Space Sustainability Rating

Virtual Workshop

15th April 2021

Agenda for the day

Agenda:

- **16:00 – 16:05 pm CET** – introduction and opening remarks by the Forum
- **16:05 – 16:25** – MIT and ESA teams present the overall SSR framework and latest technical updates
- **16:25 – 16:40 –** MIT and ESA team presents the updates from alpha and beta tests
- **16:40 – 16:55 –** Forum, ESA and MIT teams present updates related to host selection and other organizations elements
- **16:55 – 17:15 – Q and A**

Background

The **World Economic Forum**'s Global Future Council (GFC) on Space Technologies, during the **2016-2018 term,** initiated a conversation about potential **ratings** for space missions

Goal: promote the importance of space **sustainability**, with a focus on the challenge of **orbital debris**

Call for proposals to find partners to develop the Space Sustainability Rating (SSR) was launched at **IAC 2018.**

Winning consortium (post-application): **ESA + MIT/UT/Bryce** notified in January 2019

SSR in development since two years

Governance of SSR

- The project consortium is focused on the day-to-day work of developing the rating

- **Advisory Group** - Independent and multi-stakeholder group of experts who advise and provide high-level guidance.

- The current Advisory Group and project members will continue to provide independent oversight and support the **future “host” organization** to ensure continuity.

What do we mean by "Space Sustainability"

- Sustainability in space will ensure that we can continue to use and maintain the resources of the Space Environment for generations to come

- Sustainability also refers to the long term capability to avoid loss, disruption, or degradation of space services and activities

- The Space Sustainability Rating Team builds on the concepts of Sustainability developed in the United Nations Committee on the Peaceful Uses of Outer Space in the 2019 Guidelines for the Long Term Sustainability of Outer Space

- The Space Sustainability Rating draws from the principles outlined in the UN Guidelines and considers specific decisions about design, operations and post mission disposal that reduce risk of collisions, shorten orbital time for debris and increase space situational awareness

The SSR Consortium Team spreads awareness of the project via virtual events

- SWF Summit for Space Sustainability, September 2020
  - Panel discussion featuring ESA
- AMOS Conference, September 2020
  - Presentations, technical papers and panel discussions by MIT, UT and ESA
- International Astronautical Congress, October 2020
  - Technical Presentations co-authored by SSR Consortium
- AIAA Ascend Conference, November 2020
  - Two Panel discussions featuring MIT, ESA, Bryce and WEF
- ANSI Meeting on Standardization and the Commercial Space Industry, December 2020
  - Presentation and panel discussion featuring MIT
- Upcoming: ESA Space Debris Conference, April 2021
  - Presentation and panel discussion

Concept

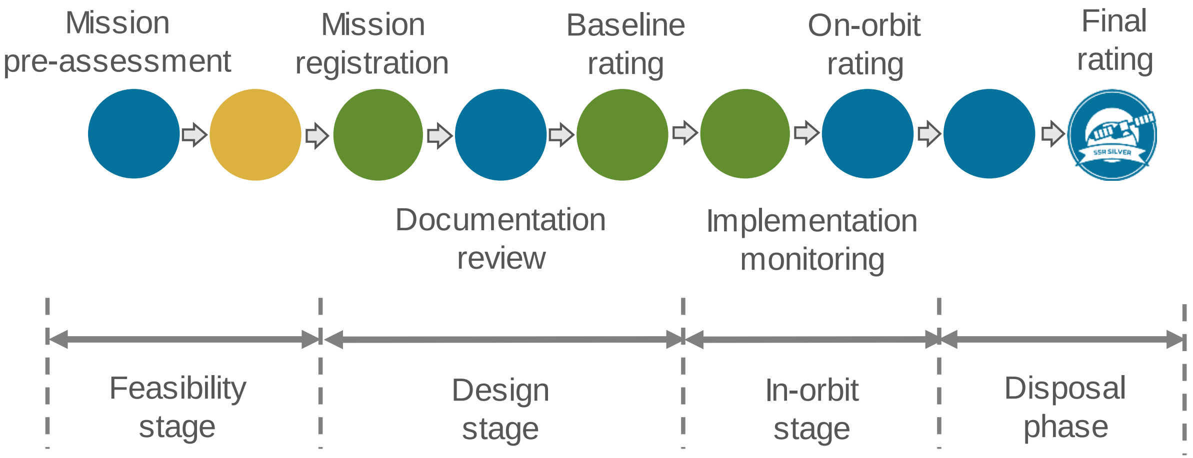
Main objective: create an **incentive** to

- **design** missions compatible with sustainable operations
- **operate** missions considering not only mission objectives & service quality, but also the potential harm to the orbital environment and the impact on other operators

Not a new set of guidelines, but a system to recognise **compliance** and **better-than-required** behaviours

Illustrative example inspired by the LEED classification system

Timeline



Tiers

SSR CERTIFIED SSR SILVER SSR GOLD SSR PLATINUM

SSR CERTIFIED

Step indicator
extra commitment beyond current practices

Framework for the Space Sustainability Rating

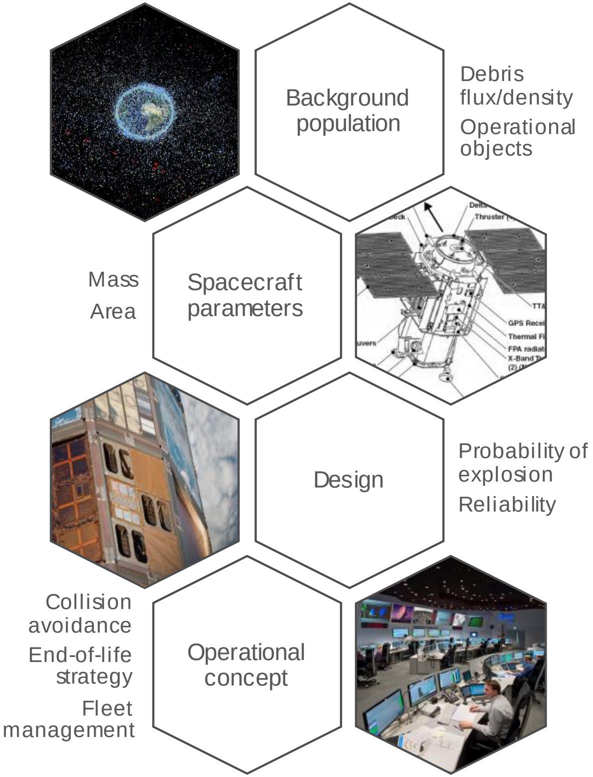
Potential scope

Selected architecture

Composite indicator based on 6 + 1 modules

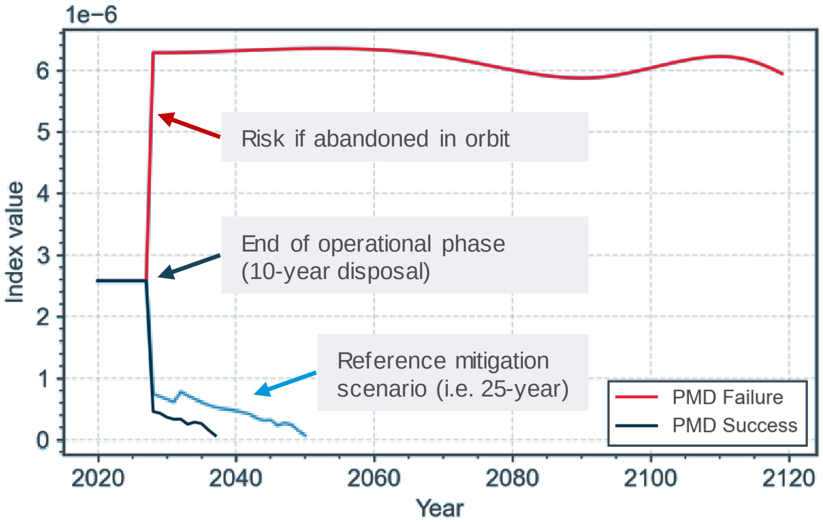
- Cross-parameter evaluation
- Simulation-based parameters
- Questionnaire-based parameters

Mission Index



Single metric to collect how several mission parameters translate into **fragmentation risk** (i.e. risk = probability x severity) ‣ Letizia et al., 7th ESDC, 2017

Evaluation of the submitted mission (*absolute* term) and comparison with a **reference mitigation scenario** (*relative* term)



Mission Index normalisation

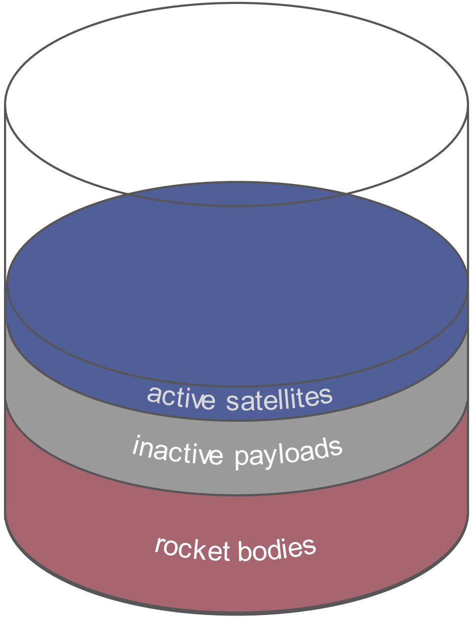
Normalisation of the absolute term based on the concept of **environment capacity** (i.e. number/type of missions compatible with the long-term stability of the environment)

Capacity instead of reference mission:

- more **complex** as it requires regular monitoring
- more **robust** approach with respect to a changing environment

Functional definition for the translation into a score, calibrated through the analysis of the score distribution across the current population of space objects

- Krag et al., ICSSA, 2017,
- Lemmens&Letizia, Springer, 2020



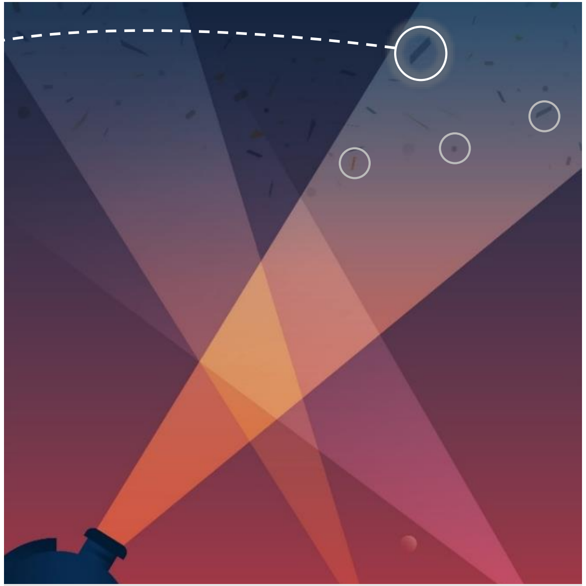
Detectability, Identification, and Tracking

‣ R. Steindl et al., IAA-UT STM conference, 2020

likelihood that an object can be **observed** by ground surveillance systems (without prior knowledge)

likelihood that an object can be **uniquely distinguished** (without coordination with the operator)

feasibility of **orbit evolution** prediction for a detected objects (for an agent different from the operator)



Metrics

Object visual magnitude

(optical sensors)

Probability of Detection

(radar sensors)

Metrics

Under development

Metrics

Sensor Pass Duration

Orbital coverage

Interval duration

+ questionnaire on tracking operations and photometric/radiometric characterisation

DIT normalisation

▸ R. Steindl et al., IAA-UT STM conference, 2020

For the **Detectability** score (D) and the **Trackability** score (S), definition of performance tiers for each metric, based on literature & analysis of the distribution across current population + score from the questionnaire (Q)

For **D**, the **maximum score** between optical and radar sensors is selected

For **T**, all metrics have **the same weight**

DIT score = (D + S + Q)/3

Sub-module	Metric	Tiers			
Detectability	Visual magnitude	< 15		≥ 15	
	Probability of detection	<50%	50-75%	≥ 75%	
Trackability	Pass duration	<120''	120-180''	180-400''	>400''
	Orbital coverage	<10%	10-25%	25-60%	>60%
	Interval duration	>12h	12-6h	<6h	

Collision Avoidance Capabilities

Risk-reduction actions are captured in the Mission Index; here focus on the operators' **capabilities** to identify, respond to, and mitigate collisions

- **Orbital state knowledge**, with levels based on state accuracy, update frequency, covariance characterisation
- **Availability to coordinate**, with levels based on personnel availability
- **Capability to coordinate**, with levels based on the presence of established procedures to handle conjunctions alerts
- **Capability during disposal**: contribution to the bonus score

Collision avoidance capabilities	Answers
Orbital state knowledge	High | Medium | Low | No
Availability to coordinate	
Capability to coordinate	
Capability during disposal	

Data Sharing

Matrix approach:

- **Which data** is shared
  - Collision avoidance coordination
  - Satellite metrics
  - Mission characterization
- **With whom** is shared
  - SSA Provider
  - With other operators upon request
  - Within a voluntary network of operators/stakeholders
  - Public

Different level of **scoring** depending on the contribution of the shared data to **spaceflight safety**
(e.g. satellite manoeuvrability > mass)

Data sharing [extract]	Answers
Collision avoidance contact information	SSA Provider | Upon request | Within voluntary network | Public | None
Satellite ephemerides (including planned manoeuvres)	
Covariance information	
Launch timing	
Satellite mass	
Satellite manoeuvrability	
Satellite operational status	
Availability of autonomous collision avoidance systems	
Spacecraft anomaly information	
API for machine-to-machine access	

Application of Design & Operation Standards

Application of standards essential to ensure a **common understanding** among operators

Distinction between mandatory and voluntary adoption:

- **mandatory**: accounted to discourage choosing looser regulatory regimes
- **voluntary**: contribution to the bonus score

Tailoring to be detailed to allow for scoring correction

Standards	Answers
Space debris mitigation guidelines (e.g. UNCOPUOS, IADC)	Mandatory | Voluntarily | N/A | No
Long Term Sustainability guidelines	
Space debris mitigation standards or verifiable laws (e.g. ISO, FSOA, NASA)	
Standardised operational product (e.g. CCSDS)	
Safety standard (e.g. CONFERS or human-graded standards)	
ITU regulations	
Has any of the above been tailored?	Yes | No
Does your launching state commit to register your payload with the UNOOSA Register of Objects Launched into Outer Space?	

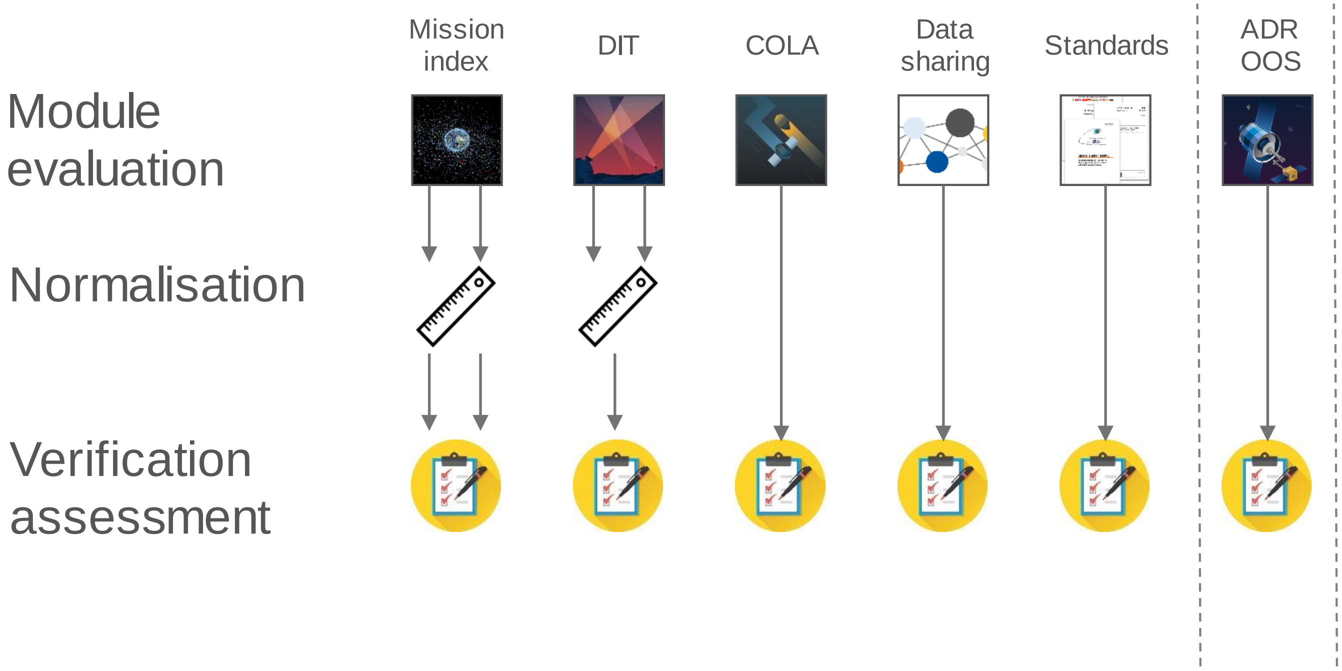
External Services

Contribution to the **bonus score** (still low maturity, low adoption)

Always intended as in **addition** to traditional disposal actions

External services	Answers
On-orbit service features	Yes | No
Standardised interfaces	
(Procurement of) life extension services	
(Procurement of) active removal services	

Composite indicator



Verification

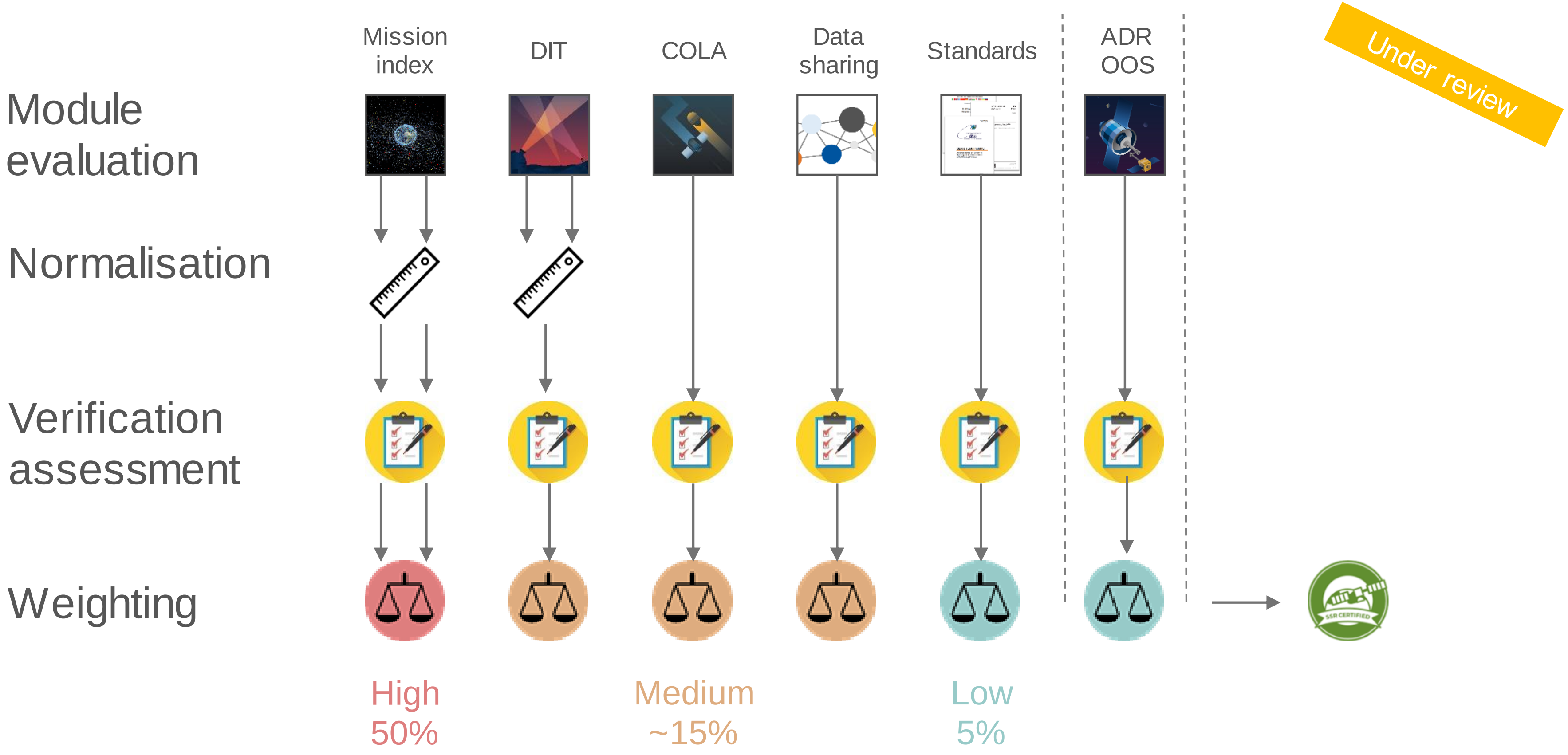
Rationale: an SSR application will **not** involve an **in-depth review** of the **mission design** on behalf of the SSR issuer.

Approach: evaluate the level of **verifiability** of the data provided and already **existing verifications** provided by technical authorities.

Verification **weighting** applied to each **input** provided for the SSR modules

Verification	Score
Assertion by applicant	0.5
Assertion with technical documentation	0.6
Technical documentation available for public review	0.8
Independent technical review	1.0

Composite indicator



Tier definition

- **Certified:** The mission meets the pre-requisite requirements to apply for an SSR. The Applicant demonstrates willingness to increase mission's sustainability. Current sustainable practices need to be incorporated into the mission.

- **Silver**: The mission incorporates current sustainability practices with areas to improve upon. The Applicant demonstrates consideration for the orbital environment in design and operation of mission.

- **Gold:** The Applicant demonstrates currently accepted best practices for sustainability in all aspects of the mission. The mission has minimal impacts on the orbital environment beyond the necessary use.

- **Platinum:** The mission incorporates innovative methods for improving the orbital environment that go beyond common best practices. The Applicant demonstrates sustainable practices that enhance sustainability outcomes across all aspects of the mission.

Conclusions

Space Sustainability Rating goals

- promote the importance of space **sustainability**, with a focus on the problems with **orbital debris**
- incentivise **positive behaviour**

Several possible components analysed:

- proposed formulation based on **6(+1) modules**
- selection based on **relevance**, **access**, **verifiability**

Normalisation & **weightings** required to combine the modules into a **single score**

- analysis of value **distribution** across existing missions
- feedback from **alpha** and **beta-tester** on the outcome of the calibration

Questions?

Case studies from alpha & beta testers

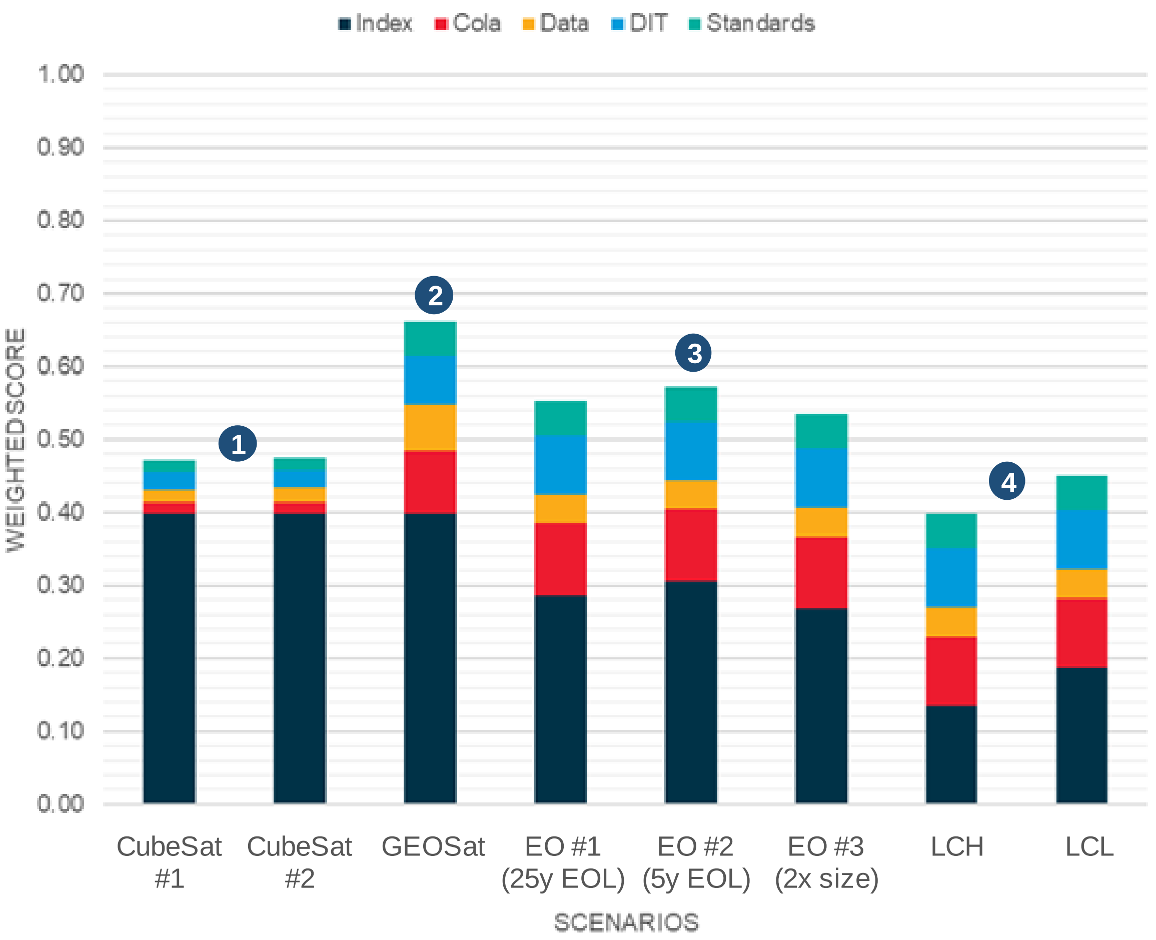
Example of mission evaluations

GEO missions benefit from reduced risk metric with respect to LEO missions

2

1

CubeSat missions have low associated risk, but are penalised by the lack of collision avoidance capabilities



Variations on an Earth Observation mission to assess the sensitivity to operator choices (e.g. disposal) and to design features (e.g. size)

3

4

Large LEO Constellations cases at High and Low altitude. Significant risk contribution.

Example of mission evaluations

Same reference Earth Observation mission, but different levels of data verifiability

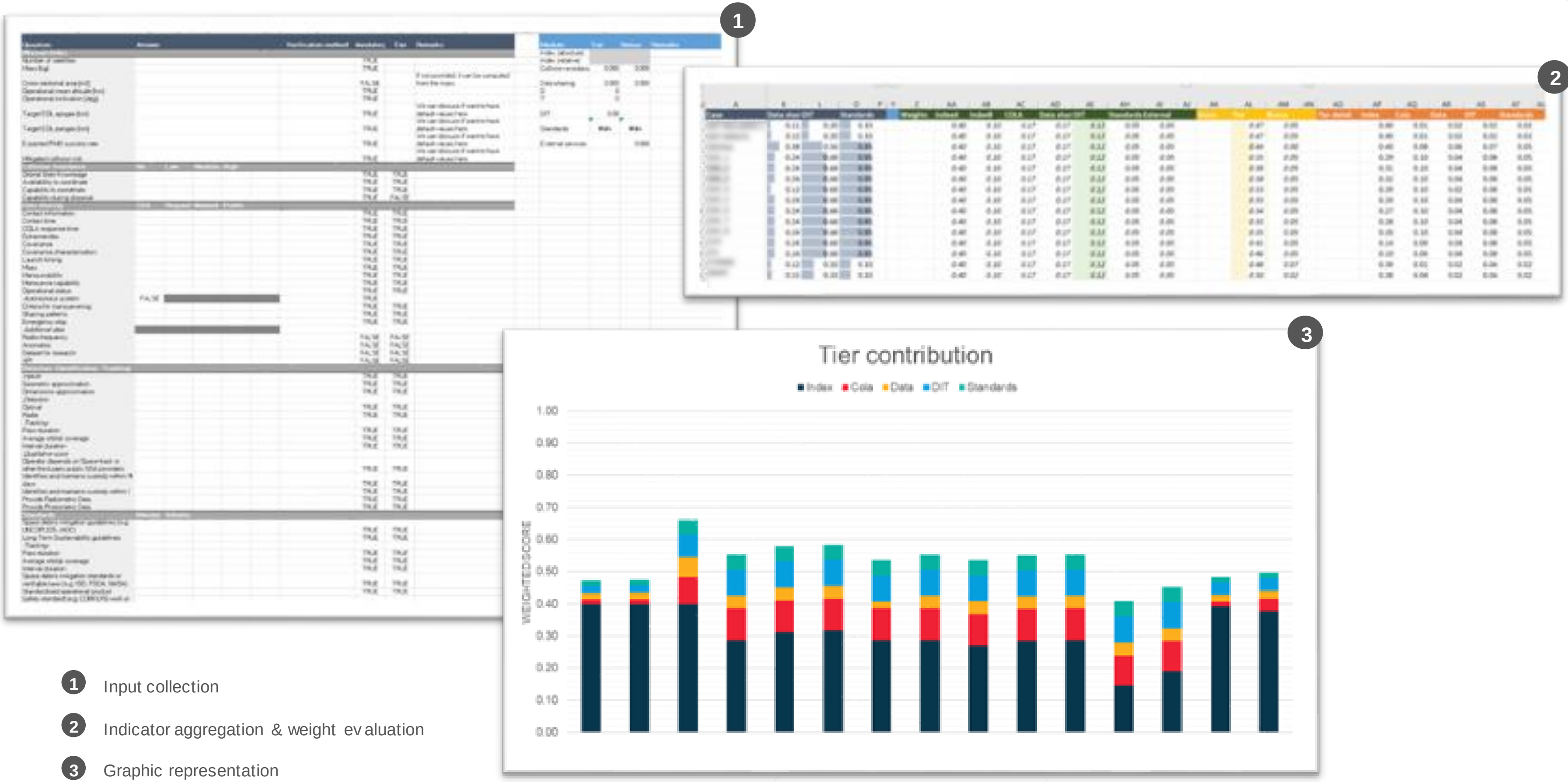
1. current
2. all inputs verified by an external authority
3. all inputs based on assertion only

Beta testers

Platform for Earth Observation
Mature design
New design
(e.g. improved compliance)

Constellation
Different orbital altitudes
Different generations

Workflow



1. Input collection
2. Indicator aggregation & weight evaluation
3. Graphic representation

Observations from Beta Testing the SSR

- Satellite operators and manufacturers design their missions in response to the constraints and needs of their end users and the physics of their orbit.
    - This leads to different options for how to pursue a high SSR score. Is there more flexibility in orbital selection, data sharing, collision avoidance, number of spacecraft? This depends on the mission requirements.

- Some satellite operators consider whether to extend the life of a satellite or replace it with a newer model. Understanding the sustainability impacts of life extension decisions and requires a life-cycle approach that considers the launch, spacecraft reliability, technology maturity and changes in the orbit.

Observations from Beta Testing the SSR

- Beta testers encouraged the SSR team to clearly communicate to operators what actions influenced their score and what actions they can take to improve it.

- Beta testers talked about how decisions are made about key mission features that influence the SSR at specific points in the design and operations phase.
  - For example, an orbital altitude is selected early in the design phase and it may not be feasible to change it; this may imply that the operator will need to consider other SSR modules to improve their score such as data sharing, collision avoidance or detectability.

Questions?

Organisational aspects

Host selection process

- The SSR Design Consortium (WEF, ESA, MIT, UT & BryceTech) issued a call for proposals in late 2020 to invite organizations to propose to serve as the SSR **future operator** or **“host” organisation.**
- The SSR operator organization should exemplify the following characteristics
  - **Trusted organization with expertise** in the space sector and experience with **space sustainability topics**
  - **Independent, unbiased organization** that is respected by organizations around the world
  - Is **non-profit** or has **capacity to run SSR as a non-profit programme** and does not have conflicts of interest
- The SSR Design consortium received several promising proposals and continues through the final selection phase.
- The vision is to complete **selection in the coming weeks.**

Considerations for the long term SSR operator organization

Key question for the SSR organization is: how big is the potential user base?

- <300 satellite operators
- Success depends on companies electing to participate

Significant participation will likely take years to develop (limited initial certification fees, total all operators; additional revenue possible from renewals/related services)

- Organization will likely require outside start-up and operational resources
- Fee / certification structure to be determined – per certification, membership model, incentives for early engagement with SSR team?
- Organization would likely benefit from continued engagement of experts

SSR organization unlikely to attract substantial for-profit investment unless tied to wider sustainable investment program or broader service offering

Narrow, near-term SSR business model is small; could conceivably be integrated with aligned business, find other paths to growth

Next Steps

- **April and May** – selection and alignment with operator/host entity(s)
    - finalization of weightings for parameters
    - finalization of first round of beta-testing with first 2 companies
    - 2nd round of beta-testing to fine tune weightings
    - initial phase of information and development history sharing with "host" entity(s)
- **Q2-Q3 2021** – transition phase and handover; support by project consortium and Advisory Group.
- **Q4 and 2022** – SSR operator finalizes the offering, initiates first commercial discussions, launches the first Ratings (*exact timeline TBC).*

Questions?