Ag2030: AWES - The Cubesat solution

Problem? Solution: AWES

By: Sophia Seumahu, Lucy Bott, Andrew Fong and Jacinta Morley

Date Due: 21/01/2022
Date Issued: 10/01/2022

NYSF 2022, Ag 2030 Challenge

Introduction:

A few small 10cm cubes are all that is necessary to monitor the agricultural industry from above. The Cubesat is a U-class spacecraft is a mini aturised satellite in low earth orbit that is either made one cube or several, each serving different purposes. The United States of America has already started using this technology for detecting and measuring ground evaporation. Likewise Lebanon and Thailand are currently using them for drought forecasting (Space for Agriculture Development and Food Security—Use of Space Technology within the United Nations System, 2015).

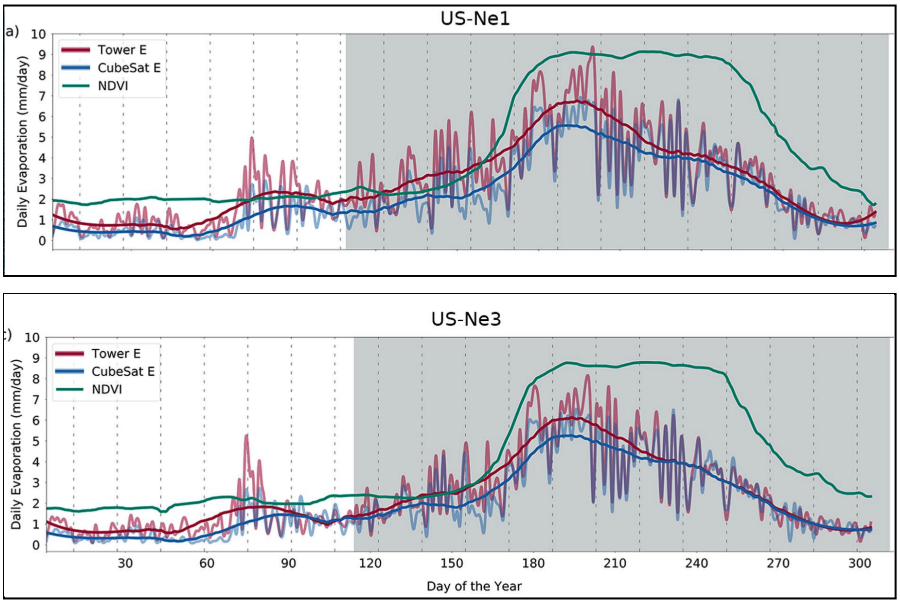
Biodiversity is a large issue that can be addressed by satellite imaging and mapping, showing species composition, and land cover of certain areas through the use of normalised difference vegetation index maps. The forecasting feature of the CubeSat software can accurately predict droughts or incoming rain, allowing farmers to prepare their land and their crops for an especially dry season or extremely wet season. These predictions will be made based on previous data (satellite infrared images) analysed through machine learning and AI. The Infrared satellite imaging and mapping can also detect the amount of soil moisture enabling farmers to irrigate crops effectively based on the health of the crops.

Data Analysis:

Lebanon and Thailand use cubesats to forecast and detect droughts, enabling their farmers and country to prepare for these harsh weather conditions. The ESCAP (Economic and Social Commission for Asia and the Pacific) and ESC (Environmental and Social Cell) organisations in these places use this data to plan for reduced harvest and still provide for the large population in those areas. Australia could use cubesats to achieve the same goal (Space for Agriculture Development and Food Security—Use of Space Technology within the United Nations System, 2015).

A 6-unit cube-sat will be launched by Saudi Arabia this year, 2022, to monitor environmental variables such as soil moisture (Cozzens, 2021). This project was introduced in order to help with the Saudi green initiative whose goal is to combat climate change and reduce carbon emissions through planting trees (saudigreeninitiative.org, 2022). Canada also uses CubeSats to achieve a similar purpose (asc-csa.gc.ca, 2015) . These examples show cubesats can be used for the purpose of monitoring soil moisture in a clean, green way.

In Nebraska, USA, a CubeSat was used to measure ground evaporation of water to a 3m resolution. The data produced from the cubesat was compared with ground data from weather towers on the ground. Even though these ground towers could also be a solution to measuring water evaporation and using the data to predict and detect droughts, it would be more viable to use CubeSats. The cost for farmers to maintain the equipment on the ground and constantly check would be greater than if cubesats were used. These CubeSats also showed a great correlation with ground data (from the instruments on the ground). Below the data shows the daily evaporation rate from three different fields in Nebraska, and the correlation of the satellite data and the ground tower data (red and blue lines). If the ground tower data was considered the accepted value, the satellite data had an r^2 of 0.86–0.89 and mean absolute error between 0.06 and 0.08 mm/h. (Aragon et al., 2021), thus showing how cubesat data could be used to replace these traditional weather towers. :



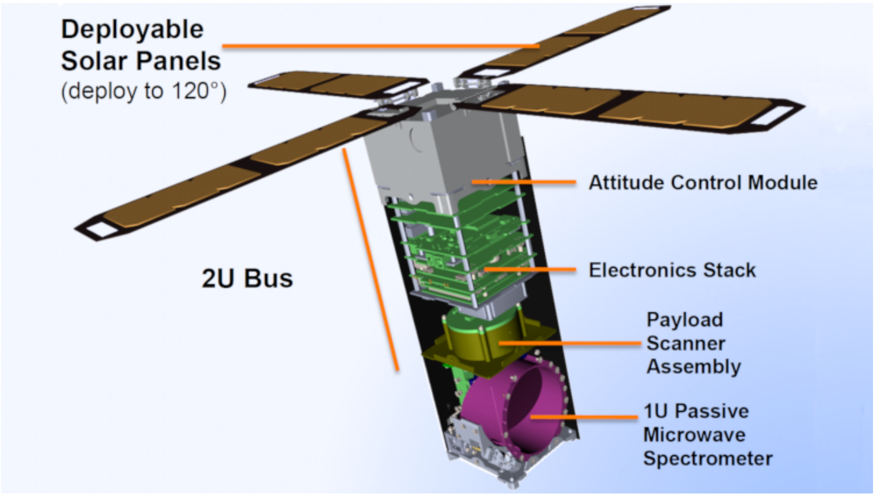
At the current moment, the agricultural industry in Australia is predicted to be valued at 78 billion in 2021-2022 and is aimed to reach 100 billion by 2030. Two years ago, (2019-2020) the industry was valued at 61 billion so there is a constant upwards trend of sustainability and profitability coming from this industry. Cubesats will help increase the industry value, by increasing the efficiency of farming practises by monitoring water evaporation and predicting droughts. This monitoring helps farmers to irrigate their crops effectively taking into account the water already present in the soil and predicted rainfall. By increasing efficiency of farming through water monitoring, we can increase the value of the agricultural industry because harvests will be more plentiful even during years that may have a drought season because farmers will be able to plan ahead and ensure their crops are properly water and ready for a drought. Biodiversity issues regarding pests and crop takeover can also be addressed using

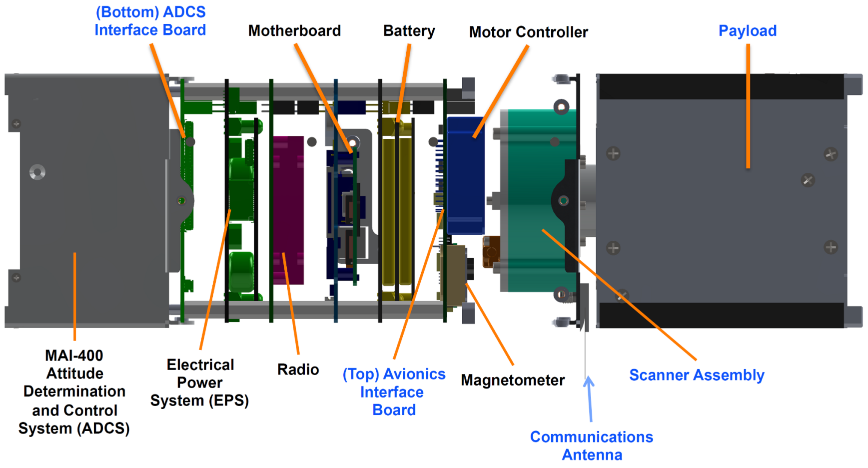
Power consumption:

Depending on the IC, integrated circuit, parts used in the electrical circuits operating the cubesat, different amounts of power will be consumed in the operation of this piece of technology. For example, some possible ICs that could be used in the cubesat could be the Virtex 4 from the company XILINX it uses 161 mW while dynamic, 199.1mW while static and in total is 360.1mW and the Spartan 3 (same company) it uses 104.19 mW while dynamic, 95.29mW while static and in total is 199.48mW. For a 3U cubesat it is expected that it will use 21413.8mW. It can store up to 11 700mW and generate 14000mW. To generate this power, solar panels will need to be attached to the cube-sat so it can generate its own power (Arnold. et.al, 2014).

Scientific instrumentation:

A cubesat can carry multiple units (payloads) ranging from 1U to 3U normally. It can also carry a variety of scientific instrumentation within the payload. General subsystems in a cubesat include the mechanical structure, thermal control, command and data handling, telecommunications, electrical power and altitude determination and control systems (Olson, 2019). For an agriculturally purposed cubesats, the scientific instrumentation payload aboard this satellite will likely consist of assorted sensors and instruments for satellite imaging so soil moisture and water evaporation can be detected.





Costs:

In launching a cube satellite, several factors must be considered in the cost of launch. Firstly, a launch pod from which the cubesat will be deployed from must be chosen. The most common types of these are the Poly Picosatellite Orbital Deployer (P-POD) and Space Shuttle Picosatellite Launcher (SSPL). A rocket must also be chosen to launch this pod which can be commercial (e.g. spacex rideshare launches) or during a space mission within the extra space in the payload. This cost 1-2 million including insurance Along with this, there will be several costs associated with scientific instrumentation and the satellite manufacturing. Below is an example of the possible instrumentation in our AWES satellite:

Satellite frame:
$3600

Attitude control system: A Passive Magnetic Attitude Stabilisation System will ensure that the satellite stays in low orbit in earth's magnetic field.
$3,200

Camera system: A Sanyo VCC-5884E 1/3 in. Color CCD DSP High-Resolution Camera, 540TVL, 1 Lux Sensitivity, 12VDC/24VAC, Automatic Gain Control (ON/OFF), used for security cameras with a mass of 167 grams and size of 68 x 63 x 52 mm.CubeSat Compatible High Resolution Thermal Infrared Imager (price unknown assume $500)
$750

Transmission system: CubeSat UHF downlink, VHF uplink full-duplex transceiver, provides telemetry, telecommand & beacon capability in a single board
$11,800

Antenna system: The ISIS deployable antenna system contains up to four tape spring antennas of up to 55 cm length, which deploy from the system after orbit insertion.
$4,200

Solar cells: The NanoPower P-series power supplies are designed for small, low-cost satellites with power demands from 1-30W which will be ideal for this satellite:
$2,800

Other minor instruments/Transport to Launch and assembly costs:
$9,300

Total for Assembly (above components) (approximate) : $42,100

Approximate cost for Launch (assuming weight is about 2kg) : $84,000

Approximate Total: $126,100

Benefits:

This cubesat will target increasing water efficiency and reducing the effect of natural disasters such as drought through measuring ground evaporation, soil moisture, and rainfall patterns. Infra-red imaging will be used to measure ground evaporation, soil moisture and rainfall patterns. This allows farmers to accurately irrigate their crops based on the moisture already present in the soil. Machine learning and AI software will also be used to predict future rainfall patterns enabling farmers to plan and prepare their crops for dry weather such as droughts. The software will be put in an app that will be simple for farmers to access and use to find this imaging. It will also address biodiversity issues by tracking animal and plant species population and enabling fast action to be taken before species overpopulate a certain land area. These three main benefits of using a cubesat will culminate in increasing water efficiency and thus resulting in an increase in the value of the Australian agricultural industry so it can reach its goal of 100 billion in 2030.

Environmental considerations

The satellite will aim to operate for a minimum of 3 years and then use the last of its energy (as generated by the solar panels) to perform a controlled crash down to earth and burn up in the atmosphere. A majority of the materials used to make the solar panels and intricate parts inside will be made of sustainably sourced materials.

References

Aragon, B., Ziliani, M., Houborg, R., Franz, T., & McCabe, M. (2021). *CubeSats deliver new insights into agricultural water use at daily and 3 m resolutions* [Ebook] (pp. 1-6). scientific reports. Retrieved 18 January 2022, from https://www.nature.com/articles/s41598-021-91646-w.pdf.

Arnold, S., Nuzzaci, R., & Gordon-ross, A. (2012). *Energy Budgeting for CubeSats with an Integrated FPGA*. Ann.ece.ufl.edu. Retrieved 20 January 2022, from http://www.ann.ece.ufl.edu/pubs_and_talks/Aero12_arnold_ERB.pdf.

Assets.publishing.service.gov.uk. (2018). Retrieved 20 January 2022, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/736211/6.4502_UKSA_SPACEUK_Solutions_for_Agriculture_220818_CMYK_web.pdf.

CubeSat Compatible High Resolution Thermal Infrared Imager. Partnerships.gsfc.nasa.gov. (2022). Retrieved 18 January 2022, from https://partnerships.gsfc.nasa.gov/conradchallenge/tops/GSC-TOPS-138.pdf.

Heyman, J. (2009). *FOCUS: CubeSats — A Costing + Pricing Challenge*. Satmagazine.com. Retrieved 20 January 2022, from http://www.satmagazine.com/story.php?number=602922274#:~:text=Currently%2C%20most%20CubeSats%20are%20being,US%2440%2C000%20per%20single%20cube.

Hindawi. (2019). *Review Article Towards the Thousandth CubeSat: A Statistical Overview* [Ebook]. Retrieved 20 January 2022, from https://downloads.hindawi.com/journals/ijae/2019/5063145.pdf.

Olson, E. (2019). *What's inside a CubeSat?*. Engineering 360. Retrieved 20 January 2022, from https://insights.globalspec.com/article/12083/what-s-inside-a-cubesat?__cf_chl_jschl_tk__=5yRZbVB2KxIwLv46c23hBpGlCfBl9gsAPvrzimWYnNw-1642722355-0-gaNycGzNDFE.

Space in service of agriculture. (2020). Retrieved 20 January 2022, from https://www.asc-csa.gc.ca/eng/satellites/everyday-lives/agriculture-in-the-satellite-age.asp.

United Nations Office at Vienna. (2015). *Space for Agriculture Development and Food Security—Use of Space Technology within the United Nations System* [Ebook] (pp. 1-15). Retrieved 18 January 2022, from https://www.unoosa.org/res/oosadoc/data/documents/2016/stspace/stspace69_0_html/st_space_69E.pdf.

wirth, p. (2021). *Predicting Rain from Satellite Images*. towards data science. Retrieved 18 January 2022, from https://towardsdatascience.com/predicting-rain-from-satellite-images-c9fec24c3dd1.