# Space Optimisation Competition (SpOC) 2022

ESA Advanced Concepts Team

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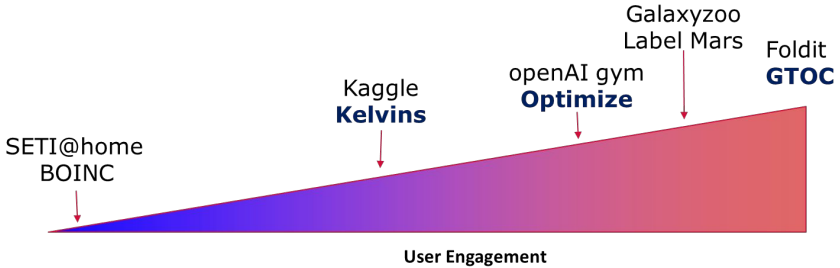
# Scientific Crowdsourcing via competitions




- **Public collaboration** and **competitions** for scientific research
- **Web platforms** to organize competitions on space problems
  - Kelvins (data driven) -> https://kelvins.esa.int/
  - Optimize (gym) -> https://optimize.esa.int
  - Global Trajectory Optimisation Competition -> https://sophia.estec.esa.int/gtoc_portal/
- **10+ competitions** organized since 2016
- **500+ international teams** participating
- **Pushing the boundaries** of research
- **Involving internal and external partners**

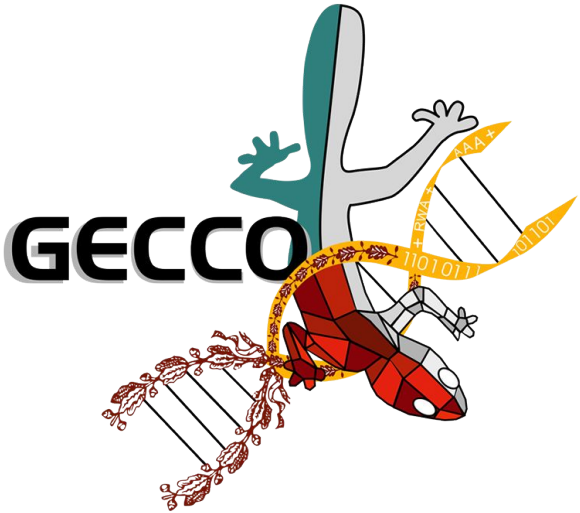
# Competition overview

- 2005 GTOC1 Save the Earth
- 2016 Mars Express Power Challenge
- 2017 Star Trackers: First contact
- 2017 GTOC9: The Kessler Run
- 2019 PROBA-V Super Resolution
- 2019 Pose Estimation Challenge
- 2019 Collision Avoidance Challenge
- 2020 spotGEO Challenge
- 2021 Space Debris: the origin
- 2021 Planetary Defence Challenge
- 2021 Pose Estimation: Bridge the domain gap with SPEED+
- 2022 Space Optimisation Competition (SpOC)
- 2022 AI on the Edge: OPS-SAT
- 2023 Event based datasets!


# What is SpOC ?

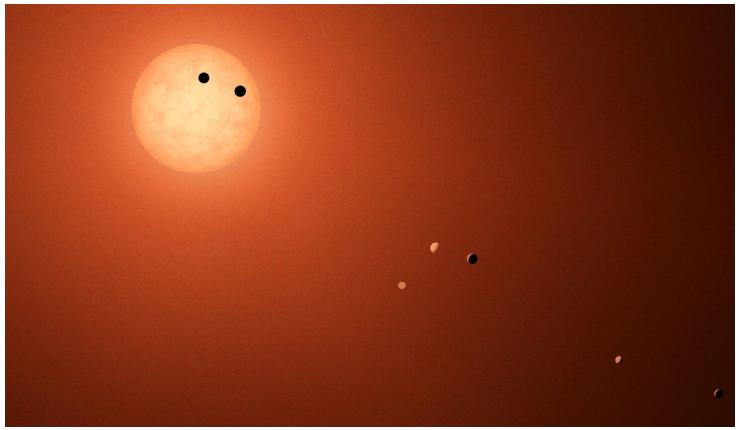
- Collaboration with the **Genetic and Evolutionary Computation conference (GECCO) 2022**
- Explore relevant space optimisation challenges wrapped in an **appealing futuristic setting**
- **Target a different scientific community**: evolutionary computation
- New competition format: **multi-challenge league**, gym-like platform with **Optimize**

⇒ https://optimize.esa.int/



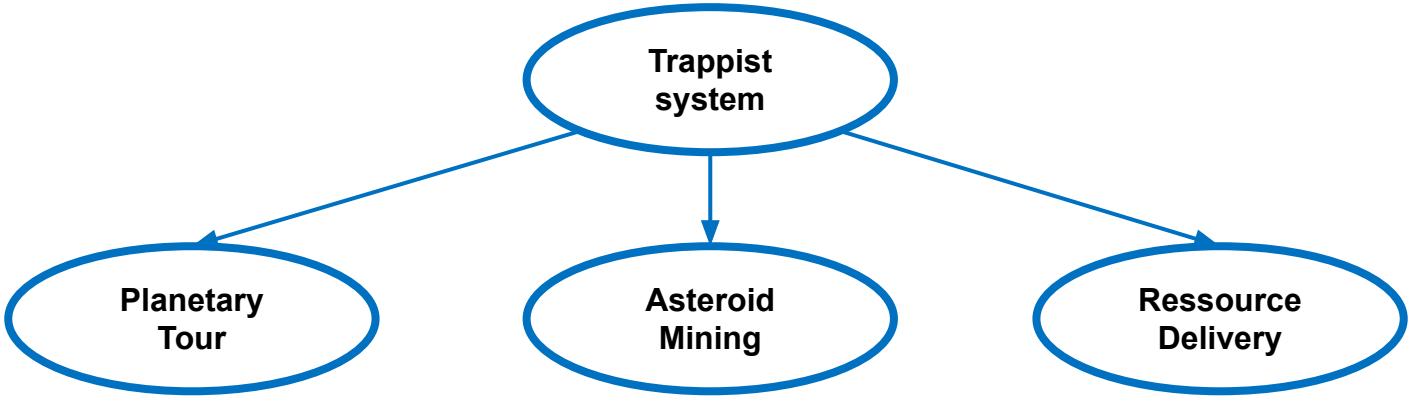
# Context for SpOC

- In 3275, **interstellar exploration and exploitation** became a possibility
- **Objective:** establish permanent human settlements on the TRAPPIST-1 system.
- Long-term effort in **3 phases**:
  - System Exploration
  - Resource Acquisition
  - Ressource Delivery & Manufacturing

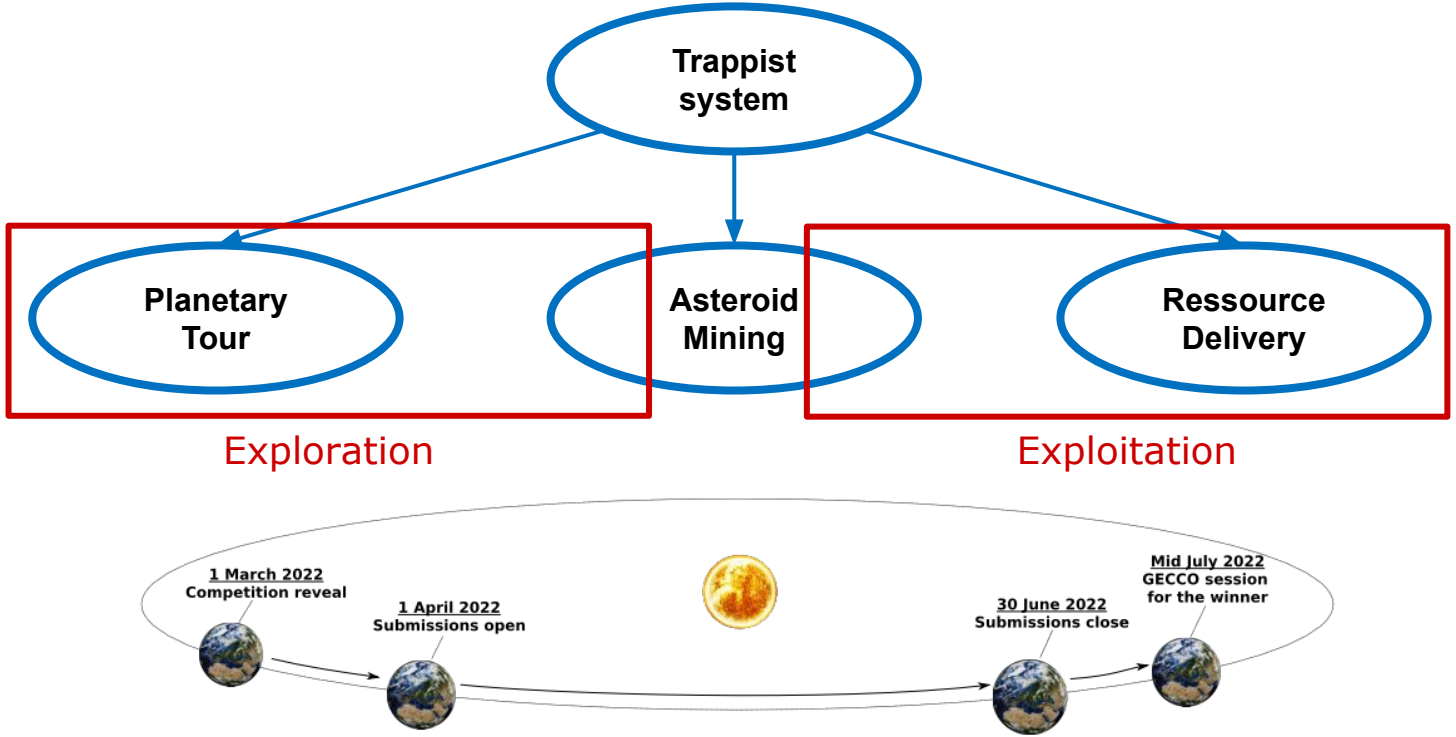


**For each phase, an optimisation challenge.**

# Themes and Activities

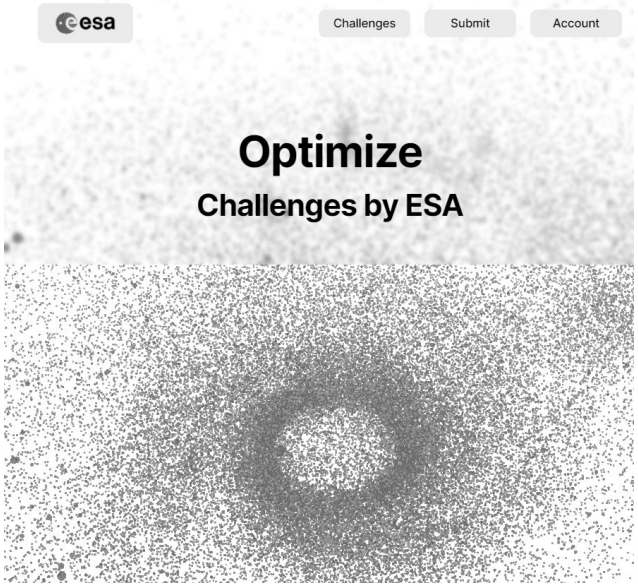


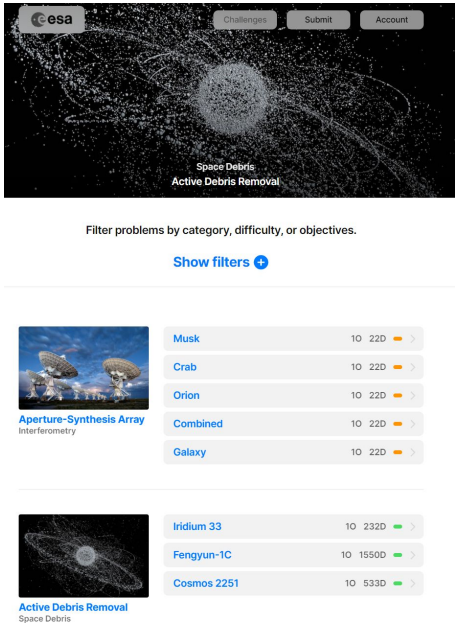
# Themes and Activities

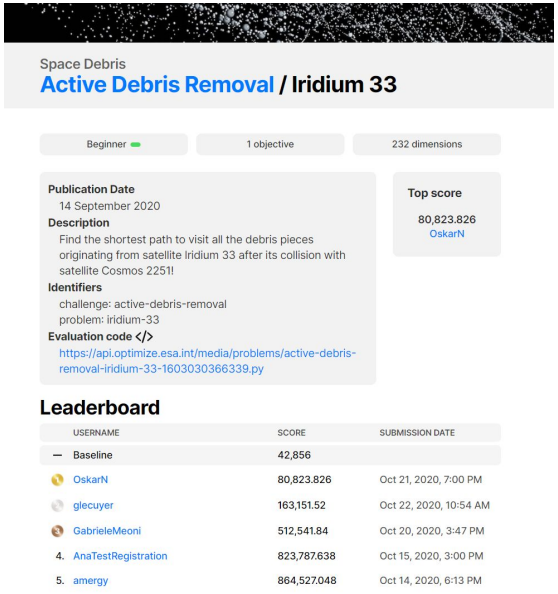


# Optimize as a playground for space problems

https://optimize.esa.int



# Code at the center of challenges

Mission Analysis

## SpOC: Mining / Mine the Belt

Intermediate | 1 objective | 30000 dimensions

**Publication Date**
01 March 2022

**Description**
Collecting precious resources from TRAPPIST's hypothetical asteroid belt
Learn more

**Identifiers**
challenge: spoc-mining
problem: mine-the-belt

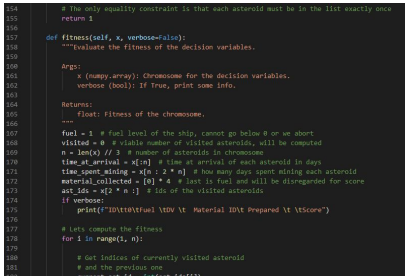
**Evaluation code </>**
https://api.optimize.esa.int/media/problems/spoc-mining-mine-the-belt-1648134150249.py

**Top score**
-6.788
Pablo

### Leaderboard

| USERNAME | SCORE | SUBMISSION DATE |
|---|---|---|
| Pablo | -6.788 | Mar 24, 2022, 4:04 PM |
| marcus | 1.213 | Mar 23, 2022, 12:48 AM |

**belt_mining.py**



```
    # The only equality constraint is that each asteroid must be in the list exactly once
    return 1

def fitness(self, x, verbose=False):
    """Evaluate the fitness of the decision variables.

    Args:
        x (numpy.array): Chromosome for the decision variables.
        verbose (bool): If True, print some info.

    Returns:
        float: Fitness of the chromosome.
    """
    fuel = 1  # fuel level of the ship, cannot go below 0 or we abort
    visited = 0  # viable number of visited asteroids, will be computed
    n = len(x) // 3  # number of asteroids in chromosome
    time_at_arrival = x[:n]  # time at arrival of each asteroid in days
    time_spent_mining = x[n : 2 * n]  # how many days spent mining each asteroid
    material_collected = [0] * n  # last is fuel and will be disregarded for score
    ast_ids = x[2 * n :]  # ids of the visited asteroids
    if verbose:
        print("ID\tt0\tfuel \tDV \t  Material ID\t Prepared \t \tScore")

    # Lets compute the fitness
    for i in range(1, n):

        # Get indices of currently visited asteroid
        # and the previous one
```

**submission.json**


```
[{"decisionVector":[20.76923076923077,25.53846153
846154,32.30769230769231,37.07692307692307,38.076
92307692307,42.84615384615384,0.0001,14.0,15.0,19
.76923076923077,66.9230769230769,71.6923076923076
8,49.615384615384606,54.384615384615537,55.3846153
8461537,60.15384615384614,43.84615384615384,48.61
5384615384606,88.0,1.0,1.0,138.0,251.0,0.0,0.0,25
9.0,0.0,0.0,289.0,0.0,0.0,303.0,0.0,0.0,324.0,0.0
,0.0,327.0,0.0,0.0],"problem":"delivery-schedulin
g","challenge":"spoc-delivery-scheduling","name":
"","description":""}]
```


Challenges | Submit | marcus

submission.json — 1 submitted

| INDEX | PROBLEM | SCORE | RANK |
|---|---|---|---|
| 0. | SpOC: Mining: Mine the Belt | -2.073 | 2 |

Optimize provides a **uniform API** for every problem
Easy to make **multiple submission at once**
**Identical workflow** for all optimize challenges

# Results


**Team HRI**
**Affiliation:** Honda Research Institute (Europe)
**Members:** Steffen Limmer, Nils Einecke, Felix Lanfermann


**Space Coders**
**Affiliation:** CS Group (Toulouse)
**Members:** Sébastien Goulet, Vincent Debout


**The Alien Colony Optimizers**
**Affiliation:** Artificial Intelligence Research Institute (IIIA-CSIC, Spain)
**Members:** Guillem Rodríguez i Corominas, Roberto Maria Rosati, Albert López i Serrano, Mehmet Anil Akbay and Christian Blum

**Honorable Mention: MS&BA Bielefeld University** (Paulina Heine, Gereon Kuiter, Michael Römer, Kevin Tierney)

# Closing SpOC … and towards SpOC 2.0!

- **SpOC in numbers:**
  - 40 participating teams, 110+ new users
  - 369 submissions
  - 11+ different countries all over the world

- **September:** Hybrid seminar with participants + ESA experts
  ⇒ https://www.esa.int/gsp/ACT/

- New features and problems for Optimize
  ⇒ https://optimize.esa.int/

**Thank you! See you for SpOC 2.0 !**