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

Supported by:

Federal Ministry of Economics and Technology

on the basis of a decision by the German Bundestag

DLR German Aerospace Center

project number: 50YB1323

ITU Workshop on the efficient use of the spectrum / orbit resource, Limassol (Cyprus) | April 14th-16th 2014

M. Buscher, K. Brieß

German Aerospace Center

Technische Universität Berlin

Content

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

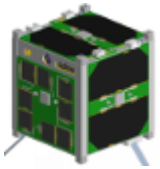
German Aerospace Center

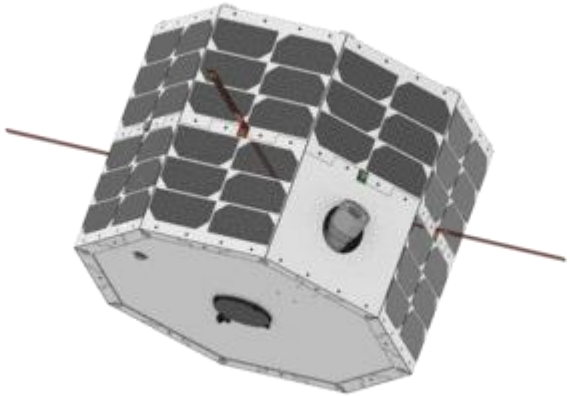
Technische Universität Berlin

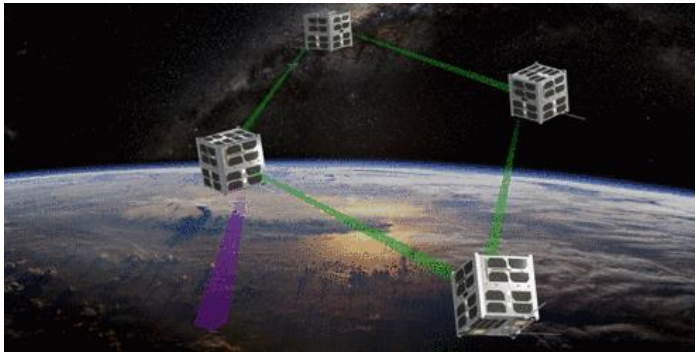
Introduction

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







German Aerospace Center

Technische Universität Berlin

Introduction

What is a small satellite?

From a regulatory perspective:

WE DON‘T KNOW!
(yet)

German Aerospace Center
DLR

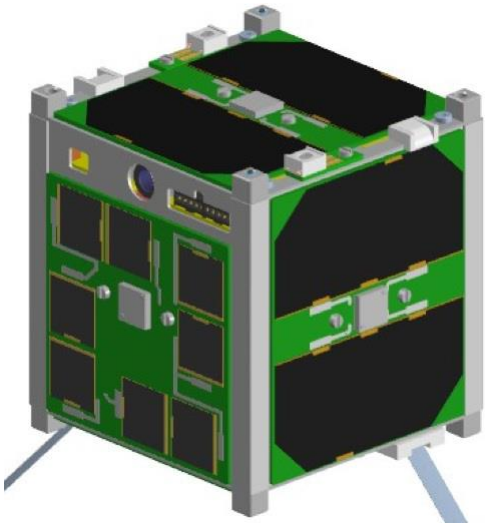
Technische Universität Berlin

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



German Aerospace Center

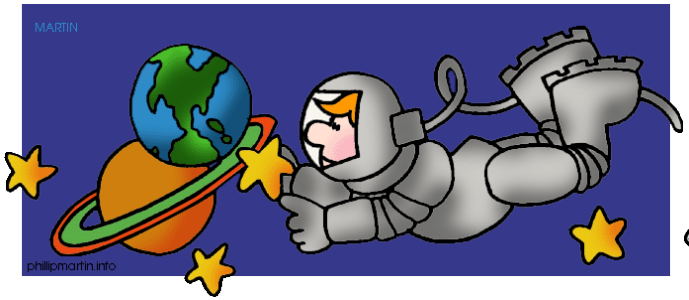
Technische Universität Berlin

Introduction

Who are small satellite developers?

- HAM radio operators

- Space Technology researchers and students



- Commercial Users

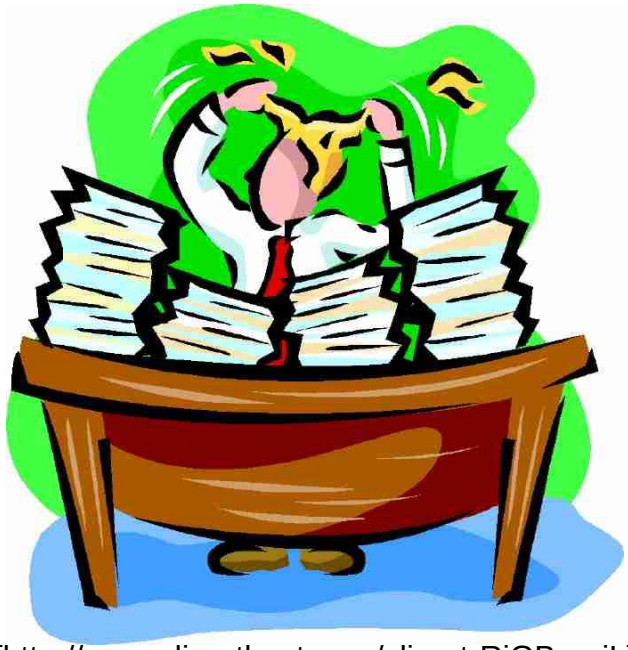
[http://occupations.phillipmartin.info]

German Aerospace Center

Technische Universität Berlin

Introduction

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

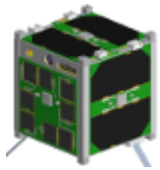


[http://www.clipartbest.com/clipart-RiGBraoiL]

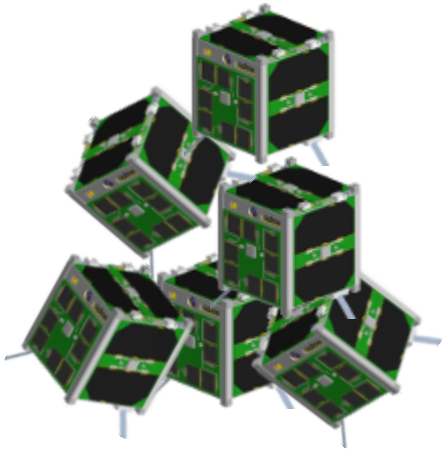
German Aerospace Center
DLR

Technische Universität Berlin

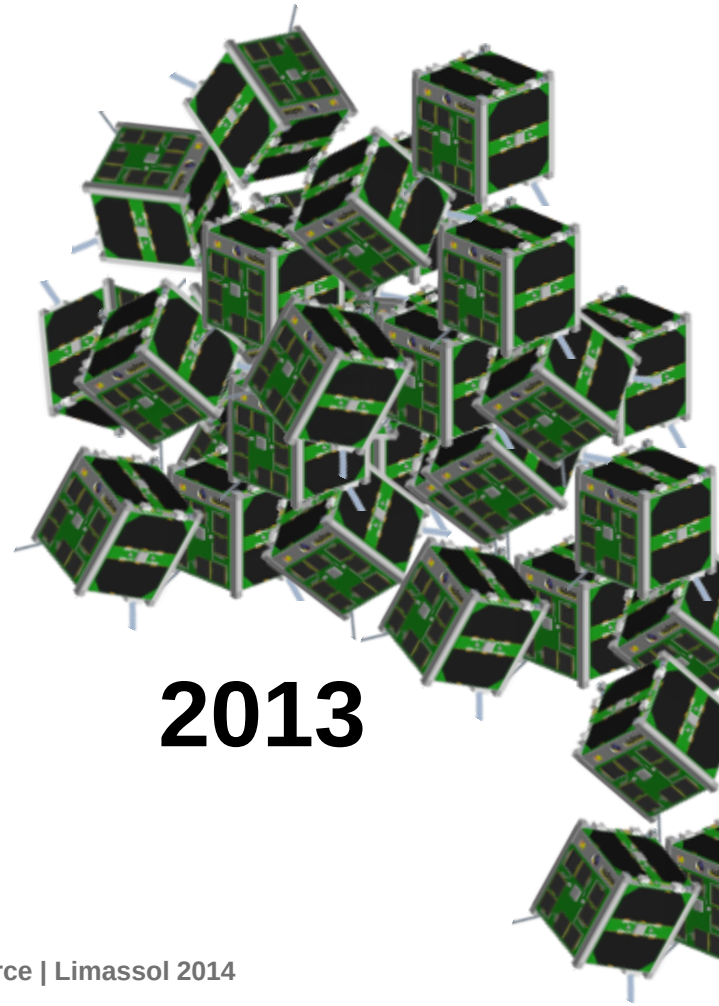
Introduction



2003



2008



2013

German Aerospace Center

Technische Universität Berlin

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

German Aerospace Center

Technische Universität Berlin

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?

German Aerospace Center

Technische Universität Berlin

Introduction

So, what are picosatellites?
What are nanosatellites?

And who defines this?

German Aerospace Center

Technische Universität Berlin

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

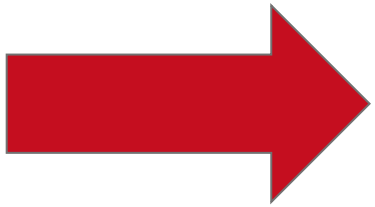
German Aerospace Center

Technische Universität Berlin

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

German Aerospace Center

Technische Universität Berlin

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

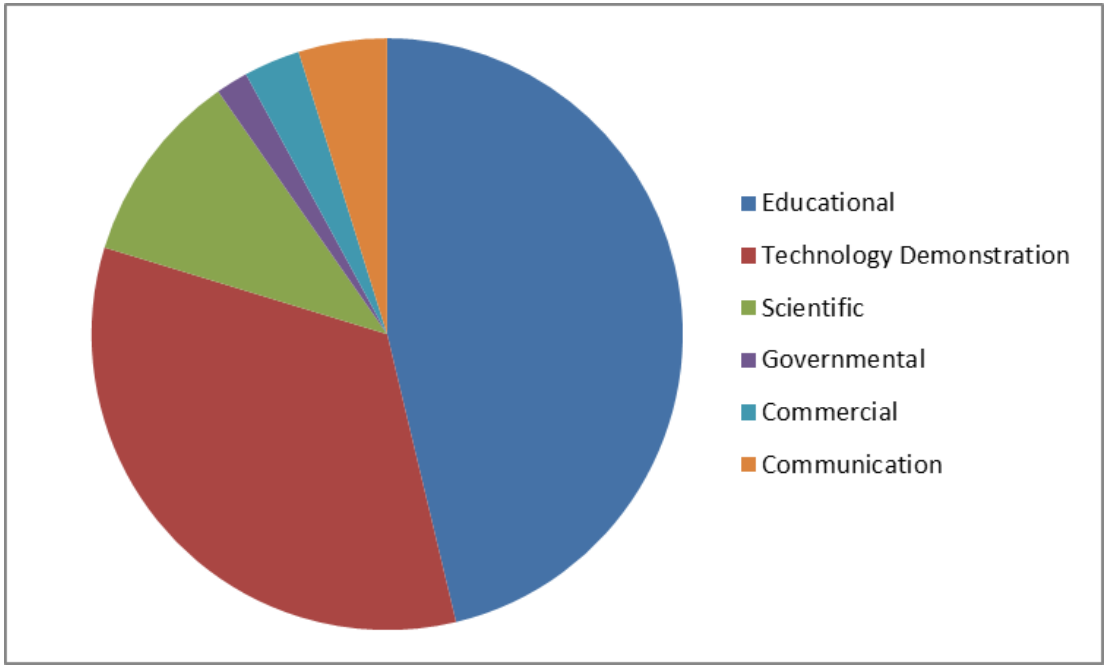
German Aerospace Center

Technische Universität Berlin

TUB Small Satellite Database

Purpose of Use

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



German Aerospace Center

Technische Universität Berlin

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

German Aerospace Center

Technische Universität Berlin

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

German Aerospace Center

Technische Universität Berlin

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
- …

German Aerospace Center

Technische Universität Berlin

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
- …

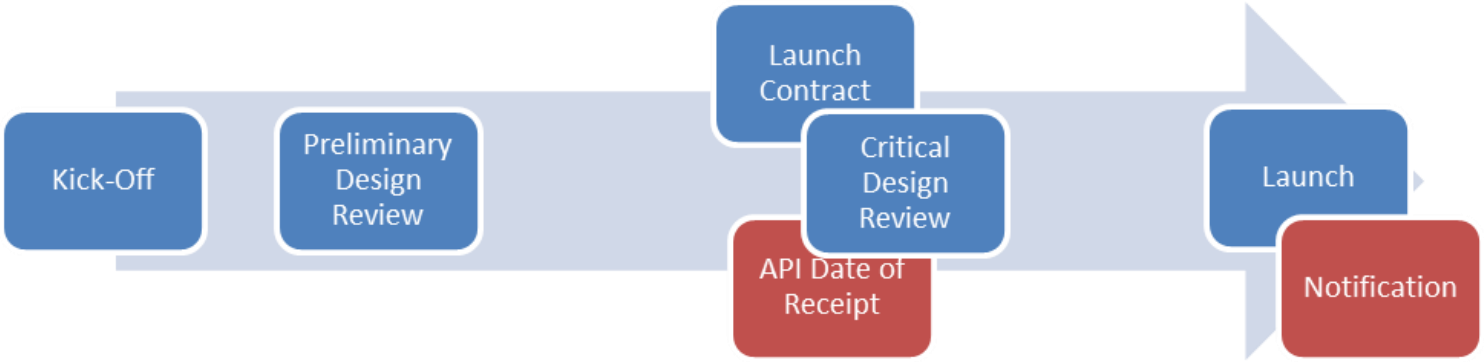
Small Satellites systems have no propulsion and for that reason no orbital control

→

Orbital parameters depend on launcher & primary payload of launch vehicle

Challenges for Small Satellite Developers

Typical mission design timeline

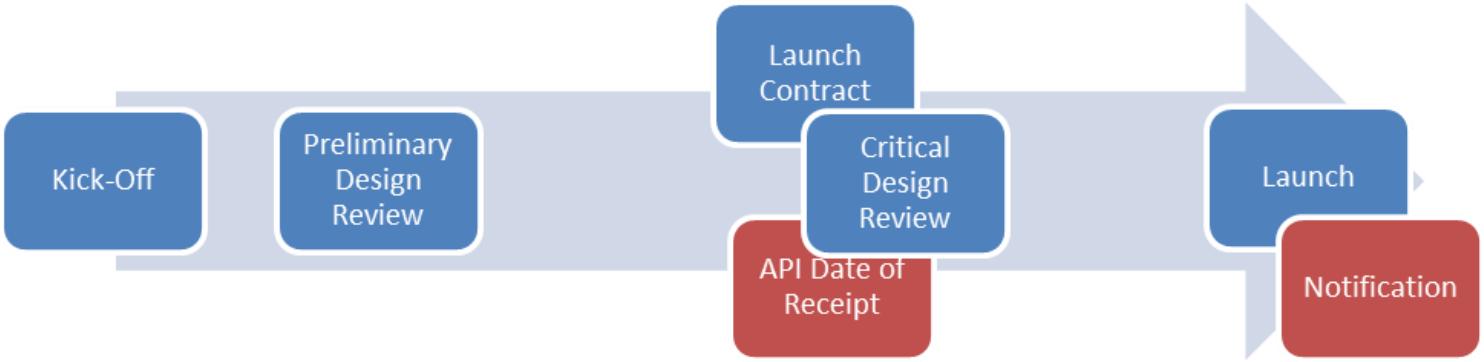


German Aerospace Center

Technische Universität Berlin

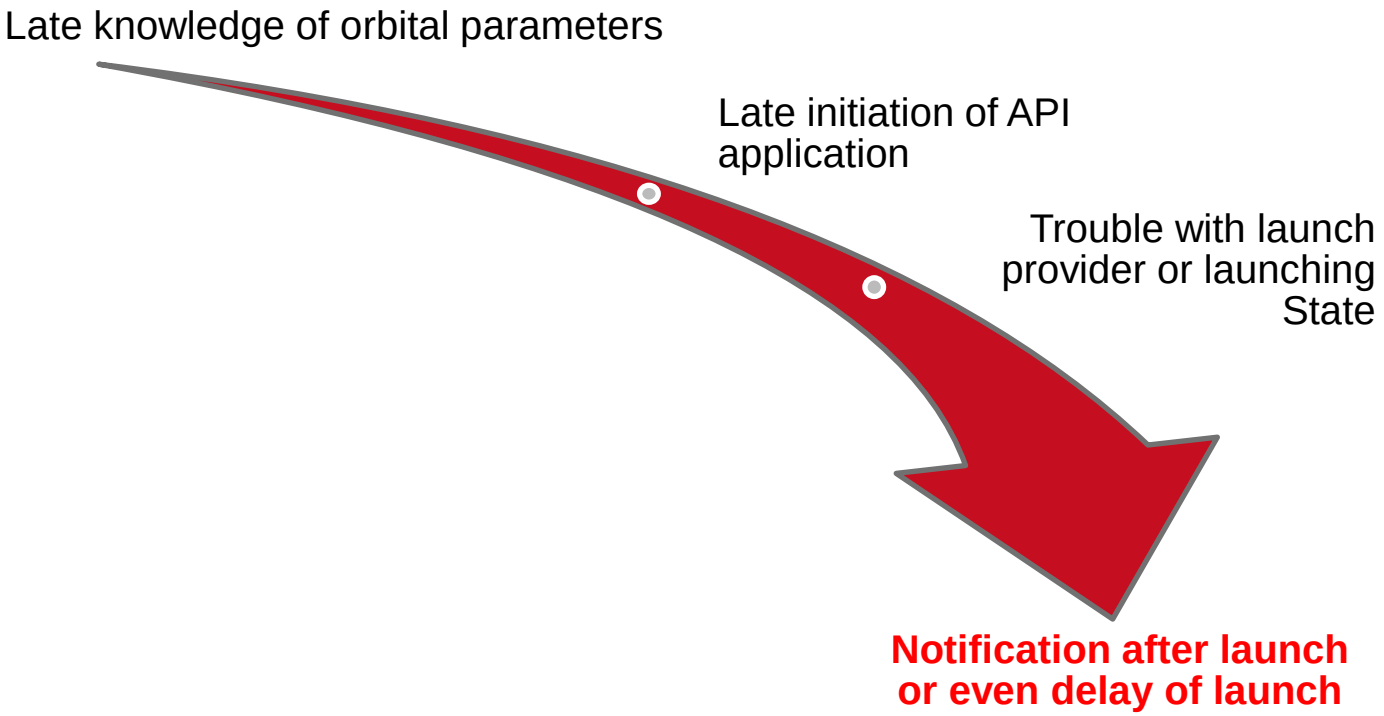
Challenges for Small Satellite Developers

Typical mission design timeline



No API before launch contract is signed

Challenges for Small Satellite Developers



German Aerospace Center

Technische Universität Berlin

Proposed solution

Relax mandatory appendix 4 items:

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

Example:

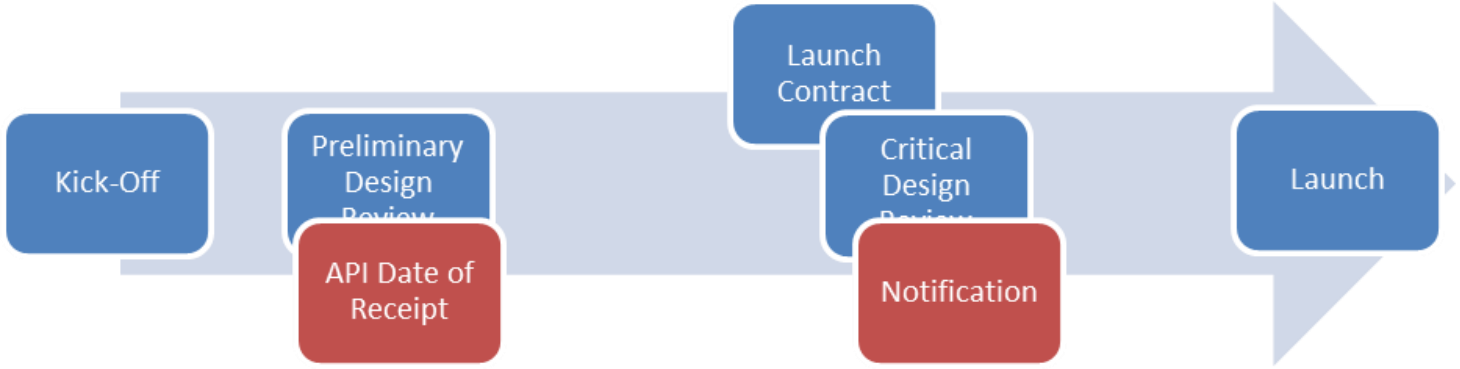
Max altitude:	550 km
Min altitude:	400 km
Inclination:	97-99°

→ API could be initiated at a much earlier point

German Aerospace Center

Technische Universität Berlin

Proposed solution



Studies are ongoing if this solution is applicable

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

German Aerospace Center

Technische Universität Berlin

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

German Aerospace Center

Technische Universität Berlin

Sources & References

- Small Satellite Database Sources
  - https://directory.eoportal.org/web/eoportal/satellite-missions
  - http://www.dk3wn.info/satellites.shtml
  - http://satellitedebris.net/Database/index.php
  - http://space.skyrocket.de/index.html
  - http://mtech.dk/thomsen/space/cubesat.php
  - http://www.itu.int/sns/specsect.html
  - https://sites.google.com/a/slu.edu/swartwout/home/cubesat-database#data
  - http://www.satelliteonthenet.co.uk/index.php/2013
  - http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html
  - Direct contact with developers
  - B. Klofas
    - „A Survey of CubeSat Communications Systems“, 2008
    - „The Future of CubeSat Data Communications“, 2012
    - „A Survey of CubeSat Communications Systems: 2009-2012“, 2013