“Status and overview on very small satellites: definition, purposes, and projects”

Abe Bonnema, Marketing Director
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ISIS group - overview

• Founded in 2006, spin-off from Delfi-C3 project
• Currently about 50 staff (FTE)
• Provider of small satellite products and services
• Vertically integrated small satellite company
• Offices in Delft, The Netherlands and Somerset West, South Africa
• 2013 highlights:
  – Triton-1 Satellite for SAT-AIS successfully launched
  – Responsible for launch 11% of all satellites in 2013
  – Record sales to 6 continents
People at ISIS

- 50 FTE
- 45% international
  - 20 Nationalities
  - 12+ languages

Age of Employees

No. of Employees
International Focus
Capabilities and competencies

- Systems Engineering
- Radio Frequency Engineering
- Attitude Control Engineering
- Embedded Software
- MAIV Expertise
- Electrical Engineering
- Mechanical Engineering
- Flight Software Engineering
## Main Activities

### Products
- CubeSat Avionics
  - Radios
  - Antennas
  - Solar Arrays
  - OBCs
  - Etc.
- Ground Stations
- Operations Centers
- Support equipment
- Software Tools

### Launches
- Launch Services
  - DNEPR
  - Soyuz
  - Long March
  - VEGA
  - ANTARES
  - Falcon-9
  - PSLV
- Piggy back
  - CubeSats
  - Nanosats
  - Microsats
- Associated Services

### Missions
- Turn key solutions
  - CubeSat platforms
  - Payloads
  - Ground segment
  - Launch
  - Operations
- Fast implementation times
- Including training, knowledge transfer and co-development
  - Deliver turn-key Space solutions To 3rd parties

### Applications
- Based on satellite networks
  - Radio Astronomy
  - Maritime Monitoring
  - Agriculture
  - Communications
- Global Coverage
- High revisit times
- Fully integrated solutions

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**Build and deliver spacecraft component**

**Launch 3rd party Satellites on 3rd party rockets**

**Deliver turn-key Space solutions To 3rd parties**
WHAT IS ‘A VERY SMALL SATELLITE’?
Size Matters

Delfi-C3

Envisat (ESA)
## Nanosatellites

### Small Satellite Classifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Mass Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini satellite</td>
<td>100-500kg</td>
</tr>
<tr>
<td>Micro satellite</td>
<td>10-100kg</td>
</tr>
<tr>
<td>Nano satellite</td>
<td>1-10kg</td>
</tr>
<tr>
<td>Pico satellite</td>
<td>0.1-1kg</td>
</tr>
<tr>
<td>Femto satellite</td>
<td>&lt;100g</td>
</tr>
</tbody>
</table>

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**CubeSats**

- Delfi-C3 TU Delft
- GeneSat NASA
- SNAP-1 SSTL
- CSTB-1 Boeing

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**ISIS**
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WHY ARE NANOSATS DIFFERENT?

- The technology used
- The way they are built
- Cost versus Risk
- Who develops them
- How they are launched
Technology Base: spin-in
Modularity

- **On Module Level**
  - Highly modular concepts
  - Line-replaceable unit

- **On Satellite Level**
  - Satellites with common interface
  - Can launch on using multiple launch systems

- **Not so much on regulatory level**
  - Operating licenses
  - Frequency coordination
  - Export Licensing
Transparancy

Welcome to the CubeSatShop, the one-stop webshop that offers a broad range of products for CubeSats and nanosatellites in general. The webshop offers standardized, off-the-shelf components and subsystems from a variety of manufacturers.

Categories

- CubeSat Structures
- Communication Systems
- Power Systems
- Solar Panels
- Attitude Control Systems
- Antenna Systems
- Command & Data Handling
- Cameras & Payloads

Login to Cubesatshop

Username: 
Password: 
Remember me
Login

Shop News

Unveiling the ISIS On Board Computer

ISIS has now made available for you its new high performance On Board Computer: providing extra interface and...
Short timelines – QB50p

- KoM (T0)
- PDR (T0 +1)
- CDR (T0 +2.5)
- TRR (T0 +5)
- FRR (T0 +6)
- Launch (T0 +7)
Low cost structure

**Platform Specifications**
- Mass: 2 - 3 kg
- Power: 5W peak, 3W AOP
- Downlink: 10 kbps
- Pointing knowledge: < 5°
- Pointing Accuracy: < 10°
- Orbit determination: -
- Propulsion: -
- Cost: 200 – 400 k€

**Payload Accommodation**
- Mass: 1 kg
- Power: 4W peak, 1.5W AOP
- Data Storage: > 2 Gbit

**Possible Payloads**
- Small camera
- Technology demonstrator
- Space Weather

**Launch Options**
- Dispenser: ISIPOD
- Cost: 125 - 175 k€

Lowest Cost

For Small Experiments

Limited data downlink
Risk Philosophy

• Technical Risk vs Financial Risk

• Risk = probability * impact

• Low impact allows higher probability of failure
  – Allow space systems to fail
    • Non-space parts
    • Rapid replacement
  – Fewer high-reliability components required
  – Flying modified consumer / industrial electronics
Various developers

Early Adopters
• University Groups (TU Delft)
• SME’s (ISIS, GomSpace, etc.)
• STEM Foundations (AMSAT)

Followers
- Space Agencies and research institutes
- NRO, Air Force, Navy, Army
- VC Backed entrepreneurs
- Large Systems Integrators
Launching very small satellites
Launched from ISS
June ‘14 – DNEPR – 23 satellites
“Status and overview on very small satellites: definition, purposes, and projects”

SO WHAT CAN YOU DO WITH VERY SMALL SATELLITES?
Education and training

- FUNcube-1
- Built under cooperation between ISIS and AMSAT UK/NL Radio Amateurs
- Launched Nov 2013
- Used for educating school children how satellite communication works
Capability building

• First steps in becoming a spacefaring nation

• In past years, ISIS helped launching:
  – First Swiss built satellite
  – First Ecuadorian satellite
  – First Estonian satellite
Technology demonstration

- Test new technology
- Try out new concepts
- Precursors to larger missions
An International Network of 50 double and triple CubeSats

in a string-of-pearls configuration for multi-point, in-situ, long-duration exploration of the lower thermosphere (90 – 320 km), for re-entry research and for in-orbit demonstration of technologies and miniaturised sensors.
Commercial applications

- Tracking and Tracing
- Low data rate communication
- Earth Observation
- Microgravity
WHAT TO EXPECT IN THE FUTURE?

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Trends: satellite numbers

# of very small satellites just keeps increasing:

2005: few 1U/3U CubeSats (~10)  
very few nanosatellites  
occasional microsatellite

2010: many 1U/2U/3U CubeSats (~200)  
various nanosats  
tens of microsats

2014: few hundred of CubeSats  
tens of nanosats  
tens of microsats
Exponential growth
## NanoSat Swarms are coming

### Nano/Microsatellite Future Program Summary (1-50 kg)

<table>
<thead>
<tr>
<th>Name of Program</th>
<th>Time</th>
<th>Organization</th>
<th>Country</th>
<th>Mass (kg)</th>
<th>No. Launched</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF Geospace &amp; Atmospheric CubeSat</td>
<td>2010-2015</td>
<td>NSF</td>
<td>USA</td>
<td>1-3</td>
<td>4</td>
<td>12</td>
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<tr>
<td>NASA EDSN</td>
<td>2013-2014</td>
<td>NASA Ames Research Center</td>
<td>USA</td>
<td>3</td>
<td>0</td>
<td>20</td>
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<tr>
<td>NASA CubeSat Launch Initiative</td>
<td>2011-2014</td>
<td>NASA</td>
<td>USA</td>
<td>1-8</td>
<td>13</td>
<td>71</td>
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<tr>
<td>F6</td>
<td>2015</td>
<td>DARPA</td>
<td>USA</td>
<td>45</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>SeeMe and ALASA payloads</td>
<td>2014-2015</td>
<td>DARPA</td>
<td>USA</td>
<td>45</td>
<td>0</td>
<td>36</td>
</tr>
<tr>
<td>NRO Colony I &amp; II</td>
<td>2010-2016</td>
<td>NRO</td>
<td>USA</td>
<td>3-5</td>
<td>4</td>
<td>62</td>
</tr>
<tr>
<td>QB50</td>
<td>2015</td>
<td>Von Karman Institute / Various</td>
<td>Various</td>
<td>2</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>HUMSAT</td>
<td>2013-2014</td>
<td>University of Vigo / Various</td>
<td>Various</td>
<td>1</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

### Large Program Breakdown for Announced Future Launches

<table>
<thead>
<tr>
<th>Large Programs</th>
<th>Announced Future Launches 2013-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF EDSN</td>
<td>Large Programs 65%</td>
</tr>
<tr>
<td>NASA CSLI</td>
<td></td>
</tr>
<tr>
<td>F6</td>
<td></td>
</tr>
<tr>
<td>SeeMe</td>
<td></td>
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<tr>
<td>NRO Colony</td>
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<tr>
<td>QB50</td>
<td></td>
</tr>
<tr>
<td>HUMSAT</td>
<td></td>
</tr>
<tr>
<td>Other (U.S.)</td>
<td></td>
</tr>
<tr>
<td>Other (Non-U.S.)</td>
<td></td>
</tr>
</tbody>
</table>
QB50: 50 satellites in one go

Belgium registered network, funded by the EU to execute a single mission

Deploy 50 CubeSats in one mission coming from 50 different providers from various countries

Launched on a Brazilian-Ukrainian Rocket in 2016
Commercial constellations

- ISIS’ Triton network
  - 20+ sats / few years
- Nanosatisfi:
  - 10 sats / year
- Planet Labs:
  - Earth Observation
  - 100+ sats/year
- Satellogic
- Outernet
- Others...
Orbiting Low Frequency Array Swarm
Moon orbit
30kHz-30MHz
Self-propelled to the moon
Deep Space missions will explore the solar system to find and characterize vast new resources, led by world-class scientists and engineers. We combine the wisdom generated during the first age of space exploration with the vitality of new technologies and systems.
Opportunities vs Challenges

• New applications, new science, new business
• Fast implementation

But...
• Large numbers of satellites to launch
• Frequency / spectrum allocation
• Space debris mitigation
• Registration
• International / national legislation
Thank you for your attention!

Abe Bonnema | A.R.Bonnema@isispace.nl | +31 15 256 9018