ESA Operational Collision Avoidance

UNOOSA – Promoting Space Sustainability
25th February 2021

Francesca Letizia
ESA Space Debris Office

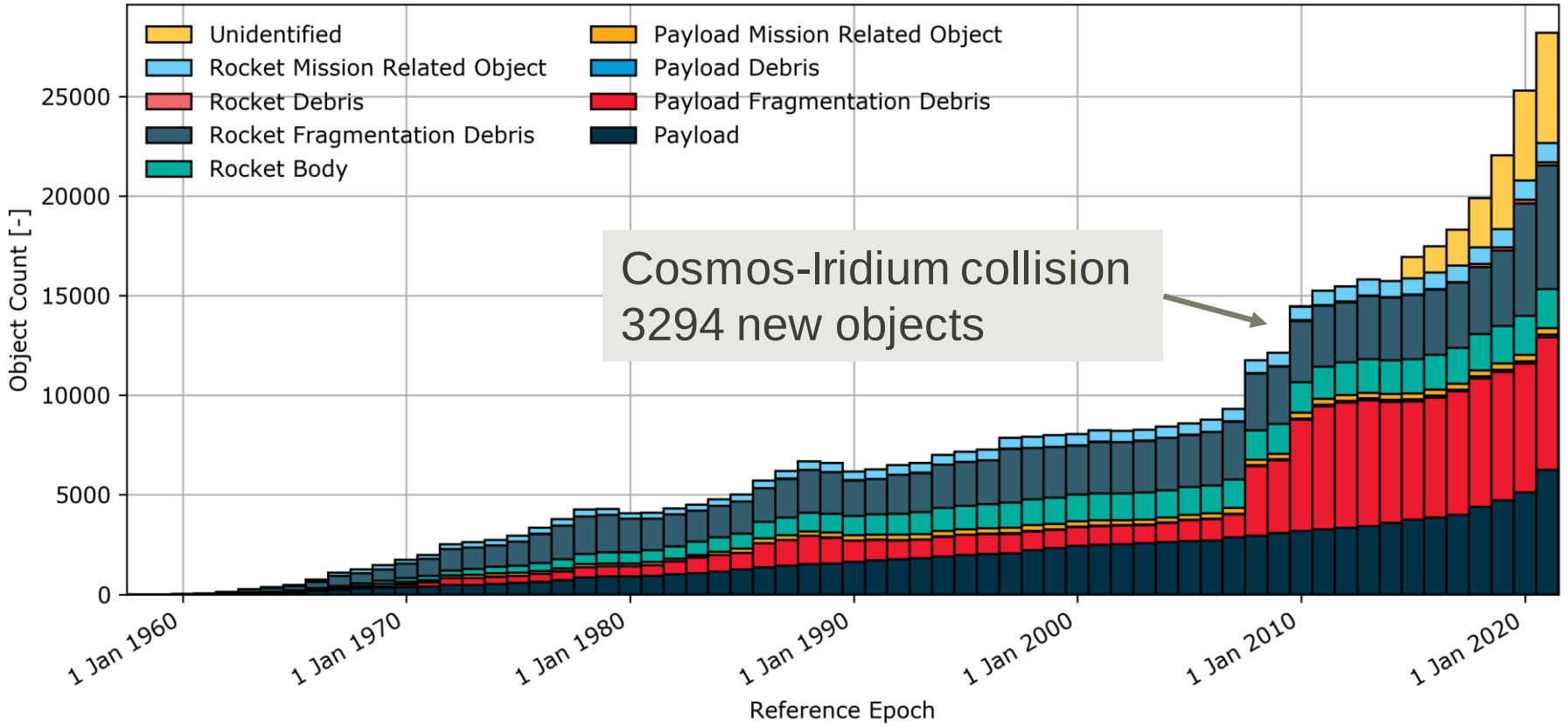
Collision avoidance service: why

Local perspective
Collisions with objects larger than 1 cm have the potential of prematurely **ending** a **mission**

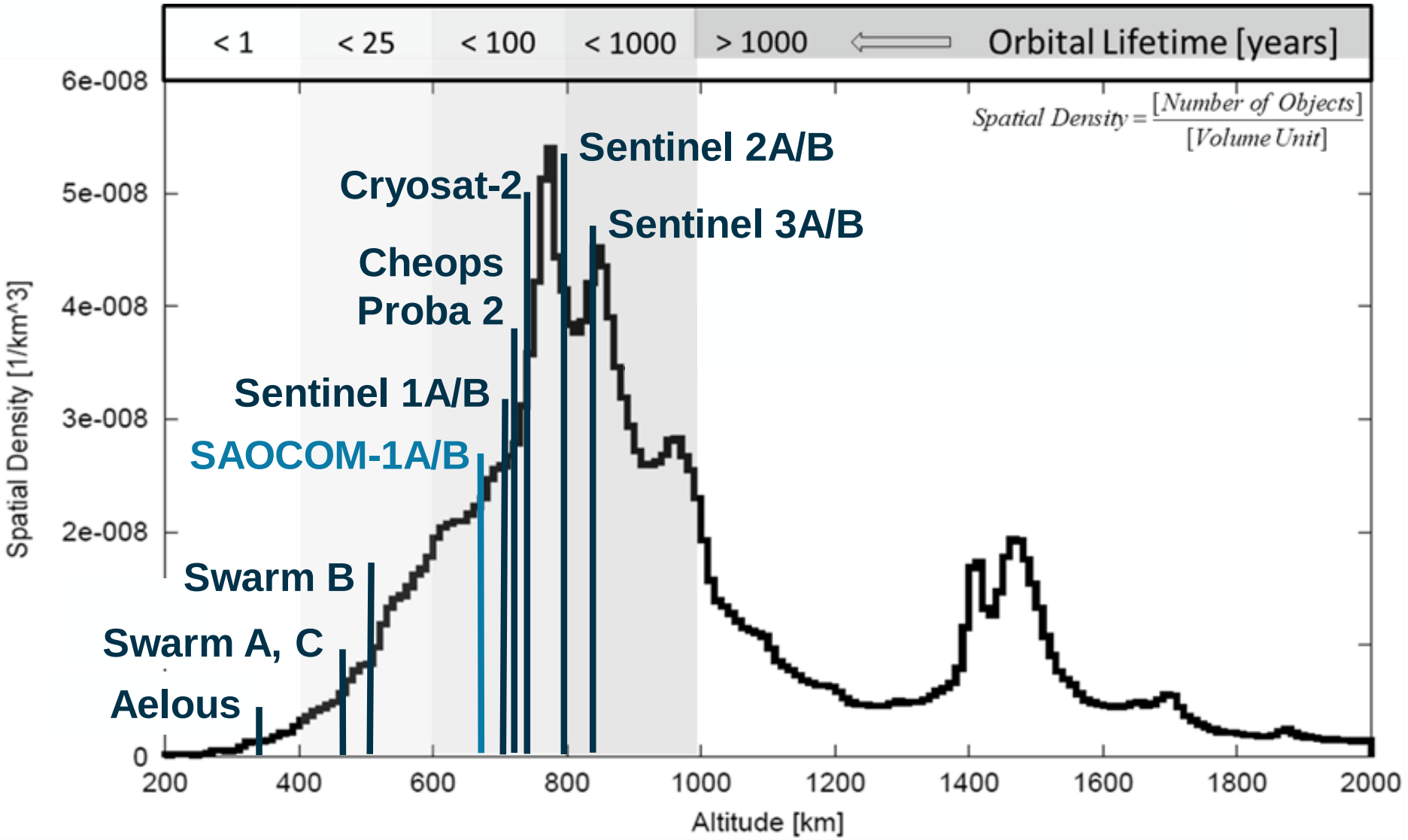
Global perspective
Collisions can significantly **contribute** to the **evolution** of the debris environment

Accidental break-ups caused by collisions covered by **standards** (ISO 24113) and **guidelines** (UN LTS B.4)

Statistics on space debris at



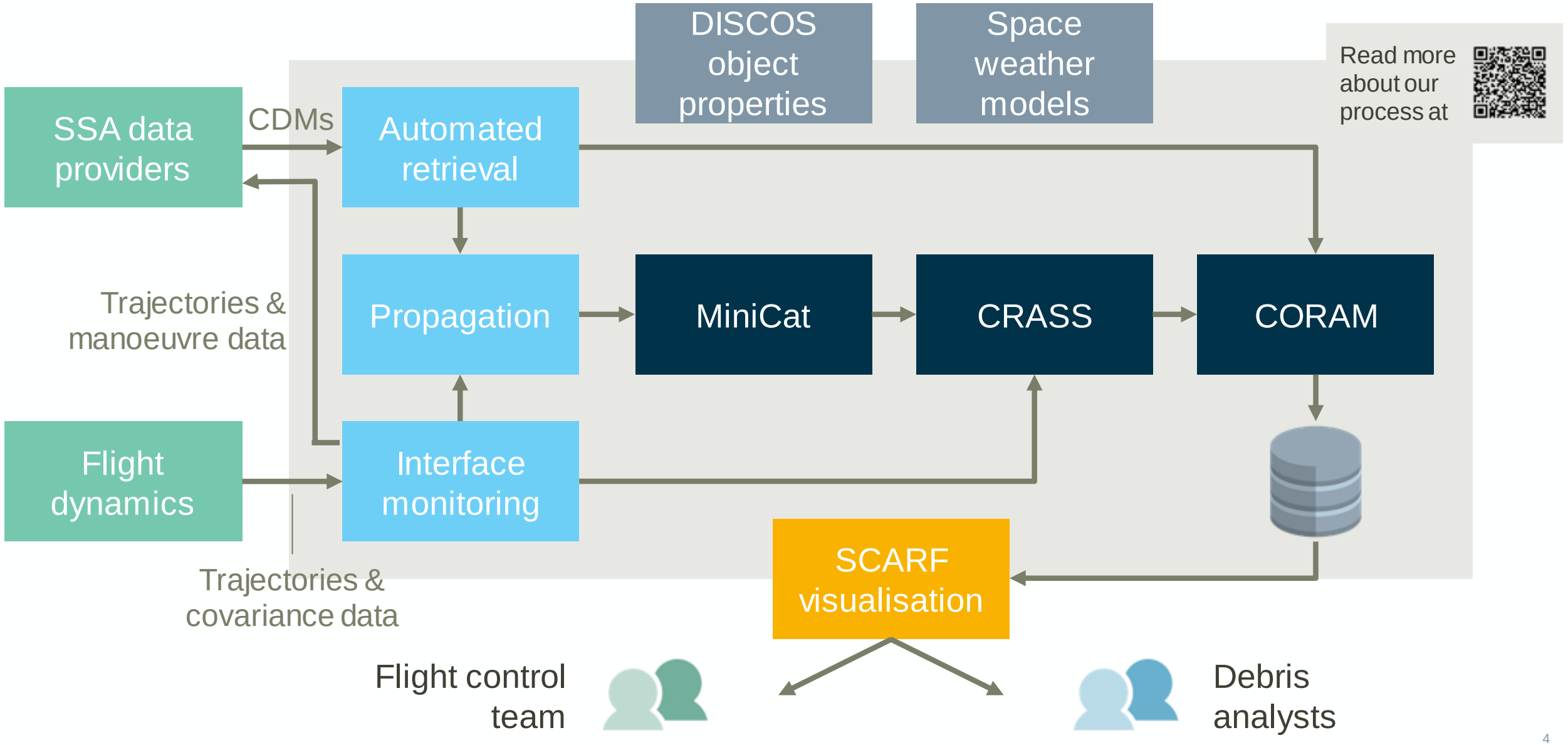
Collision avoidance service: the missions



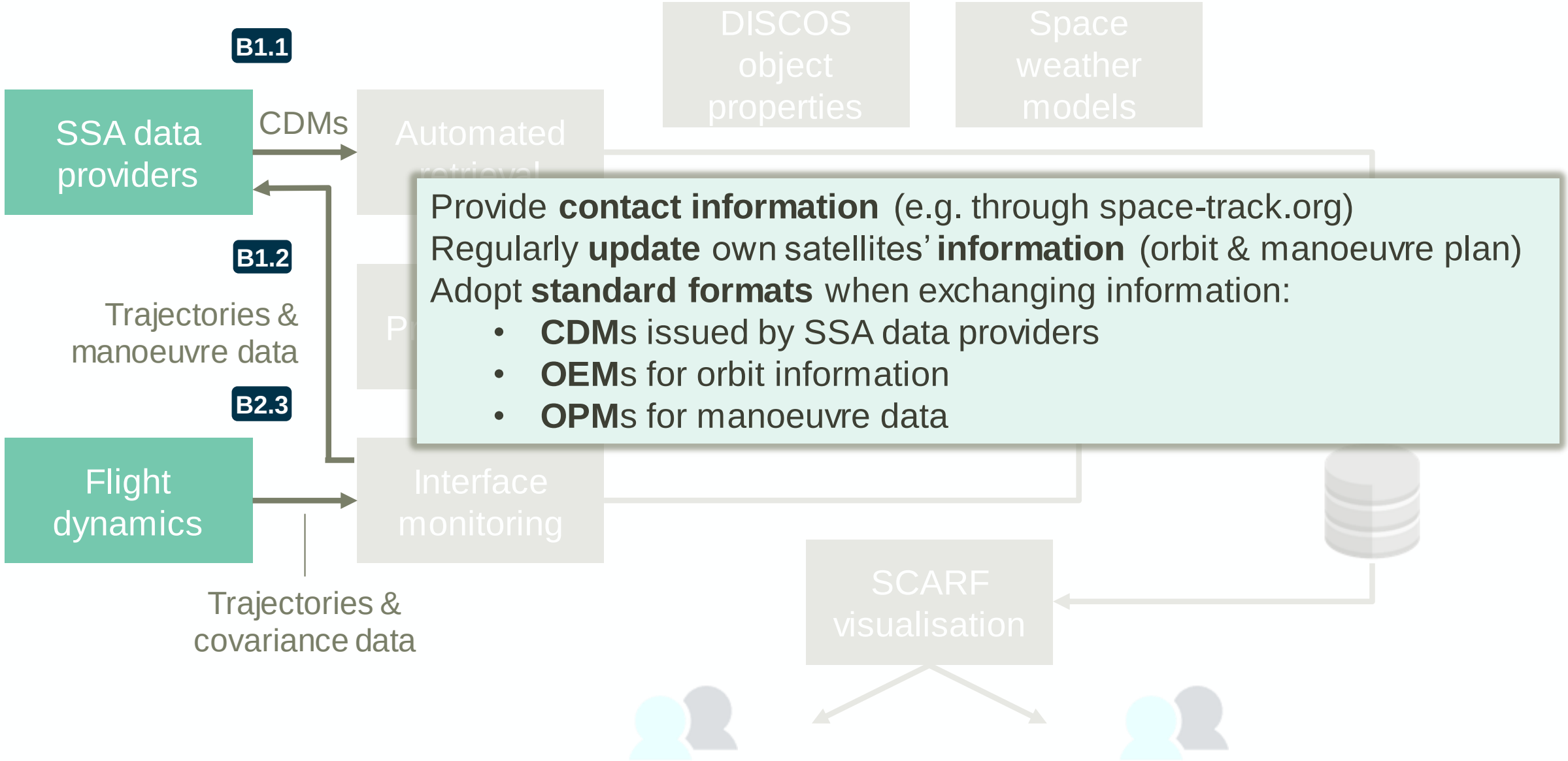
- Institutional missions
- Third-party missions

Additional support to non-LEO missions (Cluster, XMM, Integral) and during LEOPs (MSG, Galileo, MetopC, Sentinel 6)

Our process at a glance



Data sharing – Operational products



Provide **contact information** (e.g. through space-track.org)
Regularly **update** own satellites' **information** (orbit & manoeuvre plan)
Adopt **standard formats** when exchanging information:

- **CDM**s issued by SSA data providers
- **OEM**s for orbit information
- **OPM**s for manoeuvre data

Data sharing – information on objects

B1.5

DISCOS object properties

Space weather models

SSA data providers

CDMs

Automated retrieval

Trajecto manoeuvr

RAM

Flight dynamics

Data curation for objects in space
Assess provided worldwide

- **normal users**: web-based interface
- **operational users**: API available

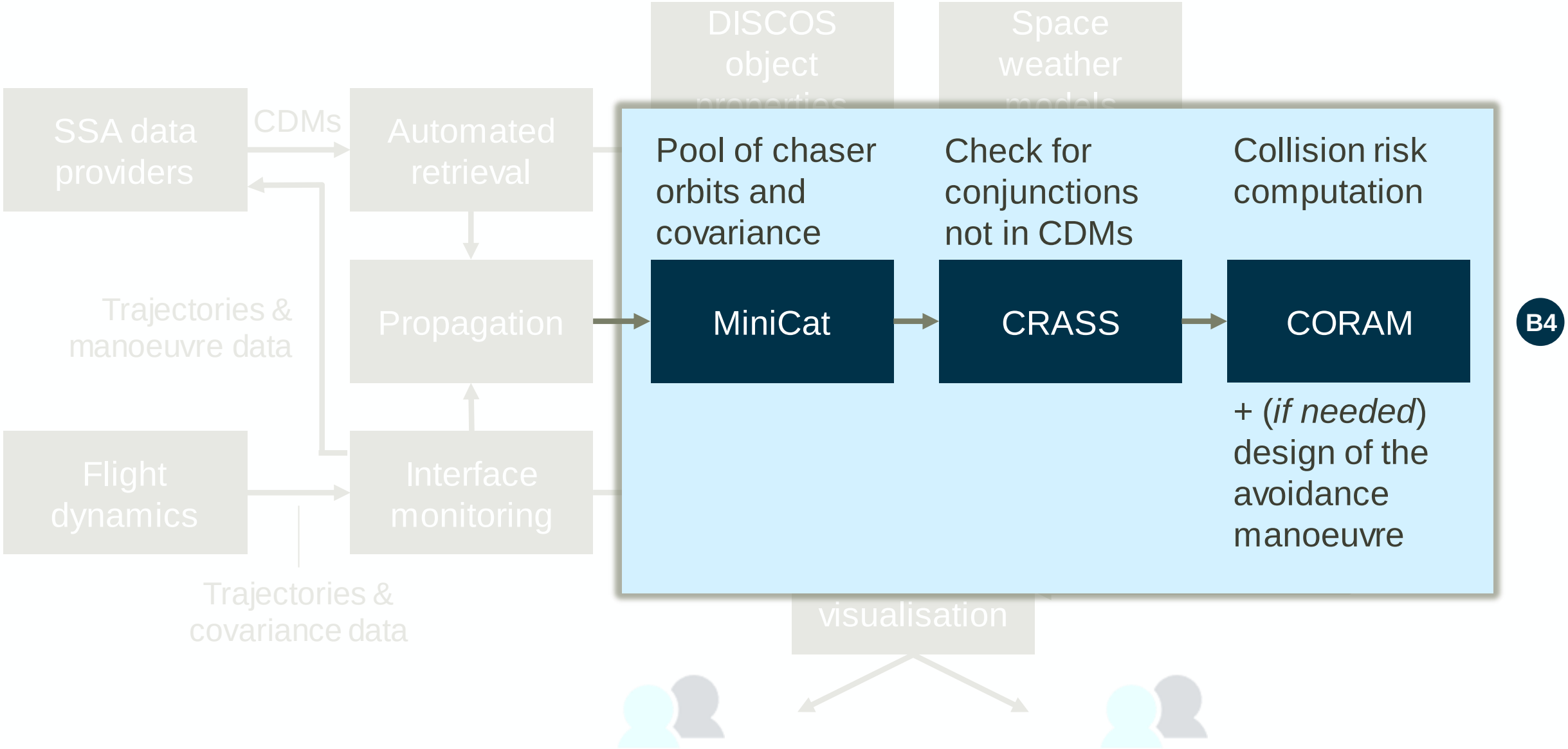
Backbone for several analysis activities such as compliance monitoring

DISCOSweb ▾ Home Data ▾ API Documentation Francesca Letizia ▾

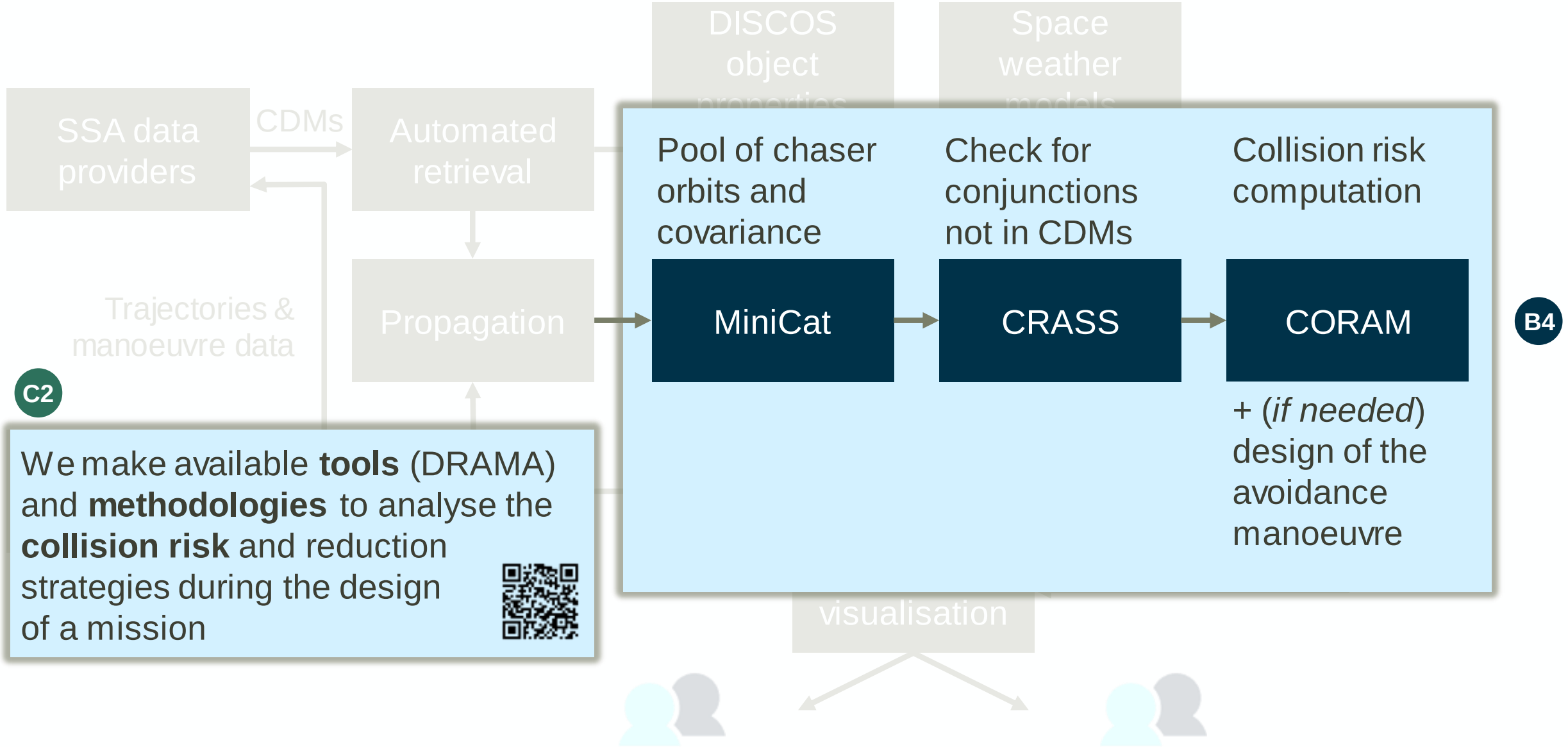
Objects

DISCOS ID	Name	SATNO	COSPAR ID	Vimpel ID	Object Class	Mass (kg)	Shape	Length (m)	Height (m)	Depth (m)	Re-entry Epoch	Max. cross section (m²)	Min. cross section (m²)	Avg. cross sectio
					Show All									
1	Sputnik (8K71PS) Blo...	1	1957-001A		Rocket Body	3964.32	Cyl	2.95	28	28	01/12/1957	82.8823	6.8349	68.2914
2	Sputnik 1	2	1957-001B		Payload	82.85	Sphere	0.58	0.58	0.58	03/01/1958	0.2642	0.2642	0.2642
3	Sputnik 2	3	1957-002A		Payload	503.77	Cone + Cyl				14/04/1958			
4	Explorer 1	4	1958-001A		Payload	13.88	Cyl	0.15	2.03	2.03	31/03/1970	0.305	0.0177	0.248
5	Vanguard 1	5	1958-002B		Payload	1.46	Sphere	0.16	0.16	0.16		0.0201	0.0201	0.0201
6	Explorer 3	6	1958-003A		Payload	13.88	Cyl	0.15	2.03	2.03	28/06/1958	0.305	0.0177	0.248
7	Sputnik (8A91) Blok-A	7	1958-004A		Rocket Body	3964.32	Cyl	2.95	28	28	03/12/1958	82.8823	6.8349	68.2914

Conjunction assessment



Conjunction assessment



Alerts & manoeuvres

Escalated events = alert to missions

collision probability near pre-defined threshold & conjunction closer than 3 days

Manoeuvre

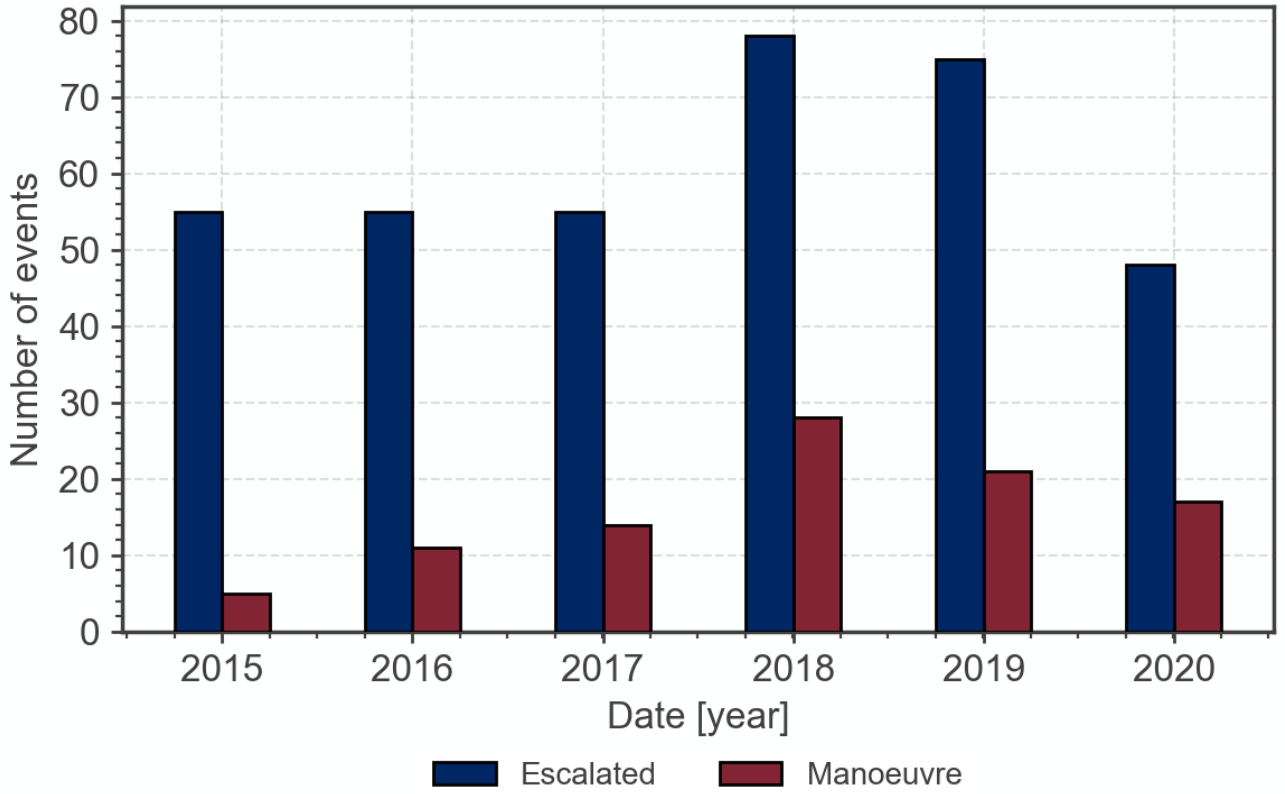
collision probability above pre-defined threshold & conjunction closer than ~ 1 day

For a Sentinel-like mission:

- **1** alert/month
- **1** manoeuvre/**3** months

For each manoeuvre

- Negligible fuel consumption
- ~8 hours of data outage



Alerts & manoeuvres

C4

Escalated events = alert to missions

collision probability near pre-defined threshold & conjunction closer than 3 days

Manoeuvre

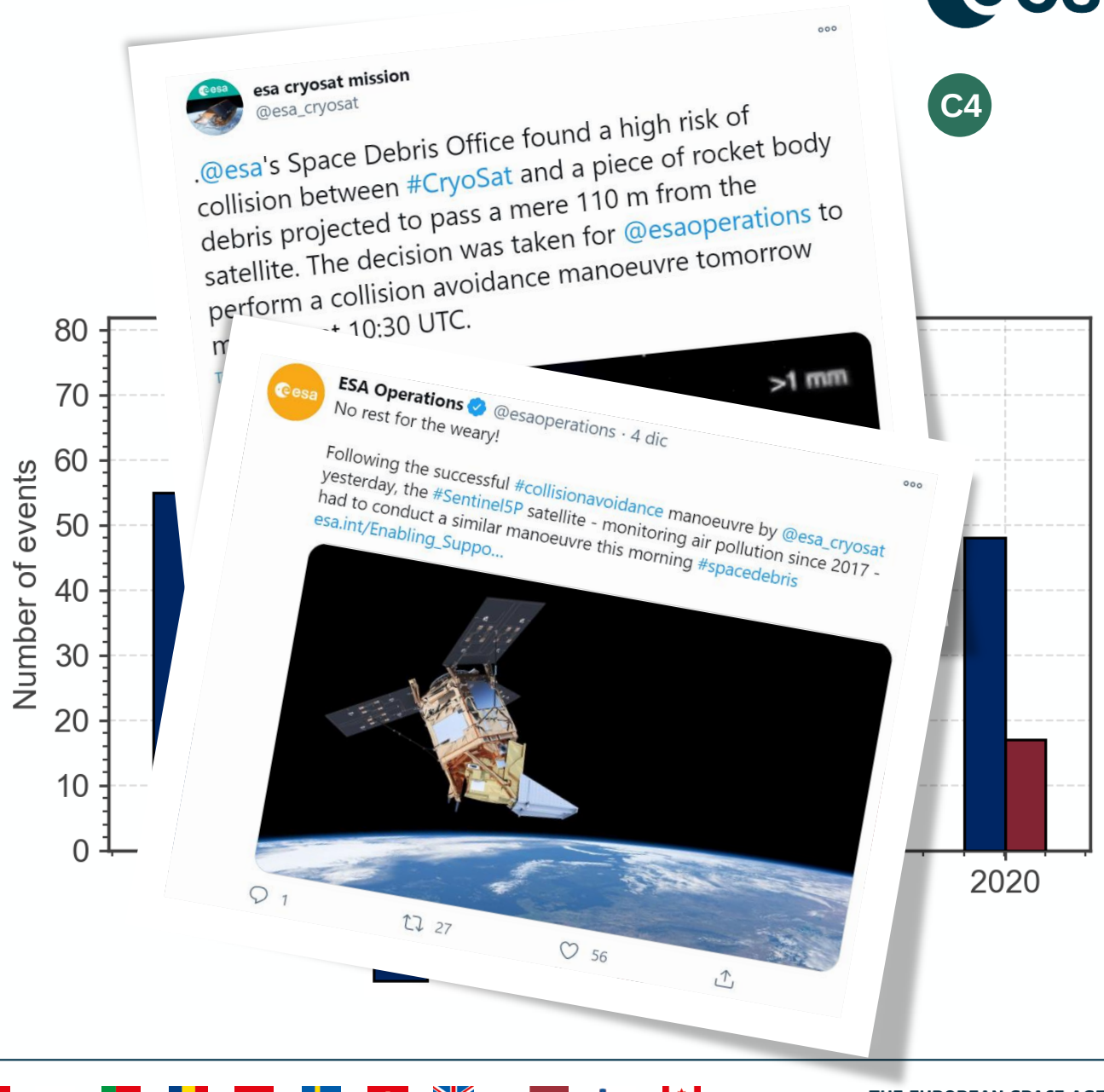
collision probability above pre-defined threshold & conjunction closer than ~ 1 day

For a Sentinel-like mission:

- **1** alert/month
- **1** manoeuvre/**3** months

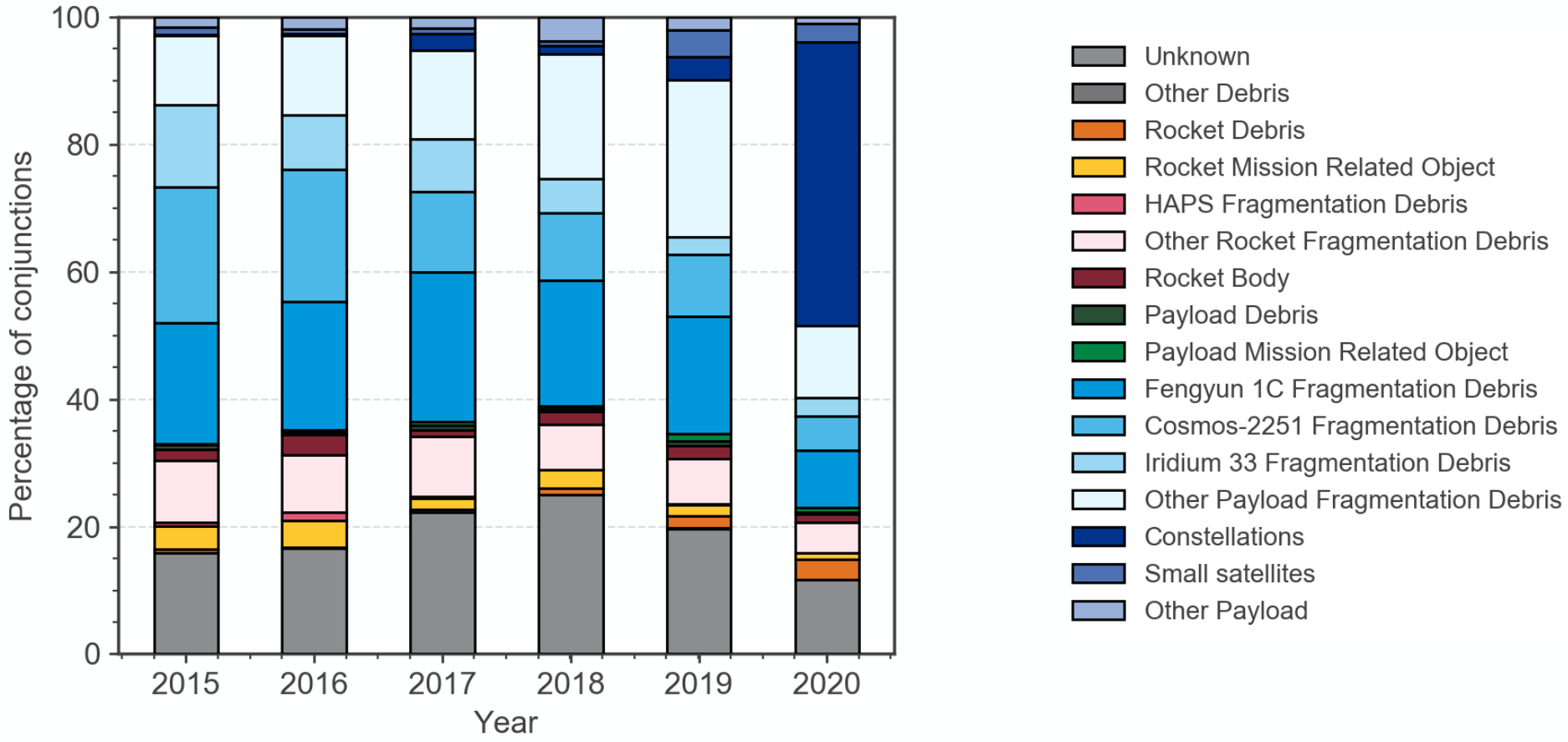
For each manoeuvre

- Negligible fuel consumption
- ~8 hours of data outage



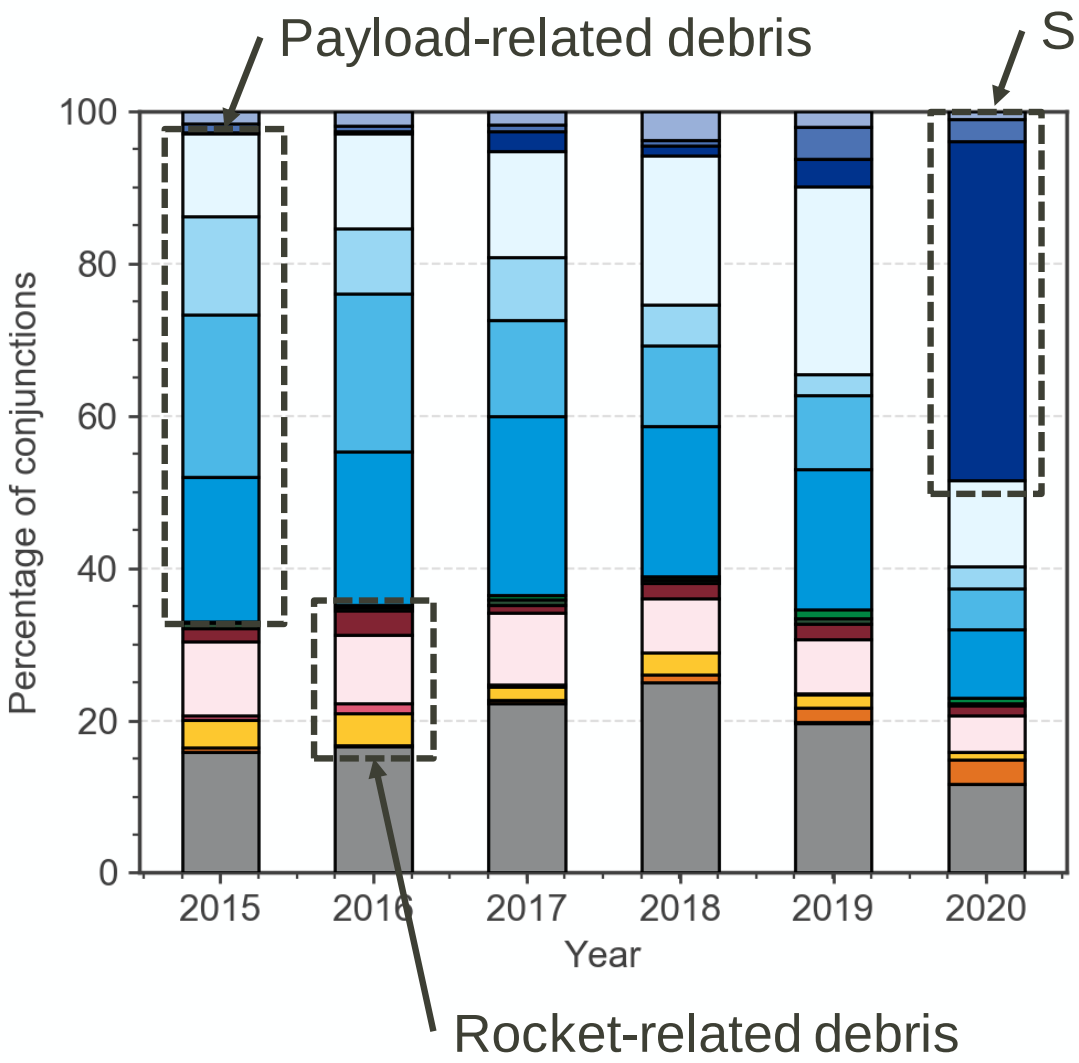
Conjunction statistics

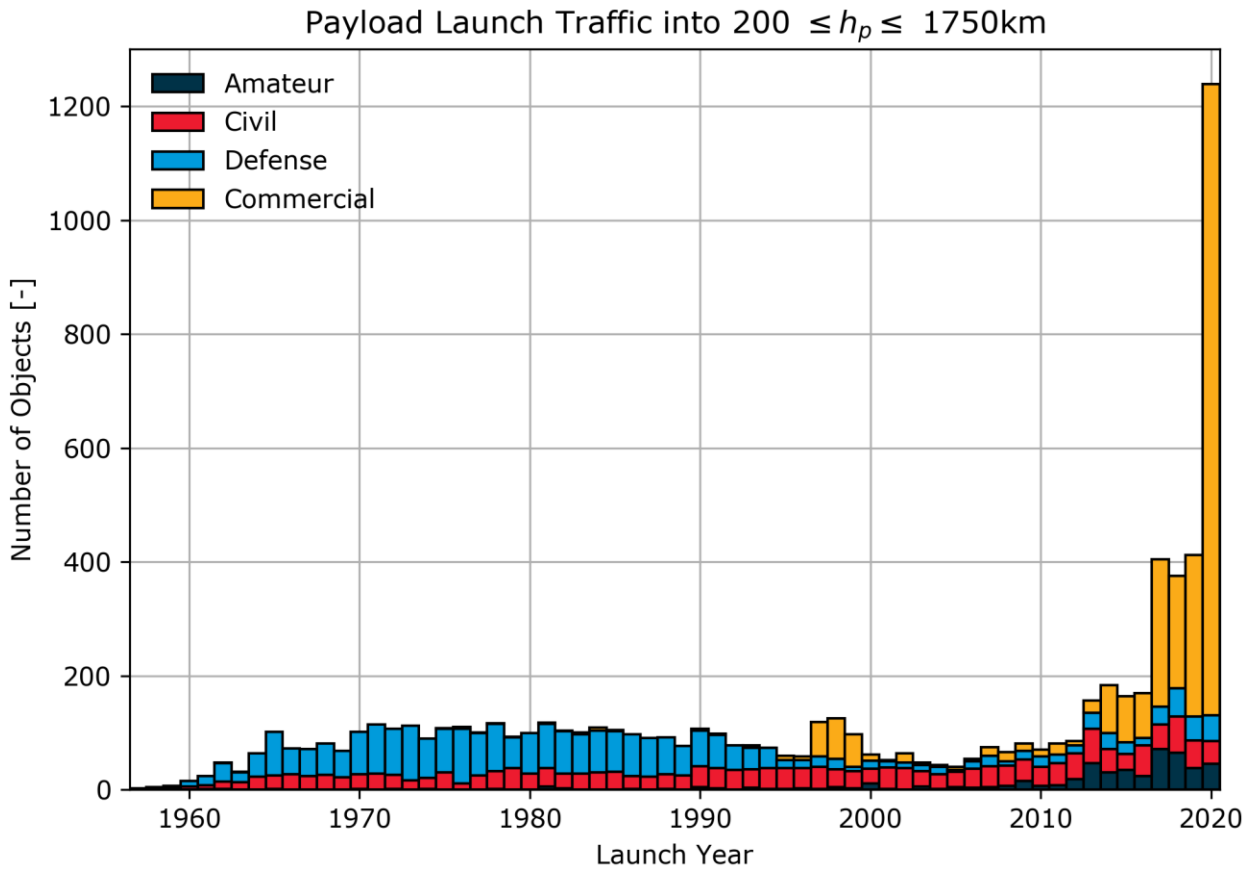
Data for events with collision probability > 10^{-6}



Conjunction statistics

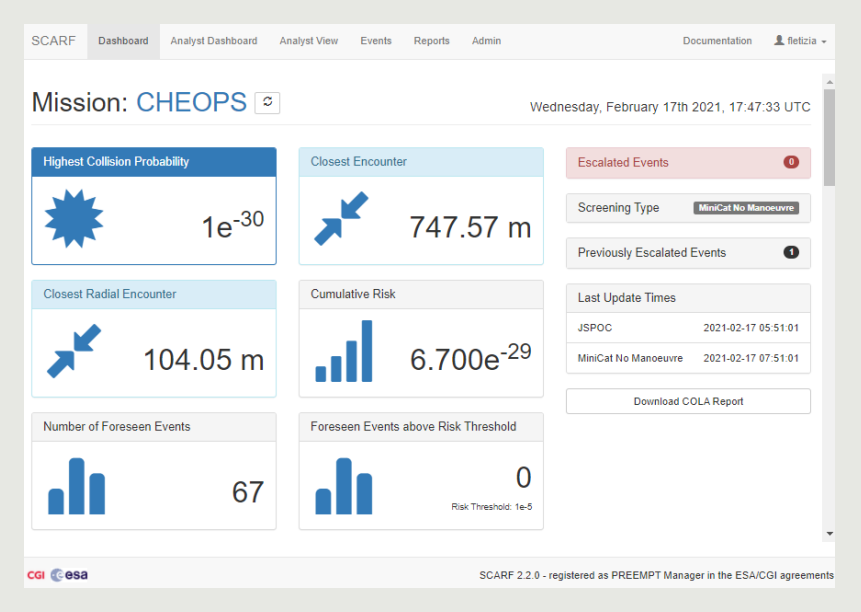
Data for events with collision probability > 10^{-6}

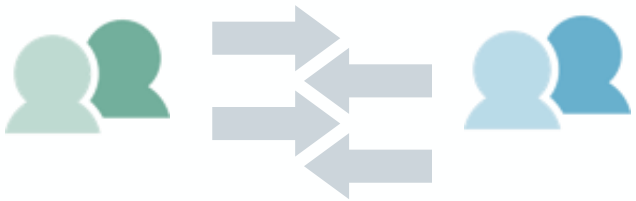




Emerging trends: towards more automated systems

Current approach

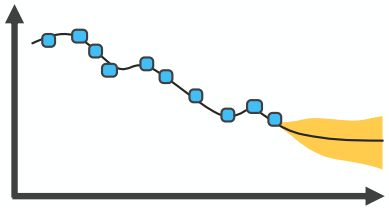




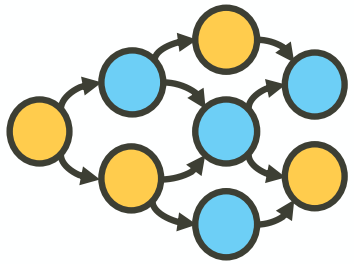
Flight control team

Debris analysts

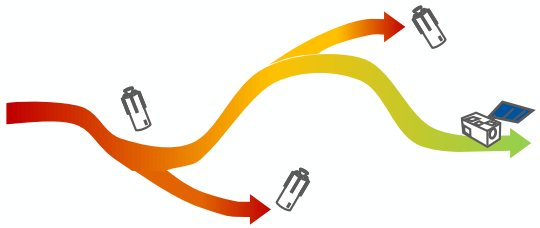
Research directions & future approaches



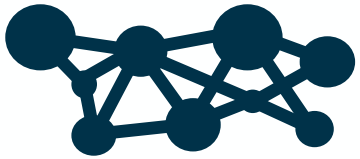
Assessment of historical conjunctions and model training



Approaches for automated (and explainable) decisions



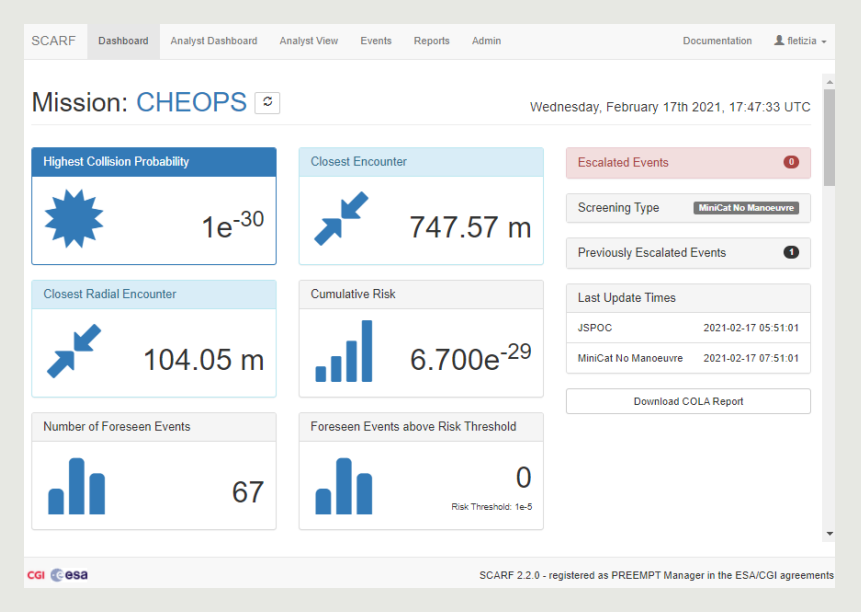
Advanced manoeuvre design

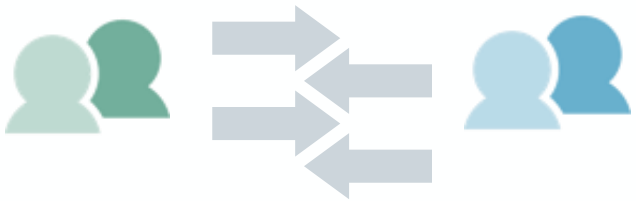


Coordination of operators and catalogue providers

Emerging trends: towards more automated systems

Current approach

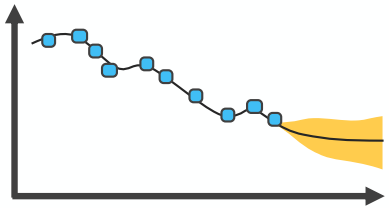




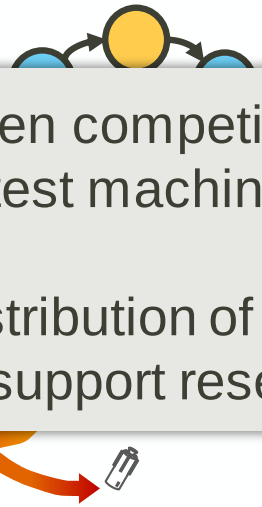
Flight control team

Debris analysts

Research directions & future approaches



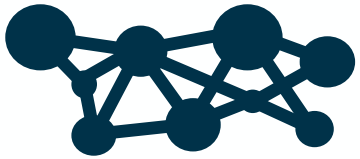
Assessment of historical conjunctions and model training



D1

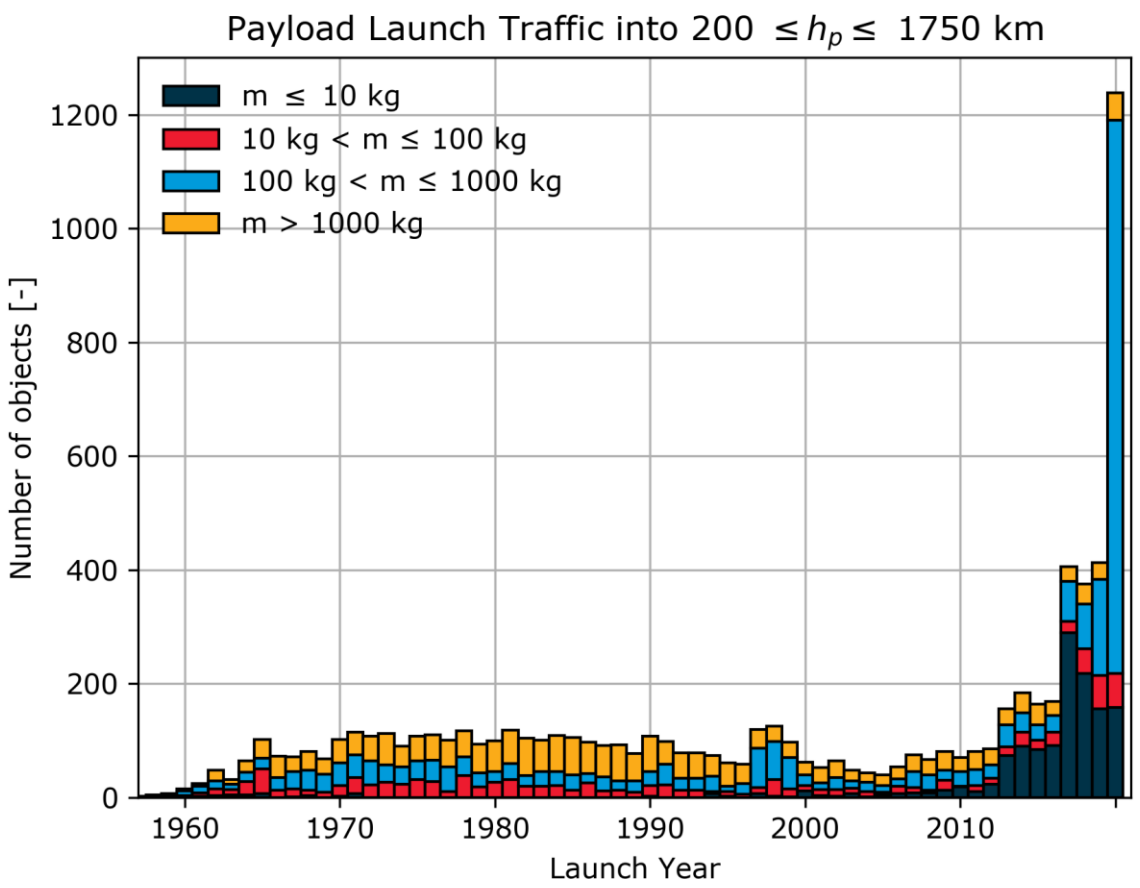
Open competition in 2019 for researchers to test machine learning approaches

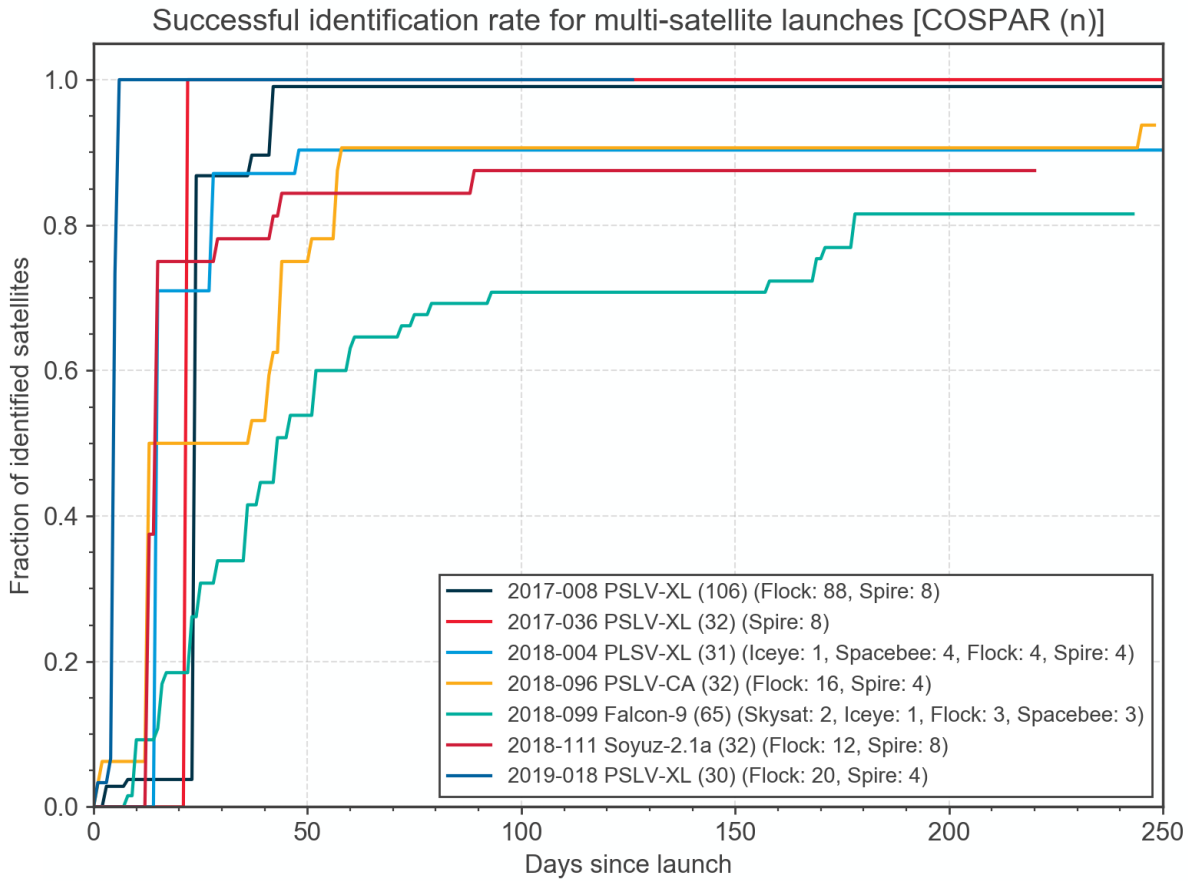
Distribution of anonymised operational CDMs to support research in conjunction evaluation



Coordination of operators and catalogue providers

Emerging trends: small satellites & trackability





Conclusions

B1

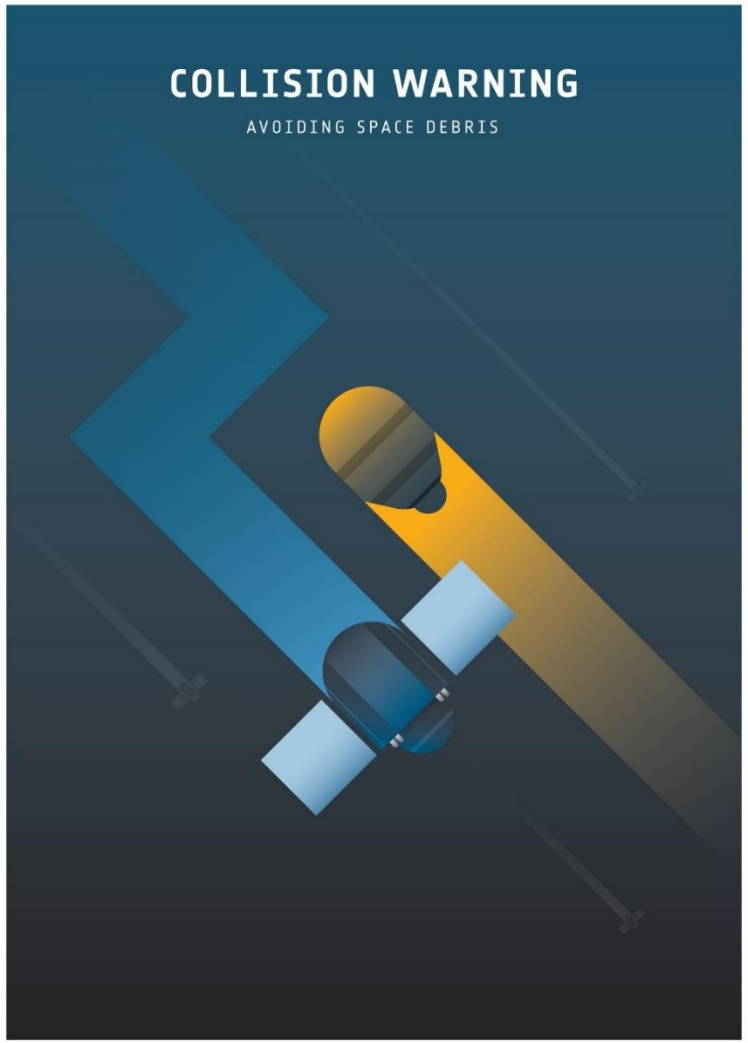
B2

B4

C2

C4

D1



Collision avoidance an **operational reality** for actors in space: convergence of **self-interest** and long-term **sustainability** of operations as captured in the **UN LTS Guidelines**

ESA process based on **standardised products**, curated **object data**, **automated workflow** + contribution in **tools** and knowledge dissemination

The changes in the use of space call for

- Increased **data quality** and **sharing**
- Improved **coordination** methods
- Increased **automation**

Developments in collisions avoidance activities are an important pillar in **ESA Space Safety Programme**

UNITED NATIONS
Office for Outer Space Affairs

esa

#SpaceCare

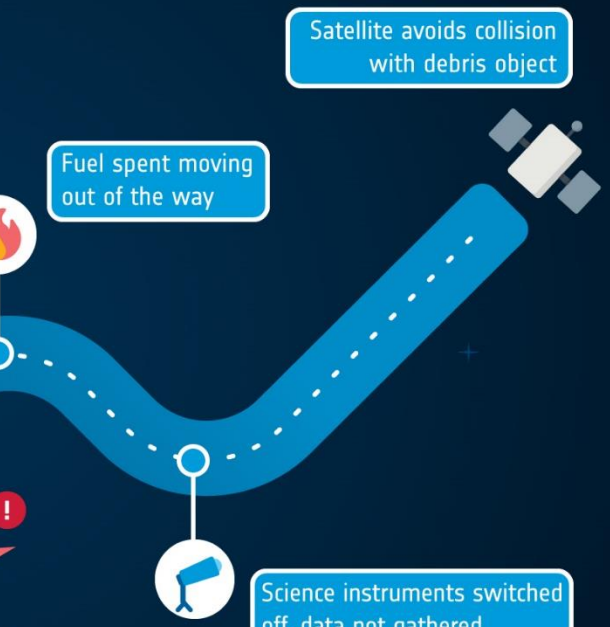
THE COST OF AVOIDING COLLISIONS

The challenge of avoiding collision with space debris has been **recognised at an international level**. The United Nations Office for Outer Space Affairs published the **Space Debris Mitigation Guidelines** in 2007, which include the need to limit the chance of accidental collision in orbit.

ESA performs roughly **two 'collision avoidance manoeuvres' per year**, with **each** of its Earth-orbiting spacecraft.

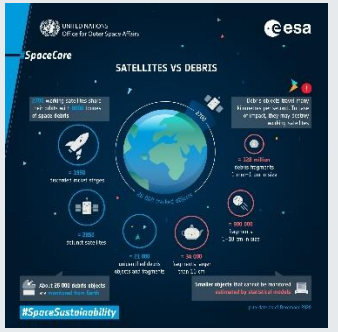
The number will increase with the **significant rise of global space activity** in years to come.

Every time a satellite swerves to avoid collision, **something is lost**:



Up-to-date as of December 2020

#SpaceSustainability



Follow **@esaoperations** for the latest graphics and podcasts on collision avoidance activity & sustainable operations realised in collaboration with UNOOSA

Dr. Francesca Letizia
ESA/ESOC Space Debris Office (OPS-SD)
Robert-Bosch-Str. 5, 64293 Darmstadt, Germany
T +496151902079
francesca.letizia@esa.int
http://www.esa.int/debris