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Standard Environment Interface (STENVI)

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Revision History

Issue	Revision	Date	Reason for Revision
1	0	2023-03-31	Issue of draft ver. 1.0 of STENVI as a standalone document: • Content transferred from Section 2.6 in the IADC Protection Manual (filename: IADC-04-03_ProtectionManual_v7.2_draft-DdW_mm_20230127). • Editorial changes made to Figure and Table numbering. • Scope section added. • Minor corrections made to the references in Section 1. • Order of references in Section 3 rearranged. • Acronyms added to Section 4.

List of Abbreviations

Abbreviation	Description
ASCII	American Standard Code for Information Interchange
STENVI	Standard Environment Interface
WG3	Working Group No.3, same as IADC Protection Working Group

Scope

This document describes a standardized file format known as the STandard ENVironment Interface (STENVI). STENVI was developed by members of the IADC Protection Working Group (WG3) to facilitate the transfer of data from orbital debris environment models to damage prediction tools.

1 Introduction

Current environment models contain information like flux, impact velocity, impact direction of particles encountering the spacecraft in its orbit and much more. This information differs not only in the values between the models but also in the structure and the content of the result files. Because of this, a damage prediction tool must use a separate interface for each environment model which is adapted. Environment models are updated regularly and become more and more complex. A fact, which makes it complicated for developers of damage prediction tools, to access the relevant data from environment models. The consequence is massive coding effort when adapting future environment models. Without a defined standard, the inaccuracy in data conversion and data transfer is high, which impacts directly the quality of the damage prediction results.

Therefore, it is recommended to use the standard environment interface (STENVI) between orbital debris environment models and damage prediction tools. A main advantage is that different environment models can be adapted easily to the damage prediction tools without much effort. This guarantees a fast use of new environment models. Furthermore, it helps to avoid failure and to reduce inaccuracy in data conversion and data transfer due to a defined format.

The interface, which is described in [1] [2] [3], supports all relevant data to perform a damage prediction for a spacecraft in a meteoroid and orbital debris environment.

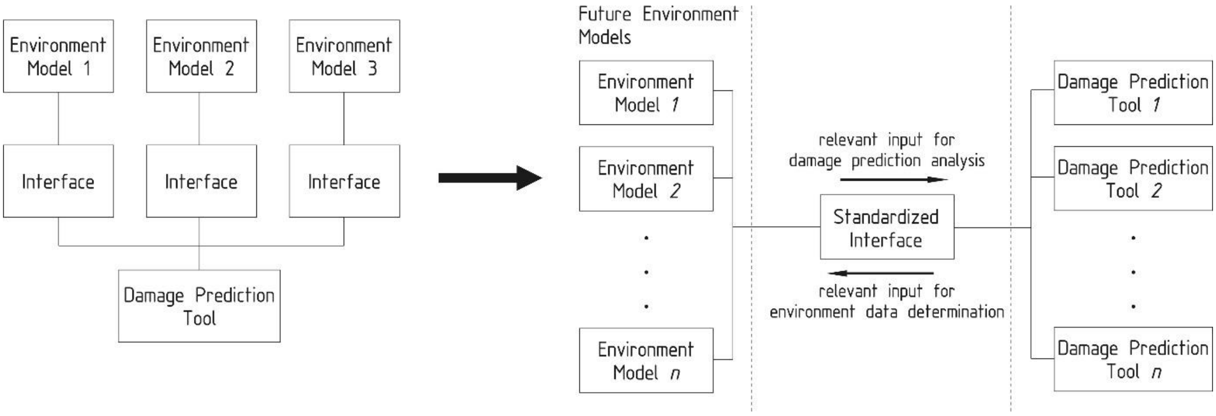

Figure 1: The standard environment interface as link between damage prediction tools and environment models guarantees a fast and standardized data transfer between the applications.

The current version of the standard interface can be characterized by the following features:

- Transfer of relevant data for damage prediction
- Distributions in one file (order of kByte)
- Transfer via ASCII file format
- Environment model needs to be run only once
- Huge output of environment models is reduced to essential information
- Support of debris and meteoroid sources

2 Technical Description of the Standard Environment Interface v1.0

The standard environment interface (STENVI) is able to support different kinds of distributions (in debris and meteoroid environment) as listed in the table below. In addition to this information, an identifier is transferred with the data as well in order to identify the version of the standard interface. Furthermore, comment lines and environment model name are transferred. In the future, both applications, damage prediction tools and environment models should be able to read and/or write current and older versions of the standard format (downward compatibility).

Table 1: STENVI interface description

Required information for damage prediction analysis	**Required information for environment model / Data Identification**
flux vs diameter/mass distribution	debris/ meteoroid sources
density (distribution)	mission/orbit parameters
directional distribution	size/mass threshold
velocity distribution	cumulative/discrete spectra
number and limits of bins for distributions	
launch time and mission duration	

All this information is written into one file in a certain way which is described below. The file must be generated by the environment models (e.g. as export option), where the user can define the number of bins and the limits of the several distributions. Additionally, a default set of bins and limits can be defined as follows:

Table 2: STENVI defaults

Distribution	**Bins**	**Min**	**Max**
Azimuth [deg]	36	-180	+180
Elevation [deg]	1	-90	+90
Velocity [km/s]	20	0.5	20.5
Diameter [m]	51	$1.0 \cdot 10^{-5}$	1.0
Argument of true latitude [deg]	1	0	+360
Density [g/cm^3]	1	2.8	2.8

2.1 File Description

The data is written into files (ASCII format).

A standard environment file has the file ending `.sei`. An interface file contains three main sections which are written in the following order:

- Header
  The header contains data for the identification of the interface file, of the environment model (including comments) and the mission/orbit parameters.
- Section of Defined Spectra
  This section contains data for the distributions of diameter, direction (azimuth/elevation), velocity, density and argument of true latitude as well as the number and limits of bins.
- Section of Flux Contribution
  This section contains the flux contribution in each bin of the defined distributions: azimuth, elevation, velocity, diameter, argument of true latitude, density.

An exemplary standard interface file is listed in figures below. They are used in order to describe the content in detail. Depending on the defined spectra, the number of lines can be different from this example when generating a STENVI file. The maximum number of characters in a line is 80. Each data line is introduced by an input card (name at the beginning of a data line, e. g. AZIMUTH or VELOCITY).

Table 3: STENVI file structure

Line(s)	Entry
1-3	`STANDARD ENVIRONMENT INTERFACE` Title of the interface file.
4 5	`# Interface Version` Input Card: `STENVI` Format: `A10,F5.0` This is the identification of the interface file. Numbers 11-15 assign the interface version. Future development in environment models will lead to upgrades of this interface e.g. in order to support new distributions.
7 8	`# Environment Model` Input Card: `MODNAME` Format: `A10,A20` This entry contains the name of the environment model (20 characters).
10-12	`# Run Comment (2 lines)` Input Card: `COMMENT` Format: each line `A10,A40` These two lines give the possibility to transfer comments from the environment model to the damage prediction tool. Those comments can be then part of the analysis output in order to identify the job.
`< Mission Parameters >`	
15-17	`# Begin and end of analysis time interval` Input Card: `MISSBEGIN` Input Card: `MISSEND` Format: each line `A10,4I5` The mission start and end time is written in these two lines with the format [yyyy mm dd hh].
18 19 20 21 22 23	`# Target orbit` Input Card: `SEMIAXIS` Input Card: `ECCENTRI` Input Card: `INCLIN` Input Card: `RAAN` Input Card: `ARGPERI` Format: each line `A10,F10.0` The basic orbit parameters are written into the lines 19-23. The units are given as follows: semimajor axis [km], eccentricity of the orbit [-], orbit inclination [deg], right ascension of ascending node [deg], argument of perigee [deg]

Line(s)	Entry
	< Definition of the output spectrum >
26 27 28 29 30 31 32	`# Bin Min Max` Input Card: `AZIMUTH` Input Card: `ELEVATION` Input Card: `VELOCITY` Input Card: `DIAMETER` Input Card: `LATITUDE` Input Card: `DENSITY` Format: each line `A10,I5,2F10.0` The lines 27-32 contain the definition of output spectra. The units are given as follows: azimuth [deg], elevation, [deg], velocity [km/s], diameter [m], argument of true latitude [deg], density [g/cm^3]
35 37-72	`# Impact Azimuth [deg]: Intervals` Input Card: `DISTAZI` Format: each line `A10,I5,2F10.0` These lines contain the defined azimuth spectrum. Each line consists of a bin number and the lower and upper limits of these bin.
74 76	`# Impact Declination [deg]: Intervals` Input Card: `DISTELE` Format: each line `A10,I5,2F10.0` These lines contain the defined elevation spectrum. Each line consists of a bin number and the lower and upper limits of these bin.
78 80-99	`# Relative Velocity [km/s]: Intervals` Input Card: `DISTVEL` Format: each line `A10,I5,2F10.0` These lines contain the defined velocity spectrum. Each line consists of a bin number and the lower and upper limits of these bin.
101 103-108	`# Particle Diameter [m]: Intervals` Input Card: `DISTDIA` Format: each line `A10,I5,2F10.0` These lines contain the defined diameter spectrum. Each line consists of a bin number and the lower and upper limits of these bin.
110 112	`# Argument of True Latitude [deg]: Intervals` Input Card: `DISTLAT` Format: each line `A10,I5,2F10.0` These lines contain the defined argument of true latitude spectrum. Each line consists of a bin number and the lower and upper limits of these bin.
114 116	`# Density [g/cm^3]: Intervals` Input Card: `DISTDEN` Format: each line `A10,I5,2F10.0` These lines contain the defined density spectrum. Each line consists of a bin number and the lower and upper limits of these bin.

Line(s)	Entry
	< Flux Contribution >
119 120-2309	`# Azi Ele Vel Dia Lat Den Flux` Input Card: `DISTSET` Format: each line `A10,6I5,E15.0` These lines assign the flux contribution to certain azimuth, elevation, velocity, diameter, argument of true latitude and density. This subsection is the longest part of the interface file. Only lines with flux > 0 are written. The flux is given as cross-sectional flux [1/(m^2yr)].
2310	`#-<EOF>` Format: `3X,A3` This identifies the file end.

```
1 #----------------------------------------------------------------------------
2 # STANDARD ENVIRONMENT INTERFACE
3 #----------------------------------------------------------------------------
4 # Interface Version
5 STENVI 1.0
6 #
7 # Environment Model
8 MODNAME MASTER-2005
9 #
10 # Run Comment (2 lines)
11 COMMENT Standard Environemt Interface
12 COMMENT Version 1.0
13 #
14 #----------------------------< Mission Parameters >------------------------------
15 # Begin and end of analysis time interval
16 MISSBEGIN 2002 01 01 00 Begin [yyyy mm dd hh]
17 MISSEND 2003 01 01 00 End [yyyy mm dd hh]
18 # Target orbit
19 SEMIAXIS 6778.0 Semimajor axis [km]
20 ECCENTRI 1.0E-4 Eccentricity of the orbit [-]
21 INCLIN 51.6 Orbit inclination [deg]
22 RAAN 90.0 Right ascension of ascending node [deg]
23 ARGPERI 0.0 Argument of perigee [deg]
24 #
```

Figure 2: Standard Environment Interface File: Header

```
#--------------------< Definition of the output spectrum >----------------------
# Bin Min Max
AZIMUTH 36 -180.0 180.0 Azimuth [deg]
ELEVATION 1 -90.0 90.0 Elevation [deg]
VELOCITY 20 0.5 20.5 Velocity [km/s]
DIAMETER 6 1.D-05 1.0 Diameter [m]
LATITUDE 1 0.0 360.0 Argument of True Latitude [deg]
DENSITY 1 2.8 2.8 Density [g/cm^3]
#
#-------------------------------------------
# Impact Azimuth [deg]: Intervals
# No Lower Border Upper Border
DISTAZI 1 -0.180E+03 -0.170E+03
DISTAZI 2 -0.170E+03 -0.160E+03
: : : : :
: : : : :
DISTAZI 35 0.160E+03 0.170E+03
DISTAZI 36 0.170E+03 0.180E+03
#-------------------------------------------
# Impact Declination [deg]: Intervals
# No Lower Border Upper Border
DISTELE 1 -0.900E+02 0.900E+02
#-------------------------------------------
# Relative Velocity [km/s]: Intervals
# No Lower Border Upper Border
DISTVEL 1 0.500E+00 0.150E+01
DISTVEL 2 0.150E+01 0.250E+01
: : : : :
: : : : :
DISTVEL 19 0.185E+02 0.195E+02
DISTVEL 20 0.195E+02 0.205E+02
#-------------------------------------------
# Particle Diameter [m]: Intervals
# No Lower Border Upper Border
DISTDIA 1 0.100E-04 0.100E-03
DISTDIA 2 0.100E-03 0.100E-02
DISTDIA 3 0.100E-02 0.100E-01
DISTDIA 4 0.100E-01 0.100E+00
DISTDIA 5 0.100E+00 0.100E+01
DISTDIA 6 0.100E+01 0.100E+02
#-------------------------------------------
# Argument of True Latitude [deg]: Intervals
# No Lower Border Upper Border
DISTLAT 1 0.000E+00 0.360E+03
#-------------------------------------------
# Density [g/cm^3]: Intervals
# No Lower Border Upper Border
DISTDEN 1 0.280E+01 0.280E+01
#
```

Figure 3: Standard Environment Interface File: Defined Spectra

```
#-----------------------------< Flux Contribution >----------------------------
-
# Azi Ele Vel Dia Lat Den Flux
DISTSET 11 1 4 5 1 1 0.12756E-09
DISTSET 11 1 5 5 1 1 0.22520E-09
DISTSET 12 1 5 5 1 1 0.38915E-10
DISTSET 12 1 6 5 1 1 0.18867E-09
DISTSET 12 1 6 6 1 1 0.22015E-10
DISTSET 12 1 7 5 1 1 0.52626E-10
: : : : : : : : :
: : : : : : : : :
: : : : : : : : :
DISTSET 30 1 2 3 1 1 0.29538E-07
DISTSET 30 1 3 4 1 1 0.18995E-08
DISTSET 30 1 3 5 1 1 0.39749E-09
DISTSET 30 1 4 1 1 1 0.28889E-04
DISTSET 30 1 4 4 1 1 0.32269E-07
DISTSET 30 1 4 5 1 1 0.11625E-08
DISTSET 30 1 5 1 1 1 0.81546E-04
DISTSET 31 1 4 1 1 1 0.81538E-04
DISTSET 35 1 3 1 1 1 0.32169E-08
DISTSET 36 1 3 1 1 1 0.30273E-05
#-<EOF>-------------------------------------------------------------------
--
```

Figure 4: Standard Environment Interface File: Flux Contribution

3 References

[1] D. Noelke and H.-G. Reimerdes, "A Standardized Interface between Orbital Debris Environment Models and Damage Prediction Tools," in *4th European Conference on Space Debris*, Darmstadt, Germany, 2005.

[2] M. Oswald and D. Noelke, "Standard Interface between Orbital Debris Environment Models and Damage Prediction Tools," in *Presentation at the 24th IADC*, Tsukuba, Japan, 2006.

[3] D. Noelke, "A Standardized Interface between Orbital Debris Environment Models and Damage Prediction Tools," in *IADC 25/26 Management Paper with Technical Appendix*, 2007/08.