

# OpenTRAC

## Open Tactical Reporting and Communication Protocol

- Purpose** This document describes a protocol for communicating information about the position, status, and nature of stations, objects, and phenomena as a simple byte stream built from a vocabulary of well-defined message elements. Intended uses of the protocol include Automatic Vehicle Location (AVL), Situational Awareness (SA), and Supervisory Control and Data Acquisition (SCADA).
- Structure** Anything about which the OpenTRAC protocol communicates information is an **entity**. A **station** is a special case of an entity that participates in OpenTRAC communications. Every entity has a unique identification number, a change sequence number, and zero or more attributes. Entity IDs are formed from the originating station's callsign/SSID pair and a 16-bit extension. Extension 0 refers to the station itself.
- The basic building block of an OpenTRAC stream is the **element**. There are two general types of elements: **stream control elements** and **attribute elements**. Stream control elements are used to indicate the current station, entity, and sequence of the following attribute elements. Attribute elements carry information about the current entity. All attribute element types are considered optional, but *all implementations must support the stream control elements*.
- Each sequence of an entity may include at most one instance of each attribute element. Sequence numbers should start at 1, and are incremented with each change in an entity's attributes. For simple implementations, the sequence number 0 may be used to indicate that a sequence number will not be provided, and each attribute element received should replace the previously received element of that type. For all other sequences, duplicated attribute elements of the same type should be ignored.
- Data Types and Units** All numeric data types are Big Endian (high octet first). Bit order is MSB to LSB. Signed integers use two's complement notation. Single and double precision floating point numbers use IEEE Standard 754 format. Character values are standard ASCII. The protocol will use SI units whenever practical.
- Element Header Format** An Element Header precedes every element. This indicates the length and type of the following element. The length is provided even in fixed-length elements to allow simple clients to skip unsupported element types.

<i>Element Header Format</i>			
<i>ExtID</i>	<i>Message Length</i>	<i>ElementID</i>	<i>ExtendedID</i>
1 bit	7 bits	8 bits	8 bits (optional)

- **ExtID** – A '1' in this field indicates a 16-bit element ID.
- **Message Length** – Length of message in octets, inclusive of element ID.

If the ExtID flag is 0, ElementID contains an 8-bit element ID. Otherwise, ElementID and ExtendedID form the high and low octets, respectively, of a 16-bit element ID. This scheme allows for 65,536 element types. Values in the range 0x00 to 0xff (0 to 255 decimal) are reserved for common, standard elements, and may be represented in either 8-bit or 16-bit format. 16-bit IDs are intended for less-frequently used elements, status flags, and experimental element types. Empty message elements are supported for instances where the presence of the element ID alone conveys the required information.

A length field of 0 (bytes 0x00 and 0x80) is reserved and currently undefined.

No CRC is provided. It is the responsibility of the underlying transport to ensure error-free delivery of messages.

## Message Element Format Definitions

### 0x00 – 0x0f: Stream Control Elements

**0x00 Sequence** The Sequence element indicates the sequence number of the following attribute elements. A blank sequence element increments the sequence number by one.

<i>Sequence</i>	
<i>Sequence</i>	
Size	16 bits
Type	Integer
Units	
Example	03 00 00 05 (Sequence #5)
Version	<a href="#">1.0 Draft</a>

**0x01 Originating Station** When using a transport protocol such as AX.25 that provides the callsign of the originating station, received elements are assumed to originate with the station indicated by the transport protocol unless otherwise specified by this element. For datagram-oriented transports like unconnected AX.25 and UDP, the scope of the identification element extends only to the end of the underlying datagram.

A Sequence element may follow an Originating Station element to indicate the start of a new sequence. The callsign and SSID values are carried over to the new message group. This may be used for transmitting a multiple-sequence history for a given station.

If the originating station did not provide a sequence number, the sequence field is set to zero.

The SSID is stored as a 6-bit number in the most significant bit of each of the 6 octets of the callsign.

<i>Originating Station</i>		
	<i>Callsign/SSID</i>	<i>Sequence</i>
Size	6 octets	16 bits
Type	ASCII	Integer
Units		
Example	08 01 4E 31 56 C7 80 80 00 (N1VG-7, No Sequence)	
Version	<a href="#">1.0 Draft</a>	

- Callsign - The originating station's callsign, right-padded with nulls (0x00).
- SSID - The SSID of the originating station.
- Sequence - See Sequence element.

**0x02  
Entity ID**

An Entity ID element denotes the start of a new entity. An empty element increments the current entity ID. If the Callsign/SSID field is omitted, the Callsign/SSID field of the current entity ID is used.

<i>Entity ID</i>			
	<i>Callsign/SSID</i>	<i>Extension</i>	<i>Sequence</i>
Size	6 octets	16 bits	16 bits
Type	ASCII	Integer	Integer
Units			
Example	09 02 4E 31 56 C7 80 80 00 01 (N1VG-7:0001, No Sequence)		
Version	<a href="#">Proposed</a>		

## Common Attribute Elements

**0x10  
Position** Positions reference the WGS84 datum. Coordinates are 32-bit signed integers with negative numbers indicating South latitude and West longitude, expressed in semicircles where  $2^{31}$  semicircles equals 180 degrees.

Altitude is in 1/100 meters measured from -10,000 meters MSL, represented as a 24-bit unsigned integer.

<i>Position</i>			
	<i>Latitude</i>	<i>Longitude</i>	<i>Altitude</i>
Size	32 bits	32 bits	24 bits
Type	Integer	Integer	Integer
Units	semicircles	semicircles	1/100 meter
Example	0C 10 18 DC 17 7B AA 5D 7A D6 0F 89 BC (34.959 N, 120.424 W, 183.0 meters)		
Version	<a href="#">1.0 Draft</a>		

**0x11  
Timestamp** Times are in seconds elapsed since 1 Jan 1970 00:00:00.0 UTC (UNIX format).

<i>Timestamp</i>	
	<i>Time</i>
Size	32 bits
Type	Integer
Units	Seconds
Example	05 11 3E 38 3E 6E (Wed, 29 Jan 2003 20:49:50 UTC)
Version	<a href="#">1.0 Draft</a>

**0x12  
Freeform  
Comment** The purpose of the comment is to provide a free-form text field associated with the entity.

<i>Freeform Comment</i>	
	<i>Time</i>
Size	0 to 126 octets
Type	UTF-8
Units	
Example	05 12 41 42 43 44 (ABCD)
Version	<a href="#">1.0 Draft</a>

**0x13**  
**Course and**  
**Speed**

Speeds are in 1/50 meter per second. Course is in degrees relative to true north.

<i>Course and Speed</i>		
	<i>Course</i>	<i>Speed</i>
Size	9 bits	15 bits
Type	Integer	Integer
Units	Degrees	1/50 meter/sec
Example	04 13 9C 04 57 (312 degrees at 80 km/hr)	
Version	1.0 Draft	

**0x14**  
**Positional**  
**Ambiguity**

This may reflect estimated position error from a GPS receiver, or it may be used to indicate a manually entered positional ambiguity. The value of the field represents the estimated error radius in meters.

<i>Positional Ambiguity</i>	
	<i>Positional Ambiguity</i>
Size	16 bits
Type	Integer
Units	Meters
Example	03 14 00 0D (13 meters)
Version	Pending

**0x15**  
**Country Code**

ISO 3166-1 country code, and optionally ISO 3166-2 country subdivision code (excluding the country code and separator). The exact meaning of this element depends on the context. Included with a station report, it should indicate the country in which the station is operating. For a ship, it should indicate the country of registry.

<i>Country Code</i>		
	<i>Country Code</i>	<i>Subdivision</i>
Size	2 octets	Up to 3 octets
Type	ASCII	ASCII
Units	ISO 3166-1	ISO 3166-2
Example	05 15 55 53 43 41 (United States - California)	
Version	Pending	

- 0x16 Display Name** The display name may be a tactical callsign or other identifying label. On a map display, it should be considered the primary identifying element for the entity, though other identifiers (such as the originating station's callsign) may be displayed as well.

<i>Display Name</i>	
<b>Display Name</b>	
Size	Up to 30 displayed characters
Type	UTF-8
Units	
Example	0C 16 33 32 2D 52 65 73 63 75 65 2D 31 (32-Rescue-1)
Version	Pending

- 0x17 Waypoint Name** When transmitting a waypoint to a GPS device, it may be desirable to provide a suggested waypoint name in the standard 6-character uppercase format.

<i>Waypoint Name</i>	
<b>Waypoint Name</b>	
Size	Up to 6 octets
Type	ASCII
Units	
Example	07 17 47 43 39 43 43 38 (GC9CC8)
Version	Pending

- 0x18 Map Symbol** Specifies the symbol that should be used to represent the entity on a map. The symbol should be chosen to reflect the nature of the entity, not to force a particular visual appearance. The symbol set is specified in the OpenTRAC Symbol Set document. Symbol codes are expressed as packed four bit values.

<i>Map Symbol</i>	
<b>Symbol Code</b>	
Size	Currently up to 4 octets (8 digits)
Type	Packed 4-bit integers
Units	
Example	04 18 31 E1 20 (3.1.14.1.2 – Ultralight Flight Area)
Version	Pending

## Network Information Elements

### 0x20 Path Trace

To request a path trace, a station may include an empty Path Trace element. Any station the element passes through should add its own callsign and SSID to the end of the Path Trace element. Any station along the path may add a Path Trace, whether the originating station requested it or not. The network ID indicates the network on which the station received the element.

<i>Path Trace</i>			
	<i>Callsign/SSID</i>	<i>Network</i>	<i>Repeat 0 or more times</i>
Size	6 octets	8 bits	
Type	ASCII	Integer	
Units			
Example	01 20 (Request a path trace)		
Version	Pending		

### 0x21 Heard-By List

A station transmitting a message group to another network must add the source network's ID to this list, if the source network is not the originating network of the message group. This element type should only be present in entities that have passed through a network gateway.

<i>Heard-By List</i>		<i>Repeat 0 or more times</i>
	<i>Network</i>	
Size	8 bits	
Type	Integer	
Units		
Example	03 21 00 01 (Heard by VHF and APRS-IS)	
Version	Pending	

### 0x22 Available Networks

A station may use this element to announce the Network IDs of the networks it is connected to and willing to pass traffic to or from.

<i>Available Networks</i>		<i>Repeat 0 or more times</i>
	<i>Network</i>	
Size	8 bits	
Type	Integer	
Units		
Example	04 22 00 01 02 (VHF, APRS-IS, and UHF)	
Version	Pending	



**0x32  
Maidenhead  
Locator**

See <http://www.arrl.org/files/contests/ln9404.pdf> for explanation of the Maidenhead Locator System.

<i>Maidenhead Locator</i>	
<i>Grid</i>	
Size	4 or 6 octets
Type	ASCII
Units	
Example	07 32 43 4D 39 34 74 77 (CM94tw)
Version	<a href="#">Pending</a>

**0x33  
Radio  
Capabilities**

(In work)

This element is used to announce the radio communication capabilities of the station. The frequency represents the center frequency in 10 Hz increments, allowing indication of frequencies from 0 hz to over 40 GHz.

<b>Radio Capabilities</b>					
	<i>Frequency</i>	<i>Signal</i>	<i>Modulation</i>	<i>Information</i>	<i>Detail</i>
Size	32 bits	3 bits	5 bits	4 bits	4 bits
Type	Integer	Enum	Enum	Enum	Enum
Units	10 Hertz				

<b>Radio Capabilities (continued)</b>							
	<i>Pad</i>	<i>Multiplex</i>	<i>Function</i>	<i>Pad</i>	<i>CTCSS</i>	<i>Bandwidth</i>	<i>Repeat 0 or more times</i>
Size	2 bits	3 bits	3 bits	2 bits	6 bits	24 bits	
Type		Enum	Enum		Enum	Integer	
Units						Hertz	

CTCSS tone

Values: 00 - No CTCSS used

01 to 44 - EIA standard CTCSS tones 67.0 through 254.1 Hz

Function

Values: 00 - Simplex

01 - Uplink / Input

02 - Downlink / Output

03 - Beacon / Broadcast

Support for odd CTCSS tones and digital PL methods?

Modulation, Signal, Information, Detail, and Multiplex fields are based on the WARC-79 emission designators. Values are translated as follows:

Modulation: A-Z -> 0-25

Signal: 0, 1, 2, 3, 7, 8, 9, X -> 0-7

Information: N, A, B, C, D, E, F, W, X -> 0-8

Detail: A-H, J-N, W, X -> 0-14

Multiplex: N, C, F, T, W, X -> 0-5

### 0x34 GPS Data Quality

<b>GPS Data Quality</b>						
	<b>Fix Type</b>	<b>Fix Validity</b>	<b>Satellites</b>	<b>HDOP</b>	<b>PDOP</b>	<b>VDOP</b>
Size	2 bits	2 bits	4 bits	8 bits	8 bits	8 bits
Type	Enum	Enum	Integer	Integer	Integer	Integer
Units				HDOP * 10	PDOP * 10	VDOP * 10
Example	05 34 D8 19 0D 15 (Valid 3D GPS fix, HDOP = 2.5, PDOP = 1.3, VDOP = 2.1)					
Version	Pending					

#### Fix Type

Values: 00 - Unknown / Not available

01 - No fix

02 - 2D fix

03 - 3D fix

#### Fix Validity (2 bits)

Values: 00 - Invalid

01 - Valid SPS

02 - Valid DGPS

03 - Valid PPS

S = Satellites used

The Satellites field indicates the number of satellites in use, as reported by the NMEA 0183 \$GPGGA sentence. PDOP, HDOP, and VDOP optionally indicate the position, horizontal, and vertical dilution of precision, respectively. DOP values are represented as integers equal to ten times the GPS-reported DOP. DOP values over 25.5 are reported as 255.

### 0x35 Aircraft Registration

Used to indicate the registration number associated with an aircraft. Dashes and other separators should be excluded. An empty element may be provided to indicate that the associated entity is an aircraft without providing a registration number.

<b>Aircraft Registration</b>	
	<b>Registration Number</b>
Size	Up to 8 octets
Type	ASCII
Units	
Example	07 35 4E 38 32 30 34 58 (N8204X)
Version	1.0 Draft

## Weather Elements

**0x40** Surface observation report element  
**Surface Observation Report** (In work)

<b>Surface Observation Report</b>					
	<b>Period</b>	<b>Pad</b>	<b>Wind Direction</b>	<b>Wind Speed</b>	<b>Gust</b>
Size	13 bits	2 bits	9 bits	12 bits	12 bits
Type	Integer		Integer	Integer	Integer
Units	Seconds		Degrees	1/10 m/s	1/10 m/s
<b>Surface Observation Report (continued)</b>					
	<b>Temp</b>	<b>Rainfall</b>	<b>Pressure</b>	<b>Pad</b>	<b>Humidity</b>
Size	12 bits	12 bits	14 bits	3 bits	7 bits
Type	Integer	Integer	Integer		Integer
Units	1/10 K	1/10 Kg/cm <sup>2</sup>	1/10 Pa		% relative
Example					

Period indicates the averaging time period for the measurement, offset from -4096 seconds relative to the associated timestamp. For example, a value of 3196 indicates an averaging time of 900 seconds, or 15 minutes.

Temperature units are 1/10 K. To convert temperatures from Fahrenheit or Celsius to Kelvins, use the following formulas:

$$K = ((5/9) * (F - 32) + 273)$$

$$K = C + 273$$

**0x41** Rainfall History (In work)

Need units here  
(mm?)

<b>Rainfall History</b>						
	<b>Last Hour</b>	<b>Last 3 Hours</b>	<b>Last 6 Hours</b>	<b>Last 12 Hours</b>	<b>Last 24 Hours</b>	<b>Since Midnight</b>
Size						
Type						
Units						
Example						

**0x42  
River Flow  
Gauge**

Reports flow rates for rivers and streams.  
(In work)

<i>River Flow Gauge</i>		
	<i>Flow Rate</i>	<i>Gauge Height</i>
Size	16 bits	16 bits
Type	Integer	Integer
Units	1/64 Meter <sup>3</sup> /sec	Centimeters
Example	05 42 80 22 00 FF (512.5 cubic meters/sec, 255 cm height)	

**0x43  
Storm Report**

(In work)  
Needs position, direction, speed, type (tropical storm, hurricane, tropical depression), wind speed, peak winds, central pressure, hurricane winds radius, tropical storm winds radius, total radius

<i>Storm Report</i>				
Size				
Type				
Units				

**0x50  
Shape** Shape geometries are represented using a format derived from the Open GIS Consortium's Well-known Binary Representation for Geometry. Significant differences include the use of 32-bit integers for coordinates (using the same format as the Position element), support for XDR byte order only, and a limit of 255 points per geometry element.

[\(In work\)](#)

**0x0100  
Emergency** Presence of this element indicates an emergency situation. No content is defined. Hardware and software implementations should take measures to ensure that the emergency flag is not transmitted accidentally. For a hardware device, this may include a recessed button, buttons that must be depressed simultaneously, or a button that must be depressed and held for several seconds. A software implementation should request confirmation of the action before transmitting the emergency flag. The flag is equivalent to a voice 'Mayday' call and should be treated as such. Both hardware and software implementations should provide a clear visual indication that the emergency flag is being transmitted.

[1.0 Draft](#)

**0x0101  
Attention** This flag serves a purpose similar to the 'Ident' function of an aircraft transponder, causing a receiving station to indicate the entity's map symbol in a visually obvious manner, possibly by causing it to 'bloom' or flash. Transmission of this flag should only be initiated by direct user action.

**0x0300  
Hazmat Inventory** This element is intended to identify hazardous materials associated with a report. An empty element may be used to indicate that the nature of the hazardous material is unknown.

<i>Hazmat Inventory</i>	
<i>Reserved</i>	<i>UN ID</i>
Size	2 bits
Type	Integer
Units	
Example	84 03 00 07 ED (UN2029, Anhydrous hydrazine)
Version	<a href="#">Pending</a>

**0x0500 to 0x05ff  
Generic  
Measurement  
Elements**

These elements allow for the reporting of values in specific units, without specifying the actual meaning of the data. For example, a remote station may report two entities with voltage measurements to indicate battery and solar panel voltage. Text comments could optionally be included with the entities to describe their function.

Each element contains a single value. The data type is indicated by the length field. Supported data types are 8-bit signed integer, 16-bit signed integer, single-precision floating point, and double-precision floating point.

(In work)

<i>ElementID</i>	<i>Measurement Type</i>	<i>Units</i>
0x500	Electric Potential	Volts
0x501	Electric Current	Amperes
0x502	Power	Watts
0x503	Temperature	Kelvins
0x504	Distance	Meters
0x505	Time	Seconds
0x506	Velocity	Meters/Second
0x507	Volume	Liters
0x508	Mass	Kilograms
0x509	Data Rate	Bits/Second
0x50a	Data Storage	Bytes
0x50b	Plane Angle	Radians
0x50c	Angular Velocity	Radians/Second
0x50d	Area	Square Meters
0x50e	Energy	Joules
0x50f	Force	Newtons
0x510	Pressure	Pascals
0x511	Frequency	Hertz
0x512	Acceleration	Meters/Second <sup>2</sup>
0x513	Specific Energy	Grays
0x514	Luminous Flux	Lumens
0x515	Flow Rate	Cubic Meters/Second
0x516	Viscosity	Pascal seconds
0x517	Mass Density	Kilograms/Meter <sup>3</sup>
0x518	Angular Acceleration	Radians/Second <sup>2</sup>
0x519	Electric Charge	Coulombs
0x51a	Capacitance	Farads
0x51b	Conductance	Siemens
0x51c	Quantity	Count

Elements 0x0100 - 0x01ff: Reserved for status flags  
Elements 0x0200 - 0x02ff: Incident Command System  
Elements 0xf000 - 0xffff: Experimental

**0xffff**  
**Null**

The Null element may be used as a filler for an otherwise empty entity. This may indicate a null response to a query.

[\(In work\)](#)