# Analysis of regulatory challenges for Small Satellite Developers based on the TUB Small Satellite Database

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# Content

- Introduction
- Satellite Database
- Challenges for Small Satellite Developers
- Solution Approach
- Conclusion

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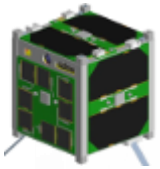
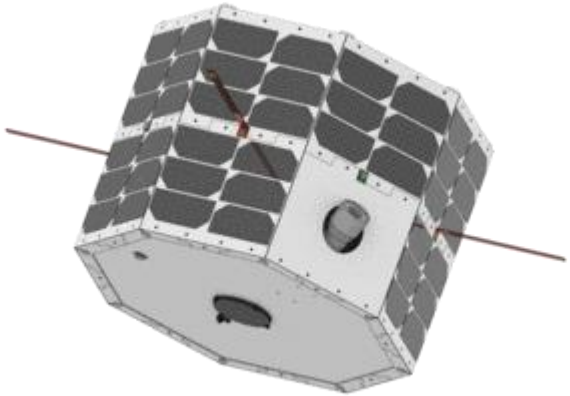
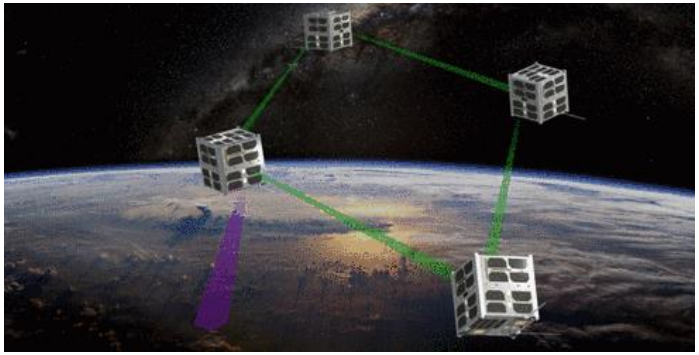
# Introduction

**Background of TU Berlin**

- 4 Picosatellites
  - BEESAT-1 2009
  - BEESAT-2 2013
  - BEESAT-3 2013
  - BEESAT-4 2015
- 2 Nanosatellites
  - Technosat 2015
  - TUBIN 2016
- 1 Nanosatellite Constellation
  - S-NET 2016







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# Introduction

**What is a small satellite?**

From a regulatory perspective:

WE DON‘T KNOW!
(yet)

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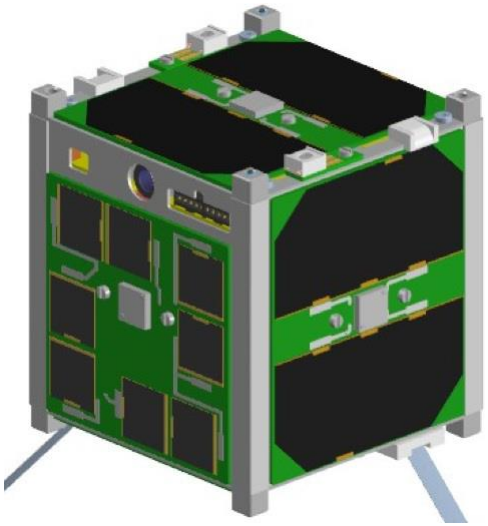
# Introduction

## What is a small satellite?

- For small satellite developers:

| | |
|---|---|
| Mass | < 10 kg |
| Edge length | < 30 cm |
| Development time | < 3 years |
| Mission lifetime | < 2 years |



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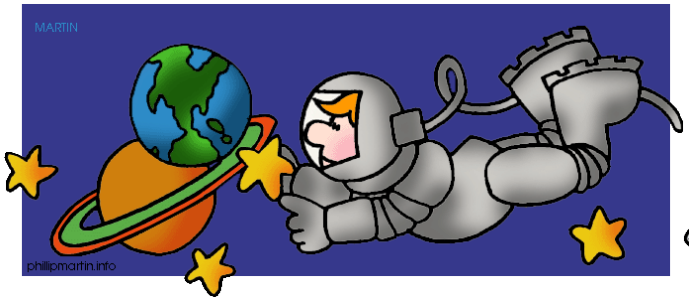
# Introduction

**Who are small satellite developers?**

- HAM radio operators


- Space Technology researchers and students




- Commercial Users


[http://occupations.phillipmartin.info]

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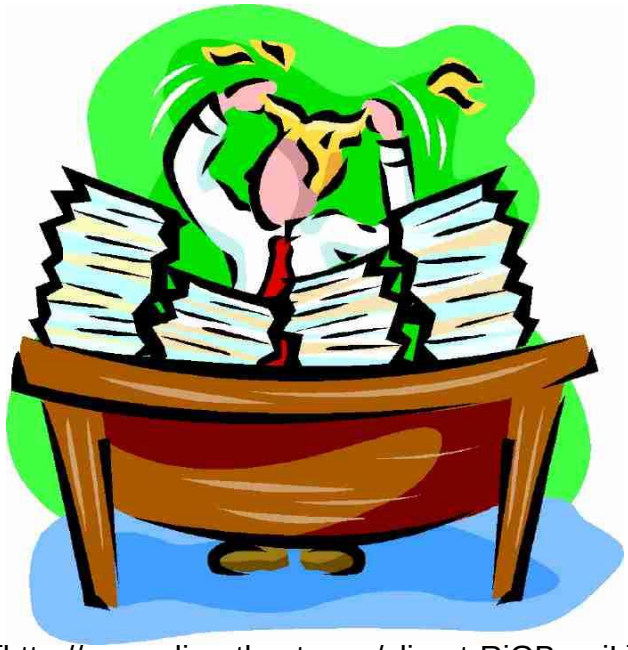
# Introduction

**Small Satellite Developers normally have no or not sufficient experience in frequency coordination, regulatory timelines and „workarounds“**



[http://www.clipartbest.com/clipart-RiGBraoiL]

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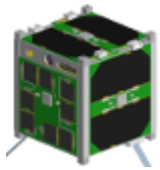
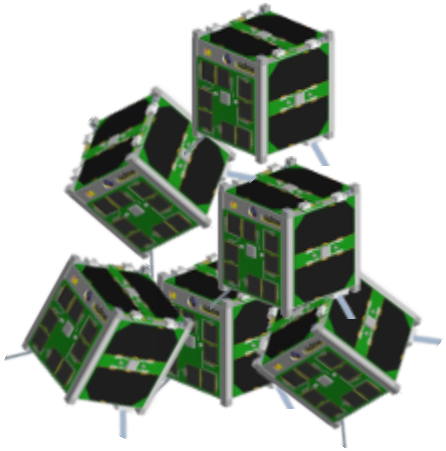
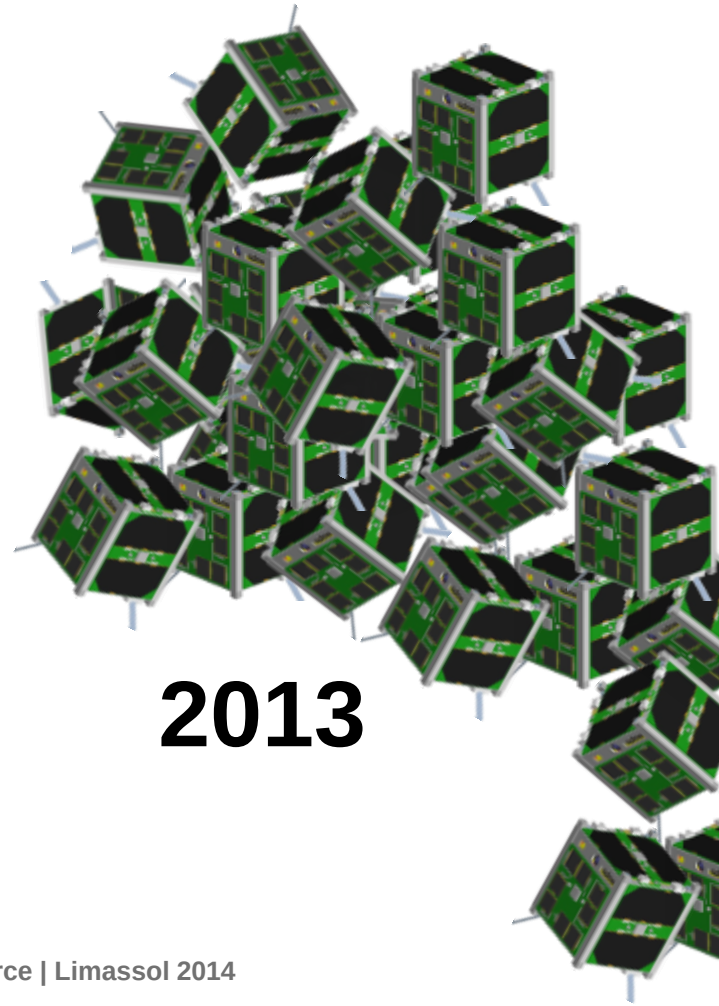


**2003**



**2008**



**2013**

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# Introduction

**WRC-12 Resolution 757 (COM6/10): Regulatory aspects for nano- and picosatellites**

The World Radiocommunication Conference (Geneva, 2012),

*resolves to invite WRC-18*

to consider whether modifications to the regulatory procedures for notifying satellite networks are needed to facilitate the deployment and operation of nano- and picosatellites, and to take the appropriate actions

*invites ITU-R*

to examine the procedures for notifying space networks and consider possible modifications to enable the deployment and operation of nano- and picosatellites, taking into account the short development time, short mission time and unique orbital characteristics

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# Introduction

## ITU-R Question 254/7

1. What are the distinctive characteristics of nano and pico satellites and satellite systems in terms of their use of the radio spectrum as defined by data rates, transmissions time and bandwidths?

2. Taking into account such distinctive characteristics, what are the spectrum requirements for nano and pico satellite systems?

3. Under which radiocommunication services can satellite systems using nano and pico satellites operate?

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# Introduction

So, what are picosatellites?
What are nanosatellites?

And who defines this?

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# TUB Small Satellite Database

**Extensive database containing 253 satellite systems (311 satellites)**

- **Built on the work of many other works (see references)**
- As of January 2014, will be continuously extended
- Regulatory aspects
- Technical characteristics
- Coordination status
- Online available! (http://www.space.tu-berlin.de/) (→ Publications → Small Satellite Database)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Argus (SLU 02) | USA | NL | | IARU | Scientific | Education | 3 | 22x10x10 | nano | |
| Arkyd-3 | USA | NL | | - | Technology Demonstration | | 4 | 30x10x10 | Nano | |
| Armadillo | USA | NL | | IARU | Technology Demonstration | Education | 4 | 30x10x10 | Nano | 2,50 |
| AtmoCube | Italy | NL | | IARU | Education | Technology Demonstration | 1 | 10x10x10 | Pico | |
| AubieSat 1 (Oscar 71) | USA | A | 37854 | IARU | Education | Technology Demonstration | 1 | 10x10x10 | Pico | |
| BeakerSat-1 | USA | ? | | - | Technology Demonstration | | | 12,5x5x5 | pico | |
| BEESAT | Germany | A | 35933 | IARU | Technology Demonstration | Education | 1 | 10x10x10 | Pico | 1,50 |
| BEESAT-2 | Germany | A | 39136 | IARU | Technology Demonstration | Education | 1 | 10x10x10 | Pico | 0,70 |
| BEESAT-3 | Germany | NA | 39134 | IARU, Notification | Education | Technology Demonstration | 1 | 10x10x10 | Pico | 1,50 |

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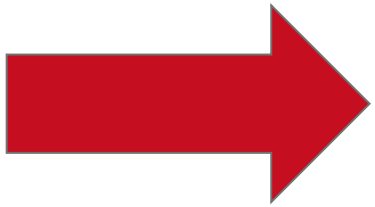
# TUB Small Satellite Database

**Small Satellite Database**

- Based on the database of the „Union of Concerned Scientists“
- Various parameters per system:
  - Name & Operator
  - Masse & Dimensionen
  - Coordination Status
  - Purpose
  - Communication
    - Uplink
    - Downlink
    - (Data Transfer)
  - Orbital Parameter
  - Timelines (Development Timeline, Mission Lifetime, …)
  - Launch Information
  - Sources



Comprehensive description of current and future Small Satellite Projects

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# TUB Small Satellite Database

## Characteristics of different types of satellites

| Category | Mass [kg] | Max. BUS Power [W] | Typical Cost [USD] | Max. Dimensons [m] | Development Time [years] | Orbit | Mission Duration [years] |
|---|---|---|---|---|---|---|---|
| **Large** | > 1000 | > 1 k | 100 – 500 M | 3 – 10 | 3 – 10 | GEO MEO LEO HEO | 10 – 20 |
| **Mini** | 100 – 1000 | 1 k | 30 – 200 M | 1 – 5 | 2 – 5 | | 5 – 10 |
| **Micro** | 10 – 100 | 150 | 10 – 150 M | 0,5 – 1 | 1 – 3 | LEO (HEO) | 2 – 6 |
| **Nano** | 1 – 10 | 20 | 100k – 10M | 0,1 – 0,5 | | | 1 – 3 |
| **Pico** | 0,1 – 1 | 5 | 50k – 2M | 0,02 – 0,1 | | | |
| **Femto** | < 0,1 | 1 | < 50k | < 0,03 | 1 | | < 1 |

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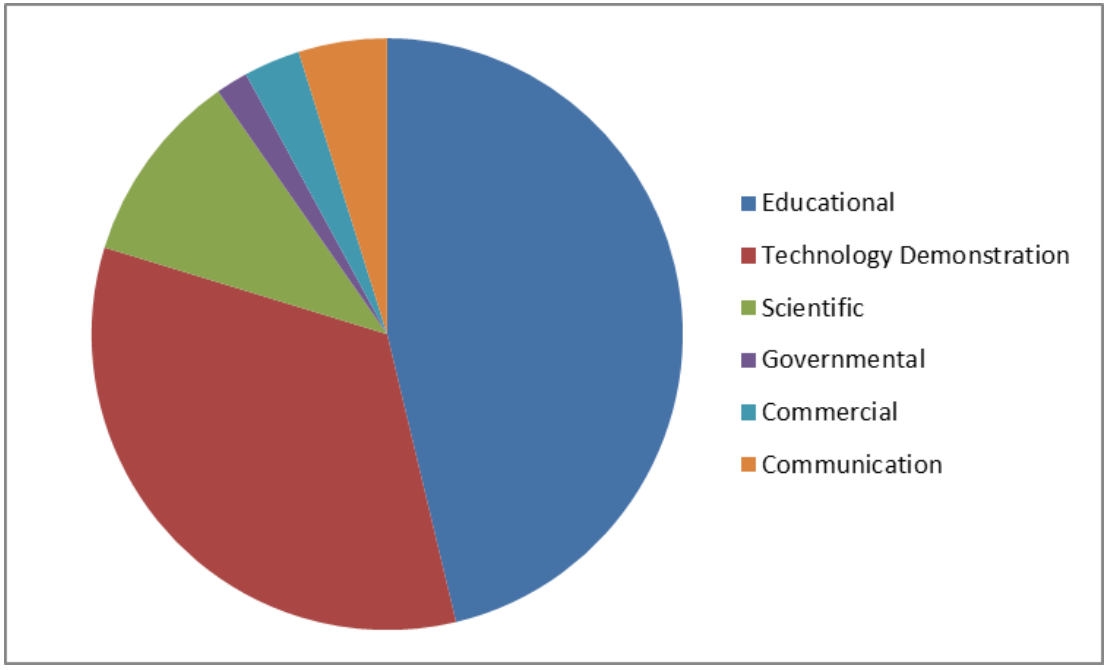
# TUB Small Satellite Database

**Purpose of Use**

- Mainly university projects
  - Education
  - Research (Technology Demonstration)
- Some governmental systems
- Commercial Systems
- Communication Systems



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# TUB Small Satellite Database

**Ground segment**

- typical characteristics:
  - Frequency band: VHF, UHF, S
  - Service: Amateur Satellite (and others!)
  - Protocol: AX.25
  - Datarate: <9600 bps
  - Modulation: (A)FSK, GMSK, (BPSK)
  - RF output power: 2-75 W
  - Antennas:
    - VHF/UHF: Yagi
    - S-Band: Dish antennas + Patch antennas

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# TUB Small Satellite Database

## Launches, Coordination & Recordings

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Launches | 6 | 8 | 3 | 22 | 14 | 7 | 16 | 20 | 14 | 26 | **88** | 87 + X | 311 |
| IARU | - | - | 3 | 16 | 5 | 5 | 11 | 6 | 8 | 14 | **44** | 32 + X | 144 |
| API | 2 | 3 | 1 | 11 | 1 | 3 | 8 | 4 | 3 | 8 | **27** | 10 + X | 81 |
| Notification | 2 | 3 | 1 | 4 | - | 2 | 7 | 2 | 2 | 2 | **11** | 2 + X | 38 |

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# Challenges for Small Satellite Developers

**Mandatory Items for API for NGSO systems not subject to coordination under Section II of Article 9**

- Orbital planes
- Reference body code
- …
- Period
- Altitude (apogee & perigee)
- Inclination
- Minimum altitude
- …

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# Challenges for Small Satellite Developers

**Mandatory Items for API for NGSO systems not subject to coordination under Section II of Article 9**

- Orbital planes
- Reference body code
- …
- Period
- Altitude (apogee & perigee)
- Inclination
- Minimum altitude
- …

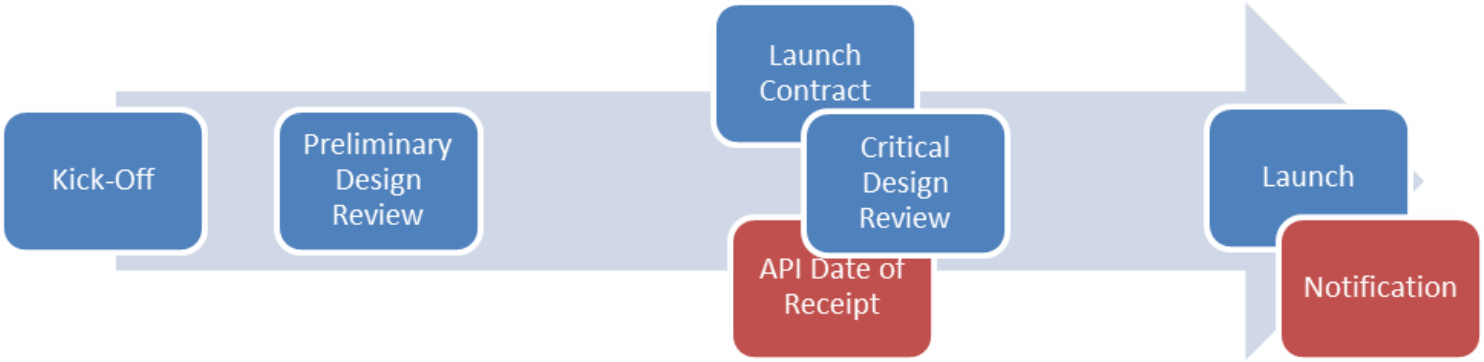
Small Satellites systems have no propulsion and for that reason no orbital control

→

Orbital parameters depend on launcher & primary payload of launch vehicle

# Challenges for Small Satellite Developers

## Typical mission design timeline



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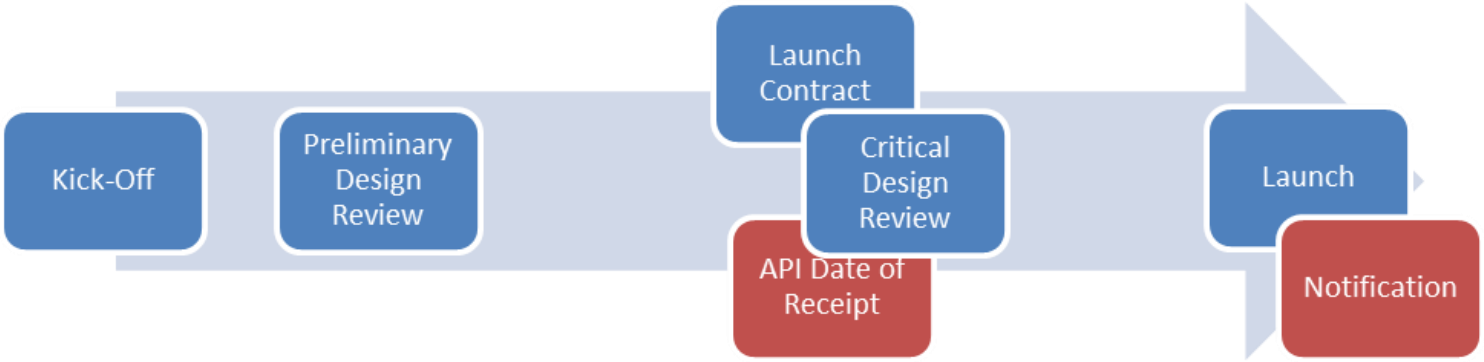
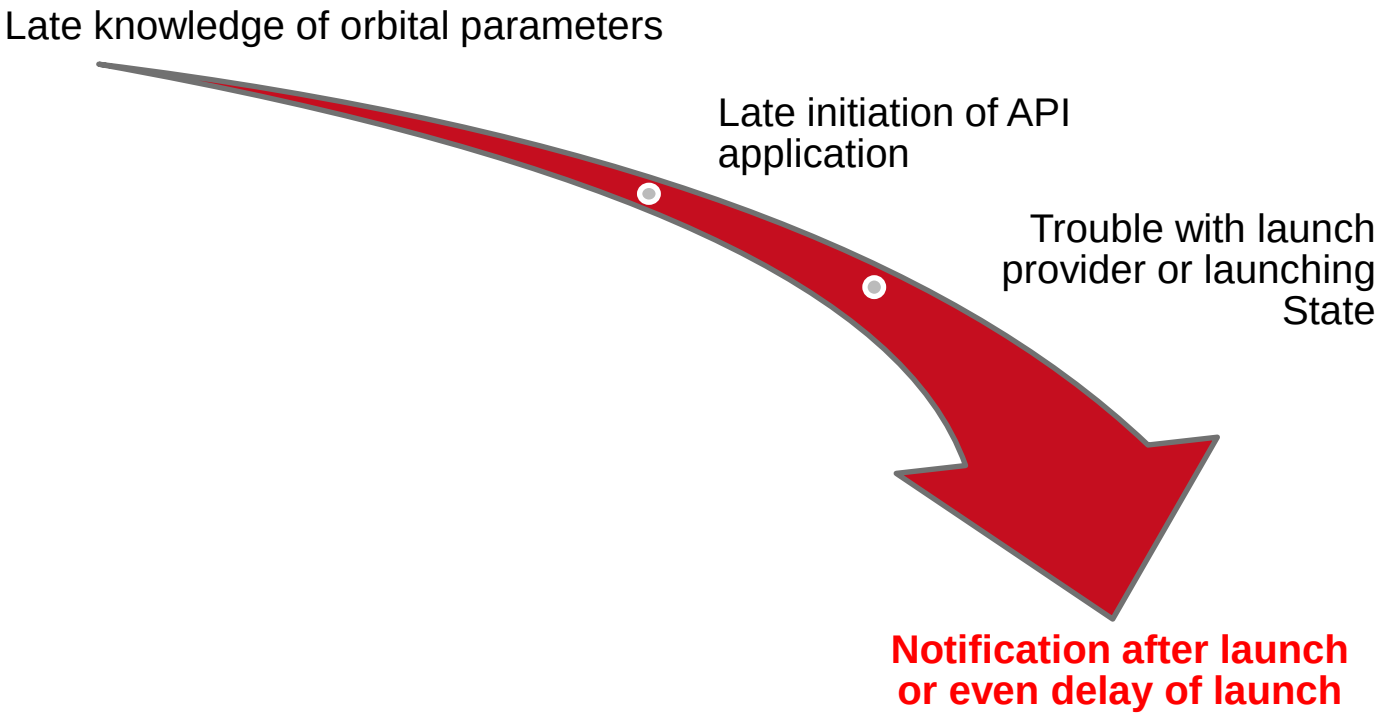
# Challenges for Small Satellite Developers

## Typical mission design timeline




No API before launch contract is signed

# Challenges for Small Satellite Developers



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# Proposed solution

Relax mandatory appendix 4 items:

Allow small satellite developers to submit a range for altitude and inclination

**Example:**

| | |
|---|---|
| Max altitude: | 550 km |
| Min altitude: | 400 km |
| Inclination: | 97-99° |

→ API could be initiated at a much earlier point

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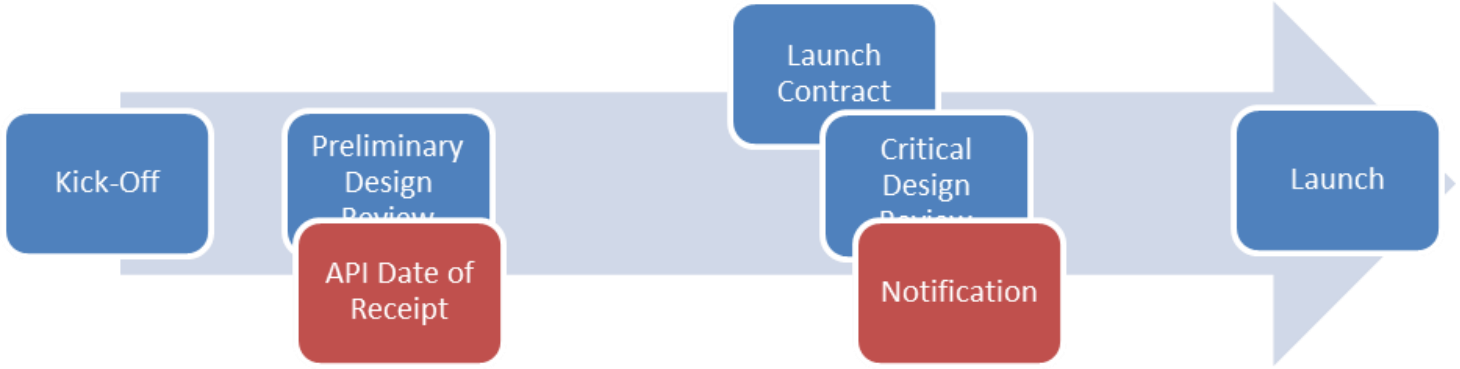
# Proposed solution




Studies are ongoing if this solution is applicable

- If this solution is applicable, further steps will be taken

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# Conclusions

- There now is a data basis for a technical definition of small satellites
- Problems of small satellite developers regarding regulatory procedures have been identified:
  - Lack of experience
  - Lack of knowledge of orbital parameters
- A feasible solution has been found and introduced to current ITU-R studies

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