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‘CUBESAT’ – an OVERVIEW

AEOLUS AERO TECH, Pvt. Ltd.

‘**Aeolus Aero Tech Pvt. Ltd.**’ (Aeolus) based in Bengaluru, Karnataka, India, provides a wide range of Products, Services and Technology Solutions in Alternative Energy, Automobile, Aeronautical, Space Tech, Defense and General Engineering OEMS. Aeolus offers a variety of equipments for laboratories to cater to R & D (educational & industry uses) and for academic institutions.

- ✓ Global Leader in Aerospace Products and Services
- ✓ Delivers affordable, high Technology Solutions
- ✓ Uncompromising Business Ethics & Delivery
- ✓ World class Technical Expertise & Collaboration
- ✓ Dedicated to Customer Satisfaction & Mission
- ✓ Assist with Manufacturing, Assembly and Testing
- ✓ Provide Life-time Engineering & Technical Support
- ✓ Champion Alternative, Green Energy Solutions

Aeolus Products & Services Domains

1. Educational Labs
2. Heat Pipes & Thermosyphons
3. Wind Tunnels
4. Space Science Products
5. Micro-Gravity Research
6. CubeSat: Design, Develop & Deploy
7. Wind Energy Technologies (500 W to 5 KW)

CubeSat: Advances in embedded technology is changing the satellite sector due to the reduced mass and size of the components. Performance by large satellites is easily imitated by the small satellites, called ‘CubeSat’ - a fast growing market due to its simplicity, low cost and freedom to be innovative. Historically satellites were developed by scientists using space grade components based on function such as telecommunication, defense, broadcast, etc. With advancing technology, now students (high school & college) and small businesses can develop and launch their own satellite by using COTS components readily available in CubeSat versions, for educational and research purposes.

Common applications of CubeSats

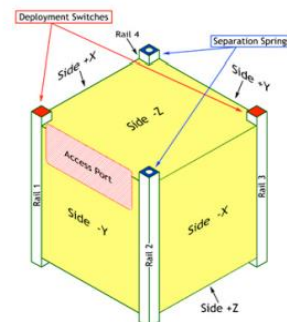
Scientific Research	Technology Demo	Earth Observation
Education	Military Application	Astronomy
Remote Sensing	Asteroid Exploration	Ship Tracking

CUBE SAT:

1U size CubeSat

10 cm x 10 cm x 11.3 cm

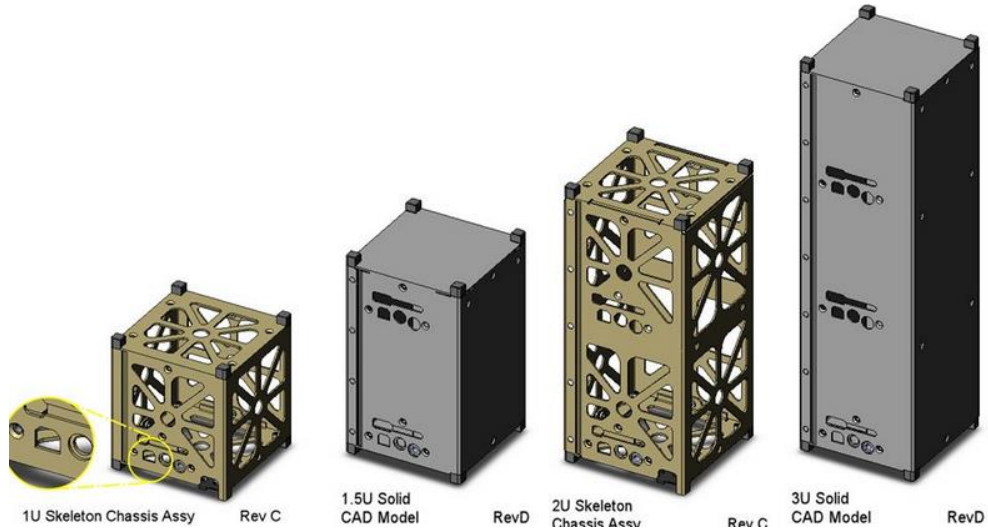
About 1.33 kg (3 lb) in mass.



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Fig 2: CubeSats come in form factors (U) - 1U, 2U and 3U for use in various applications.

CubeSat Units – 1U, 2U and 3U

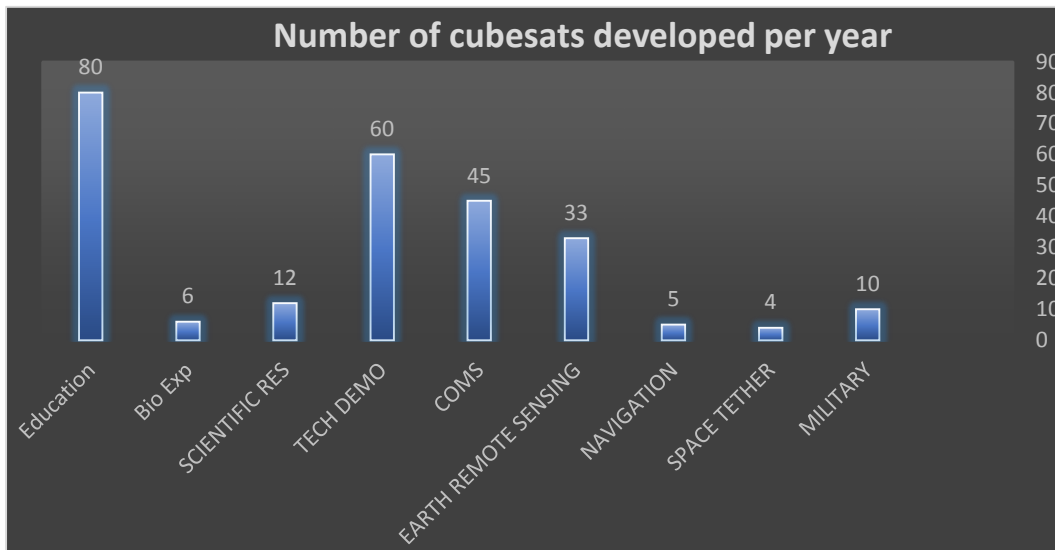


Nano / Micro Satellite Types:

<u>Satellite Type</u>	<u>Weight on the ground</u>
Femtosatellite	10 – 100 Gms
Picosatellite	< 1 KG
Nanosatellite	1 – 10 KG
Microsatellite	10 – 100 KG
Small Satellite	100 – 500 KG

Expanding Applications of CubeSat:

Fig. 3 Major applications of CubeSat (2003 to 2013)



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a) Earth Observational Satellites: Earth imaging until now has been by larger satellites with high resolution at a significant cost (several millions of dollars). Ground vehicle navigation, Traffic monitoring, etc. need continuous monitoring and a constellation of satellites. CubeSat constellation is simple in construction, easy to build, lower in cost and faster to set up with the same performance.

<ul style="list-style-type: none">• Earth mapping• Natural disaster imaging• Agricultural survey• Forest area survey• Animal tracking	<ul style="list-style-type: none">• Counter-Intelligence / Spy missions• Country border survey• Water resource management• Traffic monitoring• Weather forecasting
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b) Atmosphere Observation: The earth's atmosphere is monitored and studied for scientific purposes.

<ul style="list-style-type: none">• Study of Van allen radiation belt• Earth's magnetic field study• Disturbance in magnetic field during earthquakes• Study of greenhouse gases in earth's environment• Study of oxygen content in atmosphere• Variation in climatic changes	<ul style="list-style-type: none">• Study of thermosphere• Survey of Ionosphere• Auroral study• Asteroid monitoring• Study of ozone layer
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c) Telecommunication Satellite: Most nanosatellites use amateur radio frequency for communication - called 'Amsat', open source frequency band width in UHF/VHF and S-Band.

<ul style="list-style-type: none">• Store and Forward communication• Intersatellite communication• Technology demonstration

d) Astrophysical Observation: CubeSats are now being ideal for exo-planet observation due to its low cost and comparable performance of micro satellites.

<ul style="list-style-type: none">• Interplanetary travel like Moon, Mars or Venus.• Interplanetary observation.• Observation of sun like stars and other stars.• Observation of exo-planets and earth-like planets, using advanced sensors
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e) Technical demonstrations: Secondary Tech Demo missions undertaken in the CubeSat.

<ul style="list-style-type: none">• Novel sensors, actuators• Inbuilt communication devices• TFSC Solar cells	<ul style="list-style-type: none">• De-orbiting devices• Solar sail• Tethers
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f) Microgravity Experiments: The micro-gravity experiments will be critical in:

<ul style="list-style-type: none">• Biological study and experiments• Material strength• Chemical composition experiments

g) Public Utility: Some applications require a constellation of satellites that serve the public at large.

<ul style="list-style-type: none">• Outernet (Free wireless internet)• Navigation of ground vehicles• Traffic control and monitoring
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CUBESAT – Growing Demand:

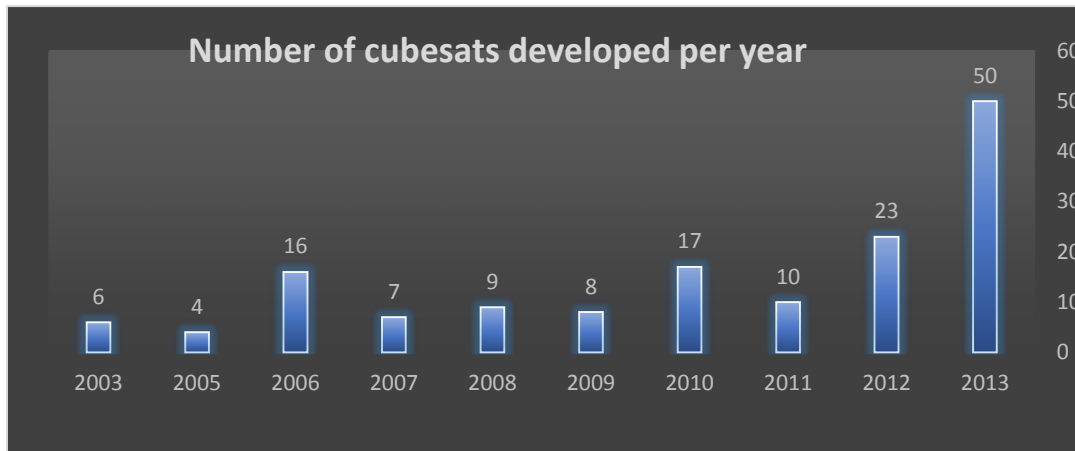
Nano / Microsatellite CAGR (Compound Annual Growth Rate)

2009 to 2013 37.2 % / year 2014 to 2020 23.8 % / year


Projected potential growth in CubeSat (Ref: SpaceWorks Enterprises, Inc. 2014)

<u>Year</u>	<u>Est.</u>	<u>Year</u>	<u>Est.</u>	<u>Year</u>	<u>Est.</u>
2014	130	2015	220	2016	380
2017	430	2018	490	2019	520

Growing demand for CubeSat (2003 to 2013)



PRODUCTS OFFERED TO SCHOOLS / UNIVERSITIES: Many Universities and High schools are keen to explore space technologies. The low cost and affordable CubeSats meet with the general & specific mission objectives. We provide the following products and services to educational institutes.

3U CubeSat	Basic Components
	<p>HARDWARE:</p> <ul style="list-style-type: none"> a) Structure – 1U, 2U & 3U b) ADCS - ADCS OBC c) ADCS – Actuators/sensors d) C&DH – C&DH OBC. e) COM – UHF/VHF Transceiver, Antenna Module. f) Ground station – Antenna setup, transceiver, TNC. <p>SOFTWARE:</p> <ul style="list-style-type: none"> a) ADCS – Attitude determination and control algorithms. b) C&DH OBC Software c) COM SDR Software

- Services:**
- a) Mission development cycle
 - b) Mission requirement preparation
 - c) Subsystem requirement identification
 - d) Subsystem development for mission
 - e) Integration and testing – unit testing (Subsystem only), system testing (Spacecraft)

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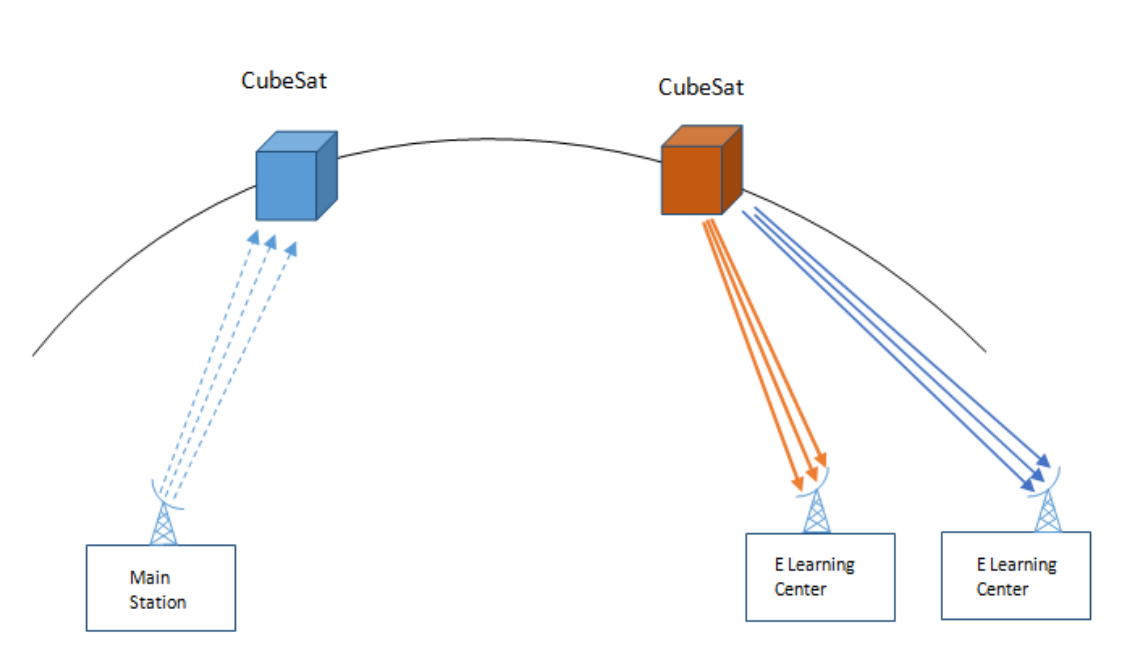
Student Learning:

- ✓ CubeSat lab kit for students to study general characteristics and operations in a lab environment.
- ✓ Improve understanding of the mission development
- ✓ Ensure lowering the mission cost by reducing potential damage to the components
- ✓ CubeSat simulator - a fully assembled CubeSat - a functional model to experiment in the lab.

INDUSTRY Sector: Industrial Clients handle compliance matters with their own country regulations and international Space Use norms. As required, Aeolus offers customized industrial applications - durable components, longer shelf-life, fully functional and reliable over its lifetime.

- (i) CubeSat designing
- (ii) CubeSat subsystems and components – based on Client’s specific needs.
- (iii) Complying with International Space Communities norms
- (iv) Reducing / eliminating space debris as an integral part of the original design

‘EDU-SAT’ Network



Satellite Subsystems:

1. Satellite Structures – 1U, 2U, 3U
2. Command and Data Handling System
3. Communication System
4. Attitude determination and control system
5. Electrical Power System
6. De-orbiter Devise / Propulsion System


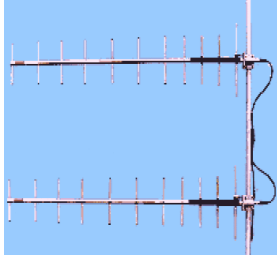
Components:

1. Reaction Wheel
2. Deployable Solar Panels
3. Ground Station Equipments
4. Magnetic Torque Rod
5. Sensors

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Services:

1. Mission Analysis
2. Product development support
3. Verification and validation
4. Integration and Testing
5. Manufacturing
6. Advanced Engineering (CAE/CFD/CAD)
7. Related software development

<p>Ground Station Set up (Example): [Customized based on the project]</p> <p>Ground station antenna: 5m (13Gbps) or 3.4m (5.8Gbps),</p> <p>Mission software (tracking and control), Data processing software, Server to store data and handle customer details.</p>	<p>Main Station</p> 
<p>Receiving Ground Station:</p> <p>UHF Yagi antennas Azimuth and elevation rotators Automatic rotor controller UHF Receiver Data processing hardware and software</p>	<p>Receiver Antenna</p> 

Affordable Pricing:

- ✓ Quite competitive, affordable & tailored to the Client's specific needs, giving the best ROI.
- ✓ Freight / Import Duty / Sales Tax (where applicable) are added as applicable.
- ✓ Indicative prices (subject to modification based on several factors & specific needs):

CubeSat Frames	1 U	10 x 10 x 11.3 cm	– USD 1,980 + freight
	2 U	20 x 10 x 11.3 cm	– USD 2,800 + freight
	3 U	30 x 10 x 11.3 cm	– USD 3,200 + freight
Command and Data Handling System			– USD 20,500 + freight
Communication System Transceiver			– USD 8,500 + freight
Deployable Antenna Module			– USD 3,000 + freight
Attitude determination and control system Module			– USD 16,500 + freight
Electrical Power System			– USD 3,600 + freight
Reaction Wheel (1 No)			– USD 3,000 + freight
Magnetic Torque Rod (1 No)			– USD 1,500 + freight
Coreless MTR (Magnetic Torque Rod) (1 No)			– USD 1,200 + freight

PROJECT BUDGET: Customer is responsible for (not limited to, but including):

- (i) Freight + Shipping Insurance,
- (ii) Import Duty,

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- (iii) Customs Clearance,
- (iv) Sales Tax,
- (v) CubeSat Approvals, Insurance & launch cost,
- (vi) Project + Satellite Insurance

	Description	Estimated base cost / Unit
1	CubeSat 1U: Design, Development, Manufacturing, Integration, Testing and related items.	US \$ 350,000.00
2	CubeSat 2U: Design, Development, Manufacturing, Integration, Testing and related items.	US \$ 450,000.00
3	CubeSat 3U: Design, Development, Manufacturing, Integration, Testing and related items.	US \$ 550,000.00

CUBESAT CUSTOMERS:

- ✓ Colleges and schools
- ✓ Oil and gas industry
- ✓ Government
- ✓ Non –government org (NGO)
- ✓ Biological research industry
- ✓ Cube sat system developer
- ✓ Space agency
- ✓ Communication industry
- ✓ Remote sensing industry
- ✓ Military application

Major Applications

- (Education and training)
- (Earth monitoring)
- (Education, earth imaging, remote sensing)
- (Remote sensing)
- (Microgravity)
- (Technology demonstration)
- (Thermal control system demo)
- (Range and efficiency)
- (Geology, environment and climate change)
- (Border security; Battle / Terrorism management)

Import Formalities: All sales are subject to Client obtaining required approvals and clearances by the respected authorities in their home country and release by the country of origin. Securing required approval / permit / import license / customs clearance, etc. and any related costs are the client's responsibility. Aeolus shall provide the standard shipping documents to facilitate these and offer customized solutions to suit the individual Client's exacting needs.

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