

AN ACCESS POINT TO ESAS SPACE DEBRIS DATA: THE SPACE DEBRIS OFFICE WEB BASED TOOLS

Q. Funke, S. Lemmens, V. Braun, T. Flohrer, H. Krag

D. Novak, D. Biamonti, A. Choudhary

European Space Agency

CGI

ABSTRACT

With DISCOS (Database and Information System Characterising Objects in Space) ESAs Space Debris Office has a very powerful database in hands when it comes to space debris related analyses. It serves as a single-source reference for launch information, object registration details, launch vehicle descriptions, spacecraft information (e.g. size, mass, shape, mission objectives, owner), as well as orbital data histories for all trackable objects, which sum up to more than 40000 object entries.

Based on DISCOS and USSTRATCOM TLEs, the Space Debris Office routinely predicts upcoming re-entries as well as performs detailed analyses on high interest re-entries and ad-hoc risk assessments to missions after severe fragmentation events. To support these processes, the Space Debris Office also does their own solar activity prediction, based on publicly available solar activity data, with the SOLMAG tool.

All this data is of high interest not only within ESA but to the whole space flight community. It can be a valuable asset for analyses and operational processes, including but not limited to Space Debris related studies and collision avoidance. A reliable and controlled access to this information with maintained data quality is thus fundamental for the community. To accomplish this, the Space Debris Office is currently developing web based tools for DISCOS data access, including a machine friendly REST API, fragmentation analyses, and re-entry predictions. These will be complemented by web pages of more static nature, like the SOLMAG solar activity predictions, and of course by the already established Space Debris User Portal (<https://sdup.esoc.esa.int>) serving as distribution point for ESAs risk and mitigation analysis tools MASTER (Meteoroid and Space Debris Terrestrial Environment Reference), DRAMA (Debris Risk Assessment and Mitigation Analysis), and ORIUNDO (On-ground Risk Estimation for Uncontrolled Re-entries Tool).

This paper will introduce all existing web based tools and those in development and outline their function. The design will be addressed with a focus on user friendliness, function and harmonised look-and-feel. Special emphasis is put on security to not only protect ESAs data and server infrastructure, but also to implement ESAs data access and usage policy.

Index Terms— DISCOS, Re-entry, Fragmentation, Solar

Activity Predictions, Web Front-ends

1. INTRODUCTION

In 1989 ESA has developed the Database and Information System Characterising Objects in Space (DISCOS) to support space debris research and operations [1]. Objects in DISCOS comprise all unclassified satellites, upper stages, mission related objects and fragments thereof, which are or have been in orbit. Where known (e.g. not for fragments) mass, shape, dimensions, cross section, owner and mission objectives as well as an image are stored. For already re-entered objects the re-entry date is recorded while lifetime prediction are available for objects still on orbit.

Besides the objects database, DISCOS also contains detailed physical properties of launch vehicles as well as details on all known fragmentations. As of 7. March 2016 DISCOS contains 296 launch vehicles, including failed ones, and 278 fragmentations. Table 1 lists selected statistics on the objects currently stored in DISCOS.

Table 1. Statistics on the objects stored in DISCOS as of 7. March 2016

Type	All	In Orbit
All Objects	41,379	17,805
With physical properties	15,408	6,386
Payloads	7,272	4,127
Rocked bodies	5,413	1,944
Debris pieces	28,632	11,675

Since the creation in 1989 DISCOS is under continuous maintenance and development, with monthly data updates. This makes it a data treasure invaluable for space debris studies and statistics as well as operational services like collision avoidance and re-entry predictions.

DISCOS also is the basis for almost all of the front-ends presented in this paper.

2. EXISTING FRONT-ENDS

To make the DISCOS data not only available within the Space Debris Office of ESA, but to open it to a wider audience, the DISCOS web front-end, or short DISCOSweb, has been developed. As part of a major upgrade in 2013/2014 DISCOSweb also got a companion with the Space Debris User Portal (SDUP), providing access to the ESA tools MASTER (Meteoroid and Space Debris Terrestrial Environment Reference Model) [2] and DRAMA (Debris Risk Assessment and Mitigation Analysis) [3] [4].

Required for DRAMA are up-to-date solar activity predictions. These are computed by the Space Debris Office with the SOLMAG tool and served to the public on the SOLMAG web interface.

2.1. DISCOSweb

<https://discosweb.esoc.esa.int/>

DISCOSweb provides access to the object, launch, launcher, launch site, launching nation and organisation, and fragmentation data available in DISCOS. It does provide this in an interactive manner with many search options. This allows the user to click through the available data pages after finding an initial starting point. Dynamic and interactive diagrams and plots complete the picture (see Figure 1).

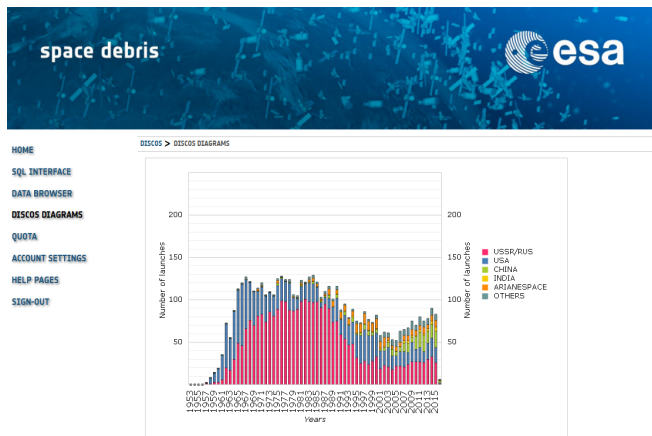


Fig. 1. DISCOSweb diagram example

Data pages are actually concatenating information on an object, launch, or other data entry. Like this the user gets all related information in one place, with links to other data entries, like a link to the launcher from an object page. Figures 2 and 3 show an example object page for the Sentinel 1A satellite. Both are actually on one page but split here for layout reasons.

Name	Sentinel-1A
COSPARID	2014-016A
SATNO	39834
Mass	2157.000 kg
Classification	Payload
Shape	Box + 4 Pan
Lenght	1.800 m
Height	3.420 m
Depth	21.040 m
X_SECT_MAX	57.919 m ²
X_SECT_MIN	2.560 m ²
X_SECT_AVG	23.488 m ²
X_SECT_RCS	10.694 m ²
Re-Entry Epoch	(value not available)
Country	EUROPEAN SPACE AGENCY (ESA)
Organization	European Space Agency
Image	
Image Source	http://space.skyrocket.de ESA
COSPARLaunchNumber	2014-016
LauncherName	Soyuz-ST-A Fregat
Site	Guiana Space Center (Kourou)
PRED_DECAY_DATE	2957-11-06
REMAINING LIFETIME UNCERTAINTY	188.33208
Mission Type	Earth observation
Activity Status	ACTIVE

Fig. 2. DISCOSweb object page example (1/2)

2.2. SDUP

<https://sdup.esoc.esa.int/>

The Space Debris User Portal (SDUP) was set up in 2014 as download portal for the MASTER and DRAMA software. It provides installers, patches and documentation on the software and takes care of the licence management. Figure 4 shows the DRAMA download section of SDUP.

A recent addition to SDUP is the online access to Oriundo, a casualty risk estimation tool.

2.2.1. MASTER

The Meteoroid and Space Debris Terrestrial Environment Reference (MASTER) is a detailed model of the space debris and micro meteoroid environment, based on modelling launch and fragmentation events.

INITIAL ORBITS

Status	Regime	Orbit Epoch	SMA [km]	ECC	INC [deg]	A_PER [deg]	T
No filter applied							
	Low Earth Orbit	2014-04-04	7066.14	0.00028304	98.17	67	9f

1 - 1 of 1 item 5 | 15 | 25 | 50 | 100 | All

RELATED FOOTNOTES

Sentinel-1 is an European two satellite constellation with the prime objectives of Land and Ocean monitoring. The goal of the mission is to provide C-Band SAR data continuity following the retirement of ERS-2 and the end of the Envisat mission. To accomplish this, the satellites carry a C-SAR sensor, which offers medium and high resolution imaging in all weather conditions. The C-SAR is capable of obtaining night imagery and detecting small movement on the ground, which makes it useful for land and sea monitoring.

Fig. 3. DISCOSweb object page example (2/2)

space debris user portal

HOME
 DRAMA
 DOWNLOADS
 FAQ
 DEVELOPMENT TEAM
 MASTER
 DISCOSWEB
 ACCOUNT
 CONTACT US
 ORIUNDO
 SIGN-OUT

SPACE DEBRIS USER PORTAL > DRAMA > DOWNLOADS

INSTALLER

Note that for the installation of DRAMA under OSX 10.10 (Yosemite) and higher, the usual installer is not working. Please unzip the DRAMA_OSX.zip into your Applications directory.

Version	md5sum	File size	Link
2.0.4	8f550291ae7d1812c5f13c932f103e6	176MiB	DRAMA_installer.zip [alternative]
2.0.4 (OSX 10.10 and 10.11)	c18c77a56fc49522949b040c048f38be	148MiB	DRAMA_OSX.zip [alternative]

PATCHES

Version	md5sum	File size	Link
2.0.1	00446dc6eb4d35a6a64c0156f695a6	26MiB	DRAMA_patch_2.0.1.zip
2.0.2	8e04851dff0304de131a1caf42b762686	19MiB	DRAMA_patch_2.0.2.zip
2.0.3	561569e511b531b6dbfca4910b23c6c4	27MiB	DRAMA_patch_2.0.3.zip
2.0.4	8bf1fc472e3444fe44a7e8f995b2c474b	120MiB	DRAMA_patch_2.0.4.zip

DOCUMENTATION

Fig. 4. DRAMA download section on SDUP

It serves as source for statistical flux analyses, from which average collision rates and satellite failure probabilities can be derived.

ESA provides this software free of charge to the general public.

2.2.2. DRAMA

The Debris Risk Assessment and Mitigation Analysis tool (DRAMa) is a set of five programs helping satellite programs to assess the compliance with ESA Space Debris Mitigation Requirements.

With the ARES tool the expected amount of collision avoidance manoeuvres can be determined. MIDAS computes the collision flux and damage statistics for a mission. OSCAR can determine the remaining orbital lifetime after end

of mission and analyse disposal manoeuvre options. CROC is used to compute projected cross-sectional area of complex bodies. SARA does a re-entry and survivability analysis as well as an on-ground casualty risk estimation. An upgrade of SARA is currently in development.

ESA provides this software free of charge to the general public.

2.2.3. Oriundo

Oriundo is a tool for on-ground casualty risk estimation for uncontrolled re-entries. A part of it is an advanced 1D population density distribution model as shown in Figure 5. This model is based on the Gridded Population of the World data set as baseline and the UN World Population Prospects to determine future population density distributions.

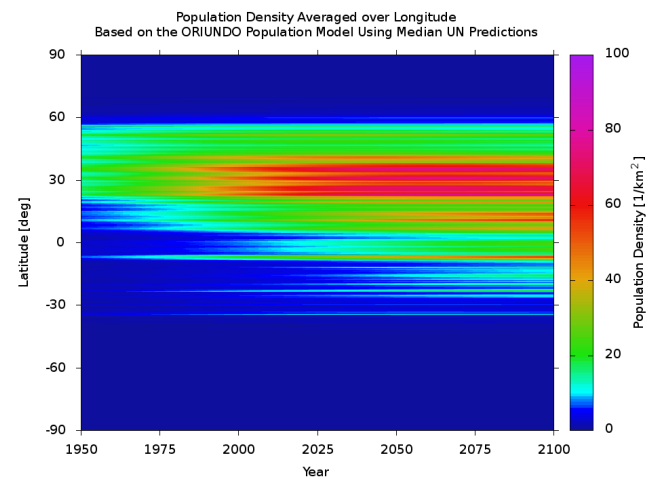


Fig. 5. Latitude dependent population density history and prediction

The online tool of Oriundo can compute the casualty probability for a given casualty cross section, inclination and re-entry year.

The casualty cross section, required as input parameter to Oriundo, can be determined with re-entry analysis tools like SARA or DRAMA. It thus serves as a supplement to any re-entry analysis tool without or with a poor risk analysis part.

2.3. SOLMAG

<https://static.sdo.esoc.esa.int/SOLMAG/>

The SOLMAG solar activity history and predictions, as needed by the orbital lifetime assessment tool OSCAR of DRAMA, can be obtained via the SOLMAG web interface. From all presented web interfaces SOLMAG is the most basic one, being purely based on file transfer.

Figure 6 shows an example output of SOLMAG.

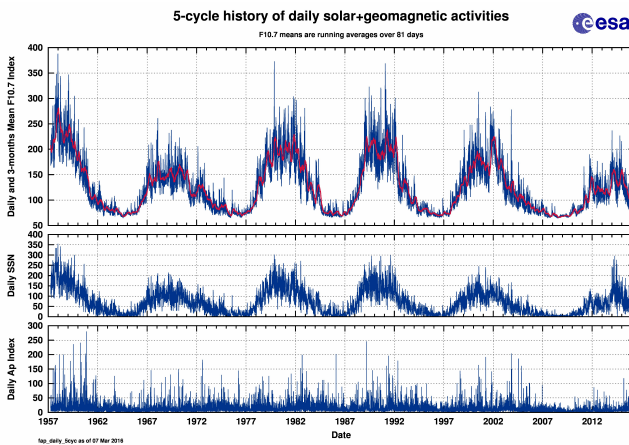


Fig. 6. 5-cycle history of daily solar and geomagnetic activities as reported by SOLMAG

3. FRONT-ENDS IN DEVELOPMENT

To further extend the service, ESA's Space Debris Office is currently developing three more front-ends, as reaction to common request.

3.1. DISCOSweb REST API

With the DISCOSweb REST API the data available via DISCOSweb will also be easily accessible from programs and scripts. With the command

```
curl -u user:password
https://discosweb.esoc.esa.int/api/
objects/39634
```

the object properties of Sentinel 1A can be queried. This will return the following JSON string

```
{
  "satno":39634,
  "cosparId":"2014-016A",
  "name":"Sentinel-1A",
  "objectClass":"Payload",
  "mass":2157.0,
  "shape":"Box + 4 Pan",
  "length":1.6,
  "height":3.42,
  "depth":21.04,
  "xSectMax":57.919,
  "xSectMin":2.56,
  "xSectAvg":23.4875,
  "xSectRes":10.6944,
  "country":"EUROPEAN SPACE AGENCY (ESA)",
  "reentryEpoch":null,
  "visMagnitude":null,
  "organisation":"European Space Agency"
}
```

The DISCOSweb REST API is currently in closed beta test phase in will be released in the next months.

3.2. Fragmentation Front-end

<https://fragmentation.esoc.esa.int/>

Directly after fragmentation events like the collision between Cosmos 2251 and Iridium 33 or the NOAA 16 fragmentation, the imminent effect on the collision risk for other satellites is of high interest for satellite operators. With the BUSTER tool, the Space Debris Office has the possibility to analyse recent fragmentations based on DISCOS data and USSTRATCOM TLEs. By determining the effect on the space debris population, the relative change in collision risk can be computed. The results of the BUSTER tool will be made available on the Fragmentation Front-end.

Figure 7 gives an example for a plot visualising the altitude-dependent relative risk increase effect of a fragmentation. Common data products like Gabbard plots (Figure 8) will be available as well.

3.3. Re-entry Front-end

<https://reentry.esoc.esa.int/>

The Re-entry Front-end, currently in development, will make the re-entry predictions done by the Space Debris Office on a daily basis, available to everyone. With a visually appealing user interface (preview in Figure 9) it will be possible to filter the upcoming and recent re-entries allowing to quickly gain an overview of the current situation. Possible subscriptions

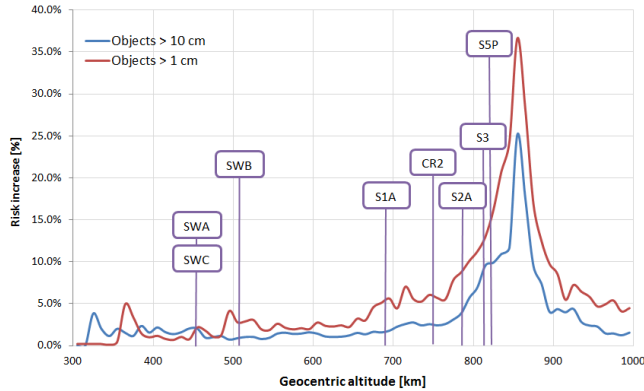


Fig. 7. Example risk increase plot as it will be provided by the Fragmentation Front-end

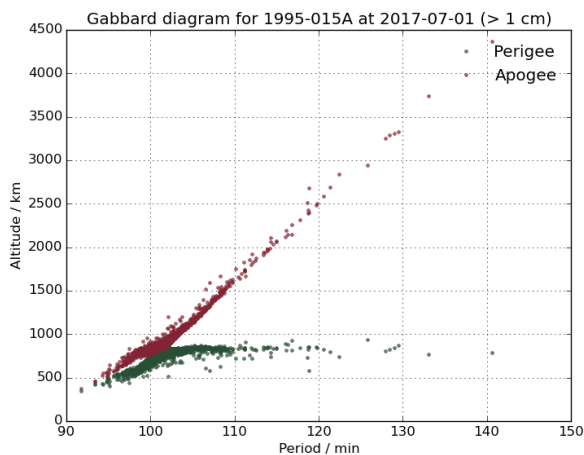


Fig. 8. Example Gabbard plot as it will be provided by the Fragmentation Front-end

to re-entry events with email alerts make following an event easy.

Advanced service, including more detailed predictions and support by space debris experts, is available to national alert centres of ESA member states.

4. CONCLUSIONS

The introduction to the web front-ends of ESA's Space Debris Office as well as the preview on the ones still in development, show a broad range of covered space debris related topics made available to as many people as possible.

With the currently ongoing development work, the Space Debris Office and CGI are not only implementing new front-ends but also work on common front-end infrastructure. One

of these developments is a common user management, allowing the user to access all front-ends with the same account.

In parallel the Space Debris Office is working on reducing the account limitations, like limits on the country of residence, wherever possible.

5. REFERENCES

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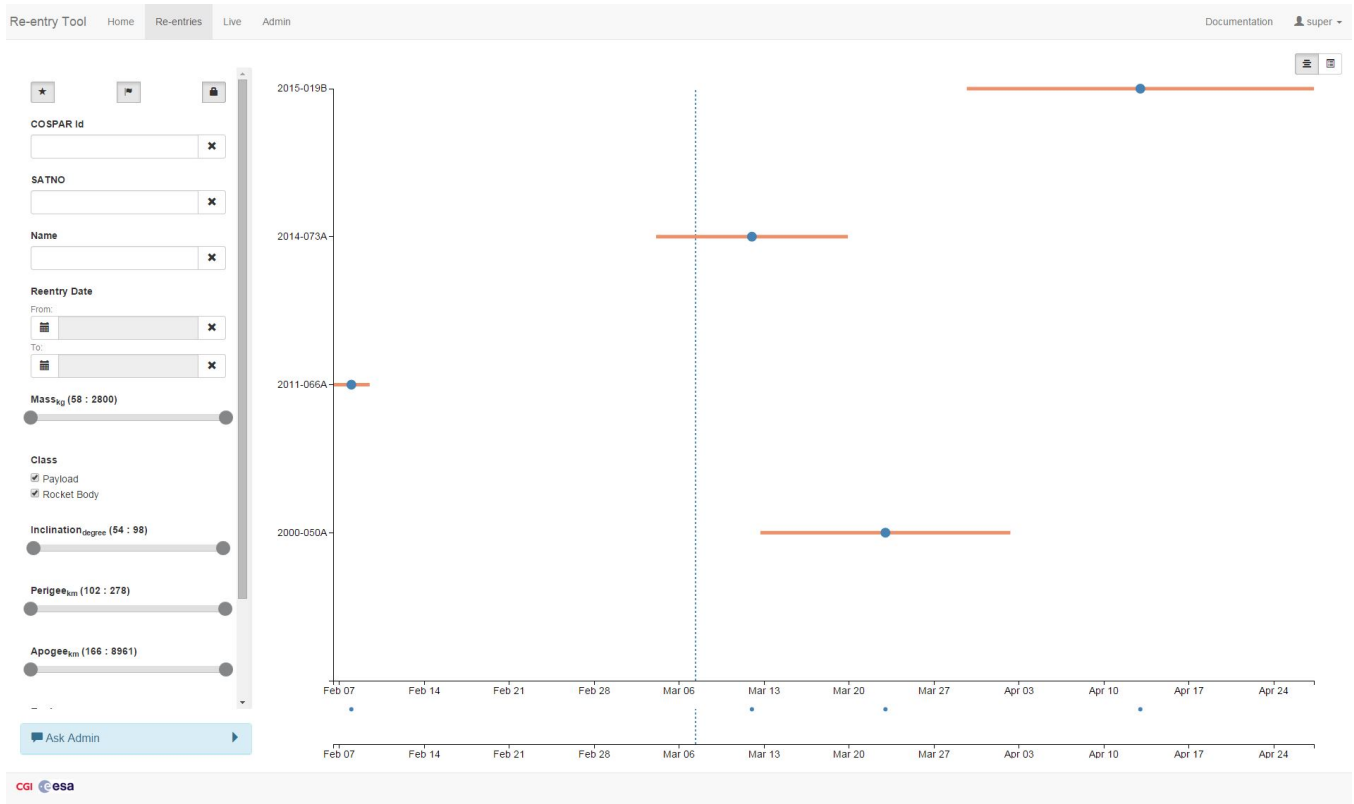


Fig. 9. Preview of the Re-entry Front-end Gantt chart view