AFF DATA STANDARDIZATION

Automated Flight Following (AFF) has developed a data format and data transfer exchange standard for all tracking data for use between the vendor Network Operations Centers (NOC) and the AFF NOC.

AFF is finishing its first phase of implementation. In this phase the user community grew from 75 users to 1,700 users. Peak use of WebTracker software was approximately 500 users per day. The number of active aircraft tracking devices increased from 50 to 195 (The heavy Air tanker fleet is subtracted from the total.) in 2004. This is roughly 10%-15% of the fleet requiring tracking equipment.

In order to support anticipated growth in the second phase of implementation, AFF developed, tested and adopted a standard transfer protocol, data format, and encryption method. This standard was designed to be flexible to accommodate new technology as AFF is integrated into the Aviation Management and Dispatch community.

A standardized data format, delivery and encryption method will allow AFF to consolidate the data security plan to simplify the review and approval process for Certification and Accreditation (or Authority to Operate).

This standard provides a framework that will be used for testing and evaluation of the tracking unit hardware, firmware, data, data distribution NOC, tracking software, and AFF program objectives.

AFF also hopes that standardization will facilitate the development of new tracking units that provide increased telemetry reporting.

The second phase of implementation begins in early (April-May) 2005. AFF would like to have all data feeds tested and converted to the new standard before then.

System History:

Various methods for data transfer using various IP protocols were used and evaluated from 2000 to 2004. The general methods for data transfer fall into the following broad categories:

- Direct communication between the unit and AFF servers via the satellite segment.
- Establishment of a TCP/IP socket from the vendor NOC to AFF and the vendor NOC pushing data to AFF servers.
- A stand-alone application connected to the vendors NOC writing position data to a local file that an AFF service application reads and parses.
- AFF server requests data from a certain time to the vendor NOC, and the vendor NOC replies will all data from that time requested using HTTP or HTTPS.

Various data formats were also used and evaluated. They fall into three general categories:

- Proprietary binary.
- Non-Proprietary ASCII
- Non-Proprietary XML

Two forms of security were used and evaluated. They were:

- SSL
- SSH

Preliminary findings:

After extensive testing, the most robust means of data transfer was a query and response method via HTTPS (SSL) at approximately 30-second intervals. This added up to approximately 30-second latency to data arriving at the AFF NOC, but latency did not exceeded 120 seconds (average was about 95 seconds).

This method had the most success in accurately detecting lost communication with a data provider, automatically and reliably failing-over to alternate servers, and automatically recovering data that was not retrieved during service interruptions.

This method also allowed AFF to provide uninterrupted data flow with no loss of historic data to clients even though a system had been taken off line for hardware/software maintenance.

Position quality metrics were crucial for verifying the validity of position report data. This information allowed AFF to filter out position reports that were of unacceptable horizontal accuracy (> 100m 3dRMS). These metrics were also used to detect hardware, firmware, and logic failures.

The most robust data format was Non-proprietary XML between the vendor and AFF NOCs. The XML data structure allowed new telemetry values to be sent to AFF for evaluation before incorporation into the production environment. The basic data structure did not require changes to accomplish this.

Proprietary data formats and the use of Non Disclosure Agreements (NDA) for data transfer between NOCs proved too complex to troubleshoot, and too expensive to implement with current AFF time and budget constraints.

XML and XML Schema allow for a common position data format, and standard for data types and data value limits across almost all Operating System platforms (OS). XML has the added benefit of being readable by humans for error checking and debugging.

AFF SYSTEM REQUIREMENTS

The ***primary requirements*** are as follows:

1: *Security*. AFF needs to know what tracking device the data originated from and that the data were not altered in transit to the AFF NOC.

A current Interconnect Security Agreement (ISA) between the vendor NOC and the Government must be in place.

2: *Position*. AFF requires one position report every two minutes. This position report must contain an Equipment Serial Number (ESN) internally generated by unit, Latitude, Longitude, Speed, Heading, Altitude, and UTC Time.

3: *Quality*. The quality of the position report must be reported. Quality indicators include type of position (invalid/2D/3D), and a position quality metric (HDOP, PDOP, GDOP).

4: *Latency*. Position reports must be able to be delivered to the AFF NOC in less than 2 minutes of the position calculation time.

5: *Consistency*. The number of lost/invalid position reports must not exceed 0.02% on a weekly running average.

6: *System Health Validation*. Two sources of system health data are also required.

One end-to-end position report is required from a device using the same hardware and satellite segment as production tracking unit every 5-10 minutes to verify that the system is working from end-to-end. New firmware may be tested using the end-to-end unit.
.
One computer generated position report every 5 minutes to verify the query is retrieving current data from the production data server. This report may be substituted by using the `rptTime` attribute in the root `data` element.

7: *Area of Coverage*. The tracking communication link should be fully operational in the lower 48 states under all flight conditions. Units operating the State of Alaska, and Canada must be fully operational in all stated geographic areas.

8: *Scheduled and Unscheduled Changes and Outages*. The data provider shall notify AFF immediately of unplanned service outages. AFF shall be given 24 hours notice of system changes, scheduled maintenance, and planned outages or so AFF users can take appropriate actions.

DATA TYPES AND PRECISION FOR AIRCTAFT TRACKING UNITS

The Government will specify the data format and data transfer exchange standards in future aviation contracts that require AFF tracking. The information provided within this document is accurate at this juncture and no changes are anticipated; however, it must be recognized that as implementation of the program progresses, some technical requirements are likely to be modified.

The tracking unit must generate all data specified below and all data except the Equipment Serial Number (ESN) must be calculated by GPS. Data units may be reformatted at the vendor NOC before delivery to AFF NOC (e.g. Latitude / Longitude may be transmitted from tracking units in Degrees Minutes and Seconds to the vendor NOC, then reformatted to decimal degrees for delivery to AFF NOC).

Mandatory data in an AFF aircraft position report

ESN, Time, **Latitude**, **Longitude**, **Altitude**, **Speed**, **Heading**, **Fix Type**, and at least one **Position Quality** metric are required for AFF aircraft position reports. Any data value falling outside the acceptable range should not be altered to meet an acceptable value unless it will cause undue bandwidth hardship to deliver actual value from the unit via satellite.

ESN (Equipment Serial Number) will be embedded in the position report by the tracking device. No lookup or pivot tables shall be used for this value when generating XML tag.

Time reports will be the position calculation date and time in UTC. Time values may be truncated to the nearest second. Minimum acceptable time value is 00:00:00.000, maximum acceptable time value is 23:59:59.999.

Latitude and **Longitude** will be reported in decimal degrees using WGS84 or NAD83 with a precision capability of no less than 6 digits to the right of the decimal place. Maximum acceptable value for Latitude is 90, minimum acceptable value is –90. Maximum acceptable value for Longitude is 180 and the minimum acceptable value is –180.

Altitude will be reported as Meters above Mean Sea Level. Precision will not need to exceed whole meters.

Speed will be reported as Meters Per Second or Centimeters Per Second. Precision will not need to exceed whole meters per second.

Heading will be the track over ground referenced to true north. Precision will not need to exceed whole degrees. Minimum acceptable value is 0 degrees, the maximum acceptable value is 359 degrees.

Fix Type will be the status of that GPS position. Valid values are:

- **3D**
- **2D**
- **Invalid**
- **Not Available**: indicates unit is unable to report **fix type**. (e.g. firmware version of this unit does not report **fix type**, but could with another version of firmware)
- **None**: indicates unit cannot report **fix type**. (e.g. device is not capable of reporting a **fix type** under any conditions)

Position Quality:

- Horizontal Dilution of Precision (**HDOP**)
- Vertical Dilution of Precision (**VDOP**)
- Position Dilution of Precision (**PDOP**) = **SQRT(HDOP^2 + VDOP^2)**
- Geometric Dilution of Precision (**GDOP**) **= SQRT(PDOP^2 + TDOP^2)**.
- Time Dilution of Precision (TDOP)

A valid position report must contain at least one **HDOP**, **PDOP**, or **GDOP** regardless of the reported **Fix Type**. DOPs need only be reported in integer values, with the lowest acceptable value being 1 and highest acceptable value being 98. Missing DOPs will indicate no measured value.

Acceptable data quality for Automated Flight Following status checks requires **3D** fixes with an **HDOP, PDOP,** or **GDOP** value greater than 0 and less than 99.

2D and **3D** fixes with an **HDOP**, **PDOP**, or **GDOP** value greater than 0 and less than 99 are acceptable for end-to-end "heartbeat" information (valid time is the critical value).

Description	Format	Data Type
Equipment Serial Number	Firmware Embedded Value	xsd:string
Latitude, Longitude	WGS84	xsd:double
Altitude	Meter Mean Sea Level	xsd:integer
Speed	M/sec or cm/sec	xsd:integer
Heading	Track over ground True N	xsd:integer
Date Time	UTC	xsd:dateTime
PDOP, VDOP, HDOP, GDOP		xsd:integer

Real values may be rounded to create an Integer Value Type.

Minimum requirements for Data Storage, Delivery, and Frequency

1: *Storage*. Data will be stored at the vendor NOC for a minimum of 14 days.

2: *Delivery Method.* HTTPS will be used for data exchange. The request page will be username and password protected. Post method will be used to request data.

3 *Frequency.* The AFF server will request data no more frequently than every 30 seconds.

4 *Data Format.* Data will be formatted into a well-formed XML document as defined by the AFF schema.

The position date and time, or server date and time, will be the subject of data requests from AFF.

The `acPos` data will be sorted in ascending order by the requested time stamp. No other sort criteria will be used for the `posList`.

For the current AFF schema please refer to appendix A

5 *Bandwidth.* The vendor NOC must be able to deliver all position data over a 60 second interval in less than 30 seconds from time of request. AFF NOC will have three to six servers requesting position reports. AFF NOC data requests will not be synchronized.

Vendor NOC must be capable of meeting these requirements 99.99% on a 7 day running average.

Data request types

Sync request type may be used for data that will always arrive at a data center in sequence by position time. The synchronous query will use tracking position date time as the query field.

Async request type is for data that will not arrive in sequence by position time. The asynchronous query will use the date time the position was inserted into the data centers database as the query field.

Position data for either request type will be sorted from least current to most recent based on the query field.

Other data requests are likely to be desired in the future. Where possible, no change will be made to the schema. These new requests will be defined, adopted and published. The **Sync** request type will be phased out by 2006.

The response document should include a schema version number, and may also include a sysID and rptTime attribute to facilitate debugging. sysID is a unique identifier to help the company identify what server(s) generated the report and the rptTime is the time the server created the document. rptTime may also serve as a replacement for a server generated heartbeat position report. Either the system heartbeat or rptTime value will validate that the response document is not cached.

source is the source device that created the position (e.g. GPS, IRIDIUM, LORAN).

fix: indicates the **fix type**.

mode: is the indicator of GPS mode (e.g. A=Autonomous, D=Differential, E=Estimated). Other modes may be defined in the future.

dataCtr: is the company name of the device producing the data, and may abbreviated.

dateTime: is the position report time.

dataCtrDateTime: is the time the position report was inserted into the database.

Synchronous Data Query

The synchronous method requires that tacking position data arrives at the provider's data center (NOC) in synchronous order, and a query based on the position GPS time will not impact data delivery. AFF will send a msgRequest element with the text "**Sync**" in the subject line. If the data center supports synchronous data requests, it will query for all data greater than and equal to the date time specified in the body. The response document does not need to include the dataCtrDateTime attribute.

```
<?xml version="1.0" encoding="UTF-8" ?>
- <data xmlns="https://www.aff.gov/affSchema" sysID="AFF-1"
    version="2.23" rptTime="2004-10-18T19:20:02.000Z ">
  - <msgRequest to="Co" from="AFF-1" msgType="Data Request"
      subject="Sync" dateTime="2004-10-18T19:20:02.000Z">
      <body>2004-10-17T19:19:32.000Z</body>
    </msgRequest>
  </data>
```

```
<?xml version="1.0" encoding="UTF-8" ?>
- <data xmlns="https://www.aff.gov/affSchema" version="2.23"
    sysID="srvr3" rptTime="2004-10-19T19:20:09+00:00">
  - <posList listType="Sync">
    - <acPos esn="00000" source="GPS" fix="3D" dataCtr="Co"
        dateTime="2004-10-19T16:42:00+00:00">
        <lat>-33.455718</lat>
        <long>-71.590759</long>
        <altitude units="meters">3353</altitude>
        <heading units="Track-True">186</heading>
        <speed units="meters/sec">94</speed>
        <telemetry name="flight_status" type="xsd:string" value="In-Flight" />
      </acPos>
    - <acPos esn="00000" source="Iridium" fix="None" dataCtr="Co"
        dateTime="2004-10-19T16:42:00+00:00">
        <lat>-33.306436</lat>
        <long>-70.042598</long>
        <altitude units="meters">-200</altitude>
        <heading units="Track-True">-200</heading>
        <speed units="meters/sec">-200</speed>
        <telemetry name="CEPradius" type="xsd:integer" value="307" />
      </acPos>
    </posList>
  </data>
```

Asynchronous Data Query

The asynchronous method allows for position data to arrive at the data center out of time order. This method does require that the servers collecting data will be synchronized to UTC time, and the server time will not drift sufficiently to impact data delivery. This method also requires a date time field that records the date and time the position data is inserted in the database. AFF will send a msgRequest element with the text "**Async**" in the subject attribute. If the data center supports asynchronous data requests, it will query for all data greater than and equal to the date time specified in the body. The response document shall include the dataCtrDateTime attribute for each position.

```
<?xml version="1.0" encoding="UTF-8" ?>
- <data xmlns="https://www.aff.gov/affSchema" sysID="AFF-1"
    version="2.23" rptTime="2004-10-18T19:20:02.000Z ">
  - <msgRequest to="Co" from="AFF-1" msgType="Data Request"
      subject="Async" dateTime="2004-10-18T19:20:02.000Z">
      <body>2004-10-17T19:19:32.000Z</body>
    </msgRequest>
  </data>

<?xml version="1.0" encoding="UTF-8" ?>
- <data xmlns="https://www.aff.gov/affSchema" version="2.23"
    sysID="srvr3" rptTime="2004-10-19T19:20:09+00:00">
  - <posList listType="Async">
    - <acPos esn="00000" source="GPS" fix="3D" dataCtr="Co"
        dataCtrDateTime="2004-10-19T16:42:15+00:00"
        dateTime="2004-10-19T16:42:00+00:00">
        <lat>-33.455718</lat>
        <long>-71.590759</long>
        <altitude units="meters">3353</altitude>
        <heading units="Track-True">186</heading>
        <speed units="meters/sec">94</speed>
        <telemetry name="flight_status" type="xsd:string" value="In-Flight" />
      </acPos>
    - <acPos esn="00000" source="Iridium" fix="None" dataCtr="Co"
        dataCtrDateTime="2004-10-19T16:42:15+00:00"
        dateTime="2004-10-19T16:42:00+00:00">
        <lat>-33.306436</lat>
        <long>-70.042598</long>
        <telemetry name="CEPradius" type="xsd:integer" value="307" />
      </acPos>
    </posList>
  </data>
```

Error Responses

The msg element should be used to report errors to AFF data requests. The to field in the response should be the from field value of the request. The msgType should be the test "**ERROR**" and the subject may be blank or a categorical description of the error. The dateTime will be the time the msg was created, and the body may contain a verbose description of the specific error. As patterns of errors are seen, categories to be used in the subject will be defined, adopted and published. This will not require a Schema change.

```
<?xml version="1.0" encoding="UTF-8" ?>
- <data xmlns="https://www.aff.gov/affSchema" version="2.23"
    sysID="srvr3" rptTime="2004-10-19T17:53:18+00:00">
  - <msgList>
    - <msg to="AFF-1" from="Co" msgType="ERROR" subject="Invalid
        request" dateTime="2004-10-19T17:53:18+00:00">
        <body>Server does not support Sync requests.</body>
      </msg>
    </msgList>
  </data>
```

Appendix A

The most current AFF data schema is located at
https://www.aff.gov/development/schema/affschema.xsd

The most current information for contract requirements will be posted at:
https://www.aff.gov/contract/current/default.asp

Historic contract specification in use for currently active contracts posted at:
https://www.aff.gov/contract/historic/default.asp

XML data types and schema definitions may be found at the World Wide Web Consortium at:
http://www.w3c.org

XML Schema requirements:
http://www.w3.org/TR/NOTE-xml-schema-req

XML Schema Primer:
http://www.w3.org/TR/xmlschema-0/