Guidance for a Standard Information Gathering Of Performances and Applications Requirements

General Guidance on Gathering Sensors/Constellations Performance Information -*Filling Out SCP Tables:*

A Sensor/Constellation Performance (SCP) table template is provided. It is meant to offer a standard way to communicate performances of sensors, satellites and constellations. This guidance is provided to facilitate this collection of information necessary to get an accurate sense of the performances of existing or proposed sensors, satellites and/or constellations of sensors/satellites. This collection of information will be standardized through the filling of the SCP (Sensor/Constellation Performance) table by providing a standard way to present these performances. This table will be used by the Govt to facilitate the assessment of the trade space of the different solutions performances. This is going to be achieved using the ASPEN tool (Advanced Systems Performance Evaluation tool for NOAA/NESDIS). This in turn will help formulate the optimal solution for NOAA's next-generation space architecture. The performances in terms of geophysical information content (temperature, moisture, etc and their associated attributes of temporal refresh, accuracy, spatial coverage, etc) are of course driven by the sensors/constellations characteristics (number of channels, bands, bandwidths, noise levels, orbit swath, number of orbits, etc). The provider of this information in the SCP, could provide either the 'geophysical' performances or the sensors/constellation characteristics. Or both if possible and desired; it will depend on the type of solution being offered. For example, sometimes, the provider of this information is not necessarily equipped with tools to convert sensors/constellations characteristics into geophysical performances. In this case, only the section about sensors/constellations characteristics should be filled. If the provider has the ability to provide the geophysical performance, it is recommended that details about that transformation (from sensors/constellations characteristics to geophysical performance) be described briefly in the table section reserved for that (description of the algorithm, training set, simulation setup, etc). The information below serves as more detailed guidance, in the form of answers to questions we expect to be asked.

Specific guidance in the form of Q&As

1. Do I have to fill the SCP table?

No. The SCP table is offered as a simplified way to standardize the collection of performance information from existing and proposed sensors and/or constellations. Its provision is totally optional. The SCP table however will facilitate the assessment of trade space of solutions in a consistent fashion.

2. What is the SCP table? What is the SC Description?

The SCP table is a way to collect information on the capabilities of a sensor (or constellation) to describe the Earth environment. In general, the SCP table describes the capabilities of a sensor to measure (or be sensitive to) certain environmental variables. (See below for more details on the performance assessment.). It is important to highlight that instruments usually measure sensor data —radiances, brightness temperatures, etc—but these sensor data are designed/optimized to be sensitive and contain information content about the state of the environment. That is what the SCP is meant to capture in the Geophysical performance section. These environmental measurements are usually generated using remote sensing (simple or sophisticated) algorithms. The SCP table contains a Notes tab that will allow you to add information deemed needed or missing in the SCP main tab.

Alternatively, providing the actual sensors characteristics: bandwidth, frequencies, polarizations, number of orbits, swath, etc, is also possible (either in addition or as an alternative to geophysical performances). The SCP table indeed contains another tab labeled 'SC description' where you can enter this information. The ASPEN Government team of remote sensing experts will then work on transforming the sensors characteristics into performance. Since determining geophysical variables requires some processing, please also describe the processing system used in determining the SCP table in the SC description tab (algorithm, training set, etc)

3: What if I don't have geophysical performances, and instead I have only sensors or constellations specific characteristics?

In this case, focus on defining the sensor/constellation description (the "SC Description" tab) which is meant to collect information on the sensor/constellation itself, primarily in terms of its sensors and constellations characteristics (examples include bandwidth, number of channels, noise levels, polarizations, SRFs, number of orbits, swaths, etc).

4. Why is the SCP table needed? Why is the SC description needed?

SCP tables are used to assess the benefits and values of various sensors (or constellations), for both LEO and GEO (as well as GEO-XO) platforms. To allow us to study the trade space of solutions which will lead us to the optimal next-generation space architecture solution. The SCP allows the provision of either the geophysical performance if appropriate or the sensors/constellation characteristics that will be used to generate the geophysical performance. The SC description is also needed to allow a potential independent evaluation of some of the SCP table geophysical entries.

5. When I have the SCP workbook ready, how should I name the file?

Files should be named SCP_orgID_sensorConstellationName_modeName_versionNumber (e.g., SCP_MIT_EON-MW_Nominal_V1.3, or SCP_STAR_ABI_CONUS_V0.0).

6. How should I fill the SCP table? (Which cells should be filled?)

All the cells without a color background should be filled if possible, except those with gray text. Rows with gray text are not currently used by ASPEN, but are additional variables now being considered for addition to ASPEN. If you have information for those variables with gray text then you can provide it for future consideration in ASPEN if you'd like. The table cells are all initialized either to TBD (to be determined) or 0. Fill the cell with 'NA' if the sensor does not provide information on this particular geophysical variable, or if the attribute does not apply to this geophysical variable. It is important to note that sometimes, sensors or constellations can measure parameters that were not the major focus for the design of the sensor/constellation. For example, a sounder might also be sensitive to clouds. A constellation of dedicated temperature and moisture sounders might also be capable of deriving atmospheric winds. It is recommended that both primary and secondary variables be captured in the SCP table. This will allow us to assess the full capability of the sensor/constellation. For values that are TBD, when appropriate, please provide a nominal value along with an uncertainty. The SC description is free form. Provide sensor and/or constellation information that will help generate the geophysical performance.

7. What about filling out descriptive information?

Yes, please fill out the cells (B1:3) labeled SCP (B1, give a name to the SCP table that reflects the sensor and/or constellation being described here), POC and Organization providing the table (B2, usually the point of contact email address is all that is needed here), version and date (B3, to distinguish several version if need be). Finally enter the Type of SCP (whether it is an SCP for a Sensor 'S' or a Constellation 'C').

8. What are the different definitions of the variables and their units?

The variables are described in Table 1.

9. What are the attributes and how do I fill them out?

The attributes are described in this Table 2. Some specific notes are provided here. For the "Geographic Coverage" attribute use a descriptive term such as Global, Tropics, CONUS, etc. Add a definition if your term is not standard in the Notes tab. For the "Robustness" attribute please report the number of sensors (often 1) in the constellation that measure the geophysical variable with the attributes reported in this row.

10. What about imagery?

Imagery is usually used as a stand-in for some geophysical variable(s). That is, the value of imagery is the sensitivity to geophysical information (aerosols, cloud, temperature, moisture, salinity, wave height, fire radiative power, volcanic ash, etc.). If the application requires imagery sensitive to a particular geophysical variable (or a set of them) please set the "imagery" attribute to TRUE for that (those) variable(s). In other words, answer the question "Does the application require an image of (or an image sensitive to) the geophysical variable in this row?" You should also provide additional information about the temporal refresh, horizontal resolution, accuracy, etc. Since not all imagery is the same in terms of these attributes, it is important to specify what requirements are important for the application.

11. What if my sensor or constellation does not cover a certain observable or does not measure it with a certain attribute?

Fill the cell with NA if the sensor does not provide information on this geophysical variable, or if the attribute does not apply to this geophysical variable. For example, if a sensor or constellation from a SounderSAT study is meant to derive exclusively temperature and moisture, then only those observables should be handled in the SCP. The other variables could be set to NA.

12. What if I have questions?

Please contact Stacy Bunin <stacy.bunin@noaa.gov> or Sid Boukabara <sid.boukabara@noaa.gov>.

13. What is this information going to be used for?

SCP tables are used by the Government to assess the trade space of performances. Learned lessons from this exercise will inform our next steps in the next-generation space architecture design.

14. What if I need to make updates or edits to this table?

A tab labeled Notes is included in the template SCP. Please add all your comments or suggested updates in there. Alternatively, please contact Stacy Bunin <stacy.bunin@noaa.gov> or Sid Boukabara <sid.boukabara@noaa.gov>.

15. What if I am uncertain about certain values?

Please provide a 1-sigma estimate of the uncertainty in the same cell in the SCP "Uncertainties" tab. These tabs are pre-filled with zeros, indicating no uncertainty. The units of these uncertainties are identical to the units of the corresponding variables. These uncertainties will actually be useful for the assessment, since these uncertainties will be used to generate overall uncertainties of the final output from ASPEN.

16. What if I have reservations or concerns about certain things in the SCP?

Please provide this commentary in the "Notes" tab of the SCP file. We will review all notes and either provide clarifications or address the issue.

17. Can I edit the units or names of other 'constants' in the table?

The table cells with color fill should not be altered. If you do, those columns or rows will be difficult to use.

18. What if I need more information?

Please contact stacy.bunin@noaa.gov or sid.boukabara@noaa.gov for additional information.

19. What about if I have more variables that I would like to highlight in terms of performance of my sensor or constellation? What if I want to volunteer more information than the tables allow?

Please add geophysical variables as needed. The geophysical variables listed were chosen as representative across the environmental domains. These are not grayed out. The geophysical variables that are grayed out are those that we are considering for future versions. Add additional geophysical variables as needed. However, if you add rows (new geophysical variables) or columns (new attributes) these will be reviewed, but cannot necessarily be used for our assessment. It is suggested that you contact the POCs above to let us know ahead of time as soon as you think of adding new variables or attributes, so we could account for that on our end.

Regarding providing information on the sensors and constellations characteristics, the SC description is meant to be open ended to provide that information. Please add additional information (comments, concerns, beyond geophysical and/or sensors/constellation information) as needed in the “Notes” tab of the SCP file.

20. What if I would like to provide an SCP table for other candidate technology solutions (sensors/constellations) that I would like to be assessed as well?

Please do so. There should be one SCP file for each sensor and/or constellation. But you can provide multiple SCPs for different solutions. For example if you want to capture multiple data points of the trade space of performances. Another example is the possibility of providing several modes of the same sensor, with different performances. Please provide a separate SCP for each operation mode.

Specific Guidance for the performance assessment (specifically the accuracy attribute)

- The geophysical algorithm choice: the USG recognizes that multiple options exist. Any reasonably performing algorithm could be used. This could be based on a regression approach on a modern Machine learning approach or a physical approach. Note however that it is viewed as important to assess the performance on a validation set that is independent from the training set used to develop the algorithm (or to develop the covariance matrix used in the physical approach). The information content of the observing systems data is what we are aiming at assessing, without help from external data.
- Independence from ancillary data: Algorithms should be tested using the data (simulated) of the observing system(s) without use of ancillary data such as forecast background or other sources.
- Representativeness and robustness of the results: The validation set used to assess performance should be as representative as possible of the geophysical situations. The following is a list of potential (not exhaustive) items to consider in the representativeness of the set: seasonal variability, diurnal cycle, meteorological situations (humid, dry atmospheres, land/ocean/cryosphere surface background, clear and cloudy conditions, etc.). This representation within the validation set should aim at resembling the naturally-occurring statistical representation of these situations. We recommend the vendor ensure the statistical results are as robust as reasonably possible.

- The assumptions made in the assessment process should be made clear in the documentation providing the results (in the Notes tab). Examples (not exhaustive list) include: assumption bias or not in the simulated data, noisiness added or not (and levels of this noise), description of the training stage and the validation stage and the representativeness included in the validation set.

Table 1. Geophysical variables describing the Earth environment.

Environmental Domain	Geophysical Variable	Symbol / Abbreviation	Units (s.d. Units)
Atmosphere	Relative Humidity	RH	%
Atmosphere	Wind Speed Profile: Eastward	u	m/s
Atmosphere	Wind Speed Profile: Northward	v	m/s
Atmosphere	Aerosol Concentration	n_A	/m3
Atmosphere	Cloud Cover	CC	Fraction
Atmosphere	Ozone Concentration (Column)	O_3	DU
Atmosphere	Cloud and Moisture Imagery	CMI	NA
Atmosphere	Incoming Shortwave Radiation: Surface	ISR	W/m2
Atmosphere	Air Temperature: Profiles	T(z)	K
Atmosphere	Water Vapor: Boundary Layer Depth	WV_BLD	km
Atmosphere	Carbon Dioxide/CO2	CO2	ppm
Atmosphere	Total Lightning	TL	**%**
Atmosphere	Specific Humidity	q	g/kg
Atmosphere	Methane CH4	CH4	ppmv
Atmosphere	Carbon Monoxide/CO	CO	ppbv
Atmosphere	Sulfur Dioxide/SO2	SO2	DU
Atmosphere	Total Precipitable Water	TPW	mm
Atmosphere	Layer Precip Water	LayerPW	mm
Atmosphere	Aerosol Optical Depth/Thickness	AOT	unitless
Atmosphere	Ozone profile (Troposphere vs stratosphere)	O3_p	%
Atmosphere	Nitrogen Dioxide/NO2	NO2	ppb
Atmosphere	Smoke (evaluated at night)	Smoke_Night	unitless
Atmosphere	Hydrometer Size and Type (Low Cloud and Fog eval at night)	HST_LCF	%
Atmosphere	Aerosol Refractive Index	ARI	TBD
Atmosphere	Effective reflectivity	ER	%
Atmosphere	Aerosol Layer Height	ALH	km
Atmosphere	UV Aerosol Index	UV_AI	km
Atmosphere	Formaldehyde/CH2O	CH2O	molecules/m2
Atmosphere	Glyoxal/C2H2O2	C2H2O2	molecules/m2
Atmosphere	Isoprene/C5H8	C5H8	ppm
Biosphere	Fire Radiative Power	FRP	MW/km2
Biosphere	Flood standing water: Extent	FI	%
Biosphere	Normalized Difference Vegetation Index	NDVI	unitless
Biosphere	Soil Moisture: Surface Wetness	W	m3/m3
Biosphere	Land Surface Albedo	LSA	unitless

Biosphere	Fires: Location and Size (taking size)	fire_size	km
Biosphere	Land Surface Temperature	LST	K
Biosphere	Surface Type	ST	unitless
Cryosphere	Sea Ice Age	SIA	yr
Cryosphere	Sea Ice Concentration	SIC	%
Cryosphere	Snow Water Equivalent	SWE	cm
Cryosphere	Ice Surface Temperature	IST	K
Cryosphere	Snow Cover	SC	%
Cryosphere	Snow Depth	SD	m
Cryosphere	Snow Grain Size	SGS	mm
Cryosphere	Sea Ice Motion, Local	SIM_Local	m/s
Hydrosphere	Cloud Liquid Water Path	LWC	g/m2
Hydrosphere	Rain Rate	RR	mm/hr
Hydrosphere	Cloud Drop Size (at Cloud Top)	CPS	um
Hydrosphere	Cloud Top Temperature	CTT	K
Hydrosphere	Precipitation Rate/Snowfall Rate	SFR	mm/hr
Hydrosphere	Cloud Base Height	CBH	km
Ocean	Ocean color: Chlorophyll-a Concentration	Chl	mg/m3
Ocean	Salinity	S	PSU
Ocean	Sea Surface Height	eta	cm
Ocean	Sea Surface Temperature	SST	K
Ocean	Bathymetry	B	TBD
Ocean	Wave Height	h	m
Ocean	Global Sea Surface Wind Speed	OSWS	m/s
Ocean	Global Sea Surface Wind Direction	OSWD	deg
Space	Electrons: Medium & High Energy, GEO	e_MedHI_GEO	#/(cm2-s-sr-keV)
Space	Electrons and Protons: Low Energy, GEO	ep_Low_GEO	#/(cm2-s-sr-eV)
Space	Protons: Medium and High Energy, GEO	p_MedHi_GEO	#/(cm2-s-sr-KeV)
Space	Solar and Galactic Protons: GEO	p_SEPGCR_GEO	#/(cm2-s-sr-MeV)
Space	Solar Wind: Low Energy Particle Population, L1	part_Low_L1	#/(cm2-s-sr-keV)
Space	Solar Wind: Plasma Ion Density, L1	rho_L1	#/cm3
Space	Solar Wind: Plasma Ion Temperature, L1	T_L1	K
Space	Solar Wind: Plasma Ion Velocity Vector, L1	Vel_L1	km/s

Space	Ionospheric Electron Density Profiles	e_iono	#/cm3
Space	Solar Wind: High Energy Electrons, L1	e_Hi_L1	#/(cm2-s-str-MeV)
Space	Electrons: Medium and High Energy, LEO	e_MedHI_LEO	#/(cm2-s-str-KeV)
Space	Ions: Medium and High Energy, LEO	ion_MedHi_LEO	#/(cm2-s-str-MeV)
Space	Geomagnetic Field: GEO	mag_GEO	nT
Space	Solar Wind: Magnetic Field Vector, L1	mag_L1	nT
Space	Geomagnetic Field: LEO	mag_LEO	nT
Space	Geomagnetic Field: MEO	mag_MEO	nT
Space	Solar Flux: EUV	sun_flux_EUV	W/m2
Space	Solar Flux: X-Ray Irradiance	sun_flux_Xray	W/m2
Space	Solar Imagery: Multi-Spectral X-Ray/EUV Radiance, EarthSun Line	sun_image	W/m2
Space	Solar Imagery: Corona, L1	sun_corona_L1	W/m2
Space	Solar Imagery: Corona, L5	sun_corona_L5	W/m2
Space	Multispectral Auroral Imaging	aurora_image	W/m2
Space	Mesosphere and Lower Thermosphere Atomic Oxygen Vertical Profiles	MT_O	#/cm3
Space	Mesosphere and Lower Thermosphere Winds Vertical Profile	MT_Wind	m/s
Space	Solar Imagery: Heliospheric, L1	Sol_Im_HelioL1	W/m2
Space	Solar Imagery: Heliospheric, L5	Sol_Im_HelioL5	W/m2
Space	Solar Imagery: Magnetogram, L1	Sol_Im_MagL1	nm
Space	Solar Imagery: Magnetogram, L5	Sol_Im_MagL5	nm
Space	Solar Imagery: White Light, L5	Sol_Im_WhiteL5	W/m2
Space	Interplanetary energetic particles	p_SEPGCR_planet	#/(cm2-s-sr-MeV)
Space	Interplanetary Solar wind: L5	part_Low_L5	#/(cm2-s-sr-keV)

Table 2. Attributes of a description of the Earth environment.

Attribute	Symbol	Units	Definition
Imagery Representation	I	logical	This parameter is represented by imagery.
Geographic Coverage	D	dimensionless	Geographic region observed
Horizontal Density	N_A	(100 km)-2	Number of observations within swath per (100 km) square region.
Horizontal Resolution	delta_x	Km	GIFOV or ground-projected instantaneous field of view
Temporal Refresh	T_R	H	Time between observations at a location, i.e, time to observe the geographic coverage region D.
Vertical Extent Bottom	E_b	Km	Bottom of vertical region observed.
Vertical Extent Top	E_t	Km	Top of vertical region observed
Vertical Resolution	N_v	d.o.f	Independent pieces of information in one GIFOV.
Accuracy (Error Standard Deviation)	a	units	Composite accuracy over the vertical layers, over the clear and cloudy conditions, and over different surface backgrounds (when appropriate).
Validity Range Low	V_l	units	Low value that can be observed.
Validity Range High	V_h	units	High value that can be observed.
Robustness	N_S	dimensionless	Number of sources making this observation
Continuity	T_C	Yr	Time for which the observations can be intercalibrated for climate monitoring purposes.
Data Latency	T_L	s	Time from ‘image taken’ to full relay of data to a ground station.