Landing prediction system requirements

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Contents

1 Purpose

This document describes the technical requirements of the on-board landing site prediction software for the 'Yerra' high-altitude balloon platform.

2 Introduction

The 'Yerra' balloon platform is designed to host scientific instrumentation at stratospheric altitudes. The platform is based on short-duration flights of a few hours, during which the balloon ascends steadily to altitudes of ~30 km. The balloon then bursts, allowing the payload to descend via parachute. Recovery of the payload is necessary for retrieval of science data and re-use of platform hardware.

Prediction of the payload landing site is a crucial aspect of a successful balloon flight. This is typically achieved via internet-based tools that use recent wind models to calculate likely ascent and descent paths, based on payload information such as mass and ascent/descent rates. However, the desire to minimise the risk of damage to property or injury to people often favours remote rural areas for balloon releases and landings. This presents a problem in that internet access may be unreliable or non-existent. A software system is therefore required to

3 System scope

The landing prediction system is a software process that runs on the balloon's main flight computer. The main process running on this computer is the tracker, which handles GPS reception, telemetry, and radio communications with the ground. The landing prediction system is separate to the tracker, but must interface with it. GPS data is an input, and a periodic prediction of the payload landing site is an output. Tracker-related tasks, such as driving GPS hardware or handling radio communications, is not within the prediction system scope.

4 Interfaces

The relevant interfaces for the landing prediction system are identified below.

Tracking system (GPS log)	
Type	Data
Description	Recent and historical latitude, longitude and altitude data.

Tracking system (data transmission)	
Type	Data
Description	The latest landing site prediction (latitude, longitude) to be transmitted by the tracking system's radio transceiver(s).

5 System requirements

The main requirements for the landing prediction system are as follows.

HAB-LPR-R01 – Purpose and inputs	
Requirement	The landing site prediction system shall estimate the landing site of the payload based only on recent and historical GPS coordinates and altitudes.
Rationale	A log of GPS data is the primary source of information from the balloon payload.

HAB-LPR-R02 – System host	
Requirement	The landing site prediction system shall run on the same computer as the tracking system. This computer will be a Raspberry Pi Zero or Raspberry Pi A+.
Rationale	Ease of data I/O and reduction of payload mass (existing computer, power supply etc.)

HAB-LPR-R03 – Start on boot	
Requirement	The landing site prediction system shall be capable of starting when the flight computer is booted, without external input from other systems or users.
Rationale	Simplicity upon launch; the computer will not have user interfaces, and reliance on other systems or people increases the chance of error before balloon release.

HAB-LPR-R04 – Input format	
Requirement	The landing site prediction system shall obtain input data from a text file at a customisable path on the flight computer. The data format is comma-separated values (CSV), using ASCII characters and terminated by a newline (\n) character. There may be up to twenty fields per line. The column numbers of the input fields (latitude, longitude, altitude) shall be customisable in the code. Numbers may be zero-padded. An example string is: `$$YERRA,698,00:23:30,-35.32110,149.00710,00747,11,16,9,50.7,31.2,932,31.1*16A8`
Rationale	An industry standard method of storing data that is compatible with the existing tracker software.

HAB-LPR-R05 – Units	
Requirement	All input and output units shall be in decimal degrees (±90 lat, ±180 lon) for coordinates, and metres for altitudes.
Rationale	Consistency with existing tracker software.

HAB-LPR-R06 – Output format	
Requirement	The landing site prediction system shall write output data to a text file at a customisable path on the flight computer. The data format shall be comma-separated values (CSV), using ASCII characters and terminated by a newline (\n) character. The column order shall be customisable in the code. The values shall be numbers only.
Rationale	An industry standard method of storing data that is compatible with the existing tracker software.

HAB-LPR-R07 – Logging	
Requirement	The landing site prediction system shall write all prediction outputs to a log in the form of an ASCII text file. All logs shall include a UNIX timestamp (nearest second or better), and any other relevant parameters, such as the latest input data.
Rationale	A historical record of the system's output will be useful for improving the system.

HAB-LPR-R08 – Internet connection	
Requirement	The landing site prediction system shall not require an internet connection to operate.
Rationale	A driving requirement of this system is that it functions without an internet connection.

HAB-LPR-R09 – Valid prediction timings	
Requirement	The landing site prediction system shall begin outputting valid prediction data within one minute after balloon burst (payload decent), or earlier. Prediction during ascent (assuming imminent burst) is desirable but optional.
Rationale	Balloon burst is the point at which all ascent data should exist and landing site prediction becomes particularly important.

HAB-LPR-R10 – Prediction update interval	
Requirement	The landing site prediction system shall output a new prediction at intervals of two minutes or less, from when the first prediction is made.
Rationale	Refining predictions based on the latest data should increase prediction accuracy, and frequent updates will benefit ground logistics to approach the predicted landing site.

HAB-LPR-R11 – Error handling	
Requirement	The landing site prediction system shall at no point jeopardise the continued operation of the flight computer and tracker system. All errors shall be handled in a way that, at worst, stops operation of the prediction software only. The system shall be fail-safe.
Rationale	Affecting the tracker system could lead to a loss of communications and a lost flight.