ASCOM ALPACA

API Reference

Abstract

This document is the technical reference for the ASCOM Alpaca APIs and describes how to use the API. It also describes the Alpaca Discovery protocol and some of the fundamental behavioural principles that underly the APIs and their effective exploitation.

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1. Introduction

1.1 Language

When used within this document, these words have the following meanings:

Term	Meaning
Alpaca Device	Hardware or software that supports the Alpaca Management and Alpaca Device API protocols to provide access to one or more ASCOM Devices.
ASCOM Device	An implementation of an ASCOM device interface such as ITelescope or IFocuser that can be accessed through the Alpaca Device API protocol.
ASCOM Device Type	One of ASCOM's supported hardware device types e.g. telescopes, focusers, rotators and cameras.
IP Endpoint	The host / IP address and port number on which the Alpaca device is operating
Must	This is an absolute, mandated, requirement; no deviation is possible.
Should	This is highly recommended best practice, but is not mandated
Could	This is optional at the implementor's discretion

1.2 Alpaca Devices

An Alpaca Device is a hardware device or software program that presents one or more ASCOM Devices through the Alpaca protocol and communicates with clients over a TCP/IP network through its IP Endpoint.

2. For the best astronomer user experience, Alpaca Devices should also implement the Alpaca Discovery protocol (see section 4, Alpaca Device Management

This section describes the HTTP and REST management APIs for Alpaca devices.

2.1 HTML Interfaces

The Alpaca Management API defines a main HTML browser URL that acts as the primary user entry point for the whole Alpaca device. The returned web page must, at minimum, display overall information about the device and its manufacturer.

In addition, the API defines a dedicated URL for each ASCOM Device presented by the Alpaca Device so that ASCOM Device specific configuration can be set. This API is intended to facilitate configuration of a single ASCOM Device, in a similar fashion to the COM SetupDialog method.

2.1.1 Main Alpaca Setup URL

The main Alpaca Device setup HTTP page should be provided on the "setup" path of the device's Alpaca Port:

<div align="center">

`http(s)://host:port/setup`

</div>

At minimum this must provide manufacturer and device descriptive information. This could be a good place to enable the astronomer user to change the Alpaca discovery port number and any other "whole device" configuration settings.

2.1.2 ASCOM Device Specific Setup URLs

These follow a similar format to the Alpaca Device API with an overall format of:

<div align="center">

`http(s)://host:port/path`

</div>

The Alpaca device API path consists of five elements:

<div align="center">

`/api/vversion_number/device_type/device_number/command`

</div>

Fixed elements are blue and variable elements are red.

Element Number	Element	Description
1	setup	Fixed lower-case text denoting the root of the API path
2	vversion_number	Integer API version number prefixed with a lower-case v
3	device_type	ASCOM device type e.g. camera, telescope, focuser etc.
4	device_number	Integer device number of the required device
5	setup	Fixed lower case text denoting the device setup page

For example, this is a device specific setup URL for telescope 0:

<div align="center">

`http://api.peakobservatory.com/setup/v1/telescope/0/setup`

</div>

2.2   JSON Management API

The Alpaca management API is described here: Alpaca Management API.

2.2.1   Supported API Versions

The Alpaca device API uses an interface version number (see section 3.9) to manage changes to the Alpaca access elements that are described in section 3.1. The format of the apiversions URL is:

<p align="center">http(s)://host:port/management/apiversions</p>

For example, this is an api version URL:

<p align="center">http://api.peakobservatory.com/management/apiversions</p>

Please note that there is no Alpaca API version number in the apiversions URL.

This is by design so that this URL will work regardless of any Alpaca interface version number changes in the future.

To provide backward compatibility, an Alpaca device can simultaneously support more than one Alpaca interface version, and this is indicated by returning more than one integer version number in the apiversions array.

At the time of writing only interface version 1 is defined and consequently all Alpaca devices should return an integer array, containing the single value 1, as the response to this command.

2.2.2   Description and Configured Devices

The "description" endpoint should return cross cutting information about the Alpaca Device as a whole, such as its name and location.

The configureddevices endpoint should return an array of device configuration objects that describe the ASCOM Device's that are presented by the Alpaca Device. Each device description must include the device's name, it's ASCOM device type, the device number that must be used to communicate with this particular ASCOM Device and a globally unique id for this particular device.

The Alpaca management API path for these commands consists of three elements:

<p align="center">/management/vversion_number/command</p>

Fixed elements are blue and variable elements are red.

Element Number	Element	Description
1	management	Fixed lower-case text denoting the root of the API path
2	vversion_number	Integer API version number prefixed with a lower-case v
3	command	Either "description" or "configureddevices" as required

For example, these are valid calls:

<p align="center">http://api.peakobservatory.com/management/v1/description</p>

<p align="center">http://api.peakobservatory.com/management/v1/configureddevices</p>

2.2.3 Globally Unique IDs (UIDs)

These are string identifiers that must be globally unique. This means that identical hardware devices must have unique individual UID's that are never assigned to other devices of the same type and are never assigned to devices of any other type.

The purpose of UIDs is to support "re-discovery" of Alpaca Devices in the event that a device's IP address changes but where client configurations are not automatically revised to match. For further information please see section 0.

Alpaca Discovery).
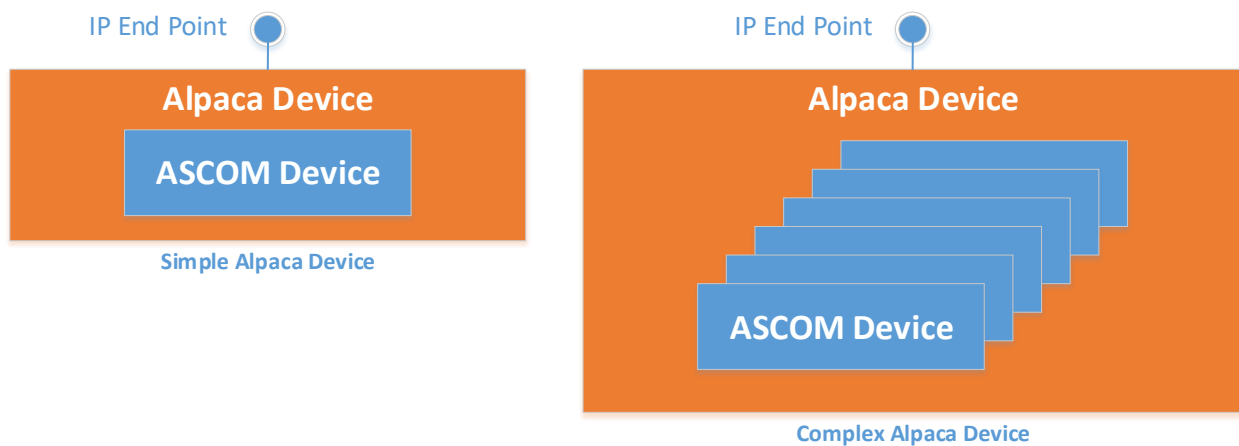
The simplest Alpaca Device would present a single ASCOM Device, such as a focuser or filter wheel, and would be dedicated to this single task. This approach will work well for existing devices that support serial or USB connections for example and that are to be updated to support network connectivity.

A **complex** Alpaca Device may present multiple[1] ASCOM Devices of several different ASCOM Device Types through its single IP Endpoint. For example, a single Alpaca Device could present a dome, a mount, several focusers, a filter wheel and a rotator together with some observing conditions devices.

In today's ASCOM COM architecture all drivers fit the "simple" model above where one ProgID, the device's well-known address, is associated with just one ASCOM Device.

2.3 Consolidation

The Alpaca API supports consolidation of multiple downstream Alpaca Devices into one virtual Alpaca Device that presents a single aggregated device tree under one IP end point. This opens the way to creation of physical devices that proxy Alpaca requests and also to use of web servers as reverse proxies that front multiple Alpaca Devices.

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[1] Each Alpaca device can support up to 2,147,483,647 instances of each of the supported ASCOM Device Types.

2.4 Supported ASCOM Device Types

All ASCOM device types are supported except for Video. This was omitted because the Video interface specifies that recorded video is saved as a file on local storage rather than being streamed over an IP network.

2.5 ASCOM Alpaca API Documentation

The ASCOM RESTful APIs are documented using the Swagger toolset and are available through a URL on the ASCOM Standards web site. The ASCOM API is fully documented here:

<p align="center"><code>https://www.ascom-standards.org/api</code></p>

To start exploring go to the above API URL and click a grey Show/Hide link to expand one of the sets of methods and then click the blue GET or orange PUT methods for detailed information on that API call.

Anyone who is familiar with the ASCOM COM based APIs will feel at home with the functionality available through the Alpaca API.

3. Alpaca Device API Contract

This section describes how to construct REST calls to devices that expose ASCOM Alpaca interfaces. It assumes a basic knowledge of HTTP, JSON and REST.

3.1 Alpaca Device API Format

3.1.1 Basic format

Alpaca APIs follow the standard Internet URL format:

`http(s)://host:port/path?parameters`

3.1.2 Alpaca API Path

The Alpaca device API path consists of five elements:

`/api/vversion_number/device_type/device_number/command`

Fixed elements are blue and variable elements are red.

Element Number	Element	Description
1	api	Fixed lower-case text denoting the root of the API path
2	vversion_number	Integer API version number prefixed with a lower-case v
3	device_type	ASCOM device type e.g. camera, telescope, focuser etc.
4	device_number	Integer device number of the required device
5	command	Command to be processed by the device in lower-case

For example, these are valid API calls:

`http://api.peakobservatory.com/api/v1/telescope/0/atpark`
`http://api.peakobservatory.com/api/v1/camera/0/imagearray`

3.1.3 Parameters

Many ASCOM methods require parameter values. All methods that use the **HTTP GET** verb should include parameters as query string name-value pairs.

All methods that use the **HTTP PUT** verb should include name-value parameters in the body using the "application/x-www-form-urlencoded" media type.

For example, these are valid API parameters on an HTTP GET transaction:

`/api/v1/telescope/0/canslew?clientid=231&clienttransactionid=23`

3.2 Case Sensitivity

3.2.1 API Path

All five elements of the API path are **case sensitive** and must always be in **lower case**. For example, this is the only valid casing for a call to the Telescope.CanSlew property:

`/api/v1/telescope/0/canslew`

These are examples of invalid casing:

~~/API/V1/TELESCOPE/0/CANSLEW~~   ~~/Api/V1/Telescope/0/CanSlew~~
~~/api/v1/telescopE/0/canslew~~   ~~/api/v1/telescope/0/CanSlew~~

3.2.2 Alpaca API Parameters

Alpaca parameters are key-value pairs where:

- The parameter **key** is **case insensitive**
- The parameter **value** can have **any casing** required.

This is the same behaviour as defined for HTTP header keys in RFC 2616 (HTTP/1.X) and RFC7540 (HTTP/2).

For example, these are all valid API parameters:

```
/api/v1/telescope/0/canslew?clientid=231&clienttransactionid=23
/api/v1/telescope/0/canslew?ClientID=231&ClientTransactionID=23
/api/v1/telescope/0/canslew?CLIENTID=231&CLIENTTRANSACTIONID=23
```

Clients and drivers must expect incoming API parameter keys to have arbitrary casing.

3.3 Locale and Culture

The Alpaca API is culture neutral in order to facilitate use between clients and devices running in different locales, e.g. a client running on a UK locale device connecting to a remote device running with a Spanish locale.

This has consequences for data formats in two circumstances:

3.3.1 Encoding Parameter Values That Have Decimal Points

When decimal parameter values are passed into the API, they must use period (0x2E) as the decimal separator. This is so that they can be reliably parsed on receipt

E.g. **23.456** is a valid value to supply when setting the Telescope.TargetRightAscension property, while ~~23,456~~ is not a valid value.

3.3.2 JSON Responses

JSON responses must be formatted in accordance with the JavaScript Object Notation (JSON) Data Interchange Format specification RFC 8259. In consequence Alpaca devices must use the period character (0x2E) as the decimal separator when returning decimal values.

Alpaca Clients must expect to receive decimal values in this invariant culture format and to interpret them accordingly.

e.g. Clients must parse the value returned by the Telescope.SiteElevation property using period as the decimal separator, regardless of the locale in which they are running.

3.4 Http Verbs

Verb	Description
GET	Used for all information retrieval where the device state is not changed, e.g. most properties and a few functions such as Telescope. AxisRates(Axis).
PUT	Used for all commands which change the state of the device, e.g. Telescope.SideOfPier and Telescope.SlewToCoordinates().

3.5 HTTP Status Codes

Returned HTTP status codes should reflect the device's status as follows:

Code	Interpretation	Extended Interpretation
200	OK	The API request was handled successfully and the response is in the expected JSON format for the supplied command.
400	Bad request	The API request could not be understood. The response is a text error message and is not in the expected JSON format.
500	Internal Server Error	A technical error occurred in the Alpaca device which prevented successful processing of the request. The response is a text error message and is not in the expected JSON format.

The following flow diagram shows how to decide which HTTP status code to return.
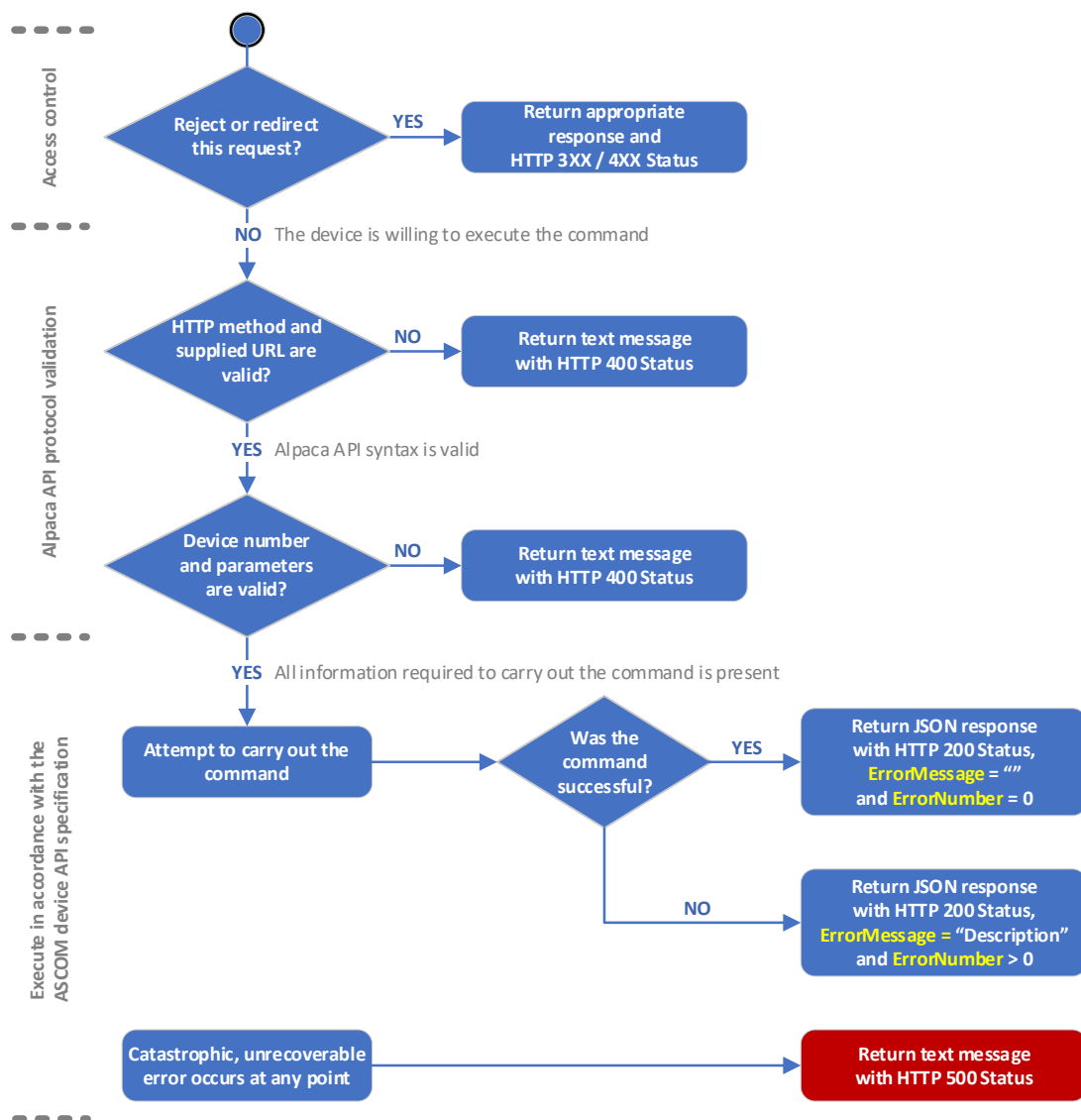
Please note that, catastrophic errors aside, a 200 status must be returned when the device understands the supplied command regardless of whether or not it can action it in an ASCOM sense.

3.5.1 Status Code Examples - Transactions with Valid Paths

A "200" status code must be returned if the transactions below were received by an Alpaca Telescope device that supports Alpaca interface version 1:

Path	Reason for Rejection with 200 Status
PUT /api/v1/telescope/0/park	Assuming this telescope device does not have park functionality, it would return a NotImplemented Alpaca error code (0x400) and message with an HTTP 200 status.
PUT: /api/v1/telescope/0/siteelevation New value: -400	Elevations lower than -300m are invalid so return an InvalidValue Alpaca error code (0x401) and message with an HTTP 200 status.

3.5.2 Status Code Examples - Transactions with Bad Paths

A "400" status code must be returned if the transactions below were received by an Alpaca Camera device that only supports Alpaca interface version 1:

Path	Reason for Rejection with 400 Status
GET: /apii/v1/telescope/0/canslew	Valid Alpaca API requests start with "api" rather than "apii".
GET: /api/v2/telescope/0/canslew	The Alpaca "v2" API is not supported by the device.
GET: /api/v1/telescop/0/canslew	"Telescop" is not one of the valid ASCOM device types.
GET: /api/v1/camera/0/canslew	"CanSlew" is not a valid Camera command.

3.6 ID Fields

To aid operational management and debugging, three optional ID fields are defined that can be supplied as parameters on read and write transactions:

ID	Maintained by	Description
ClientID	Client	This is a 32-bit unsigned integer that the client can choose to identify itself. It is recommended that values should be within the range 0::65535 so that log files appear orderly and readable!
ClientTransactionID	Client	This is a 32-bit unsigned integer that the client maintains. The value should start at 1 and be incremented by the client on each request to the Alpaca device.
ServerTransactionID	Alpaca Device	This is a 32-bit unsigned integer that the Alpaca device maintains. The value should start at 1 and be incremented by the Alpaca device on each request.

The client id and transaction numbers should be supplied by the client in the request to uniquely identify the client instance and specific transaction. The Alpaca device must return the client transaction number, or zero if no value was supplied by the client, as part of its response to enable the client to confirm that the response does relate to the request it submitted.

Alpaca devices should record client ids and transaction numbers in their logs so that issues can be tied back to specific transactions and outcomes correlated with client-side logs.

The server transaction id should be returned by the Alpaca device with every response so that issues identified on the client side can easily be correlated with Alpaca device logs.

3.7 JSON Responses

The outcome of the command is returned in JSON encoded form. The following information should1 always be returned in every transaction response that has an HTTP 200 status:

Item	Type	Contents
ClientTransactionID	Unsigned 32-bit integer	Transaction ID supplied by the client in its request
ServerTransactionID	Unsigned 32-bit integer	The server's transaction number.
ErrorNumber	Signed 32-bit integer	ASCOM Alpaca error number, see section 3.8.3.
ErrorMessage	String	If the driver throws an exception, its message appears here, otherwise an empty string is returned.

In addition, the JSON response will include the output from the command (if any) in the "Value" parameter. This example is from the Telescope Simulator SupportedActions property:

```
GET /api/v1/telescope/0/supportedactions?ClientID=1&ClientTransactionID=6
```

{"Value":["AssemblyVersionNumber","SlewToHA","AvailableTimeInThisPointingState","TimeUntilPointingStateCanChange"],"ClientTransactionID":6,"ServerTransactionID":6, "ErrorNumber":0, "ErrorMessage":"" }

This example shows the response from the Telescope simulator's CanSlewAsync property:

```
GET /api/v1/telescope/0/canslewasync?ClientID=1&ClientTransactionID=20
```

{"Value":true,"ClientTransactionID":20,"ServerTransactionID":168, "ErrorNumber":0, "ErrorMessage":"" }

3.8 Reporting Device Errors Through the Alpaca API

3.8.1 Historic COM Approach

ASCOM COM drivers use a range of reserved ASCOM exceptions and unique driver specific exceptions to report issues to COM clients such as "this method is not implemented" or "the supplied parameter is invalid" and these are documented in the Developer Help file at:

https://ascom-standards.org/Help/Developer/html/N_ASCOM.htm

Each exception has an associated HResult code in the range 0x80040400 to 0x80040FFF for historic reasons related to Microsoft's approach to error handling for COM applications. When expressed as signed integers these exception numbers translate into very large and unwieldy negative numbers e.g. 0x80040400 becomes -2,147,220,480 and 0x80040FFF becomes -2,147,217,409.

3.8.2 New Alpaca Approach

Alpaca devices still need to express different error conditions to the client so, for Alpaca, the error number range has been simplified to the range 0x400 (1024) to 0xFFF (4095) by truncating the leftmost 5 digits so that an Alpaca error number of 0x401 would have the same meaning as the original COM error with HResult of 0x80040401.

3.8.3 ASCOM Reserved Error Numbers

The following table relates the new Alpaca error codes for reserved ASCOM error conditions to the corresponding COM HResult numbers, which are in the range 0x80040400 to 0x800404FF.

Condition	Alpaca Error Number	COM Exception Number
Successful transaction	0x0 (0)	N/A
Property or method not implemented	0x400 (1024)	0x80040400
Invalid value	0x401 (1025)	0x80040401
Value not set	0x402 (1026)	0x80040402
Not connected	0x407 (1031)	0x80040407
Invalid while parked	0x408 (1032)	0x80040408
Invalid while slaved	0x409 (1033)	0x80040409
Invalid operation	0x40B (1035)	0x8004040B
Action not implemented	0x40C (1036)	0x8004040C

3.8.4 Driver Specific Error Numbers

The Alpaca error number range for driver specific errors is 0x500 to 0xFFF and their use and meanings are at the discretion of driver / firmware authors.

3.8.5 Error Number Backwards Compatibility

Native Alpaca clients will inspect the ErrorNumber and ErrorMessage fields as returned to determine if something went wrong with the transaction. However, to ensure COM client backward compatibility, ASCOM Remote clients will translate Alpaca error numbers into their equivalent COM exception numbers before throwing the expected ASCOM exceptions to the COM client.

3.8.6 Driver Error Example

The following example shows the expected invalid value JSON response when an attempt is made to set the site elevation to -400, which is below the minimum allowed value of -300.

```
PUT /api/v1/Telescope/0/SiteElevation
```
(parameters for the PUT verb are placed in the form body (not shown here) and do not appear after the URI as they do for the GET verb)

Expected JSON response:

{"ClientTransactionID":23,"ServerTransactionID":55,**"ErrorNumber":1025,**
"ErrorMessage":"SiteElevation set - '-400' is an invalid value. The valid range is: -300 to 10000."}

3.9 Alpaca API Version versus ASCOM Device InterfaceVersion

The scope of the Alpaca API version number is just the new Alpaca API presentation elements and their order as described in sections 3.1 and 4.1.2. Any change to the naming, format or order of the elements in these URLs would constitute a breaking change and require that the Alpaca API version be incremented so that clients and devices can adapt their behaviour to match the new standard.

For backward compatibility, a device can support more than one interface version. A list of supported interface versions is available through the Alpaca management API as described in section 4.2.1.

Examples of breaking changes that would require a new Alpaca API version number:
- Changing element 1 from "api" to "alpacaApi"
- Changing the element 2 version number format from "v1" to "v1.0.0.0"
- Introducing a new element 6

The ASCOM Device InterfaceVersion defines the behaviour of the specified ASCOM Device when presented with commands through the Alpaca API. InterfaceVersions will change as device APIs are developed, however these changes are independent of the Alpaca API presentation elements and so do not require that the Alpaca API version be changed as well.

3.10 Robustness Principle (Postel's Law)

"Be conservative in what you do, be liberal in what you accept from others."

Alpaca clients and devices should behave in line with the robustness principle. For example:

- Alpaca clients should ensure that their commands adhere exactly to the API specification
- Alpaca devices should ensure that their responses adhere exactly to the API specification
- Alpaca clients and devices should not return errors when optional elements such as ClientID or ServerTransactionID are not present
- Alpaca clients and devices should not return errors when unrecognised parameters are received.

4. Alpaca Device Management

This section describes the HTTP and REST management APIs for Alpaca devices.

4.1 HTML Interfaces

The Alpaca Management API defines a main HTML browser URL that acts as the primary user entry point for the whole Alpaca device. The returned web page must, at minimum, display overall information about the device and its manufacturer.

In addition, the API defines a dedicated URL for each ASCOM Device presented by the Alpaca Device so that ASCOM Device specific configuration can be set. This API is intended to facilitate configuration of a single ASCOM Device, in a similar fashion to the COM SetupDialog method.

4.1.1 Main Alpaca Setup URL

The main Alpaca Device setup HTTP page should be provided on the "setup" path of the device's Alpaca Port:

<div align="center">

`http(s)://host:port/setup`

</div>

At minimum this must provide manufacturer and device descriptive information. This could be a good place to enable the astronomer user to change the Alpaca discovery port number and any other "whole device" configuration settings.

4.1.2 ASCOM Device Specific Setup URLs

These follow a similar format to the Alpaca Device API with an overall format of:

<div align="center">

`http(s)://host:port/path`

</div>

The Alpaca device API path consists of five elements:

<div align="center">

`/api/vversion_number/device_type/device_number/command`

</div>

Fixed elements are blue and variable elements are red.

Element Number	Element	Description
1	setup	Fixed lower-case text denoting the root of the API path
2	vversion_number	Integer API version number prefixed with a lower-case v
3	device_type	ASCOM device type e.g. camera, telescope, focuser etc.
4	device_number	Integer device number of the required device
5	setup	Fixed lower case text denoting the device setup page

For example, this is a device specific setup URL for telescope 0:

<div align="center">

`http://api.peakobservatory.com/setup/v1/telescope/0/setup`

</div>

4.2 JSON Management API

The Alpaca management API is described here: Alpaca Management API.

4.2.1 Supported API Versions

The Alpaca device API uses an interface version number (see section 3.9) to manage changes to the Alpaca access elements that are described in section 3.1. The format of the apiversions URL is:

`http(s)://host:port/management/apiversions`

For example, this is an api version URL:

`http://api.peakobservatory.com/management/apiversions`

Please note that there is no Alpaca API version number in the apiversions URL.

This is by design so that this URL will work regardless of any Alpaca interface version number changes in the future.

To provide backward compatibility, an Alpaca device can simultaneously support more than one Alpaca interface version, and this is indicated by returning more than one integer version number in the apiversions array.

At the time of writing only interface version 1 is defined and consequently all Alpaca devices should return an integer array, containing the single value 1, as the response to this command.

4.2.2 Description and Configured Devices

The "description" endpoint should return cross cutting information about the Alpaca Device as a whole, such as its name and location.

The configureddevices endpoint should return an array of device configuration objects that describe the ASCOM Device's that are presented by the Alpaca Device. Each device description must include the device's name, it's ASCOM device type, the device number that must be used to communicate with this particular ASCOM Device and a globally unique id for this particular device.

The Alpaca management API path for these commands consists of three elements:

`/management/vversion_number/command`

Fixed elements are blue and variable elements are red.

Element Number	Element	Description
1	management	Fixed lower-case text denoting the root of the API path
2	vversion_number	Integer API version number prefixed with a lower-case v
3	command	Either "description" or "configureddevices" as required

For example, these are valid calls:

`http://api.peakobservatory.com/management/v1/description`

`http://api.peakobservatory.com/management/v1/configureddevices`

4.2.3 Globally Unique IDs (UIDs)

These are string identifiers that must be globally unique. This means that identical hardware devices must have unique individual UID's that are never assigned to other devices of the same type and are never assigned to devices of any other type.

The purpose of UIDs is to support "re-discovery" of Alpaca Devices in the event that a device's IP address changes but where client configurations are not automatically revised to match. For further information please see section 0.

5. Alpaca Discovery

5.1 Introduction

Clients can discover Windows COM based drivers through ASCOM's registry-based Chooser capability. However, Alpaca devices can run on any operating system and may be located on different devices than client applications. Consequently, Alpaca clients need a discovery mechanism that enables them to locate Alpaca devices within their local network environment.

5.2 Definitions

Within this section "Device" refers to something (a driver or device) that exposes the Alpaca interface and "Client" refers to client applications that want to locate and use the Device's API(s).

- **DISCOVERY PORT:** the port to which the Client Broadcasts the discovery message and on which the Device listens. The Alpaca default discovery port is 32227.
- **DISCOVERY MESSAGE:** the message broadcast by the client on the DISCOVERY PORT.
- **RESPONSE MESSAGE:** is the message that the Device sends back via unicast to the client.
- **ALPACA PORT:** is the port on which the Alpaca management and device APIs are available.
- **ASCOM DEVICE:** An implementation of an ASCOM device interface such as ITelescope or IFocuser that can be accessed through the Alpaca Device API protocol.
- **UNIQUE ID:** A string identifier for an ASCOM DEVICE that is globally unique.
- **ALPACA DEVICE:** Hardware or software that supports the Alpaca Management and Alpaca Device API protocols to provide access to one or more ASCOM DEVICES.

5.3 Alpaca Discovery Protocol - IPv4

5.3.1 Clients

Clients find devices through a UDP protocol (see Figure 1) that uses:
- the IPv4 network broadcast address
- a designated IP port number, whose default is 32227
- a structured DISCOVERY MESSAGE
- a structured RESPONSE MESSAGE

To search for and use ALPACA DEVICES, a client should:
1. Transmit a DISCOVERY MESSAGE to the DISCOVERY PORT by broadcast (IPv4).
2. Use the IP address from the RESPONSE MESSAGE together with the ALPACA PORT from the DISCOVERY RESPONSE to query the Alpaca Management API to determine which ASCOM DEVICES and device types are available.
3. When selected by the user, access specific devices through the ALPACA DEVICE API that also runs on the ALPACA PORT at the IP address of the initiator of the RESPONSE MESSAGE.

5.3.2 Devices

To listen for IPv4 DISCOVERY MESSAGEs, Alpaca devices should:

1. Listen for IPv4 broadcasts on the DISCOVERY PORT
2. Assess each received message to confirm whether it is a valid DISCOVERY MESSAGE.
3. If the request is valid, return a RESPONSE MESSAGE indicating the device's ALPACA PORT.

The following figure gives a conceptual overview of the IPv4 and IPv6 discovery processes.
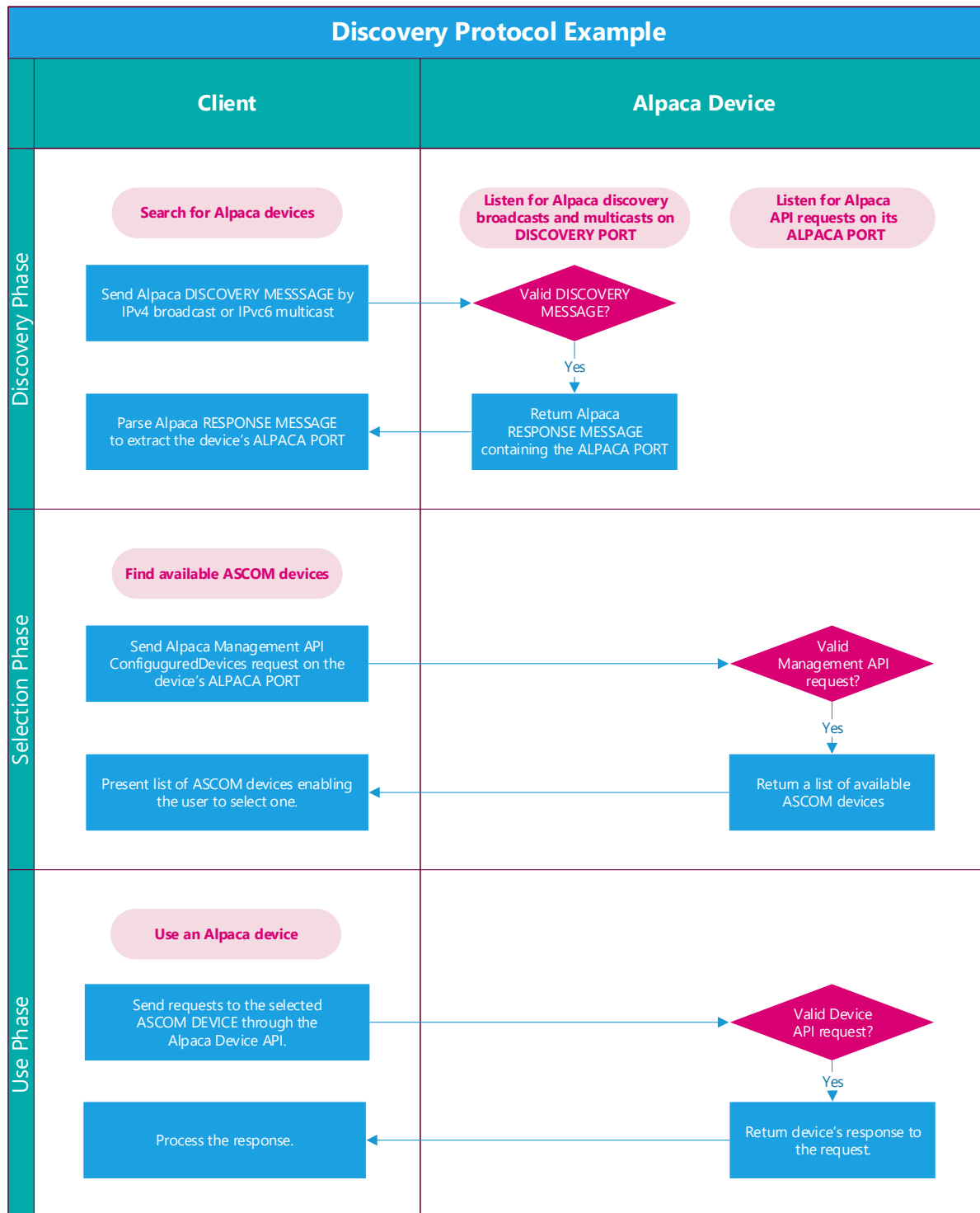
Figure 1 - Alpaca IPv4 and IPv6 discovery protocol

5.4 Alpaca Discovery Protocol - IPv6

5.4.1 Clients

Clients find devices through a UDP protocol (see Figure 1 - Alpaca IPv4 and IPv6 discovery protocol) that uses:

- the fixed IPv6 link local multicast address: ff12::a1:9aca
- a designated IP port number, whose default is 32227
- a structured DISCOVERY MESSAGE
- a structured RESPONSE MESSAGE

To search for and use ALPACA DEVICES, a client should:

1. Transmit a DISCOVERY MESSAGE to the DISCOVERY PORT using IPv6 multicast address ff12::a1:9aca.
2. Use the IP address from the RESPONSE MESSAGE together with the ALPACA PORT from the DISCOVERY RESPONSE to query the Alpaca Management API to determine which ASCOM DEVICES and device types are available.
3. When selected by the user, access specific devices through the ALPACA DEVICE API that also runs on the ALPACA PORT at the IP address of the initiator of the RESPONSE MESSAGE.

5.4.2 Devices

To listen for DISCOVERY MESSAGEs, Alpaca devices should:

1. Join the Alpaca IPv6 multicast group on address ff12::a1:9aca.
2. Listen for Alpaca IPv6 multicasts on the DISCOVERY PORT
3. Assess each received message to confirm whether it is a valid DISCOVERY MESSAGE.
4. If the request is valid, return a RESPONSE MESSAGE indicating the device's ALPACA PORT.

5.5 Discovery Message Format

To provide for future extension, if required, the DISCOVERY MESSAGE has a structured format:

Byte Number	Content
`0::14`	Fixed ASCII text: `alpacadiscovery`
`15`	ASCII Version number: 1 for the current version. The version number sequence is 1::9 then A::Z.
`16::63`	ASCOM reserved for future expansion

Table 1 - Discovery message format

The current, version 1, discovery message therefore contains 16 bytes, comprising 15 bytes from the ASCII text: "alpacadiscovery" together with a single ASCII version byte:

`alpacadiscovery1`

```
Hex: 0x61, 0x6C, 0x70, 0x61, 0x63, 0x61, 0x64, 0x69, 0x73, 0x63, 0x6F, 0x76, 0x65, 0x72, 0x79, 0x31
```

The discovery message "alpacadiscovery" has been registered to ASCOM in the IANA service registry:

https://www.iana.org/assignments/service-names-port-numbers

5.6 Discovery Response Format

The ALPACA DEVICE response must be a JSON object containing the device's ALPACA PORT e.g.:

```
{
  "AlpacaPort":12345
}
```

5.7 Unique IDs (UID)

An ASCOM DEVICE's UID is returned within the Alpaca Management API ConfiguredDevices response.

The UID is an ASCII string that MUST be unique to each ASCOM DEVICE. Its purpose is to help clients re-discover a previously used ASCOM DEVICE if its IP address changes.

1. The UID must be derived from a 48bit or larger space and converted to an ASCII string.
2. The UID must be exposed through the **UniqueID** field of the Alpaca Management API ConfiguredDevices response.
3. Manufacturers and developers must use appropriate algorithms to ensure that otherwise identical devices have different UIDs.
4. Alpaca Devices MUST send the same UIDs on every network interface to which the device is attached.
5. Once a UID has been assigned to an ASCOM DEVICE, it must never change. This means that:
   a. An ASCOM DEVICE served by an ALPACA DEVICE will always be uniquely identifiable through the assigned UID.
   b. UID must be retained when devices are powered down.

5.8 Implementation Requirements

5.8.1 Discovery Port

The Alpaca DISCOVERY PORT number must default to 32227 and should not require adjustment in most implementation scenarios. However, the DISCOVER PORT must be configurable by the astronomer user to support scenarios such as:

- the default DISCOVERY PORT is in use by another application.
- the network configuration requires multiple independent Alpaca discovery domains.

5.8.2 IP versions

All Alpaca devices should support IPv4 to ensure widest adoption and best compatibility with client devices and astronomy equipment. Devices could also support IPv6 at the discretion of the manufacturer / software author.

6. ASCOM APIs - Essential Concepts

Today's world is clearly modular, cross-platform, and distributed. The core aspect of any modular system is its interfaces. If a system is built on top of poorly designed interfaces, it suffers throughout its life with limitations, instabilities, gremlins, and the like. Interface design *and negotiation* is an engineering art, the best practitioners are those that have suffered and learned.

6.1.1 Object Models - Properties and Methods

The ASCOM APIs are built on an object model which provides properties that represent some state of the device, and methods that can change the state of the device. For example, the current positional right ascension of a telescope mount is a property, and a command to slew the mount to a different position is a method. In ASCOM COM, properties are normally accessed by assignment statements in the native syntax of any of twenty languages on Windows. Methods are represented by native syntax function calls, some with parameters. There are exceptions. Some properties require parameters to signify some aspect of state, and thus may be represented by a function call which returns the property value (which need not be a scalar), for example, Telescope.AxisRates(Axis).

6.1.2 ASCOM API Characteristics

The following information applies to the existing COM-based ASCOM APIs as well as the REST-based APIs. The behaviours must be the same to provide transparent interoperation.

- **Routine Operations:** Interface design always involves some negotiations between the parties. Inevitably, a device maker may wish to have included in the interface some clever means to make their device stand out above those of his competitors. On the other hand, client programmers don't want to be writing code to manage an ever-expanding set of these clever functions. It defeats the purpose of the standardized API. The ASCOM API was therefore designed at its outset to cover *routine operations only*.

  For example, a mount really only needs "point to these coordinates" and "track the apparent motion of my object". The more accurately it does these things, the better. As a client program developer, I don't want to be concerned about PEC or encoder resolutions or servo currents.

- **Synchronous vs Asynchronous Methods:** One may think of a method call as one that returns only when the requested operation has completed, which is a synchronous call. But some types of operations can benefit by *starting* the operation and returning immediately. For example, the Rotator.Move() method may return immediately.

  If so, its return means only that the rotation was successfully *started*. Rotators are typically slow, and the system can benefit by overlapping mount and rotator movement, so both provide asynchronous calls. The status properties such as Rotator.IsMoving and Telescope.IsSlewing are used to monitor progress of asynchronous calls.

- **"Can" Properties:** Some ASCOM APIs have "can" properties, which tell the client whether or not a corresponding capability is available. For example, in the Telescope API, the CanSlewAltAz property tells the client whether this specific mount can successfully execute

the SlewToAltAz() method. These "can" properties exist only for methods which can't be directly tested without changing the state of the device.

For example, a client *can* tell that the mount provides its positional azimuth by trying to read the Azimuth property; it will either get an answer or a "not implemented" error. However, a client *cannot* tell whether a mount can slew to alt/az coordinates without calling the method and possibly changing the mount's position. This is why a CanSlewAltAz property is provided for the SlewToAltAz() method.

6.1.3 Behavioural Rules

Heterogeneous distributed systems require both common standardized APIs and a set of behavioural rules that must be obeyed by all modules in the system. The *implementation* of a module is where these rules are effected, they do not appear in the abstract API definitions themselves. These behavioural rules are already implemented by ASCOM COM drivers.

ASCOM's modular rules are:

- **Do it right or report an error:** Fetching or changing a property, or calling a method, must always result in one of two outcomes: The request must complete successfully, or an error must be signalled, preferably with some (human readable) indication of why the request could not be satisfied. An example of violating this rule would be a method call to move a rotator to a given mechanical angle, but the rotator ends up at some other angle and no error is reported to the caller.
- **Retries prohibited:** No module must ever depend on another to provide timeouts or retry logic. If a device needs check-and-retry logic in its routine operation, that logic must be contained within the module itself. If there's a problem and your module's own retry logic can't resolve the issue report the error as required above.
- **Independence of operations:** To the extent possible with the device, each API operation should be independent of the others. For example, don't impose a specific call order such as needing to fetch the positional right ascension of a mount immediately before fetching the declination.
- **Timing Independence:** To the extent possible with the device, modules must not place timing constraints on properties and methods. Implement asynchronous calls wherever possible in order not to lock up clients unnecessarily.
- **Self-Protection – Over Use:** Drivers must protect themselves and the instrument from excessive rates of incoming requests from clients. Of course, clients should minimize the need for calling across the internet to avoid flooding, but responsibility for protecting a device from excessive request rates rests with the device and its driver.
- **Self-Protection – Illegal/hazardous operations:** Drivers and instruments should protect themselves from illegal or hazardous operations. E.g. a dome may be opening but receives a request to close the shutter. If the shutter can be safely reversed while opening, the driver could simply close the shutter and report success. Alternatively, the driver may permit the shutter to fully open and return an illegal operation error response to the close command.
- **No Status Inconsistencies:** In the example above, the driver ShutterStatus property must accurately reflect the physical shutter condition at all times. If it reports ShutterOpen, even for an instant, before the shutter starts to open, the client will assume that the shutter is properly open and move on to its next task, even though the shutter is still opening.

7. Document Revision Log

Version	Release Date	Changes
1	9/2/19	Original release
2	6/4/20	1. Added a description of the Alpaca Discovery protocol 2. Improved the description of Alpaca devices in section 1.2, including replacing references to the confusing "Alpaca Server" name with "Alpaca Device". 3. Added section on Alpaca API version number versus ASCOM device InterfaceVersion 4. Added section on the Robustness Principle 5. Added section on Alpaca Management API
3		1. Revised HTTP status flow diagram in section 3.5 to reflect ability to return HTTP 3XX redirects and HTTP 4XX rejections e.g. 403 insufficient access rights.