X WETE

Advancements in satellite data collection and relay concepts using small satellites

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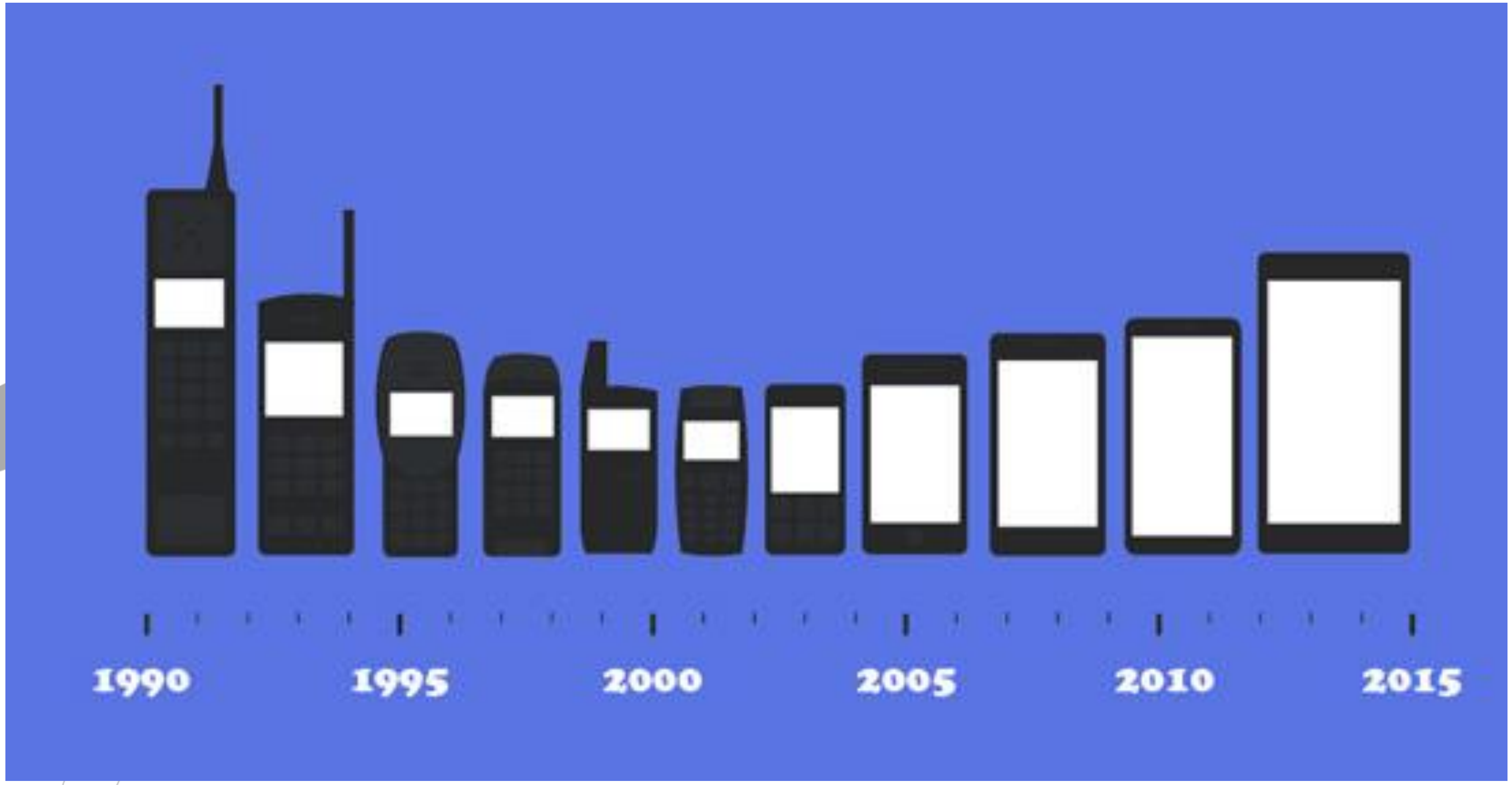
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

X Workshop em Engenharia e Tecnologia Espaciais

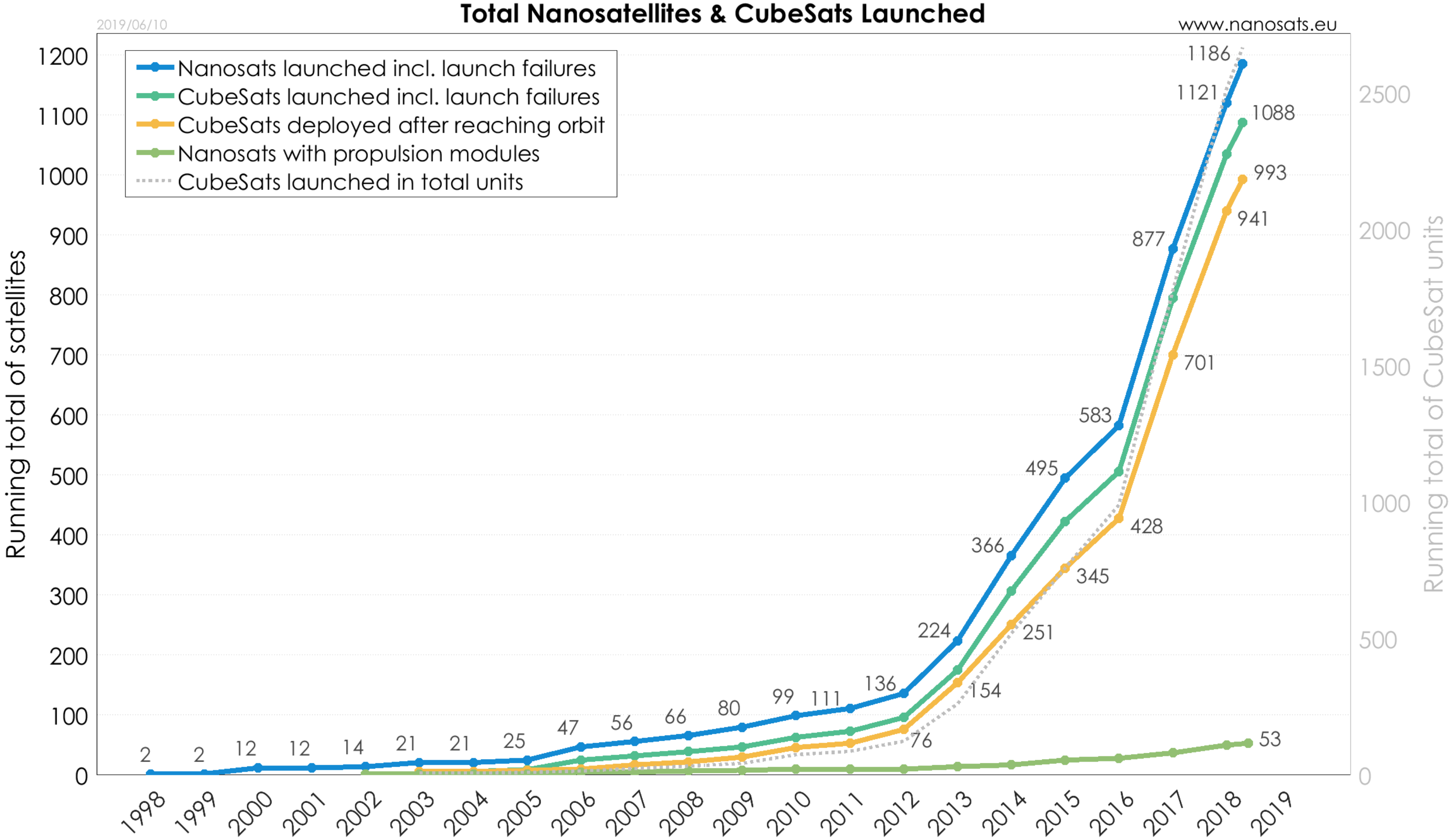
Outline

- Introduction
- Methodology
- (Some) Enabling technologies
- Results
- Discussion
- Conclusions

Introduction



Introduction



Total Nanosatellites Launched as of June 10th, 2019 (Kulu, 2018)

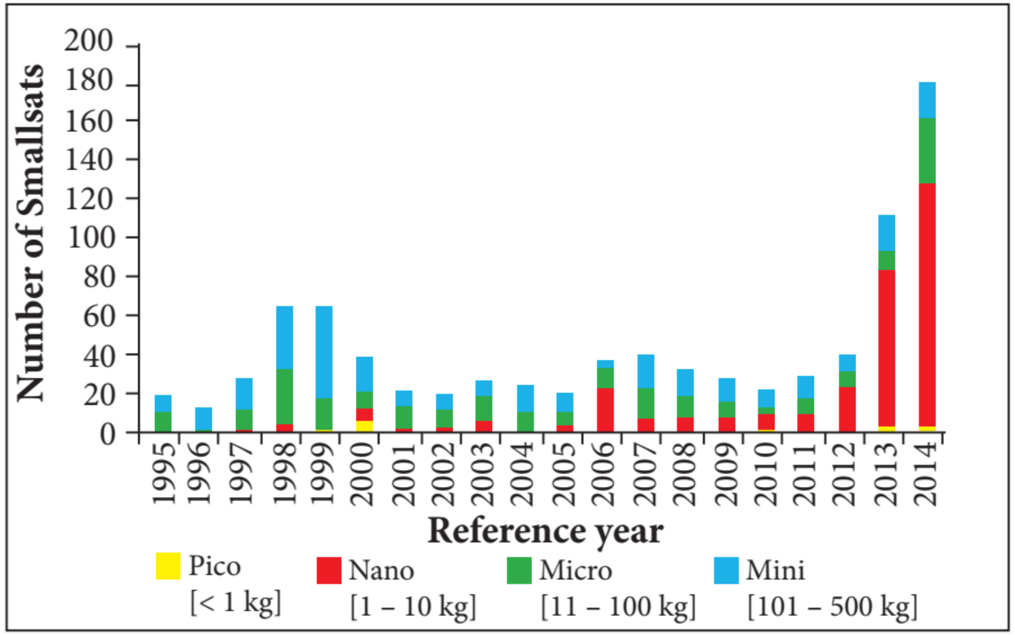


Figure 1. Smallsats launched from 1995 to 2014 ordered by launch year and class.

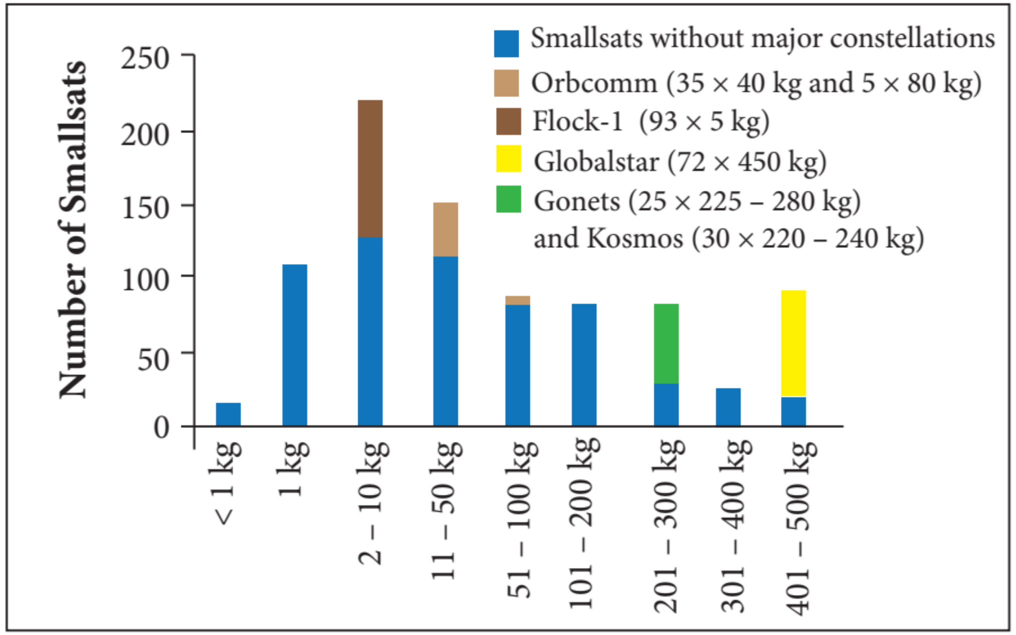


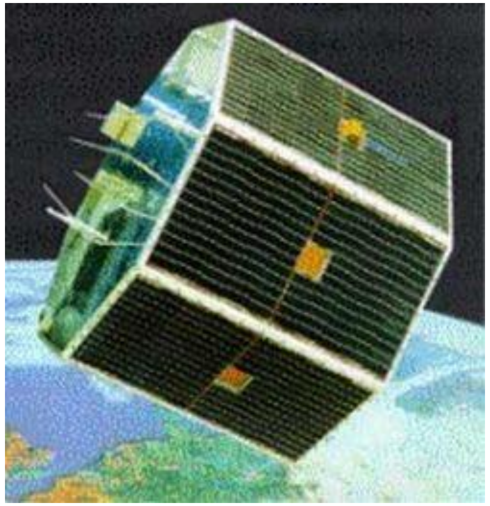
Figure 2. Histogram of Smallsats launched from 1995 to 2014 ordered by mass. Constellations are marked with color.

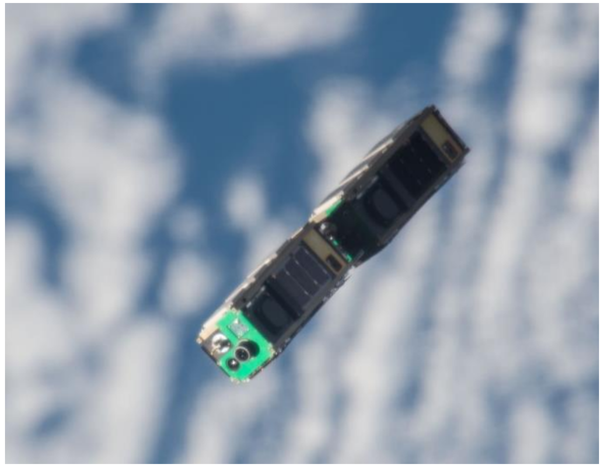
J. Aerosp. Technol. Manag., São José dos Campos, Vol.7, Nº 3, pp.269-286, Jul.-Sep., 2017

Wekerle, T. et al. 2017,

Methodology

- Case studies for Spire Global AIS constellation and SCD-2
  - Mission context
  - Satellite data relay architectures
  - Enabling technologies: SDR, Satellite AIS, Small Satellite design philosophies





(Some) Enabling technologies

(Some enabling technologies) - SDR

Home / Communication systems / UHF downlink/VHF uplink Full Duplex Transceiver

Flight heritage since 2016

€8,500

The ISIS VHF uplink/UHF downlink transceiver is a full duplex communication system for CubeSat TT&C applications. The radio can operate in commercial and amateur bands of the VHF/UHF frequency spectrum. It is low power, low mass, and highly configurable, offering the flexibility of changing data rates and frequencies in flight. This radio is tailored for CubeSat missions and cross-compatible with other subsystems such as onboard computers and antenna systems. Flight proven since 2016.

Availability: 8 – 12 weeks

Brand: ISIS

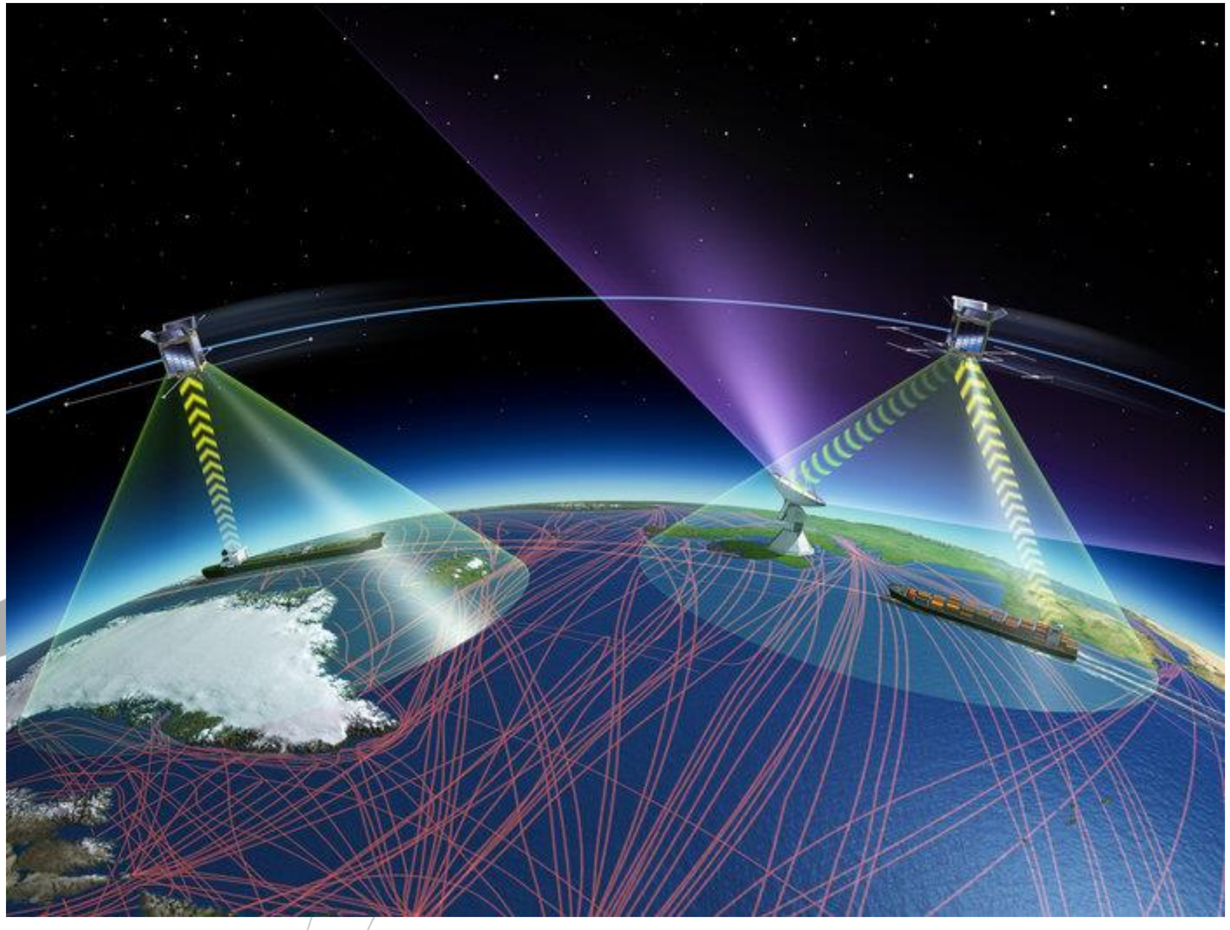
1 | Request more info

Category: Communication systems

Features | Product properties | Performance | Configuration | Documents | Testing

https://www.cubesatshop.com/product/isis-uhf-downlink-vhf-uplink-full-duplex-transceiver/

Satellie AIS: Expectation (ESA 2014)



https://www.esa.int/spaceinimages/Images/2014/07/SAT-AIS_artists_impression

Satellite AIS: Reallity

Results

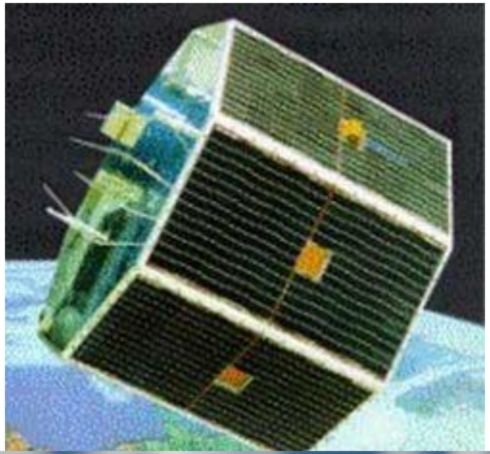
Main orbital parameters

	SCD-2 INPE	Lemur-2 Spire
Orbit type	Circular	SSO
Inclination [°]	25.0°	97.5
Altitude [km]	742km x 768 km	500km
Design lifetime	2 year	2 years
Operational lifetime	10 + years	

https://getmelisted.net/latitude-e-longitude-mapa-do-brasil/27107/

(Some) Spacecraft characteristics

	SCD-2	Lemur-2 Spire
Payload	RF communications: S-band TT&C for housekeeping. On-board storage capability for TT&C data. A UHF uplink at 401.650 MHz and 401.620 MHz used for data collection.	STRATOS (GPS radio occultation payload), SENSE (AIS payload)
Total mass	117 kg	4 kg
Power	110W	20 W
Manufacturer	INPE	Spire Global
Launched	23/Oct/1998 (on Pegasus)	15/Feb/2017 (PSLV-XL-C37
Launch cost	12 million USD	295 thousand USD



Discussion

- Note difference concerning the number of ground stations for INPE's missions and several spacecraft and contacts to be managed per day in the case of Spire's Constellation.
- SCD-2 is relevant at its launch is around the first release of the CubeSat standard in the early 2000s (Puig-Suari, 2001). Also, one should consider how many cell phone updates have we had over the past two decades, in terms of hardware and software technological evolution.
- Power and link budgets of an individual Lemur spacecraft are far inferior with respect to SCD-2. However, the temporal resolution and the size of the active constellation allow for shorter revisit periods, which allow for lower volumes of data need to be stored and relayed.

Conclusions

- A case study for SCD-2 and Lemur-2 was developed. Challenges in the availability of relevant technical details made it difficult to benchmark each concept in much details. Hence, a generalization of aspects has been provided.
- Though some principles of small satellite design philosophy can be observed in the SCD-2 mission, only two spacecraft effectively reached orbit, while over 60 spire spacecraft have been successfully deployed and operated.
- Constrains for cost-effective deployment of CubeSat in specific orbital inclinations, different than SSO or Polar and ISS near 50°, yield challenges for missions with specific orbital needs (as the case of Brazilian territory).

Further research

- Satellite internet concepts: One Web, Keppler, Starlink (Space X) and other mega LEO constellations
- Propulsion capabilities for orbital maneuvering or innovative concepts for Nano-satellite deployment will be critical to providing specific orbits to fill in the constellation or replaced decayed or nonoperational spacecraft. For this, the work of (Grönland, Palmer, Bejhed, & Elgaard, n.d.; NASA, 2019; Pascoa, Teixeira, & Filipe, 2018) will provide relevant insights in terms of current technology readiness level and trends.

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