Software Requirements Specification

for

Europa Probe Control System

Version 1.0 approved

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Revision History

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| --- | --- | --- | --- |
| **Name** | **Date** | **Reason For Changes** | **Version** |
|  |  |  |  |
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# Introduction

## Purpose

In pursuit of knowledge of the solar system, NASA is sponsoring the development of a probe to be deployed in oceans of Europa which are found below a significant (one mile thick) crust of ice. Stone Aerospace is charged with the development of the probe and is developing an AI controller program which would control the probe autonomously. The system will handle all aspects of probe route planning, navigation, sample collection, power monitoring and data transfer.

We recommend the system be developed by the firm ITEC 2775 as an embedded application and under the guidance of Stone Aerospace.

## Intended Audience and Reading Suggestions

This document is intended for use by Stone Aeronautics as well as NASA project managers and NASA engineers; we welcome others to get acquainted with it with permission.

## Product Scope

Among benefits described above,

Provided is a list of Business Benefits:

The purpose of NASA is to gather knowledge of extraterrestrial world. They key component would be knowing of existence of life on Europa. This mission contributes to the fulfillment of that research.

* Development of autonomous robotic knowledge
* Development of autonomous routing
* Enhanced capabilities of remote chemical and biological analysis
* Advance our state-of-the-art knowledge and remote exploration by probes rather than humans
* Collected data can be a basis of further research and used as an educational material

## References

### [Stone Aerospace](https://stoneaerospace.com/) (Stone Aerospace official web page)

* [**Sunfish Stone Aerospace Project**](https://sunfishinc.com/) ***(Sunfish project)***

# Overall Description

## Product Perspective

The Europa Project is one part of a long-term space exploration project developed by NASA to determine if life exists within our solar system. The probe will be collecting samples from Europa, a Jupiter’s moon (one of them), that is believed to have water on it. The probe’s mission is to collect and analyze samples of the fluid and help researchers understand Europa’s environment and the possibility of extraterrestrial life there.

## Product Functions

1. The system must gather, store, and transmit mapping, chemical and biological sample
2. information to mission control
3. The system will need to retrieve routing information from mission control and other orders as required
4. The system must navigate the probe along the routing provided by mission control
5. The system must manage the process of taking the samples of the space water as dictated by mission control
6. System must provide logic to navigate the probe back to the tether point
7. System will ensure proper “attitude” and commence navigation to route
8. System will monitor battery status and adjust mission routing accordingly
9. The system will adjust thrust levels as needed to keep the probe correctly aligned and, on the route,
10. The system will adjust its velocity by controlling its propellers
11. The system will interface with onboard gyroscope to determine the current position of the probe
12. Probe will determine speed of the probe via the sample port/ Pitot tube
13. Sonar sensors will provide navigation and minimize the risks of collision
14. System will monitor and control on board laboratory

## User Classes and Characteristics

For engineers at NASA Laboratory:

POW1 – lead engineers [stands for power user 1], who have the most capabilities with the system. While unable to change the system, they would be able to communicate with the system more than the laboratory staff [power user 2].

POW2- [power suer2], laboratory staff will have the access to data and permission to export the data.

SYSADMIN1- administrator user, a member of our team who will be your point of contact in case of a system issue.

GUEST1 – [guest user] in case you would like to show the system to the media, please use this user class to minimize exposure to sensitive information.

## Operating Environment

## A screenshot of a computer Description automatically generated with low confidenceDesign and Implementation Constraints

Hardware limitations: the system must be able to fix itself to a degree; running a risk of loosing it to an unpredicted event.

## User Documentation

1. Manuals

2. Online support

3. Direct support – we will send a member of the team to spend a week with your staff going over the system.

## Assumptions and Dependencies

# External Interface Requirements

## User Interfaces

External Interface encompasses a desktop view for researchers to be able to analyze the probe status. The probe itself does have an external interface but very limited functionality: display to calibrate and see the system status prior to launch.

## Hardware Interfaces

1 Tethering device to the probe

2 Lander to mission control – antenna

3 Lander to the tethering device

4 Series of hardware interfaces between the system and the devices found on the probe

## Software Interfaces

1 Lander software controlling data transmission to and from the probe.

2 Software in control circuit of each of the devices interacting with the control unit.

3 Control unit to onboard laboratory.

## Communications Interfaces

1. Mission Control: Lander to Probe

# Domain Model

Diagram

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# A picture containing text Description automatically generatedSystem Features (Use Cases)

## Use Case: Description for Navigation Correction – Europa Probe: Control Navigation to Route

|  |  |
| --- | --- |
| Name: | *Control Navigation to Route* |
| *Brief description:* | navigation unit supplies current location and direction information to the control unit which determines if a correction is needed. Control unit adjusts propulsion units to correct routing. |
| *Actors:* | the system navigation unit. |
| *Related use-cases* | TBD |
| *Stakeholders*: | NASA, Stone Aerospace |
| *Goal:* | Get the machine to follow to correct route and correct itself if it’s on the wrong route |
| *Input:* | current position and direction = raw input |
| *Output* | correct route following |
| *Main Scenario:* | correct direction, depth, pitch to plan route. |
| *Triggering event:* | nav unit supplies location direction data. |
| *Pre-condition:* | nav unit must be operational and periodically supplying location/direction. Control system must be operating and receiving nav data. All propulsion units are operational. |
| *Post-condition:* | the control unit issues corrective navigation commands to the propulsion units. Probe is on the correct route. |
| *Flow of Activities:* | |  |  | | --- | --- | | **Nav Unit** | **Control System** | | 1. Nav unit supplies current position and direction | 1.1 System receives and processes raw input | |  | 1.2 Control system compares nav input to planned route | |  | * 1. If probe is on correct route, terminate | | 1.4 If probe on the incorrect route, determine the action to get back on track | |  | * 1. Issue commands to propulsion units | |
| *Exceptional Scenario:* | Nav unit sends wrong data,The probe receives the incorrect route data,Collision detection on planned route |

## Use Case: Description for Sample Intake Port - Europa Probe: Control Sample Intake Port

|  |  |
| --- | --- |
| Name: | *Sample Intake Port* |
| *Brief description:* | Sample port pitot portion will report speed of fluid flow through its orifice thereby determining the current speed of the probe |
| *Actors:* | Sampling port |
| *Related use-cases* | TBD |
| *Stakeholders*: | NASA, Stone Aerospace |
| *Goal:* | Get the sample port to take the sample |
| *Input:* | current position and direction = raw input |
| *Output* | correct route following |
| *Main Scenario:* | Receive and process pitot tube flow |
| *Triggering event:* | Sample taken every second |
| *Pre-condition:* | Sample port must be operational and receiving fluid through its orifice.Electronic interfaces to the port must be operational and communicating with the control system Control system must be operational and receiving data from the sampling port |
| *Post-condition:* | the control unit issues corrective commands to the propulsion units. Probe is on the correct route. |
| *Flow of Activities:* | |  |  | | --- | --- | | **Sample Port** | **Control System** | | Sample port transmits fluids velocity data each second to the control system | System receives and processes raw input | |  | Compare calculated speed to the speed needed to complete the planned route on schedule | |  | If probe is moving at the correct speed, do nothing | | If the speed does not agree with the route plan, determine corrective adjustments to speed to speed required | |  | Issue commands to propulsion units | |
| *Exceptional Scenario:* | Pitot tube orifice is not functioning properly  1. Pitot tube readings are inaccurate. 2. Pitot tube blocked by debris 3. Communication with sample analysis unit fails |

## Use Case: Collision Detection via Sonar Units - Europa Probe: Control Collision Detection

|  |  |
| --- | --- |
| Name: | Collision Detection for Sonar Units |
| *Brief description:* | Detect another object via an ultrasound wave to be within a certain proximity and assess the distance from the object to the probe, then to determine actions needed to avoid collision |
| *Actors:* | Sonar Units |
| *Related use-cases* | TBD |
| *Stakeholders*: | NASA, Stone Aerospace |
| *Goal:* | Detect collision while it can be avoided |
| *Input:* | current position, direction, velocity of the probe and distance between the probe and the object |
| *Output* | if the object is not a threat for collision, do nothing, if it is, change the course or velocity |
| *Main Scenario:* | Receive and process the possible collisions and act on that data to avoid collisions |
| *Triggering event:* | Detect an object within a certain distance from the probe and is on the probe’s route (blocking the route) |
| *Pre-condition:* | Sonar units must be operational, hence able to detect distances with precision via ultrasound Sonar Units must send ultrasounds to check distances every couple seconds to provide most current route updates Electronic interfaces to the port must be operational and communicating with the control system Control system must be operational and receiving data from the sampling port |
| *Post-condition:* | Sonar Unit must communicate the collision threats to the control system  Control Unit must calculate an alternate route immediately upon receiving a collision threat  Sonar Unit must receive an updated route from the control system and start sending ultrasound checks in that direction  If no threat detected, do nothing |
| *Flow of Activities:* | |  |  | | --- | --- | | **Sonar Unit** | **Control System** | | 1. Sonar Unit sends ultrasound waves every second or so to approximate a distance from a probe to objects ahead of it, mostly of those on it’s route |  | | Sonar Unit Detects a Collision Threat | Control System receives and processes the collision threat. | |  | Control System changes direction | | Sonar Unit start assessing new direction |  | |
| *Exceptional Scenario:* | 1. Sonar Units aren’t functioning properly 2. The time taken for Sonar Unit to communicate with the control system is too long to avoid collision |

## Use Case: Monitored Sensors/ Thruster Status - Europa Probe: Control Sensors/Thruster Status

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| --- | --- | --- |
| Use Case Name: | Monitored Sensors / Thruster Status | |
| Scenario: | Monitor, record, and make necessary adjustments to sensors and thrusters. | |
| Triggering Event: | Real time monitoring of thrusters, position, and sensor data every second | |
| Brief Description: | Nav Unit supplies current location and direction information to control unit which determines if a correction is needed. Sensors and thrusters are also monitored by surround camera and system will alert and respond to any interference. | |
| Actors: | System Navigation Units, Echo measurement | |
| Related Use Cases: | TBD | |
| Stakeholders: | NASA, Stone Aerospace | |
| Pre-Conditions: | Nav. Unit must be operations and periodically supplying location, orientation, and direction information.  Sonic Sensor must be operational and emitting and receiving data.  Control system must be operating and receiving Nav. Data  Systems must be monitorable and should report system status regularly to the control unit. | |
| Post-Conditions: | The Control unit issues corrective navigation commands to the propulsions  The Control unit issues corrective commands based on sonic data received  Probe is on the correct route | |
| Flow of Activities: | Navigation Units | Control System |
| 1. Supplies current position and direction | 1.1 Receives and processes raw input  1.2 Compares raw input to planned route  1.3 Determine if sensors or thrusters will malfunction or not be able to complete planned route  1.3 If probe is on the correct route, terminate  1.4 Determine corrective action  1.5 Issue commands to thrusters and/or sonic sensor  1.6 Go to 1.3 |
| Exception Conditions: | 1. The nav unit sends wrong data 2. Corrupted route data 3. Obstacle located on planned route 4. Failure to communicate/correct thruster or sensor status 5. Hardware malfunction | |

# Other Nonfunctional Requirements

## Performance Requirements

1. Throughput: how much data is transmitted in each period. Data transmission is done in set time.
2. Data will be stored in redundant storage location.
3. System will ensure a sampling pattern in which all measurements lie within 2 standard deviations of the precision of the metrology character, following the Empirical rule.

## Safety Requirements

1. Reliability of the system should be less than MTBF.
2. Recovery should require no more than MTTR.

## Security Requirements

1. Data transmitted should be secure (encrypted)

2. Data will be stored in redundant storage location.

## Software Quality Attributes

1. Software to be developed in accordance with NASA software quality assurance methodologies

# Other Requirements

### Logical Database Requirements

Storage on the probe

Storage on the lander

Storage at NASA

Appendix A: Glossary

IMU (Inertial Measurement Unit)

NASA (National Aeronautics and Space Administration)

ROS (Robotic Operating System)

SSH (Secure Shell)

Appendix B: Analysis Models

Activity diagram:

Diagram

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