Compliance of NovAtel's GPS-702L Antenna to the European Union's new WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of the use of Certain Hazardous Substances) Directives

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BIOGRAPHY

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ABSTRACT

NovAtel's GPS-702L antenna is the company's first foray into the use of lead-free electronic assembly methods. This effort is driven by the European Union's (EU) directives 2002/95/EC (RoHS) and 2002/96/EC (WEEE), which seek to remove certain environmentally hazardous substances, including lead, from the waste stream and to avoid final disposal in landfills. The RoHS legislation was mandated to be passed by all national legislatures in the EU by August 2005, and will be effective July 1, 2006. After this date, all electronic equipment covered under Annex 1A of WEEE will be required to be compliant to the legislation when placed on the market in the EU. Concentrations of the listed substances must be absent from new equipment, or below the allowable threshold, including lead, as well as several heavy metals such as mercury, cadmium, hexavalent chromium and brominated compounds (PBBs & PBDEs). Annex 1A of WEEE is reproduced in the Appendix of this document.

WEEE requires manufacturers to take back products for recycling. Every country is implementing the WEEE legislation differently, so manufacturers must inform themselves about the waste recovery rules in place for each country into which it sells its products.

NovAtel makes high-precision GPS antennas and receivers for survey and machine control applications. These cover a wide range of environments from jet aircraft to arctic survey to tractor/trailer tracking and unmanned air vehicles (UAVs). Since equipment failure is not an option in these environments, NovAtel has embarked on an analysis of assemblies fabricated with lead-free SnAgCu alloy (commonly known as SAC) from two manufacturers, and has incorporated a number of design concepts into its testing, including HALT (Highly Accelerated Life Test) to destruction. In addition to qualifying every component and material used in its 702L antenna for RoHS compliance, NovAtel worked with its electronics manufacturers to determine a proper solder paste and application parameters for the GPS-702L. This paper will discuss the effectiveness of the lead-free assembly techniques for industrial products such as GPS antennas and receivers, and their suitability for widespread use in the industry. This legislation still has a low profile in the US. Users of GNSS equipment must evaluate equipment purchases for the next 12-24 months based on uncertain information in the marketplace.

OBJECTIVE

Relevance to GPS: The WEEE and RoHS legislative activity is being driven by recognition that the volume of electronic equipment finding its way into landfills is rising as society continues to increase its reliance on electronics that rapidly become obsolete. While the legislation is aimed at high-volume products such as mobile phones, computers and monitors and those products with rechargeable batteries, it covers a wide variety of electronic equipment, potentially including GPS receivers and antennas. There are exemptions for certain applications of the controlled substances, notably mercury in fluorescent lamps, cadmium for high-reliability relays, copper alloys including brass (which contains up to 4% lead), "lead in solders for network infrastructure equipment", "lead in solder for servers, storage and storage array systems" and "lead in electronic ceramic parts". There is still some controversy in industry over whether the exemptions are inclusive or exclusive. Indeed, Annex 1B of WEEE states examples of equipment that "…shall be taken into account for the purpose of this Directive and which fall under the categories of Annex 1A". Some manufacturers are taking the position that their products are exempt because their class of products is not specifically noted in the directive. Other manufacturers, including NovAtel, whose products are integrated into systems that may themselves be subject to the legislation, intend to make their products fully compliant with RoHS.

BACKGROUND

The background literature for lead-free assembly is not yet clear and is still evolving. A number of technical issues remain the subject of research and controversy. Lead-free solder paste, for example, requires a higher reflow temperature than leaded solder pastes, in some cases up to 260 degrees C, that could be 20-30 degrees higher than previous alloys. This temperature is high enough that some key assemblies, such as filters, that are built on substrates by a filter manufacturer, will have the secondary solder joints holding components to that substrate reflowed in the soldering oven during the assembly of the GPS receiver. This has required component manufacturers to redesign their products for higher temperatures, in particular components that can absorb moisture such as plastic semiconductor packaging. The moisture escapes as steam when subjected to the oven temperature profile. One related phenomenon is called "popcorning", referring to the likelihood that the package will deform, particularly in BGA packaging.

The phenomenon of "tin whiskers" is a documented failure mechanism for some electronic equipment found in satellites, telecommunications and computer systems. Tin whiskers are single filaments that emerge from the plated surface. The growth of tin whiskers is triggered by surface stress. These whiskers have been associated with bright tin finishes, growing to a length of several millimeters[i] over a period of years in the appropriate environment. They can cause electrical shorts between adjacent conductors, resulting in component failures and in some cases total system loss. Traditionally, the presence of Pb in the plating has inhibited whisker growth. There are several alternatives to bright tin, notably "matte tin",[ii] that appear to reduce the material stress of the plating, but it is important to note that there is still considerable research in this field and in fact, the exact growth mechanism of tin whiskers is not well understood. Matte tin has a larger grain structure and a significantly lower carbon content that bright tin[iii]. Tin-whisker growth characteristics of this form of tin are thought to be superior (shorter) compared to bright tin, and this has led to its adoption by semiconductor companies for the plating on leadframes. The industry is still gathering evidence to support matte-tin plating. The International Electronic Manufacturers Initiative (iNEMI) has been performing studies of tin-whisker growth to validate the use of matte-tin. [iv]

Tin whisker electron micrograph, showing the behaviour of the filament to grow at right angles to the plated surface. Photograph courtesy of EFSOT (Environmentally Friendly Soldering Technologies),
www.efsot-europe.info

The ductility / brittleness characteristics of the new substitute alloys are also being documented by a number of organizations, and are a requirement for calculations of Mean Time Between Failure (MTBF) and equipment reliability. One of the potential failure mechanisms of the SnAgCu family of alloys is additional brittleness of the alloy at temperatures below –20C. The electronics industry is only beginning to document these mechanisms. There are some recent reliability models that do predict the primary and secondary creep rates of the solder joints – the failure mechanism of most solder joints - but much work remains and is outside the scope of this paper[v],[vi]

Solder	Transition Temperature	Recommended Utility	Behaviour note
63Sn-37Pb			Gradual loss of ductility
99.3Sn-0.7Cu	"probably around –140C"	-110C	Probably sharp transition
96.5Sn-3Ag-0.5Cu	-80C	-70C	Sharp transition
95.5Sn-4Ag-0.5Cu	-60C	-45C	Sharp transition

Table reproduced from article by Future Fab International, reporting results by IMEC (Interuniversity Microelectronics Center) on the transition temperature (ductile to brittle transition, or fracture toughness) of selected alloys at the June 2005 IMAPS European Microelectronics and Packaging Conference

In 2000, NEMI recommended the use of 95.5Sn3.9Ag0.6Cu (commonly known as SAC) as a lead-free solder paste, balancing the positive characteristics of wettability and fatigue resistance with the consequences of higher solder reflow temperatures.[vii] Other manufacturers have selected different formulations of solder paste that they have characterized as acceptable for their applications. The Japanese industry has focused on a four-element alloy comprised of Sn, Ag, Cu and Bi in order to lower the critical flow temperature to be more similar to leaded-paste processes. The use of bismuth requires scrupulous attention to process quality and cleanliness with respect to possible lead contamination. Bismuth alloys contaminated with lead form a low-temperature brittle Pb-Bi alloy that can cause premature joint failure or "lift-off". Until contract manufacturers have completely transitioned to lead-free assembly, the SnAgCu alloy offers a more robust processing option for contract manufacturers supporting both lead-free and leaded assembly services.

Larger organizations are making significant progress towards lead-free assembly. Celestica, for example, has commissioned two plants, one in the Czech Republic and one in China, to create cellphones exclusively for the European market that will be compliant with the RoHS legislation[viii1]. Some Japanese manufacturers such as Panasonic, and American manufacturers including Motorola, have extensive lead-free assembly programs underway.

BOARD DESIGN

Higher reflow temperatures required for proper reflow of lead-free solder paste dictated a change to the PCB substrate material to a higher Td (decomposition temperature).

There were no issues with the chemical composition of the PCB material. Some PCB materials have those compounds banned by the RoHS directive blended into the resin used to bond the laminate sheets of glass fibre. NovAtel relied upon advice from its PCB fabricator in selecting a replacement material.

SOLDER STENCIL

The design of the solder stencil is critical to the quality of the final soldered assembly. Solder paste release from the stencil during paste application can be less consistent when using lead-free pastes, causing incomplete paste application and stencil clogging. The design of the stencil apertures is critical to obtaining good quality reflow results. The paste is more prone to component tombstoning due to differences in surface tension compared to leaded pastes.

SOLDER PASTE

Leaded solder has typically consisted of an alloy of 63% Pb 37% Sn, whether used in a liquid form (wave soldering) or paste form (reflow soldering). Over a period of decades, this alloy has been found to exhibit good characteristics of ductility (resistance to joint failure because of shock or vibration), temperature stability (maintaining ductility and fatigue resistance characteristics over a very wide temperature range) and the inhibition of the growth of tin whiskers in the resultant joint. Soldering with 100% tin is possible, but was found long ago to be susceptible to failure due to brittleness.

Lead-free soldering is susceptible to contamination by sources of lead either from assembly lines used for both leaded and lead-free assembly, or from manual repair of solder joints. Repairing a lead-free joint, for example, with a soldering iron used for leaded solder, will weaken the lead-free joint because trace amounts of lead will contaminate the SAC solder joint. The trace amounts of lead form a brittle, low-temperature alloy. A phenomenon of "lift-off" has been documented for lead-free assemblies where joints are contaminated by low levels of lead. Up to 0.5% lead in a solder-joint composed of lead-free alloy has been identified to have no detectable changes in physical properties, but fatigue life is negatively affected.[ix] A concentration above 0.5% risks a serious degradation in joint reliability. For this reason, it is important to keep lead contamination to a minimum.

COMPONENT SELECTION

The RoHS directive calls for the concentration of lead as a percentage of weight to be limited to 0.1% in homogenous materials. This has been interpreted, after some controversy, to be the weight of lead (expressed as a percentage) in each solder joint or "homogenous material" in the product – something that cannot be disassembled further by mechanical means". The ceramic bulk of a capacitor, or the plastic moulding of an integrated circuit, are examples of homogenous substances. Initially, it was thought that the weight of the lead in the product must be less than 0.1% of the weight of the product. The correct interpretation was quickly clarified by the authorities such as the national governments and the Technical Adaptation Committeee that are responsible for interpreting and implementing the EU directive.

The aspect of component selection has turned out to be one of the largest issues for equipment manufacturers such as NovAtel. Compared to the electronics industry in Japan, which is well advanced in the creation of electronic components for lead-free assembly, US manufacturers have only recently begun to move towards producing components they can claim as lead-free and RoHS-compliant. Many manufacturers have also produced new RoHS-compliant parts, but are selling them under the identical part numbers as before. For a manufacturer attempting to document 100% of the parts used in an assembly as RoHS-compliant, this presents difficulties in the management of parts. The issue here is not just one of documentation of compliance, but also of the inadvertent use of leaded components in a lead-free soldered assembly. The use of a component having a tin-lead finish together with a lead-free solder paste will result in a series of joints that are prone to failure because of the higher than acceptable percentage of lead in the alloy. The inability of some component manufacturers to clearly identify components using plating containing lead and plating free of lead, has resulted in the product lines of some manufacturers being excluded from new designs at NovAtel.

To move to the use of non-leaded terminations in components such as capacitors, integrated circuits and connectors, manufacturers have had to select alternate plating materials. For surface-mount applications, the plating must be compatible with the lead-free solder to be used. In the case of passive components, lead-free finishes have been available for a number of years to accommodate soldering to a series of PCB finishes. However, semiconductor packages have only recently moved away from leaded plating to matte-tin plating. The most common types of finishes are 100% matte tin (discussed previously) and Ni-Sn (nickel-tin plating). Some Sn-Pd (tin-palladium) and Sn-Pt (tin platinum) finishes are also used.

A number of other components should also be reviewed for their compliance to RoHS, including cabling, shielding materials, enclosure materials (some plastics also contain non-RoHS-compliant brominated compounds), ceramics (especially relevant to the GPS industry, as the vast bulk of GPS antennas use ceramic patch elements that may contain lead) and product identification labels themselves.

NovAtel modified its in-house documentation and component management tool to identify all currently used components as to their RoHS status. Only those parts that could be confirmed to have RoHS compliance (as documented in their datasheets, or confirmed in writing by the manufacturer) were authorized in the GPS-702L antenna. Some component manufacturers are claiming that their designs are lead-free as of an announced introduction date. As a result of the previously-discussed ambiguity with part numbering between leaded and unleaded devices, and because of the need to ensure these parts were not used in the GPS-702L, NovAtel purged its inventory of all component parts used for the antenna that could not be demonstrated to be lead-free and RoHS-compliant. Further, it created a physically separate RoHS-compliant stock location at the contract manufacturer to avoid mixups.

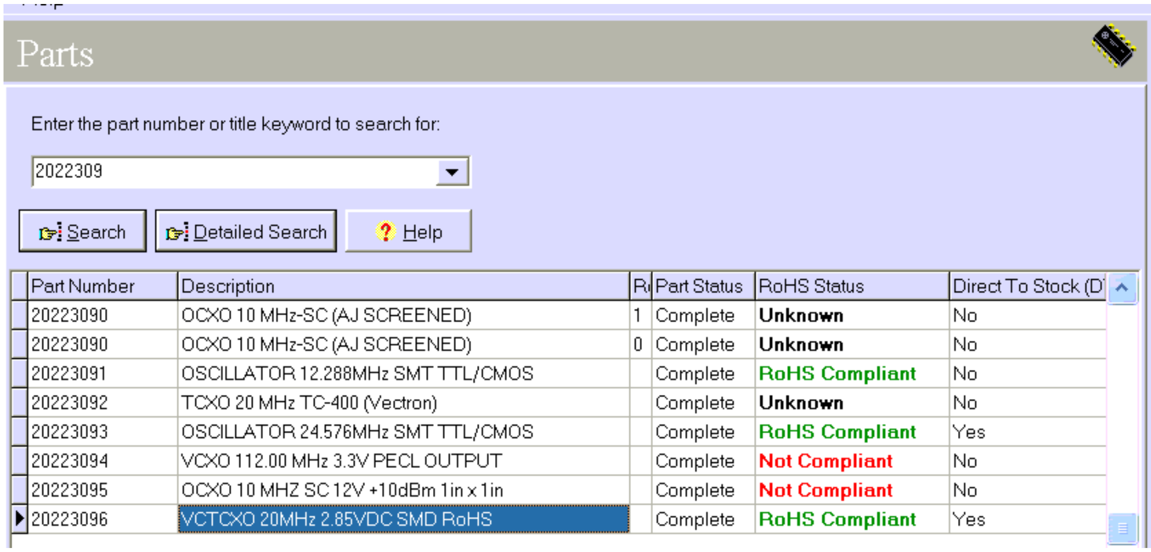


Image of NovAtel's parts management system, DSTS, showing how components are identified in the system as RoHS-compliant, not compliant, or have unknown status, likely because the components are from older designs.

Testing for lead-free compliance has also been an issue. The level of lead permitted in each solder joint is 0.1%. There is no reliable visual means of inspecting a component for its RoHS compliance status. Chemical identification kits have recently been introduced to the market that can be used for lead-free auditing purposes. A treated swab that will turn pink in the presence of surface lead can be rubbed on a lead-free joint. The test is not definitive and is only qualitative, but is sufficient to distinguish a conventional leaded assembly from a lead-free assembly. It cannot be relied upon to distinguish an RoHS-compliant assembly from an assembly that may have been poorly assembled with some leaded components, because the level of lead in some solder joints could be marginally higher. The test should be regarded as an inexpensive incoming quality test only. Another test that may be practical for incoming inspection is the use of handheld X-ray fluorescence guns. Two units now available are the Niton XLt and the Oxford Instruments X-MET3000T.

LEAD-FREE ASSEMBLY

The largest challenge to the successful assembly of components is selecting a solder paste and an in-house or contract manufacturer that has qualified the solder paste for assembly. The process engineer responsible for qualifying the lead-free solder paste can expect to vary the parameters associated with leaded-solder applications, including temperature ramp zone, peak temperature, cooling rates and solder paste application parameters. NovAtel's initial attempts at qualifying the SAC solder paste for the GPS-702L required a number of trial runs to control the quality of the solder joints. Temperature profiling is critical at this stage, especially with an amplifier design using both very small discrete devices, which have little heat capacity and large monolithic filters, which can absorb more heat before reaching the correct solder temperature.

NovAtel uses two contract manufacturers for its lead-free assembly, both of whom also process leaded paste assemblies. The risk of cross-contamination between the assembly lines' leaded and lead-free processes ideally requires that those lines performing lead-free assembly should exclusively do only lead-free designs. Since most contract manufacturers will initially only have a few customers requiring lead-free assembly, it would be impractical to allocate the capital to a lead-free line that might run at 10% or 20% capacity. It is necessary to put procedures in place for scrupulous cleaning, and if possible, to have a dedicated solder paste application machine for lead-free assembly. Using a different color solder paste squeegee for leaded and lead-free solder pastes, for example, can prevent inadvertent contamination of lead-free solder paste by a squeegee used for leaded solder paste.

The assembly of BGA (Ball Grid Array) integrated circuits poses special challenges. In particular, if a BGA specified to have lead-free solderballs is assembled with a leaded paste, the lead-free solderballs will not properly flow at the lower leaded process temperatures of leaded solder. This will result in a poor quality joint formed of a partially melted solder ball and fully melted solder paste. Normally, components specified as having lead-free finishes can be safely used with leaded solder paste, because the plating of the terminations has been designed for compatibility with both leaded and lead-free paste. This last point should be closely observed by manufacturers in a transition phase, potentially accumulating lead-free components, but still using a leaded solder paste, while trials and processes are validated.

Inspection of lead-free solder assembly also requires some changes. The alloy of the properly assembled SAC solder joint does not have the same shininess and luster as a lead-tin solder joint, so cold SAC joints are less distinguishable from good SAC joints. IPC 610A Rev D defines inspection criteria for lead-free assembly.

DEMONSTRATING COMPLIANCE

The RoHS directive is supposed to take effect through legislation enacted by each country as of July 1, 2006. In reality, different countries are proceeding at different rates, and it is not clear what will actually be required in each market as of July 1, 2006. RoHS has been transposed into law in the majority of member states. Committees of the IPC (IPC-1751, IPC-1752, IPC-1753, IPC-1754), IEC (IEC17050) and JIG (JIG-001) are reviewing proposed implementations of material declarations before July 2006.

There are no standardized test methods or reporting methods mandated under RoHS as of yet. Unlike regulatory emissions testing, for example, where certified labs actually measure emissions performance following a standardized method, standardized methods as mentioned above are still in development. Each manufacturer is expected to self-declare the compliance of its products. The ISO/IEC 17050 “Supplier Declaration of Conformity” is in draft form and is likely to be published before the end of 2005.[x] This Declaration of Conformity will likely serve as a standard format for the declaration of RoHS product compliance.

Until an alternative evolves, the declarations of the component manufacturers must be taken at face value. To determine the “provenance” of the component – to prove which factory it came from, and some form of chemical assay to back up the component manufacturer’s claim– is beyond the scope of most electronic products. X-ray fluorescence, for example, of every single component by every single manufacturer using that component, is impractical from the point of cost, logistics and required expertise. The large electronics distributors have been leading coordinated efforts to create a single industry labeling method so that buyers of electronic components can be assured of the qualification. In turn, the electronic assembly must be documented and self-declared in an official manner. The implication of self-declaration is that the manufacturer must be prepared to deliver the documentation demonstrating compliance to the appropriate authorities upon demand. To continue the analogy with regulatory testing, NovAtel currently generates a single-page summary of regulatory compliance for each product in its portfolio. Similarly, NovAtel intends to generate a single-page summary of RoHS compliance that will document that the product has been designed and assembled in accordance with RoHS directives. Additional backup can then be available upon request from authorities.

Compliance requirements will continue to evolve over the next several years. At some point, stronger declarations and audits by recognized agencies may be required.

HALT (HIGHLY ACCELERATED LIFE TESTING)

One of the concerns highlighted by users of professional GPS equipment is whether the products assembled according to RoHS directives will be reliable after several years. Decades of experience with leaded solder have validated the use of leaded solder in all manner of applications. MTBF calculations have traditionally been based on MIL-STD-217, which in turn relied upon measurements made since the 1960s to characterize the reliability of various components and assembly techniques such as leaded solder. The “creep rates” and fatigue rates of unleaded solder are different than the rates for leaded solder, and the ductile/brittle transition temperatures are abrupt, as opposed to smooth. However, no MTBF models have been published yet for the reliability of the SAC alloy in surface-mount solder joints.[xii]

HALT is a method of finding design weaknesses in products by subjecting them to highly stressful conditions of temperature cycling and vibration until the product fails in some manner. The combination of rapid temperature stresses, shock and vibration attempts to drastically compress the time to failure of a component, a solder joint or enclosure. This testing doesn’t attempt to exactly simulate the functional use of the product. For an industrial product that may be warranted to operate from -40C to +85C, HALT may attempt to subject the product to repeated temperature cycling beyond –40C to +85C, while simultaneously subjecting the product to a vibration profile that exceeds that of expected use. The product will be continuously tested for functionality during the testing. The number of cycles tested is empirical and depends on the application.

HALT testing does not seek to predict an MTBF based on empirical data derived from the testing.[xiii] However, successful completion of HALT been correlated with long-term field reliability. The goal, therefore, is to ensure that the product continues to function well beyond its operating temperature range and expected shock / vibration profiles. A number of papers are available that fully describe the advantages of HALT[xiv], why it is not appropriate for most MTBF calculations, and how to implement a HALT test.

In the case of the GPS-702L, the major concern was to demonstrate that solder joints assembled with the lead-free process do not fail due to shock and vibration when exposed to repeated temperature cycling to –50C and +90C.

RESULTS

The GPS-702L was subjected to the following tests to ensure that the datasheet specifications were still met after reliability testing.

Performance testing afterwards showed that the product performed to its datasheet specifications.

Test	Test Limits
Highly accelerated temperature stress (step temperature)	-55C to +90C
Rapid thermal transition (no step)	-55C to +90C
Random vibration step stress	5grms to 65grms, 25 degrees C
Highly accelerated combined temperature / vibration environment	-55C to +90C 13grms to 75grms

HALT testing performed to attempt induce early failures of lead-free solder joints.

NOVATEL GPS-702L

While the focus of this paper is discussing the RoHS challenges associated with the assembly of the GPS-702L antenna, we would be remiss if the GPS-702L antenna was not discussed. The intent of the GPS-702L is to offer a low phase-centre offset antenna that can also use position corrections from L-band satellites, such as Omnistar VBS, HP and XP as well as the CDGPS (Canadian Differential GPS) correction service. Applications such as precision agriculture, mining and UAVs benefit from additional position accuracy (to 1 decimeter, 1 sigma with Omnistar HP) while maintaining the autonomy and freedom from range and licensing restrictions that are necessary with land-based correction methods.

The traditional problem with dual-frequency antennas has been to increase the antenna bandwidth to cover both the L1 and L2 frequencies, while maintaining good selectivity against interfering signals near L1 and L2, and with linear response within the bands. At the same time, a dual-frequency GPS antenna requires a close alignment between geometric centre and electrical phase centre to ensure that narrow-lane RTK performance is not impaired. NovAtel's GPS-702 pinwheel antenna met these specifications[xv].

To receive the Omnistar satellite signal, the L1 bandwidth covering 1575 MHz must be widened to cover 1520-1575 MHz while not disturbing the phase centre of the NovAtel pinwheel.

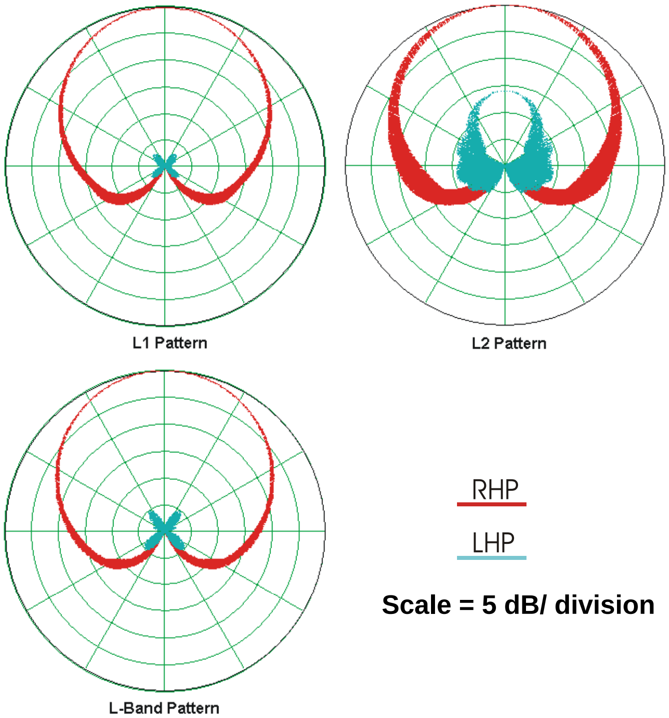
Several satellites carrying the Omnistar VBS, HP and XP signals are located in geosynchronous orbits. For most users throughout the world, the satellites will appear at low elevation angles (typically 15-30 deg.). The apparent elevation angle of Omnistar satellite will vary with the latitude and longitude of the observer. The antenna element designed to receive the Ominstar signal must be sensitive not only to receive signals at minimum 15 deg. elevation but to accomodate a 10 degree roll in the vertical plane due to a tractor/machine movement on a non-lateral surface.

GPS-702L PERFORMANCE

The value of the GPS-702L antenna in GPS applications is in acquiring the Omnistar signal while preserving those aspects of GPS-702 antenna performance that are valued, such as insensitivity to ground-bounce satellite multipath signals, phase centre accuracy, and symmetrical sensitivity in all azimuth planes.

Actual performance of the GPS-702L antenna shows that phase centre accuracy maintains L1 and L2 electrical centres in all azimuth planes within 2 mm. Gain at zenith is at least +5 dBi for the antenna element. The gain rolloff from zenith to horizon is 13 dB for L1, 12 dB for L2, and 13 dB for L-band signals. The rolloff is important to minimize the contribution of multipath signals to the final determination of L1 and L2 ranges.

Gain symmetry is within +/- 2dB across all azimuth planes. The tri-band LNA amplifies L1, L2 and LB bands by at typically 29 dB with less than 15 ns group delay across a +/- 8 MHz band around L1 and L2.



Specification	Limit
Temperature range	-40/+85C
LNA gain	29 dB
Current consumption	30 mA
L1 gain	+5 dBic
L1 rolloff, 90 deg to 0 deg	13 dB
L2 gain	+1.5 dBic
L2 rolloff, 90 deg to 0 deg	12 dB
L-band gain	+5 dBic
L-band rolloff	13 dB
L1/L2 phase centre	2 mm

Elevation angle plots for the GPS-702L, azimuth 0 degrees, showing the symmetry of L1, L2 and L-band responses.

Satellite Chart
OmniSTAR Satellites and Regional Coverage
(as of July 20, 2005)

Coverage Area	Satellite Location (Longitude)	Frequency	Data Rate ***	L-Band	Sat. Name
Eastern U.S.*	101 West	1530.3590	1200	L-Band	AMSC-E
Central U.S*	101 West	1534.7410	1200	L-Band	AMSC-C
Western U.S.*	101 West	1536.7820	1200	L-Band	AMSC-W
North, Central, and South America, including the Caribbean	98 West	1535.1375	1200	L-Band	AM-SAT
Asia, Pacific Islands	109 East	1535.1375	1200	L-Band	AP-SAT
AFRICA	25 East	1535.080	1200	L-Band	AFSAT
East Africa Middle East	25 East	1535.1525	1200	L-Band	EA-SAT
Australia, Far East	160 East	1558.510	1200	L-Band	Optus

Service Regions and Coverage Maps
* Recently changed frequencies- Coverage is Northern Canada to southern Mexico.
***A data (baud) rate of 1200 equals a symbol rate of 2438
** A data (baud) rate of 600 equals a symbol rate of 1219

An Omnistar satellite map, reproduced from the Omnistar website, showing the geostationary orbit of the Omnistar satellite transponders for each area of the world.[xvi]

CONCLUSION

It is outside the scope of this paper to comment on the evolution of RoHS directives. However, some general conclusions are possible:

- An electronics company must inform itself of the RoHS directives and whether its products are covered by the legislation. Someone in the organization should be designated as the RoHS coordinator or project manager. The legislative and regulatory aspect will continue to evolve for several years to come. A good place to start is with the EU itself, which has generated FAQs and links to other sources .

- Whether the organization decides to become RoHS-compliant depends on several factors, including the exposure / access to the EU marketplace, the potential of other parts of the world (China) to adopt RoHS legislation, and whether the products created are covered by RoHS exemptions; for instance, medical products.

- Ensure that the manufacturing organization, internal or external, is aware of the implications for reliable assembly of lead-free and RoHS-compliant products and, if appropriate, is taking action. This includes performing solder paste trials, performing an audit of inventory and flushing non-compliant material from inventory.

- Take additional steps to ensure that any RoHS-compliant products are characterized to ensure that the resulting product is robust over the expected temperature, shock and vibration profiles. HALT testing is one method that can be considered here.

ACKNOWLEDGMENTS

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APPENDIX

ANNEX 1A of 2002/96/EC (WEEE)

Categories of electrical and electronic equipment covered by this Directive

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7. Toys, leisure and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

Allowable levels of the substances mentioned in the Directive: Source: Technical Adaptation Committee for the RoHS Directive		
Pb	(lead)	0.1% by weight
Cd	(cadmium)	0.01% by weight
Hg	(mercury	0.1% by weight
Cr(VI)	(hexavalent chromium)	0.1% by weight
PBB	(polybrominated biphenyls)	0.1% by weight
PBDE	(polybrominated diphenyl ethers)	0.1% by weight

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