above procedure, each time readjusting the legs as required, until the vertical alignment is within specification.

Step 5 After final alignment, grout the pedestal legs per General Dynamics SATCOM Technologies specification 300- 2436.

Step 6 Remove the theodolite and other tools used in the alignment.

Step 7 After the grout curing time is reached, typically 2-3 days minimum, remove push bolts and torque anchor bolts to the drawing specification.

6.0 ALIGNMENT RECORD

Step 1 Record elevation look angle_____(deg)

Step 2 Verticality specification in degrees_____(Contact Project Engineer if not in work scope)

Step 3 Record horizontal radial distance from axis to scale R=_____(in)

Step 4 Record alignment readings from section 5.0 in the following table.

Table 6 - 1 Verticality Alignment Data Work Sheet and Record

	Reading (in)	Reading (in)	Reading (in)	Error* (in)	Error (in)	Error* (in)	Max Peak Error** (in)
Step	**Pos 3**	**Pos 1**	**Pos 2**	**1 – 2**	**1 – 3**	**2 – 3**	**P =**
1							
2							
3							
4							
5							
6							
7							
Final							

* Calculate the difference error by subtracting the absolute values of the noted reading positions.

** The maximum peak value (P) is the largest error calculated in the three columns to the left.

Step 5 Calculate the final verticality error using the Final Max Peak Error from the last line of above table in the equation below:

Error = P / R = _____(in)

Error = P / R x 57.3 = _____(deg)

Step 6 Finalize alignment with check and sign-off

a. Verticality specification recorded in 6.2 is correct_____
b. Verticality alignment error recorded in 6.5 is less than or equal to specification in 6.2_____
c. Record antenna model number_____
d. Record Job number_____

Step 7 Sign-off. The below signed witnesses that the pedestal in question has been properly aligned and verified per this procedure and is within the required specification of paragraph 6.2

General Dynamics SATCOM Technologies Representative _____
_____ Date_____

GENERAL DYNAMICS
SATCOM Technologies

BOLT TIGHTENING

PROCEDURE AND SPECIFICATION

400-0430

Revision E
March 10, 2000

General Dynamics SATCOM Technologies
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REV.	DESCRIPTION	DATE	WRITER	CHECK	APPR.
E	ECR #00-0444	3/14/00	CLW	HAP	CLS
D	ECR #99-1049	8/16/99	CLW	SPK	CLS
C	ECR #98-1365	9/15/98	SMB	GPR	CLS
B	ECR #	10/10/96		HLA	
A	ORIGINAL RELEASE	05/16/94	CLS	KDR	KDR

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LIST OF TABLES

1.0 SCOPE

1.1 This specification defines the accepted methods to tighten a bolt and obtain the required clamping force for structural hardware. Information for anchor bolt tightening has also been included. The two methods that will be shown are "Turn-of-Nut" and "Calibrated Torque Wrench" methods. One of the two methods shall be closely followed when tightening a bolt to the specified tension.

Note: *Unless otherwise specifically noted on the applicable drawing, this document will govern structural fasteners. Non-structural connections and special clamping bolts may require reduced torques as defined by drawings or other procedures.*

2.0 PROCEDURE

2.1 Requirements

When A325 bolts of any size, or A490 bolts less than or equal to 1" in diameter, are installed in a long slotted hole in an outer ply, a plate washer with a minimum of 5/16" thickness with standard holes shall be used. The plate washer should completely cover the slot and be made of structural grade material. The plate washer does not need hardening except when an A490 bolt larger than 1" in diameter is used. A single hardened washer conforming to ASTM F436 except with a thickness of 5/16" minimum shall be used in place of the structural grade plate washer.

A325 bolts any size and A490 bolts equal to or less than 1" in diameter require hardened F436 washers when in an oversize or short slotted hole at the outer ply.

A325 fasteners can be installed without hardened washers when tightened by the turn-of-nut method. A490 bolts installed by the turn-of-nut method and A325 or A490 bolts tightened by the calibrated wrench method shall have a hardened washer under the element turned in tightening. Additionally, a hardened washer shall be used with all A490 bolts under the element **not** turned in tightening. A beveled washer shall be used when the slope is greater than 1:20 between the bolted material and the bolt axis.

2.2 Turn-of-Nut Method

To properly tighten a bolt using the turn-of-nut method, the bolt must be brought to a snug tight condition. This is accomplished by applying effort on the bolt using an ordinary spud wrench or a few impacts of an impact wrench such that all plys of the connection are in good contact. Finish tightening the bolt by turning the bolt the required amount found in Table 1. Consistency and reliability is dependent upon assuring that the joint is well compacted when all bolts are snug tight prior to the final required partial turn (See Table 1). Reliability is also dependent upon assuring that the element not turned in tightening does not move while the required turn is applied to the turned element. Marks must be applied to both elements using a marker or small amount of paint. These marks will show the actual rotation that was applied between the elements and allow visual inspection by a second party. When properly implemented, the turn-of-nut method will slightly elongate the bolt providing uniform tension in the bolt.

2.3 Calibrated Wrench Method

To properly tighten a bolt using the calibrated wrench method, one element must be held while the other is rotated by a calibrated torque wrench. The torque wrench must be turning the bolt or nut when the final torque is achieved to ensure the torque is properly applied. Hardened washers must be used and close attention must be given to control the factors that cause variability in the bolt torque.

IMPORTANT: *The actual clamping loads may vary from day to day due to wrenches, personnel, bolt design and environmental conditions. This method must be calibrated with a tension-indicating device and with referencing Table 2.*

2.4 Lubrication

Values for lubed torque tightening are given in the tables following Section 3. Unless otherwise specified, all hardware must be lubricated prior to tightening to prevent galling and to provide consistent and more accurate torque measurements. The lubricant may consist of any common organic or synthetic petroleum oil, grease, or dry wax-based lubricant. For example, penetrating lubricant such as WD-40® or Castrol Corporation's Stick Wax® general-purpose solid lubricant may be used. The lubricant should be applied in a manner which thoroughly coats all threads of the bolts.

NOTES:

1. Tightening torque values are calculated using the formula $T = KDP/12$, where T = tightening torque, lb.-ft. (unless otherwise noted); K = torque-friction coefficient; D = nominal bolt diameter, in.; and P = bolt clamping load developed by tightening, lb. K = 0.20, for Tightening Torque Dry; K = 0.15, for Tightening Torque Lubed.
2. Clamping Load (lbs.) is calculated assuming usable bolt strength is 70% of bolt ultimate strength multiplied by the tensile stress area (sq.in.) of threaded section of each bolt size.
3. To convert the Tightening Torque Dry and Lubed to lbs.-in. simply multiply by 12.
4. A. To convert from lb.-in. to N·m multiply by 0.113.
   B. To convert from lb.-ft. to N·m multiply by 1.356.
   C. To convert from N·m to lb.-in. divide by 0.113.
   D. To convert from N·m to lb.-ft. divide by 1.356.

Table 1: Turn-Of-Nut

Bolt Length (as measured from underside of head to extreme end of point)	DISPOSITION OF OUTER FACES OF BOLTED PARTS		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces sloped not more than 1:20 from normal to bolt axis (bevel washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn
Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance should be plus or minus 30°. For bolts installed by 3/4 turn and more, the tolerance should be plus or minus 45°.			

Note: *Turn-of-Nut method is not recommended for ½ inch or 12 mm bolts or smaller. Use only published tightening torque to tighten these bolts.*

3.0 SURFACE CONDITIONS

When assembled, all joint surfaces, including surfaces adjacent to the bolt head and nut, shall be free of scale, except tight mill scale. Joint sufaces shall also be free of dirt or other foreign material. Burrs that would prevent solid seating of the connected parts, in the snug-tight condition, shall be removed. Except in slip critical connections, paint is permitted on the faying surfaces unconditionally in connections. The faying surfaces of slip critical connections shall meet the following requirements, as applicable.

3.1 In non-coated joints, paint, including any inadvertent overspray, shall be excluded from areas closer than one bolt diameter, but not less than one inch from the edge of any hole and all areas within the bolt pattern.

3.2 Coatings may be used but are subject to the approval of the Engineer.

3.3 Coated joints shall not be assembled before the coatings have cured for the minimum amount of time specified by the Engineer.

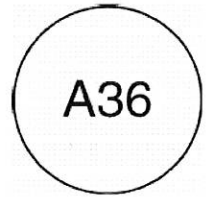
3.4 Galvanized faying surfaces that are hot dip galvanized shall be roughened by means of wire brushing by hand. **Power wire brushing is not permitted**.

Table 2: Bolt Torque and Clamping Loads

			GRADE 1 (A 307) BOLTS TIGHTENING TORQUE		
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	ULTIMATE STRENGTH (psi)	LUBED TIGHTENING TORQUE (lb.-ft.)	CLAMPING LOAD (lbs.)
1/4 - 20	0.2500	0.0318	60,000	50 (lb.-in.)	1336
1/4 - 28	0.2500	0.0364	60,000	57 (lb.-in)	1528
5/16 - 18	0.3125	0.0524	60,000	103 (lb.-in.)	2202
5/16 - 24	0.3125	0.0581	60,000	114 (lb.-in.)	2439
3/8 - 16	0.3750	0.0775	60,000	183 (lb.-in.)	3255
3/8 - 24	0.3750	0.0878	60,000	207 (lb.-in.)	3689
7/16 - 14	0.4375	0.1063	60,000	24	4465
7/16 - 20	0.4375	0.1187	60,000	27	4986
1/2 - 13	0.5000	0.1419	60,000	37	5960
1/2 - 20	0.5000	0.1600	60,000	42	6718
9/16 - 12	0.5625	0.1819	60,000	54	7642
9/16 - 18	0.5625	0.2030	60,000	60	8525
5/8 - 11	0.6250	0.2260	60,000	74	9492
5/8 - 18	0.6250	0.2560	60,000	84	10750
3/4 - 10	0.7500	0.3345	60,000	132	14047
3/4 - 16	0.7500	0.3730	60,000	147	15664
7/8 - 9	0.8750	0.4617	60,000	212	19393
7/8 - 14	0.8750	0.5095	60,000	234	21398
1 - 8	1.0000	0.6057	60,000	318	25441
1 - 12	1.0000	0.6630	60,000	348	27848
1 1/8 - 7	1.1250	0.7633	60,000	451	32058
1 1/8 - 12	1.1250	0.8557	60,000	505	35940
1 1/4 - 7	1.2500	0.9691	60,000	636	40703
1 1/4 - 12	1.2500	1.0729	60,000	704	45064
1 3/8 - 6	1.3750	1.1549	60,000	834	48505
1 3/8 - 12	1.3750	1.3147	60,000	949	55218
1 1/2 - 6	1.5000	1.4053	60,000	1,107	59021
1 1/2 - 12	1.5000	1.5810	60,000	1,245	66403

A307 FASTENER IDENTIFICATION

			GRADE 2 (A 36) BOLTS TIGHTENING TORQUE		
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	ULTIMATE STRENGTH (psi)	LUBED TORQUE TIGHTENING (lb.-ft.)	CLAMPING LOAD (lbs.)
1/4 - 20	0.2500	0.0318	58,000	48 (lb.-in.)	1292
1/4 - 28	0.2500	0.0364	58,000	55 (lb.-in)	1477
5/16 - 18	0.3125	0.0524	58,000	100 (lb.-in)	2129
5/16 - 24	0.3125	0.0581	58,000	111 (lb.-in)	2357
3/8 - 16	0.3750	0.0775	58,000	177 (lb.-in)	3146
3/8 - 24	0.3750	0.0878	58,000	201 (lb.-in)	3566
7/16 - 14	0.4375	0.1063	58,000	24	4316
7/16 - 20	0.4375	0.1187	58,000	26	4820
1/2 - 13	0.5000	0.1419	58,000	36	5761
1/2 - 20	0.5000	0.1600	58,000	41	6494
9/16 - 12	0.5625	0.1819	58,000	52	7387
9/16 - 18	0.5625	0.2030	58,000	58	8241
5/8 - 11	0.6250	0.2260	58,000	72	9176
5/8 - 18	0.6250	0.2560	58,000	81	10392
3/4 - 10	0.7500	0.3345	58,000	127	13579
3/4 - 16	0.7500	0.3730	58,000	142	15142
7/8 - 9	0.8750	0.4617	58,000	205	18746
7/8 - 14	0.8750	0.5095	58,000	226	20685
1 - 8	1.0000	0.6057	58,000	307	24593
1 - 12	1.0000	0.6630	58,000	336	26919
1 1/8 - 7	1.1250	0.7633	58,000	436	30989
1 1/8 - 12	1.1250	0.8557	58,000	489	34742
1 1/4 - 7	1.2500	0.9691	58,000	615	39346
1 1/4 - 12	1.2500	1.0729	58,000	681	43562
1 3/8 - 6	1.3750	1.1549	58,000	806	46888
1 3/8 - 12	1.3750	1.3147	58,000	917	53377
1 1/2 - 6	1.5000	1.4053	58,000	1,070	57053
1 1/2 - 12	1.5000	1.5810	58,000	1,204	64190
1 3/4 - 5	1.7500	1.8995	58,000	1,687	77118
2 - 4 1/2	2.0000	2.4982	58,000	2,536	101428
2 1 /4 - 4 1/2	2.2500	3.2477	58,000	3,708	131856
2 1/2 - 4	2.5000	3.9988	58,000	5,074	162352
2 3/4 - 4	2.7500	4.9340	58,000	6,886	200321
3 - 4	3.0000	5.9700	58,000	9,089	242382



A36 FASTENER IDENTIFICATION
(STAMPED ON END OF BOLT)

			GRADE 5 (A 325 or 4140) BOLTS	
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	ULTIMATE STRENGTH (psi)	CLAMPING LOAD (lbs.)
1/2 - 13	0.5000	0.1419	120,000	12,000
5/8 - 11	0.6250	0.2260	120,000	19,000
3/4 - 10	0.7500	0.3345	120,000	28,000
7/8 - 9	0.8750	0.4617	120,000	39,000
1 - 8	1.0000	0.6057	120,000	51,000
1 1/8 - 7	1.1250	0.7633	105,000	56,000
1 1/4 - 7	1.2500	0.9691	105,000	71,000
1 3/8 - 6	1.3750	1.1549	105,000	85,000
1 1/2 - 6	1.5000	1.4053	105,000	103,000

Note: *Only Turn-of-Nut method shall be used for A325 bolts.*

A325 FASTENER IDENTIFICATION

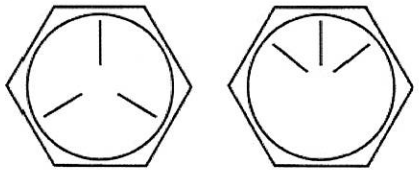
			GRADE 8 (A 490) BOLTS TIGHTENING TORQUE	
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	ULTIMATE STRENGTH (psi)	CLAMPING LOAD (lbs.)
1/2 - 13	0.5000	0.1419	150,000	15,000
5/8 - 11	0.6250	0.2260	150,000	24,000
3/4 - 10	0.7500	0.3345	150,000	35,000
7/8 - 9	0.8750	0.4617	150,000	49,000
1 - 8	1.0000	0.6057	150,000	64,000
1 1/8 - 7	1.1250	0.7633	150,000	80,000
1 1/4 - 7	1.2500	0.9691	150,000	102,000
1 3/8 - 6	1.3750	1.1549	150,000	121,000
1 1/2 - 6	1.5000	1.4053	150,000	148,000

A490 FASTENER IDENTIFICATION

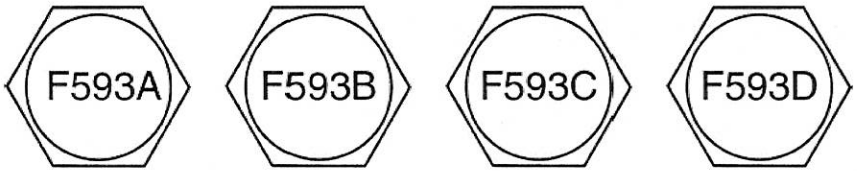
			ASTM A193 B-7 ANCHOR BOLTS TIGHTENING TORQUE		
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	ULTIMATE STRENGTH (psi)	LUBED TIGHTENING TORQUE (lb.-ft.)	CLAMPING LOAD (lbs.)
3/4 - 10	0.7500	0.3345	125,000	274	29,265
7/8 - 9	0.8750	0.4617	125,000	442	40,402
1 - 8	1.0000	0.6057	125,000	663	53,003
1 1/8 - 7	1.1250	0.7633	125,000	939	66,787
1 1/4 - 7	1.2500	0.9691	125,000	1,325	84,797
1 3/8 - 6	1.3750	1.1549	125,000	1,737	101,052
1 1/2 - 6	1.5000	1.4053	125,000	2,305	122,960
1 3/4 - 5	1.7500	1.8995	125,000	3,636	166,203
2 - 4 1/2	2.0000	2.4982	125,000	5,465	218,595
2 1 /4 - 4 1/2	2.2500	3.2477	125,000	7,992	284,173
2 1/2 - 4 1/2	2.5000	3.9988	125,000	10,934	349,897
2 3/4 - 4	2.7500	4.9340	115,000	13,653	397,188
3 - 4	3.0000	5.9700	115,000	24,029	480,585

A193 / B7 FASTENER IDENTIFICATION
(STAMPED ON END OF BOLT)

			A 449 BOLTS TIGHTENING TORQUE			STAINLESS STEEL-ANNEALED F 593 BOLTS TIGHTENING TORQUE		
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	ULTIMATE STRENGTH (psi)	LUBED TIGHTENING TORQUE (lb.-ft.)	CLAMPING LOAD (lbs.)	ULTIMATE STRENGTH (psi)	LUBED TIGHTENING TORQUE (lb.-ft.)	CLAMPING LOAD (lbs.)
1/4 - 20	0.2500	0.0318	120,000	100 (lb.-in.)	2,673	85,000	101 (lb.-in.)	1,893
5/16 - 18	0.3125	0.0524	120,000	17	4,404	85,000	209 (lb.-in.)	3,120
3/8 - 16	0.3750	0.0775	120,000	31	6,509	85,000	370 (lb.-in.)	4,611
7/16 - 14	0.4375	0.1063	120,000	49	8,930	85,000	49	6,325
1/2 - 13	0.5000	0.1419	120,000	74	11,920	85,000	75	8,443
5/8 - 11	0.6250	0.2260	120,000	148	18,984	85,000	150	13,447
3/4 - 10	0.7500	0.3345	120,000	263	28,095	85,000	267	19,900
7/8 - 9	0.8750	0.4617	120,000	424	38,786	85,000	429	27,473
1 - 8	1.0000	0.6057	120,000	636	50,883	85,000	644	36,042
1 1/8 - 7	1.1250	0.7633	105,000	789	56,101	85,000	912	45,415
1 1/4 - 7	1.2500	0.9691	105,000	1,113	71,230	85,000	1,287	57,662
1 3/8 - 6	1.3750	1.1549	105,000	1,459	84,884	85,000	1,687	68,716
1 1/2 - 6	1.5000	1.4053	105,000	1,937	103,286	85,000	2,240	83,612
1 3/4 - 5	1.7500	1.9000	90,000	2,618	119,666			
2 - 4 1/2	2.0000	2.5000	90,000	3,935	157,388			
2 1 /4 - 4 1/2	2.2500	3.2500	90,000	5,754	204,604			
2 1/2 - 4 1/2	2.5000	4.0000	90,000	8,063	258,006			
2 3/4 - 4	2.7500	4.9300	90,000	10,685	310,843			
3 - 4	3.0000	5.9700	90,000	14,098	375,945			



A449 FASTENER IDENTIFICATION



F593 FASTENER IDENTIFICATION
(IF UNDERLINED, NUMERALS INDICATE STRAIN HARDENING)

			METRIC BOLTS TIGHTENING TORQUE B.S 4395		
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	PROOF STRENGTH (psi)	LUBED TIGHTENING TORQUE (lb.-ft.)	CLAMPING LOAD (lbs.)
M16 x 2.0	0.6299	0.2434	113,000	160	20,620
M20 x 2.5	0.7874	0.3798	113,000	320	32,180
M22 x 2.5	0.8661	0.4697	113,000	430	39,800
M24 x 3.0	0.9449	0.5472	113,000	550	46,370
M27 x 3.0	1.0630	0.7115	113,000	800	60,300
M30 x 3.5	1.1811	0.8696	113,000	1,090	73,690
M33 x 3.5	1.2992	1.0757	113,000	1,480	91,170
*M36 x 4.0	1.4173	1.2664	113,000	1,900	107,320

*Not a size in British Standard; included to match the table for ASTM A 325M and A 490M.

			METRIC BOLT TIGHTENING TORQUE A 325M	
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	PROOF STRENGTH(psi)	CLAMPING LOAD (lbs.)
M16 x 2.0	0.6299	0.2434	120,000	20,446
M20 x 2.5	0.7874	0.3798	120,000	31,903
M22 x 2.5	0.8661	0.4697	120,000	39,455
M24 x 3.0	0.9449	0.5472	120,000	45,965
M27 x 3.0	1.0630	0.7115	120,000	59,766
M30 x 3.5	1.1811	0.8696	105,000	63,916
*M33 x 3.5	1.2992	1.0757	105,000	79,064
M36 x 4.0	1.4173	1.2664	105,000	93,080

*Not a size in ASTM A 325M, A 325M, or A 490M; included to match the table for British Standard.

Note: *Only Turn-of-Nut method shall be used for A325M bolts.*

			METRIC BOLT TIGHTENING TORQUE A 490M	
BOLT SIZE	BOLT DIA. (in.)	TENSILE STRESS AREA (sq.in.)	PROOF STRENGTH (psi)	CLAMPING LOAD (lbs.)
M16 x 2.0	0.6299	0.2434	150,000	25,557
M20 x 2.5	0.7874	0.3798	150,000	39,879
M22 x 2.5	0.8661	0.4697	150,000	49,319
M24 x 3.0	0.9449	0.5472	150,000	57,456
M27 x 3.0	1.0630	0.7115	150,000	74,708
M30 x 3.5	1.1811	0.8696	150,000	91,308
*M33 x 3.5	1.2992	1.0757	150,000	112,949
M36 x 4.0	1.4173	1.2664	150,000	132,972

*Not a size in ASTM A 325M or A 490M; included to match the table for British Standard.
Note: *Only Turn-of-Nut method shall be used for A490M bolts.*

GENERAL DYNAMICS
SATCOM Technologies

INSTALLATION TOOL LIST

FOR

6.1, 7.2, 8.1, 9.0 METER ANTENNA

500-0322

Revision D
February 3, 2004

General Dynamics SATCOM Technologies
2600 N. Longview St., Kilgore, TX USA 75662-6842
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SATCOM TECHNOLOGIES CONFIDENTIAL AND PROPRIETARY

D	EC# 03-1087	11/21/03	SLM	JE	AP
C	EC# 98-1243	7/08/98	BBB	RRS	RPC
B	ECR #	10-02-96		HLA	
A	Original Release	01/12/00	CLW	JED	MJR
REV	**DESCRIPTION**	**DATE**	**WRITER**	**CHK.**	**APPR.**

Description	Qty.
3/8" H.D. Reversible Drill with Chuck-Key	1
4 lb. Hammer	1
Claw Hammer	2
Bull Pins	2
1 1/16" Spud Wrench	2
7/8" Open End Box End Wrench	3
3/4" Open End Box End Wrench	3
9/16 " Open End Box End Wrench	3
7/16" Open End Box End Wrench	3
6" Crescent Wrench	2
12" Crescent Wrench	2
18" Crescent Wrench	1
24" Crescent Wrench	1
1 7/8" Open End Short Handle Wrench (Feed Rollers)	1
1/2" Drive Socket Set 7/16" thru 1 1/4"	3
1/2" Drive Ratchet 16" Lg	3
3/8" Drive Ratchet 12" Lg	1
3/8" Drive Socket Set 1/4" thru 3/4"	1
1/2" Drive Extension 6"	3
3/8" Drive Extension 12"	3
1/2" Drive Universal	3
9/16" Socket 3/8" Drive	2
1 1/4" Socket 1/2" Drive	1
1 1/8" Socket 1/2" Drive	1
1 1/16" Socket 1/2" Drive	1
7/8" Socket 1/2" Drive	2
3/4" Socket 1/2" Drive	2

Description	Qty.
Wrecking Bar	2
Plumb Bob	1
10" Channel Locks	2
Set of Allen Wrenches to 1/2"	2
8" Cold Chisel	2
Center Punch - 5/16	1
H.D. Set Reversible Snap Ring Pliers	2
10" Flat Machine File	1
10" Rat Tail File	1
25' Measuring Tape	1
Tap Set to 1/2" #4-1/2" Tap & Die	2
Drill Index to 1/2" Complete 1/16"-1/2"	2
Assorted Flat Screwdrivers	2 Sets
Assorted Phillips Screwdrivers	2 Sets
Hacksaw w/(6) 32-Teeth per Inch Blades	12
20' Nylon Slings	4
3' Nylon Slings	4
5 Gallon Buckets	1
5-Gallon Paint Mixer (Flapper)	1
8" "C" Clamps	2
Caulking Gun	2
3/8" Nylon Rope	200'
Cats Eye Level	1
2' Level	1
Tin Snips 10"	2
Wire Brush Shoe Handle	6
Electrical Crimping Tool (E50960-1) Note: This item is for 9M FM only.	1

GENERAL DYNAMICS
SATCOM Technologies

ANTENNA SYSTEM
INSTALLATION CHECKLIST
STANDARD

900-0255

Revision M
January 29, 2004

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REV	DESCRIPTION	DATE	WRITER	CHK.	APPR.
M	EC#04-0112 Both Customer and Installation surveys have been changed to indicate GDST personnel as the intended target for grading as well as an area for the name. Question 1 of the Installation survey was changed to include both a and b grading. Removed the previous questions 13, 14, 16, 23, 24 and renumbered. Changed Field Manager to Field Coordinator.	1/29/04	JMF	JE	RAY
L	EC#03-0810	8-7-03	SLM	JE	
K	EC#02-0737	6/14/02	SLM	JE	
J	EC#02-0620	5/14/02	SLM	JE	
H	EC#02-0250	1/10/02	SLM	BBB	
G	EC#01-0682	08/14/01	JLE	BBB	
F	EC# 00-0623	06/21/00	CLW	JDH	RPC
E	EC# 98-1253	12/29/98	MRG	BBB	RPC
D	EC# 99-0064	10.14.98	MRG	BBB	RPC
C	General Revision	05/27/98	RPC	RPC,JBJ,JAP	RPC
B	General Revision	8/15/96	DEW	SPK 8/19/96	DEW
A	Original Release	6/14/95	DLB	JK	SDL

GENERAL DYNAMICS SATCOM TECHNOLOGIES INSTALLATION CHECKLIST

The General Dynamics SATCOM Technologies Program Manager responsible for this job must supply a workscope with this information marked with (*) before the fieldwork can be scheduled.

Installation Site* _____

Contact* _____ Site Phone Number* _____

Antenna Size/Frequency Band* _____

General Dynamics SATCOM Technologies Job Number *_____ Site Acceptance Test Plan *_____

Installation Supervisor _____ Date of Completion_____

NOTES:

A. **General Dynamics SATCOM Technologies Field Personnel:** Leave this completed checklist at a predetermined location on site. This checklist is to be removed by the last General Dynamics SATCOM Technologies employee and returned to the Field Coordinator.

B. **Program Manager:** The customer shall be responsible to have proper single/three-phase power on site for electronics turn on and check out (when needed by the General Dynamics SATCOM Technologies supervisor). If proper power is not available, the supervisor will make these arrangements and the customer will be billed for the cost of the arrangements and equipment and the time lost while making these arrangements. If the proper power equipment cannot be located, the supervisor will complete the installation as thoroughly as possible, check off all items completed, request a provisional acceptance by the customer, then call his manager at 903/984-0555.

C. This punch list is to be a running document and continually be updated during the installation. Prior to any VAD or VCSD technician-leaving site, this form must be updated. To include Customer, Technician, End Customer, or Customer Engineering sign-offs to document progress and punch list items. Additions to the punch list do not require Customer sign-off, but must be documented by VAD or VCSD.

General Dynamics SATCOM Technologies on-site representative, please initial in the blank by each appropriate item when checked as completed. (Field Personnel write N/A in the sign-off blank if not applicable.)

Init/Date

_____1. Before starting the antenna installation, verify the following:
   a. Site has enough space for assembly.
   b. Site has either permanent or temporary power for assembly.
   c. Verify anchor bolt location, height above surface, and draft on foundation is in accordance with Drawing Number _____.
   d. All customer and General Dynamics SATCOM Technologies-supplied tools and components are on site and ready for installation. (Make a list of those shortages and report to the General Dynamics SATCOM Technologies Program Manager.)

_____2. Verify proper installation of the azimuth jack assembly (if applicable) and its components.
   a. Bushing and bearing placement.
   b. Anti-roll shims with set bolts tight.
   c. Rod end pinning bolt.
   d. Boot with zippers turned down.
   e. Lubricant requirement label in place on jack.

_____3. Verify jack travel AZ_____DEG. EL_____DEG.

_____4. Azimuth level (verticality) should be _____ degrees. Verify that all pedestal/foundation interfaces have been grouted.

_____5. Verify that all hardware has been tightened per system specifications. Ref. Installation Drawing Number _____.

_____6. Verify that all platforms, ladders and bracing have been installed correctly and according to the proper Drawing Number _____.

_____7. Verify proper installation of the elevation jack assembly (if applicable) and its components.
   a. Bushing and bearing placement.
   b. Anti-roll shims with set bolts tight.
   c. Rod end pinning bolt.
   d. Boot with zippers turned down.
   e. Lubricant requirement label in place on jack.
   f. Proper alignment through elevation jack travel.

_____8. Verify installations of all grease fittings and that all points are greased. (Ref. O&M Manual for locations and types of lubricants.)

_____9. Remove leveling bolts from support legs, Az. drive assembly, and pintle after grouting.

Verify final anchor bolt per General Dynamics SATCOM Technologies Specification 300-2436. **Fill leveling bolt holes with silicone or grout.**

_____10. Verify proper installation of the azimuth drive motor and its components.

a. Verify proper spacing of gearbox to jack coupling.
b. Check coupling setscrews for tightness.
c. Check that the mounting flanges are mated correctly.
d. Fill gearbox with proper oil to required level.
e. Check for oil leaks and repair if necessary.
f. Verify that the exposed motor shafts are coated with a rust/corrosion protective compound.
g. Check that the gearbox breather is installed in the upper plughole.
h. Verify that possible water traps have means for drainage.
i. Verify that couplings are coated with rust/corrosion protective compound.

_____11. Verify proper installation of the elevation drive motor and its components.

a. Verify proper spacing of gearbox to jack coupling.
b. Check coupling setscrews for tightness.
c. Check that the mounting flanges are mated correctly.
d. Fill gearbox with proper oil to required level.
e. Check for oil leaks and repair if necessary.
f. Verify that the exposed motor shafts are coated with a rust/corrosion protective compound.
g. Check that the gearbox breather is installed in the upper plughole.
h. Verify that possible water traps have means for drainage.
i. Verify that couplings are coated with rust/corrosion protective compounds.

_____12. Verify installation and proper sealing of the feed rain closeout.

_____13. Verify drilling of drain holes in water traps and all metal shavings are removed (rear hub closeout, coupling covers, etc.)

_____14. Verify installation of lightning rods as required per system. Ensure the rod is securely mated to the **non-painted** surface. **Remove paint if necessary** and apply touch-up paint after installation.

_____15. Verify installation of all ground straps on the antenna structure. Install with star washers; **remove all paint at point of contact on both sides**. Apply touch-up paint after installation. Verify that site representative (or customer) is aware of the customer ground field connections required at the antenna base (lower pintle, legs, azimuth drive.)

_____16. Verify tension of feed polarization drive chain (if applicable). Tighten the chain for approximately 50 percent compression of the Belleville washers.

_____17. Cassegrain antennas only – After the reflector and subreflector alignment is complete, verify accuracy by reading and recording each target location and subreflector position. Return a signed copy to General Dynamics SATCOM Technologies. After reflector and subreflector is final aligned, verify dimensions per OPTICAL GEOMETRY DRAWING _____. Installed dimensions should be recorded on "RF Geometry Worksheet", included in this checklist.

_____18. Cassegrain antennas only--Verify that the distance from the inboard edge of the panels to the feed window surface is _____.

_____19. Cassegrain antennas only--Verify that the distance from the feed window to the very center of the subreflector is _____.

_____20. Verify installation of the azimuth, elevation, and polarization resolver boots (if applicable).

_____21. Verify that all resolver / encoder couplings are properly tightened (if applicable).

_____22. Verify that all flexible conduits have been installed with proper service loops for system <u>full movement</u>.

_____23. Verify that all wiring has been installed and terminated properly per the appropriate wiring diagram noted below and has sufficient service loops.
Antenna Control System Wiring Diagram(s).
Antenna Deice System Wiring Diagram(s).
Antenna Utility System Wiring Diagram(s).
LNA System Controller/Power Supply Wiring Connections.
Other, specify_____.

_____24. Verify that the antenna structure has been cleaned and painted, as needed, to like new condition.

_____25. Verify that all junction boxes and control cabinets are clean and free of metal shavings, wiring is neatly routed and laced, and that all covers and doors are tightly secured.

_____26. Verify that the permanent power is the proper voltage and phase arrangement, it should be _____ volts, _____ phase, _____Hz, _____ wire with ground, and _____ connect (Y or Delta).

a. Voltage reading A phase to B phase is _____.
b. Voltage reading A phase to C phase is _____.
c. Voltage reading B phase to C phase is _____.
d. Voltage reading A phase to Neutral is _____.

e. Voltage reading B phase to Neutral is _____.
f. Voltage reading C phase to Neutral is _____.
g. Voltage reading Neutral to Ground _____.

_____27. Verify the proper installation and operation by drawings or written procedures of the following components when applicable.

a. Main reflector / subreflector, deicing equipment model number inside unit _____, Serial Number _____, Outside unit model number _____, Model Number _____, Installation drawings / procedures (include revision level) _____. Deice System O&M manual (include revision level). Deice system Checkout per section _____ of the O&M is completed. Sign-off of completion of closeout installation. Verify all hardware installed by drawing installation and adequately tightened.

b. Feed Rain Blower controller model number _____, serial number _____. Installation drawings/procedures include revision level) _____. Rain blower O&M manual (include revision level) _____. System checkout per section _____ of the O&M manual is completed. ***(Check that rain blower nozzle is installed and positioned exactly as specified on the installation drawing.)***

c. Antenna Control System model number inside unit _____, Outside unit model number _____, Serial number _____, Installation drawings / procedure numbers (include revision level) _____, Antenna Controller O&M manual (include revision level) _____, System checkout per section _____ of the O&M manual is completed.

d. Tracking equipment model number _____, serial number _____. Installation drawing/procedure number (include revision level) _____, Tracking equipment O&M manual (include revision level) _____. System checkout per section _____ of the O&M manual is completed.

e. LNA System equipment vendor and model number(s) _____, serial number(s)_____. Installation drawings/ procedure numbers (include revision level) _____. LNA System O&M manual (include revision level) _____. System checkout per section _____ of the O&M manual.

f. Other equipment not listed: model number(s) _____,
serial number(s) _____,
Installation drawing/procedure number(s) _____,
O&M manual(s) _____.

_____28. Verify that all terminal boards, wiring, cables and connectors are properly marked and match the as-built drawings. Verify that all cables are labeled as shown on the drawings at both ends with permanent cable markers.

_____29. Verify that all required equipment and supplies have been identified and left with the site manager.
a. Touch-up paint.
b. Hand crank equipment.
c. Grease gun with hose.
d. Spares (identify any missing spares).
e. _____.
f. _____.

_____30. Verify proper installation of the following items when required per system.
a. Over-the-axis receive coax or waveguide.
b. Over-the-axis transmit waveguide.
c. Receive IFL.
d. Transmit IFL.
e. Cable tray installation.
f. _____.
g. _____.

_____31. Verify proper operation of Hub/LNA enclosure blowers and thermostat (if applicable). Ventilation thermostat is set at _____.

_____32. Verify proper operation of Hub/LNA enclosure heaters and thermostat (if applicable). Heater thermostat is set at _____.

_____33. Verify proper operation of Hub/LNA enclosure high/low temperature alarms.

_____34. Verify proper function and operation of all E-stops.

_____35. If applicable verify proper function and operation of all associated interlocks (reflector hatch, stow pin, cable wrap, etc.).

_____36. If applicable, verify proper function and operation of radiation inhibit/low elevation limit switch. Switch is set to operate at deg. elevation.

_____37. Verify that the site has been cleaned and all trash removed.

_____38. Verify that the Customer/Site manager has been given as-built drawings, wiring schematics, and wiring lists. (One complete set is to be forwarded to the program manager for program file.

_____39. Verify transducer alignment per job requirements. **Insert values in blanks provided below.**
Az_____ El_____

_____40. Verify panel installation by serial number as required by job.

_____41. Verify limit switch settings (as applicable). **Insert values in blanks provided below.**
Az _____ El _____ Pol _____

_____42. On the sign-off sheet, make a list of any problems that occurred during installation which require correction by Engineering, Manufacturing, Quality Control, Program Management, etc.
ADD OTHER ITEMS AS REQUIRED._____

_____43. _____

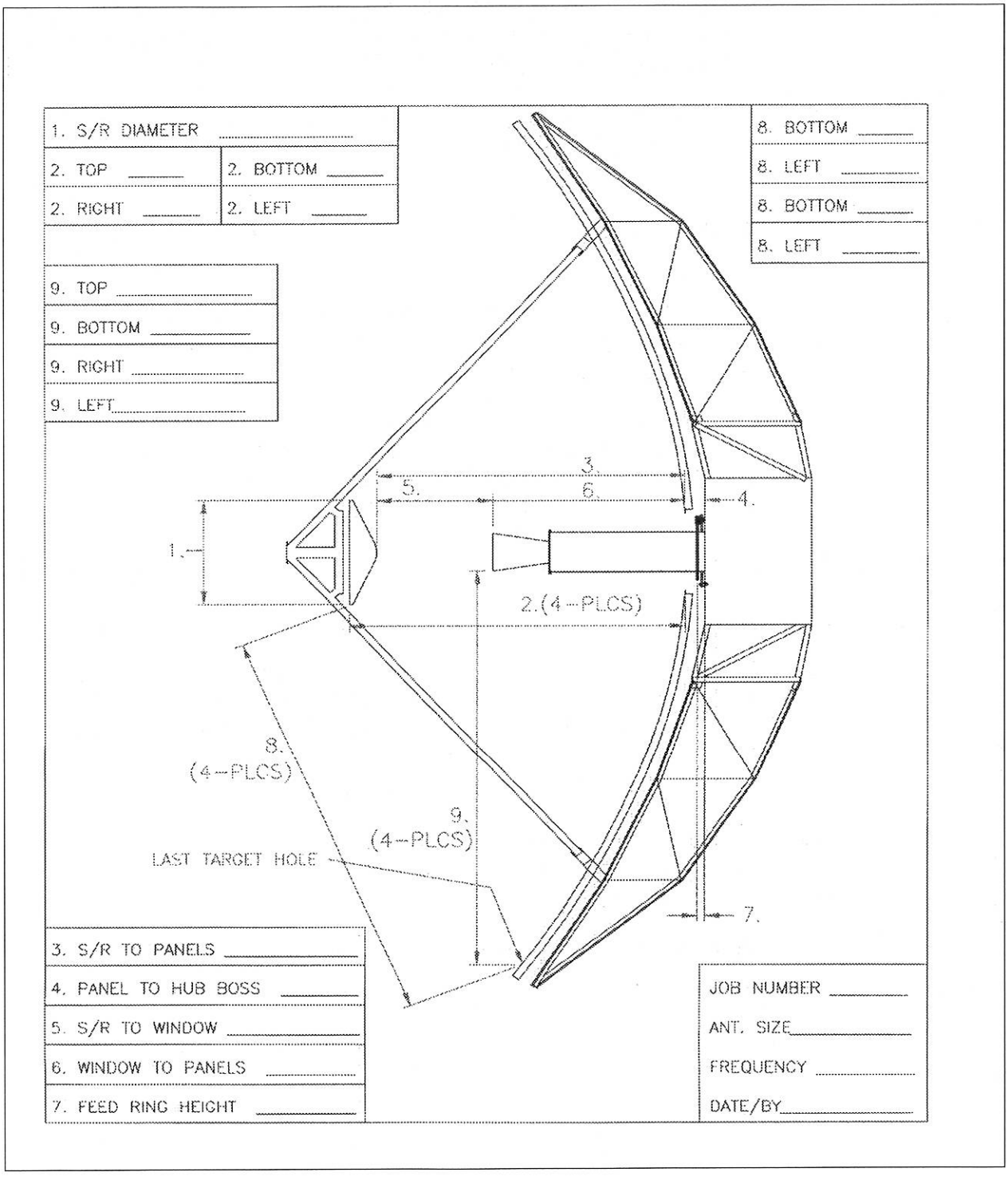
_____44. _____

_____45. Notify the Program Manager for this job and give complete status details. Have customer complete the **"CUSTOMER PULSE SURVEY"** and fax the **"PROVISIONAL ANTENNA ACCEPTANCE"** and **"CUSTOMER PULSE SURVEY"** to (903) 984-6867 to receive a release number **BEFORE LEAVING THE SITE**.

_____46. RF geometry complete.

_____47. RMS Data Work Sheet Complete.

_____48. Subreflector Alignment Worksheet Complete.


1. S/R DIAMETER
2. TOP
2. BOTTOM
2. RIGHT
2. LEFT
8. BOTTOM
8. LEFT
8. BOTTOM
8. LEFT
9. TOP
9. BOTTOM
9. RIGHT
9. LEFT
3.
5.
6.
4.
1.
2.(4-PLCS)
8.
(4-PLCS)
9.
(4-PLCS)
LAST TARGET HOLE
7.
3. S/R TO PANELS
4. PANEL TO HUB BOSS
5. S/R TO WINDOW
6. WINDOW TO PANELS
7. FEED RING HEIGHT
JOB NUMBER
ANT. SIZE
FREQUENCY
DATE/BY

Date: _____ **General Dynamics SATCOM Technologies RMS DATA WORKSHEET**

Type Antenna: _____

Job No.: _____ **Customer:** _____

General Dynamics SATCOM Technologies Supervisor: _____

TGT#	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
1															
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48															

NOTES:

1. ALL READINGS FROM TOP OF REFLECTOR CLOCKWISE
2. TEMP_____
3. WIND_____
4. DRILL TAPE_____
5. INST. HT_____
6. EL ANGLE_____
7. RMS_____
8. RMD Date_____

CUSTOMER COPY

PROVISIONAL ANTENNA ACCEPTANCE

The antenna system installation is complete except for the discrepancies as noted below. Control of the antenna system is now transferred to the customer. This discrepancy list is considered to be final.

Customer: _____

Location: _____

Antenna Size: _____

Date: _____

Job # _____

(Customer Representative)

Supervisor Release # _____

_____

(General Dynamics SATCOM Technologies Representative)

_____

Discrepancy List

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

GENERAL DYNAMICS SATCOM TECHNOLOGIES COPY

PROVISIONAL ANTENNA ACCEPTANCE

The antenna system installation is complete except for the discrepancies as noted below. Control of the antenna system is now transferred to the customer. This discrepancy list is considered to be final.

Customer: _____ Location: _____

Antenna Size: _____ Date: _____

Job # _____

(Customer Representative)

Supervisor Release # _____

_____

(General Dynamics SATCOM Technologies Representative)

_____

Discrepancy List

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Name: _____ Job # _____ Date _____

Installation Supervisor Survey

Customer Service wants to provide you with the highest level of service. Please tell us how we can do that better by completing the following survey.

Please fill in the circle that best represents your answer to the following questions. We appreciate your feedback.

1. How would you rate the technical skills of:
   a. the General Dynamics SATCOM Technologies installation crew?
      poor ① ② ③ ④ ⑤ excellent
   b. the customer supplied installation crew?
      poor ① ② ③ ④ ⑤ excellent

2. Was the documentation provided by the factory thorough and correct? _____yes _____no
   If no, please explain: _____

   _____

3. How do you rate the quality of installation components?
   poor ① ② ③ ④ ⑤ excellent

4. How do you rate the support you received from the field implementation support person?
   poor ① ② ③ ④ ⑤ excellent

5. How do you rate the administrative support you received from customer service?
   poor ① ② ③ ④ ⑤ excellent

6. Was your crew properly equipped (tools, dress, safety equipment, etc.)?
   not equipped ① ② ③ ④ ⑤ properly equipped

7. How do you rate the General Dynamics SATCOM Technologies crew's attention to safety?
   not attentive ① ② ③ ④ ⑤ attentive

8. How do you rate the General Dynamics SATCOM Technologies crew's relationship with the customer?
   poor ① ② ③ ④ ⑤ excellent

9. How would you rate <u>your</u> communication with the customer?
   poor ① ② ③ ④ ⑤ excellent

   If you experienced communication problems with the customer, please describe below:

   _____

   _____

10. Were there any delays due to site preparation? _____ yes _____no
    If yes, please explain: _____

    _____

11. What is one thing the company could do to make your job as installation supervisor easier?

_____

Did the customer site manager receive their survey? yes no

Name: _____ Job # _____ Date _____

Customer Site Manager Survey

Thank you for being a General Dynamics SATCOM Technologies customer. In order to be a better supplier and provide our customers with the highest level of products and services, we are asking you complete the survey below. Your answers will help us to continually improve the way we do business with our customers. This form is part of the sign off process.

Please fill in the circle that best represents your answer to the following questions. We appreciate your feedback.

1. How would you rate the technical skills of the General Dynamics SATCOM Technologies supplied installation crew?

   poor ① ② ③ ④ ⑤ excellent

2. How effective was the General Dynamics SATCOM Technologies crew when communicating with you about installation status, problems encountered and other relevant information?

   unskilled ① ② ③ ④ ⑤ exceptionally skilled

3. How satisfied are you that we met the following commitment dates:

   - Delivery of parts and installation materials.
     very dissatisfied ① ② ③ ④ ⑤ very satisfied
   - Installation start date.
     very dissatisfied ① ② ③ ④ ⑤ very satisfied
   - Installation completion date.
     very dissatisfied ① ② ③ ④ ⑤ very satisfied
   - Testing (if applicable).
     very dissatisfied ① ② ③ ④ ⑤ very satisfied

4. Was the General Dynamics SATCOM Technologies supplied installation crew properly equipped (tools, dress, safety equipment, etc.)?

   not equipped ① ② ③ ④ ⑤ properly equipped

5. How would you rate the General Dynamics SATCOM Technologies supplied installation crew's attention to safety?

   not attentive ① ② ③ ④ ⑤ attentive

6. Overall, how satisfied are you with the final product?

   very dissatisfied ① ② ③ ④ ⑤ very satisfied

   Why did you select that rating? _____

   _____

7. Overall, how satisfied are you with the quality of our installation?

   Dissatisfied ① ② ③ ④ ⑤ very satisfied

   Why did you select that rating? _____

   _____

8. What is one thing we could do to improve as a supplier—to make it easier to do business with us?

_____

_____

GENERAL DYNAMICS
SATCOM Technologies

OPERATION AND MAINTENANCE MANUAL FOR MOTORIZATION SYSTEM FOR SATCOM TECHNOLOGIES MODEL 3.8 – 9.3 METER SATELLITE EARTH STATION ANTENNA

600-0060

Revision C
June 7, 2010

General Dynamics SATCOM Technologies
2600 N. Longview St., Kilgore, TX USA 75662-6842
Phone (903) 984-0555 • FAX (903) 984-1826
www.gdsatcom.com

REV.	DESCRIPTION	DATE	WRITER	CHK.	APPR.
C	EC 10-0596 Updated instructions for polarization gearbox in Table 1	6/7/10	LRB	SPK	LJI
B	EC06-0776	8/17/06	MLS	SPK	LJI
A1	Preliminary – Sect 3.1 & T3.4 updated	3/10/06	SPK	LJI	LJI
A	EC98-1048	5/27/98	JLL	KLL	CLS
N/C	Original release	11/01/91	WCM	WCM	DLB

Use of *WARNINGS,* CAUTIONS, etc.

Warnings, Cautions and other notes are included throughout this document to provide necessary information. IGNORING WARNINGS, CAUTIONS AND OTHER NOTES MAY RESULT IN DAMAGE TO THE PRODUCT, INJURY, OR IN EXTREME CASES, DEATH. You should know the use of Warnings, Cautions and other markings. Definitions are:

WARNING! ***HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN INJURY TO OR DEATH OF PERSONNEL.***

CAUTION! **HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO OR DESTRUCTION OF EQUIPMENT OR THE LOSS OF MISSION EFFECTIVENESS OR LONG TERM HEALTH HAZARDS TO PERSONNEL.**

Important: **Highlights an essential installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, will ensure efficiency and/or safety of said procedures.**

Note: *Highlights an installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, could enhance efficiency and/or safety of said procedures.*

ESD: **The Electrostatic Sensitive Device (ESD) appears at the beginning of any procedure or procedural step that includes the handling of equipment sensitive to damage from electrostatic discharge.**

General Warnings and Cautions are also provided at the front of the document. These Warnings and Cautions should be read by anyone who is involved with installation, has access to the equipment or is assigned to perform maintenance on the equipment.

CAUTIONARY NOTICE

Although SATCOM Technologies has attempted to detail in this document all areas of possible danger to personnel in connection with the use of this equipment, personnel should use caution when installing, operating and servicing this equipment. Care should be taken to avoid electrical shock, whether the hazard is caused by design or malfunction. SATCOM Technologies is specifically not liable for any damage or injury arising from a technician's failure to follow the instructions contained in this document or his failure to exercise due care and caution in the installation, operation and service of this equipment. SATCOM Technologies shall not be responsible for injury or damage resulting from improper procedures or from the use of improperly trained or inexperienced personnel performing such tasks.

This document is intended as a general guide for trained and qualified personnel who are aware of the dangers of handling potentially hazardous electrical and electronic circuits. This document is not intended to contain a complete statement of all safety precautions that should be observed by personnel in using this or other electronic equipment.

ELECTRICAL HAZARDS

The antenna and feed system supplied by SATCOM Technologies is designed to be integrated with various types of electronic equipment. This system, if integrated with high power amplifiers or traveling wave tubes, will be capable of transmitting microwave energy at varying power levels. If transmitting microwave power, SATCOM Technologies cautions the end-user to review all applicable local, federal and international regulations and to comply with all such regulations in the operation and maintenance of the integrated system.

The electrical currents and voltages associated with this equipment, whether supplied by SATCOM Technologies or others, are dangerous. Personnel must at all times observe safety regulations.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Always disconnect power before opening covers, doors, enclosures, gates, panels or shields.
- Always use grounding sticks and short out high voltage points before servicing.
- Do not remove, short-circuit or tamper with interlock switches on access covers, doors, enclosures, gates, panels or shields.
- Keep away from live circuits.
- Know your equipment and do not take risks.
- Always remove all power to the system prior to working on the antenna, the reflector assembly, the reflector backup assembly or the feed assembly.
- Always tag all circuits noting that the power is OFF, the date and your name, prior to commencing any work on that system.

In case of emergency, be sure that power is disconnected.

POTENTIAL DAMAGE TO ANTENNA

The antenna limit switches and resolvers have been pre-set to allow for maximum antenna performance. Any subsequent adjustment may jeopardize antenna performance and/or result in damage to the antenna.

SAFETY NOTICE

The following safety procedures are listed to remind those performing any work on the antenna system that safety rules must be observed. Failure to observe safety rules may result in serious injury or death. Always work safely and in accordance with established procedures.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Care shall be taken in all operations to safeguard other people as well as property and to comply with all local safety procedures as established by the customer's site representative, as well as local building codes and fire protection standards.
- All persons performing work on the antenna system shall also comply with the Occupational Safety and Health Act (OSHA) standards and all other federal state and local laws, ordinances, regulations and codes relating to designated work.
- Unless the customer's representative on site specifically designates an individual responsible for site safety, the SATCOM Technologies Site Supervisor shall be responsible for and establish a site safety program for the SATCOM Technologies installation work. The site safety program shall incorporate all SATCOM Technologies safety procedures and requirements
- Never make internal adjustments or perform maintenance or service when alone or fatigued.

ELECTROMAGNETIC RADIATION

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Do not stand in the direct path of the feed system when the system is transmitting!
- Do not work on the feed system when the system is on!

ALWAYS WORK SAFELY!

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

The purpose of this manual is to provide information for the operation and maintenance of the Standard Motorization Package supplied with Satcom Technologies 4.5 through 9.0-meter kingpost antennas. A motorization package consists of an optional upgrade to motorize a manual drive antenna. Included in this manual is information pertaining to motors, couplings, limit switches, position transducers and gearboxes. Should any repair or maintenance problems arise which are not discussed within this manual, such problems should be referred to the equipment manufacturer:

General Dynamics SATCOM Technologies
Customer Service Department
2600 N. Longview Street
Kilgore, Texas 75662
903-984-0555

A listing of antenna components and characteristics are included, followed by various operation and maintenance procedures and vendor catalogs, where applicable.

Refer to preceding Table of Contents to locate section(s) describing operational or maintenance information required.

2.0 MOTORIZATION COMPONENTS AND CHARACTERISTICS

This section lists a brief general description of the motorization system. More detailed operation and maintenance instructions are covered in subsequent sections. All pertinent motorization system drawings are provided in the print pack supplied at time of shipment.

2.1 Azimuth and Elevation Drive Assemblies

The Azimuth and Elevation Drive Assemblies are supplied as part of the Basic Antenna. The Satcom Technologies 3.8 and 4.5-meter manual drive antennas may be equipped with struts that will be replaced with jacks as part of the motorization system. The Satcom Technologies 6.1 through 9.0-meter antennas are supplied with jacks as standard product. A gearmotor and coupling cover will be supplied for each drive assembly as part of the motorization system.

2.2 Couplings

The gear motors are coupled to screw jacks with Boston Gear couplings with elastomer inserts. With the jaw-engaging couplings, there is no alignment necessary; each half is installed on its respective shaft, the insert is placed into either half and the engagement is made when the gearbox is mated with its adapter flange.

2.3 Limit Switches

Limit switches are provided on the elevation, azimuth and polarization (if applicable) axes to prevent structural and/or electrical damage due to excessive rotation of the system. The units are Cutlar Hammer #E50NN1-9. The limit switches are activated by tripping the lever arm against an adjustable stop angle. The lever arms and the stops are adjustable to the travel range.

2.4 Angular Position Indication

Angular position indication is given by two synchro transducers or resolvers. One is mounted on the azimuth and one on the elevation axes. Their electrical outputs are monitored as digital readouts integral with the antenna position controller.

2.5 Gearmotors

Gearmotors are supplied on the azimuth and elevation screw jacks to position the antenna at the desired look angle. The gearmotors are attached to the screw jacks by means of a coupling cover, which has machined flanges that match the screw jacks and the gearmotor.

2.6 Polarization Drive

A motorized polarization drive is supplied to position the antenna feed for linearly polarized systems. The polarization drive consists of a gearbox, synchronous ac motor, position transducer and limit switch. The synchronous ac motor drives a gearbox, which contains two output shafts. One shaft is mechanically connected to a position transducer by means of a speed reducer and zero- backlash couplings. The second output shaft of the gearbox is mechanically connected to the feed tube of the antenna feed by means of a chain and sprocket. This drive mechanism provides a 1:1 translation between the feed tube and the position transducer. The synchronous motor supplied is capable of bi-directional rotation.

2.7 Control System

The control system is defined per contract. Refer to the Control System O&M Manual for a detailed description of the operation and maintenance procedures associated with the antenna-positioning controller. Many options and configurations are available which includes all domestic and international voltages and numerous drive rates.

3.0 RECOMMENDED MAINTENANCE SCHEDULES AND PROCEDURES

3.1 Lubrication Schedule

Table 1 identifies the items on the motorization assembly, which require lubrication. Refer also to the basic Antenna O&M Manual for locations requiring lubrication.

The gearmotors can be considered low maintenance, however, the reducers should be checked at least every two months for signs of oil leakage. Unless an oil leak is detected, it is not necessary to change or add oil to the reducer for the life of the antenna. Since there is no provision for adding lubrication to the gear reducer, contact SATCOM Technologies for instructions if a leak is detected. See Table 1 for the proper lubricant for use with the gearmotor, inspection frequency, and remarks.

Table 1. Lubrication Schedule

ITEM	FREQUENCY	LUBRICANT	REMARKS
1. Motors	Indefinite	None Required	*Permanent* grease factory installed for at least 10,000 hours of motor operation-- there is no provision for adding grease externally.
2. Az. & El. Drive Gearboxes	Every 2 Months	Mobilgear SHC 629 Gear Oil	Inspect gear reducer every 2 months. Check for signs of oil leaks (oil on foundation, leaking from seals, etc).
3. Polarization Gearbox Check levels	Every 2 Months	Polyglycol 460	Inspect gear reducer every 2 months. Check for signs of oil leaks.

4.0 ELECTRICAL COMPONENT WIRING

Kingpost antennas requiring motorized axis drives are factory equipped with pull strings to provide a smooth and straightforward interface during initial erection. The antennas are equipped to interface with any one of a number of control systems which may be used with the antenna to provide varying levels of control, from simple jog, to sophisticated steptrack systems. The following is a description of electrical component and subassembly wiring for the motorized kingpost antenna.

4.1 Hub

Cables from the various peripheral devices about the elevation axis, including elevation synchro and limit switch, polarization drive motor, limit switch, and synchro, are gathered together and carried down to the pedestal via electrical conduit.

4.2 Pedestal Wiring

The various cables exiting the hub in conduits are routed to the top of the pedestal and then through the pedestal to the main conduit fittings, located on the front of the pedestal, approximately four feet above the foundation. All wires and cables are then routed through flexible conduit from the main fittings to the local antenna control unit.

4.3 Azimuth Drive Motor

Wiring for the azimuth drive motor is facilitated by cabling in conduit above ground or underground (as applicable), between the outside control unit and drive assembly.

4.4 Connection Diagrams

Connection diagrams for the above-mentioned peripheral devices are shown on the electrical installation drawings for the system provided per the contractual requirements.

5.0 VENDOR PUBLICATION

Contact SATCOM Technologies sales department for information regarding purchase, replacement and/or special servicing of OEM components.

6.0 WARRANTY

SATCOM Technologies warrants the items ordered hereunder at the time of shipment to be free from defects in material, workmanship, and to conform to the contract specification. SATCOM Technologies' liability under this Warranty shall terminate one (1) year after date of acceptance or eighteen (18) months from the date of shipment, whichever comes first. Some individual products include extended warranties as stated in brochure(s) and extended warranties may be purchased as requested and quoted. Written notice of any defects shall be given SATCOM Technologies upon discovery and SATCOM Technologies shall promptly correct such defects by repair or replacement, at its option, without charge, either FCA SATCOM Technologies' plant or service in the field.

IN NO EVENT SHALL SATCOM TECHNOLOGIES' LIABILITY UNDER THIS WARRANTY EXCEED THE COST OF REPAIR OR REPLACEMENT OF SUCH DEFECTIVE ITEM AND UNDER NO CIRCUMSTANCES SHALL SATCOM TECHNOLOGIES BE LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

Specifically excluded from this Warranty are:

a. Defects or nonconformance caused by and resulting from improper operation, maintenance, or storage of the equipment.
b. Items of characteristically indeterminate life, such as bulbs, fuses, etc.

THIS WARRANTY CONSTITUTES SATCOM TECHNOLOGIES' SOLE AND EXCLUSIVE LIABILITY HEREUNDER AND BUYER'S SOLE AND EXCLUSIVE REMEDY FOR DEFECTIVE OR NONCONFORMING ITEMS AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS IMPLIED OR STATUTORY (INCLUDING THE WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE).

GENERAL DYNAMICS
SATCOM Technologies

FEED MAINTENANCE MANUAL
FOR
C/S/X-BAND CASSEGRAIN FEEDS
WITH CORRUGATED HORN

600-0067

Revision D
June 17, 2005

General Dynamics SATCOM Technologies
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SATCOM TECHNOLOGIES CONFIDENTIAL AND PROPRIETARY

REV.	DESCRIPTION	DATE	WRITER	CHK.	APPR.
D	EC #05-0587	6/17/05	JDT	HD	MB
C	EC #99-0582	3/17/99	JLL	KLL	SDL
B	General Revision	6/20/96	JBJ	JBJ	KDR
A	Original release	9/18/91	DPJ	JBJ	KDR

Use of *WARNINGS,* CAUTIONS, etc.

Warnings, Cautions and other notes are included throughout this document to provide necessary information. IGNORING WARNINGS, CAUTIONS AND OTHER NOTES MAY RESULT IN DAMAGE TO THE PRODUCT, INJURY, OR IN EXTREME CASES, DEATH. You should know the use of Warnings, Cautions and other markings. Definitions are:

WARNING! ***HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN INJURY TO OR DEATH OF PERSONNEL.***

CAUTION! **HIGHLIGHTS AN INSTALLATION, OPERATING OR MAINTENANCE PROCEDURE, PRACTICE, CONDITION, STATEMENT, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO OR DESTRUCTION OF EQUIPMENT OR THE LOSS OF MISSION EFFECTIVENESS OR LONG TERM HEALTH HAZARDS TO PERSONNEL.**

Important: **Highlights an essential installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, will ensure efficiency and/or safety of said procedures.**

Note: *Highlights an installation, operating or maintenance procedure, practice, condition or statement, which, if heeded, could enhance efficiency and/or safety of said procedures.*

ESD: **The Electrostatic Sensitive Device (ESD) appears at the beginning of any procedure or procedural step that includes the handling of equipment sensitive to damage from electrostatic discharge.**

General Warnings and Cautions are also provided at the front of the document. These Warnings and Cautions should be read by anyone who is involved with installation, has access to the equipment or is assigned to perform maintenance on the equipment.

CAUTIONARY NOTICE

Although SATCOM Technologies has attempted to detail in this document all areas of possible danger to personnel in connection with the use of this equipment, personnel should use caution when installing, operating and servicing this equipment. Care should be taken to avoid electrical shock, whether the hazard is caused by design or malfunction. SATCOM Technologies is specifically not liable for any damage or injury arising from a technician's failure to follow the instructions contained in this document or his failure to exercise due care and caution in the installation, operation and service of this equipment. SATCOM Technologies shall not be responsible for injury or damage resulting from improper procedures or from the use of improperly trained or inexperienced personnel performing such tasks.

This document is intended as a general guide for trained and qualified personnel who are aware of the dangers of handling potentially hazardous electrical and electronic circuits. This document is not intended to contain a complete statement of all safety precautions that should be observed by personnel in using this or other electronic equipment.

ELECTRICAL HAZARDS

The antenna and feed system supplied by SATCOM Technologies is designed to be integrated with various types of electronic equipment. This system, if integrated with high power amplifiers or traveling wave tubes, will be capable of transmitting microwave energy at varying power levels. If transmitting microwave power, SATCOM Technologies cautions the end-user to review all applicable local, federal and international regulations and to comply with all such regulations in the operation and maintenance of the integrated system.

The electrical currents and voltages associated with this equipment, whether supplied by SATCOM Technologies or others, are dangerous. Personnel must at all times observe safety regulations.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Always disconnect power before opening covers, doors, enclosures, gates, panels or shields.
- Always use grounding sticks and short out high voltage points before servicing.
- Do not remove, short-circuit or tamper with interlock switches on access covers, doors, enclosures, gates, panels or shields.
- Keep away from live circuits.
- Know your equipment and do not take risks.
- Always remove all power to the system prior to working on the antenna, the reflector assembly, the reflector backup assembly or the feed assembly.
- Always tag all circuits noting that the power is OFF, the date and your name, prior to commencing any work on that system.

In case of emergency, be sure that power is disconnected.

POTENTIAL DAMAGE TO ANTENNA

The antenna limit switches and resolvers have been pre-set to allow maximum antenna performance. Any subsequent adjustment may jeopardize antenna performance and/or result in damage to the antenna.

SAFETY NOTICE

The following safety procedures are listed to remind those performing any work on the antenna system that safety rules must be observed. Failure to observe safety rules may result in serious injury or death. Always work safely and in accordance with established procedures.

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Care shall be taken in all operations to safeguard other people as well as property and to comply with all local safety procedures as established by the customer's site representative, as well as local building codes and fire protection standards.
- All persons performing work on the antenna system shall also comply with the Occupational Safety and Health Act (OSHA) standards and all other federal state and local laws, ordinances, regulations and codes relating to designated work.
- Unless the customer's representative on site specifically designates an individual responsible for site safety, the VertexRSI Site Supervisor shall be responsible for and establish a site safety program for the VertexRSI installation work. The site safety program shall incorporate all VertexRSI safety procedures and requirements
- Never make internal adjustments or perform maintenance or service when alone or fatigued.

ELECTROMAGNETIC RADIATION

- It is recommended that a lockout/tagout process be utilized while servicing the antenna system. In the United States, see OSHA 1910.147.
- Do not stand in the direct path of the feed system when the system is transmitting!
- Do not work on the feed system when the system is on!

ALWAYS WORK SAFELY!

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

The purpose of this manual is to provide information for the operation and maintenance of a C/S/X-band Cassegrain Antenna feed system. The feed system consists of passive waveguide components generally not subject to wear or deterioration. Thus, very little activity is necessary to perform preventive or corrective maintenance, or for troubleshooting. Should any repair or maintenance problems arise, which are not discussed within this manual, such problems should be referred to the equipment manufacturer:

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A listing of feed components and characteristics are included, followed by various maintenance procedures.

Refer to preceding Table of Contents to locate section (s) describing maintenance information required.

2.0 PREVENTIVE MAINTENANCE

Preventive maintenance consists primarily of routine inspections performed at periodic intervals. The maintenance technician should maintain an equipment log to record the type of inspection performed, date of inspection and corrective action taken. Periodic inspections of the feed system fall into two categories:

1. Pressurization check.
2. Abrasion, corrosion and physical damage inspection and connecting hardware tightness.

2.1 Pressurization Check

A pressurization check should be performed at an interval ground to be compatible with facility conditions and usage rate of dry air. Check of leakage rate is achieved by noting the cycling interval of the dry air source. Feeds are typically pressurized at 0.3 psi with relief valve set at 0.5 psi.

2.2 Detecting Pressure Leaks

In many instances, pressure leaks are audible and can be localized quickly. Small leaks may be difficult to pinpoint and will require careful inspection for detection. The following suggestions will help locate the source of pressure leakage.

CAUTION! MAKE SURE RF POWER HAS BEEN TURNED OFF FROM ALL HPA'S BEFORE GOING IN FRONT OF FEED HORN OR OPENING ANY TRANSMIT WAVEGUIDE FLANGES.

Step 1. After power has been turned off, inspect Teflon window membrane on horn for scratches, tears, or distortion. If pressure window assembly is damaged, replace the window in accordance with the enclosed procedure.

Step 2. If there are no visible tears or punctures in membrane, place ear against window; the hiss of escaping gas may be audible. A stethoscope can be used for this test to increase audio sensitivity.

Step 3. If there are no audible indications of leakage, leak points may be found with soap solution; bubbles will appear at points of leakage.

Step 4. Inspect flanges between waveguide components and spot check bolted connection for tightness. Use stethoscope and/or soap solution to locate point of leakage.

2.3 Corrosion, Abrasion, and Tightness Checks

At frequent intervals, such as 2,000 operational hours, a general inspection of the feed system should be conducted. Flange mounting hardware and all bolts should be tested for tightness. After turning the RF power off, the pressure window on the horn should be carefully examined for blockage by foreign matter.

2.4 Corrective Maintenance

Because of the physical nature and relative simplicity of the feed system, corrective maintenance in the field is minimal. Corrective maintenance is generally limited to tightening hardware and parts replacement.

If a pressure leak is detected in the pressure window or pressure window seal, replace window assembly. If the leak is around the mounting flange of window, tighten bolts and determine if leak has been eliminated. If leakage persists, apply Dow Corning RTV sealant (or equal) to area around leak. Replace window if leak persists.

When a leak has been detected at an interface of waveguide flange connections, tighten flange-mounting hardware. Determine if tightening hardware removed leak; if not, replace gasket.

3.0 FEED WINDOW REPLACEMENT

CAUTION! MAKE SURE RF POWER HAS BEEN TURNED OFF FROM ALL HPA'S BEFORE GOING IN FRONT OF FEED HORN.

The following parts are required to replace the feed window:

Antenna Size	Part Number	Description
7.2 thru 15 Meter	G263002-012	0.010" Teflon sheet, etched in one side.
18 and 21 Meters	F263002-002	0.010" Teflon sheet, etched in one side.

Use: Part # G164014-010 Sealant RTV3145 (Dow Corning)

Or: Part # G165015-001 Sealant RTV738 (Dow Corning)

The following instructions for feed window replacement are applicable for all Satcom Technologies C/S/X-Band feed models with a corrugated horn.

3.1 Instructions

Step 1. Remove all hardware holding retaining ring to end of horn.

Step 2. Gently pry off retaining ring from horn being careful not to drop or bend ring at any time.

Step 3. Remove old window being careful not to drop anything down into the horn.

Step 4. Clean feed window mounting surface on the end of horn thoroughly. Be sure to remove all old adhesive, grease, dirt, corrosion, or any other foreign matter from end of horn. Mounting surface area must be clean and dry.

Step 5. Apply a 1/8 to 1/4 inch bead of RTV3145 CLR or equivalent to the mounting surface area and smooth out.

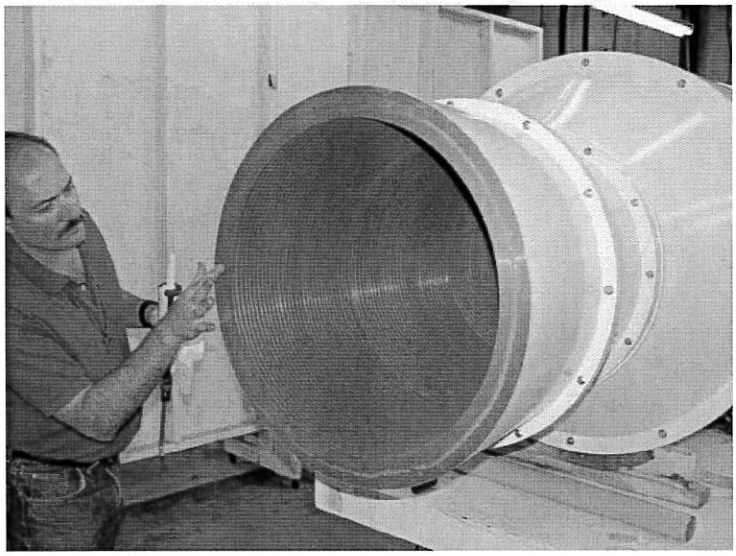

Figure 1. Applying RTV3145 CLR to Mounting Surface

Step 6. Lay new sheet of Teflon window material with etched brown side toward the feed opening. Be careful not to stretch or distort Teflon while doing this portion of the window replacement. Press firmly around edge to seat new window.

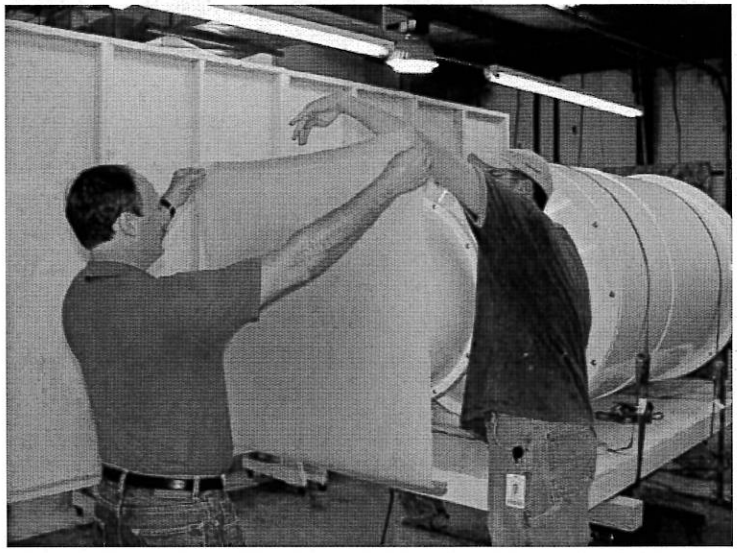

Figure 2. Placing Teflon Sheet on Feed Opening

Step 7. Using a sharp instrument such as an awl or an ice pick, punch holes through Teflon window centered on the mounting holes.

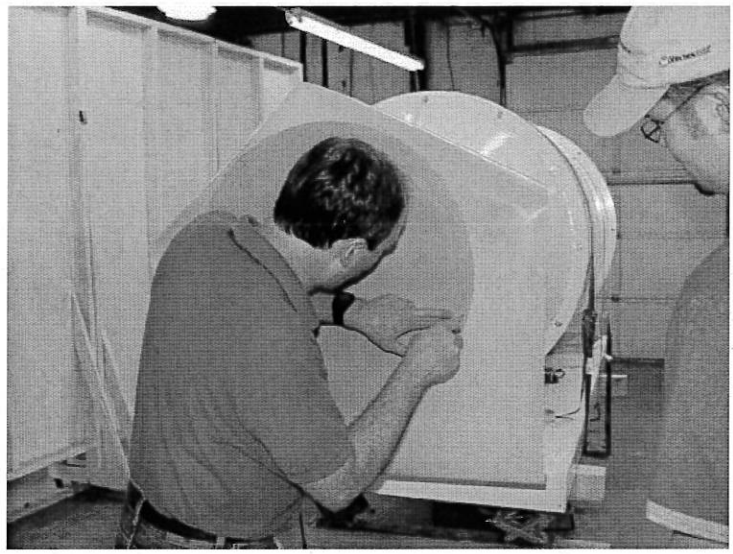

Figure 3. Punching Holes through Teflon

Step 8. Using existing hardware removed in Step 1 (screw, flat washer and lock washer), place the retaining ring in position over feed and bolt down. Do not fully tighten until the next step.

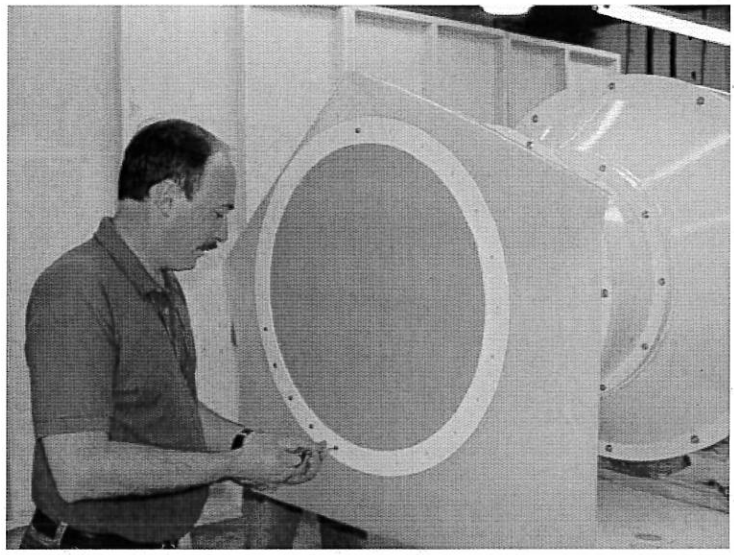

Figure 4. Installing Hardware on Feed Window

Step 9. Pull the Teflon sheet tight and tighten hardware.

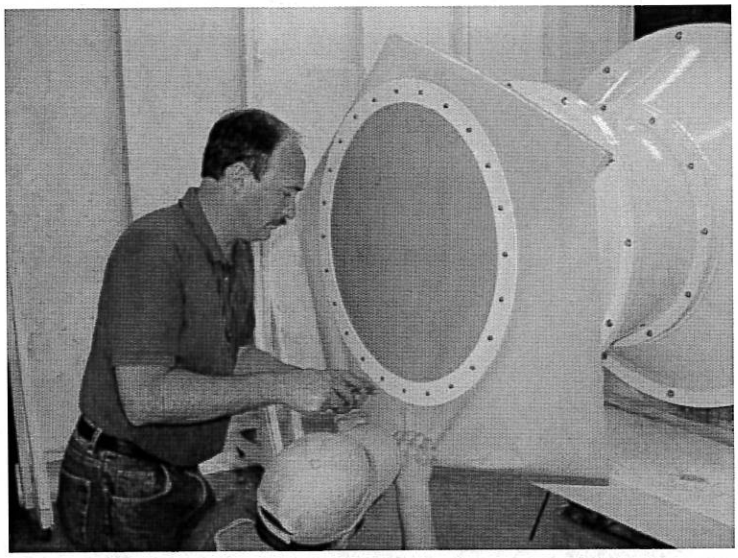

Figure 5. Tightening Feed Window Hardware

Step 10. Trim off excess material with a sharp Exacto or utility knife.

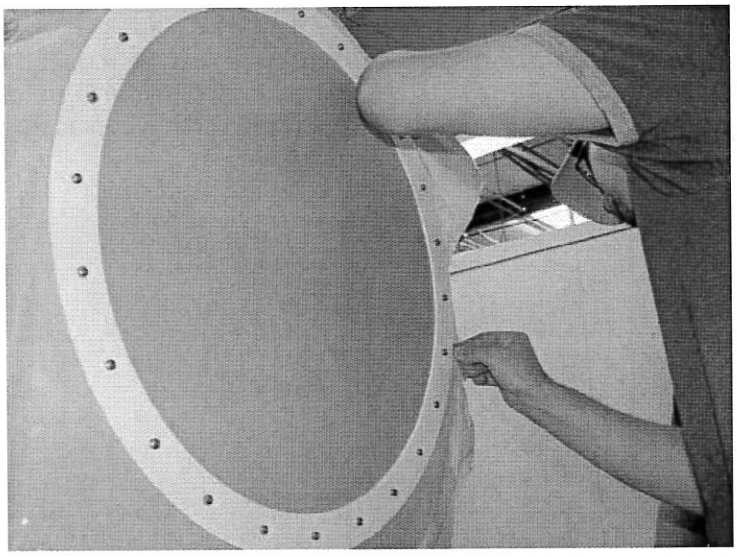

Figure 6. Trimming Excess Teflon

Step 11. Allow a minimum of three hours for the adhesive to set before pressurizing. Total cure will take place within 24 hours depending on temperature and humidity.

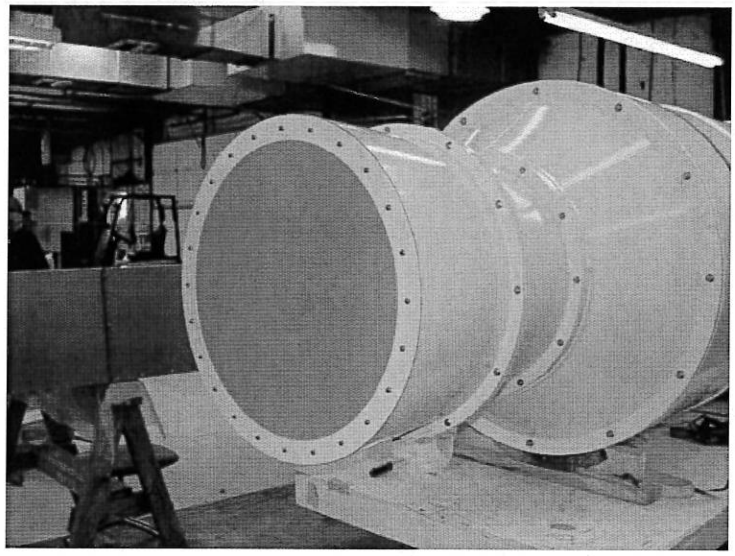

Figure 7. Installed Feed Window

3.2 Special Instructions

Should a new retaining ring, o-ring gasket, hardware, etc. be required in replacing the feed window, these parts will have to be ordered from General Dynamics SATCOM Technologies, as they are not part of the basic feed window replacement kit.

4.0 WARRANTY

SATCOM Technologies warrants the items ordered hereunder at the time of shipment to be free from defects in material, workmanship, and to conform to the contract specification. SATCOM Technologies' liability under this Warranty shall terminate one (1) year after date of acceptance or eighteen (18) months from the date of shipment, whichever comes first. Some individual products include extended warranties as stated in brochure(s) and extended warranties may be purchased as requested and quoted. Written notice of any defects shall be given SATCOM Technologies upon discovery and SATCOM Technologies shall promptly correct such defects by repair or replacement, at its option, without charge, either FCA SATCOM Technologies' plant or service in the field.

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