ENTERPRISE > IIoT

IsatData Pro Modem Integration

Version: 2020-11-23

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The mobile satellite company™

Objectives

At the end of this training module you should be able to…

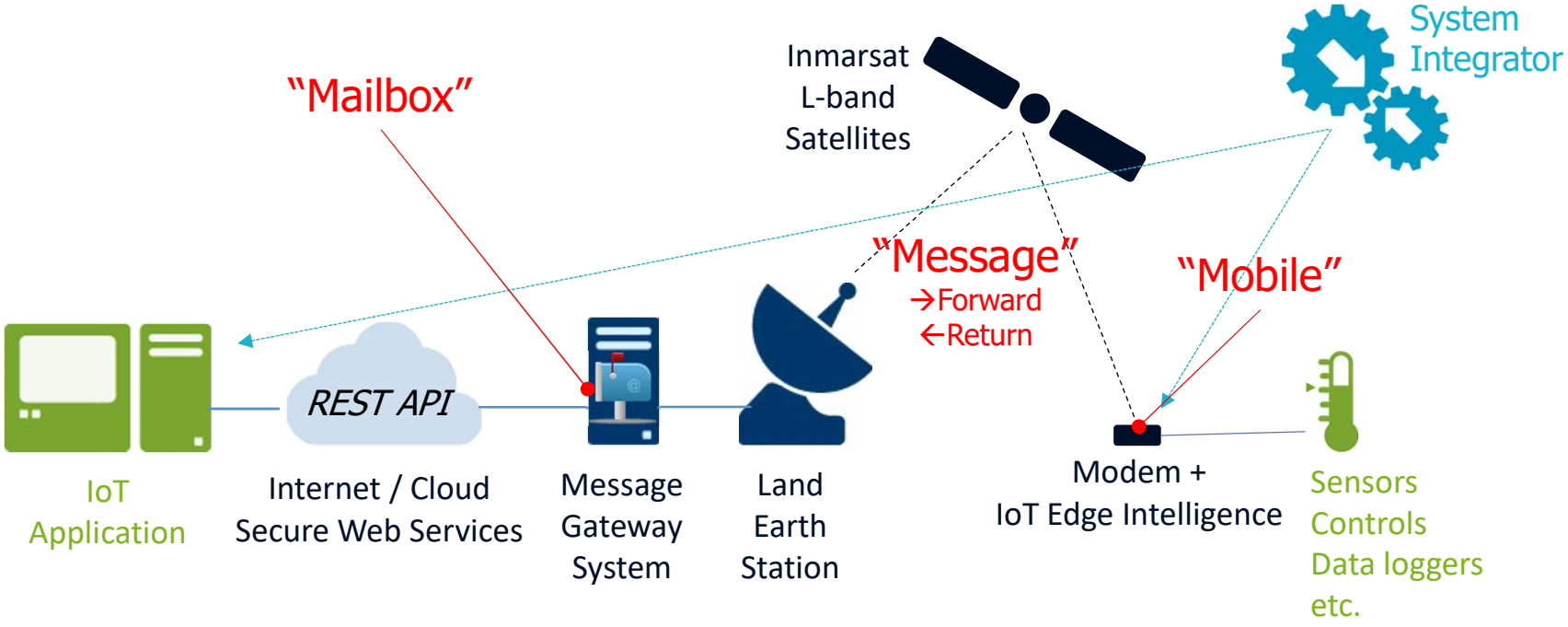
- Identify which IDP modem(s) are best for your integration
- Describe the Type Approval Process
- Describe the key system integration considerations
- Begin working with a modem developer kit

01

IsatData Pro System Review

IsatData Pro System Architecture Key Concepts

Event-driven IoT messaging for sensors, controls and simple devices

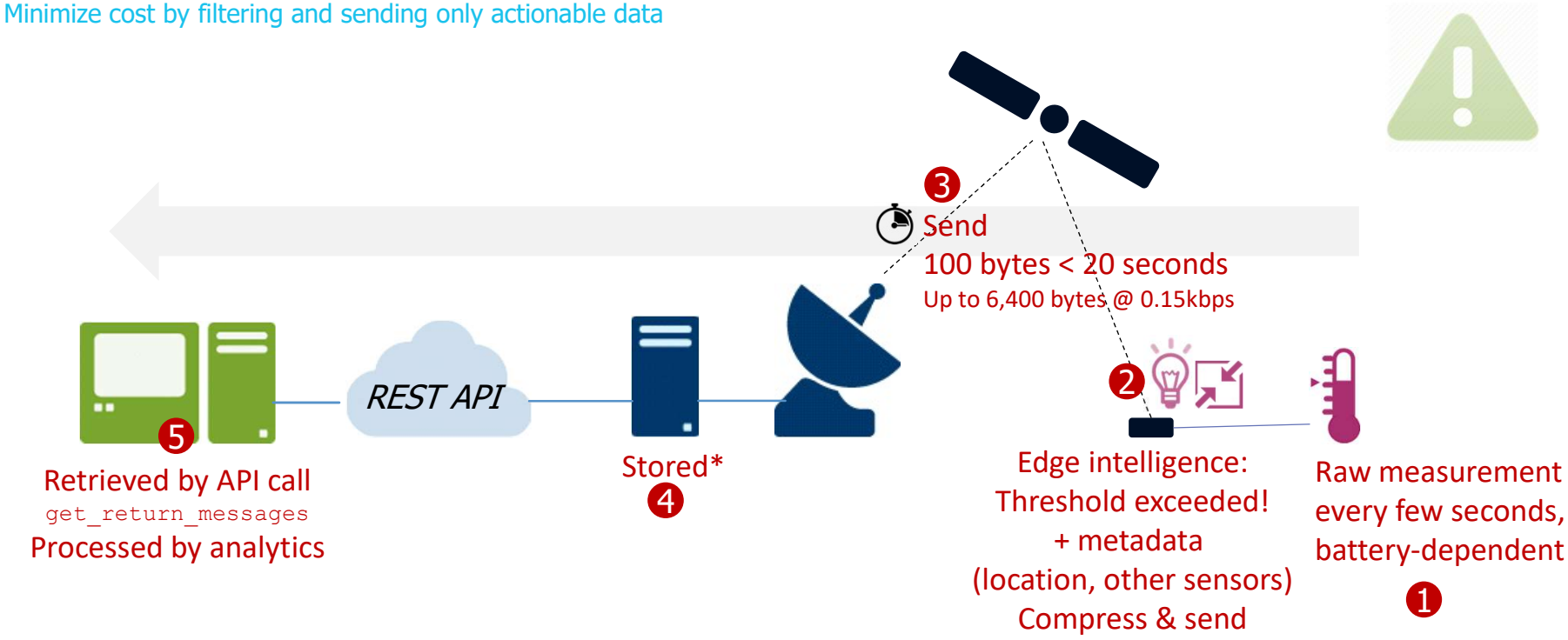


HOW IT WORKS: IDP

Event-Driven Messaging (Mobile-Originated)

Send only relevant data when a condition is met or a periodic "ok" heartbeat

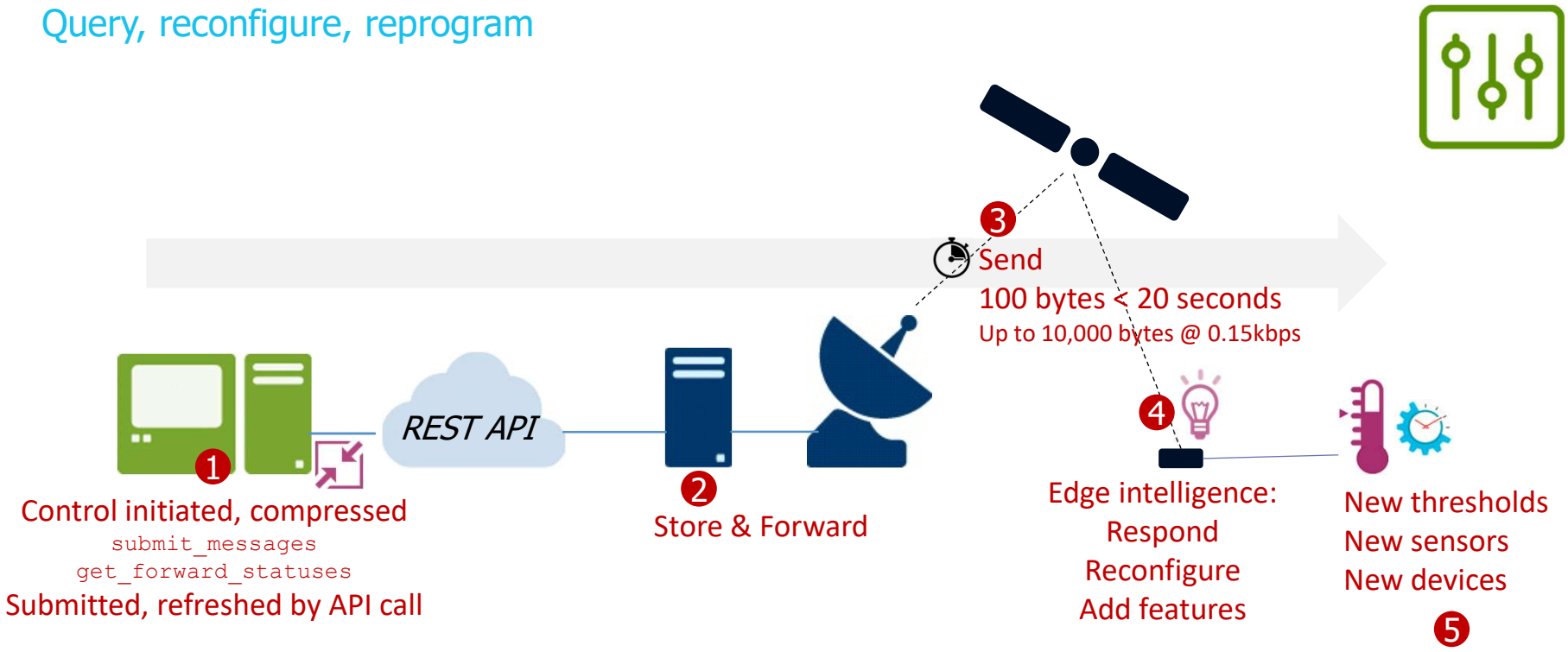
Minimize cost by filtering and sending only actionable data



HOW IT WORKS: IDP

Remote Control (Mobile-Terminated)

Query, reconfigure, reprogram

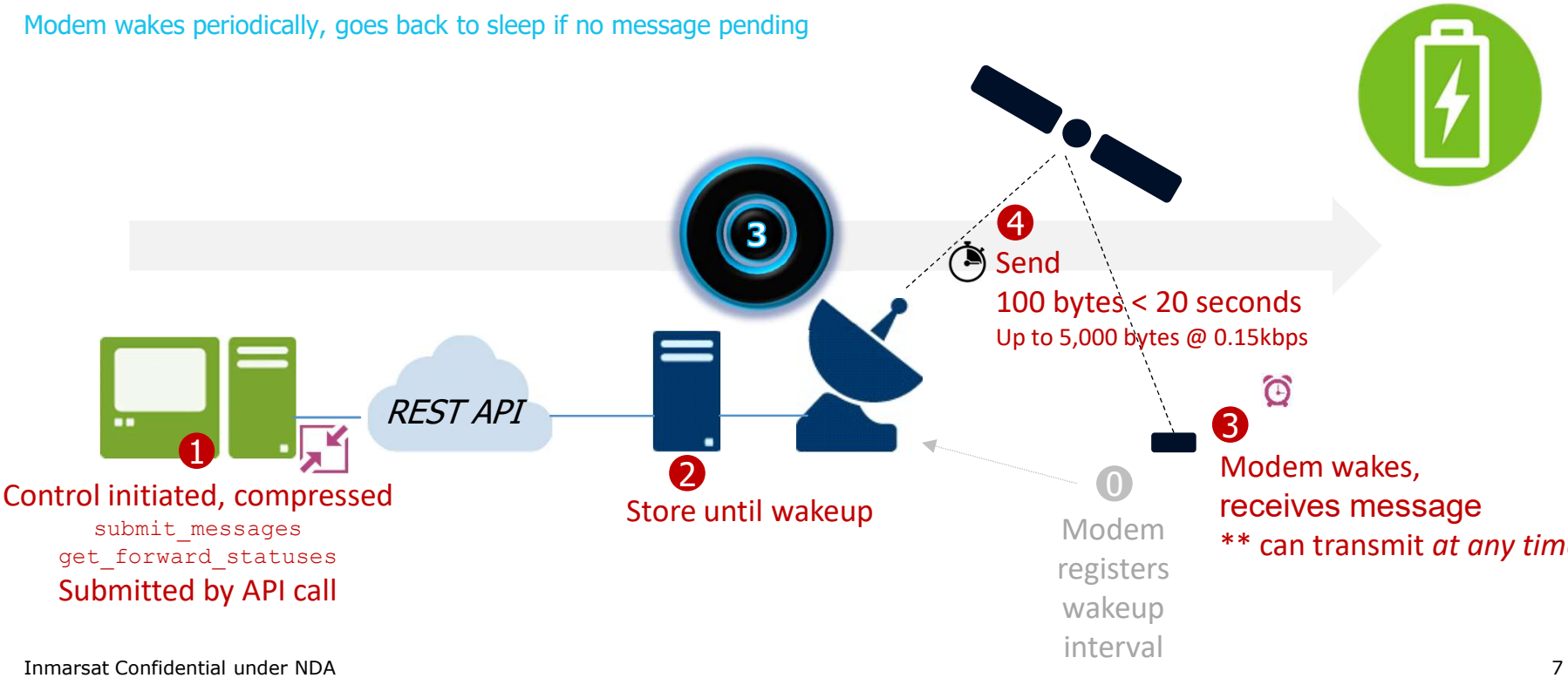


HOW IT WORKS: IDP

Ultra Low Power Wakeup (Mobile-Terminated)

Message gateway queues message until modem wakes up

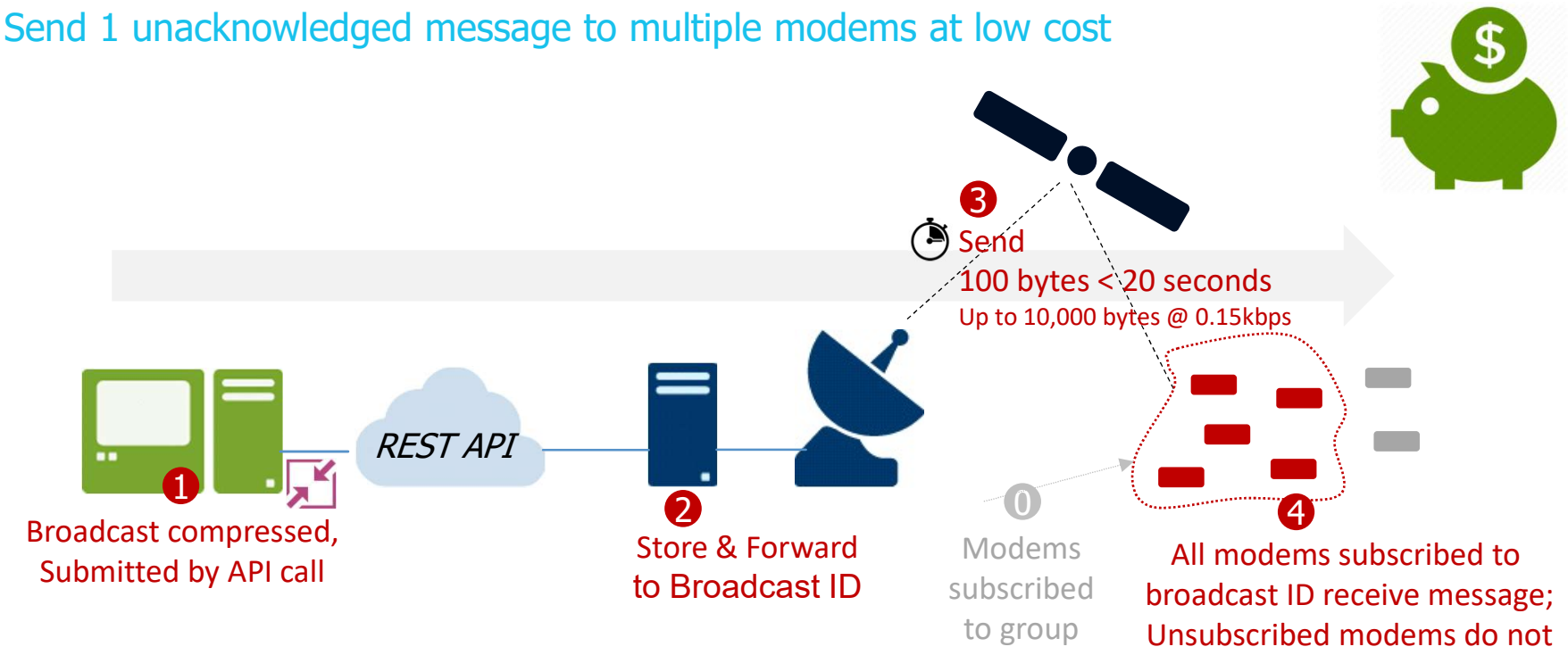
Modem wakes periodically, goes back to sleep if no message pending



HOW IT WORKS: IDP

Multicast Capability (Mobile-Terminated)

Send 1 unacknowledged message to multiple modems at low cost



Application Data Access

Web Service Operations

- Secure mailboxes accessed using REST web service over TLS/HTTPS
  - Each mailbox provides a unique authentication id/password
  - Multiple terminals are assigned to a mailbox
  - Interaction with remote device requires deep knowledge of embedded app/API
- Simple RESTful web service operations for your cloud/enterprise micro services
  - GET get_return_messages
  - POST submit_messages
  - GET get_forward_statuses

03
IsatData Pro Modems

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ORBCOMM IDP Modem Family

All use common AT command set

OGi

Lowest cost & size

Requires packaging

Low power

Separate passive antenna

(short distance)

UART/PCIe interface

5V ~ 15V input

-40C ~ 85C operation

High volume

ST2100

Medium cost & footprint

IP67 / SAE J1455 package

Ultra-low power

Integrated active antenna

(any distance)

RS232 + digital notification

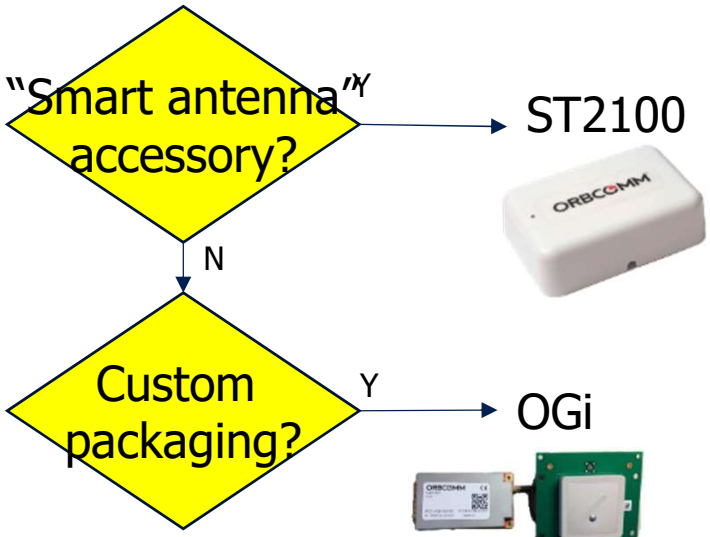
9V ~ 32V input + surge protection

-40C ~ 85C operation

Any volume

Which IDP Modem Should I Use?

Application dependent



- ✓ Type Approved
- ✓ IP67 package
- ✓ No RF cabling
- ✓ RS232
- ✓ 9-32V input

- ! Type Approval may require RF interference tests
- ! Antenna choice: patch/helix
- ! RF cable loss max 0.5-1.5dB
- ! 5V input
- ! Antenna located with modem

Inmarsat ST2100 Developer Kit

Available Q4 2020

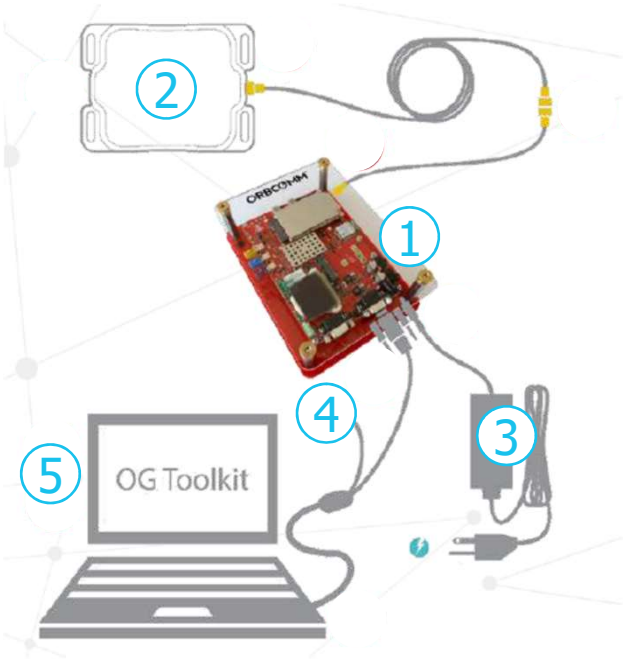
1. "Smart antenna" ST2100 (land coverage)
2. Magnet-mount base
3. Serial/USB cable
4. Serial/Power interface cable
5. AC/DC power supply adapter
6. DC automotive power supply adapter
7. Edge/WiFi Dongle
8. Modem SDK with software simulator

OGi Developer Kit

Purchase from ORBCOMM (est. $500 USD)

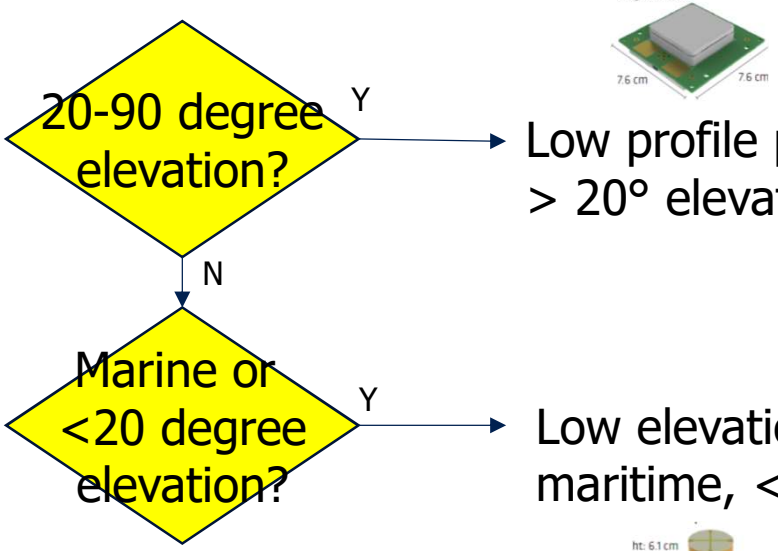
1. Development board including modem
2. Passive antenna (low profile patch)
3. International power supply adapter
4. Serial/USB cable
5. Modem SDK, including simulator

Use in “AT” mode for Inmarsat compatibility



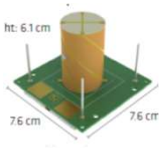
Which OGI Antenna Should I Use?

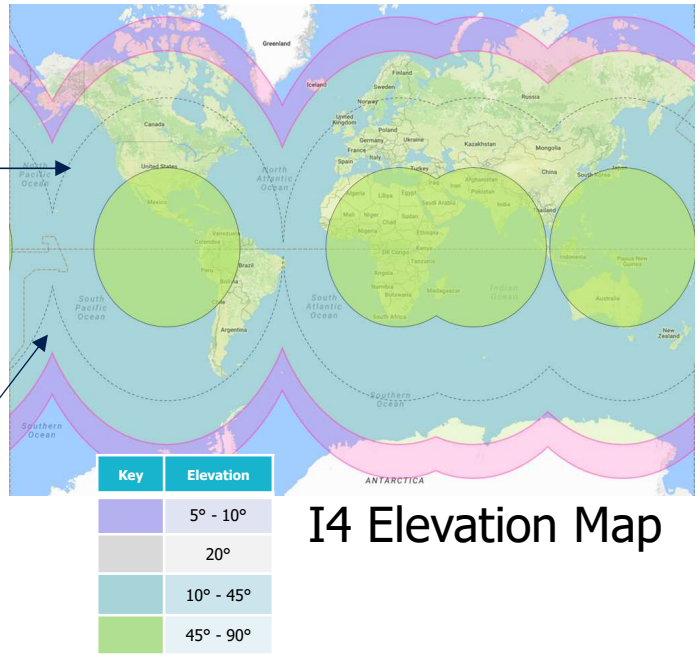
Deployment dependent



Low profile patch
> 20° elevation

Low elevation helix
maritime, < 20° el.



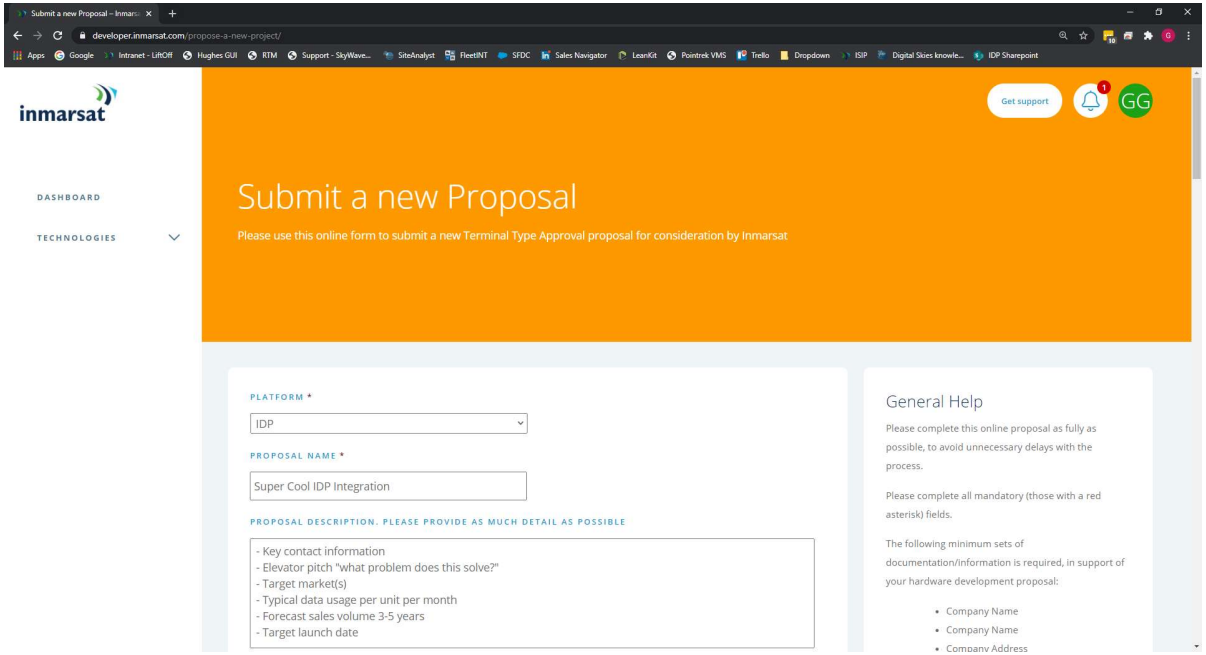


I4 Elevation Map

02
Type Approval for IsatData Pro

Type Approval applies to OGi module integration or new radio/antenna design

https://developer.Inmarsat.com/propose-a-new-product

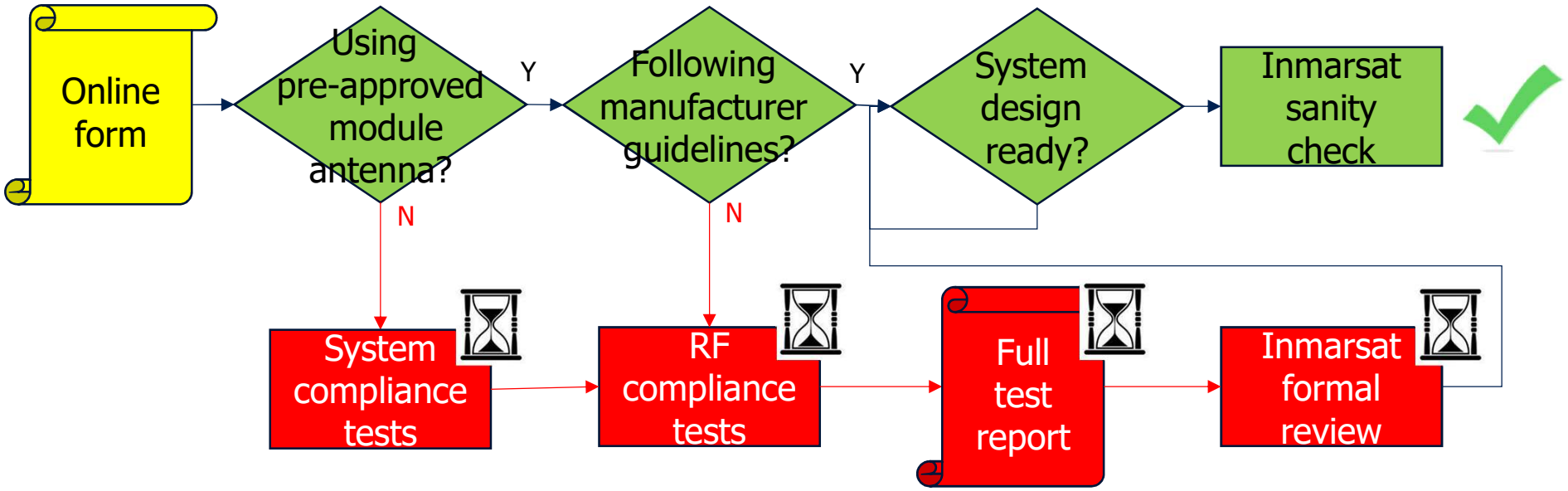


Technical information:

- Detailed diagram of integration assembly
- Distances & cable type clearly marked
- Checklist showing manufacturer guidelines used

Type Approval Process: https://developer.inmarsat.com

Use Inmarsat pre-approved modules and antennas for "green lane" rapid approval



Integrator Guidelines

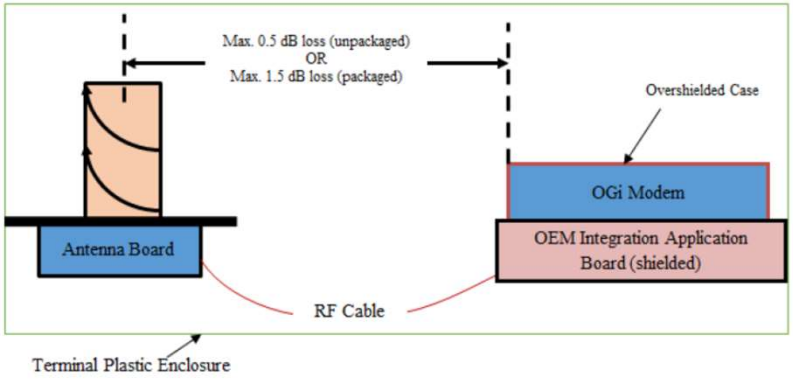
Obtain latest hardware specification from manufacturer and READ ALL DETAILS

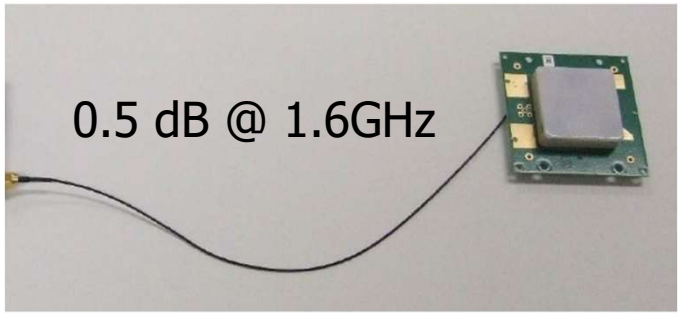
4.5 Typical Integration

The modem is intended to be used in a larger system. The system must provide adequate power (low noise and relatively high current) and must possess an electrical signaling mechanism compatible with the modem. Ensure that the custom designed circuit board does not create undesirable signals that can impact the performance of the modem. An external antenna is required to complete the modem design.

OGi constraint #1 RF cable/connector loss

Maximum length of cable depends on antenna type, cable type and connectors





Application	Cable Type	Connector	Max. Total Loss at 1.6 GHz	Cable Example
Packaged/Remote Antenna cable	RF Coaxial 50 Ω	MMCX male/SMA male	1.5 dB	LMR195
Unpackaged Antenna Cable	RF Coaxial 50 Ω	MMCX male/IPEX plug male	0.5 dB	-

OGi Receiver Sensitivity

RF Sweep test ensures performance integrity after integration

- Geostationary satellite requires high sensitivity receiver which is more susceptible to low order harmonic interference than many other radios
- ORBCOMM hardware guides specify recommendations for shielding and separation (>30 cm) between module and antenna
- RF sweep test strongly recommended to ensure integrator electronics do not create 'spurs' (dead bands) within the extended L-band spectrum
- ORBCOMM can perform this test for a one-time fee

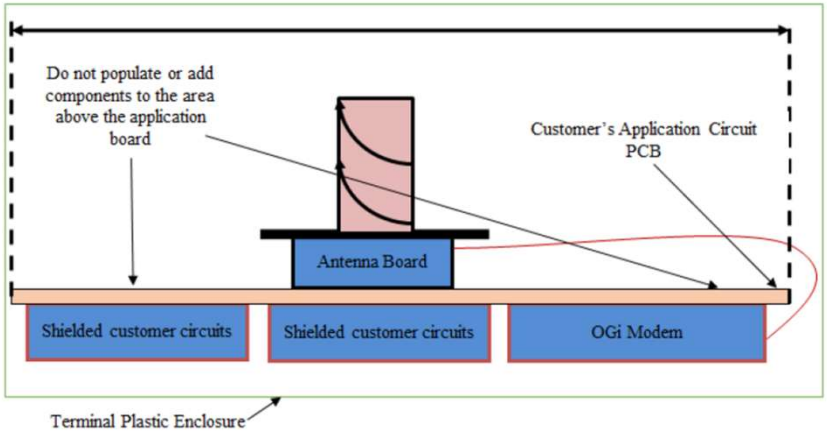
OGi constraint #2 Local Interference / Shielding

Recommended distance >30 cm between microcontroller and antenna

4.5.3 Host Shielding

In a typical integration, the modem is controlled by a microcontroller.

The microcontroller and supporting circuitry, such as memory, high speed data/address bus, clock references and power supply sources are normally noisy and could potentially affect the highly sensitive satellite or GPS receiver performance if the antenna is placed too close to the circuitry.

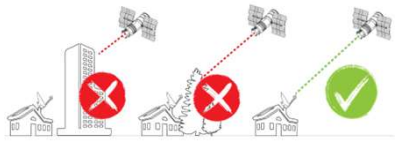


04
Modem Serial Communications

IsatData Pro Network: Before You Begin

Geostationary satellites are always on, but can be blocked by obstruction

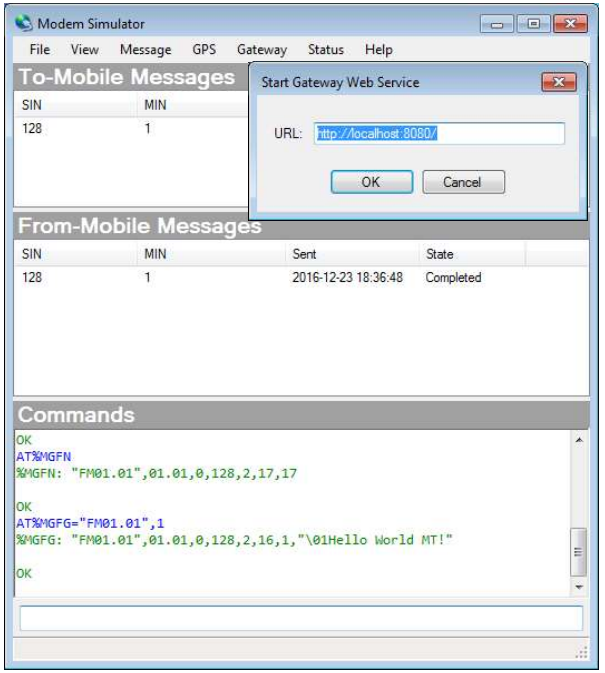
- Inmarsat (licensed from ORBCOMM) provide an IDP SIMULATOR for indoor software development
  - Simulates modem AT commands, blockage, etc.
  - Simulates network API on localhost
- Need unobstructed view of the sky toward the Equator "line of sight" for the antenna
  - IMPORTANT: Not all windows pass L-band (some have metallic pigment)
- GPS/GNSS is built into every IDP modem and antenna
  - IMPORTANT: Operating too close to a wall may affect GPS acquisition time and accuracy
- When powered on, a modem registers on the network
  - Registration message is non-billable and does not include location or user data



Useful Tools

Developer tools available for IDP

- Windows (.NET) apps bundled in IDP SDK
  - Scope: online modem GUI
  - Modem Simulator: offline test GUI/CLI and network web service simulator
  - Console: drag-n-drop serial firmware update
- Python open source reference code
  - GitHub.com/Inmarsat
- Postman: network API test environment
  - Collections, Environment available from Inmarsat



Modem Operation (Cold Boot)

Typical 'ready' time 35 – 60 seconds

1. Power on
2. Acquire GNSS location (3D fix) and time (UTC synchronization)
3. Tune to regional beam frequency (based on location, internal lookup)
4. Acquire Forward Channel
5. Send registration message, await authorization
6. Ready to send/receive data

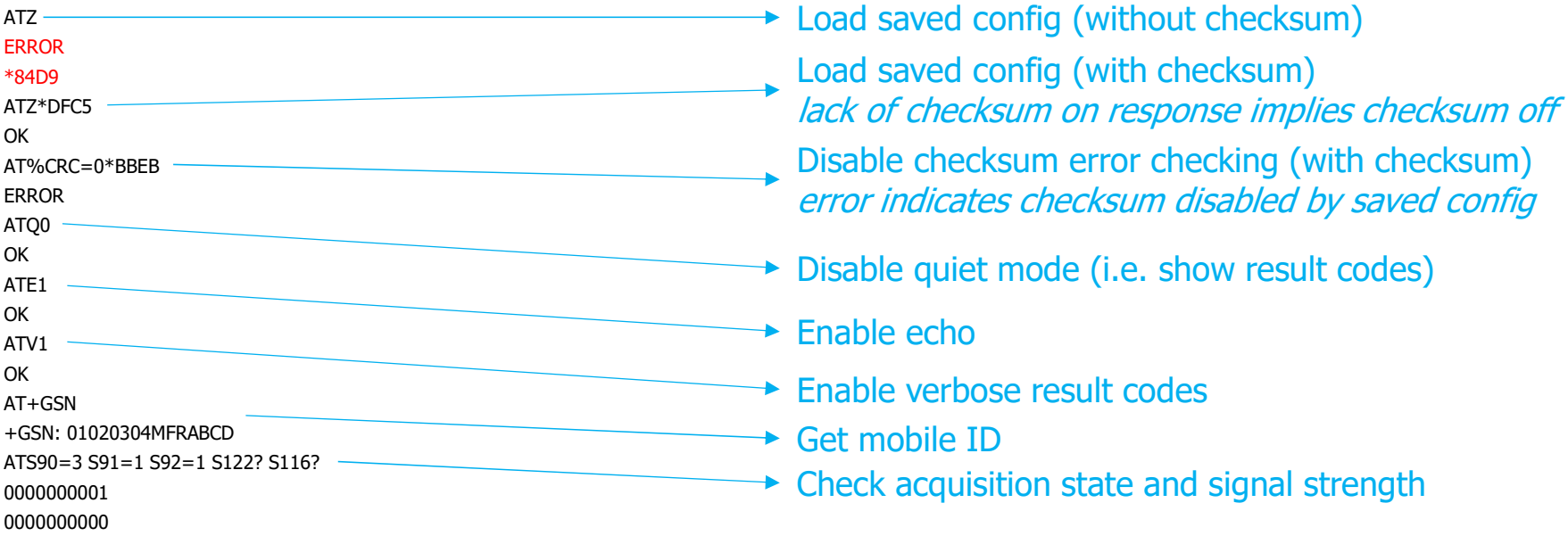
Establishing AT Communications

Define a robust sequence

- Consider power-up and fault/recovery cases so that a host can re-establish communications with the modem if either are reset
- Typical sequence:
  - Detect if CRC error check is enabled
  - Load factory or last-saved configuration
  - Enable CRC error check
  - Configure how modem responds to commands (echo, quiet, verbose)
  - Configure application settings (wakeup interval, power mode)
  - Check for received messages in modem non-volatile Rx queue
  - Check/synchronize transmit messages in modem non-volatile Tx queue

Communication Handshake Example

Robust to recover and establish known good state



AT Command Parsing

Using GNSS may add delays

- AT command responses have variable time to respond
  - Recommended wait 100 ms, sometimes delayed
  - Modem queues subsequent requests and processes in order
  - *** GPS requests may take several seconds and have configurable time out ***
- Recommended use of CRC for long cables. CRC-16-CCITT xmodem with start 0xFFFF
- Command format with response:
  - Factory default (echo on, verbose, quiet off):
    - <echo><cr><lf><response><cr><lf><cr><lf><verbose code><cr><lf>
  - CRC enabled:
    - <echo><cr><lf><response><cr><lf><cr><lf><verbose code><cr><lf><checksum><cr><lf>
  - Multi-command response:
    - <cr><lf><response1><cr><lf><cr><lf><response2><cr><lf>

AT Error Handling

Error Codes populated in S-register 80

- Response Code is either OK (0) or ERROR (4)
- To get detailed error reason must query using ATS80? (before next command)
- Microcontroller function to send AT commands should include subsequent query of ATS80 in case of error before next command is processed

Verbose Code	Numeric Code	Description
OK	0	No error
ERROR	4	Error – lookup in S80
	100*	Invalid CRC
	102*	Invalid command parameter
	108*	Timeout

** Not returned with response; must query S80 'last error code'*

Sending a Mobile-Originated Message

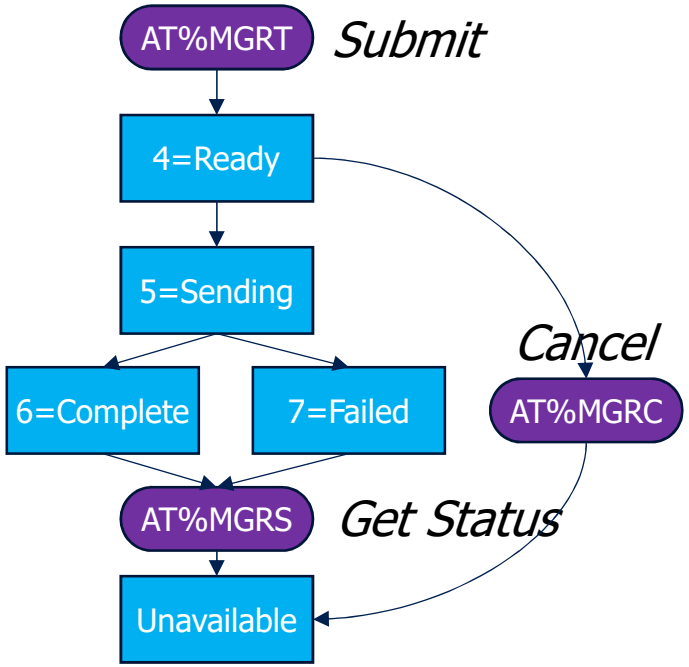
Message Return Transmit, Message Return Status, Message Return Cancel

- Host submits **AT%MGRT** command with following details:
  - Unique message name
  - Priority (1 = High, 4 = Low)
  - SIN byte (Service Identification Number, must be > 15) and (optional) MIN byte (Message Identification Number)
  - Data format (1=text, 2=Hex/ASCII, 3=Base64)
  - Data (using specified format)
- Host must poll status using **AT%MGRS** to clear the queue
  - Returns name, modem-assigned number, priority, SIN, state, length, # bytes acknowledged
  - Alternatively poll **ATS89?** bitmask 0x04; IDP-100/200 can assert notification output
  - Status must be read periodically until complete or messages will fill queue
- Messsages can be cancelled using **AT%MGRC**, if they are not in Sending state

Mobile-Originated Message States

State values 4-7 defined

- Messages in 'sending' state cannot be cancelled
- Failure cases include timeout
- Shortly after host reads a final message state, modem frees up the memory slot used
- 'Unavailable' state returns AT error code 109
- Note: error code 106 'insufficient resources' in response to %MGRT means queue is FULL



Mobile-Originated Message Transmit Example

Hello World!

```
AT%MGRT="RM1",4,128.1,1,"Hello World!"
OK
AT%MGRS="RM1"
%MGRS: "RM1",0.0,4,128,4,14,0
OK
AT%MGRS="RM1"
%MGRS: "RM1",0.0,4,128,5,14,0
OK
AT%MGRS="RM1"
%MGRS: "RM1",0.0,4,128,6,14,14
OK
AT%MGRS="RM1"
ERROR
```

Transmit message
Named: "RM01" (Return Message)
4=Low Priority
128.1 = SIN 128, MIN 1 (user defined)
1 = Text format
Content=Hello World! (12 bytes)

0.0=Modem-assigned number
4=Ready
14=Message size (SIN, MIN, content)

5=Sending

6=Complete/success (14 of 14 bytes)

Unavailable/removed

Receiving a Mobile-Terminated Message

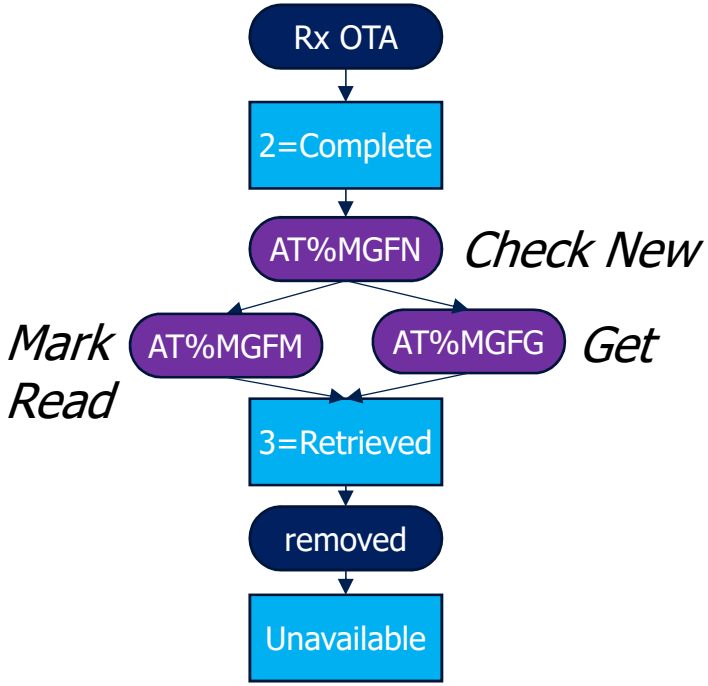
Message Forward New, Message Forward Get

- Host polls modem for new received messages using **AT%MGFN**
  - Alternatively poll **ATS89?** bitmask 0x02 for new message received; IDP-100 and IDP-200 can assert notification output
- Modem returns information:
  - Modem-assigned message name, modem-assigned message number, priority, SIN, state, length
  - No response with OK means no new message waiting
- Host retrieves message using **AT%MGFG**, specifying message name and desired data format
- Modem returns information and content:
  - Message name, number, priority, SIN, state, length, data format, data including MIN but not SIN
  - Raw payload = SIN + data

Mobile-Terminated Message States

State values 2-3 defined

- Host may read message content or mark read (ignore)
- Read/marked messages may be deleted by modem at any time
- 'Unavailable' state returns AT error code 109



Receiving Mobile-Terminated Message Example

Response to Hello World!

```
AT%MGFN
%MGFN:
OK
AT%MGFN
%MGFN: "FM28.43",28.43,0,128,2,13,13
OK
AT%MGFG="FM28.43",1
%MGFG: "FM28.43",28.43,0,128,2,13,1,"\01Hello User!"
OK
AT%MGFN
%MGFN:
OK
```

New message named FM28.43
28.43=modem-assigned number
0=low priority
128=SIN
2=Complete (ready)
13=size (bytes including SIN, MIN)

1=GET using text format

1=text format
Payload=MIN ("\01") & "Hello User!"

No new Rx messages

Modem Queues

ORBCOMM/SkyWave modems

- Modem stores all messages in non-volatile memory (survive reset)
- Transmit and Receive messages share storage buffers based on size:
  - Up to 17 ‘small’ messages (2-235 bytes)
  - Up to 16 ‘medium’ messages (236-1235 bytes)
  - Up to 8 ‘large’ messages (1236-5235 bytes)
  - Up to 4 ‘extra-large’ messages (5236-10 000 bytes)
- Modem can use a larger message slot for smaller message if the smaller buffer is full
- Modem returns an error when a message cannot be stored:
  - MT memory full, modem transmits return message ‘protocolError’ (SIN 0, MIN 2)
  - MO memory full, modem replies AT error code 106 (insufficient resources)

Requesting Location

ORBCOMM/SkyWave modems

- Modem's GNSS chip can operate in 2 different modes:
  - On-request (default) saves power but takes longer to respond
  - Continuous, updates every second (unless blocked/jammed) configured by **AT%TRK** or **ATS55**
- Host requests fix using **AT%GPS**
  - %GPS=<staleSecs>,<waitSecs>[,"GGA"][,"RMC"][,"GSA"][,"GSV"]
    - Stale secs specifies maximum age of fix; Wait secs how long before error is returned
    - NMEA sentence types contain different information
  - On-request mode, initial response returns error. Subsequent polls will eventually return a valid response. IDP-100/200 can assert notification output
  - Continuous mode, response is immediate

GNSS On-Request Mode Example

Request location using standard NMEA-0183 sentences RMC, GGA, GSV

AT%GPS=5,1,"RMC" → Get fix up to 5 seconds old, wait 1 second

ERROR

ATS80? → Get last error code (S80) Error 108 = Timeout

108

OK

AT%GPS=25,1,"RMC" → Get fix up to 25 seconds old, wait 1 second

%GPS: $GPRMC,193512.00,A,4517.8939,N,07555.1871,W,000.058,032.83,110313,*37

OK

GPS Continuous Mode Example

Configure refresh rate, then query

AT%TRK=10

OK

AT%GPS=15,1,"GGA","RMC"

%GPS: $GNRMC,194326.000,A,4517.8718,N,07555.1776,W,2.21,355.62,110313,,,A*74

$GNGGA,194326.000,4517.8718,N,07555.1776,W,1,04,3.1,129.6,M,-34.3,M,,0000*62

OK

Set continuous mode with 10 second "new fix" event notification

Get fix up to 15 seconds old, wait 1 second

$GN source GLONASS
$GP source GPS
$GB source BeiDou

S-Registers

Configuration settings and status information

- Configuration changes made via S-registers are lost after reset unless saved to non-volatile memory using AT&W
  - S51 (wakeup interval) is saved automatically when configured
- Commonly used S-registers:
  - S50 = power mode (configuration)
  - S51 = wakeup interval (configuration)
  - S88 = event notification control (configuration)
  - S89 = event notification assert status (status)
  - S80 = last (AT) error code (status)
  - S81 = most recent (AT) result code (status)

GNSS S-Registers

Fine tuning location information

- S39 = mode (e.g. GPS/GLONASS)
- S55 = continuous mode
- S36 = standby timeout
- S40, S41 = satellite detection timeout, fix timeout
- S56, S57 = jamming/antenna cut status and indicator
- S31, S32, S33, S35, S37 = position precision thresholds

Event Notification & Hardware Interrupts

S-register status useful to trigger host state changes and reactions

- Event bitmap mask can be configured using register S88
- Typical event notifications:
  - Modem registered
  - New MT (Rx) message received
  - MO transmit (Tx) completed
  - New GNSS fix available
- Bitmap values are held in register S89, and cleared when the host reads the register
- ST2100 (pin 7 active high) and OGi (pin 10) have digital output lines which assert to prompt an attached microcontroller to read S89 and then read relevant S-registers or %EVNT

Event Notifications Supported

ATS89? query returns a bitmap based on how S88 is configured

Bitmask	Event
0x1	New GNSS (position) fix
0x2	New MT (Rx) message received
0x4	MO message transmit (Tx) completed (success or fail)
0x8	Modem registered on network
0x10	Modem has been reset
0x20	Jamming/antenna cut status changed
0x40	Modem reset imminent
0x80	Wakeup interval changed
0x100	UTC time updated
0x200	Position fix timed out
0x400	Requested event cached

Event Monitoring with %EVMON and %EVNT

Useful for low power applications to reduce polling S-registers

- Configure relevant Trace records using %EVMON
  - Low Power: Class 2, Subclass 2 e.g. Wakeup for scheduled receive
  - Satellite Events: Class 3, Subclass 1 e.g. Satellite control state / registration
- Enable hardware notification using S88 – bit 10
- %EVMON indicates updated statuses with star e.g. 3.1*
- %EVNT retrieves data and metadata as comma-separated values
  - <count>,<bitmask>,<MTID>,<timestamp>,<class>,<subclass>,<priority>, <data0>,…,<dataN>

Trace Event S-Registers

Detailed information about modem operational state

- S90, S91, S92 = define trace capture (Class, Subclass, Initiate)
- S93..S99 = captured trace metadata
- S100..S123 = captured trace data (each class has up to 24 parameters)
- Example use:
  - Monitor satellite connection status and signal level
  - Low level troubleshooting

Satellite Status Information

Contained in satellite general status trace (Class 3, Subclass 1)

- Satellite Control State (index 23 = S122, enumerated list)
  - Registration status
  - Blockage status
- Signal quality (index 17 = S116, C/N*100)
  - “Good” above 44 dB
  - “Poor” below 37 dB

Monitoring Satellite Status Example

Class 3, Subclass 1 = Satellite General Status Trace

```
ATS90=3 S91=1 S92=1 S122? S116?
0000000001
0000000000
OK
ATS90=3 S91=1 S92=1 S122? S116?
0000000007
0000004102
OK
ATS90=3 S91=1 S92=1 S122? S116?
0000000010
0000004129
OK
```

Class 3, Subclass 1 = Satellite General Status
S122 = Satellite Control State
S116 = C/N x 100

Waiting for GPS, no satellite signal

Registration in progress, C/N = 41.02 dB

Active, C/N = 41.29 dB

Low Power Mode

Set using S-registers

- S50 controls power profile
  - 2 = mobile battery powered
  - 3 = fixed battery powered
- S51 sets wakeup interval
  - 0 = 5-second “always on”
  - 4 = 10-minute
  - 5 = 30-minute
  - 6 = 60-minute (maximum)

Parameter	Power Mode					
	0–Mobile, Powered	1–Fixed, Powered	2–Mobile, Battery	3–Fixed, Battery	4–Minimum Mobile Battery	5–Mobile Parked
GPS Stale Time - Maximum time between GPS fixes	3 hours	24 hours	6 hours	14 days	12 hours	24 hours
Transmit Message Age Timeout - Maximum duration for a Tx message	3 hours	3 hours	3 minutes	3 minutes	3 minutes	3 minutes
Background Beam Search Interval - Minimum time between background beam searches	20 minutes	60 minutes	20 minutes	60 minutes	20 minutes	60 minutes
Short Term Blockage Duration - Minutes before switching to beam search	5 minutes	5 minutes	20 minutes	20 minutes	20 minutes	15 minutes
Beam Search Maximum Timeout - Maximum timeout for beam search (minutes)	0	0	1600 minutes (26.6 hrs)	1600 minutes (26.6 hrs)	1600 minutes (26.6 hrs)	1600 minutes (26.6 hrs)

AT Command Summary

Command	Function	Command	Function
AT%CRC	Enable/disable CRC	AT%MGRT	Transmit message
AT%UTC	Get date/time	AT%MGRS	Check transmit status
AT%OFF	Shutdown	AT%MGRC	Cancel transmit
AT%EVNT	Retrieve a single trace record	AT%MGFN	List new received messages
AT%EVMON	Configure/retrieve monitored trace records	AT%MGFG	Get received message
AT%GPS	Request GNSS fix	ATS<n>=<v> AT&WS<n>=<v>	Set s-register n to value v Set & save s-register n to value v
AT%TRK	Enable/disable continuous fix mode	ATS<n>?	Get s-register n value

05
Standard Modem Messages

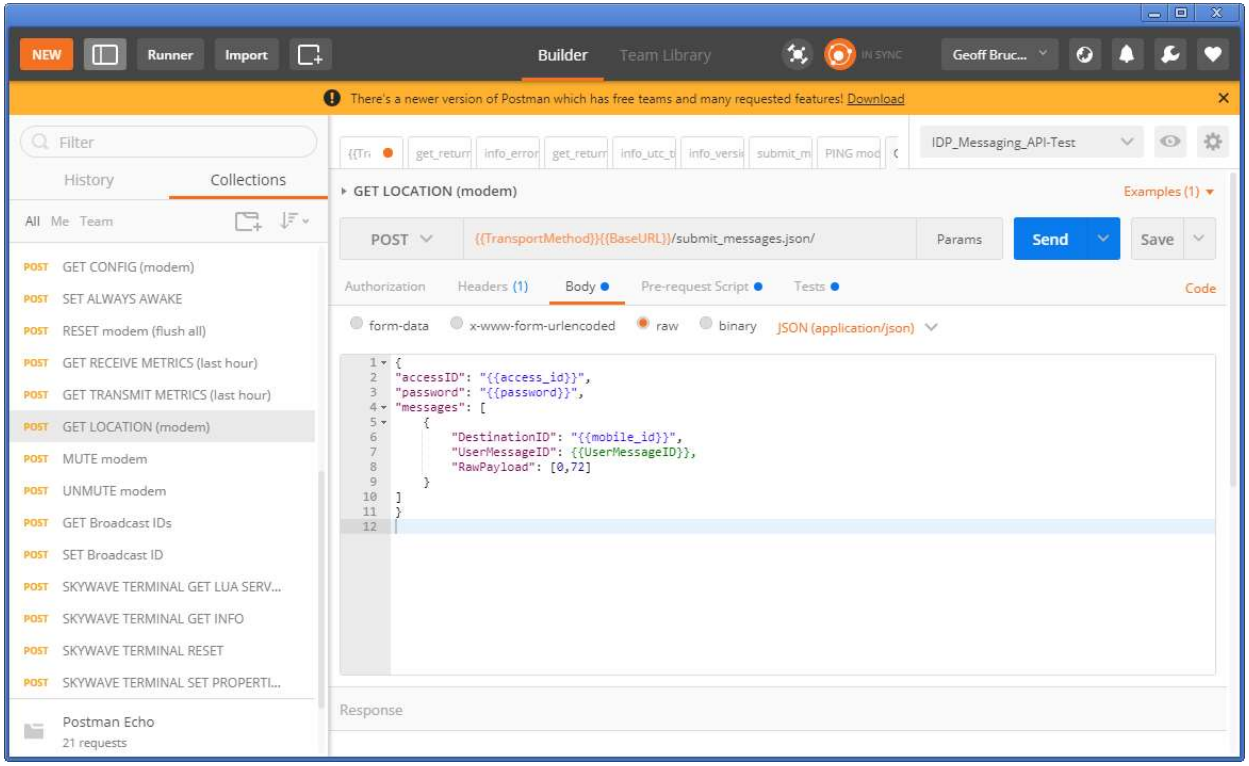
Over-The-Air Modem Command Messages

Standard messages used for remote operations and troubleshooting

Command	Response	Contents
GetLocation (2 bytes)	Location (15 bytes)	Lat/Lng, alt, spd, hdg, time
Ping (2 bytes)	Response (2 bytes)	Receipt time
SetWakeupInterval (3 bytes)	WakeupInterval (6 bytes)	Enumerated value
Reset (3 bytes)		
MuteTransmit (3 bytes)		
GetConfiguration (2 bytes)	Configuration (15 bytes)*	Versions, wakeup, broadcast subscriptions, operator information
GetBroadcastIds (2 bytes)	BroadcastIds	List of IDs subscribed

Example API message: Get Location

SIN=0, MIN=72



06
Modem/System Inter-Operation

Background: Glossary

- MO = Mobile-Originated aka From-Mobile aka Return
- MT = Mobile-Terminated aka To-Mobile aka Forward
- SAS = Satellite Access Station (Inmarsat private up/downlink)
- GNSS = Global Navigation Satellite System (e.g. GPS, GLONASS)
- UTC = Coordinated universal time aka Greenwich Mean Time (GMT)
- Blockage = impaired line-of-sight to satellite (no communication path)
  - May also be experienced from multipath or external interference
  - EMI = Electro-Magnetic Interference (typically caused by nearby antennas or unshielded electronics)

IsatData Pro Applications Development

Design for store-and-forward messaging

- Best-in-class latency on event messages (typical ~15 seconds)
- Relatively low throughput (limit ~0.14 kbps)
- Shared system access requires dispersal of messages in time
  - Mobile-Terminated messages share a common queue at the SAS
  - Mobile-Originated messages use time- and frequency-division multiplexing
  - DO NOT 'synchronise' messages to/from populations of terminals (i.e. do not schedule all to transmit daily at 07:00:00)
- "Intelligent Edge" several techniques help optimize system design performance
  - Define decision-affecting ***events*** to supplement time-based *reports*; statistically fewer but with greater impact
  - Measure at specific known time, transmit dispersed in time, and back-fill to correct time in data warehouse
  - Aggregate multiple measurements into fewer message transmissions (also reduces power consumption)
  - Use natural randomization, e.g. report at fixed offset from power-up (statistically rare for many units to power at exactly the same time)

Low Power Application Design

Balance latency against power consumption

- Modem must be powered on and actively listening to receive MT messages
  - 'Ready time' from power on can be variable, so applications using ON/OFF mode must budget a 'listening window duration'
    - Inmarsat recommends at least 2 minutes window duration (power on, get GNSS, acquire network, register)
    - Worst case recovery (e.g. reattempt later) must allow window up to 15 minutes in case modem must download network changes
    - Embedded host controller must detect "download BB change" scenario and leave modem powered ON for up to 15 minutes
  - Listening window start time must be distributed across installed base to avoid message loss
    - Inmarsat recommends a pseudo-random offset within a fixed window
      e.g. mobileId%windowDuration, where windowDuration is a multiple of 5-second frames offset from 00:00:00 UTC
    - Back-office application must queue messages until next window start time, then submit to mailbox
- Using a modem that supports synchronous low power wakeup, addresses above considerations automatically
  - Back-office can submit a message any time. IDP gateway stores message until next window start time, then forwards
  - Window start times are automatically pre-negotiated between modem and network
  - Window duration can be less than 5 seconds, since modem has pre-acquired and pre-registered
  - Download of network changes is done automatically in background

Modem Operation (Cold Boot vs Low Power Wakeup)

Typical 'ready' time 35 – 60 seconds

COLD BOOT (35~60 seconds typical)

1. Power on
2. Acquire GNSS location (3D fix, UTC time) (dominates 'ready' time)
3. Tune to regional beam frequency (based on location, internal lookup)
4. (Re)Acquire Forward Channel
5. Send registration message, await authorization
6. Ready to send/receive data

WAKEUP (<5 seconds typical)

1. Wakeup at predefined time (combination of user-provisioned interval and modem-calculated offset)
2. Directly Acquire Forward Channel
3. Listen for wakeup frame preview
4. If no data to receive, return to sleep

Transmission from modem can be done any time, no need to wait for wakeup time.

Modem Recovery (Failed Forward Channel Acquisition)

Typical ready time 10~20 minutes

1. Re-tune to global beam frequency (universal for all locations)
2. Acquire global Bulletin Board Channel
3. Download and validate new internal lookup table (takes several minutes)
4. Re-aquire GNSS location (if stale)
5. Tune to regional beam frequency (based on location, internal lookup)
6. Acquire Forward Channel
7. Send registration message, await authorization
8. Ready to send/receive data

Dominant time factor

Forward Channel Link Protocol

Aka "Traffic Channel", used for Mobile-Terminated messages

- 5-Second frames, divided into ½-second subframes
  - Subframes numbered 0 – 179 799 (00:00:00.0 to 23:59:59.5)
- Each modem knows exactly which subframe to listen for
  - Algorithm based on unique mobile ID and user-configured wakeup interval
  - Distributed evenly across all modems to avoid collisions
  - Fully synchronized with IsatData Pro network (automatic Forward delivery on wakeup)
- Messages consist of fragments up to 159 bytes in size
- Acknowledgements to Return fragments are sent (by the network) in the 2nd frame following modem transmit
- Forward Channel also transmits network configuration information similar to Bulletin Board

Return Channel Link Protocol

Used for Mobile-Originated messages

- Each modem can transmit on any of (7 of 10) subframe slots of the current receive frame
- Each return channel (frequency) is divided into subchannels each supporting either acknowledgement, ½-second or 1-second transmit fragments
- A modem selects an appropriate coding rate based on signal quality and location within the regional beam:
  - 0.33 = 25 bytes or 63 bytes user data per fragment
  - 0.50 = 41 bytes or 98 bytes of user data per fragment
  - 0.75 = 66 bytes of user data per fragment
- Acknowledgement bursts are sent in response to Forward fragments, within the current frame
- Protocol allows for fragments of multiple messages in parallel, for efficiency. As a result, messages may arrive out of order from how they were sent from the modem.

Global Bulletin Board Channel

Broadcasts network configuration details

- Globally assigned frequency for all modems in all beams
  - Forward/Return channel frequencies may change over time
  - Bulletin Board frequency never changes
- Broadcasts/repeats network configuration information continuously, every ?? minutes
- Allows automatic recovery if any modem has been powered off during a network change

Modem Registration

Authentication and routing use

- All modems must register to authorize on the network and enable routing via the proper regional beam
- Special system message (SIN 0, MIN 0)
  - No user data, no location information, contains modem configuration details
  - Non-billable, but delivered to customer mailbox for optional application use
- Modems being powered off or reset, must re-register each time they power on
  - Registration also depends on GNSS fix, which takes time and consumes power
- Modems using synchronized low power mode do not need to re-register each wakeup
  - Power savings from avoiding turning on GNSS receiver, re-acquiring Forward Channel, and transmitting registration message
- Modems may also send modem registration if it changes 'Virtual Carrier' due to a network change

Synchronized Low Power Wakeup Detail

Optional system feature supported by some modems

- Optional feature allows modem to be awake to receive for as little as one ½-second subframe
- Wakeup Interval is a configuration parameter sent to the network:
  - Included in modem registration message
  - Remote user-configurable using "setSleepSchedule" modem message
  - Special "sleepSchedule" modem message sent when interval is changed remotely or by device connected locally to modem
- Several wakeup intervals are defined, ranging from 5-second (always awake), to 60-minute
- Worst-case Forward message latency is defined by wakeup interval
  - Typical latency will be lower, statistically when messages are queued in relation to wakeup time

Modem ON/OFF Power Conservation Detail

Use with caution

- Powering off the modem to save power implies special considerations
- To-Mobile messages need careful handling:
  - Must wait for a registration message before being sent
  - Application and remote host must coordinate to disperse receive times and avoid causing network congestion
- If the modem must re-acquire the Bulletin Board, the host controller must supply power long enough for acquisition (at least 10 minutes)

Message Order Detail

IDP modems are not required to preserve FIFO

- Modems may interleave fragments of different messages during transmission, such that large messages do not "block" small messages
- As a result, messages may arrive at the gateway in a different order than transmitted from the modem
- Applications requiring precise message sequence order must consider this. Candidate approaches:
  - Wait for message to complete before queuing next message
  - Add message ID and sequence number (or timestamp) to payload

Satellite Control State

Modem metric can be queried by local host

0. Stopped
1. Waiting for GNSS fix
2. Starting search
3. Beam search
4. Beam found
5. Beam acquired
6. Beam switch in progress
7. Registration in progress
8. Receive only
9. Downloading Bulletin Board
10. Active
11. Blocked
12. Confirm previously registered beam
13. Confirm requested beam
14. Connect to confirmed beam

Beam Switching

Analogous to cell hand-off

- If the current beam signal becomes weak, the modem starts monitoring adjacent beams in the background to find a better signal
- Adjacent beam monitoring has no impact on messaging
- If a substantially better beam is found, the modem switches to the new beam and sends a registration message
  - beamNotification (SIN 0 MIN 1) if the beam is part of same Forward Channel
  - modemRegistration (SIN 0 MIN 0) if the beam is part of a new Forward Channel (possibly on a different satellite)
  - beamNotification is non-billable, contains no user or location data

Line of Sight Blockage

ORBCOMM/SkyWave modem algorithm

- Blockage algorithm triggered when no GNSS or IDP signal can be found, or if the current beam signal is suddenly lost
- Multi-stage algorithm with each stage taking more power/time
- Duration of each stage and interval between attempts (“back-off”) are configured in the modem’s power mode setting
- A modem may also enter a receive-only mode if unable to determine its location but still able to receive the current beam

Short-term Blockage

ORBCOMM/SkyWave modem algorithm

- After 5 unsuccessful receives in a row, at the configured wakeup interval, control state changes to Blocked
- Modem continues listening (receives) only on the current beam
- Interval between receives slowly increased to 2 minutes, in Battery power modes
- Duration of short-term blockage stage (based on power mode):
  - Powered = 5 minutes
  - Battery = 20 minutes

Long-term Blockage

ORBCOMM/SkyWave modem algorithm

- After short-term blockage duration expires, the modem starts searching for other Forward Channels available at its current (last known) location, if any
- Satellite control state changes from Blocked to Beam Search
- Interval between receives slowly increases to 24 hours, if power mode is Battery
- Duration of stage (based on power mode):
  - Powered = 30 minutes
  - Battery = 60 minutes
- When long-term blockage duration expires it includes Bulletin Board in its search, taking longer time to listen

Short-term Blockage Configuration

ORBCOMM/SkyWave modems

		Power Mode (configuration register S50)					
Parameter Name	**Description**	**Mobile Powered**	**Fixed Powered**	**Mobile Battery**	**Fixed Battery**	**Mobile Min Battery**	**Mobile Parked**
gst	GNSS stale time	180 min	1440 min	360 min	20160 min	720 min	1440 min
txl	Tx message lifetime	180 min	180 min	3 min	3 min	3 min	3 min
rit	Rx Retry Initial Timeout	0 min	0 min	1 min	1 min	1 min	1 min
rts	Rx Retry Factor	0%	0%	20%	20%	20%	100%
rmt	Rx Max Timeout	0 min	0 min	2 min	2 min	2 min	8 min
sbd	Short-term Blockage Duration	5 min	5 min	20 min	20 min	20 min	15 min

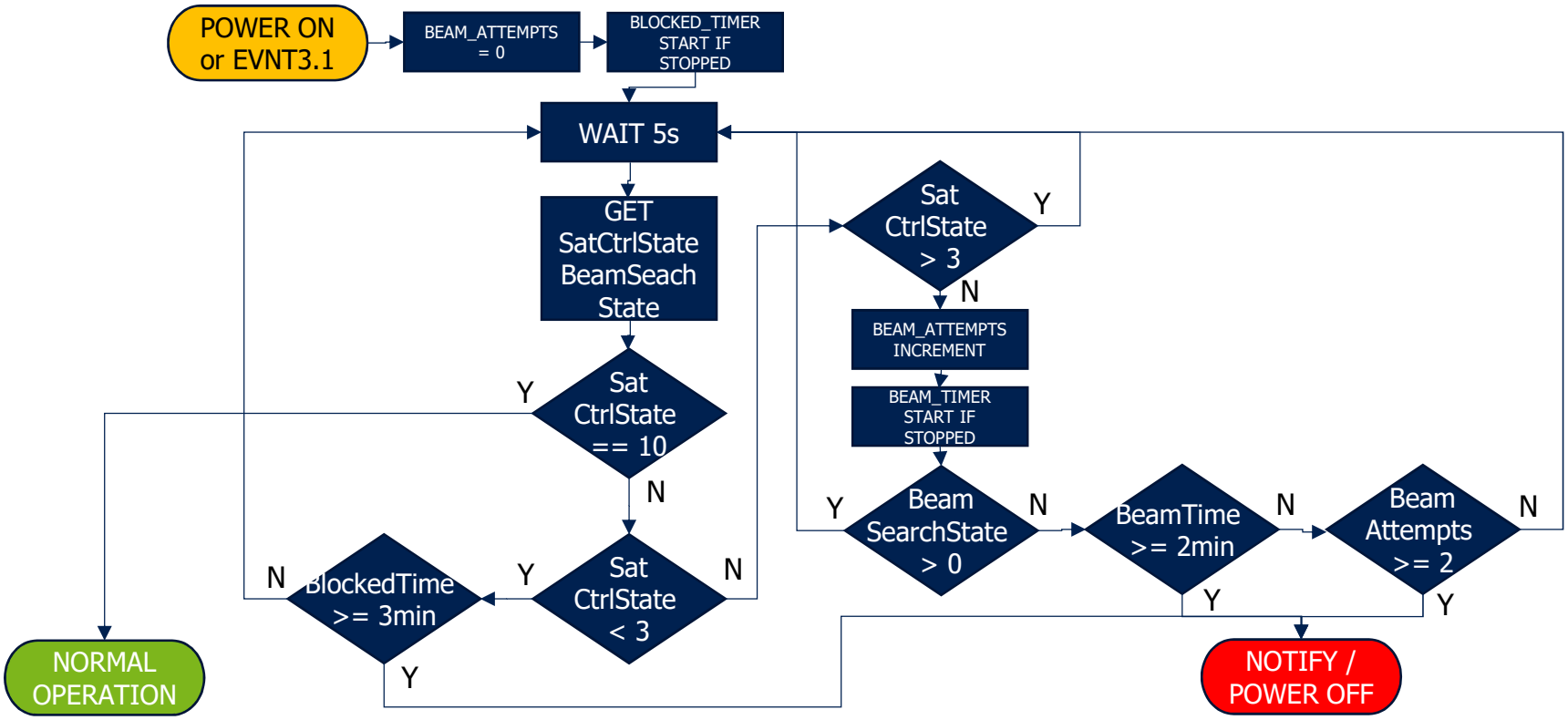
Long-term Blockage Configuration

ORBCOMM/SkyWave modems

		Power Mode (configuration register S50)					
Parameter Name	**Description**	**Mobile Powered**	**Fixed Powered**	**Mobile Battery**	**Fixed Battery**	**Mobile Min Battery**	**Mobile Parked**
bit	Beam Search initial timeout	0 min	0 min	5 min	5 min	5 min	1600 min
bts	Beam search scale factor	0%	0%	100%	100%	100%	0%
bmt	Beam search max timeout	0 min	0 min	1600 min	1600 min	1600 min	1600 min
mbd	Beam search primary beam	10 min	10 min	20 min	20 min	20 min	1440 min
lbd	Long-term Blockage duration*	30 min	30 min	60 min	60 min	60 min	1440 min

** Minutes to search for Forward Channel before including Bulletin Board*

Low Power Acquisition Monitoring Algorithm



07
Developer Tips

Developer Tips: Software in parallel with Hardware

Beyond [T203] IDP Modem Developer Guide

- ORBCOMM SDK provides "Modem Simulator" that interworks with another SDK tool "Messenger" to simulate end-to-end communications on PC
  - Connect together using localhost TCP port
  - "Scope" tool can be connected to Modem Simulator using virtual COM port mapping
- ST6100ME/ST3100 can be used as a certified, environmentally sealed modem+antenna without waiting on PCB-level design of the modem and hardware 'wrapper'
  - If using a long serial cable, consider using low baud rate and CRC error checking on AT commands
  - IDP-800 can be put in "passthru" mode to act like a modem with battery, if you can't reach a power source
- AT software integration with Modem Simulator can be fully reused with ST or OGi modems

Developer Tips: Modem Simulation

Desktop convenience

- From Windows Start, launch IDP Toolkit → Modem Simulator
  - Select File → Open Serial Port to connect relevant COM port for USB/serial cable
  - Select Gateway → Start Web Service
    - Select localhost:port
- From Windows Start, launch IDP Toolkit → Messenger
  - Click Gateway button
    - Select Local Gateway (Modem Simulator), confirm localhost:port
  - Click Connect button