Satlantic Instrument File Standard

Satlantic's Data Format Standard for Calibration and Telemetry Definition Files

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1.0 *Overview*

Satlantic's *instrument file* format is a data format standard used to define and interpret telemetry from Satlantic's wide range of instrumentation. All Satlantic instrumentation transmits telemetry. The telemetry is composed of packets of data, called frames, which are broadcast periodically. Each frame contains sensor sampling information and/or other pertinent instrument data that is to be received by some type of data acquisition system. Frames have a defined structure that must be known by any software application that reads and/or processes the instrument telemetry. Instrument files were developed to give instrument developers a platform from which frames can be interpreted and processed. Because of the flexibility of this platform, instrument files can also be used to interpret and process telemetry from non-Satlantic instrumentation, such as a GPS receiver. In addition, this standard defines how data acquisition or processing systems can interpret special case sensor definitions for higher level calculations.

An instrument file has two purposes. First, instrument files specify the format and structure of a frame of telemetry. These frames must start with a frame synchronization string, or frame header, used to differentiate one frame type from another. The frame header definition also defines a frame as either fixed or variable length. Fixed size frames always have the same number of bytes. Sensor data is always located at the same place, or offset, in the frame. Variable length frames are formatted with ASCII characters only. Special characters located throughout the frame delimit sensor data.

Secondly, instrument files provide calibration coefficients that can be used by data acquisition or processing systems for converting the raw sensor data in the frame into calibrated physical units. Periodically, an instrument will need to be recalibrated, which means a new instrument file must be made.

The most common form of an instrument file is known as a *Calibration File*. A calibration file is generally used with all Satlantic instrumentation. Calibration files use the ".cal" file extension. Another type of instrument file is the *Telemetry Definition File*. These files are generally used with non-Satlantic instrumentation for which the instrument or data source telemetry can be defined with the Satlantic data format standard. Telemetry definition files use the ".tdf" file extension.

Throughout this document, references are made to sensor values (or data) and sensor definitions. These two references have different meanings and should not be confused. A *sensor value* is the sensor sampling information obtained from a frame of telemetry. A *sensor definition* is the line(s) of text found in an instrument file that define where a sensor value can be found in a frame and how it should be interpreted.

2.0 *Instrument File Format*

All instrument files follow a set of formatting rules. These rules are explicit and must be followed accordingly for an application to correctly interpret the file. The following is a list of basic rules for authoring instrument files:

- Instrument files are ASCII text files. Valid file extensions are ".cal" and ".tdf".
- Each line is terminated with a ‹CR›‹LF› (carriage return and line feed) pair.
- All lines are considered case insensitive, except the UNITS field. See ***Table 1: Sensor Definition Line parameters*** for more information.
- A '#' character delimits a comment line. All characters including and following a comment indicator are ignored when processing the file.
- Sensor definition lines are listed in the order in which they appear in the telemetry frame. These lines each describe a section of frame information.

- A sensor definition line has seven fields delimited by white space. Therefore, individual fields cannot contain white space. All fields must be present.
- A sensor definition line may be followed by *n* lines of calibration coefficients. The number of lines to follow is explicitly listed in the sensor definition line. All calibration coefficients are interpreted as floating-point numbers. Each field is delimited by white space, so individual fields cannot contain white space.

As the name implies, a *Sensor Definition Line* is used to define the size and location of a specific sensor value in the frame. These lines can also allocate parts of frames that are not useful or define application specific properties for data acquisition or processing systems. A sensor definition line is formatted from the following template:

```
TYPE  ID  UNITS  FIELD-LENGTH  DATA-TYPE  CAL-LINES  FIT-TYPE
```

The seven fields of a sensor definition line are defined as follows:

FIELD	DESCRIPTION
TYPE	Describes the type or name of the sensor represented in this section of the frame.
ID	Extra information about the sensor (such as the center wavelength of an optical sensor). If the sensor has no ID information, the string "NONE" should be used. A "NONE" string is ignored.
UNITS	Physical units obtained after applying the FIT-TYPE processing to the data. This field is a case sensitive string enclosed by single quotes.
FIELD-LENGTH	Number of bytes in this telemetry field. For fixed length sensor definitions, field length is a positive integer number. For variable length sensor definitions, this field is the character "V".
DATA-TYPE	Data type keyword indicating the format of the data in the telemetry field. See ***Table 2: Data type descriptions*** for valid values for this field.
CAL-LINES	Number of lines with calibration coefficients (calibration lines) to immediately follow the current sensor definition line. This field is a positive integer number.
FIT-TYPE	Fit type keyword indicating the type of special processing needed to convert the sensor value of the frame into physical units. See section ***2.1 Sensor Fit Types*** for more information.

Table 1: Sensor Definition Line parameters

The following table describes valid data types and associated keywords currently supported under the Satlantic data format standard:

DATA-TYPE	DESCRIPTION
BU	Unsigned binary integer. Most significant byte first. The field length used with this data type must be between "1" and "4" bytes inclusive.
BULE	Unsigned binary integer. Most significant byte last (Little-Endian). The field length used with this data type must be between "1" and "4" bytes inclusive.
BS	Signed binary integer (2's complement). Most significant byte first. The field length used with this data type must be between "1" and "4" bytes inclusive.
BSLE	Signed binary integer (2's complement). Most significant byte last (Little-Endian). The field length used with this data type must be between "1" and "4" bytes inclusive.
BF	IEEE single precision floating-point number. The field length used with this data type must be "4" bytes.
BD	IEEE double precision floating-point number. The field length used with this data type must be "8" bytes.
AI	ASCII integer number.
AF	ASCII floating point number.
AS	ASCII string (text).

Table 2: Data type descriptions

2.1 Sensor Fit Types

Many fit types are available so that calibrations can be specified more easily for a variety of sensors with different characteristics and requirements. The following tables describe each fit type of the Satlantic data format standard. The first table summarizes the fit types. The rest of the tables show the fit type keyword used for the FIT-TYPE parameter of the sensor definition line in the top left cell of each table. Sub tables, which are referenced from these optical tables for further information, are indented.

In the Application section of the fit type tables, formulas are sometimes depicted to show how the fit is to be processed. The *y* parameter denotes the resultant fitted value in physical units while *x* denotes the sensor value in the telemetry frame. The value of *x* is interpreted based on the sensor's data type. Calculation of *y* depends on *x*, the fit type, and any calibration coefficients. *Im* is an immersion coefficient that is used to correct optical sensor calibrations (performed in air) for use in water.

The FIELD-LENGTH field of the sensor definition line must be greater than zero for all fit types, except NONE. A NONE fit type has no restrictions on field length. It is therefore legal for a sensor definition to have a field length of "0" with this fit type. This field length restriction does not apply to variable length sensor definitions. See section ***3.2 Variable Length Frames*** for more information on variable length sensors.

FIT-TYPE	DESCRIPTION
OPTIC1	Special factored polynomial with multiple gain ranges. For optical sensors only.
OPTIC2	Special factored polynomial with one gain range. For optical sensors only.
OPTIC3	Special factored polynomial with one linearly adaptive gain range. For optical sensors only.
THERM1	Special factored polynomial for thermal responsivity sensors.
POW10	Special exponential equation for logarithmic sensors.
POLYU	Un-factored polynomial.
POLYF	Factored polynomial.
GPSTIME	Universal Coordinated Time of GPS data.
GPSPOS	GPS global position.
GPSHEMI	GPS global position hemisphere.
GPSMODE	GPS Positioning System Mode Indicator.
GPSSTATUS	GPS system status.
DDMM	GPS global position in degrees, minutes, and seconds.
HHMMSS	Universal Coordinated Time of GPS data in hours, minutes, and seconds.
DDMMYY	GPS date of global position.
TIME2	Time tag for the frame.
COUNT	Raw or un-calibrated information.
NONE	Unusable data.
DELIMITER	Field delimiter used in variable length frame formats.

Table 3: Fit type descriptions

OPTIC1	Special factored polynomial with multiple gain ranges. For optical sensors only.
Coefficients	**a_0 a_1 Im**
Application	$y = \mathrm{Im} \cdot a_1 \cdot (x' - a_0)$, if the sensor is immersed. $y = 1.0 \cdot a_1 \cdot (x' - a_0)$, if the sensor is not immersed. where: $x' = x \otimes \bar{3}$
Notes	Valid data types for OPTIC1 are BU, BS, and AI. The lower two bits of *x* are calibration line bits that must be masked off to form *x'* prior to the application of the coefficients. There are between one and four calibration lines used with this fit type. Each line represents calibration coefficients for each gain level. The gain bits are used as an index into this list of gain ranges. The application of the immersion coefficient can be overridden if the sensor is calibrated for water but used in air. The default is to use the immersion coefficient found in the instrument file. The wet or dry status of an instrument's optical sensors can normally be determined from the log file headers. Refer to the document ***Satlantic Log File Standard*** for more information on these headers. The resultant fitted value is a floating-point number.

Table 4: OPTIC1 fit type

OPTIC2	Special factored polynomial with one gain range. For optical sensors only.
Coefficients	**a_0 a_1 Im**
Application	$y = \mathrm{Im} \cdot a_1 \cdot (x - a_0)$, if the sensor is immersed. $y = 1.0 \cdot a_1 \cdot (x - a_0)$, if the sensor is not immersed.
Notes	All data types are valid with OPTIC2, except AS. Only one calibration line is allowed. The application of the immersion coefficient can be overridden if the sensor is calibrated for water but used in air. The default is to use the immersion coefficient found in the instrument file. The wet or dry status of an instrument's optical sensors can normally be determined from the log file headers. Refer to the document ***Satlantic Log File Standard*** for more information on these headers. The resultant fitted value is a floating-point number.

Table 5: OPTIC2 fit type

OPTIC3	Special factored polynomial with one linearly adaptive gain range. For optical sensors only.
Coefficients	**a_0 a_1 Im CInt**
Application	$y = \mathrm{Im} \cdot a_1 \cdot (x - a_0) \cdot (CInt / AInt)$, if the sensor is immersed. $y = 1.0 \cdot a_1 \cdot (x - a_0) \cdot (CInt / AInt)$, if the sensor is not immersed. where: *CInt* is the integration time used during calibration (in seconds) and *AInt* is the adaptive or adjusted integration time used during the sensor sampling (in seconds).
Notes	All data types are valid with OPTIC3, except AS. Only one calibration line is allowed. The *AInt* coefficient is determined from the INTTIME sensor described in section *4.3.1 INTTIME*. The application of the immersion coefficient can be overridden if the sensor is calibrated for water but used in air. The default is to use the immersion coefficient found in the instrument file. The wet or dry status of an instrument's optical sensors can normally be determined from the log file headers. Refer to the document ***Satlantic Log File Standard*** for more information on these headers. The resultant fitted value is a floating-point number.

Table 6: OPTIC3 fit type

THERM1	Special factored polynomial for thermal responsivity sensors.
Coefficients	**m_0 m_1 m_2 m_3 T_r**
Application	$I^{\lambda} = \alpha_{Tc}^{\lambda} C_{Tm}^{\lambda} \left(\frac{1 + (T_c - T_r)(m_0 + m_1\lambda + m_2\lambda^2 + m_3\lambda^3)}{1 + (T_m - T_r)(m_0 + m_1 + m_2\lambda^2 + m_3\lambda^3)} \right)$ where: α is the optical sensor intensity value when sensor was calibrated, T_c is the temperature (in C) when sensor was calibrated, *C* is the optical sensor dark corrected count during sampling, T_m is the measured temperature (in C) during sensor sampling, λ is the wavelength of the optical sensor.
Notes	All data types are valid with THERM1, except AS. Only one calibration line is allowed. The resultant fitted value is a floating-point number.

Table 7: THERM1 fit type

POW10	Special exponential equation for logarithmic sensors.
Coefficients	$\mathbf{a_0}$ $\mathbf{a_1}$ **Im**
Application	$y = \mathrm{Im} \cdot 10^{((x-a_0)/a_1)}$, if the sensor is immersed. $y = 1.0 \cdot 10^{((x-a_0)/a_1)}$, if the sensor is not immersed.
Notes	All data types are valid with POW10, except AS. Only one calibration line is allowed. The application of the immersion coefficient can be overridden if the sensor is calibrated for water but used in air. The default is to use the immersion coefficient found in the instrument file. The wet or dry status of an instrument's sensors can normally be determined from the log file headers. Refer to the document ***Satlantic Log File Standard*** for more information on these headers. The resultant fitted value is a floating-point number.

Table 8: POW10 fit type

POLYU	Un-factored polynomial.
Coefficients	$\mathbf{a_0}$ $\mathbf{a_1}$ $\mathbf{a_2}$ **...** $\mathbf{a_n}$
Application	$y = \sum_{k=0}^{n} a_k x^k = a_0 x^0 + a_1 x^1 + a_2 x^2 + \cdots + a_n x^n$
Notes	All data types are valid with POLYU, except AS. Only one calibration line is allowed. The resultant fitted value is a floating-point number.

Table 9: POLYU fit type

POLYF	Factored polynomial.
Coefficients	$\mathbf{a_0}$ $\mathbf{a_1}$ $\mathbf{a_2}$ **...** $\mathbf{a_n}$
Application	$y = a_0 \prod_{k=1}^{n} (x - a_k) = a_0 \cdot (x - a_1) \cdot (x - a_2) \cdots (x - a_n)$
Notes	All data types are valid with POLYF, except AS. Only one calibration line is allowed. The resultant fitted value is a floating-point number.

Table 10: POLYF fit type

GPSTIME	Universal Coordinated Time of GPS data.
Coefficients	No calibration lines are used with GPSTIME.
Application	The sensor value (*x*) for this field is interpreted as a floating-point number representing the hours minutes and seconds of the GPS system in Universal Coordinated Time. This value is assumed to be in the format *hhmmss.s*, where *hh* is hours, *mm* is minutes, and *ss.s* is seconds. This value is converted to decimal hours by applying the fit.
Notes	Valid data types for GPSHOURS are BF, BD, and AF. The resultant fitted value is a floating-point number.

Table 11: GPSHOURS fit type

GPSPOS	GPS global position.
Coefficients	No calibration lines are used with GPSPOS.
Application	The sensor value (*x*) for this field is interpreted as a floating-point number representing latitude or longitude coordinates. The format of the data source is *dmm.m* where *d* is any length number representing degrees and *mm.m* is decimal minutes (*mm* is two digits only). This value is converted into decimal degrees by applying the fit.
Notes	Valid data types for GPSPOS are BF, BD, and AF. The resultant fitted value is a floating-point number.

Table 12: GPSPOS fit type

GPSHEMI	GPS global position hemisphere.
Coefficients	No calibration lines are used with GPSHEMI.
Application	The sensor value (*x*) for this field is interpreted as a single character indicating the hemisphere of a GPS global position. A GPSHEMI fitted sensor is normally associated with a GPSPOS fitted sensor. Applying the fit converts the value to a signed number indicating the hemisphere.
Notes	The only valid data type for GPSHEMI is AS. The resultant fitted value is a floating-point number. See ***Table 14: GPSHEMI fitted values*** for more information on the resultant values of this fit type.

Table 13: GPSHEMI fit type

***Sensor* Value**	**Fitted Value**
N	1.0
E	1.0
S	-1.0
W	-1.0
other	0.0

Table 14: GPSHEMI fitted values

GPSMODE	GPS Positioning System Mode Indicator.
Coefficients	No calibration lines are used with GPSMODE.
Application	The sensor value (*x*) for this field is interpreted as a single character indicating the positioning mode of the GPS system. Applying the fit converts the value to a number representing the positioning mode.
Notes	The only valid data type for GPSMODE is AS. The resultant fitted value is a floating-point number. See ***Table 16: GPSMODE fitted values*** for more information on the resultant values of this fit type.

Table 15: GPSMODE fit type

Sensor **Value**	**Fitted Value**
A	1.0
D	2.0
E	3.0
M	4.0
S	5.0
N	6.0
other	0.0

Table 16: GPSMODE fitted values

GPSSTATUS	GPS system status.
Coefficients	No calibration lines are used with GPSSTATUS.
Application	The sensor value (*x*) for this field is interpreted as a single character indicating the validity of the current GPS frame. Applying the fit converts this value to a number indicating the TRUE (valid) or FALSE (invalid) nature of the frame data.
Notes	The only valid data type for GPSSTATUS is AS. The resultant fitted value is a floating-point number. See ***Table 18: GPSSTATUS fitted values*** for more information on the resultant values of this fit type.

Table 17: GPSSTATUS fit type

Sensor **Value**	**Fitted Value**
A	1.0
V	0.0
other	0.0

Table 18: GPSSTATUS fitted values

DDMM	GPS global position in degrees, minutes, and seconds.
Coefficients	No calibration lines are used with DDMM.
Application	The sensor value (*x*) for this field is interpreted as a floating-point number representing latitude or longitude coordinates. The format of the value must be *dmm.m*, where *d* is any length number representing degrees and *mm.m* is decimal minutes (*mm* is two digits only). This value is converted into degrees, minutes and seconds.
Notes	Valid data types for DDMM are BF, BD, and AF. The resultant fitted value is a string of text formatted as *d mm' ss"*.

Table 19: DDMM fit type

HHMMSS	Universal Coordinated Time of GPS data in hours, minutes, and seconds.
Coefficients	No calibration lines are used with HHMMSS.
Application	The sensor value (*x*) for this field is interpreted as a floating-point number representing hours, minutes, and seconds. The format of the value must be *hhmmss.s*, where *hh* is hours, *mm* is minutes, and *ss.s* is seconds.
Notes	Valid data types for HHMMSS are BF, BD, and AF. The resultant fitted value is a string of text formatted as *HH:MM:SS.ss*.

Table 20: HHMMSS fit type

DDMMYY	GPS date of global position.
Coefficients	No calibration lines are used with DDMMYY.
Application	The sensor value (*x*) for this field is interpreted as an integer number representing the day, month, and year. The format of the value must be *ddmmyy*, where *dd* is days, *mm* is months, and *yy* is the year.
Notes	Valid data types for DDMMYY are BU, BS, and AI. The resultant fitted value is a string of text formatted as *DD/MM/YY*.

Table 21: DDMMYY fit type

TIME2	Time tag for the frame.
Coefficients	No calibration lines are used with TIME2.
Application	The sensor value (*x*) for this field is interpreted as the number of seconds since the start of January 1st, 1970. This is a standard time format available from most C compilers and UNIX systems.
Notes	All data types are valid with TIME2, except AS. The resultant fitted value is a string of text formatted as *yy-mm-dd HH.MM.SS*.

Table 22: TIME2 fit type

COUNT	Raw or un-calibrated information.
Coefficients	No calibration lines are used with COUNT.
Application	$y = x$
Notes	All data types are valid with COUNT. This fit type is used to denote frame data that cannot be processed beyond its native data format. Therefore, applying a fit to a COUNT sensor has no effect.

Table 23: COUNT fit type

NONE	Unusable data.
Coefficients	No calibration lines are used with NONE.
Application	None.
Notes	All data types are valid with NONE. Used if frame data is to be ignored. Fit type processing cannot be applied to a NONE sensor.

Table 24: NONE fit type

DELIMITER	Field delimiter used in variable length frame formats.
Coefficients	No calibration coefficient lines are used with DELIMITER.
Application	This is a special case fit type used only for defining field delimiters in variable length frames. The UNITS field of the sensor definition line contains the delimiter characters to be expected in the frame. The field length must equate to the resultant length of the characters specified for the units.
Notes	The only valid data type for DELIMITER is AS. Delimiter characters can also be specified using their hexadecimal equivalents with a "\x" character string followed by a two character hexadecimal value. Hexadecimal equivalents can be mixed with normal character values. DELIMITER sensors do not contain useful data so can therefore not be processed into a fitted value. Sensors with this fit type can only be used in specific situations. See section ***3.2 Variable Length Frames*** for more information.

Table 25: DELIMITER fit type

The following is a typical example of how a sensor would be defined in an instrument file:

```
Lu 555.9 'uW/cm^2/nm/sr' 3 BU 2 OPTIC1
  8390442 1.3620e-006  1.74
  8391075 1.4031e-007  1.74
```

The sensor definition line defines an optical radiance sensor (Lu) for a waveband centered at 555.9 [nm]. The frame field is three bytes long, formatted as an unsigned binary integer. The field data can be fitted for OPTIC1 processing using two gain ranges. The fitted sensor value is in $uW/cm^2/nm/sr$. For more information on the interpretation of optical sensors, see section ***4.3 Optical Sensors***.

3.0 *Instrument Definition*

One of the most important functions of an instrument file is to define the frame synchronization or frame header string. Definition of a frame header string is mandatory for all Satlantic instrumentation. This string should uniquely identify an instrument so any data acquisition or processing system can correctly ascertain one frame from another in a stream of interlaced telemetry. A frame header must be the first series of bytes (characters) in the frame. In addition, the frame header section of an instrument file defines the frame type; fixed or variable length. The following sections describe how to define instruments for both types of frames.

3.1 Fixed Length Frames

Fixed length frames are the most commonly defined frame format for Satlantic instrumentation. Two special sensor definition lines are used to define the frame synchronization string. For a fixed length frame, these sensors are called **INSTRUMENT** and **SN**, for instrument name and serial number respectively. The following is an example of how a frame synchronization string might be defined for a fixed length frame format:

```
INSTRUMENT SATPRO ′′ 6 AS 0 NONE
SN 0004 ′′ 4 AI 0 COUNT
```

The **INSTRUMENT** sensor definition line must be defined at or near the beginning of the instrument file. No other sensor definition lines may precede the first **INSTRUMENT** sensor definition unless the sensor is defined with a field length of zero. The ID field identifies the frame header string that will appear at the beginning of the instrument frame. The FIELD-LENGTH field must indicate the size of the string. The only valid data type is AS. Valid fit types are COUNT or NONE and the UNITS field should be ignored.

If a **SN** sensor definition line immediately follows the **INSTRUMENT** sensor definition, a serial number should be appended to the frame header. The ID field identifies the serial number string that will immediately follow the frame header string defined by the **INSTRUMENT** sensor. The FIELD-LENGTH field must indicate the size of the string. The only valid data type is AI. Valid fit types are COUNT or NONE and the UNITS field should be ignored.

In the above example, an instrument is defined with the name *SATPRO* with serial number *0004*. This defines the frame header for the instrument as *SATPRO0004*. Variable length sensor definitions are not allowed in fixed length frames. Additional **INSTRUMENT** or **SN** sensor definitions are also not allowed beyond the definition of the frame synchronization string. If additional frame header sensor definition lines are encountered, the instrument file should be considered invalid.

3.2 Variable Length Frames

Variable length frames are commonly defined for non-Satlantic instrumentation, such as NMEA 0183 formatted sentences. As with fixed length frames, two special sensor definition lines are used to define the frame synchronization string. For a variable length frame, these sensor definitions are called **VLF_INSTRUMENT** and **VLF_SN**, for instrument name and serial number respectively. The following is an example of how a frame synchronization string might be defined for a variable length frame format:

```
VLF_INSTRUMENT $GPRMC '' 6 AS 0 NONE
```

The same rules apply for defining the frame header of a variable length frame as those for a fixed length frame. The difference is that the VLF modifier as added to the beginning of the sensor definition lines.

In the above example, an instrument is defined with the name *$GPRMC*. Because no **VLF_SN** sensor definition has been defined, this also defines the frame header for the instrument. Additional **VLF_INSTRUMENT** or **VLF_SN** sensor definitions are not allowed beyond the definition of the frame synchronization string. If additional frame header sensor definition lines are encountered, the instrument file should be considered invalid.

Once a variable length frame has been defined, sensor definitions for the rest of the frame are specified in much the same manner as a fixed length frame. However, fixed length sensor definitions are not allowed in variable length frames, unless the field length is zero. Variable length frames use delimiters, rather than byte offsets, to determine sensor positions in a frame. Because the field length of these sensor values is variable, a "V" is used for the FIELD-LENGTH parameter of the sensor definition line. Because variable length frames are ASCII only, valid data types for variable length sensors are AI, AF, or AS. There are no restrictions on fit types, other than those imposed by the data type. In addition, for every variable length sensor defined in the instrument file, a **FIELD** delimiter sensor must immediately precede it to define the delimiter used to retrieve the sensor value in a frame. The following example illustrates how a variable length sensor is defined:

```
FIELD NONE ',' 1 AS 0 DELIMITER
LAT GPS 'deg' V AF 0 GPSPOS
```

The above example shows a variable length LAT sensor definition, normally seen in NMEA 0183 telemetry. Sensor definitions with a field length of zero may be placed at any point in the instrument file, except immediately following a **FIELD** delimiter sensor. The last sensor defined in the file must be a **TERMINATOR** delimiter sensor. This sensor defines the characters used to indicate the end of the variable length frame. See section ***3.3 Delimiter Sensors*** for more information on **FIELD** and **TERMINATOR** delimiter sensors.

Unlike fixed length frames, it is perfectly acceptable for an instrument to drop sensor values from a variable length frame, as long as all the frame delimiter values are present. This is sometimes necessary when a frame is generated but not all sensor values are available for transmission.

3.3 Delimiter Sensors

When defining variable length sensors for a variable length frame, delimiter sensors are needed to define where certain parts of a frame are located. Delimiter sensors are not recognized as normal sensors. They should therefore be ignored beyond the scope defined below. There are only two types of delimiters and each has a specific purpose. Only the following sensor definitions are permitted to use the DELIMITER fit type.

3.3.1 FIELD Delimiter

Variable length frames must use field delimiters to locate a sensor value in a frame. The **FIELD** delimiter sensor is necessary to define this delimiter. For every sensor defined in a variable length frame, a **FIELD** sensor definition line must *immediately* precede the actual sensor definition, as shown below:

```
FIELD NONE ',' 1 AS 0 DELIMITER
```

The keyword **FIELD** must be used for the TYPE field of the sensor definition line. The ID field must be NONE. This type of sensor definition must have a DELIMITER fit type in order to qualify as a proper **FIELD** delimiter sensor. See ***Table 25: DELIMITER fit type*** for more information.

3.3.2 TERMINATOR Delimiter

A data acquisition or processing system reading a variable length frame does not know in advance how many bytes to read to obtain a full frame. Instead, a terminator string must be defined that signals the end of a frame. The **TERMINATOR** delimiter sensor is necessary to define this string. There must be only one **TERMINATOR** delimiter sensor located at the end of the instrument file, as shown below:

```
TERMINATOR NONE '\x0D\x0A' 2 AS 0 DELIMITER
```

The keyword **TERMINATOR** must be used for the TYPE field of the sensor definition line. The ID field must be NONE. This type of sensor definition must have a DELIMITER fit type in order to qualify as a proper **TERMINATOR** delimiter sensor. See ***Table 25: DELIMITER fit type*** for more information.

4.0 *Special Sensor Definitions*

Once the frame header, and consequently the frame type, is defined in the instrument file in accordance with section ***3.0 Instrument Definition***, the rest of the sensor definitions to follow are considered normal sensors. This of course excludes sensors defined in section ***3.3 Delimiter Sensors***. These sensors make up the body of a frame. However, many of these sensor definitions have defined structures and special meanings. Some of these sensors are used to further define the context of how information from an instrument should be interpreted. This section defines the special sensors of the Satlantic data format standard.

4.1 Pseudo Sensors

Any sensor defined with a NONE fit type is generally unusable and should be ignored. If a NONE fit type sensor definition has a field length, the section of the frame denoted by the sensor should be considered unusable data. However, if the ID field of the sensor definition line is not NONE, the sensor definition line itself may contain useful information. These types of sensors are called pseudo sensors. The sensors defined in this section are recognized pseudo sensors that data acquisition or processing systems can use for application specific purposes.

Pseudo sensors with a field length of zero can be placed at any point in the instrument file, including before the frame header definition. Although this type of pseudo sensor does no need a field delimiter, sensor definition placement is restricted in variable length frame formats as described in section ***3.3 Delimiter Sensors***.

4.1.1 RATE

Instrument files can be used to define the rate at which frames from the instrument will be broadcast. This information can be used to calculate the time at which a frame was sent from the instrument relative to another frame. An example of a **RATE** sensor is as follows:

```
RATE 6 ’Hz’ 0 BU 0 NONE
```

The keyword **RATE** must be used for the TYPE field of the sensor definition line. The ID field represents the defined frame rate for the instrument. This field should be interpreted as a floating-point number. The only acceptable UNITS field for a **RATE** sensor is 'Hz'. The field length must be zero and the fit type must be NONE. The data type is ignored. Only the first instance of a **RATE** sensor definition should be interpreted to mean the frame rate. Subsequent **RATE** sensor definitions should be processed as normal sensors. A data acquisition system would interpret the above sensor definition line to indicate that the instrument transmits frames at 6.0 Hz.

4.1.2 DATARATE

Instruments transmit their telemetry through an asynchronous serial interface. The baud rate of this transmission can be defined by the **DATARATE** sensor, as shown below:

```
DATARATE 19200 ’bps’ 0 BU 0 NONE
```

The keyword **DATARATE** must be used for the TYPE field of the sensor definition line. The ID field represents the defined baud rate for the instrument. The only acceptable UNITS field for a **DATARATE** sensor is 'bps'. The field length must be zero and the fit type must be NONE. The data type is ignored. Only the first instance of a **DATARATE** sensor definition should be interpreted to mean the transmission baud rate. Subsequent **DATARATE** sensor definitions should be processed as normal sensors. A data acquisition system would interpret the above sensor definition line to indicate that the instrument transmits frames at a baud rate of 19200 bps.

4.1.3 SENSOR

In some cases, instrument files define macro frames, which are essentially frame definitions from several instruments grouped together in one file. However, additional instances of the frame synchronization sensors are not allowed in the middle of an instrument file. To accommodate this rule, the **INSTRUMENT** sensor definitions of the embedded frames must be renamed **SENSOR**. This gives data acquisition or processing systems a way of ignoring imbedded frame synchronization strings and read all the defined instrument frames as one. This type of sensor definition is only available for fixed length frames. See section ***3.0 Instrument Definition*** for more information. The following example illustrates the use of **SENSOR**:

```
SENSOR SATHSL ’’ 6 AS 0 NONE
```

The keyword **SENSOR** must be used for the TYPE field of the sensor definition line. The ID field identifies the frame header string of the embedded instrument. The FIELD-LENGTH field must indicate the size of the string. The fit type must be NONE. The UNITS and DATA-TYPE fields are ignored. The sensor definition line can be placed at any position after the frame header definition in the instrument file. The number of **SENSOR** sensor definitions that can be placed in an instrument file is not limited.

4.1.4 SENSORSN

The **SENSORSN** sensor serves the same purpose as the **SENSOR** sensor described above, except this sensor applies to **SN** sensor definitions. See section ***3.0 Instrument Definition*** for more information. The following example illustrates the use of **SENSORSN**:

```
SENSORSN 0018 ’’ 4 AI 0 NONE
```

The keyword **SENSORSN** must be used for the TYPE field of the sensor definition line. The ID field identifies the serial number string for the embedded instrument. The FIELD-LENGTH field must indicate the size of the string. The fit type must be NONE. The UNITS and DATA-TYPE fields are ignored. The sensor definition line can be placed at any position after the frame header definition in the instrument file. The number of **SENSORSN** sensor definitions that can be found in an instrument file is not limited.

4.1.5 CALTEMP

The **CALTEMP** sensor serves to provide the calibration temperature for an instrument’s optical sensors. This can be required to apply a correction calculation on the optical sensor data. The following example illustrates the use of **CALTEMP**

```
CALTEMP 22.268254 ’C’ 0 BU 0 NONE
```

The keyword **CALTEMP** must be used for the TYPE field of the sensor definition line. The ID field specifies the calibration temperature value. The only acceptable UNITS field for a **CALTEMP** sensor is 'C’. The FIELD-LENGTH field must be 0. The DATA-TYPE field is ignored and the fit type must be NONE.

4.1.6 THERMAL_RESP

The **THERMAL_RESP** sensor serves to provide the polynomial coefficients and a temperature reference value to apply thermal responsivity correction to an instrument’s optical sensor data. The following example illustrates the use of **THERMAL_RESP**

```
THERMAL_RESP NONE '' 0 BU 1 THERM1
```

The keyword **THERMAL_RESP** must be used for the TYPE field of the sensor definition line. The ID field must be NONE. The FIELD-LENGTH field must be 0. The fit type must be THERM1. The UNITS and DATA-TYPE fields are ignored. This sensor must be used with the **CALTEMP** sensor.

4.2 Data Integrity Sensors

Data integrity or error checking sensors can be used by data acquisition or processing systems to assert the validity of a frame of telemetry. The sensor values obtained from a data integrity sensor do not contain useful sensor information; they are used only for error checking.

4.2.1 FRAME COUNTER

The value of a **FRAME COUNTER** sensor is simply a numerical counter that can help ensure all frames received by the data acquisition system are sequential. A **FRAME COUNTER** sensor will increment the counter sensor value for each frame transmitted. This counter value should remain sequential until a maximum value imposed by the field length is reached, at which point the counter will roll over to zero. An example of a **FRAME COUNTER** sensor definition is as follows:

```
FRAME COUNTER ′′ 1 BU 0 COUNT
```

The keyword **FRAME** must be used for the TYPE field of the sensor definition line. The ID field must be **COUNTER**. The UNITS field is ignored and the only valid fit type is COUNT. Valid data types are BU and AI. If the data type is AI, the maximum sensor value is 255, regardless of the field length. The field length must range between 1 and 4 for a BU data type. The following table outlines the maximum counter values for a BU formatted sensor based on field length:

FIELD-LENGTH	MAXIMUM SENSOR VALUE
1	255
2	65535
3	16777215
4	4294967295

Table 26: FRAME COUNTER maximum values

The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **FRAME COUNTER** sensor definition should be used for frame data validation. Subsequent **FRAME COUNTER** sensor definitions should be treated as normal sensors.

4.2.2 CHECK SUM

The value of a **CHECK SUM** sensor is the last byte of the sum of all bytes, up to but not including the **CHECK SUM** sensor, in a frame of telemetry subtracted from 0. Only the least significant byte of the sum is relevant. A valid check sum helps ensure that all bytes in a frame of telemetry received by the data acquisition system have been received correctly. An example of a **CHECK SUM** sensor is as follows:

```
CHECK SUM ′′ 1 BU 0 COUNT
```

The keyword **CHECK** must be used for the TYPE field of the sensor definition line. The ID field must be **SUM**. The UNITS field is ignored and the only valid fit type is COUNT. Valid data types are BU and AI. The field length must be 1 for a BU data type. The sensor definition line can be placed at any position after the frame header definition in the instrument file. However, it should be noted that this sensor is only useful for sensors up to the **CHECK SUM** sensor definition line. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **CHECK SUM** sensor definition should be used for frame data validation. Subsequent **CHECK SUM** sensor definitions should be treated as normal sensors.

4.3 Optical Sensors

Optical sensor definitions in an instrument file describe optical measurements like radiance and irradiance. These sensors are defined by any sensor definition line with an OPTICX fit type. Although the fit type is the defining criteria, certain sensor types have special meanings in the Satlantic data format standard. The following table describes how the TYPE field of the sensor definition line is interpreted for optical sensors:

TYPE	DESCRIPTION
Lu	Upwelling Radiance
Ls	Surface Upwelling Radiance
Ld	Surface Downwelling Radiance
Lt	Above Water Total Radiance
Li	Sky Radiance
Eu	Upwelling Irradiance
Es	Surface Downwelling Irradiance
Ed	Downwelling Irradiance
Ev	Surface Upwelling Irradiance
Ef	Surface Downwelling Diffuse Irradiance

Table 27: Recognized optical sensors

Any value for the TYPE field can be used in the sensor definition line for an optical sensor, but only those listed above have specific meaning. The ID field always indicates the center wavelength of the optical channel in nanometers [nm]. These ID fields should be written as floating-point numbers. Standard units for an optical sensor is 'uW/cm^2/nm' for irradiance and 'uW/cm^2/nm/sr' for radiance.

Optical sensor definitions are seldom found alone in an instrument file. Normally, optical sensors that make the same type of measurement are physically grouped together. The only difference in the sensors is their center wavelength. Similar optical sensors should be grouped together in an instrument file according to the TYPE, UNITS and FIT-TYPE fields of their sensor definition lines. A new optical grouping must be formulated once a sensor definition is found that does not follow the previously set pattern. This gives any data acquisition or processing system the ability to view and process optical data as a group. This is necessary for generating processed data in formats like a spectral graph.

4.3.1 INTTIME

An **INTTIME** sensor is used in conjunction with optical sensors defined with an OPTIC3 fit type. OPTIC3 sensors have linearly adaptive gains that can change during the normal operation of the instrument. This change usually occurs as a result of fluctuating light levels. An **INTTIME** sensor defines the adaptive or adjusted integration time for all subsequent optical sensors for which the sensor was defined. **INTTIME** sensors are actually special case ancillary sensors. See section ***4.4 Ancillary Sensors*** below for more information. The following is an example of an **INTTIME** sensor:

```
INTTIME LU ’sec’ 2 BU 1 POLYU
4.9025e-3   16.0e-6
```

The keyword **INTTIME** must be used for the TYPE field of the sensor definition line. The ID field indicates the type of optical sensor for which the sensor is used. In the above example, any subsequent LU sensors with an OPTIC3 fit type will use this sensor for its adaptive integration time. The UNITS field must be 'sec' to coincide with the units used in the OPTIC3 fit type. The resultant fitted value for the sensor must be a floating-point number. However, it should be noted that this is not an optical sensor, so the OPTICX fit types cannot be used.

The placement of the sensor definition line in the instrument file is important. It must be after the frame header definition but before any optical sensors that are to use its adaptive integration time. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance a particular **INTTIME** sensor should be recognized as a special case ancillary sensor. Subsequent **INTTIME** sensor definitions should be processed as normal sensors.

4.3.2 Dark Sensors

Some instruments have optical sensors that are shielded from light exposure. These dark sensors are used for establishing a noise floor for a related optical sensor grouping. Dark sensors are actually special case ancillary sensors that can be used to directly influence the value of other optical measurements. See section ***4.4 Ancillary Sensors*** below for more information.

All dark sensors must use the COUNT fit type. All data types are valid except AS. The field length is dependent on the type of dark measurement and the type of associated optical measurements. The UNITS field of the sensor definition line is ignored. The sensor definition lines can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance each sensor definition should be recognized as a special case ancillary sensor. Subsequent dark sensor definitions should be processed as normal sensors.

The most common form of dark sensor is defined with the same TYPE field as its related optical sensors. However, the ID field of the sensor definition line must be **DARK** as shown below:

```
LU DARK '' 3 BU 0 COUNT
```

The above example defines a dark sensor for an upwelling radiance optical sensor grouping. This sensor actually defines an optical measurement, but the sensor is shielded from light. The data type and field length must be the same as its related optical sensor grouping. The value of this sensor is raw A/D digital counts.

In some cases, dark sensors are found in groups; their sensor values averages together. Two different sensor definitions are needed to accommodate this situation. The first is a **DARK_SAMP** sensor used to indicate the number of dark sensors used to calculate a dark average. The ID field of the sensor definition line represents its related optical sensor grouping, as shown below:

```
DARK_SAMP LU '' 1 BU 0 COUNT
```

The above example defines a dark sensor count for an upwelling radiance optical sensor grouping. A **DARK_AVE** sensor defines the actual average value, as shown below:

```
DARK_AVE LU '' 2 BU 0 COUNT
```

The above example defines a dark sensor average for an upwelling radiance optical sensor grouping. Each dark sensor used in the average is shielded from light. The data type and field length must be the same as its related optical sensor grouping. The value of this sensor is raw A/D digital counts.

4.4 Ancillary Sensors

Ancillary sensors are any useful sensors on an instrument of non-optical measurements. Specifically, ancillary sensors are all the normal sensors defined in an instrument file with a fit type other than NONE. Most importantly, these sensors do not fall under any of the other subsections of section ***4.0 Special Sensor Definitions***, except possibly any defined superfluous instances found in the instrument file. Ancillary information is important in complimenting optical data. This gives optical measurements a more specific context and is therefore more useful.

There are no restrictions on the naming of an ancillary sensor. Ancillary sensor names are normally based on the sensor's type of measurement and purpose. However, as with optical sensors, certain sensor types have special meanings in the Satlantic data format standard. These special case ancillary sensors may be recognized by data acquisition or processing systems for higher level calculations. The table below gives a brief summary of these special ancillary sensors and their meanings:

TYPE	DESCRIPTION	UNITS
PRES	Pressure sensor (distance from surface)	m
ALTIM	Altimeter sensor (distance from bottom)	m
T	Temperature sensor	C
TILT	Tilt sensor	deg
PITCH	Tilt sensor along horizontal axis	deg
ROLL	Tilt sensor about horizontal axis	deg
COMP	Compass heading sensor	deg
COND	Seawater conductivity sensor	mmho/cm
FLUOR	Fluorometer sensor	ug/l
TRANS	Transmissometer sensor	/m
PAR	Photosynthetically Active Radiation sensor	uE/m^2
STRAIN	Strain gauge sensor	Newtons
BETA_RED	Red wavelength water backscatter sensor	1/(m*sr)
BETA_BLUE	Blue wavelength water backscatter sensor	1/(m*sr)
CDOM	Coloured dissolved organic matter sensor	ppb/l
NTR_CONC	Nitrate concentration sensor	uMolar
SAL	Salinity sensor	psu
SNDVEL	Sound velocity sensor	m/sec
TIMER	Number of seconds since power up	Sec

Table 28: Recognized ancillary sensors

The following sections describe the application of these sensors in further detail.

4.4.1 PRES

A **PRES** sensor is used to define a pressure sensor measurement. Pressure measurements are normally used with submersible instruments to gauge their depth. Calculation of depth, velocity, and salinity are dependent on a pressure measurement. An example of a **PRES** sensor is as follows:

```
PRES NONE 'm' 2 BU 1 POLYF
0.01546     33810
```

The keyword **PRES** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'm' for meters of water. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **PRES** sensor definition should be recognized as a valid pressure sensor. Subsequent **PRES** sensor definitions should be processed as normal ancillary sensors.

4.4.2 ALTIM

An **ALTIM** sensor is used to define an altimeter sensor measurement. An altimeter measurement is normally used to gauge the distance from a submersible instrument to the ocean floor. Sensor values from an **ALTIM** sensor can be used for calculation involving distance. An example of an **ALTIM** sensor is as follows:

```
ALTIM NONE 'm' 2 BU 1 POLYU
0 2.441e-2
```

The keyword **ALTIM** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'm' for meters of water. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of an **ALTIM** sensor definition should be recognized as a valid altimeter sensor. Subsequent **ALTIM** sensor definitions should be processed as normal ancillary sensors.

4.4.3 T

A **T** sensor is used to define a temperature sensor measurement. Temperature sensors can be placed anywhere on an instrument. Temperature measurements can be used for a variety of purposes, such as salinity calculations. An example of a **T** sensor is as follows:

```
T i 'C' 2 BU 1 POLYU
-5.2732262199e+00 9.5420070268e-04 -8.8203200746e-09
```

The keyword **T** must be used for the TYPE field of the sensor definition line. The UNITS field must be 'C' for degrees Celsius. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

The ID field of a **T** sensor definition line indicates the type of temperature measurement the sensor represents. The only valid ID values allowed in a **T** sensor definition are shown in the following table:

ID	DESCRIPTION
W	External water temperature
AIR	External air temperature
INT	Internal temperature
I	Internal irradiance sensor array temperature
R	Internal radiance sensor array temperature
IR	Remote infrared temperature

Table 29: Recognized temperature sensors

If more than one **T** sensor definition is defined with the same ID field, only the first instance should be considered valid for that particular temperature sensor. Subsequent **T** sensor definitions should be processed as normal ancillary sensors.

4.4.4 TILT

TILT sensors are used to define a tilt or attitude measurement for an instrument. A tilt measurement is normally used to determine the alignment of an instrument with the vertical, ensuring that any optical sensors are pointed in the right direction. An example of a **TILT** sensor is as follows:

```
TILT X 'deg' 2 BU 1 POLYU
82.1289 -0.0024793 -400e-12
```

The keyword **TILT** must be used for the TYPE field of the sensor definition line. The UNITS field must be 'deg' for degrees. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

The ID field of a **TILT** sensor definition line indicates the axis about which the tilt sensor measures. There are only three valid ID values allowed in a **TILT** sensor definition, as shown in the following table:

ID	DESCRIPTION
X	Tilt on X axis
Y	Tilt on Y axis
Z	Tilt on Z axis

Table 30: Recognized tilt sensors

If more than one **TILT** sensor definition is defined with the same ID field, only the first instance should be considered valid for that particular tilt sensor. Subsequent **TILT** sensor definitions should be processed as normal ancillary sensors.

4.4.5 PITCH

A **PITCH** sensor is used to define a tilt sensor along the horizontal axis. A pitch sensor can be used to determine an instruments orientation relative to the horizon. An example of a **PITCH** sensor is as follows:

```
PITCH NONE 'deg' 2 BU 1 POLYU
8.5254394e+001    -2.6100146e-003    3.0470563e-010
```

The keyword **PITCH** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'deg' for degrees. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **PITCH** sensor definition should be recognized as a valid pitch sensor. Subsequent **PITCH** sensor definitions should be processed as normal ancillary sensors.

4.4.6 ROLL

A **ROLL** sensor is used to define a tilt sensor about the horizontal axis. A roll sensor can be used to determine an instruments orientation relative to the horizon. An example of a **ROLL** sensor is as follows:

```
ROLL NONE 'deg' 2 BU 1 POLYU
8.4961359e+001    -2.5893730e-003    -7.6925994e-011
```

The keyword **ROLL** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'deg' for degrees. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **ROLL** sensor definition should be recognized as a valid roll sensor. Subsequent **ROLL** sensor definitions should be processed as normal ancillary sensors.

4.4.7 COMP

A **COMP** sensor is used to define a compass heading sensor measurement. These sensors measure magnetic flux to establish a compass direction. This measurement would nominally be between 0-360 degrees. An example of a **COMP** sensor is as follows:

```
COMP NONE 'deg' 2 BU 1 POLYF
0.03052 33423
```

The keyword **COMP** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'deg' for degrees. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **COMP** sensor definition should be recognized as a valid compass heading sensor. Subsequent **COMP** sensor definitions should be processed as normal ancillary sensors.

4.4.8 COND

A **COND** sensor is used to define a seawater conductivity sensor measurement. A conductivity measurement is necessary for calculation of salinity. An example of a **COND** sensor is as follows:

```
COND NONE 'mmho/cm' 2 BU 1 POLYU
1.584  8.130e-4  1.735e-9
```

The keyword **COND** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'mmho/cm'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **COND** sensor definition should be recognized as a valid conductivity sensor. Subsequent **COND** sensor definitions should be processed as normal ancillary sensors.

4.4.9 FLUOR

A **FLUOR** sensor is used to define a fluorometer sensor measurement. An example of a **FLUOR** sensor is as follows:

```
FLUOR NONE 'ug/l' 2 BU 1 POLYF
3.030e-3 33456
```

The keyword **FLUOR** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'ug/l'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **FLUOR** sensor definition should be recognized as a valid fluorometer sensor. Subsequent **FLUOR** sensor definitions should be processed as normal ancillary sensors.

4.4.10 TRANS

A **TRANS** sensor is used to define a transmissometer sensor measurement. A transmissometer measurement indicates the attenuation of a light beam in a given media. An example of a **TRANS** sensor is as follows:

```
TRANS NONE '/m' 2 BU 1 POLYF
2.460e-3 20445
```

The keyword **TRANS** must be used for the TYPE field of the sensor definition line. Because it may be useful to have multiple transmissometers on an instrument, the ID field can have any unique identifier to separate one transmissometer from another in an instrument file. Typically, if only one transmissometer is used, the ID field should is **NONE**. If multiple devices are used, the ID fields are a positive integer sequence beginning with 1. The UNITS field must be '/m' for light beam attenuation coefficient per meter. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

4.4.11 PAR

A **PAR** sensor is used to define a sensor for measuring Photosynthetically Active Radiation. PAR measurements indicate the total light energy available for photosynthesis per unit area. An example of a **PAR** sensor is as follows:

```
PAR NONE 'uE/m^2' 2 BU 1 POLYF
1.295e-3 33456
```

The keyword **PAR** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'uE/m^2'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **PAR** sensor definition should be recognized as a valid PAR sensor. Subsequent **PAR** sensor definitions should be processed as normal ancillary sensors.

4.4.12 STRAIN

A **STRAIN** sensor is used to define a sensor for measuring strain. A STRAIN measurement indicates the force of the strain. An example of a **STRAIN** sensor is as follows:

```
STRAIN NONE 'Newtons' 4 BU 1 POLYF
1.4581348e-4      2233191228
```

The keyword **STRAIN** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'Newtons'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **STRAIN** sensor definition should be recognized as a valid STRAIN sensor. Subsequent **STRAIN** sensor definitions should be processed as normal ancillary sensors.

4.4.13 BETA_RED

A **BETA_RED** sensor is used to define a red backscatter sensor measurement. A red backscatter measurement indicates the backscatter of water for a specified ‘red’ wavelength. An example of a **BETA_RED** sensor is as follows:

```
BETA_RED 700 '1/(m*sr)' V AI 1 POLYF
3.241E-06 153.767
```

The keyword **BETA_RED** must be used for the TYPE field of the sensor definition line. The UNITS field must be '1/(m*sr)'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

The ID field of a **BETA_RED** sensor definition line indicates the specific ‘red’ wavelength used to measure the water backscatter.

4.4.14 BETA_BLUE

A **BETA_BLUE** sensor is used to define a blue backscatter sensor measurement. A blue backscatter measurement indicates the backscatter of water for a specified ‘blue’ wavelength. An example of a **BETA_BLUE** sensor is as follows:

```
BETA_BLUE 470 '1/(m*sr)' V AI 1 POLYF
2.675E-05 67.8
```

The keyword **BETA_BLUE** must be used for the TYPE field of the sensor definition line. The UNITS field must be '1/(m*sr)'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

The ID field of a **BETA_BLUE** sensor definition line indicates the specific ‘blue’ wavelength used to measure the water backscatter.

4.4.15 CDOM

A **CDOM** sensor is used to define a coloured dissolved organic matter sensor measurement. A CDOM measurement indicates the amount of coloured dissolved organic matter in water. An example of a **CDOM** sensor is as follows:

```
CDOM QSDE 'ppb/l' V AI 1 POLYF
0.0298 320
```

The keyword **CDOM** must be used for the TYPE field of the sensor definition line. The UNITS field must be 'ppb/l'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

The ID field of a **CDOM** sensor definition line indicates the type of the CDOM measurement. An example of **CDOM** measurement type is: QSDE (Quinine Dihydrate Equivalent).

4.4.16 NTR_CONC

A **NTR_CONC** sensor is used to define a nitrate concentration sensor measurement. A nitrate measurement indicates the concentration of nitrate in water. An example of a **NTR_CONC** sensor is as follows:

```
NTR_CONC NONE 'uMolar' V AF 0 COUNT
```

The keyword **NTR_CONC** must be used for the TYPE field of the sensor definition line. The UNITS field must be 'uMolar'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

4.4.17 SAL

A **SAL** sensor is used to define a salinity sensor measurement. A salinity measurement indicates the concentration of salt in water. An example of a **SAL** sensor is as follows:

```
SAL NONE 'psu' V AF 0 COUNT
```

The keyword **SAL** must be used for the TYPE field of the sensor definition line. The UNITS field must be 'psu'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

4.4.18 SNDVEL

A **SNDVEL** sensor is used to define a sound velocity sensor measurement. A sound velocity measurement indicates the velocity of sound in water. An example of a **SNDVEL** sensor is as follows:

```
SNDVEL NONE 'm/s' V AF 0 COUNT
```

The keyword **SNDVEL** must be used for the TYPE field of the sensor definition line. The UNITS field must be 'm/s'. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement.

4.4.19 TIMER

A **TIMER** sensor is used to define a timer sensor for indicating the number of seconds that have elapsed since the instrument was powered up. A **TIMER** sensor value can be at any precision to accommodate the required resolution. An example of a **TIMER** sensor is as follows:

```
TIMER NONE 'sec' 10 AF 1 POLYU
0.0   1.0
```

The keyword **TIMER** must be used for the TYPE field of the sensor definition line. The ID field must be **NONE**. The UNITS field must be 'sec' for seconds. The resultant fitted value for the sensor must be a floating-point number. The sensor definition line can be placed at any position after the frame header definition in the instrument file. If the defined frame type is variable length, see section ***3.3 Delimiter Sensors*** for further restrictions on sensor definition placement. Only the first instance of a **TIMER** sensor definition should be recognized as a valid timer sensor. Subsequent **TIMER** sensor definitions should be processed as normal ancillary sensors.

4.5 GPS Sensors

Satlantic instrument telemetry and global positioning information is used together in many situations where accurate knowledge of an instruments position is critical. Satlantic instrument telemetry is often interlaced with GPS data for this purpose. The format of these data must be of the NMEA 0183 Standard For Interfacing Marine Electronic Devices. The data sentences defined by this standard are easily adopted into the Satlantic data format standard for variable length frames. Any of these sentences can be interpreted by Satlantic data acquisition or processing systems if they have an associated telemetry definition file.

There are no restrictions on the naming of sensors in a GPS telemetry definition file. Sensor names are normally based on the field represented in the NMEA 0183 standard mentioned above. Although they are referred to as sensors, they do not actually represent physical sensors, but fields in a GPS data stream. As with ancillary sensors, certain fields have special meaning in the Satlantic data format standard. GPS sensors are defined as special case ancillary sensors used in GPS telemetry definition files. These sensors may be recognized by data acquisition or processing systems for higher level calculations. See section ***4.4 Ancillary Sensors*** for more information these types of sensors.

To follow the NMEA 0183 standard, there must be only one of each GPS sensor defined in a telemetry definition file. Subsequent similar GPS sensors should be processed as normal ancillary sensors. The sensor definition line of any sensors in a GPS telemetry definition file must be placed after the frame header definition and follow the order specified in the NMEA 0183 standard. Because GPS telemetry is variable length, see section ***3.2 Variable Length Frames*** for more information on variable length frames and sensor definition placement.

This section defines the GPS sensors of the Satlantic data format standard. Because each sensor follows the NMEA 0183 standard mentioned above, the field delimiters are specified along with the actual sensor definitions. See section ***3.3 Delimiter Sensors*** for more information on field delimiters.

The table below gives a brief summary of the GPS sensors of the Satlantic data format standard and their meanings:

TYPE and ID	DESCRIPTION	UNITS
TIME UTC	Current Universal Coordinated Time	
LAT GPS	GPS Latitude	deg
LAT HEMI	Hemisphere of GPS Latitude	
LON GPS	GPS Longitude	deg
LON HEMI	Hemisphere of GPS Longitude	
SPEED GROUND	Speed over ground	knots *or* km/h
HEADING TRUE	Course over ground in degrees True	deg
HEADING MAG	Course over ground in degrees Magnetic	deg
MAG VAR	Magnetic variation	deg
MAG HEMI	Hemisphere of Magnetic variation	
DAY GPS	Current day of the month	
MONTH GPS	Current month of the year	
YEAR GPS	Current year	
LOCALZONE HOURS	Local time zone hours to UTC	
LOCALZONE MINUTES	Local time zone minutes to UTC	
ALTITUDE MSL	Altitude above mean sea level (geoid)	m
QUALITY GPS	Quality or state of current GPS frame	
MODE GPS	Positioning System Mode Indicator	
DATA VALID	Validity status of current GPS frame	

Table 31: Recognized GPS sensors

The following sections describe the application of these sensors in further detail.

4.5.1 TIME UTC

A **TIME UTC** sensor is used to define a GPS field indicating the Universal Coordinated Time of the current GPS frame. An example of a **TIME UTC** sensor is as follows:

```
# UTC of position
FIELD NONE ',' 1 AS 0 DELIMITER
TIME UTC 'hours' V AF 0 GPSHOURS
```

The keyword **TIME** must be used for the TYPE field and **UTC** for the ID field of the sensor definition line. There are two options for the fit type, depending on the how the data is to be used. For a fitted value that is a floating-point number, the fit type must be GPSHOURS. The UNITS field must be 'hours' for this fit type. If a readable character string output is desired, the DDMMSS fit type must be used. There must be no units specified for this fit type. Because this is a variable length field, the only valid data type is AF.

4.5.2 LAT GPS

A **LAT GPS** sensor is used to define a GPS field indicating latitude coordinates. An example of a **LAT GPS** sensor is as follows:

```
# GPS Latitude
FIELD NONE ',' 1 AS 0 DELIMITER
LAT GPS 'deg' V AF 0 GPSPOS
```

The keyword **LAT** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. There are two options for the fit type, depending on the how the data is to be used. For a fitted value that is a floating-point number, the fit type must be GPSPOS. The UNITS field for this fit type must be 'deg' for degrees. If a readable character string output is desired, the DDMM fit type must be used. There must be no units specified for this fit type. Because this is a variable length field, the only valid data type is AF.

4.5.3 LAT HEMI

A **LAT HEMI** sensor is used to define a GPS field indicating the hemisphere of the associated latitude coordinates. An example of a **LAT HEMI** sensor is as follows:

```
# Hemisphere indicator of GPS Latitude
FIELD NONE ',' 1 AS 0 DELIMITER
LAT HEMI '' V AS 0 GPSHEMI
```

The keyword **LAT** must be used for the TYPE field and **HEMI** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is GPSHEMI. Because this is a variable length field, the only valid data type is AS. There must be no units specified. Multiplying the resultant fitted values of a **LAT GPS** sensor with its associated **LAT HEMI** sensor gives signed decimal degrees, indicating magnitude and direction.

For quick reference, the unfitted sensor value can be interpreted from the table below:

SENSOR VALUE	DESCRIPTION
N	North
S	South

Table 32: Latitude hemisphere indicators

4.5.4 LON GPS

A **LON GPS** sensor is used to define a GPS field indicating longitude coordinates. An example of a **LON GPS** sensor is as follows:

```
# GPS Longitude
FIELD NONE ',' 1 AS 0 DELIMITER
LON GPS 'deg' V AF 0 GPSPOS
```

The keyword **LON** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. There are two options for the fit type, depending on the how the data is to be used. For a fitted value that is a floating-point number, the fit type must be GPSPOS. The UNITS field for this fit type must be 'deg' for degrees. If a readable character string output is desired, the

DDMM fit type must be used. There must be no units for this fit type. Because this is a variable length field, the only valid data type is AF.

4.5.5 LON HEMI

A **LON HEMI** sensor is used to define a GPS field indicating the hemisphere of the associated longitude coordinates. An example of a **LON HEMI** sensor is as follows:

```
# Hemisphere indicator of GPS Longitude
FIELD NONE ',' 1 AS 0 DELIMITER
LON HEMI '' V AS 0 GPSHEMI
```

The keyword **LON** must be used for the TYPE field and **HEMI** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is GPSHEMI. Because this is a variable length field, the only valid data type is AS. There must be no units specified. Multiplying the resultant fitted values of a **LON GPS** sensor with its associated **LON HEMI** sensor gives signed decimal degrees, indicating magnitude and direction.

For quick reference, the unfitted sensor value can be interpreted from the table below:

SENSOR VALUE	DESCRIPTION
E	East
W	West

Table 33: Longitude hemisphere indicators

4.5.6 SPEED GROUND

A **SPEED GROUND** sensor is used to define a GPS field indicating ground speed. An example of a **SPEED GROUND** sensor is as follows:

```
# Speed over ground
FIELD NONE ',' 1 AS 0 DELIMITER
SPEED GROUND 'knots' V AF 0 COUNT
```

The keyword **SPEED** must be used for the TYPE field and **GROUND** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be either 'knots' or 'km/h'.

4.5.7 HEADING TRUE

A **HEADING TRUE** sensor is used to define a GPS field indicating the course over ground in degrees True. An example of a **HEADING TRUE** sensor is as follows:

```
# Course over ground - degrees True
FIELD NONE ',' 1 AS 0 DELIMITER
HEADING TRUE 'deg' V AF 0 COUNT
```

The keyword **HEADING** must be used for the TYPE field and **TRUE** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'deg' for degrees.

4.5.8 HEADING MAG

A **HEADING MAG** sensor is used to define a GPS field indicating the course over ground in degrees Magnetic. An example of a **HEADING MAG** sensor is as follows:

```
# Course over ground - degrees Magnetic
FIELD NONE ',' 1 AS 0 DELIMITER
HEADING MAG 'deg' V AF 0 COUNT
```

The keyword **HEADING** must be used for the TYPE field and **MAG** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'deg' for degrees.

4.5.9 MAG VAR

A **MAG VAR** sensor is used to define a GPS field indicating the magnitude of the magnetic variation to be used between True and Magnetic degrees. An example of a **MAG VAR** sensor is as follows:

```
# Magnetic variation
FIELD NONE ',' 1 AS 0 DELIMITER
MAG VAR 'deg' V AF 0 COUNT
```

The keyword **MAG** must be used for the TYPE field and **VAR** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'deg' for degrees.

4.5.10 MAG HEMI

A **MAG HEMI** sensor is used to define a GPS field indicating the direction (east or west) of the magnetic variation to be used between True and Magnetic degrees. An example of a **MAG HEMI** sensor is as follows:

```
# Hemisphere indicator of Magnetic variation
FIELD NONE ',' 1 AS 0 DELIMITER
MAG HEMI '' V AS 0 GPSHEMI
```

The keyword **MAG** must be used for the TYPE field and **HEMI** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is GPSHEMI. Because this is a variable length field, the only valid data type is AS. There must be no units specified. Multiplying the resultant fitted values of a **MAG VAR** sensor with its related **MAG HEMI** sensor gives signed magnetic variation, indicating magnitude and direction.

4.5.11 DAY GPS

A **DAY GPS** sensor is used to define a GPS field indicating the current day of the month. An example of a **DAY GPS** sensor is as follows:

```
# UTC Day of month
FIELD NONE ',' 1 AS 0 DELIMITER
DAY GPS '' V AI 0 COUNT
```

The keyword **DAY** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.5.12 MONTH GPS

A **MONTH GPS** sensor is used to define a GPS field indicating the current month of the year. An example of a **MONTH GPS** sensor is as follows:

```
# UTC Month of year
FIELD NONE ',' 1 AS 0 DELIMITER
```

```
MONTH GPS '' V AI 0 COUNT
```

The keyword **MONTH** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.5.13 YEAR GPS

A **YEAR GPS** sensor is used to define a GPS field indicating the current year. An example of a **YEAR GPS** sensor is as follows:

```
# UTC Year
FIELD NONE ',' 1 AS 0 DELIMITER
YEAR GPS '' V AI 0 COUNT
```

The keyword **YEAR** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.5.14 LOCALZONE HOURS

A **LOCALZONE HOURS** sensor is used to define a GPS field indicating the local zone hours to obtain UTC. This sensor definition is usually used in conjunction with a **LOCALZONE MINUTES** sensor definition. See section ***4.5.15 LOCALZONE MINUTES*** for more information on these sensors. An example of a **LOCALZONE HOURS** sensor is as follows:

```
# Local zone hours
FIELD NONE ',' 1 AS 0 DELIMITER
LOCALZONE HOURS '' V AI 0 COUNT
```

The keyword **LOCALZONE** must be used for the TYPE field and **HOURS** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.5.15 LOCALZONE MINUTES

A **LOCALZONE MINUTES** sensor is used to define a GPS field indicating the current day of the month. This sensor definition is usually used in conjunction with a **LOCALZONE HOURS** sensor definition. Local time zone is the magnitude of hours plus the magnitude of minutes added, with the sign of local zone hours, to local time to obtain UTC. Local zone is generally negative for East longitudes with local exceptions near the International Date Line. An example of a **LOCALZONE MINUTES** sensor is as follows:

```
# Local zone minutes
FIELD NONE ',' 1 AS 0 DELIMITER
LOCALZONE MINUTES '' V AI 0 COUNT
```

The keyword **LOCALZONE** must be used for the TYPE field and **MINUTES** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.5.16 ALTITUDE MSL

An **ALTITUDE MSL** sensor is used to define a GPS field indicating the altitude above mean sea level (geoid). An example of an **ALTITUDE MSL** sensor is as follows:

```
# Altitude re: mean-sea-level (geoid)
FIELD NONE ',' 1 AS 0 DELIMITER
```

```
ALTITUDE MSL 'm' V AF 0 COUNT
```

The keyword **ALTITUDE** must be used for the TYPE field and **MSL** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'm' for meters.

4.5.17 QUALITY GPS

A **QUALITY GPS** sensor is used to define a GPS field indicating the quality or state of the current GPS frame. An example of a **QUALITY GPS** sensor is as follows:

```
# GPS Quality indicator
FIELD NONE ',' 1 AS 0 DELIMITER
QUALITY GPS '' V AI 0 COUNT
```

The keyword **QUALITY** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified. Refer to the NMEA 0183 standard for more information on the meaning of this sensor value. For quick reference, the sensor value can be interpreted from the table below:

SENSOR VALUE	DESCRIPTION
0	Fix not available or invalid
1	GPS SPS Mode, fix valid
2	Differential GPS, SPS Mode, fix valid
3	GPS PPS Mode, fix valid
4	Real Time Kinematic. System used in RTK mode with fixed integers
5	Float RTK. Satellite system used in RTK mode, floating integers
6	Estimated (dead reckoning) Mode
7	Manual Input Mode
8	Simulator Mode

Table 34: GPS Quality indicators

4.5.18 MODE GPS

A **MODE GPS** sensor is used to define a GPS field of the Positioning System Mode Indicator. An example of a **MODE GPS** sensor is as follows:

```
# Positioning system mode indicator
FIELD NONE ',' 1 AS 0 DELIMITER
MODE GPS '' V AS 0 GPSMODE
```

The keyword **MODE** must be used for the TYPE field and **GPS** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is GPSMODE. Because this is a variable length field, the only valid data type is AS. There must be no units specified. Refer to the NMEA 0183 standard for more information on the meaning of this sensor value. For quick reference, the unfitted sensor value can be interpreted from the table below:

SENSOR VALUE	DESCRIPTION
A	Autonomous mode
D	Differential mode
E	Estimated (dead reckoning) mode
M	Manual input mode
S	Simulator mode
N	Data not valid

Table 35: GPS Positioning system mode indicators

4.5.19 DATA VALID

A **DATA VALID** sensor is used to define a GPS field indicating the validity status of the current GPS frame. An example of a **DATA VALID** sensor is as follows:

```
# GPS Status indicator
FIELD NONE ',' 1 AS 0 DELIMITER
DATA VALID '' V AS 0 GPSSTATUS
```

The keyword **DATA** must be used for the TYPE field and **VALID** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is GPSSTATUS. Because this is a variable length field, the only valid data type is AS. There must be no units specified. Refer to the NMEA 0183 standard for more information on the meaning of this sensor value. For quick reference, the unfitted sensor value can be interpreted from the table below:

SENSOR VALUE	DESCRIPTION
A	Data valid
V	Data not valid

Table 36: GPS Status indicators

If a **MODE GPS** sensor exists in the same GPS frame as a **DATA VALID** sensor, the **MODE GPS** sensor value will supplement this sensor value. The sensor value will be set to "V" for all values of the **MODE GPS** sensor value except "A" and "D".

4.6 Weather Station Sensors

The MET-1000 is Satlantic's automated meteorological station designed for marine applications. Atmospheric conditions can have a significant impact on the measurements taken by Satlantic instrumentation. There are many situations where current weather conditions must be known to fully interpret the context of Satlantic instrument telemetry. Weather station telemetry is often interlaced with Satlantic instrument telemetry for this purpose. Refer to the ***MET-1000 Manual*** for more information on Satlantic's weather station instrumentation.

The telemetry stream output by a Satlantic weather station does not fully comply with the Satlantic data format standard. However, with special processing, a data acquisition system can read the telemetry stream and format the data into variable length frames compliant with the standard. To do this, a telemetry definition file will be needed by the data acquisition system to define the weather station frames.

The special processing that is needed by the data acquisition system includes filtering non-ASCII characters from the telemetry stream. Also, because no frame synchronization string is transmitted, the serial interface must be dedicated solely to the weather station. This means that no other instrumentation can transmit telemetry on the same interface. To comply with the standard, the data acquisition system must insert a header string to the beginning of the incoming frame once a complete frame has been read.

There are no restrictions on the naming of sensors in a weather station telemetry definition file. However, as with ancillary sensors, certain fields have special meaning in the Satlantic data format standard. Weather Station sensors are defined as special case ancillary sensors used in weather station telemetry definition files. These sensors may be recognized by data acquisition or processing systems for higher level calculations. See section ***4.4 Ancillary Sensors*** for more information these types of sensors.

There must be only one of each Weather Station sensor defined in a telemetry definition file. Subsequent similar Weather Station sensors should be processed as normal ancillary sensors. The sensor definition line of any sensors in a GPS telemetry definition file must be placed after the frame header definition and follow the order specified the ***MET-1000 Manual***. Because weather station telemetry is variable length, see section ***3.2 Variable Length Frames*** for more information on variable length frames and sensor definition placement.

This section defines the special case Weather Station sensors of the Satlantic data format standard. Because each sensor follows the format defined in the ***MET-1000 Manual*** mentioned above, the field delimiters are specified along with the actual sensor definitions. See section ***3.3 Delimiter Sensors*** for more information on field delimiters.

The table below gives a brief summary of the Weather Station sensors of the Satlantic data format standard and their meanings:

TYPE and ID	DESCRIPTION	UNITS
YEAR MET	Current year	
DAY MET	Current day of year	
TIME MET	Current local or UTC time of day	HHMM
HUMIDITY MET	Average relative humidity	%
PRES MET	Average barometric pressure	mbar
WINDSPEED MET	Wind speed	m/s
WINDDIR	Wind direction	deg
WINDDIR STDDEV	Standard deviation of wind direction	deg
WINDSPEED STDDEV	Standard deviation of wind speed	m/s
SOLARRAD MET	Average solar radiation	W/m^2
V BAT	Internal battery voltage	V

Table 37: Recognized Weather Station sensors

Not mentioned in the above table are the temperature sensors used by the weather station. **T AIR** and **T INT** are described in section ***4.4.3 T***. The following sections describe the application of WEATHER Station sensors in further detail.

4.6.1 YEAR MET

A **YEAR MET** sensor is used to define a weather station field indicating the current year. An example of a **YEAR MET** sensor is as follows:

```
# Year
FIELD NONE ',' 1 AS 0 DELIMITER
YEAR MET '' V AI 0 COUNT
```

The keyword **YEAR** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.6.2 DAY MET

A **DAY MET** sensor is used to define a weather station field indicating the current Julian day of the year. An example of a **DAY MET** sensor is as follows:

```
# Day of year
FIELD NONE ',' 1 AS 0 DELIMITER
DAY MET '' V AI 0 COUNT
```

The keyword **DAY** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. There must be no units specified.

4.6.3 TIME MET

A **TIME MET** sensor is used to define a weather station field indicating the local or Universal Coordinated Time of the current weather station frame. An example of a **TIME MET** sensor is as follows:

```
# Local or UTC time of day (hours and minutes)
FIELD NONE ',' 1 AS 0 DELIMITER
TIME MET 'HHMM' V AI 0 COUNT
```

The keyword **TIME** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AI. The units must be 'HHMM' for hours and minutes, the format of the sensor value.

4.6.4 HUMIDITY MET

A **HUMIDITY MET** sensor is used to define a weather station field indicating the average relative humidity. An example of a **HUMIDITY MET** sensor is as follows:

```
# Average relative humidity
FIELD NONE ',' 1 AS 0 DELIMITER
HUMIDITY MET '%' V AF 0 COUNT
```

The keyword **HUMIDITY** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be '%'.

4.6.5 PRES MET

A **PRES MET** sensor is used to define a weather station field indicating the average barometric pressure. An example of a **PRES MET** sensor is as follows:

```
# Average barometric pressure
FIELD NONE ',' 1 AS 0 DELIMITER
PRES MET 'mbar' V AF 0 COUNT
```

The keyword **PRES** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'mbar'.

4.6.6 WINDSPEED MET

A **WINDSPEED MET** sensor is used to define a weather station field indicating the wind speed. An example of a **WINDSPEED MET** sensor is as follows:

```
# Wind speed
FIELD NONE ',' 1 AS 0 DELIMITER
WINDSPEED MET 'm/s' V AF 0 COUNT
```

The keyword **WINDSPEED** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'm/s'.

4.6.7 WINDDIR MET

A **WINDDIR MET** sensor is used to define a weather station field indicating the wind direction. Wind direction is relative to the orientation of the weather station itself. An example of a **WINDDIR MET** sensor is as follows:

```
# Wind direction - relative to weather station orientation
FIELD NONE ',' 1 AS 0 DELIMITER
WINDDIR MET 'deg' V AF 0 COUNT
```

The keyword **WINDDIR** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'deg'.

4.6.8 WINDDIR STDDEV

A **WINDDIR STDDEV** sensor is used to define a weather station field indicating the standard deviation of the wind direction. Wind direction is relative to the orientation of the weather station itself. An example of a **WINDDIR STDDEV** sensor is as follows:

```
# Standard deviation of wind direction
FIELD NONE ',' 1 AS 0 DELIMITER
WINDDIR STDDEV 'deg' V AF 0 COUNT
```

The keyword **WINDDIR** must be used for the TYPE field and **STDDEV** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'deg'.

4.6.9 WINDSPEED STDDEV

A **WINDSPEED STDDEV** sensor is used to define a weather station field indicating the standard deviation of the wind speed. An example of a **WINDSPEED STDDEV** sensor is as follows:

```
# Standard deviation of wind speed
FIELD NONE ',' 1 AS 0 DELIMITER
WINDSPEED STDDEV 'm/s' V AF 0 COUNT
```

The keyword **WINDSPEED** must be used for the TYPE field and **STDDEV** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'm/s'.

4.6.10 SOLARRAD MET

A **SOLARRAD MET** sensor is used to define a weather station field indicating the average solar radiation. An example of a **SOLARRAD MET** sensor is as follows:

```
# Average solar radiation
FIELD NONE ',' 1 AS 0 DELIMITER
SOLARRAD MET 'W/m^2' V AF 0 COUNT
```

The keyword **SOLARRAD** must be used for the TYPE field and **MET** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'W/m^2'.

4.6.11 V BAT

A **V BAT** sensor is used to define a weather station field indicating the internal battery voltage. An example of a **V BAT** sensor is as follows:

```
# Internal battery voltage
FIELD NONE ',' 1 AS 0 DELIMITER
V BAT 'V' V AF 0 COUNT
```

The keyword **V** must be used for the TYPE field and **BAT** for the ID field of the sensor definition line. The only valid fit type for this sensor definition is COUNT. Because this is a variable length field, the only valid data type is AF. The units must be 'V'.