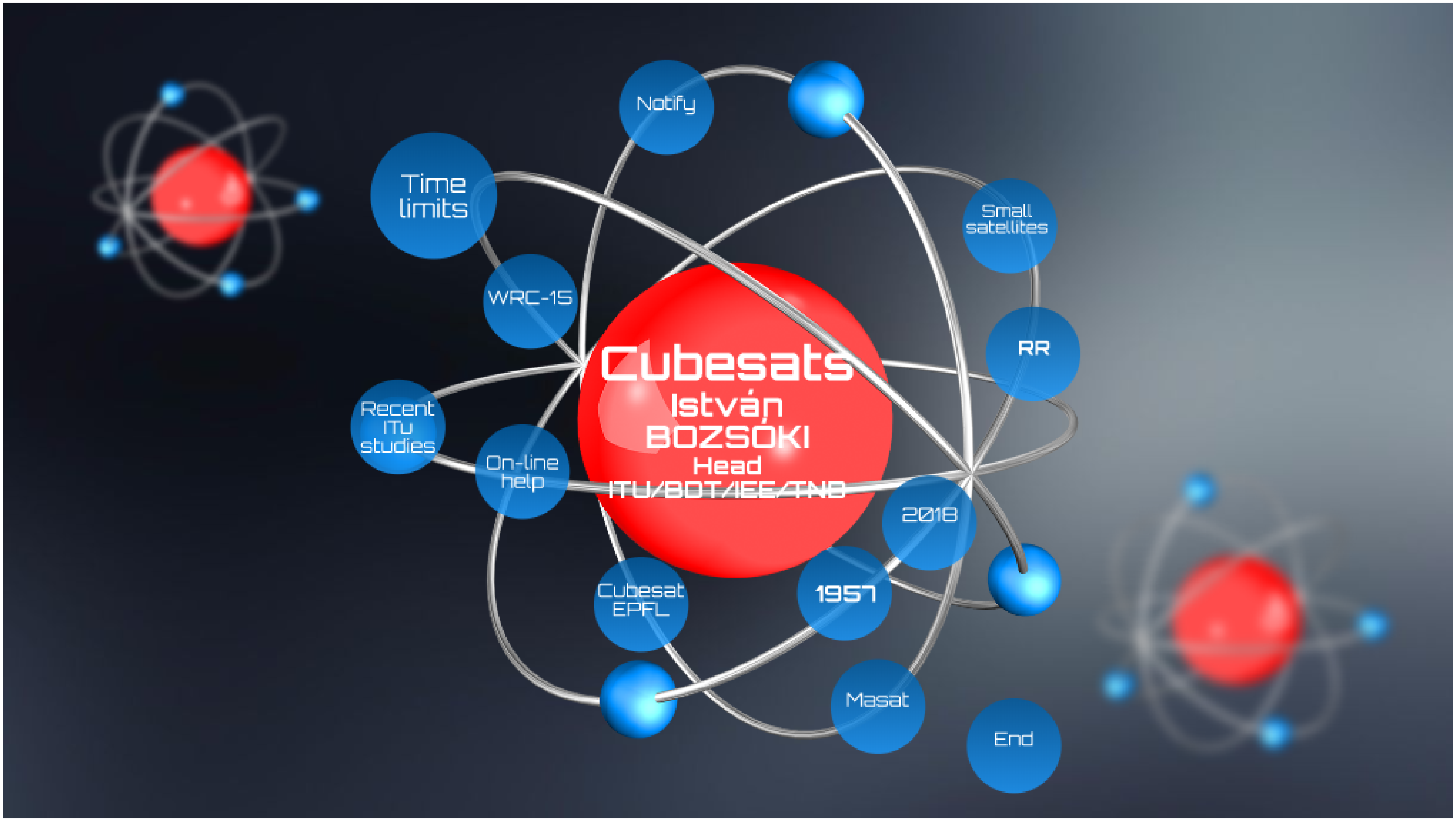
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Time limits
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Small satellites
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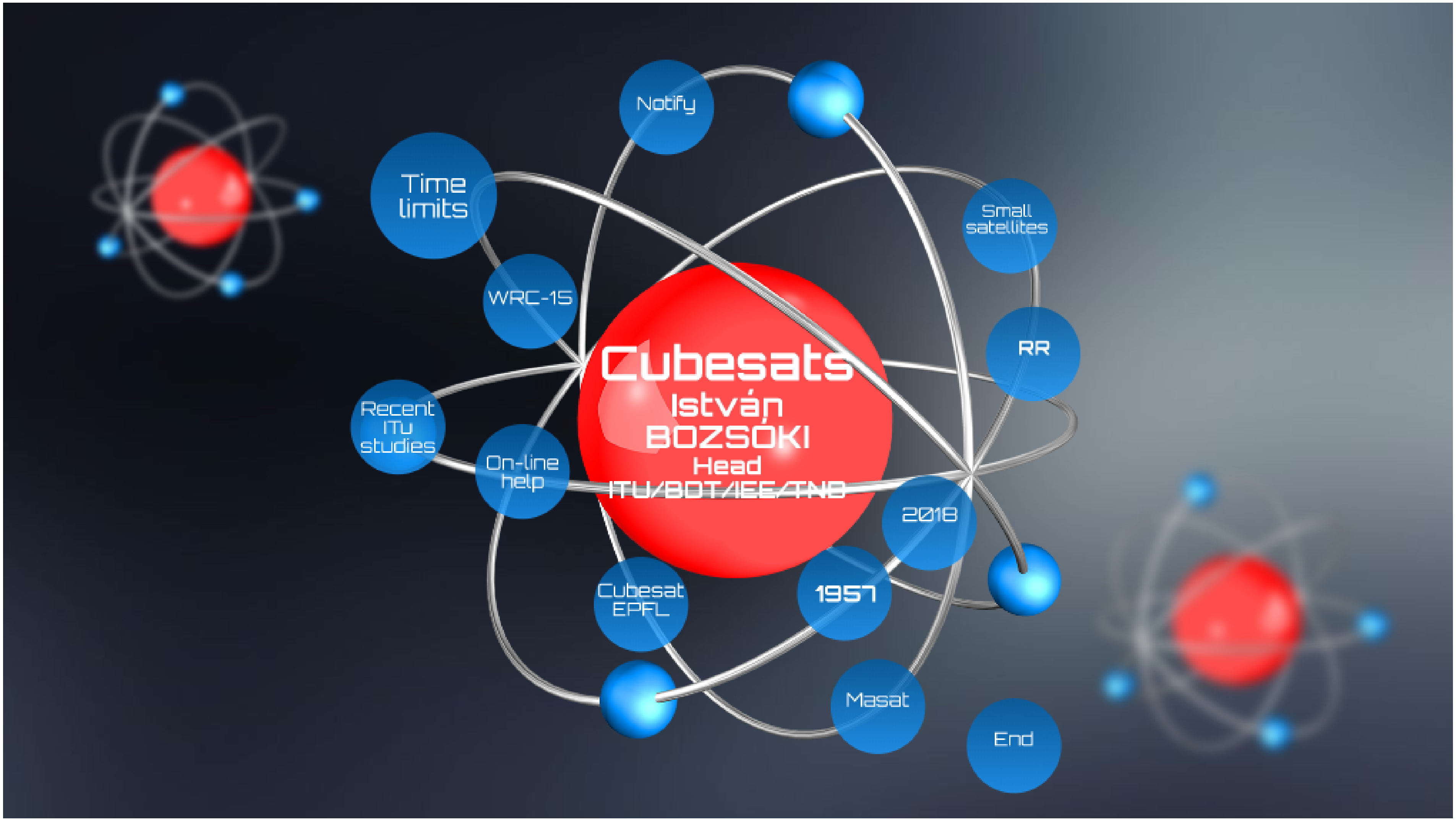
Recent ITu studies
On-line help
2018
1957
Cubesat EPFL
Masat
End


1957....
development of
communication
satellites
Sputnik 1 was the first artificial Earth "SMALL" satellite launched on 4th October 1957 with external radio antennas to broadcast radio pulses. It was a 58 cm diameter, 83 kg polished metal sphere with a 1 W transmitter on 20.005 and 40.002 MHz.
Analysis of the radio signals was used to gather information about the electron density of the ionosphere. Temp and pressure were encoded in the duration of radio beeps.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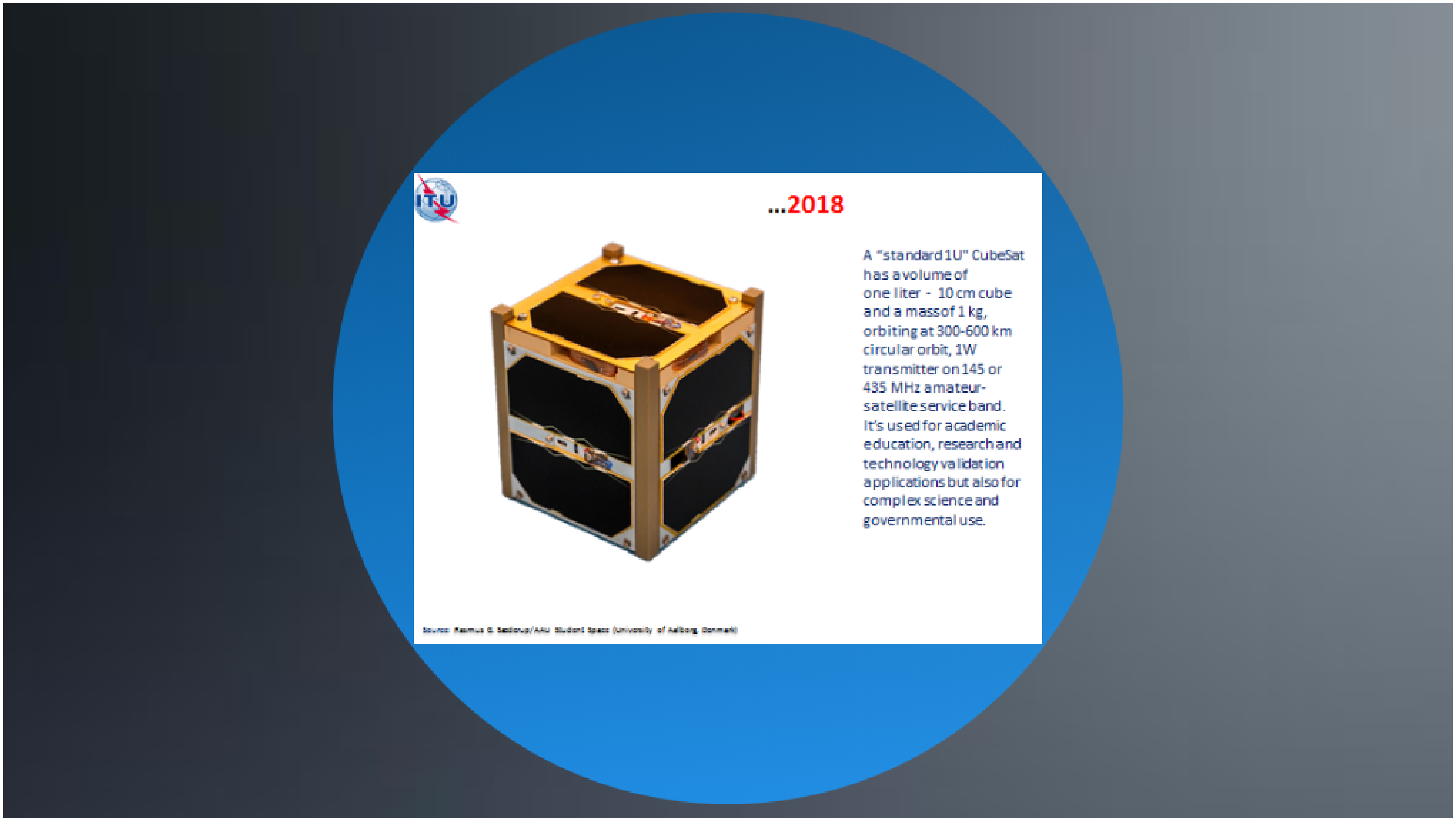
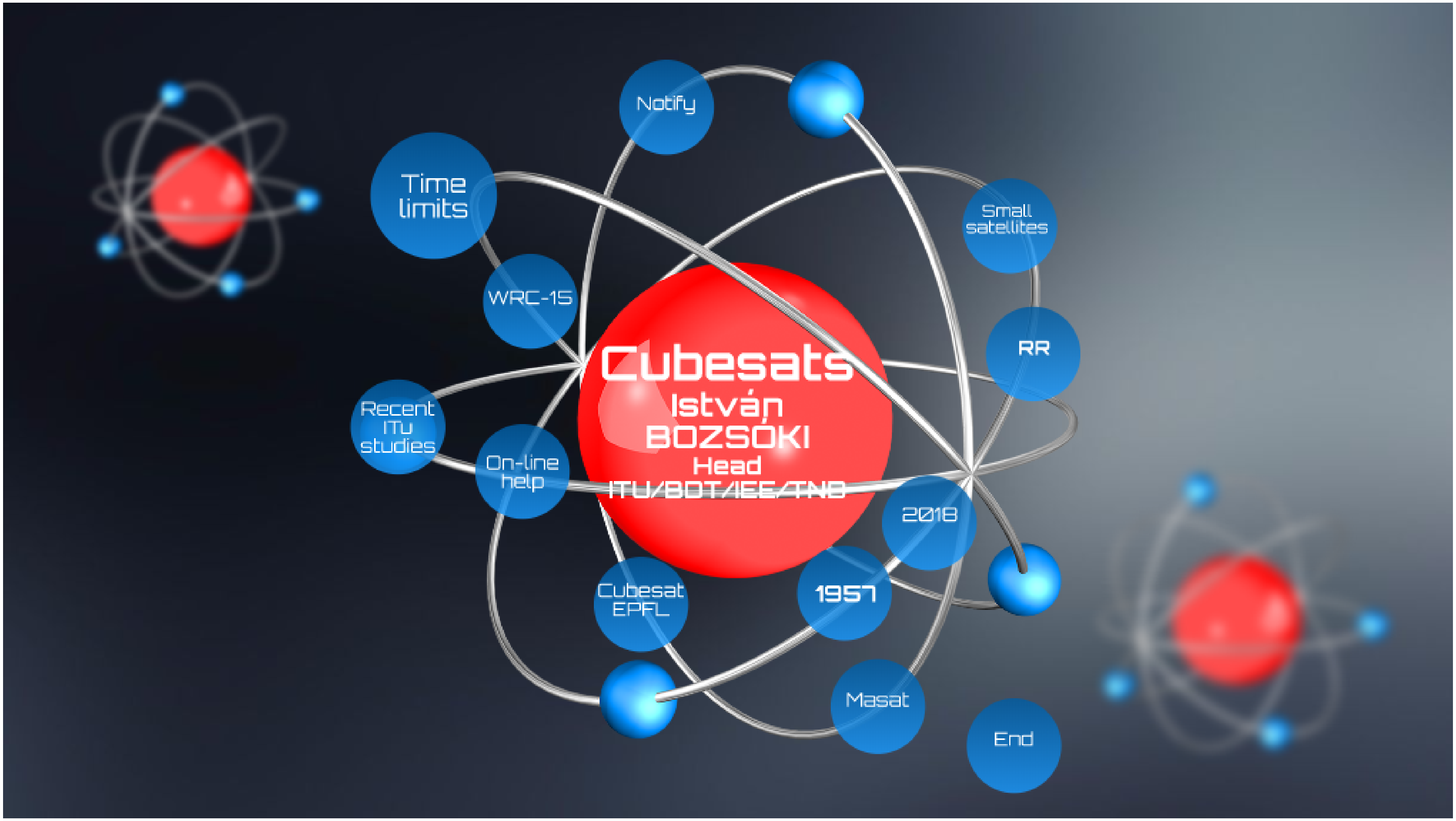

...2018
A "standard 1U" CubeSat has a volume of one liter - 10 cm cube and a mass of 1 kg, orbiting at 300-600 km circular orbit, 1W transmitter on 145 or 435 MHz amateur-satellite service band. It's used for academic education, research and technology validation applications but also for complex science and governmental use.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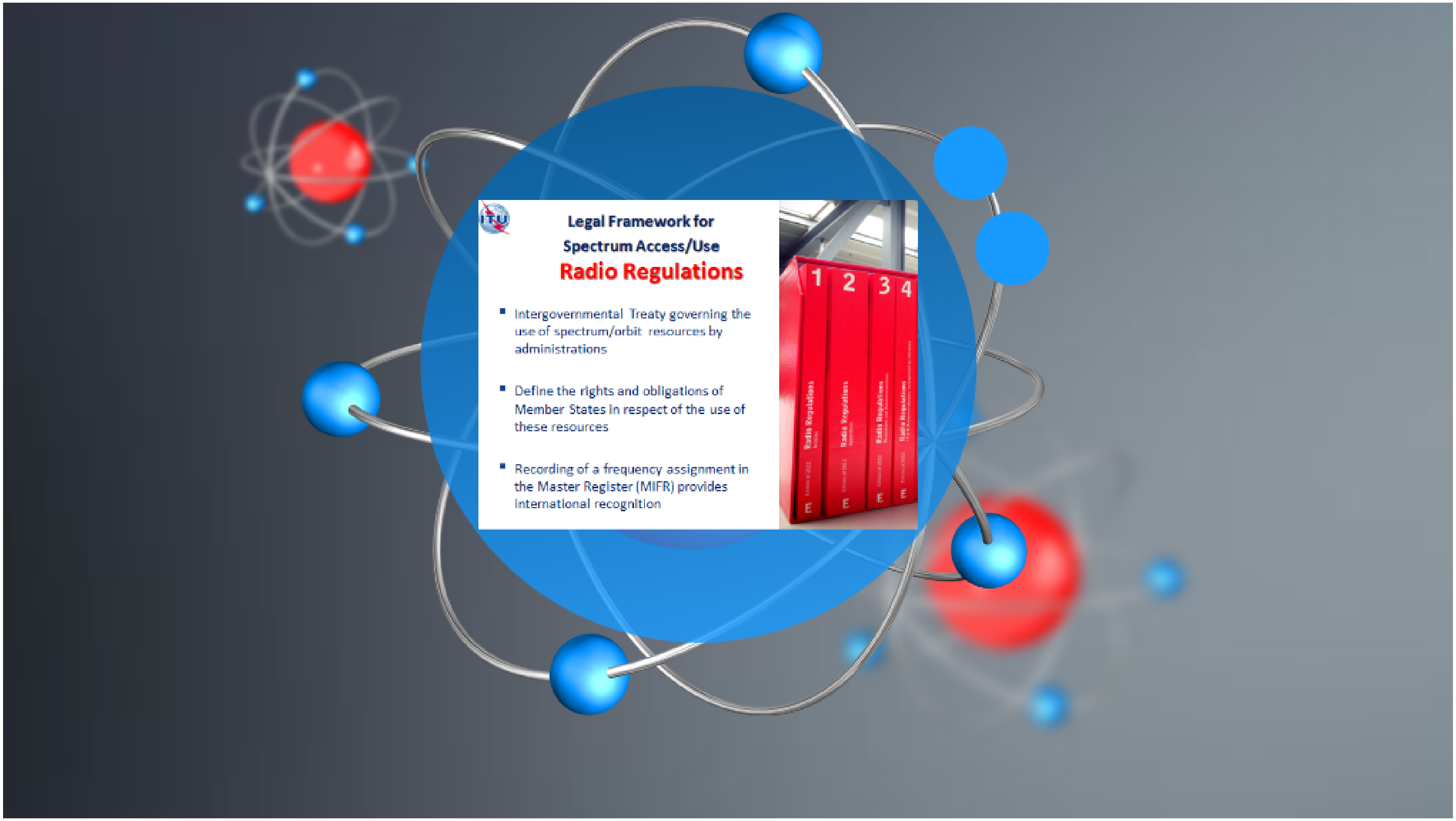
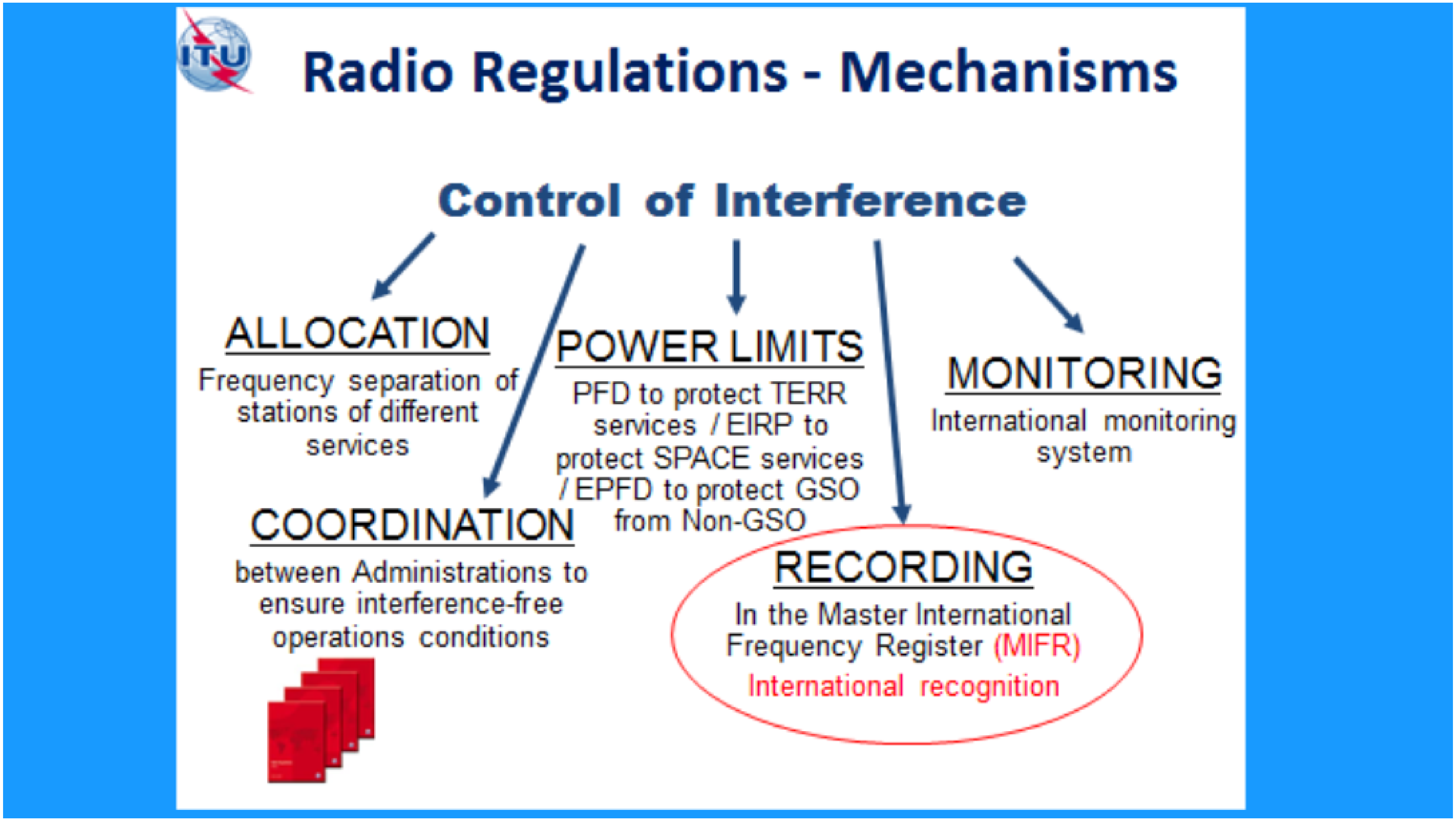
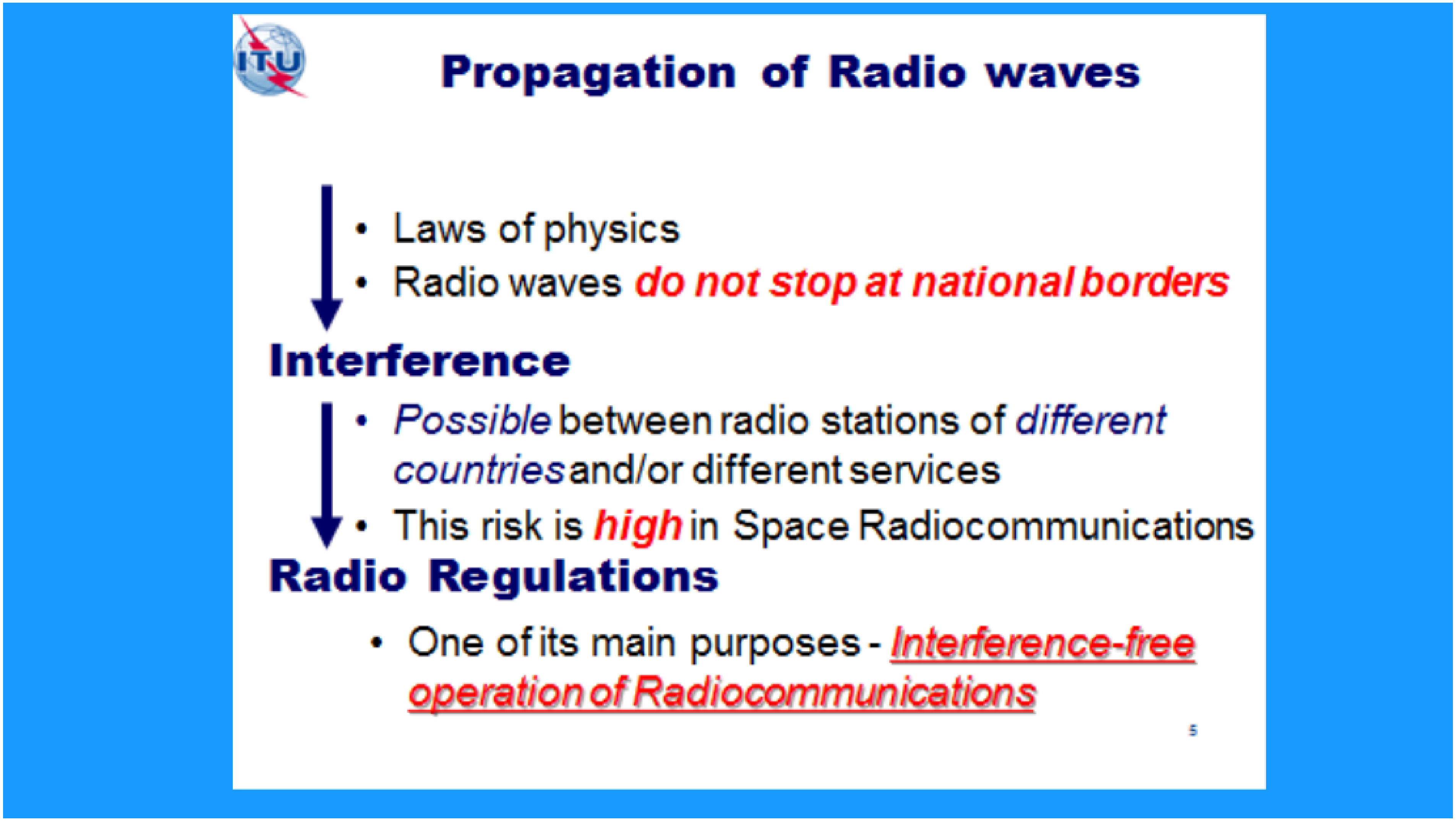
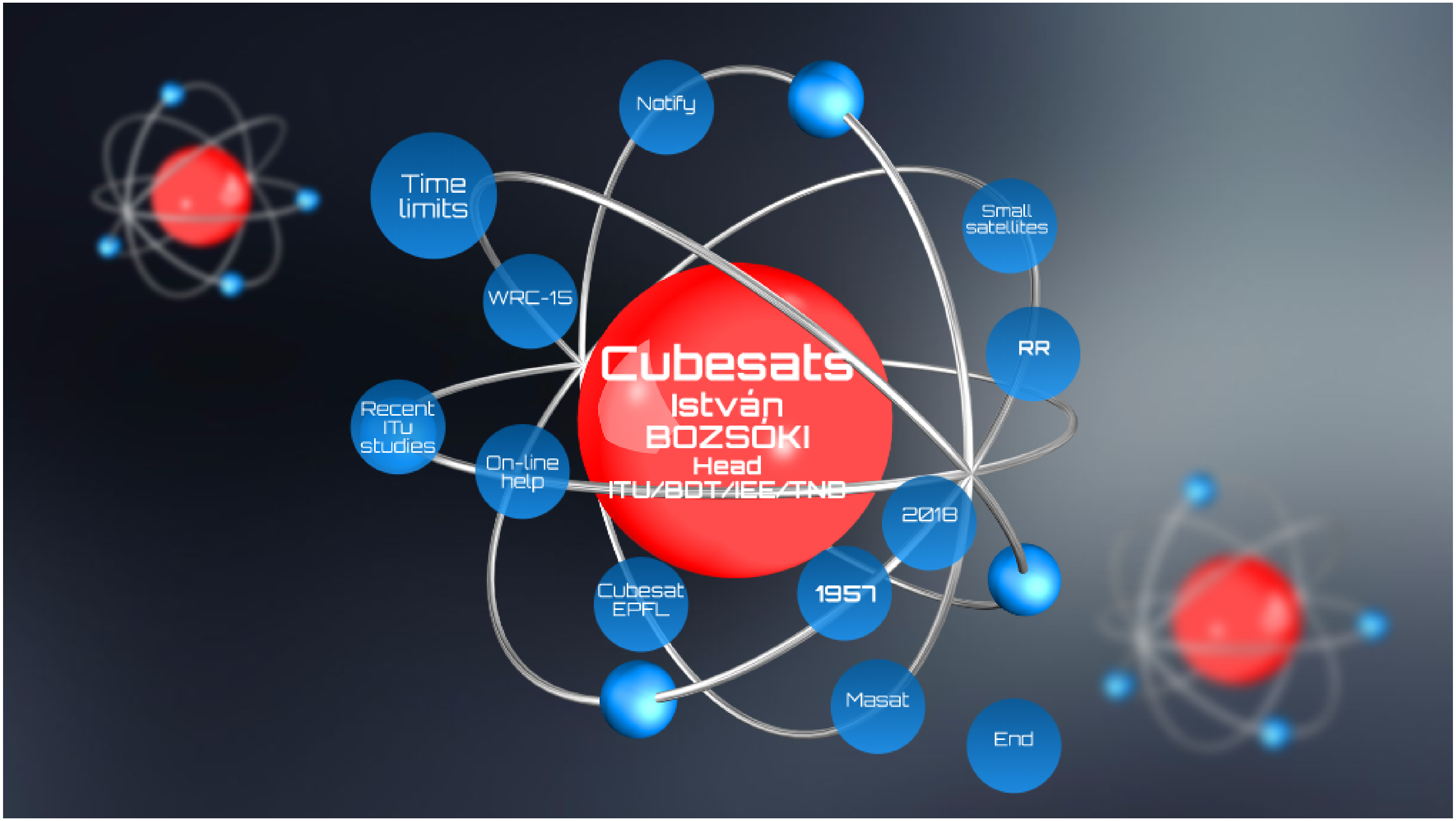

Legal Framework for
Spectrum Access/Use
Radio Regulations
Intergovernmental Treaty governing the use of spectrum/orbit resources by administrations
Define the rights and obligations of Member States in respect of the use of these resources
Recording of a frequency assignment in the Master Register (MIFR) provides international recognition
1
2
3
4
Radio Regulations
E


Radio Regulations - Mechanisms
Control of Interference
ALLOCATION
Frequency separation of stations of different services
POWER LIMITS
PFD to protect TERR services / EIRP to protect SPACE services / EPFD to protect GSO from Non-GSO
MONITORING
International monitoring system
COORDINATION
between Administrations to ensure interference-free operations conditions
RECORDING
In the Master International Frequency Register (MIFR)
International recognition


ITU
Propagation of Radio waves
Laws of physics
Radio waves do not stop at national borders
Interference
Possible between radio stations of different countries and/or different services
This risk is high in Space Radiocommunications
Radio Regulations
One of its main purposes - Interference-free operation of Radiocommunications
5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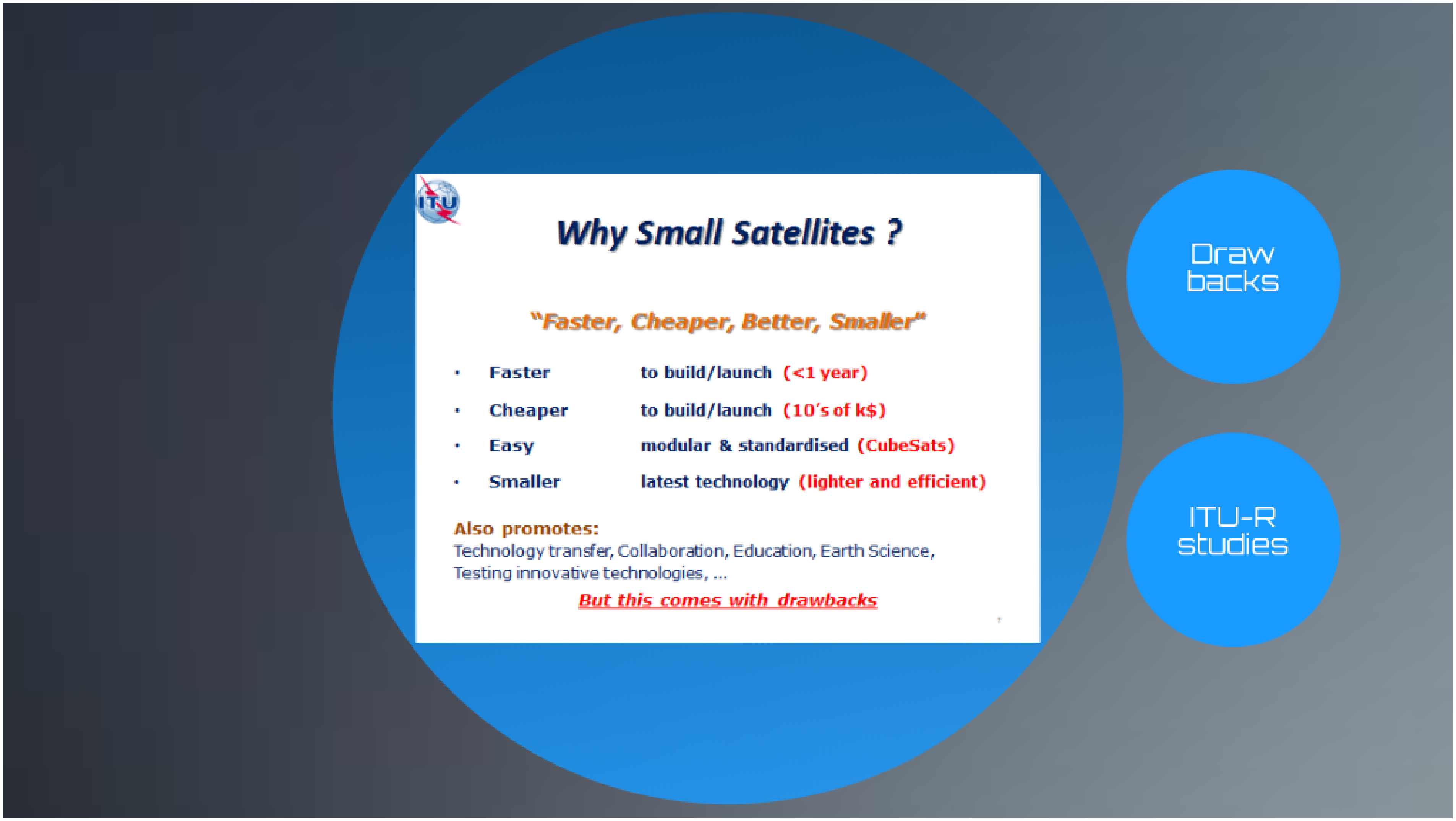

Why Small Satellites ?
"Faster, Cheaper, Better, Smaller"
Faster to build/launch (<1 year)
Cheaper to build/launch (10's of k$)
Easy modular & standardised (CubeSats)
Smaller latest technology (lighter and efficient)
Also promotes:
Technology transfer, Collaboration, Education, Earth Science,
Testing innovative technologies, ...
But this comes with drawbacks
Draw backs
ITU-R studies

Drawbacks!

No regulatory definition *for small satellites in the ITU RR*
only geostationary (GSO) and non-GSO satellites

- **Limited Launching opportunities**
  > mission delays
- **No/Little Orbit Control**
  > higher collision risks
- **Small/Unreliable Power Source**
  > large & costly ground stations
- **Limited Lifetime**
  > low reliability of electronics
- **Limited Mission Types**
  > commercially unsustainable
- **Limited Regulatory Certainty**
  > Lengthy time for Space Activity License

ITU-R studies related to small satellites

small satellites

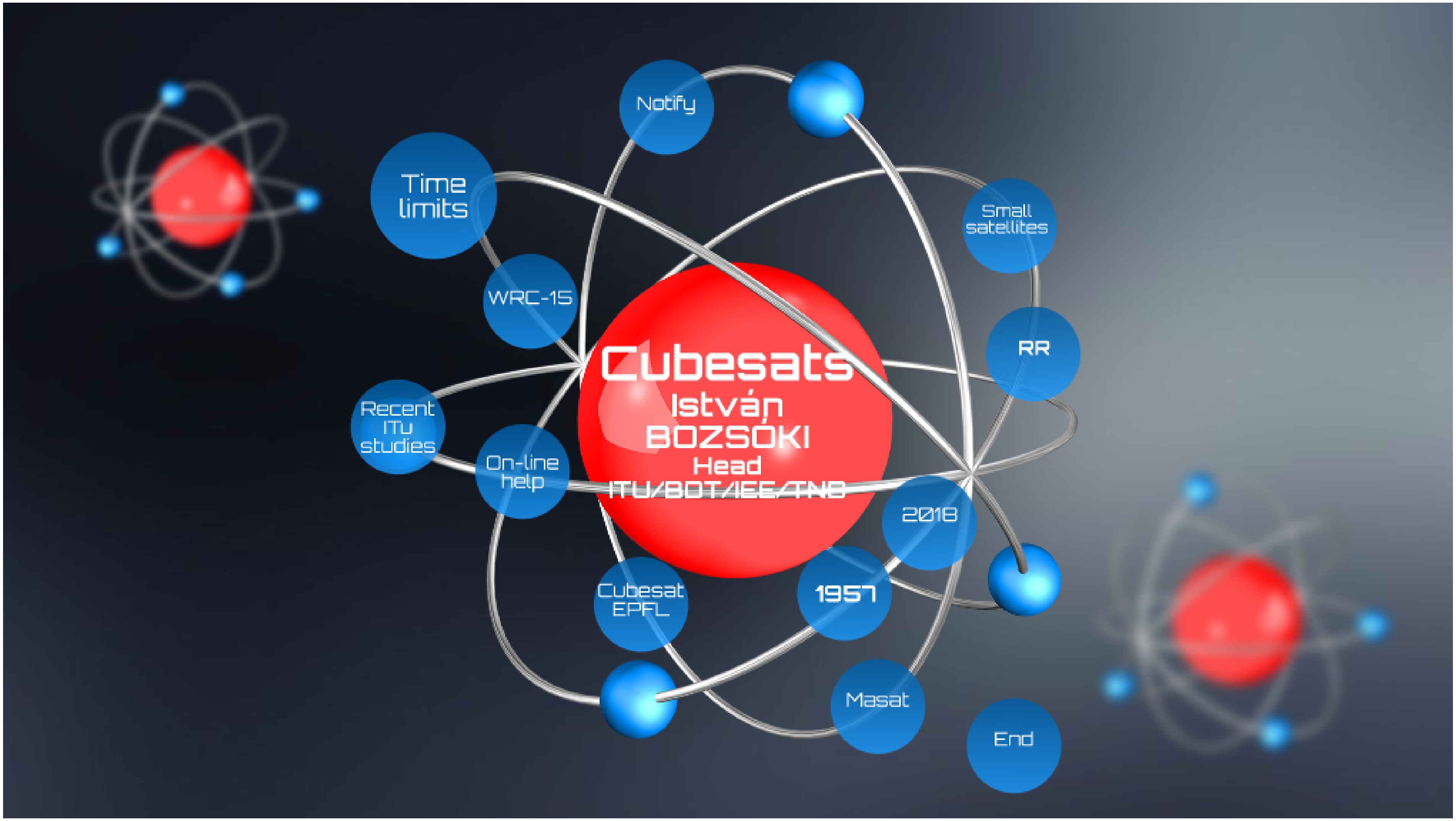
- *provide a means for testing emerging technologies*
- *offer new opportunities for new satellite operators that might not otherwise have considered or been able to afford the use of satellite technologies*
- *operation or demonstration in a variety of practical space based applications*

➢ Report ITU-R **SA.2312** - Characteristics, definitions and spectrum requirements of nanosatellites and picosatellites, as well as systems composed of such satellites

➢ Report ITU-R **SA.2348** - Current practice and procedures for notifying space networks currently applicable to nanosatellites and picosatellites

- **WRC-15 decision -** Resolution **659** (WRC-15)
  Studies to accommodate requirements in the space operation service for *non-geostationary satellites with short duration missions*

4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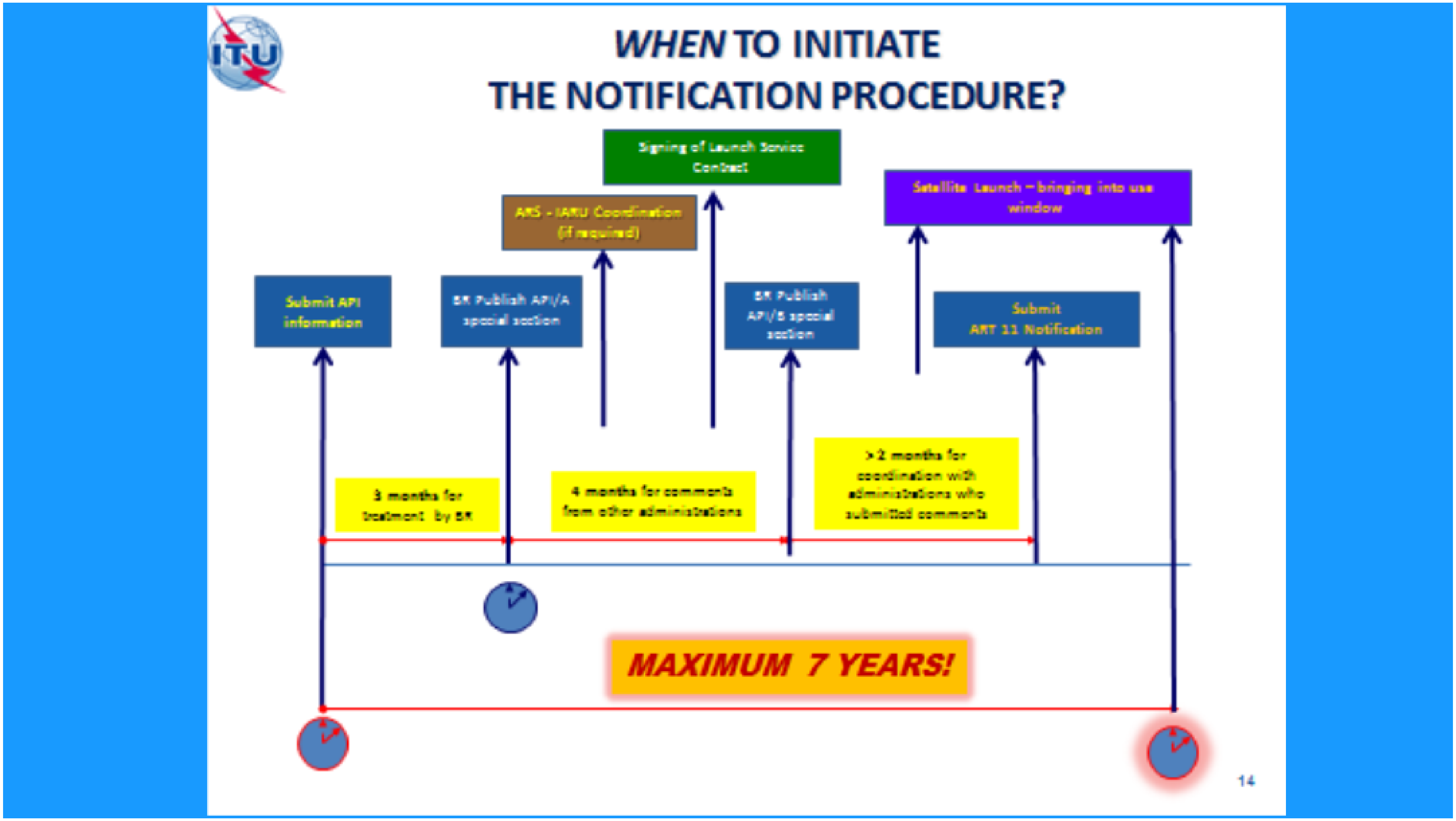
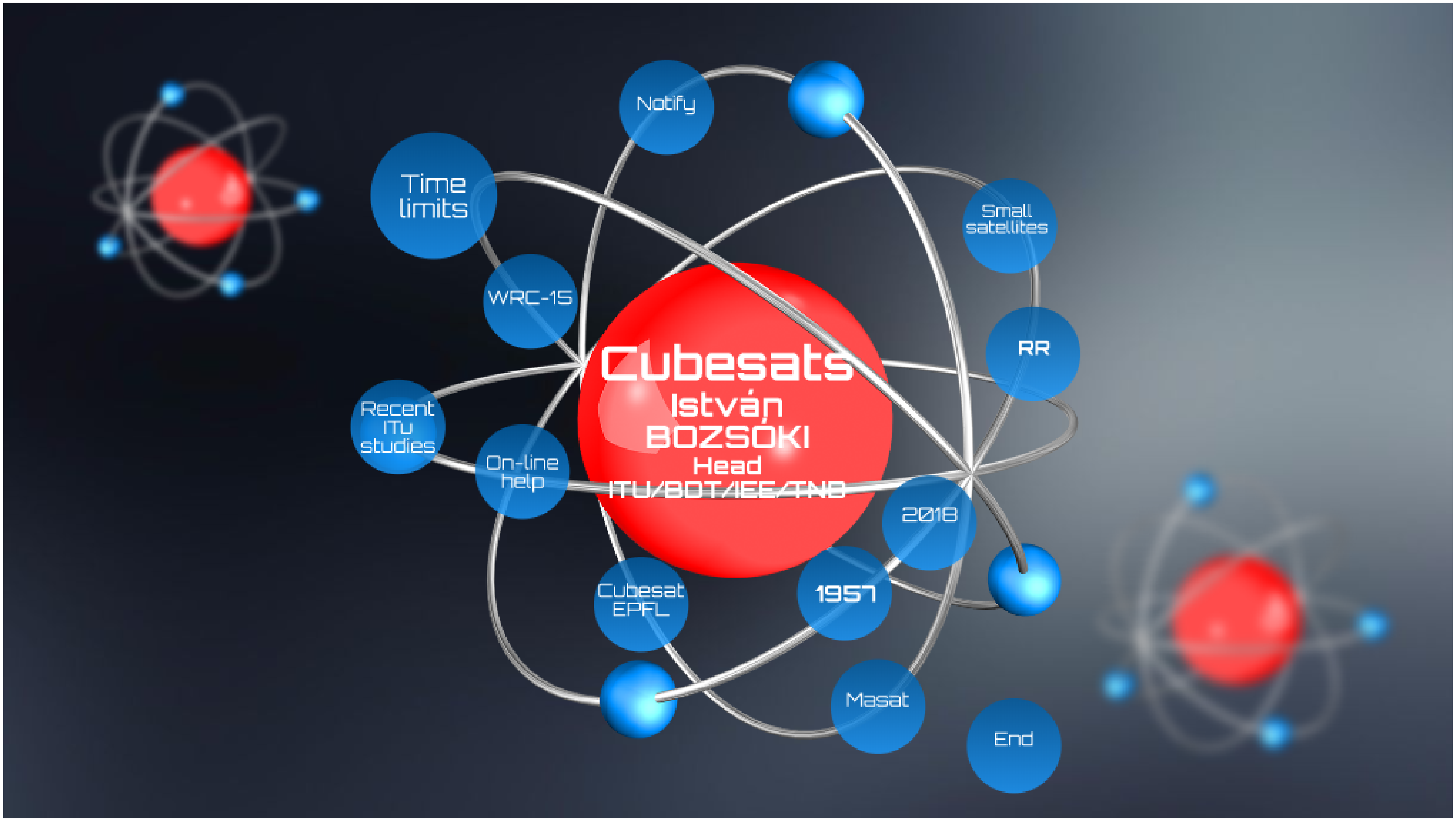
WHAT NEEDS TO BE NOTIFIED ?
Any frequency assignments of transmitting and receiving earth and space stations shall be notified to the Bureau (No. 11.2) if:
Capable of causing harmful interference; or
Used for international radiocommunication; or
Subject to coordination procedure of Article 9; or
Seeking to obtain international recognition; or
Non conforming assignment under No. 8.4 seeking to be recorded into MIFR for information purposes only
When
When

WHEN TO INITIATE THE NOTIFICATION PROCEDURE ?

- No. **9.1** of the RR stipulates that **before initiating any action under Article 11** (Notification) in respect of frequency assignments for a satellite network, *an administration shall send to the Bureau* a general description of the network for **API** publication *not earlier than seven years* and preferably *not later than two years* before the planned *date of bringing into use (DBiU)* of the satellite network or system
  - API phase is ***obligatory***
  - Starts the ***"regulatory clock" for notification***

13


ITU
WHEN TO INITIATE
THE NOTIFICATION PROCEDURE?
Signing of Launch Service Contract
ARS - IARU Coordination (if required)
Satellite Launch – bringing into use window
Submit API information
BR Publish API/A special section
BR Publish API/B special section
Submit ART 11 Notification
3 months for treatment by BR
4 months for comments from other administrations
> 2 months for coordination with administrations who submitted comments
MAXIMUM 7 YEARS!
14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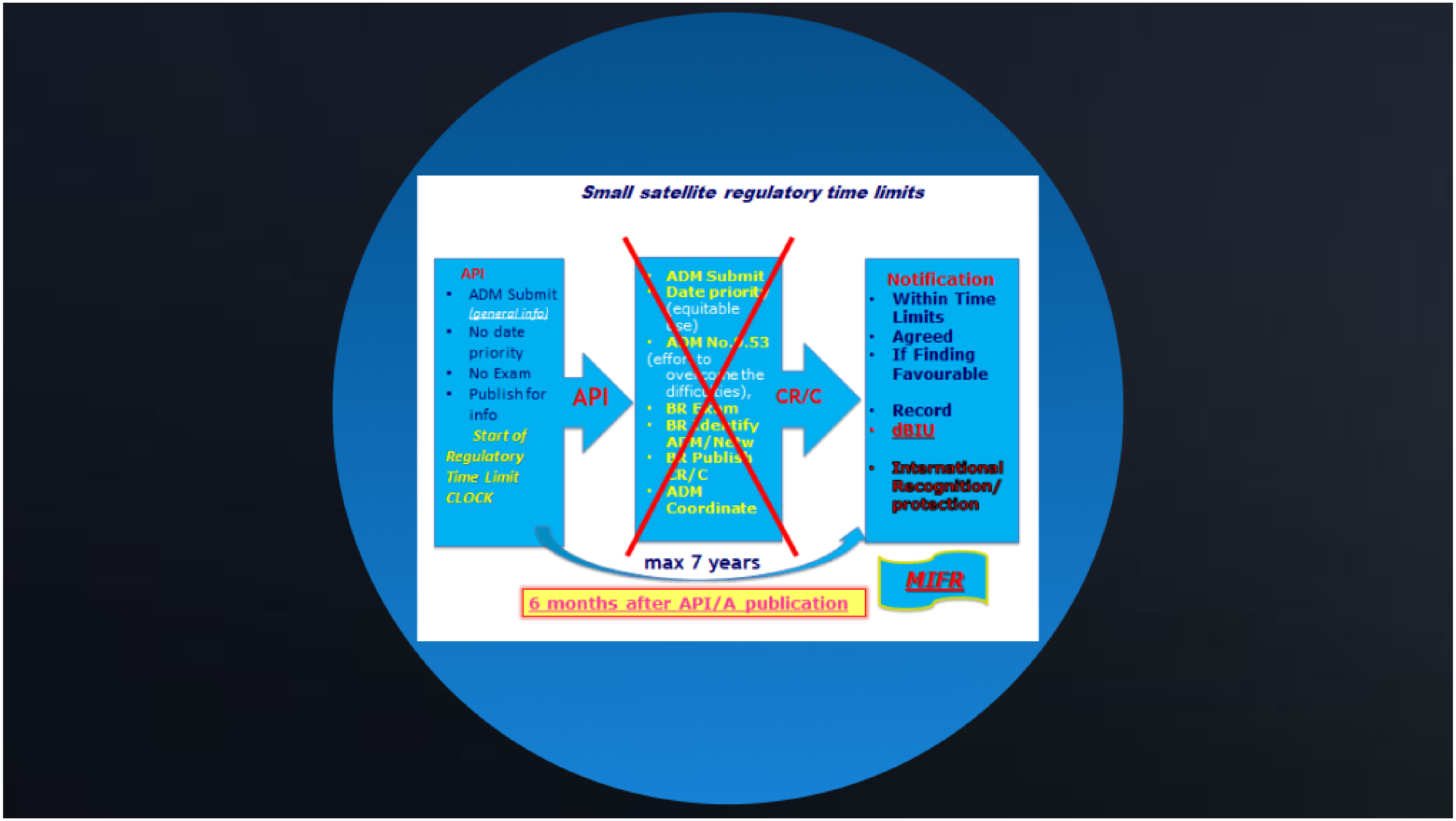
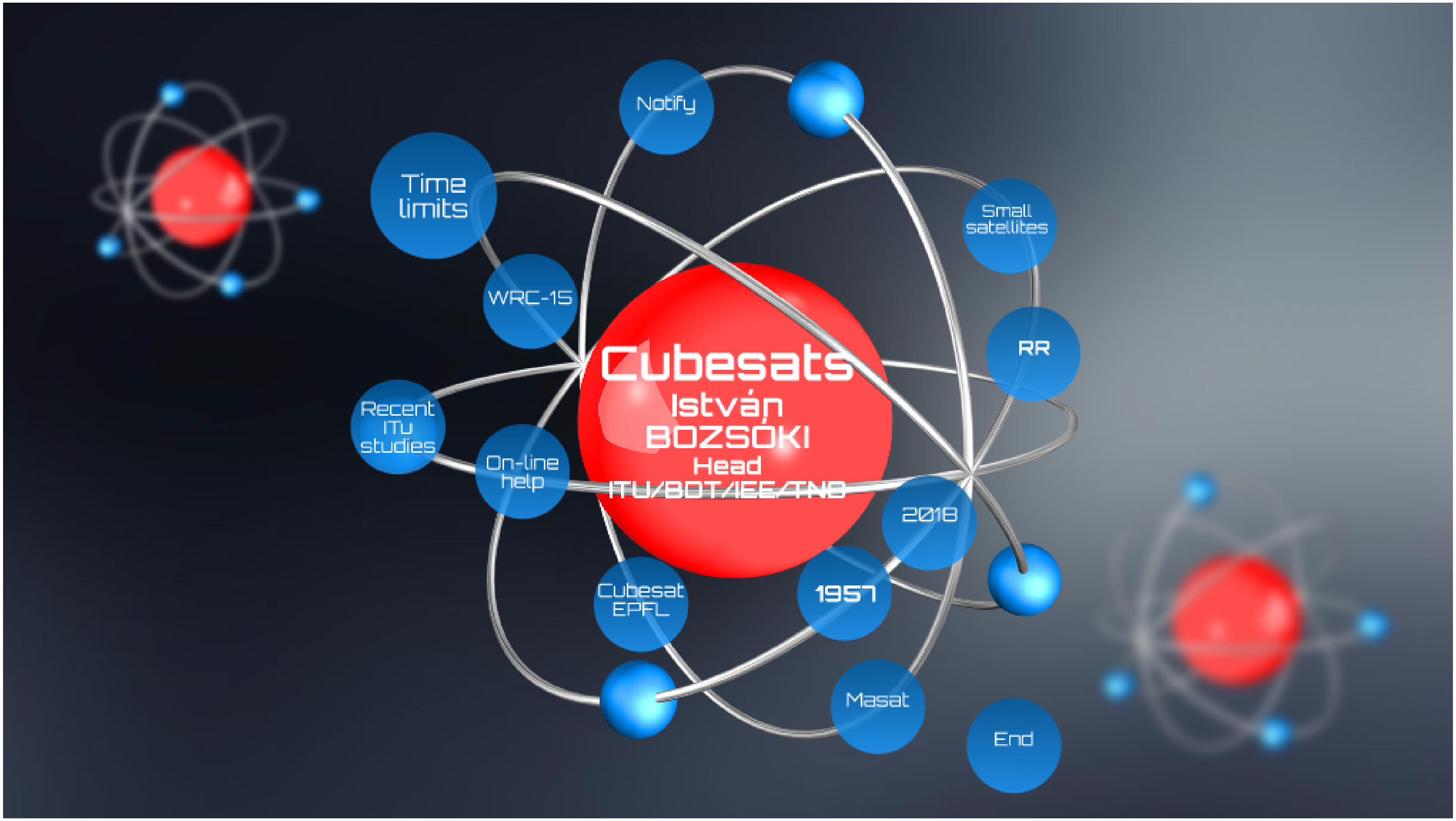


Small satellite regulatory time limits
API
ADM Submit
(general info)
No date priority
No Exam
Publish for info
Start of Regulatory Time Limit CLOCK
API
ADM Submit
Date priority (equitable use)
ADM No.9.53 (effort to overcome the difficulties),
BR Exam
BR Identify ADM/Netw
BR Publish CR/C
ADM Coordinate
CR/C
Notification
Within Time Limits
Agreed
If Finding Favourable
Record
dBIU
International Recognition/ protection
max 7 years
6 months after API/A publication
MIFR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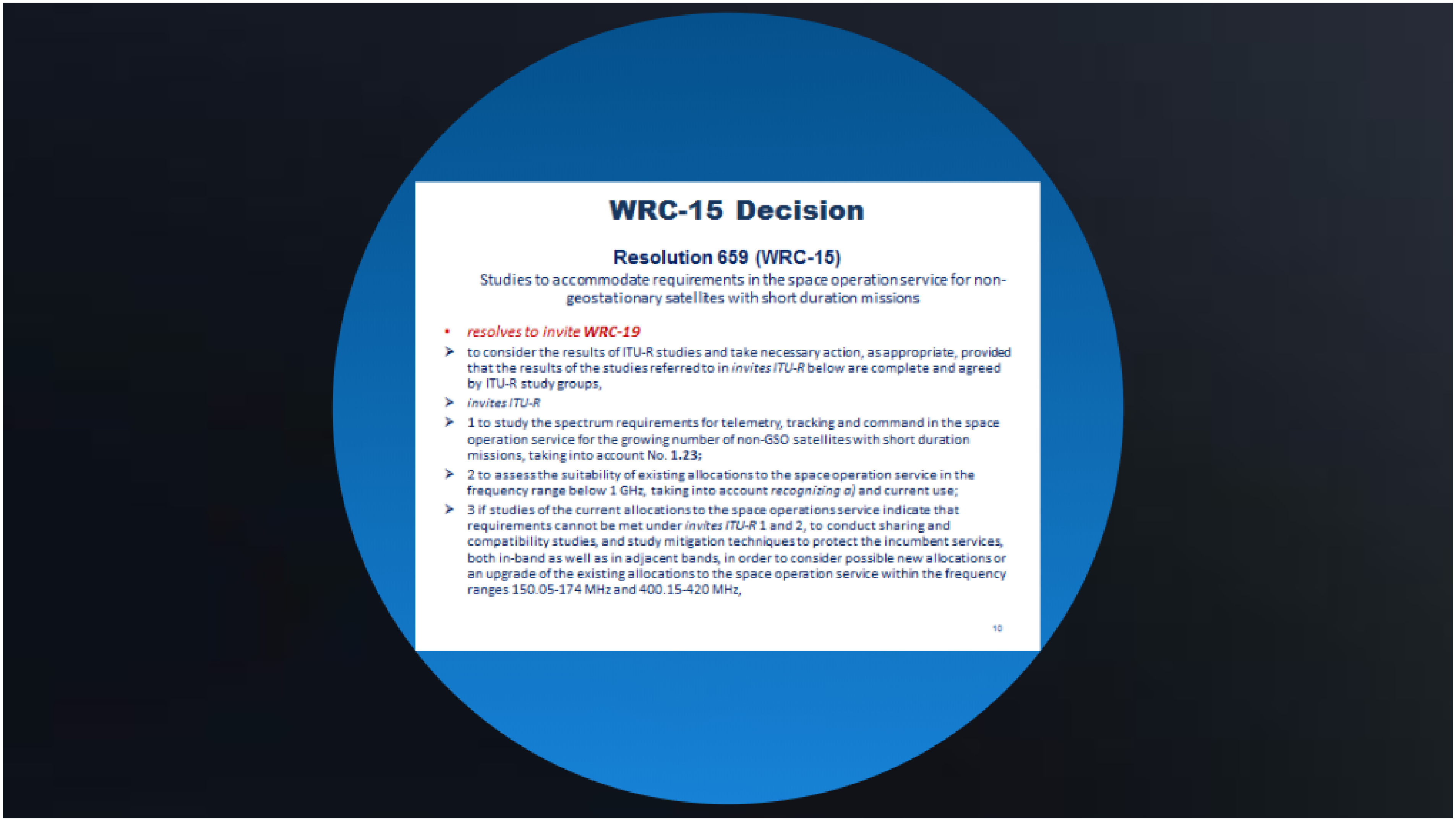
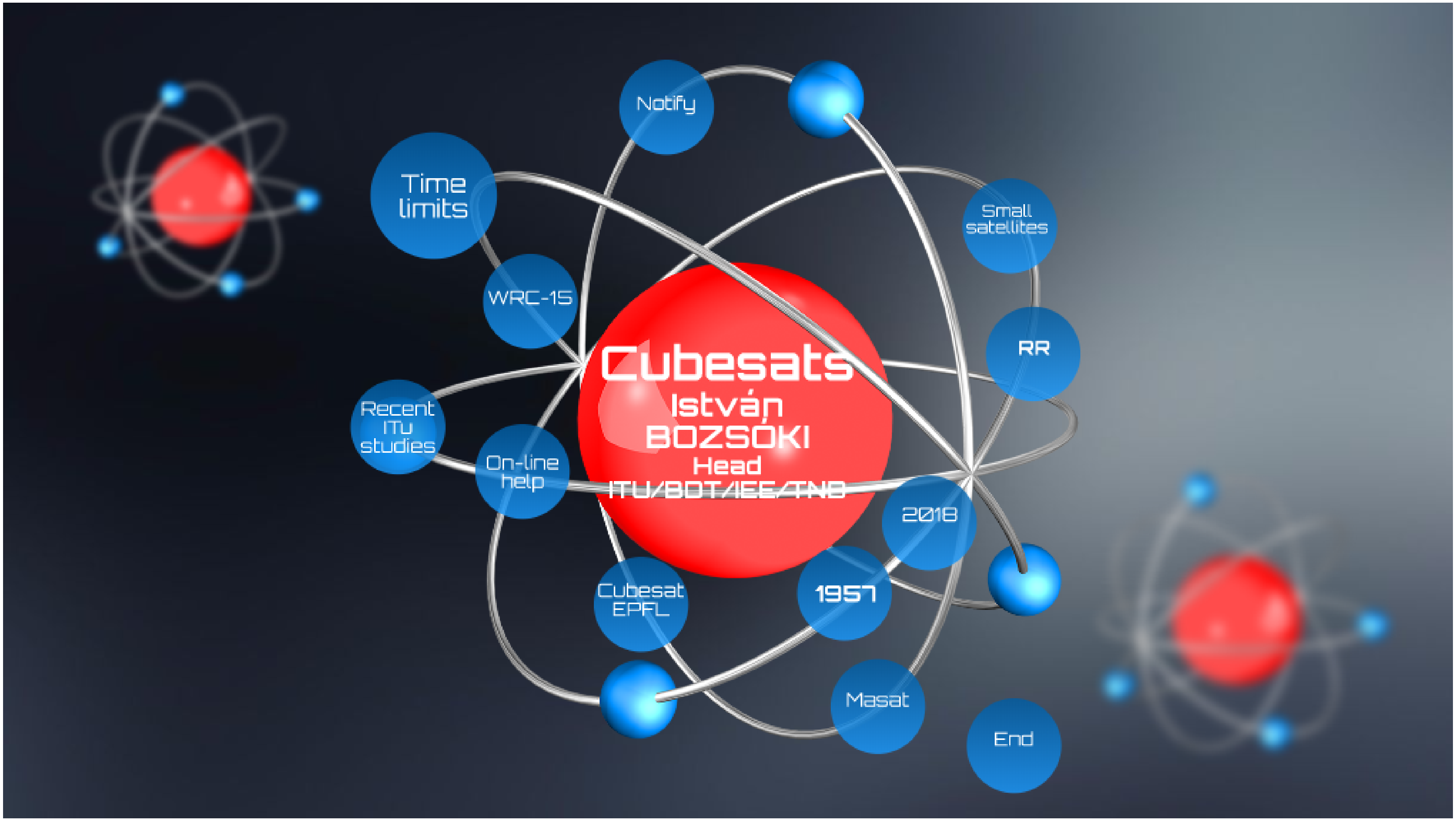

WRC-15 Decision
Resolution 659 (WRC-15)
Studies to accommodate requirements in the space operation service for non-geostationary satellites with short duration missions
resolves to invite WRC-19
to consider the results of ITU-R studies and take necessary action, as appropriate, provided that the results of the studies referred to in invites ITU-R below are complete and agreed by ITU-R study groups,
invites ITU-R
1 to study the spectrum requirements for telemetry, tracking and command in the space operation service for the growing number of non-GSO satellites with short duration missions, taking into account No. 1.23;
2 to assess the suitability of existing allocations to the space operation service in the frequency range below 1 GHz, taking into account recognizing a) and current use;
3 if studies of the current allocations to the space operations service indicate that requirements cannot be met under invites ITU-R 1 and 2, to conduct sharing and compatibility studies, and study mitigation techniques to protect the incumbent services, both in-band as well as in adjacent bands, in order to consider possible new allocations or an upgrade of the existing allocations to the space operation service within the frequency ranges 150.05-174 MHz and 400.15-420 MHz,
10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WP 7B

PRELIMINARY DRAFT NEW REPORT ITU-R SA.[SHORT DURATION NGSO – SHARING STUDIES]

Annex 5 to Document 7B/326-E (21 May 2018)
https://www.itu.int/md/R15-WP7B-C-0326/en

Studies on the suitability of existing allocations to the space operation service below 1 GHz and additional sharing studies on possible new and/or upgraded allocations

This report responds to invites 2 and invites 3 in Resolution 659 (WRC-15):

- Studies the suitability of existing space operation service allocations below 1 GHz based on spectrum requirements determined in [DN] Report ITU-R SA.[SHORT DURATION NGSO – REQUIREMENTS] for telemetry, tracking and command in the space operation service (SOS) for non-GSO (NGSO) satellites with short duration missions (NGSO SD).
- Presents summaries on whether spectrum requirements can be met in the existing allocations, and if not, additional compatibility studies are presented on possible new and/or upgraded allocations.

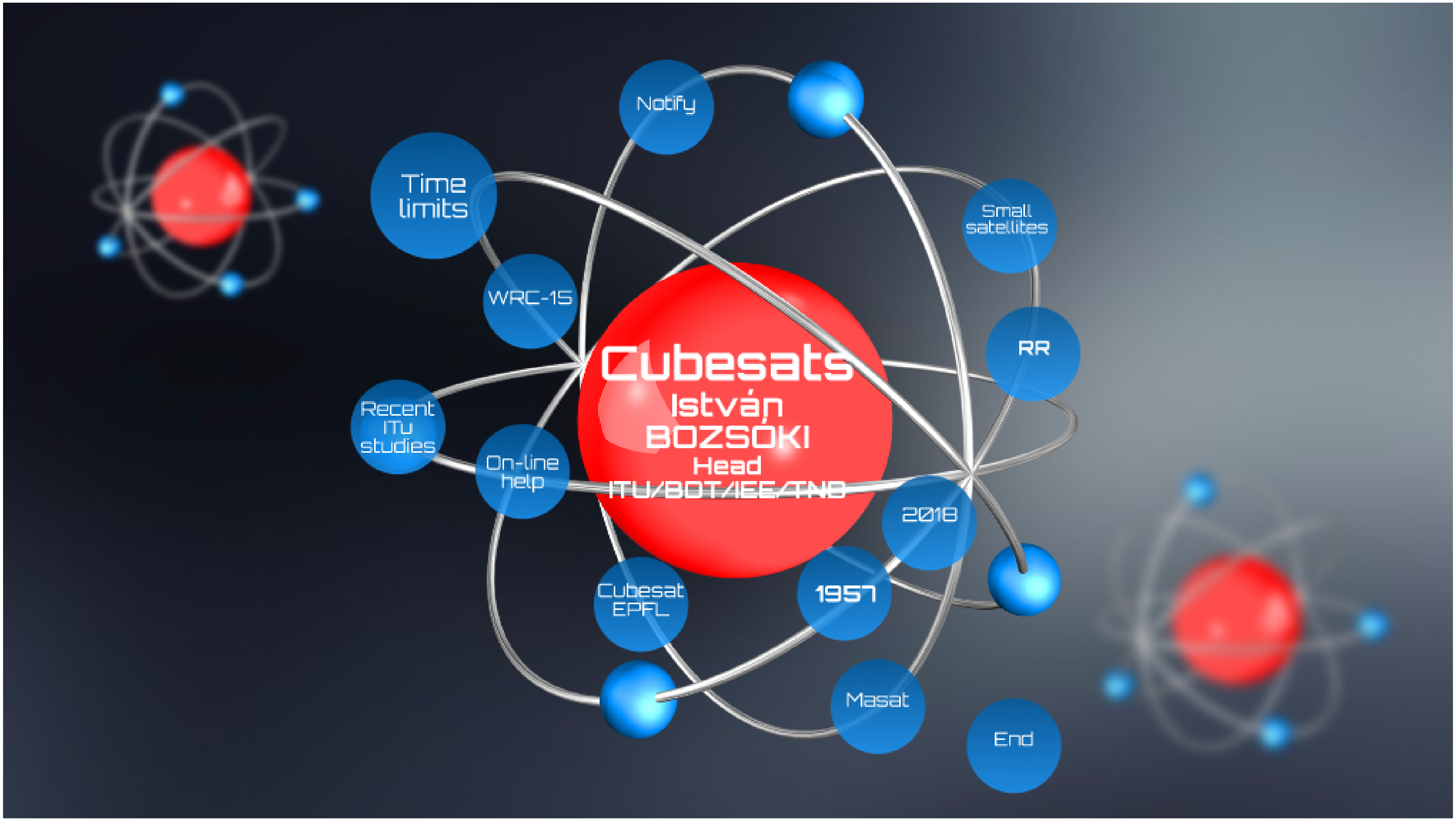
Workshop

ITU Regional Seminar for CIS and Europe "Development of modern radiocommunication ecosystems", 6 to 8 June 2018, St. Petersburg, Russian Federation

Session III. - Satellite Applications

Martin Buscher (Technische Universität Berlin)
State of the art and future development of (very) small satellites

https://www.itu.int/en/ITU-R/study-groups/workshops/DMRE-CIS-Europe/Pages/DMRE-CIS-Europe-Presentations.aspx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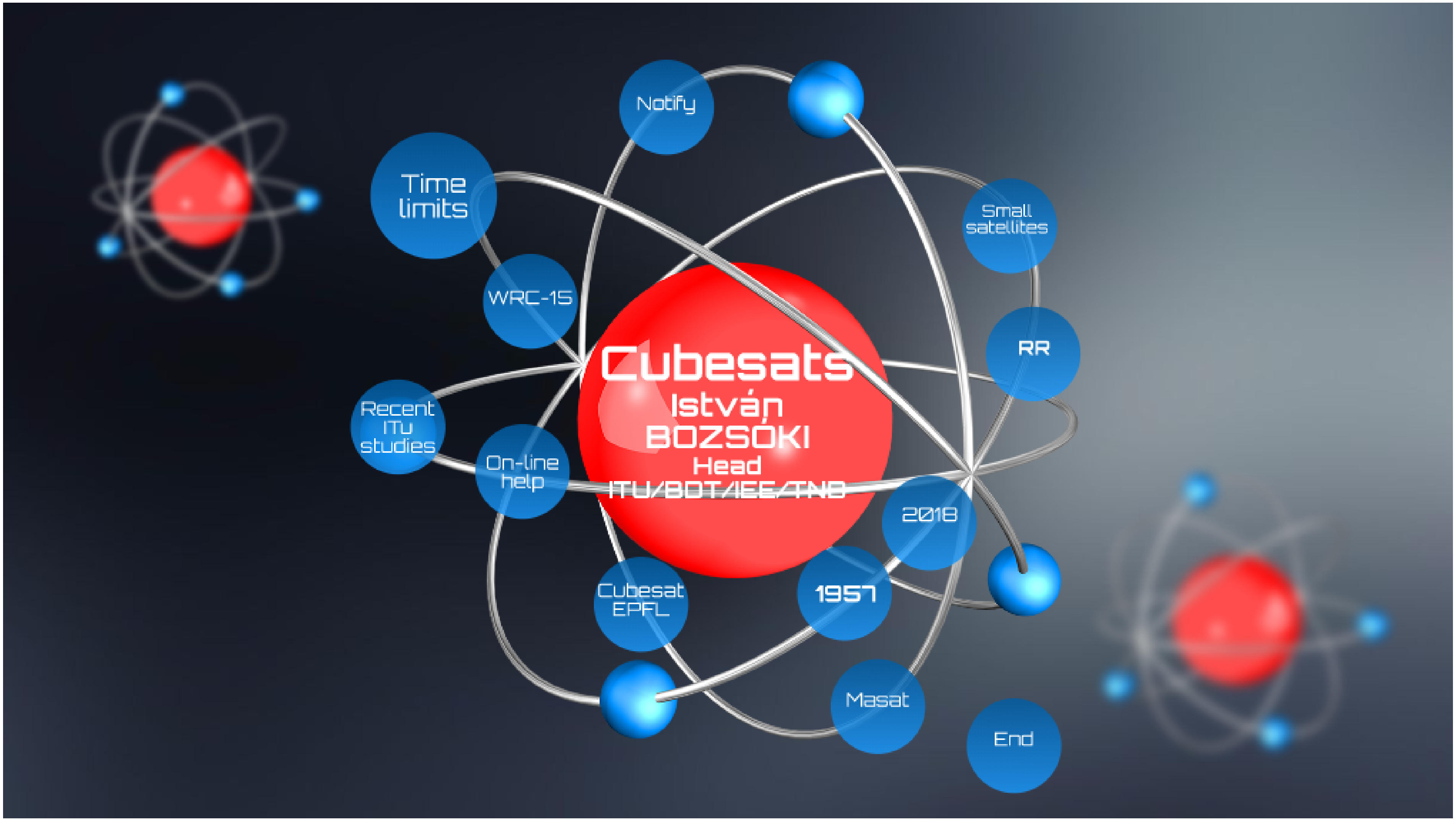
Free on-line ITU-R help & documents
Space service web page http://www.itu.int/ITU-R/go/space/en
Small Satellite support
http://www.itu.int/en/ITU-R/space/Pages/SupportAmateur.aspx
ITU RR @ 2016 http://www.itu.int/pub/R-REG-RR/
WRC-15 https://www.itu.int/en/ITU-R/conferences/wrc/2015/
ITU-R Recommendations http://www.itu.int/publ/R-REC/
ITU-R Reports https://www.itu.int/pub/R-REP/
SNL ONLINE (basic reference info concerning space stations)
https://www.itu.int/ITU-R/go/space/snl/en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SwissCube

- SwissCube is the first satellite entirely built in Switzerland.
- Very small in size
  - volume of 1 litre (10x10x10 cm)
  - weights less than 1 Kg.
- Follows the Cubesat standard developed by Standford and CalPoly (USA)
- Allows universities and research centres to build their own satellites.
- Due to its size and available power (less than a few Watt are generated by the solar panels), SwissCube can of course not compete with the capabilities of much larger satellites.
- It carries most of the sub-systems (e.g. structure, on-board computer, communication, attitude control, antennas) that exist on large satellites
- Allowed students to build a complex engineering system: More than 180 students participated.
- http://swisscube.epfl.ch/

Photo

Objectives

Launch

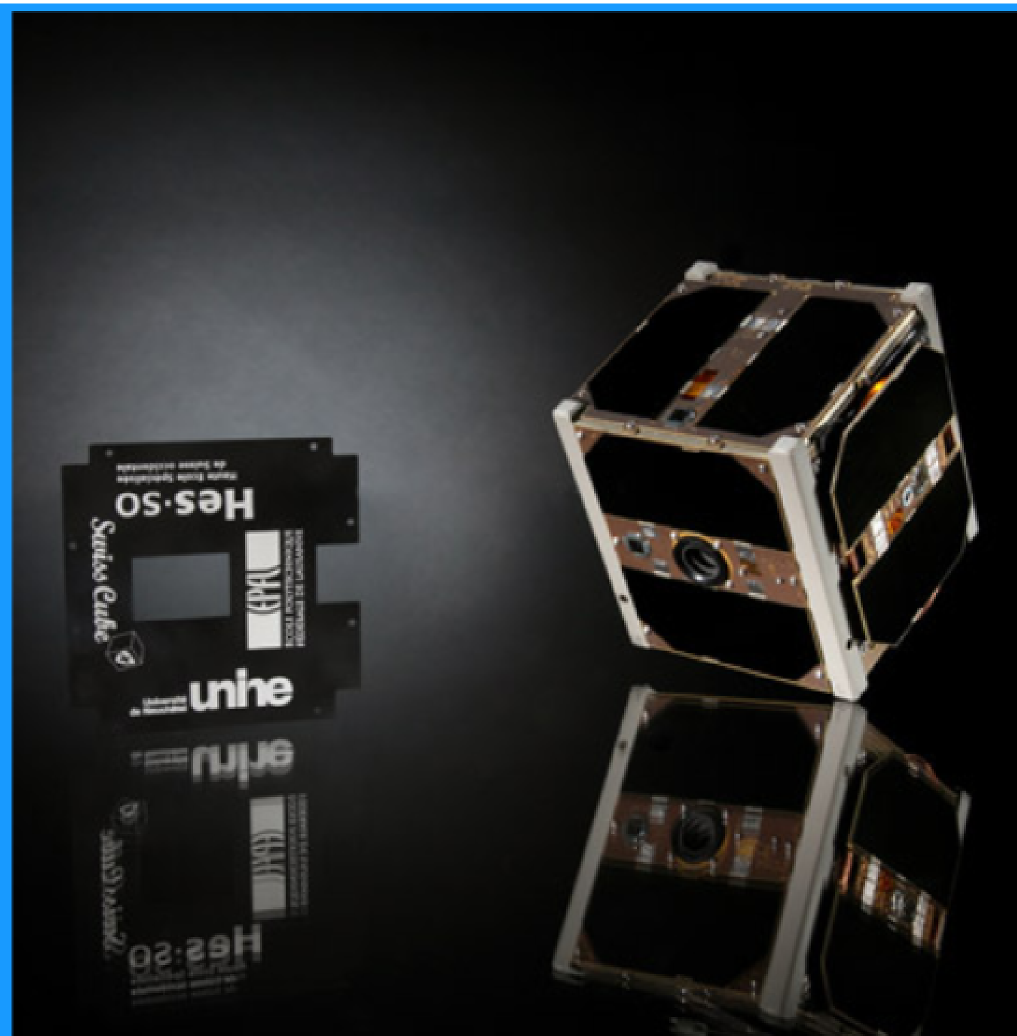
Ground segment

Payload

Antenna

Some news

Photo



Three objectives

- Educational and to show the students how to build a complex engineering system from A to Z like a satellite
- Scientific: it carries a small telescope which will allow to obtain images of the nightglow, a luminescence phenomena occurring at 100 km of height above the Earth surface
- Technological: If the nightglow phenomena can be correctly mapped, then an opportunity arises to use the technology developed in the SwissCube programme to produce a new type of Earth sensors that equipped most of satellites flying today.

Launch

The launch took place from India

- 23 September 2009
- PSLV (Polar satellite launch vehicle) developed by the Indian Space Research Organisation (ISRO).
- Three other Cubesats (from the universities of Berlin, Würzburg and Istanbul) were launched as secondary payload
- Primary payload was the Indian satellite "Oceansat-2"

Receiving station

Two ground stations (for redundancy)

- Fribourg (already received digital data transmitted by a radio amateur satellite)
  - The uplink has 11.4 dBi of antenna-gain. The downlink has 14.5 dBi of antenna gain.
- EPFL, Lausanne
  - The performances of the EPFL ground station are slightly higher than the performances of the Fribourg ground station as there are 4 70-cm yagi antennas in reception (20.4 dBi gain) and 2 2-m yagi antennas in emission (13 dBi gain).

Telescope

- The payload consists of a telescope which takes images of the airglow emissions.
- The telescope has a length of 50 mm.
- A CMOS detector captures images with a resolution of 188 x 120 pixels.
- A baffle protects the optical system and the detector from straylight.
- The payload is commanded by the ground to take images and sends back down about one image per week.

Communications

The SwissCube telecommunication system includes two data transmission types.

- A beacon signal (20.8 dBm or 120mW, 10 bits/sec in Morse code at 437 MHz) constantly operational
- Switched off by a command from the ground to be replaced by the main RF data transmission.
- The main data stream sends the scientific and engineering telemetry at 1200 bits/sec at an output power of 30 dBm (1W) and is FSK modulated at a frequency of 437 MHz.
- The uplink signal uses the 145 MHz carrier frequency.
- The VHF antenna is 610 mm long when the antenna is in straight ideal position.
- The UHF antenna of 176 mm when the antenna is in straight ideal position.

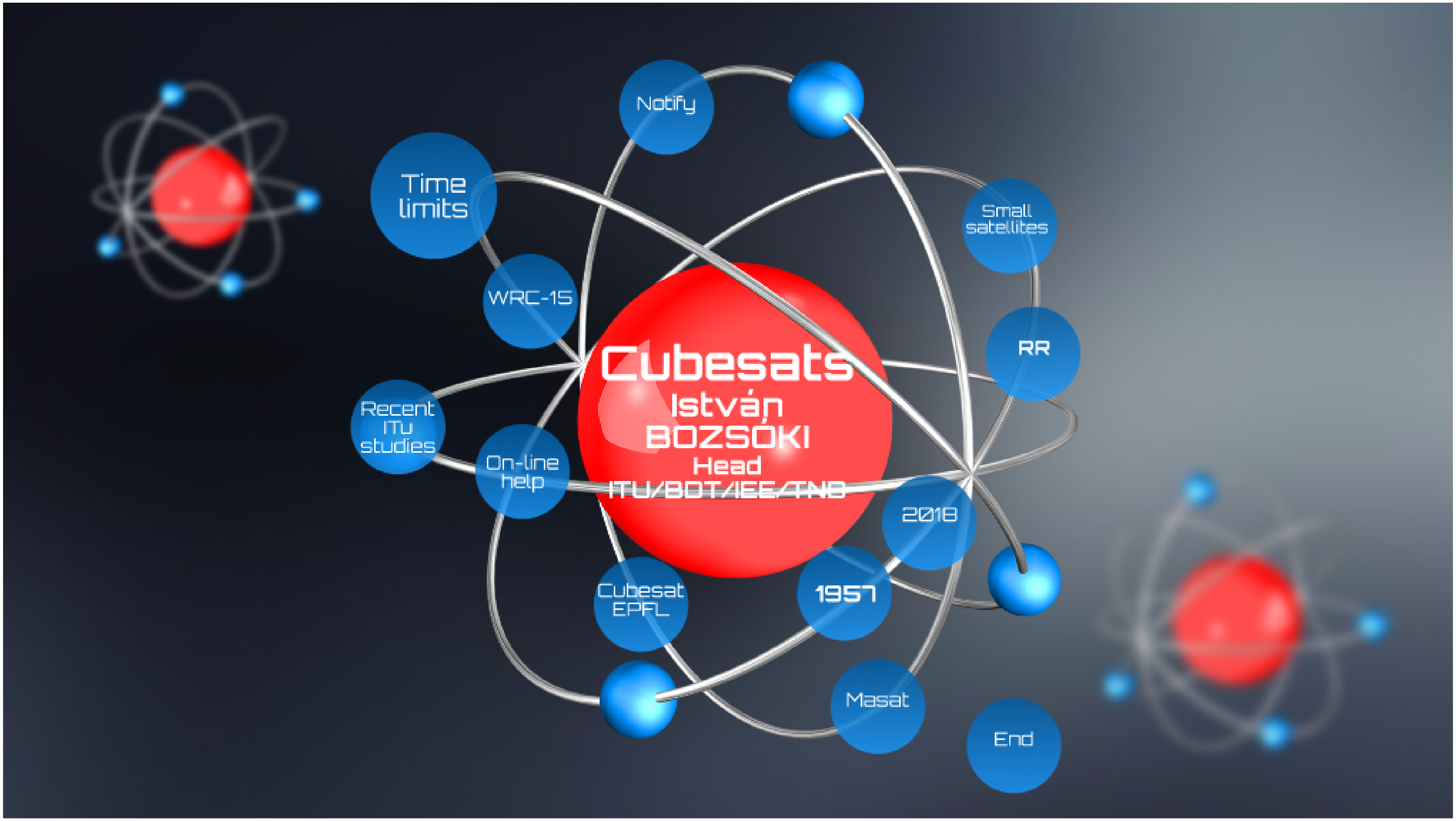
Info

22 October 2013:
Twenty-two thousand trips around the planet

- Four years after its launch Swisscube was still in operation.
- The mission was supposed to last three months to one year, but four years later, Swisscube was still orbiting the Earth.
- After more than 22,000 trips around the planet, all its functions were still operational. Only one of its six solar sensors has been irreversibly damaged.

"The goal was above all educational" (Muriel Richard, an engineer at the Swiss Space Center and Swisscube project manager).
"It allowed nearly 200 students from EPFL and the Universities of Applied Science to learn about space technology. Still valuable for current students as an extraordinary experimentation platform, with which we can, for example, check movements and altitude or test ground-based algorithms."

2018
Swisscube's demise has been programmed for 2018. It will be the first object captured and destroyed by CleanSpace One, the space debris clean-up satellite currently under development at the Space Center.



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Masat-1

In September 2007 a group of undergraduate and PhD students at Budapest University of Technology and Economics, Hungary (BME) decided to design and build a small satellite.
The initiative was encouraged by two departments of BME

- Electron Devices
- Broadband Infocommunications and Electromagnetic Theory
- also by the BME Space Research Group.

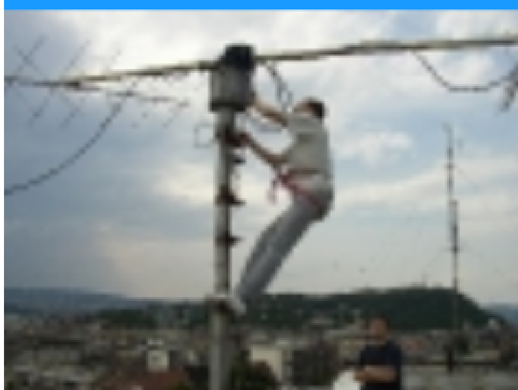
The objectives of the initiative:

- to train qualified engineers, who can support the existing domestic space industry
- to enable the developers to gain experience and obtain references in the design, implementation and operation of space devices
- to demonstrate Hungary's aptitude in the design and implementation of space devices
- to set up a new technology baseline launch and operation also other professional domestic laboratories' scientific experiments

http://cubesat.bme.hu/en

Photo
Objectives
Launch
Ground segment
Payload
Antenna
Some news
Next Phase

Photo



Objectives and success criteria

- To design and implement the basic subsystems of a custom-built satellite.
- To gain experience in the leadership, logistics, testing and launch arrangement aspects of a complex space project, which are all essential to proceed to the next step
- Minimum success
  - A basic success criteria will be met if students design, build and test a satellite which can survive the launch process and the environment in space.
  - Deliver a fully tested satellite to the launch site and get a successfully released acknowledgement from the launch vehicle.
  - If the Ground Station operates reliably 24/7.
- Intermediate success
  - Successfully receive telemetry packets from the satellite.
  - Control the satellite operation modes via telecommands
  - Correct and reliable operation of all satellite subsystems
- Full mission success
  - Reception of all scientific data and telemetry of the satellite

Launch

The launch site was Kourou in French Guyana as a secondary payload.

- 13 February 2012
- Vega launch vehicle of ASI and ESA.
- Although ESA's Education Office is providing 9 CubeSat positions on the maiden flight of Vega, only 7 CubeSats are confirmed as of December 2011 (Vigo, Spain; Montpellier, France; Torino, Italy; Bucharest, Romania; Warsaw, Poland; BME, Budapest; Roma, Italy). Not all universities that were preselected for the launch opportunity in June 2008, were able to deliver their CubeSat and the requested documentation. Other CubeSat projects, like SwissCube and HiNCube, decided to be launched on commercial flights.

- primary payload of 400 kg called LARES (LAser RElativity Satellite)

Receiving station

MaSat-1 has been transmitting data to the:

- primary ground control station (Budapest University of Technology) and
- secondary ground control station (Erd, Hungary).

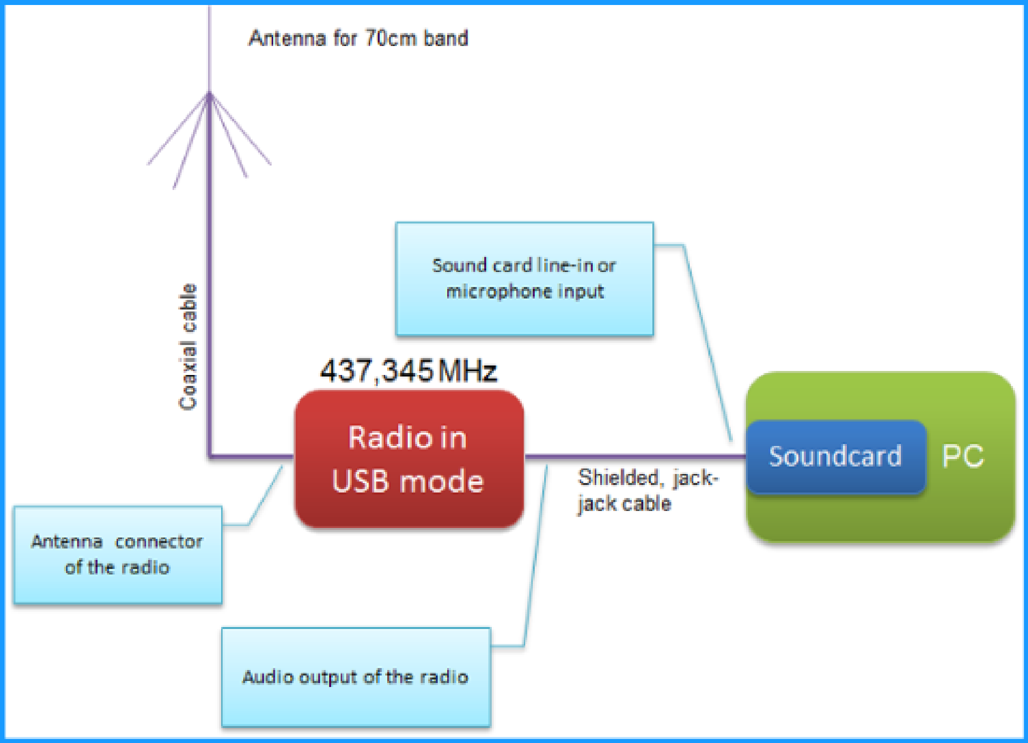
In addition to these domestic control stations, more than 120 radio amateurs have received the satellite worldwide.
Their total contribution to the success of the mission exceeds 200, 000 data packets

Photographs prepared

- The flawless operation of the passive attitude control system made it possible to capture photographs ahead of schedule, but with this passive system only the Southern Hemisphere of the Earth may be targeted by the camera.
- As the first month of the mission passed, almost every mission objective was fulfilled.
- The flawless run of the satellite opens a new scientific and technological horizon for experiments.
- The first month of the mission was the most critical from the engineering perspective.
- Not only did the satellite survive the first month without any error, but it also transmitted more than 20 MB of data about its operation and the space environment.
- MaSat-1 was classified as an OSCAR satellite by AMSAT. This classification brought a new name (MO-72) along with an inherent reputation

Receiving station

A minimal arrangement of the receiving station



The structure of a radio amateur station optimized for satellite reception

Minimum list of devices required for receiving Masat-1

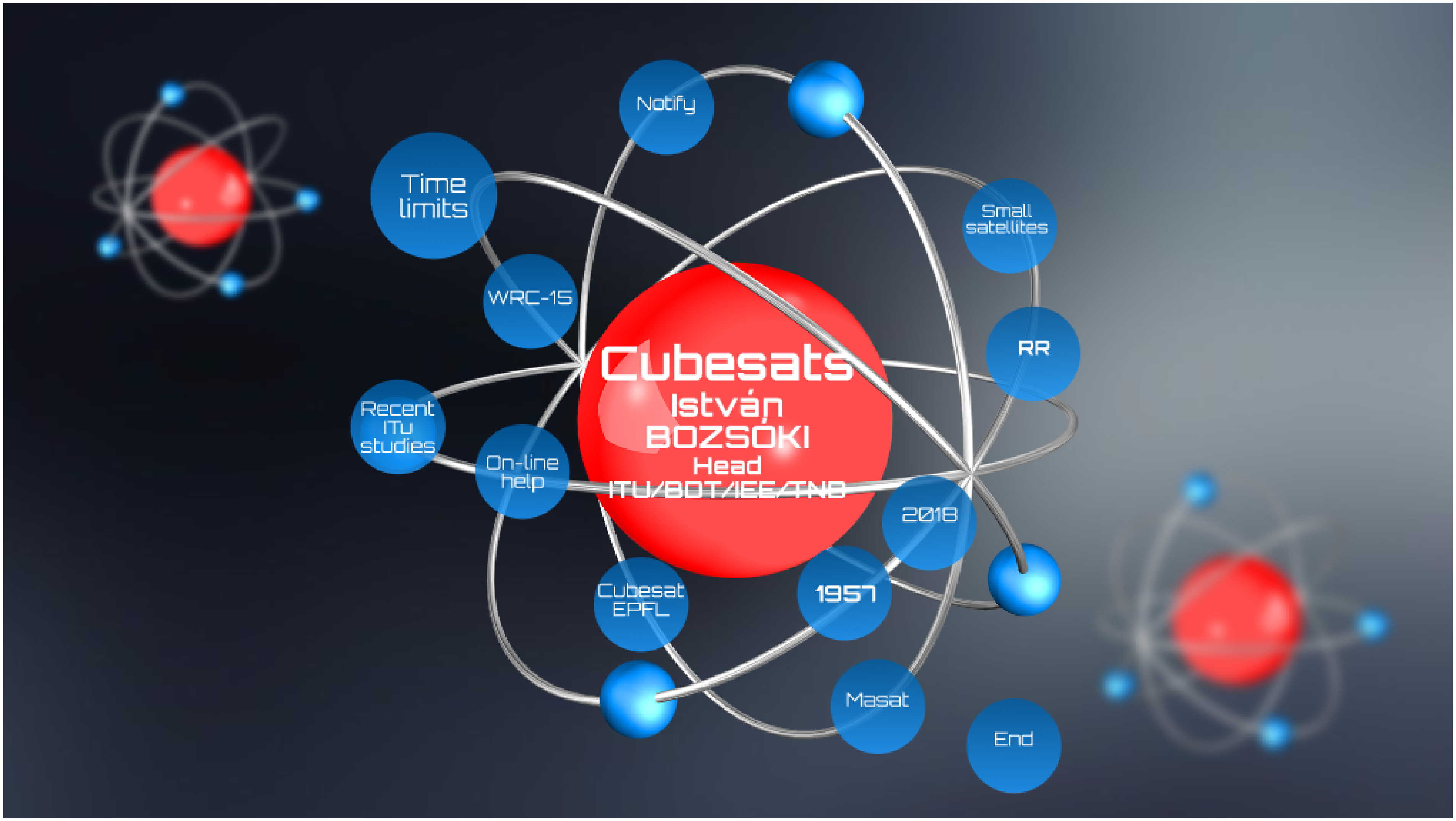
- Antenna suitable for the 70 cm band (in open air, pointed towards the sky)
- Tuneable radio receiver with 70 cm SSB USB mode, such as FT-817, FT-897D, TS-2000, etc.
- PC with sound card, running the telemetry packet decoder SW in JAVA environment.

Info

- The Hungarian team received the first signals from MaSat-1 from a radio amateur in Florida less than two hours after launch, and by many others shortly after. A couple of hours later the team's ground station in Budapest gathered the first ‘official' satellite data which confirmed that the spacecraft is in perfect shape
- March 2012: MaSat-1 has been continuously and fully operational since its first passes over the ground station in Budapest, Hungary. Spacecraft data - which include beautiful images of the Earth as well as telemetry data - are regularly received and all systems are operating nominally. During the first weeks of flight, the team was able to monitor the performance of the CubeSat's electronics and sensors. The team will continue to collect data on the behavior of all systems and demonstrate the satellite's active attitude control capability
- The MaSat-1 CubeSat is operational in Feb. 2014. On January 10, 2014, the MaSat-1 CubeSat completed 10,000 orbits.
- MaSat-1 was expected to end its successful mission and burn up during reentry in early January (current prediction is January 10th). The last days and hours can provide much useful information that is also necessary for continuing on, therefore we want to track its path especially closely in these days
- January 2015: According to the MaSat-1 project, the CubeSat reentered Earth's atmosphere on January 9, 2015, completing almost 3 years of on-orbit operations. The last data of the CubeSat was received by radio amateurs from Argentina

SMOG-1

- In recent years, a new type of satellite emerged called PocketQube. A PocketQube is a type of miniaturised satellite made up of 5x5x5 cm cubic units. It has a mass of no more than 180 grams. It is half the size of a CubeSat satellite.
- Smog-1 is a PocketQube type of satellite.Smog-1 is a PocketQube type of satellite.
- Smog-1 will be used as a UHF band spectrum monitoring system. This system can measure the UHF band digital terrestrial TV signal levels around the world on a low Earth orbit as RF smog.
- The digital terrestrial TV signals cause interference in the communication system of satellites, thus complicating satellite control.
- Smog-1 will also measure how solar wind activities affect the satellite. The ionising radiation from the Sun severely damages the electronics, and the satellite will measure this destructive influence of the ionising radiation.
- Smog-1 will be operating for approximately 6 months; then it will “die”. It will eventually return to the atmosphere and burn out.
- When Smog-1 will be put into orbit has not been decided yet, but it will definitely not happen before the summer of 2018.
- https://www.youtube.com/watch?v=zMzEMR8Gdp8
- http://home.agh.edu.pl/~rydosz/MIKON/M23.3.pdf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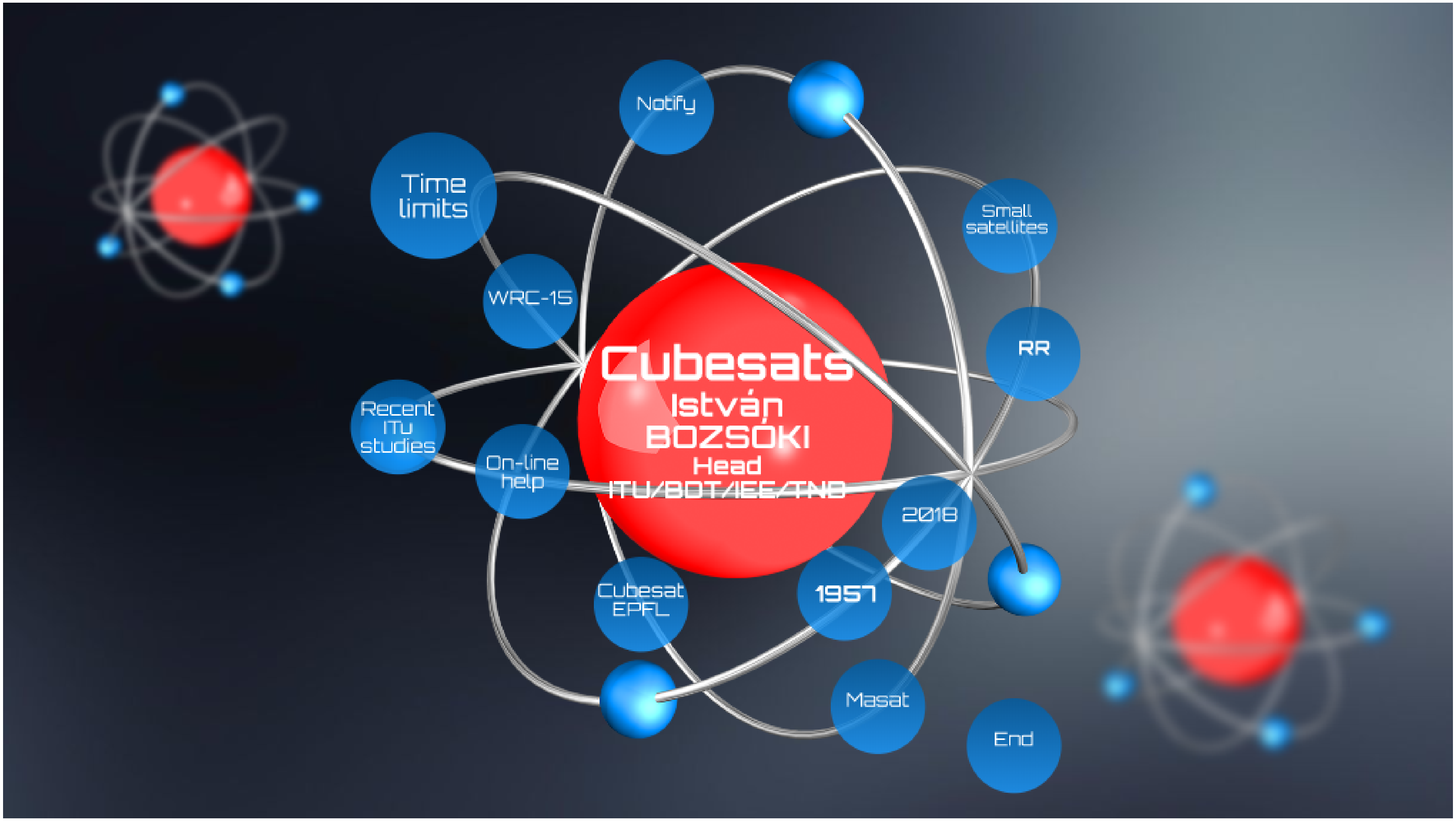
THANK YOU !!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