DEBRIS DETECTING CUBESAT

TEAM: 31

Rakan Almujalli AE
Abdussamad Saeed CS
Muhannad Baismaeel AE
Ahmad Badghaish CS
Meshal Alshamekh EE

PROJECT **SPACES**

SPACE DEBRIS DETECTING CUBESAT

INTERDISCIPLINARY RESEARCH CENTER for Intelligent Secure Systems

VISION رؤية 2030 المملكة العربية السعودية KINGDOM OF SAUDI ARABIA

ABSTRACT

PROJECT SPACES aims to revolutionize space debris detection by deploying an AI-powered CubeSat constellation in Low Earth Orbit (LEO). Unlike traditional ground-based detection systems, which are limited by coverage gaps and atmospheric interference, our CubeSats provide real-time, high-resolution tracking of debris directly from orbit. By integrating advanced image recognition algorithms with autonomous onboard processing, the system offers unparalleled precision and efficiency. This innovative approach not only enhances collision avoidance capabilities but also sets a new standard for sustainable space operations, positioning Saudi Arabia as a leader in cutting-edge space technology.

PROBLEM STATEMENT

Space debris has become one of the most pressing challenges in the space industry, with over 34,000 pieces of debris larger than 10 cm and millions of smaller fragments orbiting Earth. These objects threaten active satellites and exploration missions, necessitating effective debris detection solutions. This project addresses the urgent need for effective space traffic management, contributing to the long-term sustainability of space activities. Moreover, it enhances Saudi Arabia's position as a global leader in space technologies, reflecting its commitment to safeguarding space assets and fostering innovation within the rapidly growing Saudi space industry.

WHAT IS A CUBESAT

A CubeSat is a type of miniaturized satellite standardized in cubic units (U), with each unit measuring 10 cm × 10 cm × 10 cm and weighing about 1.33 kg. Designed for cost-effective and efficient space missions, CubeSats are commonly used for scientific research, Earth observation, and technology demonstration in Low Earth Orbit.

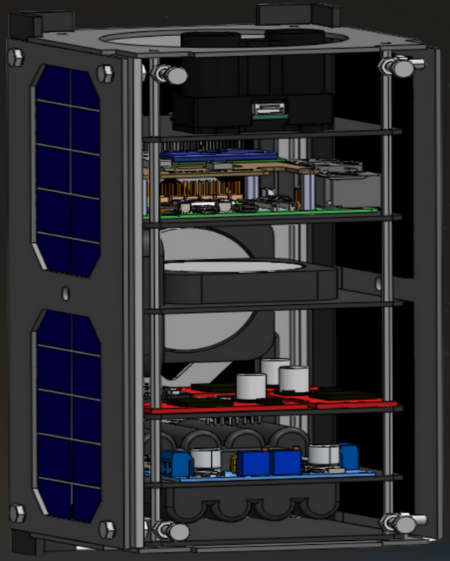
CONSTRAINTS

- STANDARD SIZE
- STRUCTURAL INTEGRITY
- WITHSTAND LAUNCH ENVIRONMENT
- WITHSTAND THERMAL CYCLING
- WEIGHT LIMITS
- POWER SOURCE
- ATTITUDE DETERMINATION
- HIGH CAMERA RESOLUTION

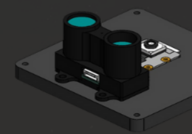
SPECIFICATIONS

- 2 UNITS SIZE
- AI-BASED DEBRIS DETECTION
- 90°–120° FIELD OF VIEW
- 8MP CAMERA RESOLUTION
- 12 VOLT SUPPLY
- 3-AXIS REACTION WHEELS
- ON-BOARD COMPUTING
- 99 Wh BATTERY CAPACITY

CUBESAT SYSTEM ARCHITECTURE & INTEGRATION

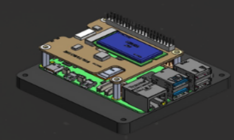


PAYLOAD



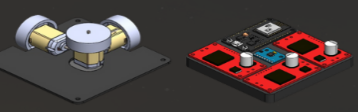
2 RASPBERRY PI CAMERAS

MAIN ON-BOARD COMPUTER



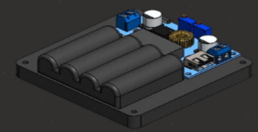
RASPBERRY PI 5

ATTITUDE DETERMINATION AND CONTROL SYSTEM



IMU // MAGNETOMETER // MOTOR DRIVER // REACTION WHEELS

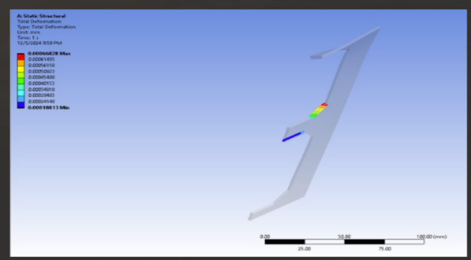
ELECTRIC POWER SYSTEM

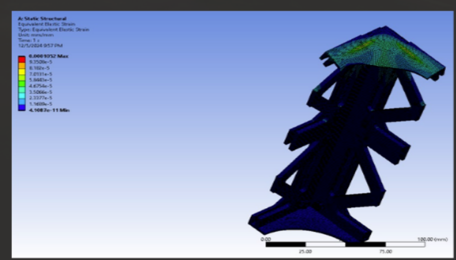


BATTERY PACKS // BUCK CONVERTERS //SOLAR ARRAYS

TESTS & VALIDATION

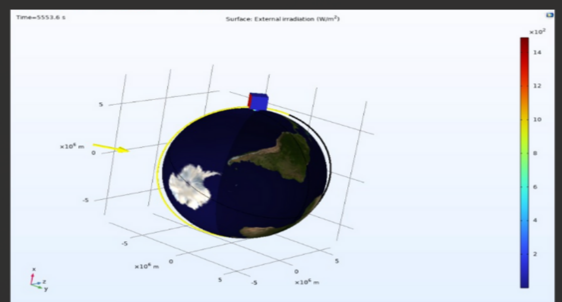
STRUCTURAL ANALYSIS

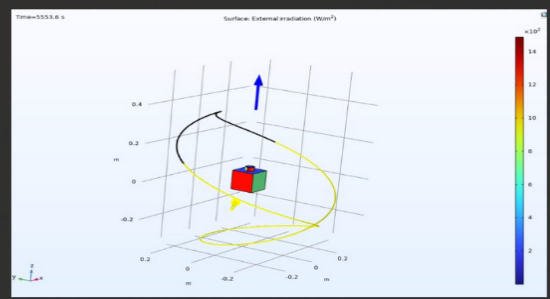




Structural analysis using ANSYS Mechanical shows that the CubeSat's structure will withstand up-to 16 g's of force

RADIATION ANALYSIS

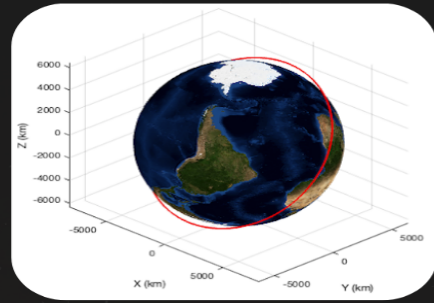




Radiation analysis using COMSOL Multiphysics shows that the CubeSat will experience a maximum of 14e02 W/m2 of radiation in Low Earth Orbit

ORBITAL SIMULATION & KEPLERIAN ELEMENTS

- $e = 0$
- $i = 51.6°$
- $a = 6{,}738$ km
- $\Omega = 185.8°$
- $\omega = 305.3°$
- $\nu = 164.1°$



REACTION WHEEL SIZING

Wheel mass = 10 g | Wheel Diameter = 3 cm

$I_{sat} = 0.5 \times m \times 1.125*10^{\wedge} r^{\wedge}2 = 0.01625$ Kg.m2

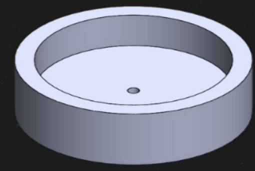
$I_{Wheel} = -5$ Kg.m2

$\omega_{Wheel} = (2\pi \times RPM)/60 = 733$ rad/s

$I_{Wheel} \times \omega_{Wheel} = I_{Sat} \times \omega_{Sat}$

$\omega_{Sat} = (I_{Wheel} \times \omega_{Wheel}) / I_{Sat}$

$\omega_{Sat} = (1.125*10{-}5 \times 733) / 0.01625$



DETECTION AI MODEL

The CubeSat project utilizes an AI-driven object detection system powered by a Raspberry Pi 5 and the YOLO11 model. The AI model was trained on a dataset of 66,000 images using the NVIDIA A6000 GPU provided by the Interdisciplinary Research Center for Intelligent Secure Systems (IRC-ISS). This advanced system enables the CubeSat to detect and identify space debris and other objects in real-time, enhancing the accuracy and efficiency of space debris monitoring and orbital management.

ultralytics YOLO11

COMMERCIALIZATION OF SPACE PROJECTS

Our CubeSat System enhances safety, lowers insurance costs, and prevents costly collisions, making space more accessible and profitable. By fostering trust and stability, it encourages greater private investment, strengthening Saudi Arabia's role in the global space economy and promoting a more sustainable, commercialized future in orbit.

CONCLUSION

By shifting debris detection from the ground to orbit, we gain more precise, uninterrupted insights free from atmospheric limitations and coverage gaps. This advancement elevates the safety and sustainability of space operations while strengthening Saudi Arabia's leadership in cutting-edge aerospace technologies. Ultimately, our CubeSat constellation sets a new global benchmark for proactive debris management, ensuring a safer and more vibrant future in space.

1 SPACESU 24001A 24340 .00001 00000-0 31492-3 0
2 SPACESU 51.6381 185.8361 0007043 305.3104 164.1439 15.50252031485142