Sounding Rocket Systems Engineering Mission
Design: From Concept to Proposal

Sophia Zaccarine(1), Douglas Rowland(2)

1Embry-Riddle Aeronautical University, 2NASA Goddard Space Flight Center

1. Abstract

The goal of this internship was to develop a proposal for the VISIONS-3 sounding rocket mission, and to understand the mission proposal process. The results of this project are a trajectory and launch vehicle selection, defined mass and monetary budgets, mechanical sizing of the payload, data simulation, and a science traceability matrix.

2. VISIONS and VISIONS-2 Mission Objective

The primary mission of the VISIONS and VISIONS-2 rockets are to determine how, when, and where ions are accelerated to velocity in the auroral zone and cusp below 1000km [1]. VISIONS-1 used one sounding rocket, and VISIONS-2 used two launched along the same trajectory, VISIONS-3 will use two sounding rockets launched on different trajectories to use topographical reconstruction, graphically displayed in figure 2.

3. Why Sounding Rockets?

1. Much less expensive than larger launch vehicles; can be launched more often.
2. Allows testing of components in zero-gravity; can be tested and improved for larger and longer missions.
3. Average life span of mission is shorter than larger missions; allows exposure to entire mission cycle.

4. Tasks Completed

Completing the tasks listed below is a circular process, since each aspect is dependent on the rest. The flow chart displays the chronological order which tasks were completed for this internship.

5. Conclusions

Most communications and scientific satellites in orbit around Earth are in the region that radiation from space weather can damage their electronics – the Van Allen radiation belts. This belt of charged particles is primarily caused by the Sun, which can be accelerated to near-light speeds. This radiation can damage electronic components on satellites, causing them to fail and rendering them useless. To understand how this radiation affects satellites, a sounding rocket mission was proposed.

6. Why is this important?

The goal of this internship was to develop a proposal for the VISIONS-3 sounding rocket mission, and to understand the mission proposal process. The results of this project are a trajectory and launch vehicle selection, defined mass and monetary budgets, mechanical sizing of the payload, data simulation, and a science traceability matrix.

Acknowledgments

This project was completed as part of a summer internship at NASA’s Goddard Space Flight Center, under the mentorship of Doug Rowland, with additional assistance from Sarah Jones and CAD files from Michael Tolbert. Additional thanks to Kathryn Wolfinger, Madison Rae Smith, and Riley Sidlok.

References


Figure 1: Sounding rocket

Figure 2: Diagram detailing benefits of tomographic reconstruction. Having two “viewers” (in this case, sounding rockets) allows for an on-site line of sight region, which provides a realistic and total view to mathematically constrain the data

Figure 3: Overlap region shaded in purple of two sounding rockets. The red lines are approximate semi-major and minor axes of the ellipse. The area of this ellipse is dependent on how close the rockets are, and mass of the payload

Figure 4: The spacing between the sounding rockets

Figure 5: Performance metric of two sounding rocket smoke plumes

Figure 6: Mechanical CAD model of the Experimental Energized Neutral Atom (E-ENA) Imager instrument. The instrument was too large to fit in the original payload size, so a different orientation and rocket were analyzed, and knowing a desired altitude range of >650km, and mass of each rocket determined how high the rocket could be launched, received from Mike Tolbert.

Figure 7: Mechanical CAD model of the Experimental Energized Neutral Atom (E-ENA) Imager instrument. The instrument was too large to fit in the original payload size, so a different orientation and rocket were analyzed, and knowing a desired altitude range of >650km, and mass of each rocket determined how high the rocket could be launched, received from Mike Tolbert.

Figure 8: The Science Traceability Matrix details the relationship between all main instruments and compares the different aspects of the instrument and their effect on the outcome of the mission.

Figure 9: The Science Traceability Matrix details the relationship between all main instruments and compares the different aspects of the instrument and their effect on the outcome of the mission.

Figure 10: Estimated budget for scientific instruments. The sounding rocket payload has a defined mass that combined with the number of E-ENA instruments to increase the field of view for scientific measurements.

Figure 11: The Science Traceability Matrix details the relationship between all main instruments and compares the different aspects of the instrument and their effect on the outcome of the mission.

Figure 12: Final draft of payload of sounding rocket. Each section of this payload has a different mass that combined with the number of E-ENA instruments determines the total mass of the payload.

Figure 13: The Science Traceability Matrix details the relationship between all main instruments and compares the different aspects of the instrument and their effect on the outcome of the mission.

Figure 14: The Science Traceability Matrix details the relationship between all main instruments and compares the different aspects of the instrument and their effect on the outcome of the mission.