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Research Paper

Venus TinySat- The Smallest, Ever Proposed Interplanetary Satellite

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ABSTRACT: *Miniaturization of electronic and mechanical components has significantly reduced the size and mass of many of the astronautical components. This paper discusses the Venus TinySat (VETS), a new gram-scale satellite, member of the ChipSat/Femto-Satellite class spacecrafts. ChipSats/Femto-Satellites are far less complex and far cheaper than CubeSats or PocketQube, let alone traditional satellites developed by State Agencies.*

VETS is a femto-satellite, proposed to be a square of 1x1 cm each side.
Due to the relatively small number of components on board, a single VETS costs approximately 20-50 USD.
Featuring a supercapacitor for battery, a microcontroller, a radio transceiver, and a payload experiment, these spacecrafts can be launched in large numbers at the same time, perhaps even more than 100.
For university and high school-run research projects, or even small associations, VETS is a low-cost solution for measuring the atmosphere and surface of Venus.

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I. INTRODUCTION

In order that satellites be produced as tiny and lighter as feasible to enable cheaper construction and start-up operations, a succession of downsizing of space components (miniaturization) have dominated the industry for the last 2 decades.

Because satellite development until the 21st Century was extremely costly, especially with larger satellites (often over 500kg), miniaturization became a necessity in the space industry. Smaller satellites can be developed and launched for less cost by utilizing technology miniaturization. [1]

Over the past few years, the industry of shrinking satellites has largely succeeded. Due to their low cost and quick development time, CubeSats (kg-scale spacecraft) have recently enabled universities and start-ups to develop their own spacecraft at a lower cost than traditional spacecraft.

Through miniaturization of electronic and mechanical components, spacecraft sizes, masses, and costs have been reduced in an unprecedented way. [2]

From concept to launch, CubeSats still require considerable funding and take several years to develop. Even at a university, developing a CubeSat requires considerable fundraising and project management efforts.

Although CubeSats have been even made smaller with the introduction of PocketQubes (5x5x5 cm) and FemtoSats (100-gram satellites), the underlying cost to procure the components, build and launch these spacecraft has not changed very much over the years.

Recent efforts to develop and launch even small satellites have resulted in an entirely new class of systems. Named ChipSat, these are ultra-compact (3.5 x 3.5 cm) flat satellites with every component on a single circuit board as shown in Figure 1.

The price of developing these super-small satellites are significantly reduced by their reduced size and mass. A single ChipSat costs less than $100, and their development from concept to flight hardware can be finished within 6 months, according to Zachary Manchester, an integral person behind the development of the ChipSat.

This paper focuses on discussing a completely new type of SmallSat, developed by members of the Saudi Students' Rocketry Association (SSRA), named the Venus TinySat (VETS), inspired by the ChipSat, discussed above.

The Venus TinySat is patented in the USPTO, under SSRA's name.

The VETS is a unique, proposed femto-satellite, because not only is it the first gram-scale satellite proposed for an interplanetary journey, but also the smallest free-flying satellite ever. VETS is specifically designed for safely reaching the surface of Venus, allowing humanity to take measurements of the planet whose surface cannot be seen from on top of the it's atmosphere because of the fact that it is too dense. This also makes it the smallest satellite proposed to reach the surface of another planet.

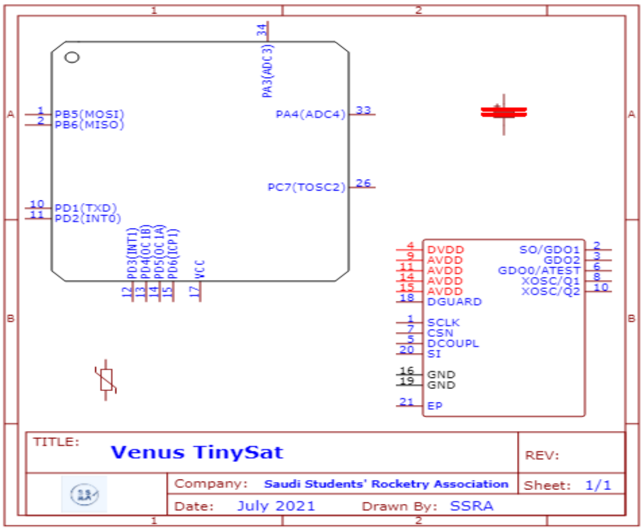
II. CHARACTERISTICS

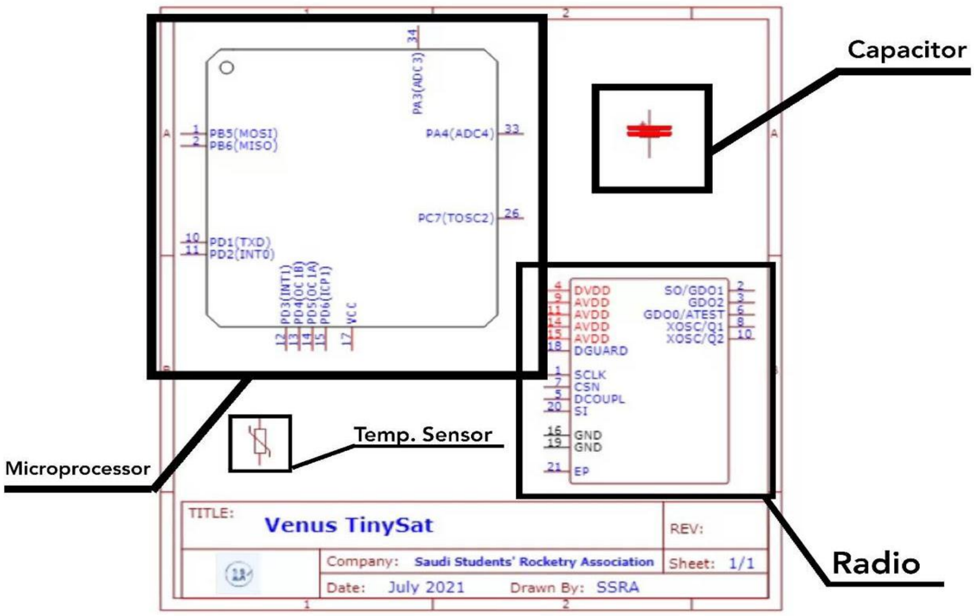
The VETS is an extremely tiny single board satellite, meaning that it consists of only a single printed Circuit board (PCB). Measuring about 1x1 centimetre, a single piece of this spacecraft contains only 4 components- A Microcontroller (ATMEGA 328P-AU), only one experiment payload (either a gyroscope, or a temperature sensor, or any other kind of sensor), a radio transceiver (LoRaWAN), and a supercapacitor.

The reason why we placed only 1 experiment payload on the spacecraft was (1) to make it as small and light as possible, (2) to allow distributed missions, making it cheap to build individual pieces of the craft.

The cost of a complete VETS will be roughly between 20-50 USD, also making it one of the cheapest ever to build.

With the VETS being a single-payload-craft, distributed data collection becomes possible for individuals. So, if an individual wants to only get the measurement of the varying temperatures of the Venusian atmosphere, he/she can do it by only placing a single temperature sensor. And hence, several of these ChipSats are to be produced, if one wishes to fly more than one experiment on board.





Shown here are the components of an example VETS.

Because the LoRaWAN Radio Transceiver is equipped with a short-range telemetry transmitter, there will also be a mothership, which will also release these VETSs into the atmosphere of Venus, hence also known as the dispenser. The mothership will receive data signals from the tiny satellites, and transmit it back to ground controls on Earth, hence acting as also a relay station.
The mother-dispenser will be radiation and heat insulated.

Because of the fact that solar arrays on board would make VETS bigger and heavier, we choose to use a supercapacitor as a power source, which will be charged inside the dispenser before being released.

Comparison of the smallest-ever satellites proposed-

Name of the ChipSat	Size	Developed/Proposed By
Venus TinySat	1x1 cm	Saudi Students' Rocketry Association
Sprite ChipSat	3.5x3.5 cm	Cornell University
SpinorSat	3.5x3.5 cm	Space Technologies at California
ThumbSat	40.6 cm (Total Lenght)	ThumbSat
Wafer Scale Spacecraft	9 cm (Diametre)	University of California Santa Barbara

III. CAPABILITIES

Because of the varying characteristics of VETS, many capabilities are also unlocked. Some of these are:
1. As a result of VETS having a lower mass than previous crafts, more VETS satellites can be launched into Venus's atmosphere while maintaining the same available mass.
2. Extremely cheap to manufacture.
3. Because there are fewer components and it is easier to modify, there is a correlation between low mass and rapid development.
4. Even in case most of the VETSs do not survive the harsh environments of Venus, a sufficient number may survive to transmit data back from the surface.
5. It is the capability of these satellites to be developed quickly, even within a few hours, that allows for rapid technology testing in space, especially for small components.
6. Open deep space to femto-satellites.
7. Demonstrate that such small satellites are also capable of carrying out the same experiments which much larger spacecrafts carry out.
8. Show an example of mother-daughter mission architectures by relaying communication from one spacecraft, through the other, and then on to the Earth.
9. Mass Production is possible.
10. Limited communication power is required, as the data is only to be transmitted to the mothership, and not directly to Earth.
11. Taking measurements of the lower atmosphere of Venus, and also the surface is possible.
12. Hundreds of such satellites can be dispensed at a single time.
13. The failure of a single ChipSat does not destroy the other experiments, because they are on another chip. Hence allowing independent experiments running at the same time, and also with a lower risk of destroying all of the payload experiments.
14. Lastly, VETS are capable of serving as relay stations in case another larger spacecraft lands or is inserted into orbit, transferring information about its status, just like how Mars Cube One CubeSats acted when InSight landed on Mars' surface.

There are a lot more benefits of VETS, which The Saudi Students' Rocketry Association will talk about in later publications.

Sample Experiments to be carried on board individual VETS-
1. Temperature Sensor
2. Camera- to picture the surface of Venus, which has not been done a lot of times before. More will be talked about in the 'Why is it important to picture the surface of Venus?' section.
3. Humidity Sensor
4. Pressure Sensor
5. UV Sensor
6. Carbon Emissions Sensor
7. Magnetometer

Why is it important to picture the surface of Venus?

Because of their similar size, mass, density, composition, and gravity, Venus and Earth are often referred to as twins.

The hottest planet in the solar system is Venus. Venus, while not being the closest planet to the sun, has a thick, toxic atmosphere packed with carbon dioxide and is constantly blanketed in thick, yellowish clouds of sulfuric acid that trap heat, generating a runaway greenhouse effect.
In fact, Venus is the hottest planet in the solar system, which, combined with the planet's high atmospheric pressure, makes it a dreadful place to live.

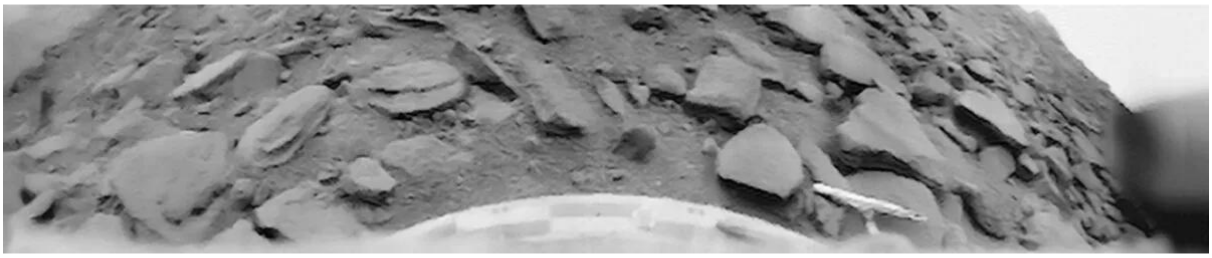
On December 14, 1962, NASA's Mariner 2 successfully flew by and examined the cloud-covered planet Venus, making it the first planet to be explored by a spacecraft.
Since then, a number of spacecraft from the United States and other countries have studied Venus, including NASA's Magellan, which used radar to survey the planet's surface.

The most successful landings on the surface of Venus so far were accomplished by Soviet spacecrafts, but they didn't last long owing to the intense heat and crushing pressure.
After impacting the surface of Venus in 1978, an American probe, one of NASA's Pioneer Venus Multiprobes, survived for roughly an hour.

There were just four spacecraft that returned images from Venus's surface.
Because of the scorching heat and crushing pressure, no landers can live long in Venus' atmosphere. In 1975 and 1982, four Venera spacecraft from the Soviet Union took the only photos we have of Venus' surface.

The Veneras, which translates to "Venus" in Russian, scanned the surface back and forth to produce panoramic pictures of their surroundings.
They displayed a yellow sky and broken, barren landscapes that were both foreign and familiar—views of a world that may have been similar to Earth before catastrophic climate change. [4]

Here are a few images of the Venusian surface captured by *Venera 9, 10, 13 and 14.*



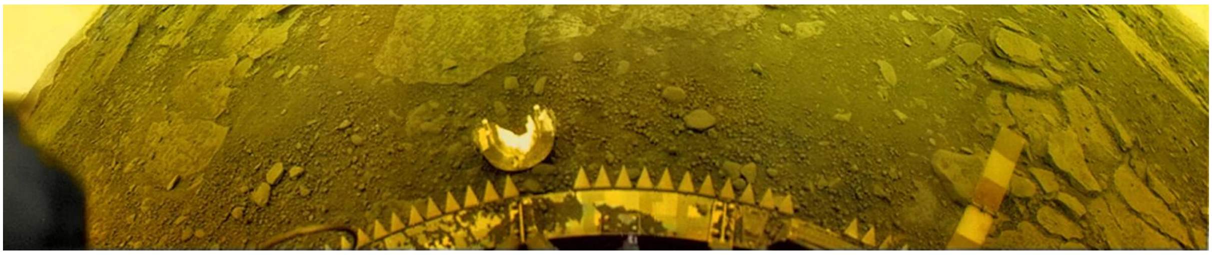


Image credits: Russian Academy of Sciences / Ted Stryk

The last spacecraft we sent even near to Venus was the Magellan probe, which was launched by NASA to circle the planet in 1989. It was in a parked orbit for nearly 4 years before plunging to the surface.

Because our previous journey to Venus was 32 years ago, every sensor, monitor, and transmitter we may employ now is far superior than what we had then.

Furthermore, given the recent surge in miniaturization, we will be able to pack better and cheaper technology in a much smaller space than ever before.

Remember that the Earth froze solid twice, maybe three times, and the oceans froze almost to the bottom.
As a result, life had to be restarted from scratch. And if humans can recover from these freezing cycles, Venus might be able to rebound from its present hothouse cycle. And perhaps, there's nothing stopping Earth from entering a hothouse cycle! It would be interesting to learn more about how and why Venus came to be the way it is today.

The reason we need to photograph Venus's surface is so that we can study it, which will help scientists comprehend our planet Earth and how it developed.
Although Venus has a dense atmosphere, as opposed to the earth, it has many features that are comparable to the earth!
We'd understand why Venus devolved into an inferno.
Also, why is Earth livable when the other planets in our solar system are not?

IV. CONCLUSION

In short, the VETS is a flat spacecraft, also called a ChipSat, made of only a single PCB. It consists of 1 microcontroller, a supercapacitor, a radio transceiver, and a payload, which may be any sensor or experiment small enough to fit on the craft.

As a conclusion, the above sections describe the plans and benefits of the Venus TinySat, which is possible;

1. The Smallest and the lightest free-flying satellite proposed.

2. The First Nanosatellite aimed at probing Venus.

3. The First Nanosatellite aimed at reaching the lower atmosphere and eventually the surface of a hostile planet as Venus.

Once common, these small spacecrafts will allow spacecraft development to become accessible to almost everyone, at the cost of a few bucks.

Due to their small size and mass, these crafts can be developed rapidly, which in turn results in a shorter timeframe of the build-and-launch cycles, where new designs and experiments can be directly flown and tested quickly.

Lastly, VETS is unique in the field of astronautics, both in terms of its capabilities and its characteristics.

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