PADS Cursor-on-Target (CoT) Output Schema

Schema version: 1.0 **Date:** 24 November 2026 **Revision:** A (example values made uniform and marked as placeholders; no change to the message format) **Publisher:** Rendeer Systems, LLC **Applies to:** PADS gateway software, CoT output **Audience:** developers of TAK clients, TAK Server plug-ins and other systems that receive CoT

This document describes the messages PADS sends. It describes the message format only. All coordinates, identifiers, times and values in the examples are placeholders.

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1. Overview

1.1 What a PADS alert is

PADS is a passive acoustic sensor for small unmanned aircraft. Sensors (“patches”) report through a gateway, which is the phone or computer they are paired with. The gateway turns each report into Cursor-on-Target events.

PADS sends four kinds of map item:

Item	What it shows	CoT type
Patch marker	Where a patch is	`a-f-G-E-S`
Line of bearing	A direction from one patch toward a contact	`u-d-f`
Contact position	Where a contact is, when PADS holds a position for it	`a-h-A-M-H-Q` or `a-u-A-M-H-Q`
Delete	Removes an item PADS sent earlier	`t-x-d-d`

A single patch reports a direction, not a position. Its alert is therefore a line of bearing and never a point target. A contact position is sent only when PADS has combined reports from more than one patch into a position.

Every alert carries one of three categories:

Category	Meaning for the receiver
`noise`	Something was heard that may be a small unmanned aircraft. Lowest confidence.
`unconfirmed`	A probable small unmanned aircraft.
`confirmed`	A small unmanned aircraft.

A contact normally moves up through the categories as it firms up. Each step is sent as an update of the same item (section 2.6).

1.2 CoT version and encoding

- CoT XML, `<event version="2.0">`.
- UTF-8. Each event begins with its own XML declaration: `<?xml version="1.0" encoding="UTF-8"?>`.
- The TAK Protocol version 1 protobuf encoding is **not** produced. PADS sends XML only.
- Labels contain the degree sign (U+00B0), so receivers must decode UTF-8.

1.3 Transport

The gateway is always the client. It connects out to the receiver and does not listen.

Transport	Status in schema 1.0	Notes
TLS stream to a TAK Server streaming input	Supported	TLS 1.2 or later. The gateway presents a client certificate and verifies the server against a certificate authority supplied by the operator. This is the normal path.
Plain TCP stream	Supported	For a receiver on the same device or a trusted local link, for example a TAK client's local TCP input.
UDP unicast	Supported	One event per datagram.
UDP multicast (mesh SA)	Not supported	The gateway does not set a multicast interface or time-to-live. Do not rely on PADS alerts appearing on the standard SA multicast group.

PADS defines no port of its own. The operator points the gateway at the receiver's address and port. With a TAK Server this is normally the server's TLS streaming input (commonly 8089). On a stream, events are written one after another with no separator; receivers should frame on `</event>`.

When PADS sends through a TAK Server, the server distributes the events to its clients according to its own group rules. PADS adds no group, mission or destination information to the events.

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2. Event element

2.1 Attributes

Attribute	Value
`version`	`2.0`
`uid`	See 2.3
`type`	See 2.2
`time`	Time of the report, UTC, `YYYY-MM-DDThh:mm:ss.sssZ`
`start`	Same value as `time`

Attribute	Value
`stale`	`time` plus the stale interval (2.5)
`how`	See 2.4

2.2 Type strings

Type	Used for
`a-f-G-E-S`	Patch marker (friendly ground equipment, sensor)
`u-d-f`	Line of bearing (free-form drawing with two vertices)
`a-h-A-M-H-Q`	Contact position, category `confirmed` (hostile air, rotary-wing unmanned)
`a-u-A-M-H-Q`	Contact position, category `unconfirmed` (unknown air, rotary-wing unmanned)
`t-x-d-d`	Delete

No contact position is sent for category `noise`. A `noise` contact appears as a line of bearing only.

2.3 UID formats

Item	UID	Notes
Patch marker	`pads-<node-id>`	<node-id> is a version-4 UUID that is stable for a given patch.
Line of bearing	`pads-lob-<node-id-8>-<contact-id>`	<node-id-8> is the first 8 characters of the patch's node id. One line per patch per contact.
Contact position	`pads-uas-<contact-id>`	One position per contact, whichever patches contributed.
Delete	`del-<uid-being-deleted>`	

<contact-id> is a 26-character ULID (Crockford base 32, upper case). The same contact keeps the same contact id for as long as PADS reports it, across all patches and all categories.

All PADS UIDs begin with `pads-` or `del-pads-`. Receivers may use the prefix to recognise PADS items.

2.4 `how`

Item	`how`
Patch marker	`m-g` (machine, position from the gateway device's GPS)
Line of bearing, contact position	`m-p` (machine, passed)
Delete	`m-g`

2.5 Time, start and stale

- `time` and `start` are the time of the report.

- `stale` is `time` plus the stale interval. The default interval is **60 seconds**. The operator can change it; receivers must use the `stale` attribute and not assume the default.
- PADS sends no `<archive/>` element. Items are meant to expire and need not be kept by the receiver.

2.6 Updates

An update is a new event with the **same** `uid` and a later `time`. The receiver should replace the earlier item.

- When a contact changes category, its line of bearing is re-sent with the same UID and with a new label, colour, line style and bearing.
- When a contact's position changes category from `unconfirmed` to `confirmed`, the position is re-sent with the same UID and the type changes from `a-u-A-M-H-Q` to `a-h-A-M-H-Q`. Receivers must accept a change of `type` on an existing UID.
- A patch marker is re-sent with the same UID when the patch reports again or moves.

Updates to one UID are not sent closer together than the gateway receives them from the patches. Receivers should order by `time`, not by arrival.

2.7 End of a contact and cancellation

- **Normal end:** PADS stops sending. The items pass their `stale` time and the receiver removes or greys them by its own rules. Schema 1.0 sends no explicit "contact lost" message.
- **Explicit delete:** the gateway can send a delete event, type `t-x-d-d`, whose detail names the UID to remove (section 4.4). The gateway does not send deletes automatically in schema 1.0; they are sent on operator action.

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3. Point element

All five attributes are always present. The value `9999999` means unknown, as is conventional in CoT.

Attribute	Patch marker	Line of bearing	Contact position	Delete
`lat`, `lon`	Position of the patch, taken from the paired gateway device. WGS 84, decimal degrees, 7 decimal places.	Position of the reporting patch (the origin of the line).	Position of the contact.	`0`, `0` (not meaningful)
`hae`	`9999999`	`9999999`	`9999999`	`9999999`
`ce`	`10` (a fixed placeholder in schema 1.0, not a measured value)	`9999999`	Horizontal position error of the contact in metres, rounded to a whole number, or `999 9999` if unknown	`9999999`

Attribute	Patch marker	Line of bearing	Contact position	Delete
le	9999999	9999999	9999999	9999999

PADS reports no altitude in schema 1.0. Receivers must not treat the point of a line of bearing as the location of the contact; it is the location of the sensor.

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4. Detail element

PADS uses only detail sub-elements that TAK clients already understand. Schema 1.0 adds **no custom PADS sub-element**, and sends no <track>, <precisionlocation>, <__group>, <status>, <takv> or <archive> element.

4.1 Patch marker (a-f-G-E-S)

Element	Attribute	Type	Required	Value
contact	callsign	string	yes	Operator-assigned name of the patch, for example PADS-1.
remarks	(text)	string	yes	Fixed text: Rendeer PADS patch, passive acoustic
usericon	iconsetpath	string	optional	7c1f0d5e-2a44-4b7e-9d1a-rendeer00001/Rendeer/pads.png. Shown only by clients that have the Rendeer icon set installed; other clients draw the standard symbol for the type. The operator can turn this element off.

4.2 Line of bearing (u-d-f)

Element	Attribute	Type	Required	Value
link (first)	point	lat,lon decimal degrees	yes	Origin of the line: the reporting patch. Same as the <point> element.
link (second)	point	lat,lon decimal degrees	yes	Far end of the line, along the reported bearing. See the note on line length below.
strokeColor	value	signed 32-bit ARGB integer	yes	−65536 (red) for confirmed, −256

Element	Attribute	Type	Required	Value
				(yellow) for `unconfirmed`, −1 (white) for `noise`.
`strokeWeight`	`value`	decimal	yes	`3.0`
`strokeStyle`	`value`	string	yes	`solid` for `confirmed`, `dashed` for `unconfirmed` and `noise`.
`contact`	`callsign`	string	yes	The label, see 4.5.
`remarks`	(text)	string	yes	See 4.6.
`labels_on`	`value`	boolean	yes	`true`

Line length. The line is drawn 300 metres long. This is a drawing length only. It is not a range to the contact and not a statement of how far the sensor can hear. A single patch gives no range. To recover the bearing, compute the direction from the first `link` point to the second (section 7.3), or read it from the label.

4.3 Contact position (`a-h-A-M-H-Q`, `a-u-A-M-H-Q`)

Element	Attribute	Type	Required	Value
`contact`	`callsign`	string	yes	The label, see 4.5. A position label carries no bearing.
`remarks`	(text)	string	yes	See 4.6.

4.4 Delete (`t-x-d-d`)

Element	Attribute	Type	Required	Value
`link`	`uid`	string	yes	UID of the item to remove.
`link`	`relation`	string	yes	`none`
`link`	`type`	string	yes	`none`
`__forcedelete`	(none)	empty element	yes	Present.

4.5 Label format (`contact/@callsign` on alerts)

The label is for people to read. Its wording may change in a later minor version (section 6), so receivers should not parse it if they can avoid it.

Category	Line-of-bearing label	Position label
`confirmed`	`SMALL UAS CONFIRMED BBB° hh:mm:ssZ`	`SMALL UAS CONFIRMED hh:mm:ssZ`
`unconfirmed`	`UAS UNCONFIRMED BBB° hh:mm:ssZ`	`UAS UNCONFIRMED hh:mm:ssZ`

Category	Line-of-bearing label	Position label
`noise`	`ACOUSTIC NOISE – POSSIBLE UAS BBB° hh:mm:ssZ`	(no position is sent)

- `BBB` is the bearing from the patch toward the contact in whole degrees from **true north**, three digits with leading zeros, `000` to `359`.
- `hh:mm:ssZ` is the UTC time of the report.

4.6 Remarks format on alerts

One line of text:

```
<category> from <patch callsign>, confidence <c>, bearing error <e> deg
```

Field	Type	Units and range
`<category>`	string	`noise`, `unconfirmed` or `confirmed`
`<patch callsign>`	string	Callsign of the reporting patch
`<c>`	decimal, two places	Confidence, `0.00` to `1.00`, no units
`<e>`	whole number	One-sigma bearing error in degrees

On a contact position, the remarks are those of the patch report that produced the event; the position itself comes from more than one patch.

In schema 1.0 the category, confidence, bearing and bearing error are available **only** in the label and remarks text. There is no machine-readable element for them yet (section 6.3).

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5. Example

5.1 Complete message: line of bearing, category `confirmed`

Shown on several lines for reading. On the wire the event is a single line with no whitespace between elements.

```
<?xml version="1.0" encoding="UTF-8"?>
<event version="2.0"
       uid="pads-lob-00000000-01EXAMPLE000000000000000A"
       type="u-d-f"
       time="2026-01-01T12:00:00.000Z"
       start="2026-01-01T12:00:00.000Z"
       stale="2026-01-01T12:01:00.000Z"
       how="m-p">
  <point lat="10.0000000" lon="20.0000000" hae="9999999" ce="9999999" le="9999999"/>
  <detail>
    <link point="10.0000000,20.0000000"/>
    <link point="10.0019077,20.0019372"/>
    <strokeColor value="-65536"/>
    <strokeWeight value="3.0"/>
    <strokeStyle value="solid"/>
    <contact callsign="SMALL UAS CONFIRMED 045° 12:00:00Z"/>
    <remarks>confirmed from PADS-1, confidence 0.50, bearing error 10 deg</remarks>
    <labels_on value="true"/>
  </detail>
</event>
```

The confidence, bearing-error and `ce` values shown are arbitrary placeholders, the same in every example, and say nothing about PADS performance.

5.2 The other message kinds, for reference

The confidence, bearing-error and `ce` values shown are arbitrary placeholders, the same in every example, and say nothing about PADS performance.

Patch marker:

```
<?xml version="1.0" encoding="UTF-8"?>
<event version="2.0" uid="pads-00000000-0000-4000-8000-000000000001" type="a-f-G-E-S"
       time="2026-01-01T12:00:00.000Z" start="2026-01-01T12:00:00.000Z" stale="2026-01-01T12:
        01:00.000Z" how="m-g">
  <point lat="10.0000000" lon="20.0000000" hae="9999999" ce="10" le="9999999"/>
  <detail>
    <contact callsign="PADS-1"/>
    <remarks>Rendeer PADS patch, passive acoustic</remarks>
    <usericon iconsetpath="7c1f0d5e-2a44-4b7e-9d1a-rendeer00001/Rendeer/pads.png"/>
  </detail>
</event>
```

Contact position, category `confirmed`:

```
<?xml version="1.0" encoding="UTF-8"?>
<event version="2.0" uid="pads-uas-01EXAMPLE000000000000000A" type="a-h-A-M-H-Q"
       time="2026-01-01T12:00:00.000Z" start="2026-01-01T12:00:00.000Z" stale="2026-01-01T12:
        01:00.000Z" how="m-p">
  <point lat="10.0010000" lon="20.0010000" hae="9999999" ce="25" le="9999999"/>
  <detail>
    <contact callsign="SMALL UAS CONFIRMED 12:00:00Z"/>
    <remarks>confirmed from PADS-1, confidence 0.50, bearing error 10 deg</remarks>
  </detail>
</event>
```

Delete:

```
<?xml version="1.0" encoding="UTF-8"?>
<event version="2.0" uid="del-pads-uas-01EXAMPLE000000000000000A" type="t-x-d-d"
       time="2026-01-01T12:00:00.000Z" start="2026-01-01T12:00:00.000Z" stale="2026-01-01T12:
        01:00.000Z" how="m-g">
  <point lat="0.0000000" lon="0.0000000" hae="9999999" ce="9999999" le="9999999"/>
  <detail>
    <link uid="pads-uas-01EXAMPLE000000000000000A" relation="none" type="none"/>
    <__forcedelete/>
  </detail>
</event>
```

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6. Versioning and compatibility

6.1 Version numbers

The schema version is `major.minor`. This document is version 1.0.

- A **minor** version (1.1, 1.2, …) only adds. It may add optional detail sub-elements, optional attributes, new values for an existing free-text field, or a new CoT type for a new kind of item. Everything in the previous minor version keeps its meaning.
- A **major** version (2.0) is used for any change that could break a receiver written to this document: removing or renaming an element, changing a UID format, changing units, or changing the meaning of an existing type.

Schema 1.0 messages do not carry the schema version. A version marker will be added in a minor version (6.3); a message with no marker is schema 1.0.

6.2 Rules for receivers

A receiver written to this document will keep working across minor versions if it:

1. Ignores detail sub-elements and attributes it does not recognise.
2. Recognises PADS items by UID prefix (`pads-`) and CoT type, not by label text.
3. Uses the `stale` attribute and does not assume a fixed interval.
4. Accepts a change of `type` on an existing UID.
5. Treats `9999999` as unknown.
6. Does not depend on the order of sub-elements inside `<detail>`.
7. Does not assume the far end of a line of bearing is the contact's position.

6.3 Known limits of schema 1.0

These are stated so that receivers are not surprised. Each can be lifted in a minor version without breaking the rules above.

- Category, confidence, bearing and bearing error are carried only as text in the label and remarks. A machine-readable PADS detail sub-element, carrying the same values and the schema version, is

the intended addition. It will be a new optional element; the label and remarks will remain.
- No explicit end-of-contact message; items expire by `stale`.
- No altitude, elevation angle, course or speed.
- No TAK Protocol protobuf encoding and no multicast transport.
- The `ce` on a patch marker is a fixed placeholder.

6.4 Related output

PADS also produces SAPIENT (BSI Flex 335 v2.0) detection reports from the same alerts. That interface follows the published standard and is not described here.

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7. Direction of arrival, for slew-to-cue

This section tells the developer of an optic, radar or counter-drone system how to take a pointing cue from a PADS alert. It restates fields defined above; it adds nothing to the format.

7.1 Does PADS send a bearing?

Yes. Every alert from a patch is sent as a line-of-bearing event (type `u-d-f`, UID `pads-lob-...`), and that event carries the direction from the patch toward the contact.

Schema 1.0 has **no dedicated numeric bearing field**. The bearing is carried in two places:

Where	Form	Resolution	Use
The two `<link point="lat,lon"/>` elements in `<detail>`	Geometry: the first point is the patch, the second lies on the bearing from it	Coordinates to 7 decimal places	**Preferred for machines.**
`contact/@callsign` (the label)	Text `BBB°`, three digits	Whole degrees, `000` to `359`	For people. Usable by machines, but the wording may change in a minor version.

The remarks text carries the one-sigma **bearing error** in whole degrees (section 4.6). It does not repeat the bearing.

7.2 Units and reference

- Degrees, clockwise from **true north**. Not magnetic and not grid. Apply your own declination or grid convergence if your mount works in another reference.
- Azimuth only. Schema 1.0 sends **no elevation angle** and no altitude, so a cue fixes the pan axis only.
- The bearing is measured **from the patch's position**, which is the `<point>` of the event and the first `link` point. That position is the position of the gateway device the patch is paired with.
- No range is sent with a line of bearing. The second `link` point is 300 metres along the bearing for drawing only; it is not the contact's position.

7.3 Recovering the bearing from the geometry

Take the first `link` point as (lat1, lon1) and the second as (lat2, lon2), in radians. The bearing is the initial great-circle azimuth from the first to the second:

```
bearing = atan2( sin(lon2 − lon1) ∗ cos(lat2),
                 cos(lat1) ∗ sin(lat2) − sin(lat1) ∗ cos(lat2) ∗ cos(lon2 − lon1) )
```

Convert to degrees and reduce to the range 0 to 360. The gateway places the second point with the matching great-circle formula on a sphere, so this recovers the bearing the gateway was given.

7.4 Pointing from somewhere other than the patch

A line of bearing is a line on the map that starts at the patch. A system standing at the patch can pan straight to the bearing. A system standing anywhere else cannot turn one line of bearing into a single pointing angle, because the contact may be anywhere along the line; it must search along the line.

When PADS holds a position for the contact it also sends a contact-position event (UID `pads-uas-<contact-id>`, section 4.3) with the contact's latitude and longitude and a horizontal error in `ce`. A remote system should cue to that position when it is present, and use lines of bearing when it is not. The line of bearing and the position for one contact share the same `<contact-id>`.

7.5 Timing: how fresh a cue is

- `time` (and `start`) is the time of the patch report the cue is based on. The age of a cue is the receiver's clock minus `time`; both ends need UTC for this to mean anything.
- `stale` is `time` plus the stale interval, 60 seconds by default and settable by the operator. **Stop cueing on a line of bearing once it is stale.**
- A newer report for the same contact from the same patch arrives as an event with the **same UID** and a later `time`. Replace the old bearing with the new one; do not average across events unless your own tracker chooses to.
- Schema 1.0 defines no fixed update rate and sends no heartbeat. Updates arrive when the patch reports.
- There is no end-of-contact message. A contact that is no longer heard simply stops updating and goes stale.
- The category can change between updates (section 2.6). It is in the label and the remarks, and is reflected in `strokeColor` and `strokeStyle`. A cueing system may choose which categories it acts on.

7.6 Example: a cue at bearing 270° true

Placeholder values throughout.

```
<?xml version="1.0" encoding="UTF-8"?>
<event version="2.0" uid="pads-lob-00000000-01EXAMPLE0000000000000000B" type="u-d-f" time="20
        26-01-01T12:00:00.000Z" start="2026-01-01T12:00:00.000Z" stale="2026-01-01T12:01:00.0
        00Z" how="m-p">
  <point lat="10.0000000" lon="20.0000000" hae="9999999" ce="9999999" le="9999999"/>
  <detail>
    <link point="10.0000000,20.0000000"/>
    <link point="10.0000000,19.9972604"/>
    <strokeColor value="-256"/>
    <strokeWeight value="3.0"/>
    <strokeStyle value="dashed"/>
    <contact callsign="UAS UNCONFIRMED 270° 12:00:00Z"/>
    <remarks>unconfirmed from PADS-1, confidence 0.50, bearing error 10 deg</remarks>
    <labels_on value="true"/>
  </detail>
</event>
```

The confidence, bearing-error and `ce` values shown are arbitrary placeholders, the same in every example, and say nothing about PADS performance.

Reading it as a cue:

Item	Value	Taken from
Sensor position	10.0000000, 20.0000000	`<point>`, or the first `link`
Bearing	270° true	Computed from the two `link` points (7.3); also `270°` in the label
Bearing error	10° (one sigma)	Remarks
Category	`unconfirmed`	Remarks; yellow dashed line
Time of report	2026-01-01T12:00:00.000Z	`time`
Valid until	2026-01-01T12:01:00.000Z	`stale`
Contact	`01EXAMPLE0000000000000000B`	Last part of the UID
Elevation, range	not sent	

7.7 What a cueing integrator should know is missing

- No machine-readable bearing element (planned as an optional addition, section 6.3).
- No elevation.
- No range from a single patch.
- No bearing rate, course or speed.
- No explicit loss-of-contact message.

Rendeer Systems, LLC. This document describes a message format. It contains no sensor design, processing or performance information.