

# A guide to GPS/GNSS antenna installations



## Application Note 1

Rev 1 - June 2018



AS9100D Certificate Number : C0210021-AS3



# Application Note 1 : GPS Antenna Installations

## Document overview

This application note aims at providing the reader with a broad explanation and understanding of best practise when considering the installation of a GPS antenna, in-line amplifier, lightning arrestor and associated cabling..

While it is not entirely necessary for the reader to acquire a detailed technical understanding of the equipment prior to an installation, the following technical overview provides some useful background which may help optimise any given application.



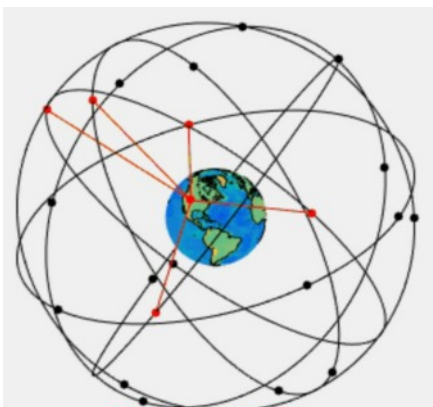
## Technical Overview - GPS, antenna positioning and operation

Global Positioning System (GPS) signals are commonplace in many positioning, navigation and timing applications and almost always, the reception and routing of these low level signals into equipment that can process them requires fixed antenna installations on the outside of buildings and structures.

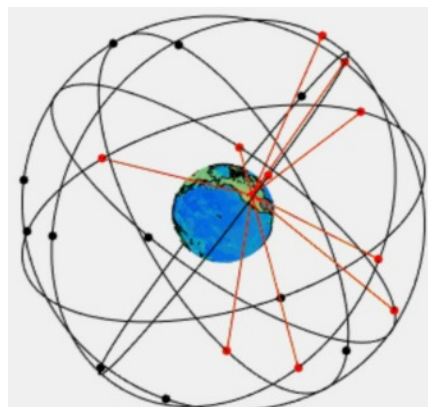
The GPS system is a space based satellite radio navigation system that is owned and operated by the US government. The generic term for such a system is known as a Global Navigation Satellite System (GNSS) of which there are other systems owned and operated by other countries. Examples of these include Russia's GLONASS system, China's BeiDou system, India's NAVIC and Europe's Galileo system. Global navigation satellite systems are designed to provide precise geolocation and time information to suitable receivers on the Earth where there is an unobstructed line of sight from the receiver to four or more satellites.

The GPS system comprises a constellation of 32 orbiting satellites (31 in use) arranged in an array around the earth, each following the same ground tracking route. The constellation is arranged to provide full coverage of the earth's surface at all times. Each satellite contains and updates precise information about its position in space along with precise time information derived from atomic clocks. This information is modulated and transmitted at a relatively low level for any suitable GPS receiver to detect, decode and utilise for the purpose of time and/or position determination.

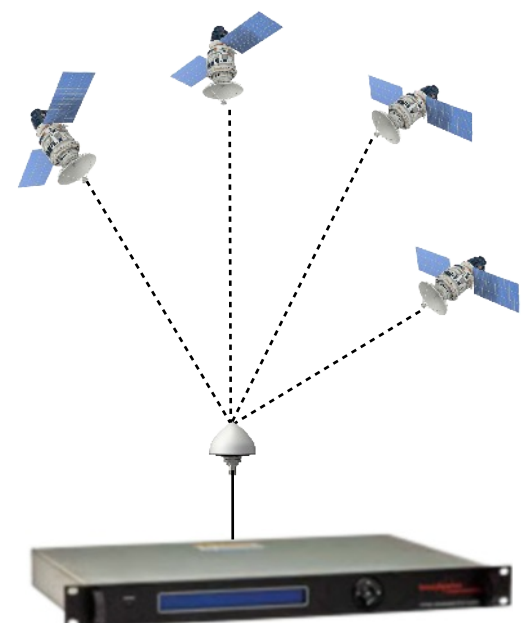
Since the satellites and Earth are all moving relative to one another, the number of visible satellites from any given point can and will vary from time to time. In order to meet the minimum visibility criteria of four satellites for an accurate measure of position and time, it should be clear that **consideration is needed** as to how best to physically position a GNSS antenna for optimum satellite visibility.



5 visible satellites



10 visible satellites

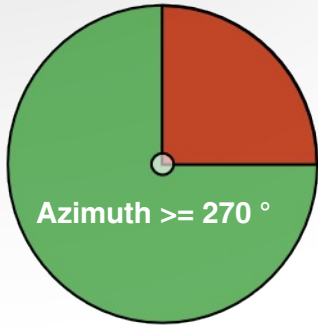


*Without antenna obstruction, typically between 6 & 8 satellites are usable at any one time.*

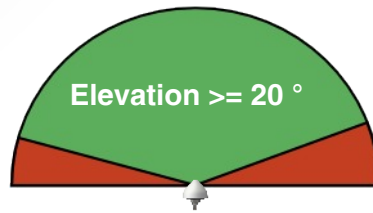
## Choosing an antenna location

A GPS antenna is “omni-directional” meaning that it will receive signals from all directions above the horizon equally well and does not need to be aimed at a specific part of the sky. Since the GPS system requires “line of sight” between satellites and antenna, for best continual reception it is important that as much of the sky is as visible as possible to the antenna.

If the antenna horizon is greatly obstructed, then the GPS receiver may experience times when it is unable to receive signals from sufficient satellites and/or may be unable to provide accurate outputs. In general the antenna should have a view of the sky that is unobstructed for at least 270 degrees in azimuth and with no obstruction above 20 degrees in elevation.



**Minimum unobstructed antenna sky exposure**



**Advice :** For maximum satellite visibility, position the antenna facing toward the equator.

It is not necessary to raise and mount the antenna up on a mast, unless this additional height is required to raise it above the level of the horizon.

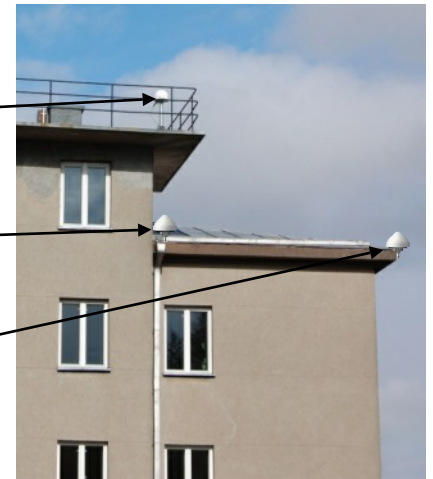
## **Antenna Location comparisons**



Best

Poor

Good



## Mounting the antenna

The standard Brandywine / TFS, high gain and down/Up converter antennae are mounted using a **1.0 inch x 14UNS-2A thread**. This thread type is commonly used in marine applications. Other manufacturers may use different thread types. For best installation longevity, it is important protect and seal the antenna cable connections against water ingress and corrosion.

**Antenna Mount Mast Adapters :** To facilitate mounting the antenna, a mast adapter is usually supplied. Brandywine / TFS offers a mast adapter, which comprises a 12” length of pipe with 1x14 UNS thread at one end, and two 2” diameter hose clamps. **Brandywine P/N 003000230**

## GNSS/GPS Antenna Types

### Active Antenna

The most common GPS antenna type used in precision timing applications is known as an Active Antenna. The term “Active” indicates that the antenna requires power to activate it’s internal amplifier circuitry. It is important therefore to appreciate whether the GPS equipment intended for use with the antenna is able to provide the appropriate power to drive it. Usually the DC power required to power the antenna is provided via the central conductor within the coaxial antenna cable.

A simple check with a DC voltmeter can be made at the GPS equipment end to verify that power is available for the antenna. This is typically 5V DC between the centre conductor and the shield.

**NOTE :** Always check the antenna type against the GPS equipment capability.

#### **For reference :**

The standard 40dB Active GPS antenna is Brandywine / TFS part number :

For sensitive equipment such as board level systems, a 30dB antenna may be used :

Pt No : 012000002

Pt No : 012000283



### Passive Antenna

As the name suggests, a passive antenna has no electrically “Active” components within it, relying purely upon passive filtering components to discern the GPS signal from the ambient.

As such, no electrical energy is required to drive internal active amplifiers and the like and thus, such an antenna can be considered SAFE FOR USE in potentially hazardous environments such as Oil, Gas and some military applications.

Without active amplification, the gain of these antenna types is 0dB. This characteristic may also be advantageous where there is high signal and/or high equipment sensitivity.

**For reference :** The standard passive GPS antenna Brandywine / TFS part number :

Pt No 210AF000M



### Head End Long Distance Antenna

In situations where the GPS receiving equipment is a long way from the antenna (typically >100m (300ft) ), a “Head End” or “Long Distance” antenna system can be used. Usually this is a proprietary solution in which a standard GPS antenna is locally mounted on an enclosure containing a GPS decoder (see right).

Such systems receive and separate the GPS signals locally and then re-transmit the data in a format and form suitable for long distances. Typically this transmission will be in differential current mode e.g. RS422 using CAT5 cabling.

The GPS signal processing system, typically a GPS Master Time Clock, will contain a compatible proprietary decoding system enabling the GPS data to be re-constituted and utilised.

**For reference :** Long distance GPS antennae are none generic - always check availability and compatibility.



## GNSS/GPS Antenna Cable Types and Selection

### GNSS Cable function

The low level GPS signal broadcast from the orbiting satellites is at 1575.42 MHz. This means that the signal will not pass through walls or penetrate inside buildings and that careful consideration must be given to the type and length of antenna cable used in order to ensure that antenna feed cable signal losses do not detrimentally impact upon the available signal arriving at the GPS master clock receiver unit.

The reference table below shows some standard cable configurations offered by Brandywine & TFS. Further more generic cable information is provided at the bottom of the page.

Cable Length	Through-Roof Mount with integral 25' cable P/N 002205068	Pole Mount Standard 40 dB Antenna P/N 012000002	Pole Mount 37dB P/N 051000006	GPS Down/Up Converter Antenna 002-0067 Fiber Optic	GPS/Down Up Converter Antenna 002-0087 Copper
25 feet 7.6 metres	Captive Cable				
50 feet RG58 15.2 metres	003-0028 extender	002-0091	002-0091		
100 feet RG58 30.4 metres		002-0037 (std)	002-0037 (std)		
150 feet RG8 45.7 metres		002-0040	002-0040		
250' RG8 76.2 metres		002-0052	002-0052		
330' RG8 100 metres		002-0039	002-0039		
500' RG8 152.4 metres		002-0042	002-0042		
>500' > 152.4 metres			Requires line amp	Up to 1.25 miles multimode fiber (2km)	Up to 1000 feet RG 58 (300 m)

### GPS antenna cable selection

To determine the appropriate cable choice or to simply review a new or existing installation, the following approach should be adopted.

1. Determine the cable's attenuation figure per foot or per metre at 1575 MHz in dB/foot or dB/metre. This information can be found from the cable manufacturer's data or from generic tables.
2. Calculate the expected loss in dB for the cable. Subtract the cable loss figure from the lowest antenna gain figure to determine the approximate signal strength level at the receiving equipment.
3. Brandywine & TFS recommend a signal level of 18dB at the equipment, 15dB worst case. If the calculation yields a figure lower than this, then it will necessary to reconsider the cable type and length to ensure reliable operation.

## GNSS/GPS Antenna Cable Types & Selection

### GPS antenna cable selection calculation example

Common cable types with loss figures at 1575 MHz

Cable Type - Loss dB	dB/100ft	dB/100m
RG-8	9.3	30.4
RG-8/U	9.3	30.4
RG-8X	16.8	55.1
RG-58	19.6	64.3
RG-59	14.7	48.2
RG-213	9.3	30.4
RG-217	7	23
RG-218	4.7	15.5

#### Calculation example :

Antenna gain : 40dB

Cable run : 25 metres

Cable type : RG-58

Total cable loss =  $(64.3 \times (25 / 100)) = 16\text{dB}$

Signal level at equipment : Antenna gain - loss =  $40 - 16 = 34\text{dB}$

**CHECK : 34dB >= recommended 18dB = O.K.**

## GNSS/GPS Antenna Line Amplifiers & Lightning Arrestors

### GPS In Line Signal Amplifiers

Where longer cable runs or an existing cable type imply a shortfall in the available signal strength at the GPS receiver, a 20dB in-line amplifier may also be used to boost the GPS signal.

In line amplifiers require an active antenna type system, thereby facilitating a derivation of internal power from the DC supplied along the centre conductor. Typically the amplification provides a 20dB gain to the signal. The in line GPS amplifier should be installed closer to the antenna as opposed to the receiver but no less than 6 foot (2 metres) from the antenna itself.

#### For reference :

The standard 20dB Active In Line GPS antenna amplifier is Brandywine / TFS part number : Pt No : 051000001



## GNSS/GPS Antenna Lightning Arrestors and General Precautions

As with all ground referenced antenna systems, a GPS antenna and more particularly, the equipment to which it connects, can easily and permanently be damaged by a lightning strike discharge.

The highly sensitive electronic circuitry that detects and decodes a GPS signal is simply unable to deal with the high energy levels associated with a lightning discharge and rather like a fuse, becomes a sacrificial element unless lightning strike prevention and protection is considered and applied.

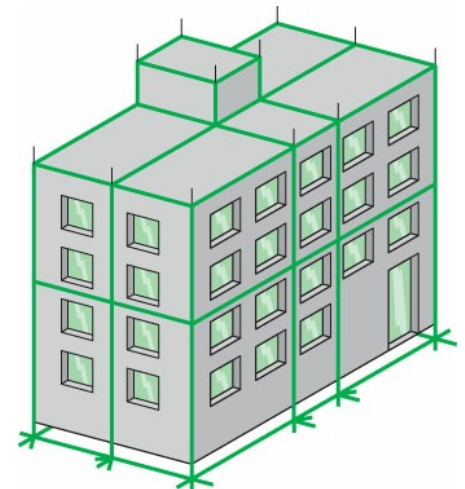
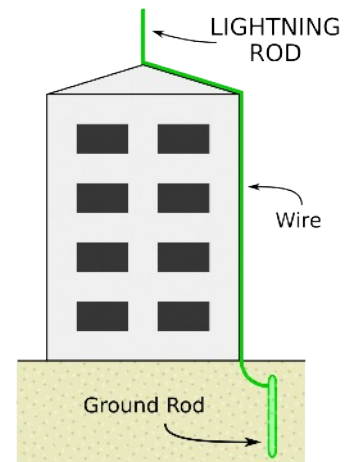
### Lightning strike prevention

Prevention is always better than cure ! Equipment lightning strike prevention is normally implemented through the use of lightning conductors or rods.

Put simply, a lightning conductor deliberately sets out to attract and provide the most electrically desirable path to Earth Ground for a potential lightning discharge. In electrical terms, this will likely be the shortest and least electrically resistive route from the air borne discharge point to the Earth Ground.

It is no wonder therefore, that a typical lightning conductor normally extends to the highest practical point on a building and is usually constructed from thick copper material which is physically connected to a large plate or stake buried in the ground.

For large buildings, an array of lightning conductors may be installed and connected to an electrically connected Earth grounding matrix in order to maximise the protection coverage.



**Advice :**      ***Avoid making yourself or the GPS antenna the preferred lightning conductor !***  
                      ***NEVER attempt to install any type of antenna when there is likelihood of lightning.***

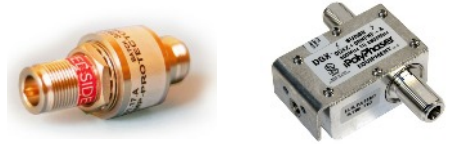
Clearly then, when considering installing a GPS antenna, it is advisable to assess any existing lightning protection rods and to try and ensure the antenna is positioned below the the lighting conductors and preferably at least 15 metres away from the nearest lightning conductor in order to minimise transient coupling to the antenna.

It is also advisable to assess and understand the Earth Grounding methods employed at an installation if there is intention to provide additional equipment protection through the use of a lightning arrestor.

Lightning arrestors require a good earth ground connection.

## GNSS/GPS Antenna Lightning Arrestors

### General Installation guidelines



Antenna and GPS equipment should be connected to a single point earth ground. The best type of earth ground is a 2.5 metre (8 foot) or longer copper rod driven into the soil. Alternate grounds in order of decreasing effectiveness are building steel or rebar, cold water pipe, metal building skin, or electrical system ground.

With pole and tower grounding, the use of copper braid or strapping for maximum energy dispersion is recommended. Ground all coaxial cable at the antenna and where the cable leaves the tower or mounting pole. If the antenna mounting pole is properly grounded, then the antenna and coax are grounded via the antenna mounting bracket system. The coax should also be grounded as low as possible where the cable leaves the tower or mounting pole.

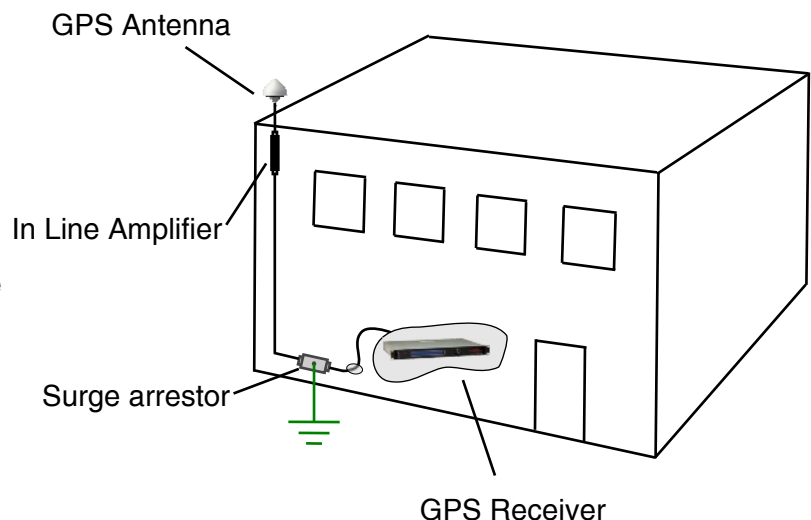
Locate the lightning arrestor within 2 metres (6 feet) of the GPS equipment or at the entry point of the antenna cable and the outside of the building, ideally use two arrestors and do both.

The connection point for the earth ground wire should always be closer (with lower impedance connection) to the single point earth ground than the GPS radio equipment grounding location. Ground all of the components mentioned above together to a common node (such as the antenna mast) if each is a short distance away. This reduces the possibility of ground loops through different earth grounds.

If the distance from the grounding point to the common node is greater than 3.5 metres (20 feet), it may be better to use separate earth grounds. Test the earth impedance at each earth ground node to ensure ground potentials are equal.

Waterproof all connections using a good waterproofing tape such as a self-annealing rubber tape. Use an outer coating of high quality vinyl electrical tape. Apply the tape in a spiral pattern so the overlaps act to shed water externally.

### Basic Installation Overview



For further information concerning GPS antenna installation and associated devices, please contact :-  
[sales@brandywinecomm.com](mailto:sales@brandywinecomm.com)

For an instructional antenna installation video please see the Brandywine YouTube :-  
<https://www.youtube.com/watch?v=srymDx9Uqx8>

For further technical information regarding surge arrestors, please refer to white papers :-  
<https://www.polyphaser.com/services/media-library>



AS9100D Certificate Number : C0210021-AS3



Disclaimer : Brandywine and TFS make every effort to ensure the data contained herein is both accurate and relevant. Brandywine and TFS do not accept any responsibility whatsoever for the misuse, misinterpretation or any other consequence related to the publication of this information.



## GNSS/GPS Antenna Lightning Arrestors

Lightning arrestor devices provide additional physical equipment protection and are recommended by Brandywine and TFS for all external GPS antennae installations. There are generally two types of device that can be used, both of which connect in line with the antenna cabling and both of which require a good earth ground connection for them to be effective.

### Principle of operation

Lightning strikes are typically a combination of pulsed DC with an RF component around 2.2MHz. The first pulse typically averages 18kA with subsequent pulses at about 9kA with an average of three or more pulses in total

A lightning arrestor is designed to shunt the potential high voltage, high energy of a lightning strike, away from the equipment and down to an earth ground point for rapid dissipation.

Since a lightning strike electrical transient is extremely fast and at a potential voltage & energy much greater than that which a GPS receiver is designed to cope with, the effectiveness of an arrestor is broadly determined by the speed at which it can react to such a transient and the levels to which the resultant energy seen by the equipment are minimised.

Broadly speaking, an arrestor is designed to operate at a minimum voltage threshold, within a certain time and with a maximum energy dissipation rating. Both the voltage threshold and the energy dissipation capability depend very much upon a good, low impedance connection to a solid grounding earth, hence it is important to consider the points in the previous section.

### Gas discharge arrestors

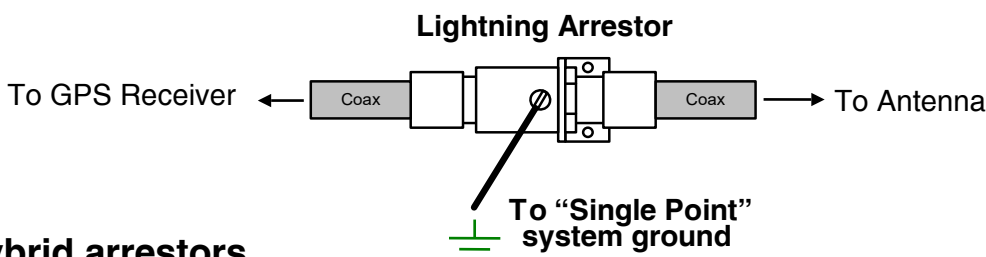
Gas discharge arrestors typically contain a replaceable gas cartridge, the gas of which is designed to ionise, breakdown and conduct lightning energy current to earth.

This ionisation process depends to some extent on the rate of change of the lightning energy along with other factors such as voltage and temperature, which can allow sort duration spikes to permeate across the arrestor.

These simple devices can provide broad effective GPS lightning protection but are less sensitive than more modern hybrid arrestors which contain additional components that improve reaction speed and lower the maximum clamped line voltages.



HGPSEMPFILTER\_2



### Hybrid arrestors

Brandywine & TFS recommend and supply hybrid surge arrestors which provide operational advantages over basic gas discharge arrestors.

These units deliver high reliability, zero maintenance and multi strike capability.



# Satisfied customers include..

ABB Singapore Airbus Defence & Space ASM Technologies Ltd Atkins Babcock International BAE Systems BBC BP CMC Engineering Malaysia	EDF Energy Indian Navy Jakarta Metro Leonardo Electronics Defence And Security London Stock Exchange London Underground MBDA Ltd MTRC Hong Kong National Air Traffic Services	NASA NEC Network Rail Northrop Grumman Park Air Systems Ltd Qinetiq Ltd Raytheon Systems Ltd Rockwell Automation SBS Transit Singapore Siemens Transportation	Singapore Stock Exchange Telent Technology Services Limited Teligent Thales UK Transport For London Viacom
--	---	---	---

## Sales Contacts and Global Representatives

### TFS UK Head Office

Mrs Laura Cain  
 Sales Coordinator  
 TFS, Witham, CM8 3AL, UK  
 Tel : +44 (0) 1376 514114  
 laura.cain@timefreq.com

### Europe, Middle East, Africa, Australia

Mr David Wright  
 Director of Sales, Europe, Middle East,  
 Africa, Australia  
 Tel : +44 (0) 1694 722891  
 dwright@timefreq.com

### Asia, China, India, Japan

Mr Neil Pitman  
 Director of Sales - Asia  
 China, India, Japan  
 Mobile : +44 (0) 7973 859342  
 neil.pitman@timefreq.com

<b>Austria, Germany &amp; Switzerland</b> <b>Semic RF Electronic GmbH</b> <i>Contact : Wolfgang Gruber</i> Tel: +0049 89 614 1520 Email: sales@semic.de Web : www.semic.de	<b>Israel</b> <b>IES Electronics Agencies (1986) Ltd</b> <i>Contact : Avi Nataf</i> Tel: +00972 37530700 Email: info@nisko-ies.com Web : www.nisko-ies.com	<b>Philippines</b> <b>Imaginet International Inc</b> <i>Contact : Mr Blair Duncan</i> Tel: +63 2 895 9755 / Fax : +63 2 895 9766 Email: blair@imaginet.com.ph Web : www.imaginet.com.ph
<b>Australia &amp; New Zealand</b> <b>Unitronix</b> <i>Contact : Tim Marshall</i> Tel: +0061 02 4977 3511 Email: sales@unitronix.com.au Web : www.unitronix.com.au	<b>Italy</b> <b>Millimettrica RF &amp; Microwave Components SRL</b> <i>Contact : Aldo Cagno</i> Tel: +0039 011 317 9910 Email: acagno@millimettrica.it Web : www.millimettrica.it	<b>Singapore</b> <b>PROGRESO Networks (S) Pte Ltd</b> <i>Contact : Victor Tang</i> Tel: +65 6509 9600 / Mobile +65 9735 1700 Email: victor@progreso.com.sg Web: www.progreso.com.sg
<b>Brazil</b> <b>Sigtron Instrumentos e Servicos Ltda</b> <i>Contact : Eduardo Strafacci</i> Tel: +0055 11 5031 7359 Email: eduardo@sigtron.com.br Web : http://sigtron.com.br/	<b>Japan</b> <b>Nacelle Co Ltd</b> <i>Contact : Mr Hisato Tadokoro</i> Tel : +81 3 5921 5099 Email : tadokoro@nacelle.co.jp Web : www.nacelle.co.jp	<b>Thailand</b> <b>CSG Solution (Thailand) Company Ltd</b> <i>Contact : Mr Chinnaret Kusathisiriphan</i> Tel: +66 2 575 2971 / Mobile +66 94 951 6524 Email: chinnaretk@csgs.co.th Web: www.csgs.co.th
<b>China, Hong Kong &amp; Macau</b> <b>Spectrum &amp; Master Comms. Technologies</b> <i>Contact : Mr William Lai</i> Tel: +852 2529 1111 / Mobile +852 9378 9271 Email: smcthk@netvigator.com	<b>Korea</b> <b>ETOOB</b> <i>Contact : Jaydon Lee</i> Tel : +82-2-6677-3409 Email : jaydon.lee@etooob.co.kr Web : www.etooob.co.kr	<b>Turkey</b> <b>Merit Elektronik</b> <i>Contact : Levent Celebi</i> Tel: +0090 312 472 7495 Email: leventc@meritelektronik.com.tr Web : www.meritelektronik.com.tr
<b>Indochina (Vietnam, Laos, Cambodia)</b> <b>Hanova JSC</b> <i>Contact : Mr Hai Le</i> Tel: +84 91 351 4905 Email: hai.le@hanova.vn Web : www.hanova.vn	<b>Malaysia</b> <b>Alam Sinergi Teknik Sdn. Bhd.</b> <i>Contact : Mr HH Chew</i> Tel: +60 3 7847 5925 / Mobile: +60 13 5131068 Email: hhchew@alamsinergitekNIK.com	<b>South Africa</b> <b>Satellite 2000 Systems International Inc</b> <i>Contact : Fred Joubert</i> Tel: +001 818 991 9794 Email: sales@sat-2k.com Web : www.sat-2k.com
<b>India</b> <b>PDAC Microsystems Pvt Ltd</b> <i>Contact : Mr Pradeep Dhar</i> Tel: +91 40 40247626 / Mobile +91 80082 95670 Email: pradeep@pdac.in Web : www.pdac.in	<b>North America : USA &amp; CANADA</b> <b>Brandywine Communications Inc.</b> Tel: +1 877 367 7962 Fax: +1 714 755 0175 Email: info@brandywinecomm.com Web : www.brandywinecomm.com	<b>U.A.E.</b> <b>Zener Fire &amp; Security LLC</b> <i>Contact : Ranjith Nambiar</i> Tel: +0021321548618 Email: ranjith@zenerfire.com Web : www.zenerfire.com
<b>Janus Trading Co</b> <i>Contact : Mr Santosh Krishnan</i> Tel: +91 124 408 6641 Email: santosh@januscorp.in Web : www.januscorp.in	<b>North Africa, Mauritania, Morocco, Tunisia, Algeria, Libya, Egypt, Chad, Mali</b> <b>ProComSat</b> <i>Contact : Hussein Ait Si Selmi</i> Tel: +0021321548618 Email: hussein@procomsat.com Web : www.procomsat.com	
<b>Signowave Solutions Private Limited</b> <i>Contact : Santosh Kulkarni</i> Tel : +91 40 6717 2356 / Mobile : +91 70327 09060 Email: santosh.kulkarni@signowave.com Web : www.signowave.com	<b>Spain &amp; Portugal</b> <b>Tecnologia GPS S.A.</b> <i>Contact : Jose Luis Estaban</i> Tel: +34 91 323 72 30 Email: comercial@tecnogps.es Web : www.tecnogps.es	

**tfs Time & Frequency Solutions**

25 Eastways, Witham, Essex, CM8 3AL, UK  
 Phone +44 (0) 1376 514114 | Fax +44 (0) 1376 516116  
 Email : enquiries@timefreq.com

**brandywine communications**

153 Warner Ave, Tustin, CA 92780, USA  
 Phone +1 714 755 1050  
 Email : Info@brandywinecomm.com

Disclaimer : Brandywine & TFS are always seeking to improve our products, the information in this document only provides general indications of product capability, suitability and performance, none of which shall form any part of any contract.