KIM1

Integration manual

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1. Introduction

Kinéis products makes satellite connectivity easy to access and it is our goal to make integration and industrialization process as streamlined as possible.

The KIM1 module developed by Kinéis is a low-power transmitter module based on Argos-2 standard and fully certified by Kinéis and CNES (French Space Agency).

It enables communication with all the Kinéis/Argos polar LEO satellites and provides global connectivity to IoT devices for data collection and positioning. The use of Argos RF signals and protocols ensures very low power consumption for device within line of sight of Kinéis/Argos satellites.

The module is specifically designed for ease of use, to shorten development time and thus decrease time to market. It offers IoT device manufacturers the possibility to integrate their end devices quickly and easily into the Kinéis network and is available for industrialization of satellite connected device in large volumes.

This document is an integration manual for the KIM1 transmitter module by Kinéis, complementing the component datasheet (see §**1.3 Related documents** for reference).

This manual will bring you information regarding:

- Typical integration circuit
- UART interface
- Transmission protocol, including message formatting and transmission strategies

Warning: Please refer to the paragraph below, **1.1 Versioning**, to make sure you are reading the documentation suited to your module version.

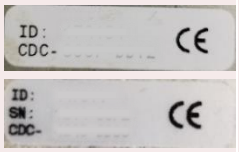
For further assistance, feel free to contact Kinéis at the following link: https://www.kineis.com/contact/

1.1. Versioning

Please refer to the table below to identify the version of the documentation (Datasheet and Integration Manual) related to your module series, considering the following information:

- The hardware (HW) version, determined by the Serial Number
- The firmware (FW) or software (SW) version, determined with the AT command AT+FW=?

Warning: most of the time, the Serial Number can be an indication for the FW version looking at the correspondence table below. However, the FW version must be finally determined with the AT command AT+FW=? since the KIM1 may have been reprogrammed with a newer FW version after manufacturing.

Label	Serial number	Manufacturing FW version	Datasheet reference and version	Integration Manual reference and version
	**0719**-xxxx **1219**-xxxx **0120**-xxxx **0220**-xxxx	KIM_HW1.1_ • SW0.2 • SW1.0 KIM_HW1.3_ • SW1.0 • SW1.1 • SW1.2	*KINEIS-SP-20-0147 KIM1 Datasheet v1.0.pdf*	*KINEIS-NT-19-0018 KIM1 Integration Manual v2.0.pdf*
	**KIM132008**xxxxx	KIM_HW1.3_SW1.3	*KINEIS-SP-20-0147 KIM1 Datasheet v1.2.pdf*	*KINEIS-NT-19-0018 KIM1 Integration Manual v2.0.pdf*
	**KIM132103**xxxxx	KIM1_V1.4	*KINEIS-SP-20-0147 KIM1 Datasheet v1.2.pdf*	*KINEIS-NT-19-0018 KIM1 Integration Manual v2.1.pdf*
	**KIM132109**xxxxx	KIM1_V2.0	*KINEIS-SP-20-0147 KIM1 Datasheet v2.0.pdf*	*KINEIS-NT-19-0018 KIM1 Integration Manual v2.2.pdf*
	**KIM132111**xxxxx **KIM132112**xxxxx **KIM132201**xxxxx	KIM1_V2.1		*KINEIS-NT-19-0018 KIM1 Integration Manual v2.3.pdf*

All further modules will be produced and distributed with the latest hardware and software versions. In case of any doubt regarding your module version and corresponding documentation, do not hesitate to contact us.

1.2. Revision history

Issue	Date	Ref	Modifications
1.0 to 1.6	Apr 23, 2019 to Jul 26, 2019	JI, AJ, SV	Document creation and updates
2.0	Jun 12, 2020	CT	Suppression of the following paragraphs (transferred into KIM1 Datasheet): 1. Product description 2. Device information 3. Electrical characteristics Update of the following paragraphs: 2. Typical application circuit 3. UART communication 4. Transmission protocol
2.1	Feb 8, 2022	CT, VG	• Modification of **§2 Typical application circuit** • Addition of **Boosted 3.3V integration** paragraph • Note about Frequency Use (**§5.3**) [Update corresponding to FW version 1.4] • Modification of KIM1 responses syntax (**§3.1**)

2.2	Feb 8, 2022	CT	[Update corresponding to FW version 2.0]
			• Change in UART serial interface settings (**§3**)
			• Modifications of AT commands:
			  ○ AT+ID (**§3.3.1.a**)
			  ○ AT+TX (**§3.3.3.c**)
			• Deletion of AT commands:
			  ○ AT+BAND
			  ○ AT+FRQ
			• Addition of AT commands:
			  ○ AT+ATXFRQ (**§3.3.1.d**)
			  ○ AT+AFMT (**§3.3.2.b**)
			  ○ AT+SAVE_CFG (**§3.3.3.a**)
			  ○ AT+PING (**§3.3.3.b**)
			  ○ AT+CW (**§3.3.3.d**)
			• Modification of ERROR responses syntax (**§3.3.4**)
			• Addition of **§4.1 Frame format**
			• Modification of **§4.2 Message format**
			• Modification of **§4.3 Transmission strategy**

2.3	Feb 8, 2022	CT	[Update corresponding to FW version 2.1]
			• Modifications of AT commands:
			  ○ AT+TX (**§3.3.3.c**)
			  ○ AT+AFMT (**§3.3.2.b**)
			  ○ AT+ATXFRQ (**§3.3.1.d**)
			• Modification of +ERROR responses syntax (**§3.3.4**)

All further modules will be produced and distributed with the latest HW and SW version. In case of any doubt regarding your module version and corresponding documentation, do not hesitate to contact us.

1.3. Related documents

- KINEIS-SP-20-0147 KIM1 Datasheet
- KINEIS-MU-2019-0094 Satellite pass predictions – User guide

2. Typical application circuit

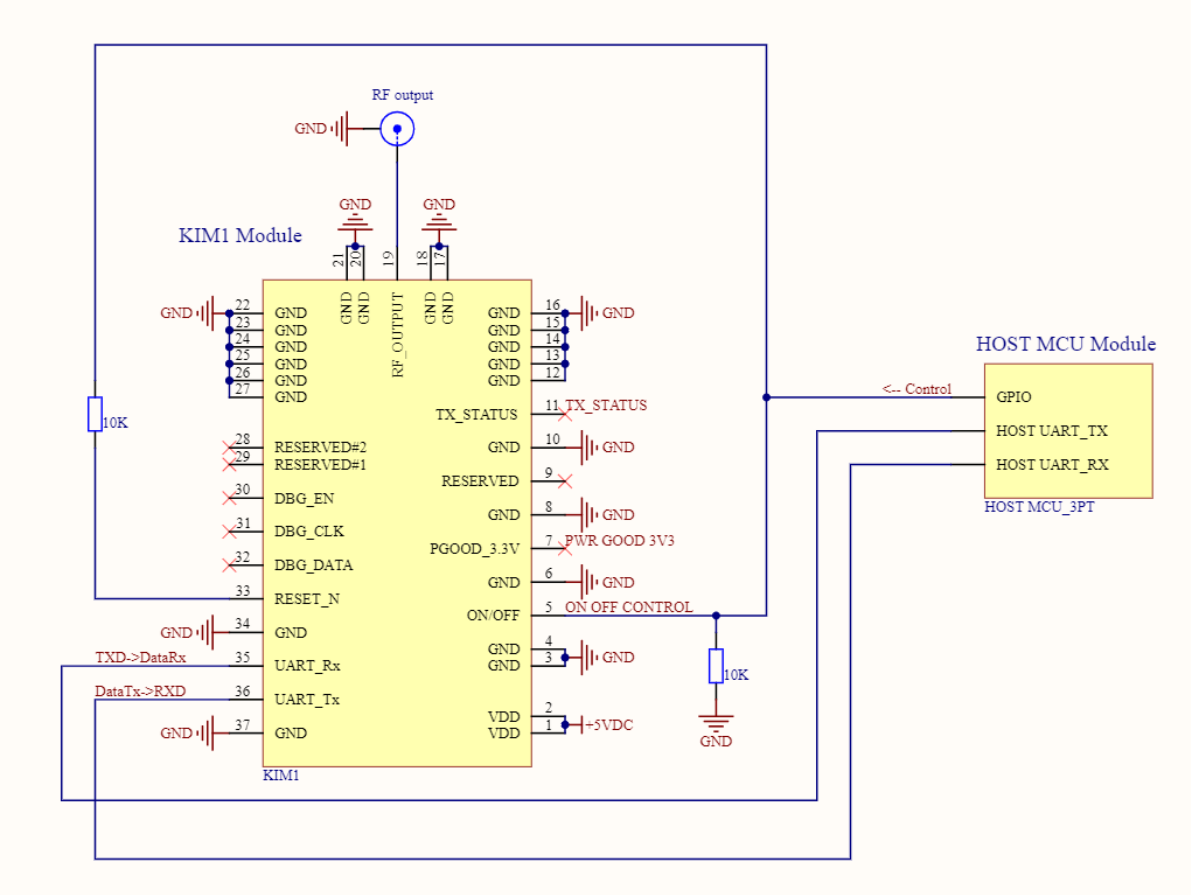


Figure 1: Example of Typical integration of MCU with the KIM1

KIM1 must be powered with 5V typical DC supply voltage between VDD pins and GND pins, and all GND pins connected to the ground plane.

The microcontroller unit (MCU) can control the KIM1 through UART communication and GPIOs:

- UART interface needs two pins for the two-way communication: UART_Tx and UART_Rx
- ON/OFF pin **must be actively terminated** and can be controlled to put the module in OFF mode between two transmissions and have the lowest consumption possible
- RESET_N pin **must be connected to the ON/OFF pin through a 10k resistor**

TX_STATUS pin can be connected to a LED (high when a transmission is occurring)

PWR_GOOD pin can be connected to a LED (high when the module is correctly supplied)

An antenna matched at 50Ω for the transmission frequency must be connected at RF output.

Boosted 3.3V integration

The supply voltage tends to be standardized around 3.3V for IoT devices, in order to take advantage of some battery technologies that can range from 3V to 4.2V in supply voltage. To integrate the KIM1 in a design with such a power supply level, Kinéis recommends adding a boost converter to raise the voltage to 5V to provide an adapted power supply to the KIM1.

Possible references for the boost converter are (see component datasheets for more details):

- TPS61236P 8-A Valley Current Synchronous Boost Converter with Constant Current Output Feature from Texas Instrument
- TPS81256 3-W, High Efficiency Step-Up Converter In MicroSiP™ Packaging from Texas Instrument (requiring a limited number of extra components)

3. UART Communication

The KIM1 serial interface uses a basic TTL 3.3V level signals with UART protocol (RX link is 5V-tolerant).

UART interface uses fixed parameters:

SPECIFICATION	DESCRIPTION
Baud Rate	9600
Data bits	8 bits
Parity	None
Stop Bits	1 bit
Flow Control	No

Table 1 : UART Setting

***Warning**: in order to avoid the occurrence of a latch-up effect on the UART serial interface, Kinéis recommends to implement initialization and deinitialization of the UART link respectively before KIM1 power On and after KIM1 power Off in the software controlling the KIM1.*

3.1. AT commands syntax

There are three types of extended AT commands:

- Information type read-only commands: allows to read l the module information.
- Parameter type commands:
  - "Set" to store a value or values for later use
  - "Read" the current value or values stored
- Action type commands: invokes a function of the equipment, which generally involves more than the simple storage of a value for later use. (e.g : Transmission command)

For each AT command, there will be the following possible responses:

- `+OK`, means the command is accepted and executed
- `ERROR,<errorno>` means an error occurred during the execution of the command
  - Possible values for `<errorno>` parameter are detailed in §3.4 Error responses)

The AT command or response will be a sentence terminated by <CR><LF> on both sides of communication.

3.2. Timing constraints

Once an AT command has been sent to module, one shall not send again a new command until previous has been completed with a response.

User shall wait at minimum 10ms before sending a new command after previous is completed.

3.3. AT commands description

1. Information type commands

a. ID number

`ID` – **Read Kinéis ID number**	
`AT+ID=?`	Read the Kinéis hexadecimal ID number of the module Answer: `+ID=<id_number>` Parameters: • `<id_number>` – Kinéis ID number in hexadecimal format (7 digits)

b. Firmware version

`FW` – **Read Firmware version**	
`AT+FW=?`	Read the firmware version from KIM1 module Answer: `+FW=<fw_version>` Parameter: • `<fw_version>` – Firmware version flashed into the module o Format: **`KIM1_Vx.x`** (in this case **`KIM1_V2.0`**)

c. Serial number

`SN` – **Read Serial Number**	
`AT+SN=?`	Read the serial number from KIM1 module Answer: `+SN=<sn>` Parameter: • `<sn>` – KIM1 serial number (14 digits)

d. Transmission frequency

`ATXFRQ` – **Transmission frequency**	
`AT+ATXFRQ=?`	Read the transmission frequency used by module Answer: `+ATXFRQ=<frq>` Parameters: • `<frq>` – transmission frequency in Hz (9 digits) o If the transmission frequency has not been modified from the factory setting, the value of `<frq>` returned is 0

2. Parameter type commands

Warning**: all parameter values configured with the following AT commands are stored in RAM while the KIM1 is On and are thus lost when powering Off the KIM1. They can be saved in flash memory with the command* `AT+SAVE_CFG` *(see* **§3.3.3.a Save configuration) to be restored after KIM1 power Off and On again, but the flash memory has a limited number of writing cycles. Therefore, it is recommended to set the value for each parameter and to call only once the command* `AT+SAVE_CFG` *to store simultaneously all these parameters. When regularly modifying the values for these parameters, to perform some tests for instance, it is recommended not to call the command* `AT+SAVE_CFG` *and potentially to set the values at every power On.*

a. Transmission power

`PWR` – **Transmission power**	
`AT+PWR =<pwr>`	Set the transmission power in mW of the module. Parameter: • `<pwr>` – an integer that specifies the transmission power in mW, among the following values: o 100 o 250 o 500 o 750 o 1000 (default) Note: transmission power is calibrated at manufacturing and guaranteed for 1W configuration. Calibrations for 250mW, 500mW, 750mW are not guaranteed.
`AT+PWR=?`	Read the transmission power in mW used by module Answer: `+PWR=<pwr>` Parameter: • `<pwr>` – as described above

b. Message format

AFMT – **Message format**	

AT+AFMT=<fmt>,
<crc>,<bch>
	Select the message format (see **§4.20 Message** format for the description of message formats)
	
	Parameters:
	• <fmt> – an integer to select the message format
	  o 0: Raw format (default, see **§4.2.1 Raw format (default)**)
	  o 1: Kinéis standard format (see **§4.2.2 Kinéis standard format**)
	• <crc> – length of the CRC
	  o 0: deactivated (applicable for Raw format)
	  o 16: CRC-16/XMODEM (applicable for Kinéis standard format)
	• <bch> – length of the BCH
	  o 0: deactivate BCH (applicable for Raw format)
	  o 32: BCH(255,223,4) (applicable for Kinéis standard format)
	
	Note: considering the above, the implementation of this command should be
	• AT+AFMT=0,0,0 for Raw format (default)
	• AT+AFMT=1,16,32 for Kinéis standard message

AT+AFMT=?	Read the selected message format Answer: +AFMT=<fmt>,<crc>,<bch> Parameters • <fmt> – as described above • <crc> – as described above • <bch> – as described above

3. Action type commands

a. Save configuration

The parameters configured with the parameter type commands above are stored in RAM until this command is called. This command must be called if the configuration needs to be recovered at KIM1 power On after power Off.

SAVE_CFG – **Save configuration**	
AT+SAVE_CFG	Store in flash memory the current user configuration of the device, including: • Transmission power • Frame format

***Warning**: due to the flash memory writing cycles limitation, this command should be used carefully to set the parameters once and for all. When regularly modifying the values for these parameters, to perform some tests for instance, it is recommended not to call the command* AT+SAVE_CFG *and potentially to set the desired values at every power On.*

b. Ping

PING – **Communication test**	
AT+PING=?	Test the communication with the KIM1 Answer: +OK

c. Message transmission

`TX` – **Transmit one message**	
`AT+TX=<data>`	Transmit one message Parameter: • `<data>` – user data in a hexadecimal string o Maximum length is either 184 bits or 248 bits depending on the message format selected with the command AT+AFMT o See **§4.2 Message format** for more details on the data field length o If the data length does not correspond to a value listed in **§4.2 Message format** for the selected message format, the module performs zero-padding to complete the incomplete 32-bit block Answer: `+TX=0,<data>` after the message transmission • `<data>` – user data in a hexadecimal string, including zero-padding

***Warning**: the transmission period between two transmissions should never be below **60 seconds**.*

d. CW

`CW` – **Generate a CW**	
`AT+CW=<duration>[,<frq>[,<pwr]]`	Generate a Carrier Wave signal Parameters: • `<duration>` – duration of the CW, in steps of 100 milliseconds o Maximum value: 3000 (300 seconds) • `<frq>` – frequency of the CW signal, in Hz • `<pwr>` – transmission power of the CW signal Note: if the optional parameters are not detailed, the values considered for these parameters are the values stored in RAM. Answer: `+CW=OK` after the end of the CW signal duration

***Warning**: the `AT+CW` command should exclusively be used for conducted tests or antenna measurement campaigns in a lab environment (ex: anechoic chamber), but never for real transmission to the satellites.*

3.4. Error responses

`ERROR` – **Error response**	
`ERROR=<errorno>`	Error response to an AT command from the KIM1 module Parameters: `<errorno>` – an integer that specifies the error • 1: Unknow error • 2: format of parameter is incorrect • 3: parameters are missing • 4: too many parameters • 5: the value of the parameter is incompatible • 6: the AT command is unknown • In case of any other value, please reach out to Kinéis technical support

4. Transmission protocol

4.1. Frame format

The messages transmitted by the KIM1 follow the low-data rate Argos-2 frame format shown below:

Low-data rate Argos-2 frame format

The KIM1 module performs the following parts in a transparent way for the integrator:

- Physical header: carrier wave
- Data link header: data link information, including 28-bit ID number

Each KIM1 module has a unique couple of ID numbers:

- Hexadecimal ID number, for integration in the transmitted message (28 bits or 7 hexadecimal digits), programmed into the module and unmodifiable by the integrator
- Decimal ID number, for online access to the transmitted data, written on the KIM1 marking (see KIM1 Datasheet)

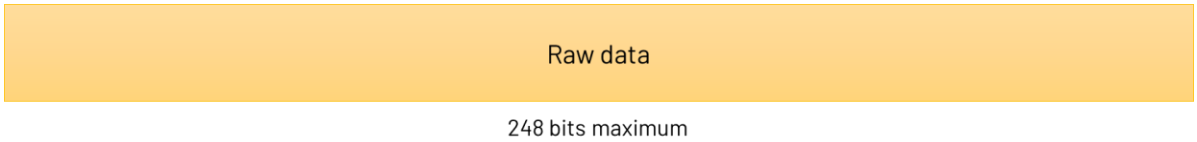
***Warning**: there is no possible conversion between these two ID numbers, only an allocation table. If there is a doubt on the value of any of these two ID numbers, feel free to reach out to Kinéis technical support.*

The Message field content is defined by the user with the appropriate AT commands, and can be formatted using the command `AT+AFMT` to the message formats described in the next paragraph (see **§4.2I.A.1.b Message format** for the detail on the command `AT+AFMT`).

4.2. Message format

This paragraph describes the different formats possible for the "Message content" field of the frame, including the network-layer mechanisms offered by Kinéis.

1. Raw format (default)



The raw format does not include any network-level mechanism and allows the use of the maximum number of available bits for the user data, for compatibility of the message format with existing devices. In order to take advantage of the network-level mechanisms introduced by Kinéis, we recommend to use the Kinéis standard format detailed in §**4.2.2 Kinéis standard format** for any new device development.

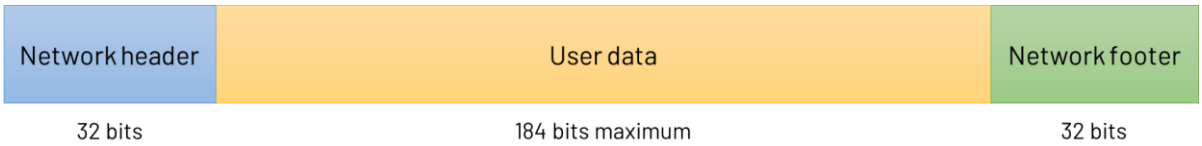
The Raw data field must be written in hexadecimal format and follows one of the following length values (N being the number of 32-bit blocks):

N	Data length (Bytes)	Data length (bits)	Message duration (ms)
1	3	24	360
2	7	56	440
3	11	88	520
4	15	120	600
5	19	152	680
6	23	184	760
7	27	216	840
8	31	248	920

- If the data specified with the AT+TX command does not follow one of these length values, it will be zero-padded by the KIM1 until it reaches the next possible length value.
- If the data length is greater than the maximum possible length, the KIM1 will automatically truncate the message to the maximum data length.

***Warning**: to prepare compatibility with the future KIM1 generations, it is highly recommended to use the Kinéis standard format described below. If using the Raw format, it is highly recommended to reserve the first 4 bits of the Raw data field for the ID extension from the current 28-bit to the future 32-bit ID number.*

2. Kinéis standard format



This message format includes all network-level mechanisms offered by Kinéis:

- Network header includes:
  - ID extension to switch from the Argos 28-bit ID number to the Kinéis 32-bit ID number
  - CRC-16/XMODEM for error detection, computed on the SF, MC and Data fields
  - Service Flag: service (or no service) attached to the uplink message received onboard
  - Message Counter: value incremented every time the device generates a new message
- Network footer includes a BCH(255,223,4) code for error correction (up to 4 error bits corrected), computed on CRC, SF, MC and Data fields
- Data contains the user data to be collected and transmitted. It must be written in hexadecimal format and follows one of the following length values (N being the number of 32-bit blocks):

N	Data length (Bytes)	Data length (bits)	Message duration (ms)
3	3	24	520
4	7	56	600
5	11	88	680
6	15	120	760
7	19	152	840
8	23	184	920

  - If the data specified with the AT+TX command does not follow one of these length values, it will be zero-padded by the KIM1 until it reaches the next possible data length value.
  - If the data length is greater than the maximum possible length, the KIM1 will automatically truncate the message to the maximum data length.

4.3. Transmission strategy

Kinéis system offers the possibility to collect short messages of up to 23 Bytes of useful data on a regular basis. With 7 satellites available today and more to come, Kinéis system provides many timeslots per day in which data can be transmitted to the satellites, enabling to collect up to 2kB of useful data per day.

Depending on the latitude of the terminal, the satellite passes occur more or less often and the revisit time varies. Transmitting data between the satellite passes means that they will not be received by any satellite, and it can be very costly for the device in power consumption.

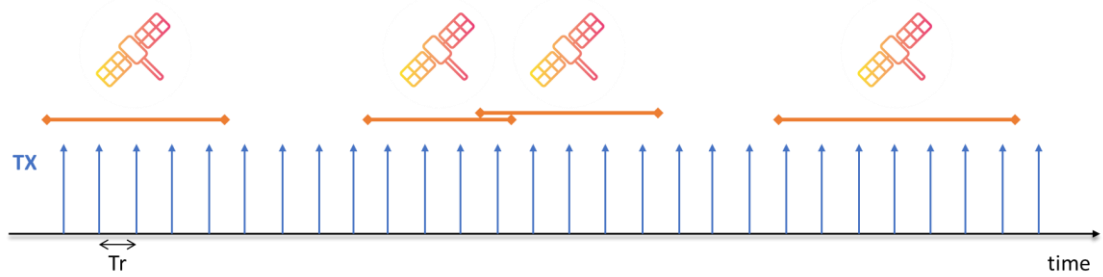
Kinéis can offer transmission strategy recommendations to define the best transmission strategy, in order to optimize power consumption and maximize the probability of good reception of your data by the satellites. A few types of transmission strategies possible with the KIM1 are briefly described below and are detailed in the rest of the documentation provided by Kinéis. The support team is also available to advise a transmission strategy adapted to the targeted use case.

***Warning**: the transmission period Tr between two transmissions should never be below **60 seconds**.*

1. Positioning/continuous tracking

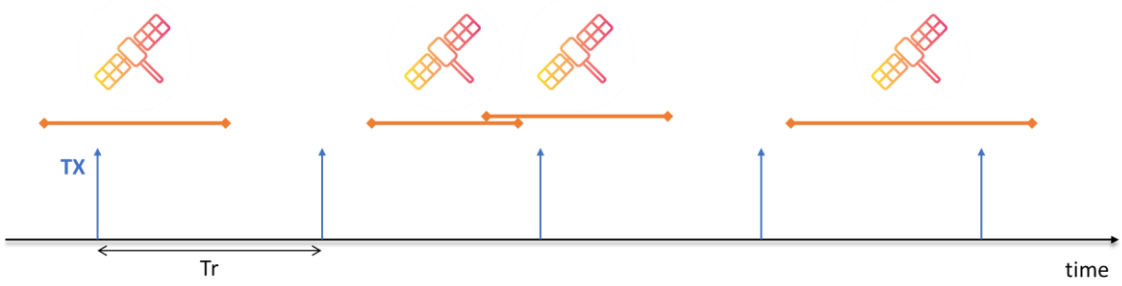
Random periodic transmission with no knowledge of the satellites passes with transmission period < 120 seconds. The messages can also contain user data (see §**4.3.3 Simple data collection**).

The Transmission period under 120s allows for multiple messages reception during satellite passes and allows for doppler positioning of the device.



2. “Keep alive”

Random periodic transmission with long transmission period, for up to 4 messages per day.

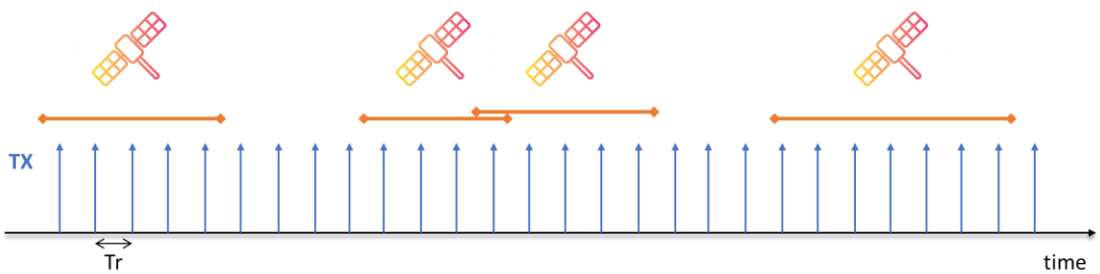


Below are the typical values of the transmission period, according to the average target data amount to be transmitted, for the current Argos Legacy system and the future Kinéis system:

Target data amount (average)	Transmission period	
	Argos Legacy	Kinéis
1 msg/day	2 hours	6 hours
2 msg/day	1 hour	3 hours
3 msg/day	40 minutes	2 hours
4 msg/day	30 minutes	1.5 hours

3. Simple data collection

Random periodic transmission with no knowledge of the satellites passes, for up to 24 messages per day. Messages have to be repeated to ensure a good statistical reception of the useful Data.



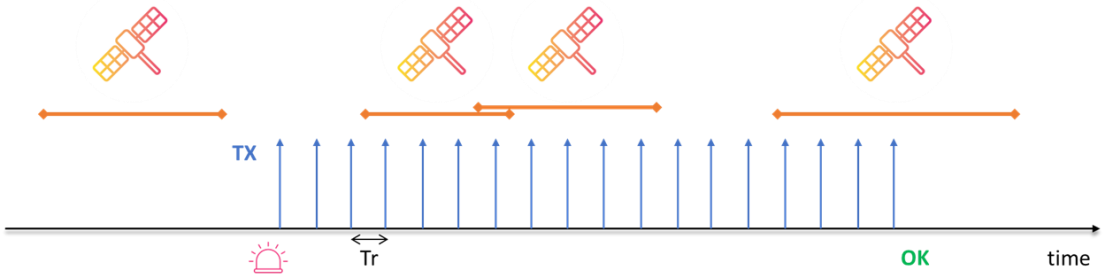
Additional mechanisms can be implemented to improve the probability of reception:

- Redundancy: repetition of the same data in several messages
- Historization: including several data sets in a single message, with an adapted FIFO memory management

- Pseudo-random transmissions: limitation to one or several time windows during the day, especially those when the satellite passes are frequent (for Argos legacy system), thanks to UTC time synchronization and potential knowledge of satellite orbital plans

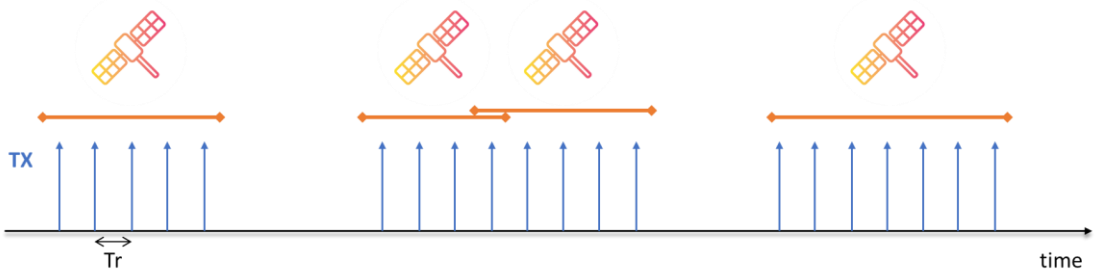
4. Alerting

Random periodic transmission when an alert is triggered and until it is deactivated. A transmission period < 120s can be implemented to ensure quick satellite reception and positioning of the device. This mode is most useful for occasional alerting, back-ups, asset recovery use cases. The typical transmission window is 7 hours with the current Argos Legacy system and 1 hour with the future Kinéis system.



5. Transmission on satellite passes

Kinéis developed a satellite pass prediction algorithm for embedded targets. The device can transmit only when a satellite is in visibility, thus saving on battery power and increasing the probability of good reception by the satellites.



***Warning**: using the KIM1, which is a transmission module with no reception capability, the device will need an independent way of updating the AOP (Adapted Orbital Parameters) for the computation of satellite passes (typical validity = 3months after update). Please refer to* KINEIS-MU-2019-0094 Satellite pass predictions – User guide.pdf *for more details.*

5. Additional information

5.1. Contact & support

Product information, technical support and commercial contact are available from Kinéis at the following link: https://www.kineis.com/contact/

5.2. Legal Notices

Kinéis reserves the right to make changes, corrections, enhancements, modifications, and improvements to their products and/or to this document at any time without notice. Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

Kinéis products are warranted as per contract and general purchase condition, as long as they are used under the conditions described in the datasheet and the integration manual.

5.3. Frequency Use

The frequency band 401-403MHz is designated by International Telecommunication Union (ITU) as usable for Global satellite data collection and positioning system as ARGOS.

The Centre National Etudes Spatiales (CNES) is in charge of Argos program. The CNES endorses Kinéis to operate the frequency band allocated to Argos.

This frequency band is usable with limitations. Please contact Kinéis to verify your application with Kim1 respect those limitations.