Launch Service 101:
Managing a 101 CubeSat Launch Manifest on PSLV-C37

Abe Bonnema, Co-founder and Marketing Director
ISIS – Innovative Solutions In Space B.V.
ISIS - Innovative Solutions In Space
Vertically integrated small satellite company

6 Jan 2006 to Date

<table>
<thead>
<tr>
<th>Years in Space</th>
<th>Employees</th>
<th>Cubesat Products Available</th>
<th>Spin-out Companies</th>
<th>Satellites Launched</th>
<th>12 Launches from 5 Launch Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>80</td>
<td>76</td>
<td>2</td>
<td>250</td>
<td></td>
</tr>
</tbody>
</table>

Number of Satellites Currently Operated/Monitored from Our Control Room:

- 11

Lightest Sat

- 1kg

Heaviest Sat

- 25kg

Longest Duration ISIS Satellite in Orbit (Years):

- 3

Antennas Delivered

- 250+

Ground Stations Deployed

- 25+

Radios Delivered

- 80+

Satellite Solutions

Launch Services

Cubesat Products

R&D and Services
Small satellite products

Off-the-shelf standardized products

- CubeSat structures
- On board computer
- Magnetorquer board
- Radios
- Antenna Systems
- Solar panels
- Ground support equipment
- Ground stations
- CubeSat deployers

Small satellite products include CubeSat structures, on-board computers, magnetorquer boards, radios, antenna systems, solar panels, ground support equipment, ground stations, and CubeSat deployers.
One-stop-webshop for cubeSats and nanosats

www.cubesatshop.com

- Launched in 2009
- 23 vendors joint so far
- 100+ products online
Satellite solutions
One-stop-shop for small satellites

TURN-KEY NANOSAT SOLUTIONS

CubeSat platforms  Payload development & integration  Launch services  Ground stations  Commissioning & operations support
ISL - Launch services

It is our mission to launch yours

Launch acquisition and coordination
Launch deployer and interface hardware
Technical interface control
Full campaign management
Launch vehicle integration
Logistics coordination and support
ISL - Launch services
It is our mission to launch yours

- Launch Acquisition and Coordination
- Technical Interface Control
- Launch Deployer and Interface Hardware
- Full Campaign Management
- Logistics Coordination and Support
- Launch Vehicle Integration

ISIPOD Cubesat deployer
DUOPACK Cubesat deployer
QUADPACK Cubesat deployer
ISL - Launch services

It is our mission to launch yours

- 100% Launch Success
- 14 ISILaunch Campaigns
- 6 Different Launch Vehicles
- Launch Record:
  - 249 CubeSats
  - 1 Microsatellite
  - 23 ISIPODs
  - 2 DuoPack
  - 52 QuadPack
  - 11 iMDC Sequencers
ISILaunch17 Introduction

How to get to a world record launch

Opportunity came about really fast:

- Discussions during ISILaunch12 Campaign in June 2016
- Launch with large excess capacity planned end 2016
- Interest for significant number of satellites from Planet
- Additional payloads through general ISILaunch Services
- Configuration options determined over Summer
- Launch configuration confirmed end of Summer – **for 81 CubeSats**
ISILaunch17 Introduction

How to get to a world record launch

Some key parameters that made this possible

- Long-standing relation with Launch Provider
- ISIS QuadPack Deployer already flight proven on PSLV
- ISIS iMDC Sequencer already flight proven on PSLV
- Familiarity with majority of the satellites
- Interface hardware production line already in place
ISILaunch17 Introduction
Timeline and schedule

A challenge from the start, but it can always be greater:

- Swap of Primary Payloads – more capacity available
- Interest for 20 more Cubes confirmed
- Configuration for 100+ feasibility confirmed
- Agreements and timelines updated

THE question: why don’t we go for the 100+?

But can we make the additional IF HW as well?

Additional IF HW feasibility confirmed

OK ... the challenge just got even bigger ...
ISILaunch17 Introduction

The overview

**ISRO managed payloads**
- 1 x CARTOSAT-2
- 1 x INS-1A
- 1 x INS-1B

**ISL managed payloads**
- 25 x Quad Packs
- 5 x IMDCs
- 101 x satellites

**PSLV - C37**
- Height: 44.4m
- Payload Mass: 1378kg
- Rocket Mass: 329000kg
- Orbit type: Sun Synchronous Orbit
- Orbit height: 505km
- Orbit inclination: 97.46 degree
- Orbit period: 94.72 min

**Payloads**
- 88 x Dove
- 8 x Lemur
- 1 x BGUSat
- 1 x PEASSS
- 1 x DIDO-2
- 1 x Al-Farabi-1
- 1 x Nayif-1
ISILaunch17 Campaign

How to place 101 CubeSats on a Launch Vehicle

The challenge in figures:
- 25 QuadPack deployer systems to be placed
- 101 objects to be integrated and deployed safely
- 100 deployer door openings to be precisely timed
- 200 telemetry signals to be processed

The configuration solution:
- QuadPacks spread over multiple decks
- ISIS iMDC sequencers to command
- Telemetry signals processed by upper stage
ISILaunch17 Campaign

How to place 101 CubeSats on a Launch Vehicle

The deployment brains - 5 iMDC sequencer systems

- 100 harnesses (4 km of wires in total) to route and test
- 6000 pin-to-pin connections to verify
- 21000 cross connections to test (shorts, ground loops, etc.)
ISILaunch17 Campaign

The deployment challenge

The challenge to guarantee safe orbit insertion:
- 101 objects to be released in < 20 mins
- All CubeSats to be placed in similar orbital plane
- Spread of payloads as equal as possible
- Minimum distance requirements to satisfy

The implemented deployment solution:
- Opposite, simultaneous QuadPack door deployment
- Several upper stage attitude changes
- Continuous slow roll of upper stage
- Varying iMDC timing programmed

A major achievement of ISRO, showcasing PSLV’s upper stage capabilities!
ISILaunch17 Campaign

The deployment challenge – Where are they now?

One launch efficiently deployed a whole constellation of satellites for multiple customers (credit: orbitron)
ISILaunch17 Campaign

The QuadPack integration campaign
ISILaunch17 Campaign

The integration campaign
ISILaunch17 Campaign

The integration campaign
ISILaunch17 Campaign

The Launch – 100% success!

PSLV C37 MISSION

1 LAUNCH
104 SATELLITES
Thank you for your attention!

Come visit us at booth 1-2 from Monday to Thursday
ISILaunch17 Campaign
ANTRIX/ISRO’s on board surprise