RV-M7 GX with TDMA Data

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Overview

The RV-M7 GX radio modem with built in GPS is an exceptional AVL transceiver, and it is also possible to use it to send mobile data.

The RV-M7 GX uses a TDMA protocol to transmit data over the air. TDMA protocols greatly increase the available channel bandwidth but they require more system planning than conventional carrier-sense methods.

The Technical Brief describes various issues related to transmitting data using the RV-M7 GX to transmit and receive position information *and* data via the serial port.

For data transmission, Raveon Recommends setting the RV-M7 GX into the GPS 2 mode. This sets the serial port data rate to 38400, and the unit will output $PRAVE messages when it receives data. After issuing the **GPS 2** command, other parameters may be modified to optimize the system. Another useful GPS mode for data is **GPS 6**. It will output $GPWPL messages, and sets the serial port to 4800 baud. Both GPS modes 2 and 6 will allow the user to send data sent into the RV-M7's serial port over-the-air. **GPS 12** mode disables the sending of GPS position reports, and the unit will send the serial-port data over the air in the radio's allocated time slot.

GPS Mode	TX GPS Position	GPS RX Format	
GPS 2	YES	$PRAVE	
GPS 6	YES	$GPWPL	
GPS 12	NO	$PRAVE	

The GPS X command is a macro that tells the transponder to configure a variety of parameters. When re-configuring a transponder, this command should be the first one issued. If you issue it after setting other parameters, it may override them and change your previous settings. Configure other parameters after issuing the **GPS X** command.

1. Low-Latency Configuration

Low-latency data transmission is useful when real-time data must be transmitted from one unit out to many other units. Differential GPS corrections and Mobile Dispatch Messaging are examples of system which require outbound data from one unit to be quickly sent. The latency on the return path is less critical.

1.1. Over-the-air Rates

For low-latency data, the over-the-air data rate should be as fast as possible. For narrow-band radios, the choice is usually 4800 baud 2-level. For wide-band versions, the best choice is 9600 2-level.

Table 1

| Over-the-air rate	Radio Bandwidth	Number of Modulation Levels	Position /Status Transmission Duration	Recommended TDMA SLOTTIME in mS
4800bps (**ATR2 3**)	12.5kHz	2	70mS	100 (200 with repeaters)
9600bps (**ATR2 5**)	25kHz	2	45mS	50 (100 with repeaters)

Use the **ATR2** x command to set the over the air rate.

Use the **SLOTTIME xx** to set the TDMA slot time. The SLOTTIME must be wide enough to accommodate a Position/Status transmission from the GPS. Refer to the table above to determine how long a position/status transmission will take.

1.2. The TDMA Frame Length

The TDMATIME is the length of one TDMA frame/epoch. A TDMA frame contains small time slots where each radio is allowed to transmit in. The slots are sequentially numbered.

Figure 1
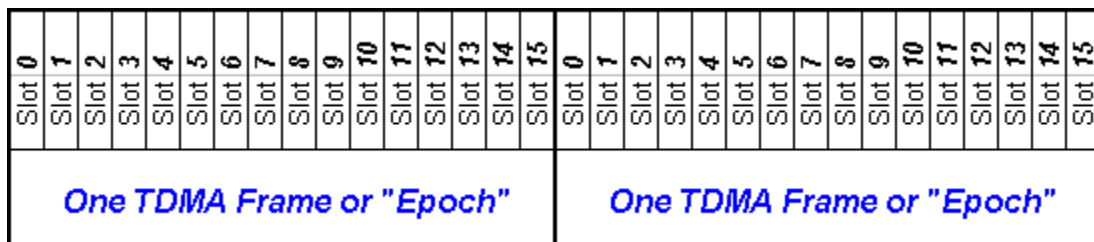
Radio number 1 transmits in Slot 1. Radio number 2 in slot 2…

TDMA Frames have a pre-set number of slots, and once the TDMA Frame Time has passed, the frame restarts at slot 0 again. Slot 0 is reserved for future base-station control signals. The length of a TDMA Frame is set with the **TDMATIME xx** command.

The TDMA Slot Time is programmable, in 50mS increments. The **SLOTTIME xx** command is used to set the slot width. Typically it is set at 50, 100, 150, or 200mS. The factory default is 200mS.

For example, with a **TDMATIME** of **1** second, and a **SLOTTIME** of **100mS**, there are enough slots to support 9 radios reporting every second. The Frame will repeat every second so every second, each of the 9 radios has 100mS of air-time available.

Figure 2

1.3. *Position/Status Transmissions*

At a pre-programmed rate, the RV-M7 may report its position and its status. This rate should normally be at the **TDMATIME** rate or longer.   The rate at which a unit transmits its position/status is set with the **TXRATE xx** command. For example to have the unit number 4 transmit its position every 3 seconds, set the TXRATE to 3 (**TXRATE 3**) in the RV-M7 which has the MYID of 0004. With a **TDMATIME** of 1 second, unit number 4 will transmit at 2.4 seconds and 5.4 seconds, and continue on every 3 seconds.

Figure 3

With a **TXRATE** of 1, it will transmit every second as shown below.

Figure 4

1.4. *Disabling GPS Position Reports*

TDMA transmissions can be disabled by setting **TXRATE 0** and **IDLERATE 0**. This will disable transmission of the GPS position.

To disable only GPS position reports, but still allow the serial port data to be sent in the TDMA time slot, use the **REPORT 0** command. This disables GPS position reports.

If the transponder is set to **GPS 12** mode, GPS position reporting is disabled and serial port data will be transmitted in the units TDMA time slot.

1.5. *Standard RV-M7 GX Output Messages*

There are three types of messages that routinely come out the serial port of the RV-M7 GX. They are:

1. **Position/status** information received from other transponders. These messages are usually sent out the serial port in the $PRAVE, $GPWPL, $GPTLL,… NMEA format. Every time an RV-M7 GX receives a position from another RV-M7, it outputs the received information via its serial port, in one of these formats. Disable these messages with **OUTPUT 0** command.

2. **Local GPS information.** Local GPS position information may also be periodically sent out the serial port. Internal to the RV-M7 is a GPS receiver, and in certain GPS modes, the local GPS's position and settings will be sent out the serial port of the RV-M7.   The standard NMEA messages are sent out ($GPRMC and $GPGLL messages). Disable this with the **NMEAOUT 0** command.

3. **User Data.** If data from one radio is sent over the air to another, the data bytes will come out of the serial port, exactly as they went into the sending unit's serial port. To stop a unit from ever transmitting data that enters the serial port over the air, use the **DATAMUTE 1** command. This command does not stop receiving of data, only the transmission of serial port data.

To disable the Position/Status messages from coming out the serial port, use the **OUTPUT 0** command to set the output message format to nothing. This must be done after the **GPS x** command that told the unit what GPS operation mode to be in.

To disable the local GPS NMEA messages from coming out the serial port, use the **NMEAOUT 0** command to disable local GPS NMEA messages. **NMEAOUT 1** enables them. This must be done after the **GPS x** command that told the unit what GPS operation mode to be in.

1.6. *Data Transmission*

With the release of RV-M7 firmware B8, the RV-M7 GX radio transceiver includes TDMA data transmission as well as GPS position reporting.

When serial data enters the RS-232 serial port of the radio modem, it will transmit the data over the radio to other RV-M7 modems.

When sending data with the RV-M7 GX with the built-in GPS and TDMA protocol, data is buffered in the modem, and only transmitted in the radio's assigned time slot. When the units time-slot arrives, the radio sends the data over the air. If there was more data to send than will fit in the slot, then the data that will fit is sent, and any additional data is stored and sent during the next Frame.

Position/status reports always take precedence, so when it come time to transmit in a unit's assigned time slot, the position transmission will be sent first, immediately at the beginning of the unit's assigned slot. If there still is room for data in the slot, the data will be sent also. In the example below, units 1, 2 and 3 report their position, and unit 2 also sends some data after the position report is sent.

Figure 5
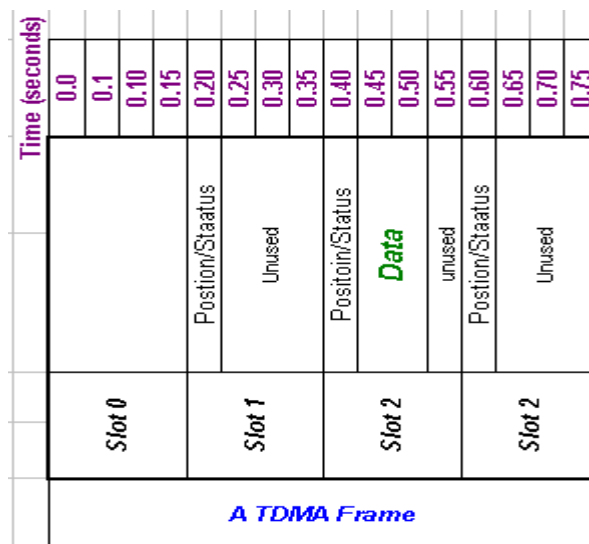
To send data, there must be enough time in the TDMA slot after a position report to send a data message in. If the user sends the SLOTTIME very narrow, say 50mS, then there is only enough time in the slot for the position report, and no data would ever be sent.

There are three ways to ensure that there is time to send data and position report. Any or all of them may be used to add data bandwidth to an GPS system.

1. Set the **SLOTTIME** wider to give extra time for data. (As shown in the diagram above)

2. Use the **SLOTQTY** command to allocate some specific RV-M7 GX transceivers extra slots. **SLOTQTY** is normally 1, and each unit gets one slot. If it is set to some other number, the unit will assume it has additional slots.

3. Increase the time between position/status transmission with the **TXRATE** command.

For example, if the **TDMATIME** frame rate is 2 seconds, setting the TXRATE to 10 seconds will allow the RV-M7 to use 4 out of every 5 of its time slots for data as shown below. Unit 0002 reports position every 5th frame, and uses its other slots for data.

Figure 6
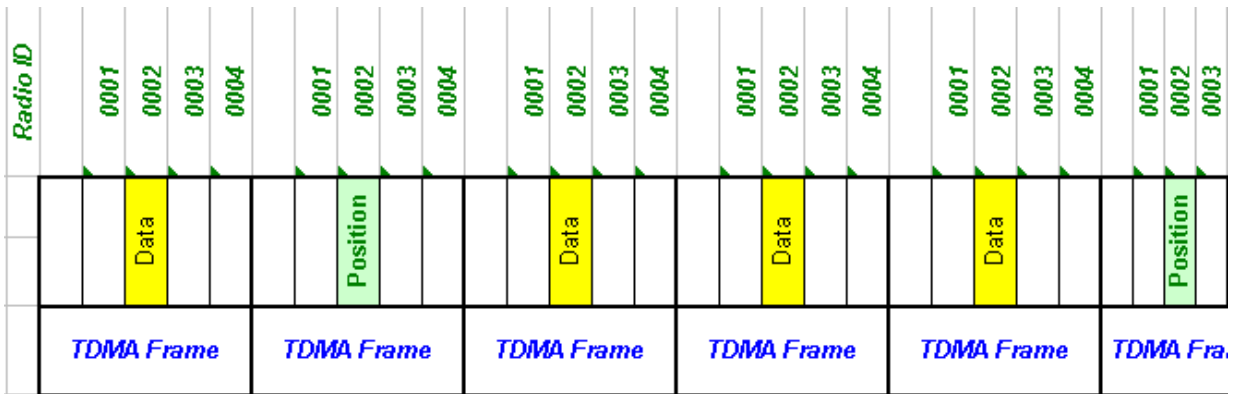
In the example above, the **SLOTQTY** could have been increased by one (**SLOTQTY 2** command), giving unit 0002 extra time, but then there cold be no unit 0003, as his slot was allocated to 0002.

Figure 7
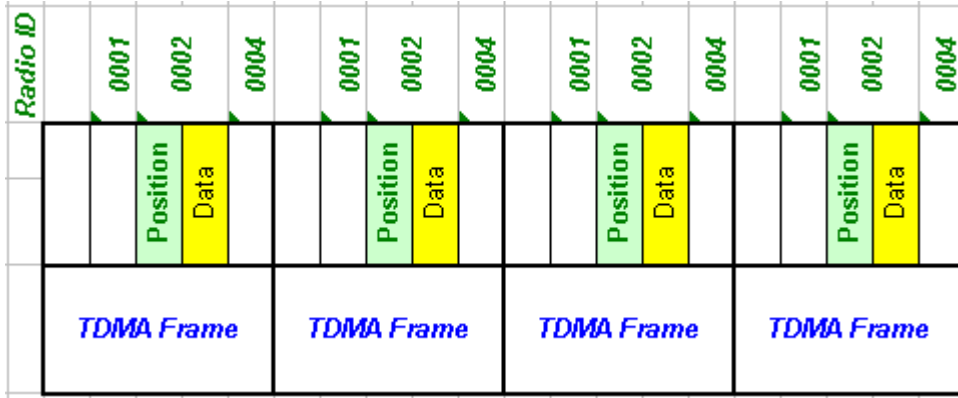
1.7. Base Station Aliasing

One interesting method of creating more transmission bandwidth and reduce latency is to use "*aliasing*" of the TDMA Frame. When the number of RV-M7 radio in a system gets large, the TDMA Frame time must also be large, so that all radios have a slot to transmit in. This creates latency in transmitting data as a stating wishing to transmit must wait until its slot time arrives, which may take almost a whole frame. If the TDMA Frame time is set to say 30 seconds, this delay can become noticeable when sending data messages.

When a system needs low-latency, but has a long TDMA Frame, there is a simple way to allocate additional periodic slot to one or more units by setting the TDMA Frame time very short on a select few units. For example, the TDMA Frame time may be set to 30 seconds for most RV-M7s in the system, but the base-station's TDMA Frame time may be set to 1 second.

The effect of this is that each unit in the system, except for the base, will transmit every 30 seconds. The base station, (which originates most messages), will have a time slot every second. This is illustrated in the diagram below.

Figure 8
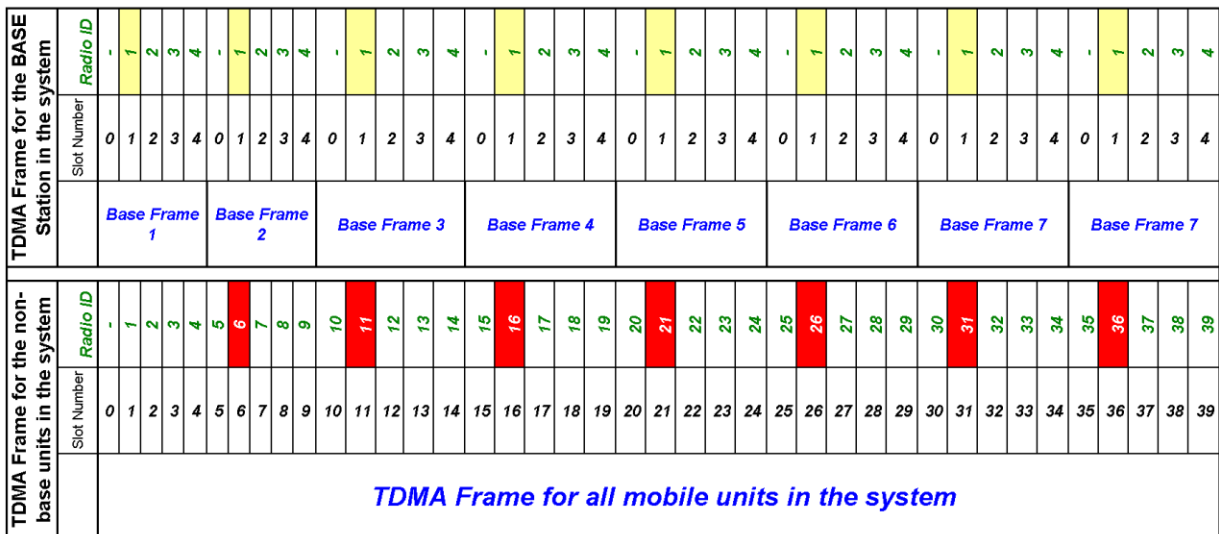
The "BASE" station will have a slot (Slot 1) every second where it may send data and position out. Because the BASE's available slots arrive every second (as shown in yellow), there are certain ID codes that cannot be used by the other radios in the system. The ID codes that cannot be use are shown in RED (6 ,11 ,16 ,21 , …).

This aliasing technique will increase the TDMA Frame time of the system by 20%, but it can reduce the latency of outbound messages from the base by 09% or more.

2. Example Transmissions

2.1. Example 1

4800 baud position transmission followed by a data transmission of 20 bytes. The SLOTTIME was set to 100mS and the SLOTQTY set to 2, so that this unit had 200mS per Frame allocated to it. It used about 170mS of its slot.

Figure 9
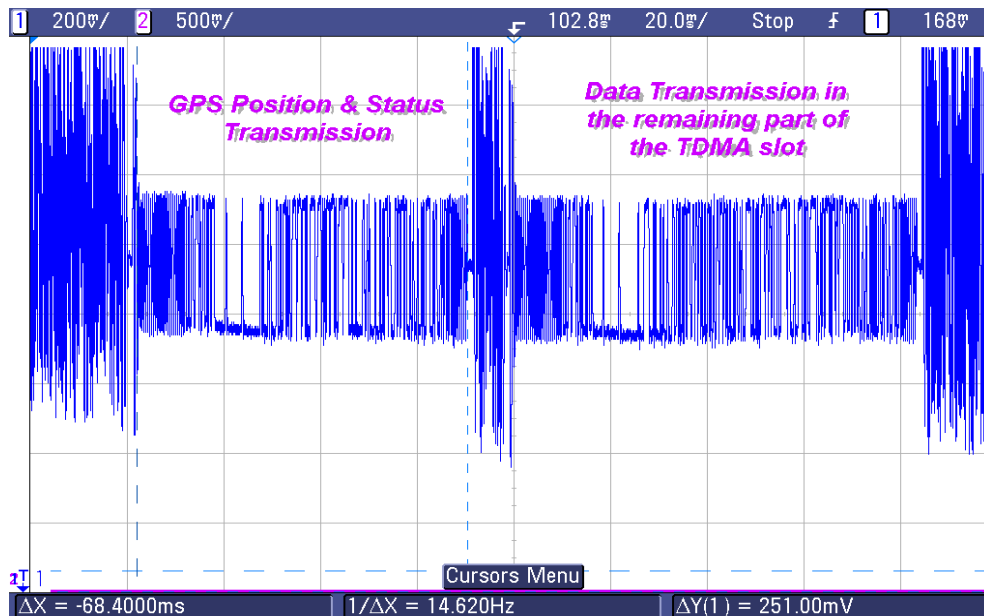
2.2. Example 2

14400 baud (4-level) position transmission followed by a data transmission of 200 bytes. The SLOTTIME was set to 50mS and the SLOTQTY set to 4, so that this unit had 200mS per Frame allocated to it. It used about 180mS of its slot.

Figure 10

2.3.

2.4. *Example #3*

27 bytes of data sent into a transponder configured for 90mS time slots. A repeater was also on the air, so you see the same message twice back-to-back.

3. Data Related Configuration Parameters

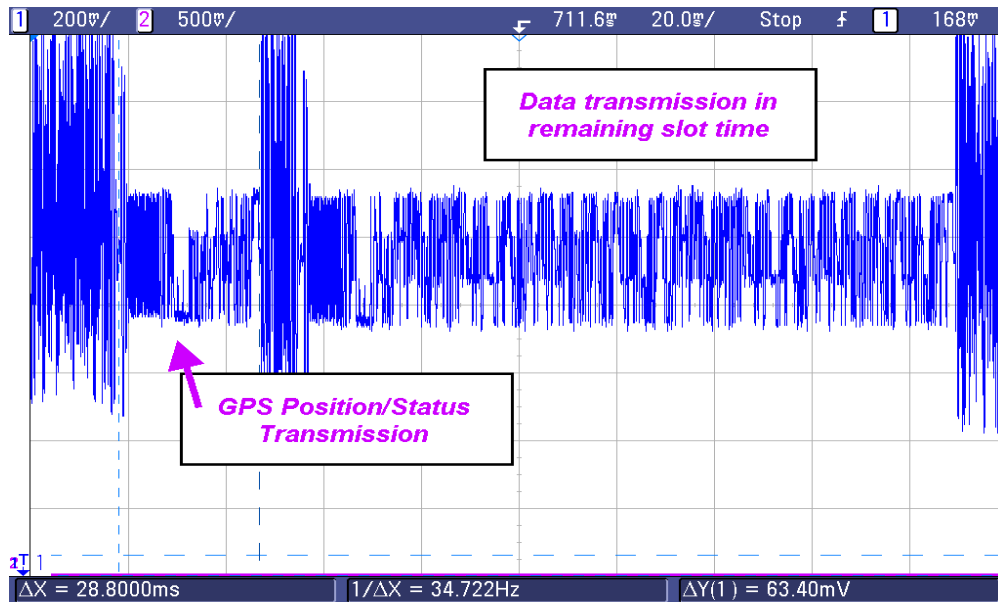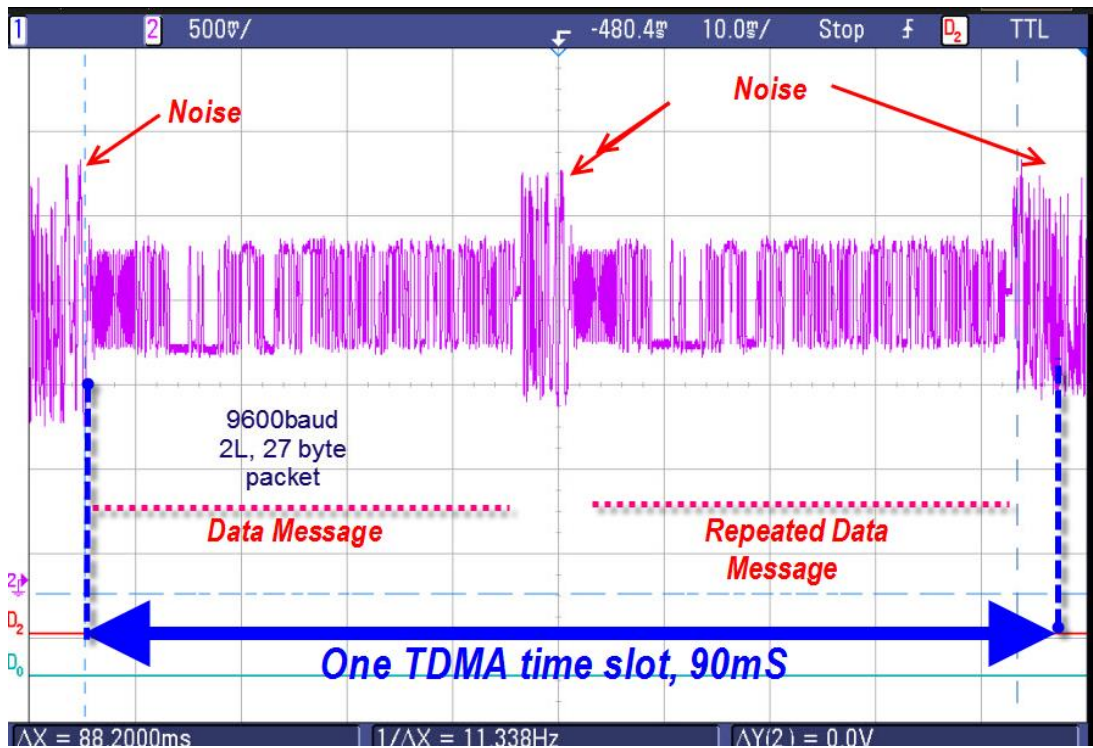| Command	Command Description	Parameters	Factory Default
ATRV	**Disable Remote Access** – When enabled (set to a 0), the modem will respond to over-the-air RPR requests, Pings, and over-the-air commands. Default is OFF (1).	0= Remote Access on 1=Remote Access off	1
ATJF	**Set CTS assertion threshold (bytes)** – Different transponders have different CTS thresholds. The factory default is 80% of the serial port buffer size.	1-3999	3200
DATAMUTE	**Set/Read Serial Port TX Data Mute.** 0=Unit will transmit serial data over the air. 1=Unit will not send any serial port input data over the air, only position transmissions.	0, 1	0
FREEWHEEL	**Freewheel time.** Read/set the number of seconds that the unit will continue to transmit when it looses GPS lock. If the GPS signal is lost, then the unit will stop transmitting position or TDMA data after the free-wheel period. 0=infinite free-wheeling.	1-7200	120
GPS	**GPS Operation Mode.** Set the GX version's Operating mode. Modes 2 and 6 may be used to send data as well as position reports.	1 – 9	1
SLOTQTY	**Quantity of TDMA Slots.** Normally this parameter is set to 1. Each unit gets one slot. To facilitate data transmission, it is possible to set this to a number other than 1. For example, if set to 3, and the ID of the unit is 0008, the unit will be allowed to transmit in slots 8, 9, and 10.	1-9999	1
SLOTTIME	**TDMA Slot duration.** Configure the width of a TDMA slot. 50mS increments.	50 - 1000	200
TDMADATA	**Set/read TDMA Data Priority.** Configure the unit to give transmit priority to serial port data over GPS position data. 0=GPS position priority, 1=Serial Data priority. If set to 1, GPS position transmission s are suppressed when there is serial port data to send. If set to 0, GPS is always sent, and extra space in TDMA slot will be filled with any available serial-port data.	0, 1	0 (GPS)
TDMATIME	**Set/read TDMA Frame time.** The length of one TDMA time frame, in seconds.	0-3599	10
TXRATE	**GPS Report Rate.** Set number of seconds between GPS reports. This is also the rate at which the internal GPS will measure position, speed, etc. Even if the unit is not moving, the GPS periodically measures position and speed to determine if it has triggered a speed or position transmission.	1 - 9999	10

4. Data Operation with a Repeater

Any M7 GX transponder may be configured to also be a repeater. See the technical manual for details on configuring the repeater table. But, for a quick start, use the **REPEAT 1** command to turn any M7 GX into a repeater.

When configured to be a repeater, the M7 will immediately re-broadcast any over-the-air data, position, or status report it receives. This can greatly extend the communication range of a system.

In most systems, there should only be one repeater. Multiple-repeaters often interfere with each other and the system must be carefully planned for this to work.

4.1. Repeater Issues

There are a number of issues with using a repeater in a system. The main ones to consider are:

1. Repeaters immediately re-transmit whatever they receive. There must be no other radio or repeater on the air during the re-transmission. Thus, the TDMA slot width must be wide enough to fit the original transmission in, plus the repeated version of the original transmission.

2. If two repeaters repeat the same message at the same time, then it is likely neither one of the repeaters will be heard. It is important on radio systems that only one radio be on the air at any one time.

3. If you are sending data along with GPS position/status reports, the data is sent out after the position report. If there is a repeater in the system, the data will be interfered with by the repeater, because the repeater will be on the air repeating the GPS position when the data is also being sent.

Items 1 &2 require careful system planning to solve. Item 3 may be solved with the **TDMADATA** command. If **TDMADATA** is set to **0**, then the M7 will send position reports followed by any data. If **TDMADAT**A is set to **1**, then the M7 will suppress a GPS position/status report if there is data to be sent, thus there will only be one transmission per TDMA time slot. TDMADATA is only available in the Personal Locator or M7 GX transponders with firmware version B16 or higher.

5. Serial Port Buffers

Within the M7 transponder is a data buffer to hold the data bytes as the go in and out the serial port. On the M7 radio, the input buffer size and output buffer size is typically 4000 bytes each. These buffers will queue the incoming and outgoing data so that the serial port of the M7 can be set to rates that are independent of the over-the-air data rates.

When an M7 transponder is used for sending TDMA data, the M7 radio will monitor the input buffer for incoming data. It will begin the transmission process when:

A) The number of bytes in the input buffer is equal to or greater than the Max Packet size as set by the **ATTT XX** command. Typically 500 bytes.

B) Some number of data characters are in the serial port input buffer, and no more data has come in within the serial port timeout period set with the **ATR3 XXX** command. Typically 20mS.

When an M7 transponder's TDMA time slot number arrives, the processor in the M7 will take as many bytes as will fit in one TDMA slot out of the buffer and send them over the air. If the Max Packet setting is less than this, then the number of characters removed from the buffer will be equal to the Max Packet setting.

The CTS handshake line is asserted when the number of bytes in the input buffer exceeds a threshold. The threshold is set by the **ATJF XX** command. If it is set to **ATJF 1**, then CTS will be asserted any time there is any data in the serial buffer. It will be negated when a transmission takes the last byte out of the serial buffer and sends it over the air.

The following flow diagram illustrates the data transmission process within the M7 transponder.
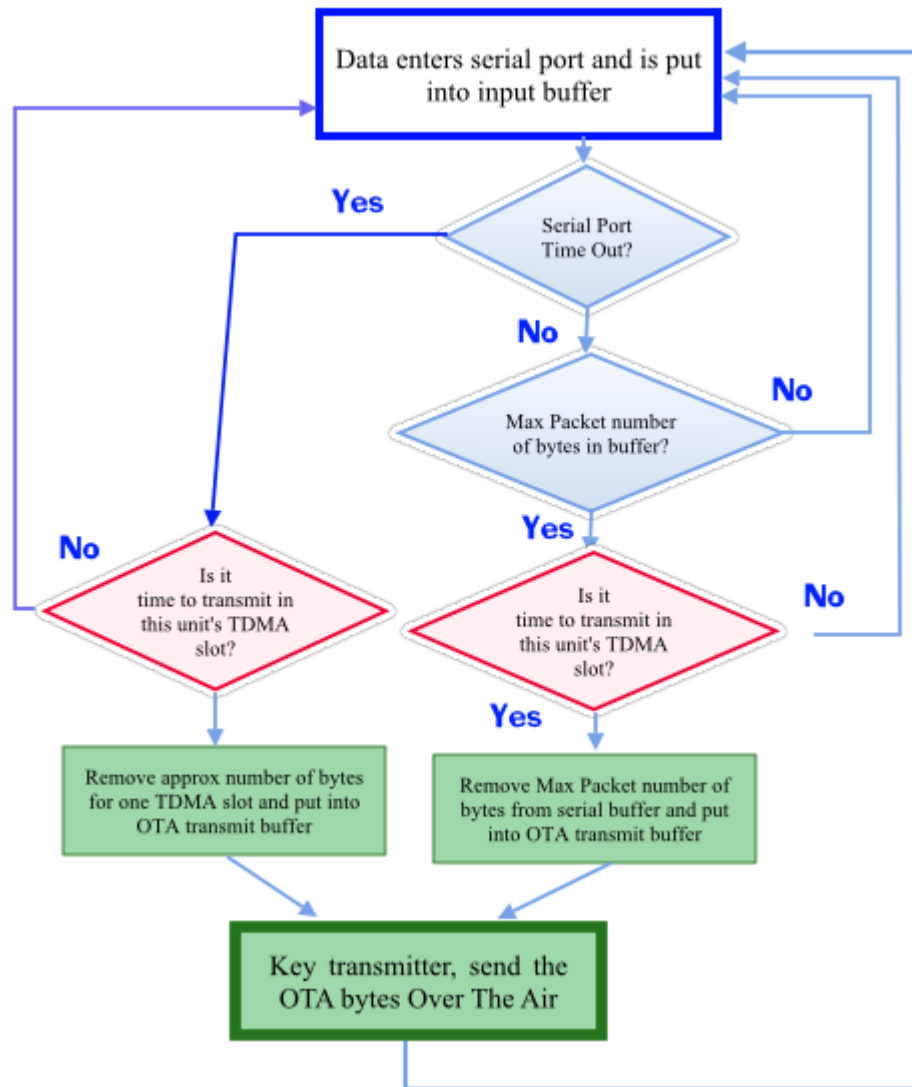
6. TDMA Data System Design Considerations

6.1. Buffered Data

A. Initial Power On

When an M7 transponder does not have GPS lock such as when first powered on the transponder will not send data even if there is data in the input buffer. The transponder will continue to buffer data until it gets GPS lock, and then it will start transmitting the buffered data.

Once it gets a lock to the GPS signals, the unit will transmit its buffered data in its TDMA slot as set by the **SLOTNUM XX** command. It will do this at a rate set by the **TXRATE XX** interval. The number of bytes sent each transmission will be determined by the size of the TDMA slot as set with the **SLOTSIZE XXX** command. The M7 will compute what it thinks is the maximum number of bytes that will fit into the slot, remove them from the buffer, and send them over the air. If this number of bytes exceed the Max Packet size as set by the **ATTT XXX** command, then it will send the max Packet number of bytes.

B. Loss of GPS lock

When an M7 transponder had a GPS lock and then lost it because the GPS antenna could not see the sky, or some other issue, it will stop sending data after a while. The time period it will continue to allow TDMA data transmissions is defined by the **FREEWHEEL XX** command. 50-300 seconds is usually OK. Freewheeling much longer than this can cause system problems because the TDMA timing may drift and the transponder may start transmitting in the adjacent slot times.

If the transponder does stop transmitting due to loss of GPS, then the incoming data will be stored in the serial port buffer for transmission once the GPS signal comes back. Once it gets a lock to the GPS signals, the unit will transmit its buffered data in its TDMA slot as set by the **SLOTNUM XX** command. It will do this at a rate set by the **TXRATE XX** interval. The number of bytes sent each transmission will be determined by the size of the TDMA slot as set with the **SLOTSIZE XXX** command. The M7 will compute what it thinks is the maximum number of bytes that will fit into the slot, remove them from the buffer, and send them over the air. If this number of bytes exceed the Max Packet size as set by the **ATTT XXX** command, then it will send the max Packet number of bytes.

6.2. Repeaters

To use a repeater in a TDMA data system, you will have to make sure that there is enough time on the air for the repeater to do its job. Each transmission from a transponder must be less than ½ as long as the time allocated for the transmission and it to be repeated.

Remember, a Raveon M7 configured as a repeater will not pay attention to TDMA timing, and needs no GPS. A repeater will store-and-forward repeat any packet it is configured to repeat, as soon as it receives it over the air. Repeaters have no concept of slot time and TDMA timing. The repeat what they hear. The oscilloscope screen

capture shown below illustrates this. It is the over-the-air signal of an M7 sending 27 bytes of data, followed by a repeater repeating this signal on the same radio channel.
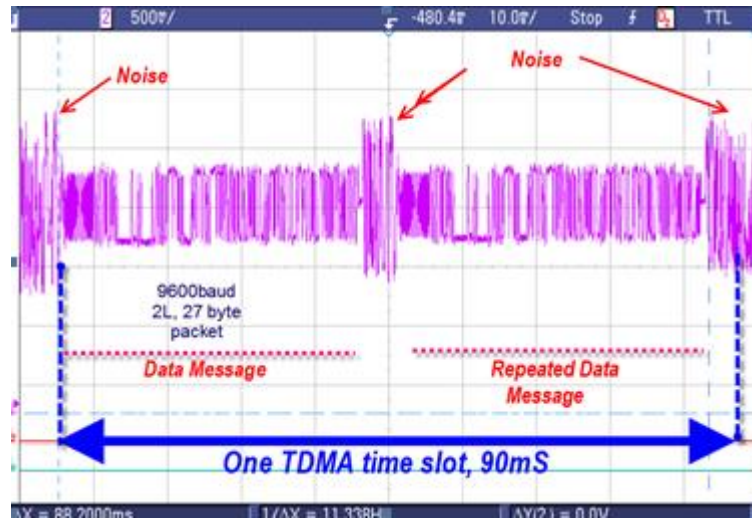
As you can see, the amount of air-time taken up by a repeater is a little more than 2X the amount of air-time needed for a single transmission. In this case, the SLOTTIME was set to 90mS. The user sent in 27 byte of data into the M7.

There are a number of ways to make sure that the size of a TDMA data transmission is short enough to allow for a repeater to do its job. They are:

A) *Use every other slot.* If the transponders are assigned to the even slot number only, then the odd numbered slots will always be empty. These odd numbered slots are where the repeater will be retransmitting the even slot data, so leaving them unused for the repeater to fill. In the example above, instead of one 90mS slot, the SLOTTIME could be set to 50mS, and the repeater would have 50 more mS to repeat in. This will mean each transponder is allocated 100mS of air time.

B) *Limit the Data Input.* If there is a repeater, it is important that the number of bytes in the input buffer is not more than will fit in ½ the TDMA slot. If there is more than ½ a slot full, then the repeater will not finish repeating a message before the end of the slot.
If there is no data in the serial buffer of the M7, it will not key its transmitter. If there is *any* data, and the serial port time-out has expired, it will send data over the air. If a small number of bytes is in the input buffer, these bytes will be sent out over the air. If the buffer has more data than will fit in the slot, the M7 will only send part of the buffer each transmission.
The user can flush the buffer by entering the command mode. (+++) When the command mode is exited, it will flush the input buffer. Then, the user can send a precise number of bytes into the M7 for transmission. By monitoring the flow control lines when **ATJF 1** is set, the user will be able to tell when the buffer is empty.

7. Message IDs

Most communication system must identify the sender of a message. Every M7 data radio sends a 16 bit ID in each transmission. Normally, the user will not see this ID because the M7 acts as a transparent radio modem. But, there are a number of ways the user can find out the ID of the M7 that sent a particular packet of data to it. This can reduce the number of bytes the user's application must send.

7.1. ID Protocol

The "ID Protocol" may be enabled on the serial port of the M7 radio, so that every time it receives a message from another M7, it first outputs a header indicating the ID of the sending M7. The format of the ID protocol is:

SOH	4-digit hex from ID	4-digit hex TO ID	Sequence number 0-7	STX	Data from sender	ETX	Checksum	EOT

If the ID protocol is enabled on the receiving M7, then the user's application need not embed it in the data portion because it already is sent by the M7 in the message header.

7.2. WMX

WMX is a serial communication protocol, used in Raveon's wireless modems, to allow a user to have full control over these sending and receiving of data. It allows the user of a Raveon modem to specify the destination ID when sending data. It also allows the user to identify the source of data when data is received.

Without the WMX protocol, a Raveon wireless modem transparently send and receives data to and from other Raveon modems, and the ID of the modems in the network are all pre-configured at time of installation.

With WMX, the user my specify "on-the-fly" the destination ID of data that is to be transmitted. All received data is passed to the user in a pre-defined format, so the source of the data may be determined.

Details of the WMX protocol are available from Raveon. In summary, WMX packets are pass in/out of the M7 radio if WMX is enabled **WMX 1**.   This allows the user to specify IDs and also know the ID of a station that sent data. If WMX is enabled, every reception of data will come out of the M7 formatted as a WMX packet instead of the raw data.

WMX Frames are used to pass data into and out of a radio modem. The same frame format is used to send and receive data.

Data Frame Format

Field Number	Number of bytes	Field Name	ASCII Code	Function
	1	Start of Header (SOH)	1 (0x01)	Indicates beginning of a frame
1	1	Control Field[*1]	Variable 0x40 – 0xFF	This byte contains frame control information specific to the type of frame.

2	0-4	Destination Address	ID in ASCII hex, 0000-FFFF	0-4 ASCII HEX representation of the destination address. For transmitting, may be left NULL (no characters). If NULL the destination address will then be set by the ATDT address programmed into the sending modem.
	1	Separator 1 (**!**)	33 (0x21)	Field separator character 1.
3	0-4	Source Address (Optional when transmitting)	ID in ASCII hex, 0000-FFFF	0-4 ASCII HEX representation of the source address. For transmitting, usually left NULL (no characters) as the source address will then be set by the MYID address programmed into the sending modem.
	1	Separator 2 (**"**)	34 (0x22)	Field separator character 2.
4	0-4	Group Number (Optional when transmitting)	Group number in ASCII 0-255	0-3 ASCII decimal digits representing the group this Frame belongs to. Group 0=255 is the wildcard.
	1	Separator 3 (**#**)	35 (0x23)	Field separator character 3 (when transmitting, may be left out if sequence field is not used)
5	0-4	Sequence (Optional when transmitting)	ASCII number 0-255	A sequence number for this transmission to uniquely identify it. Set to 0 or NULL to let the modem automatically assign the sequence.
	1	Separator 4 (**$**)	36 (0x24)	Field separator character 4 (may be left out if info field is not used)
6	0-16	RSSI Field (Optional	ASCII digits	RSSI Information about this packet.
	1	Start of Text (SOT)	2 (0x02)	Indicates beginning of data
7	1-500	Data Field		The data bytes sent/received by the user. May be any binary data bytes except the DLE ETX sequence. *See Binary Encoding* section on how to send 8-bit binary data.
	2	End of Text (DLE ETX)	16 (0x10) 3 (0x03)	ETX end of the data frame
8	0 - 4	ASCII hex Checksum (Optional)	Variable 0-FFFF	The 16-bit checksum of all the previous bytes, starting with the SOH through the end of the data bytes, not including DLE/ETX. Most significant digit first.
	1	End of Transmission (EOT)	4 (0x04)	Indicates end of the frame

8. Summary

To configure the RV-M7 GX radio for data and position there are 7 very important parameters to consider:

1. The MYID of the transmitting RV-M7. Programmed with the **MYID xxxx** command.

2. The TDMA Frame time, programmed with the **TDMATIME xx** command.

3. The TDMA Slot Time, programmed with the **SLOTTIME xx** command.

4. The number of TDMA slots the RV-M7 uses, programmed with the **SLOTQTY x** command.

5. The time interval between position/status transmissions, programmed with the **TXRATE xx** command.

6. The data input bit, bit must not be used for a digital input bit. The command TRIGBITS enables/disable various input bits.

7. If you wish to execute Remote Procedure Requests (RPRs), then they must be enabled on the receiving modem with the ATRV command. **ATRV 1** disables them. **ATRV 0** enables them.

8. If you will have a repeater in the system, set **TDMADATA** to **1** to give data priority over position reports.

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