

1. INTRODUCTION

The Remora tracking unit uses 4 x “C” cell batteries. The circuitry is designed to handle battery cell voltages from 1.5V to 3.6V. This allows the Remora to operate off a range of primary cells including low cost Alkaline batteries and top of the range Lithium-Thionyl-Chloride batteries for longer battery life and operations in extreme temperatures.

Predicting the battery life is quite difficult, due to the wide range of operating conditions. The battery life is affected by:

- The type and quality of batteries used
- The type of modem (2G, 3G, LTE), and the average signal strength
- The average GPS signal strength available when installed
- The average temperature of operation
- The operating mode (periodic, GPS based tracking, accelerometer based tracking)
- The particular configuration of that mode
- The level of asset activity (trip quantity and length, loading / unloading jostling)

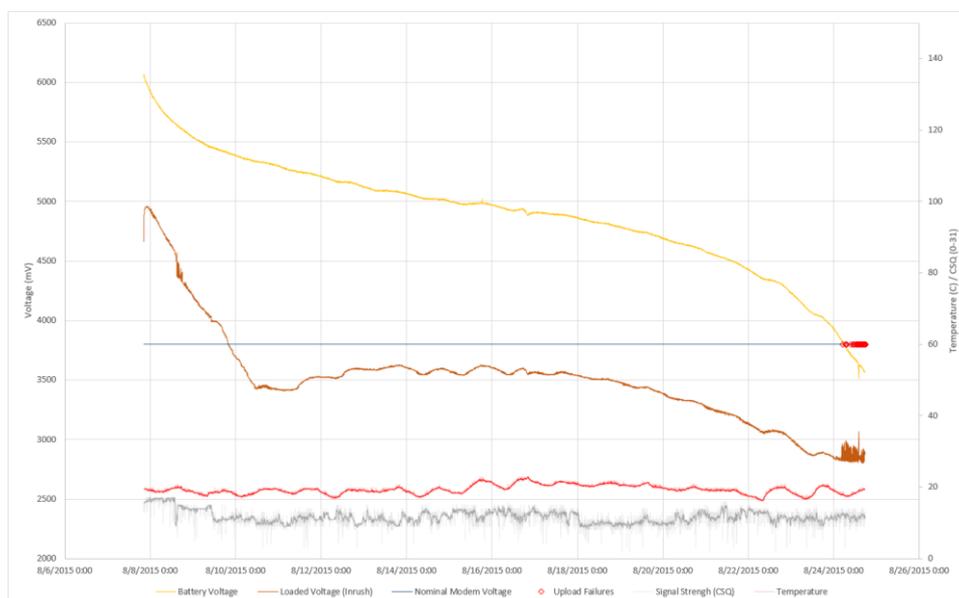
To help inform the battery life prediction and evaluation process, many discharge tests have been performed, and approximate battery cost constants extracted.

2. TEST DESCRIPTION

In our standard discharge tests, a variety of units with different battery chemistries and various board variations were configured to repeatedly connect to our management server and upload their battery levels. There was only a 90 second rest period between connections, so this constitutes a fairly high load on the batteries compared to regular use. The tests were done at two room temperature test sites (one with excellent signal strength, one with barely useable signal strength), and in a refrigerator with moderate signal.

3. SAMPLE TEST RESULTS

Each test discharge produced a discharge graph similar to this sample:



4. SUMMARY OF UPLOAD ONLY TESTS

The average uploads achieved were similar at both room and refrigerator temperatures. These tests represent the current consumption of the microprocessor and modem only:

Batteries	Chemistry	Average Uploads
4x Duracell Ultra	Alkaline	10000 - 12000
6x Duracell Ultra	Alkaline	18000
4x LSH14	Lithium Thionyl Chloride	21000

5. FURTHER CHARACTERISATION

Similar tests were run with GPS fix time included, and current measurements were performed on the microprocessor, GPS, and modems. Comparing these result sets and solving for the average current consumptions and battery capacity, we arrived at the following approximate constants:

Effective Battery Capacity (4x Alkaline)	7	Ah
Cost per connection	620	µAh
Cost per data record	4.2	µAh
Cost per second of GPS time	7.5	µAh

Further characterisation is pending using real-world field data. At this stage, these simple cost constants appear to be somewhat conservative on average, with a ~30% variation in battery life due to particular asset conditions. All Remoras report detailed breakdowns of their battery usage on a regular basis, allowing for continued monitoring and refinement of battery life predictions.

6. TRIP TRACKING PERFORMANCE

While the maximum possible uploads and the current consumption breakdown are important to know, they don't answer the question '*How long will the battery last on my asset?*'. The short answer is *4,000 to 9,000 uploads* and *4,000 to 40,000 positions*, depending heavily on your particular application. For more details on predicting the final battery life in your application, please see the user manual.