ASTRONODE PILOT SATELLITE DEVELOPMENT KIT USER GUIDE

Astrocast SA

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1 Definitions

1.1 Applicable Documents

[AD1] Pilot Wi-Fi Development Kit User Guide
[AD2] Astronode Pilot Asset API User Guide
[AD3] Data Management Platform Introduction
[AD4] Pilot Program Welcome

1.2 Hardware

Asset. Device controlling the Astronode, such as: Nucleo, Raspberry Pi, Arduino or custom electronics.
Astronode. Astrocast terminal name.
Pilot Satellite Dev. Kit. Satellite version of the Astronode dev kit, as described by this document.
Nucleo. STMicroelectronics board used as the Example Asset in this document
Example Asset. Nucleo board acting as an Asset (main use case covered by this use guide)
Wi-Fi Dev. Kit. Pilot User non-commercial development kit, providing Wi-Fi connectivity instead of L-band satellite connectivity. The Wi-Fe Dev Kit provides the Asset with the same serial connection as the Beta Terminal, allowing easy exchange for development purposes.
Development Kit. In this document general references to “Development Kit” refer to the Astronode Pilot Satellite Development Kit.

1.3 Acronyms and Abbreviations

AES. Advanced Encryption Standard
API. Application Programming Interface
DL. Down Link: Satellite to the Development Kit, RF link
DM. Data Management
HW. Hardware
IoT. Internet of Things
M2M. Machine to Machine
RF. Radio Frequency
SW. Software
MCU. Microcontroller Unit
TC. Telecommand: incoming command from satellite Down Link to Development Kit
TM. Telemetry: outgoing payload from the Asset, Dev. Kit to the satellite via Up Link
UL. Up Link: Development Kit to Satellite. RF link

1.4 Terminology

Before you start using the Astronode Pilot Satellite Development Kit, it is helpful to provide a more detailed definition of some key terms.

1.4.1 Asset

The Asset is the computer or the electronics, which communicates and controls the Development Kit via its main serial link interface.

1.4.2 Data Management Platform

The Data Management platform is where Astrocast gathers and stores all the data generated by connected Assets. You can access this data on a per-customer basis via a web interface or a secure REST API. Refer to document [AD3] for an introduction to this system.

1.4.3 Third-party Application

Third-party applications can be any program, including your proprietary program, that can connect to the Astrocast Data Management platform to retrieve messages generated by your Assets via the Astrocast REST API. Your solution may use such a third-party application to connect and integrate the Astrocast Data Management platform.

1.4.4 Data Messages (Uplinks)

Assets can send small data messages to the Astrocast Data Management platform. In the satellite context, these messages go from the Asset to the satellite development kit, to the satellite, to the ground station, and into the Astrocast Data Management platform. For the Wi-Fi context, they go from the Asset to the Wi-Fi development kit, through the user's Wi-Fi network, to the Astrocast Data Management platform. These have a maximum payload size of 44 bytes (160 for commercial). These are sometimes called "Telemetry Messages" (TM).

1.4.5 Acknowledgment

The acknowledgment is an important part of the system that is available in the precursor mission. Data Messages (Uplinks) will be acknowledged. In the Wi-Fi context, this means the Data Management Platform has received the message. In the Satellite context, it means the satellite has received the message, and it must still make its way to the ground station and Data Management Platform.

1.4.6 Data Commands (Downlink)

Your solution may also send small data commands to your Assets via the Astrocast Data Management platform. In the satellite context, the command moves from the user's system to the Astrocast Data Management platform, then to the satellite, then down to the satellite development kit, and finally to the Asset. These have a maximum payload size of 40 bytes (availability: service level 2) and should only be used to transmit instruction sets to remote Assets. These are sometimes called "Telecommand Messages" (TC).
Sending data commands to a terminal will be possible via satellite communication in the commercial mission. This feature is currently not available in your Wi-Fi Development Kit.

2 ICONS

Within this document, the following icons may help the reader on some aspects:

Important to read and remember

Insight into the NUCLEO64 Example_Asset driver

Additional details for a given function

A system performance constraint

3 INTRODUCTION

This document describes how to use the Astronode Pilot Satellite Development Kit.
At the highest level, the Astronode Pilot Satellite Development Kit provides these functions:

- Send data messages using Astrocast's satellite network.
- Receive acknowledgments from the satellite.

This user guide covers all aspects of how to integrate the Satellite Development Kit into your remote Asset:

- Chapter 4: Mechanical Interface
- Chapter 5: Electrical Interfaces, including RF and Antenna Interfaces
- Chapter 6: Environmental Specifications
- Chapter 7: Certifications

The Asset communication protocol is common for the Wi-Fi and Satellite Development Kits, and as such, is described in a separate document. Refer to document [AD2].

3.1 THE SCOPE OF THE PILOT PROGRAM

The Astronode Pilot Satellite Development Kit is a non-commercial product that is provided to a limited number of pilot users to allow testing a version of the Astrocast Service.
The Development Kit has two purposes:

- Firstly, to assess communications with both Asset and back-end APIs.
- Secondly, to receive your feedback to enhance our Astrocast service.

The Satellite Development Kit allows communication with the two satellites in the precursor mission. An accompanying document [AD4] describes the service level and expected performance of the precursor system.

3.2 OVERALL ARCHITECTURE

The system architecture is depicted in Figure 1. To send and receive information, a remote Asset connects to the Development Kit via a UART serial link as pictured below on the left-hand side.
The Development Kit uses L-band wireless communication to and from the satellites. It is capable of autonomously detecting the passage of the satellite.
The Development Kit receives and stores TM payloads from the Asset. There is no need to time communications with the Development Kit for when the satellite is passing overhead. The communication via the satellite link will be managed by the Development Kit when the satellite is overhead and ready to receive data.

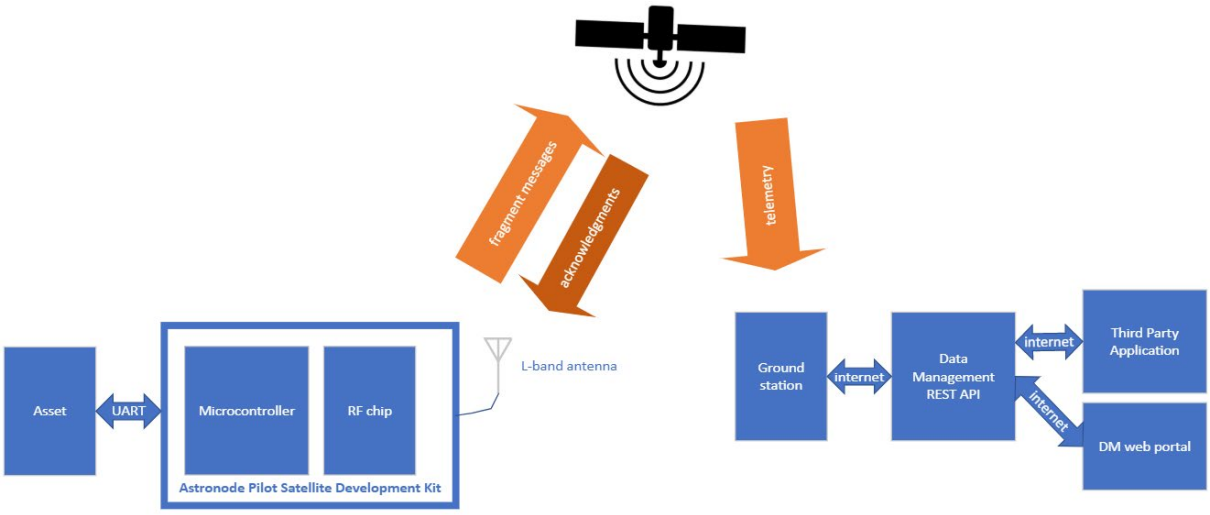


Figure 1: Satellite Terminal Architecture

Astrocast bidirectionality service (i.e., customer downlink messages) will be introduced in commercial products in the future. The pilot development kits do not support this.

The pilot development kits use a simple timer to estimate when the satellite is overhead. Each kit is customized with two alarm times per day, chosen according to the kit's location. The alarms will trigger a 90 min satellite search. This is hidden from the user but will be apparent in the development kit's power consumption. The device will be in an active satellite detection mode for a total of 180 min per day. This amount of time spent detecting a satellite will be significantly improved in the commercial missions, bringing the power consumption down.

3.3 Wi-Fi and Satellite Development Kits

The Wi-Fi development kit provides a low latency transport alternative to the satellite development kit. The Satellite Development Kit interface is designed to have similar interfaces to the Wi-Fi Development Kit. This includes the physical Picoblade connector, allowing the two kits to be easily exchanged. The protocol is also designed to work on both kits, speeding up development.

The Astronode Pilot Satellite Development Kit can directly be used with the NUCLEO64 Example_Asset project provided with the Wi-Fi Development Kit.
For details of the protocol, refer to document [AD2]. The two notable differences between Wi-Fi and Satellite kits are:

1. The Wi-Fi settings command is simply ignored by the satellite terminal.
2. The configuration read response will indicate which type of kit it is: Wi-Fi or Satellite.

It is also worth noting the implication of the latency differences between Wi-Fi and Satellite communication. The Wi-Fi latency is the round trip from the device, over the Wi-Fi, and

subsequent networks, to the Astrocast cloud service and back. This is usually in the order of seconds. The satellite latency will be much longer and possibly in the order of days. The Asset interface implementation should be designed with this difference in mind.

3.4 Suggested Path for Testing

The Astrocast Pilot Development Kits have been designed for the following development path:

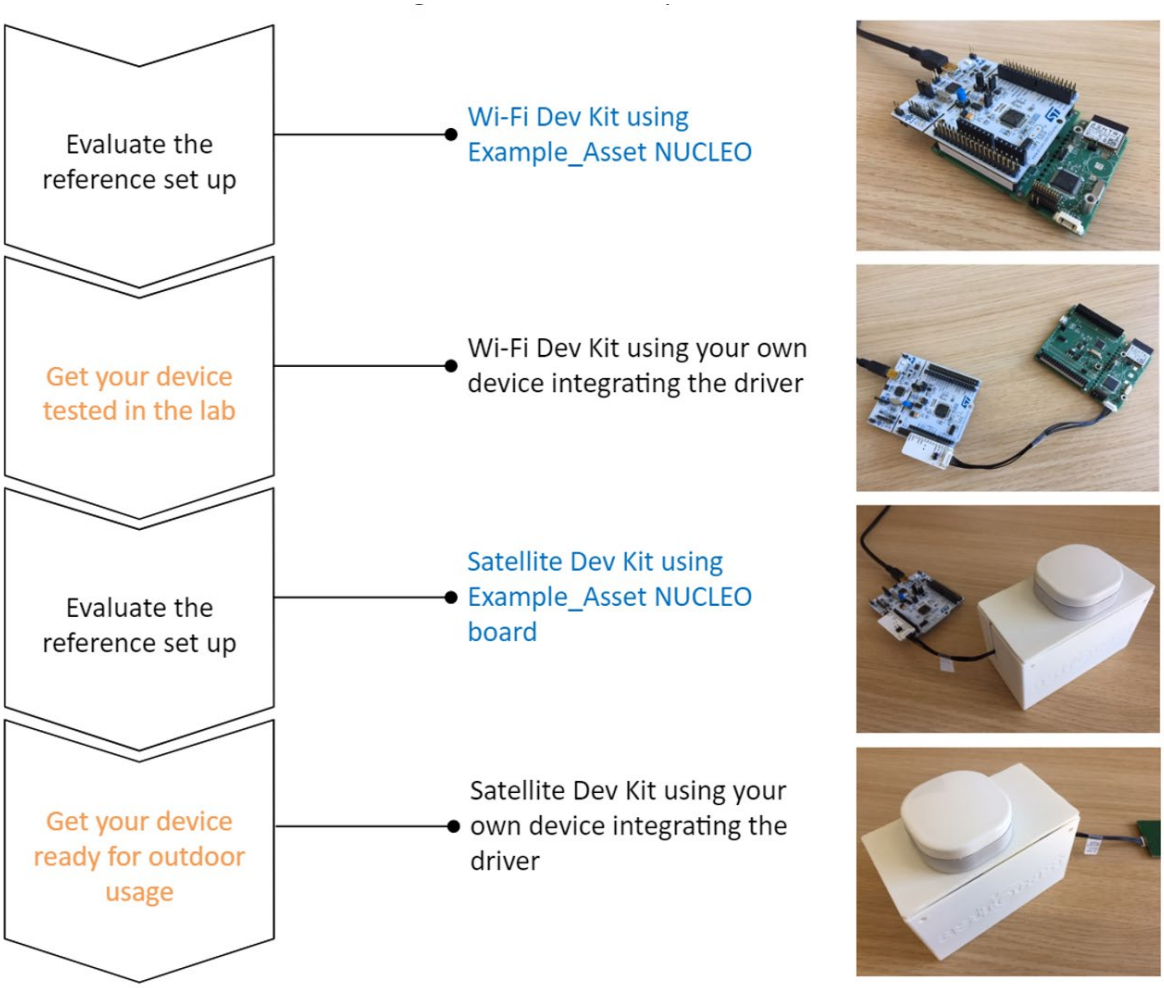


Figure 2: Use cases with proposed order

Which can be described as follows:

1. Read through the user guides. The guides for the Satellite and Wi-Fi Development Kits are most important to start with.

Start with the Wi-Fi Development Kit:

2. Setup the Wi-Fi development kit with the Nucleo Example Asset, as described in document [AD1] i.e., pressing the blue button to send message(s). Get the Wi-Fi setup working and send some messages to the Data Management Platform.
3. Use the Data Management Platform Web Portal to view the messages. Refer to document [AD3]

Move to the Satellite Development Kit:

4. Connect the Nucleo Example Asset to the satellite development kit. Send some messages from the Nucleo similarly to step 2, making sure of pressing the blue button to enqueue message(s) as many times as wished (eight times max for eight enqueued messages).
5. Prepare the satellite development kit for an extended period with a full view of the sky. Take care of powering the setup and protecting it from the weather.
6. Wait for some satellite passes, which may take a few days (refer to [AD4] for more information).
7. Check the web portal for the messages sent via the satellite.

Integrate with your Assets:

8. Integrate the Wi-Fi development kit with your system. You would need to handle mechanical, electrical, and protocol integration. Details are in the various user guides. Aim to send messages from your system via the Wi-Fi development kit.
9. Once the Wi-Fi development kit is working with your system, simply swap to the satellite development kit. The protocol is designed so that if the Wi-Fi development kit is working, the satellite development kit should work on the same interface. Aim to send messages from your system via the satellite development kit.

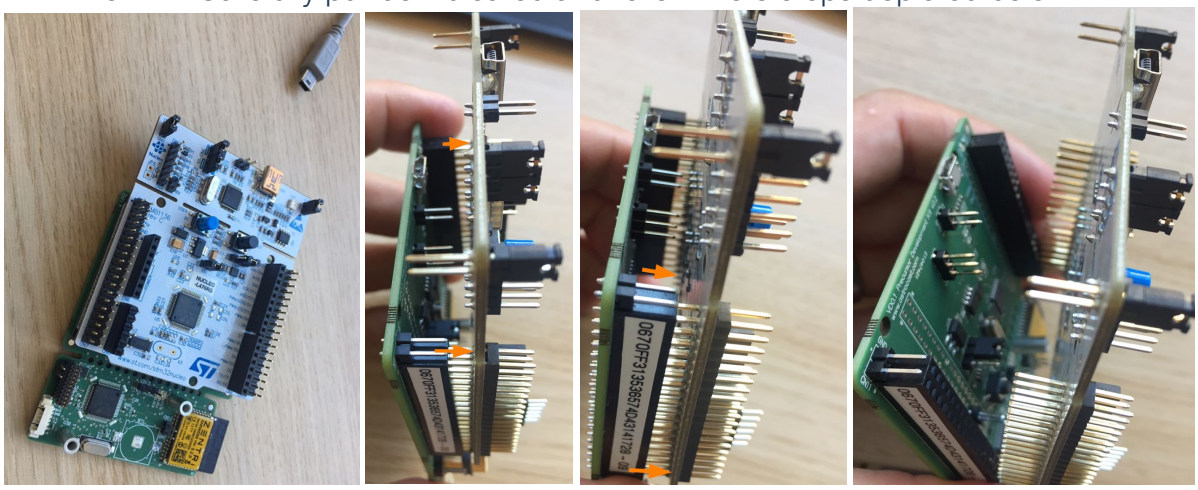
Investigate the Data Management Platform further:

10. Experiment with and integrate the Data Management Platform API.

This suggested path should demonstrate all the system elements in a sensible order. You may choose to bypass or rearrange the steps as required.

Note:

To plug it later to the Satellite Dev Kit, the NUCLEO board can be unplugged from the Wi-Fi Dev Kit. Carefully pull as indicated and follow the 3 steps depicted below:



4 MECHANICS

4.1 SUPPLIED MOUNTING STRUCTURE

The Development Kit is composed of a Solder Down Terminal (SDT) and a Carrier Board (CB). The SDT comes calibrated and tested and is soldered onto a CB. The PCB and Antenna are supplied mounted to a customized holder. Astrocast strongly suggests doing the initial testing with this setup. This setup has been tested and characterized by Astrocast, and it is recommended that customers use this proven setup before moving to their mechanical integration.

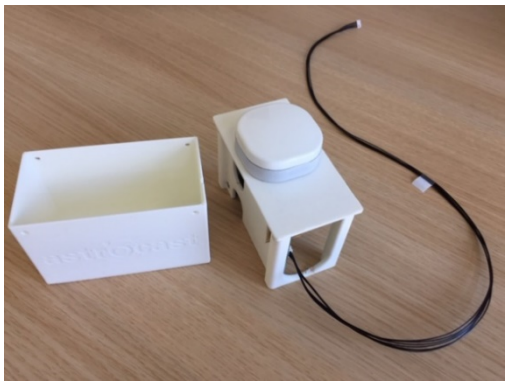


Figure 3: supplied structure, here with longer picoblade flat ribbon cable

This is an ESD-sensitive device, and ESD prevention methods are recommended. Wearing an ESD bracelet each time the board is manipulated and use an anti-ESD bag each time it is transported.

Third-party applications connect via the Asset Interface. The Carrier Board provides a Picoblade interface (clearly labeled “Asset” on the left, below), which exposes a TTL serial interface. The Wi-Fi Development Kit contains the same connector, allowing the kits to be easily interchanged.

🗝 For the use of the Precursor Satellite Dev Kit with the Nucleo Example Asset, a Nucleo adaptor board is included. This connects the picoblade cable to the Nucleo. With the TrueStudio project described in the Wi-Fi Development Kit User Guide [AD1], you can enqueue messages from the Nucleo by pressing on the blue button as many times as messages to be enqueued before a pass. Refer to [AD1] for more information on how the Nucleo Example Asset works. The same Nucleo project should work with both the Satellite and Wi-Fi Development Kits. Figure 6 shows the picoblade cable adapter connected to the Nucleo Example Asset. This could be plugged into the Satellite Development Kit.

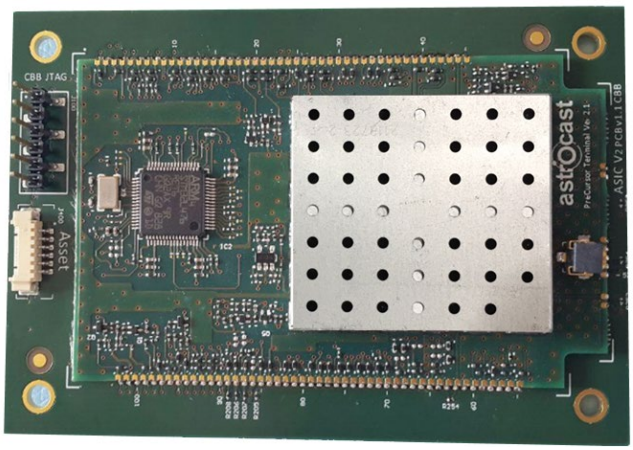


Figure 4: The Pilot Satellite Development Kit, composed of the SDT attached to the CB.

On the opposite side of the board (on the right of the picture above), an MMCX connector allows the connection of an MMCX to SMA adaptor cable and an antenna:

Figure 5: The approved antenna, complete with MMCX to SMA cable and SMA -SMA adapter.

The MMCX connector cable is glued onto the Solder Down Terminal for mechanical strength. Great care should be taken when handling the MMCX cable and connectors as they can break under strain.

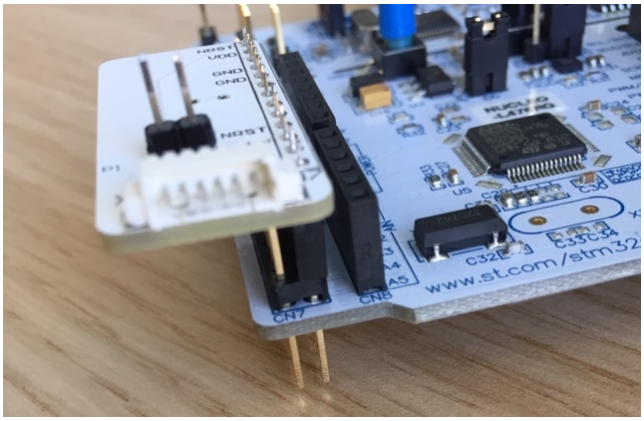


Figure 6: Picoblade on Morpho pins (NUCLEO board).

4.2 Custom Mechanical Integration

The Development Kit is designed to be directly integrated within an Asset; however, it is recommended that an opening be left to allow the antenna to be easily connected and looking at the sky. The system should work without any additional ground plane for the antenna, but a slight improvement can be expected with a 5x5cm^2 ground plane.
The Development Kit is designed to be screwed down or bolt mounted. The hole size is suitable for M3 sized screws. The relevant dimensions are shown in the picture below.
The performance of the system is highly dependent on the installation and environment. **Contact support to discuss your specific environment.**
A Molex picoblade 6 circuit 100mm ref. 0151340601 is recommended as the cable assembly, and a sample is included with the Development Kit.

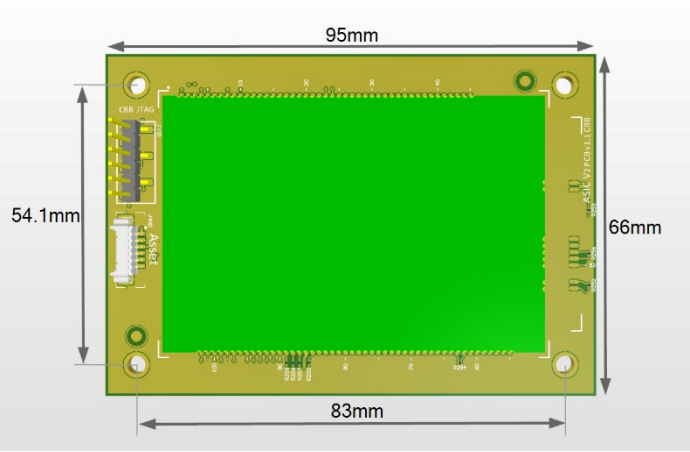


Figure 7: Mechanical dimensions of the Carrier Board, including hole measurements.

This diagram summarizes the different interfaces to be considered during integration:

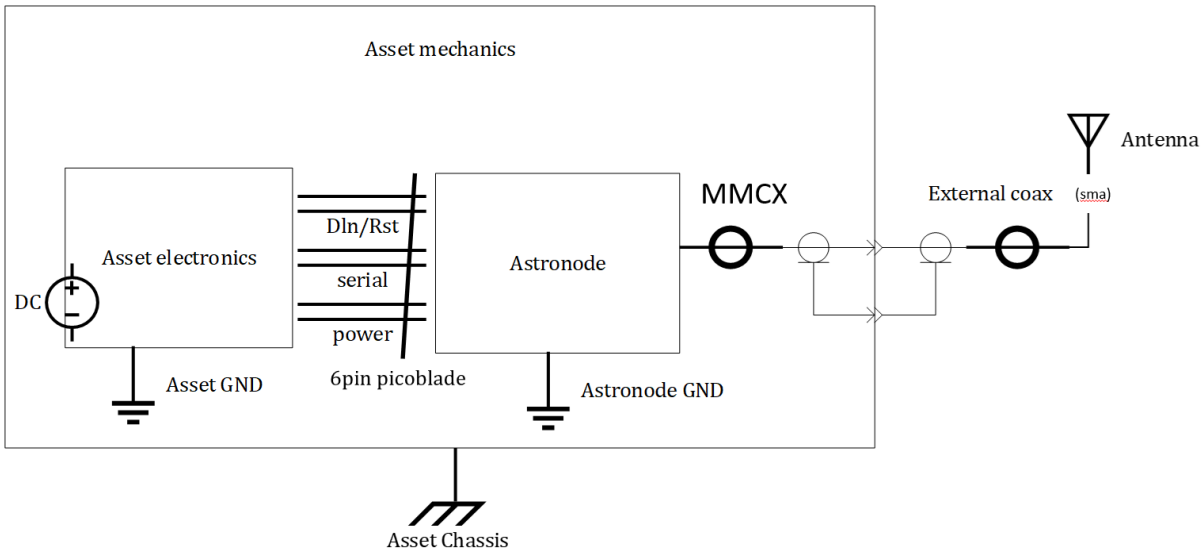


Figure 8: Mechanical interfaces, including the asset interface and antenna.

Note: Each RF connector generally introduces a 0.5dB loss. The introduction of additional RF connectors or cables other than Astrocast's supplied cables should be avoided.

4.3 Asset Interface Pinout

The Asset interface is exposed via a picoblade connector. The pinout on the PCB is shown in Figure 7. The electrical properties of each pin are described in section 5. Note that the harnesses supplied with the development kit mirrors the pin mapping: pin 1 to pin 6. Take note of the mirroring if using the supplied harness to power the development kit.

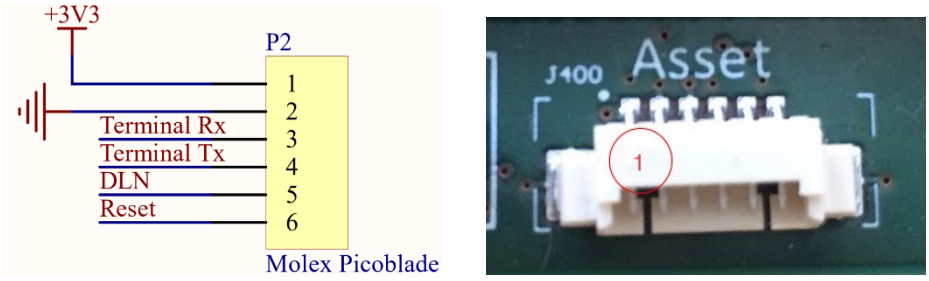


Figure 9: Picoblade connector pinout as found on the PCB, with pin 1marking

5 Electrical Characteristics

5.1 Asset Electrical Interface

Pin	Designation	Description	Min.	Typ.	Max.	Notes
1	VDD	Main voltage supply to the Satellite Development Kit		+3.3V+/-10%		
2	GND					
3	RX	UART Rx. To be connected to the Asset **transmit** line.	0V	0 or 3.3V	+3.6V	Above 2.3V for high level; Below 1V for low level.
4	TX	UART Tx. To be connected to the Asset **receive** line	0V	0 or 3.3V	+3.6V	Above 2.9V for high level, Below 0.4V for low level.
5	DLN	Down Link Notification pin (active high) e.g. satellite data acknowledge - or telecommand for future use	0V	0 or 3.3V	+3.6V	Above 2.9V for high level; Below 0.4V for low level.
6	RST	Hardware Reset* (rising edge triggered)	0V	0 or 3.3V	+3.6V	Above 2.3V for high level; Below 1V for low level.

ⓘ *Terminal is operational 15 ms after the reset, resulting in a clean empty message input buffer.
Inputs and Outputs are protected with ESD diodes.
There is no reverse-voltage protection on the 3.3V supply.

5.2 RF and Antenna Parameters

Operating Frequencies:

- Tx: 1626.5 to 1675.0 MHz
- Rx: 1518.0 to 1559.0 MHz

Transmitter power < 17 dBm. Maximal EIRP < 20 dBm.
Antenna connector: MMCX, plus a short cable to SMA format.

The antenna should be directed up to the sky, avoiding surrounding buildings, to allow a 30° minimum elevation visibility from the horizon. A reduced sky view will degrade service quality.

5.3 Operational Modes

5.3.1 Definitions

The operation of the Satellite Development Kit is introduced in section 3.2. The Satellite Development Kit has two customized alarms, which have been pre-programmed according to your location to wake up and scan for a satellite ("satellite detection"). Both morning and evening satellite detection periods are 90 min long, and the device is in **Rx mode** during this time. If a satellite is detected, the device will go into Tx mode. Tx mode can be expected to last for a maximum of 10 minutes, depending on the number of messages to send and the acknowledgment status. The Satellite Development Kit will be in **Sleep mode** the rest of the time unless woken up by the Asset interface. If not woken by the Asset interface, it can be expected to sleep for 21h per day. The Asset can enqueue a TM payload at any time of the day, in this case it will reach **Standby mode** for 20-40ms. The Satellite Development Kit switches automatically between Standby, Rx, and Tx in view of the satellite, then goes to Sleep otherwise. It should not be powered off completely because the volatile memory contents will be lost (configuration and message queue).

Sleep	The device is in a low power mode. It can be woken by the Asset interface and will move to Standby mode. Or it can be woken by the satellite search timer, which triggers twice per day, and moves to Rx mode.
Standby	The Development Kit is woken by communication on the Asset interface. It will transition back to Sleep mode 2 ms seconds after the end of a UART command, or 100ms after unknown characters on the UART interface.
Rx	RF front-end is active in Rx mode. The device will typically stay in this state for 1h30 while searching for a satellite. At the end of the period, it will go back to Sleep mode. If a satellite is detected, it will transition to Tx mode.
Tx	RF front-end is active in Tx mode. A transmit involves several phases (synchronization, transmit and ack receive) and may be repeated many times based on message fragmentation. Tx mode starts on satellite detection and lasts for a maximum of 10 minutes.

5.3.2 POWER CONSUMPTION

Description	Min.	Typ.	Max.	Expected Duration
Sleep (uA)		10		Up to 21h per day.
MCU Standby (mA)	1.2	2	2.5	When the Asset interface UART is active. Awake for ~20ms to queue a 1byte message. ~34ms to queue a 12bytes message
Rx (mA)	20	26	50	The satellite detection lasts max 90mn, during which it periodically tries to detect the satellite when it consumes the indicated value. Once a satellite is detected, the dev kit will move to the Tx mode.
Tx (mA)	30	40	90	Synchronization, transmit, and ack reception process is about 9 s per message, at an average current of 40 mA. The actual transmit is 90 mA for 1.4 s. It will return to sleep mode after all messages have been sent, or the 10 min timer expires.

Table 1: Current consumption

All values will be optimized in Astrocast's first commercial Satellite Development Kit.

6 ENVIRONMENTAL

6.1 ENVIRONMENTAL SPECIFICATION

Table 2: Temperature and Humidity range

State	Temperature range	Humidity
Operational	-10°C - +70°C TBC	TBD

6.2 ENVIRONMENTAL TESTS PERFORMED

Environmental tests will not be performed on this version of the terminal. The commercial kits will be tested and approved for the operating conditions listed below.

- Thermal shock
- Humidity
- Vibration
- Shock

7 CERTIFICATIONS

The Astronode Pilot Satellite Development Kit will not be certified and should not be used for commercial purposes.
Astrocast will go through an extensive homologation process to certify the commercial Astronode product according to applicable international standards.
Standards under consideration are:

- ROHS
- WEEE
- CE - RED
- FCC
- IC
- UL (flammability class) and/or CSA (TBC)

8 ANTENNA DOCUMENTATION

This antenna model is supplied with the Satellite Development Kit. It is the only characterized antenna for the demonstration mission. It is provided with a 15cm RF cable.

Figure 10: L-band precursor antenna

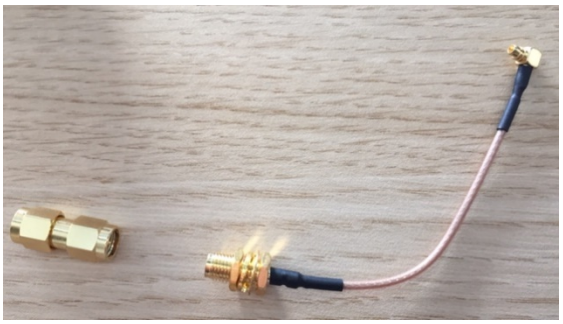


Figure 11: RF Accessories (cable and SMA adaptor)

9 DISCLAIMER

The information contained within this document (the "Astronode Pilot Satellite Development Kit User Manual") is furnished for informational purposes only. Even though Astrocast SA does its best to deliver this Astronode Pilot Satellite Development Kit User Manual with correct and complete information, we cannot warrant that this document is free from any errors, inaccuracies, or omissions. We reserve the right to make additions, deletions, or modifications to the content of the Astronode Pilot Satellite Development Kit User Manual at any time.

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10 L-Band Licensing

The Satellite development kits used L-Band spectrum, and access rights vary by country. Terminals will be supplied to potential customers in specific countries where Astrocast has obtained these rights. The terminals should only be used in the country that it was supplied to.