2023 EARTH OBSERVATIONS ASSESSMENT REPORT: OVERVIEW AND METHODOLOGY

Product of the

SUBCOMMITTEE ON U.S. EARTH OBSERVATION

COMMITTEE ON ENVIRONMENT

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About the Subcommittee on the United States Group on Earth Observations

The United States Group on Earth Observations (USGEO) is chartered as a Subcommittee of the NSTC Committee on Environment. The Subcommittee's purpose is to plan, assess, and coordinate Federal Earth observations, research, and activities; foster improved Earth system data management and interoperability; identify high-priority user needs for Earth observations data; and engage international stakeholders by formulating the United States' position for, and coordinating U.S. participation in, the intergovernmental Group on Earth Observations (GEO).

About this Document

This report explains the methodology, including the structure and content, used to conduct an Earth Observations Assessment (EOA). It also highlights the ways in which such an assessment can provide value to users. USGEO is making readily available, either through related reports or through the online visualization services (https://usgeo.gov/eoa), those elements that are most valuable for agency and public analysis.

Copyright Information

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Introduction and Background

The 2010 NASA Authorization Act instructed the Director of the Office of Science and Technology Policy (OSTP) to establish a mechanism to ensure greater coordination of civilian Earth observations. In response, OSTP established a process for a government-wide assessment of the Nation's Earth observation portfolio, which yielded the Earth Observation Assessment (EOA). The EOA informs the National Plan for Civil Earth Observations (the Plan, or the National Plan), significantly enhancing coordination of civil Earth observations. The EOA is overseen by the National Science and Technology Council, Committee on Environment and Natural Resources, U.S. Group on Earth Observations (USGEO) Subcommittee. It is coordinated and guided by the USGEO Subcommittee's Assessment Working Group (AWG), and supported by an assessment team of technical experts.

This report explains the methodology, including the structure and content, used to conduct an EOA. It also highlights the ways in which an assessment can provide value to users. In general terms, the EOA provides:

1. A representative list of Earth observation systems and datasets—referred to as inputs below—that the Nation relies on to meet its objectives,
2. Tables that show which inputs support various societal benefit areas (SBAs),
3. Linkages between each input and the key products, services, and outcomes (KPSOs), key objectives (KOs), and SBAs that rely on them, and
4. Impact scores for each input, including overall impact within each SBA, SBA sub-area, and KO.

Overview

The EOA dataset is a potentially powerful tool for improved Earth observation coordination and planning. The observing systems architecture analysis capability is designed to help users understand where various inputs are used, how much they may impact multiple objectives and missions, and how the loss of an asset or the development of new assets might affect mission activities. Many more questions can be answered by querying the dataset, such as identifying which agencies are using each input for which purposes. Also, since the dataset includes evaluations of satisfaction with the inputs as well as degrees of reliance on them, it can be queried to identify areas for improvement. The USGEO Subcommittee will work with agencies interested in such queries.

One additional type of information preserved in the dataset is comments from users that describe specific concerns related to inputs. These can be used, in conjunction with other analyses, to answer questions about what changes might yield the greatest benefits, or what benefit might be gained by filling a data gap with a proposed capability.

In summary, the dataset can be used to help answer many questions at the product and input levels, such as:

- Which agencies use a product or service (who are the customers) and for what applications?
- Which agencies and products or services are highly reliant on a given data input?
- How satisfied are users with a particular product or service?
- If users are not fully satisfied with a product or input, what are the issues and limitations?
- Which objectives and agencies would be affected if a particular input was removed?
- What would happen to a KO if a sensor or platform was lost?
- For what purposes is a particular input most impactful?
- Are there gaps in the types of observations for certain SBAs that could be filled?

The results quantify the relative reliance of the Federal Government on individual observing systems, sensors, networks, and surveys. It does not fully address private, business, State, Tribal and local governments' needs. It is also intended to be used by others as a tool for improved coordination of Earth observation systems, products, information, and data. The dashboard created for each SBA provides a means to explore these data in detail (https://usgeo.gov/eoa/).

The first two EOAs in 2012 and 2016 assessed all 13 societal benefit areas (SBAs) at once. Future EOA's will instead assess two to four SBAs per cycle, updating all SBAs over a period of 5 years. While this limits the analyses that can be done across the SBAs, and therefore the conclusions that can be drawn about the overall Earth observation enterprise, it establishes a viable cadence with more frequent updates.

The methodology and tools used for this assessment are refined and improved to overcome shortcomings as they are identified; therefore, this should be considered a living document. Updates and improvements to the process will be included as they are identified. The following subsections describe the major activities carried out during an assessment. The SBA annexes provide the analysis results, while the SBA reports describe more fully the findings and recommendations based on the analysis results.

Value Tree Structure

The EOA captures the environmental, economic, and social domains in which public services and research provide societal benefit (Figure 1). Organizing the EOA by SBAs ensures that all the information it contains—the lists, the usage tables, the linkages, and the impact scores—pertains to national needs and objectives. The EOA enables improved coordination by providing perspective on the importance of the portfolio to the Nation, not just to a particular agency or product, and thereby encourages and supports deliberation and decision-making based on the Nation's wellbeing.

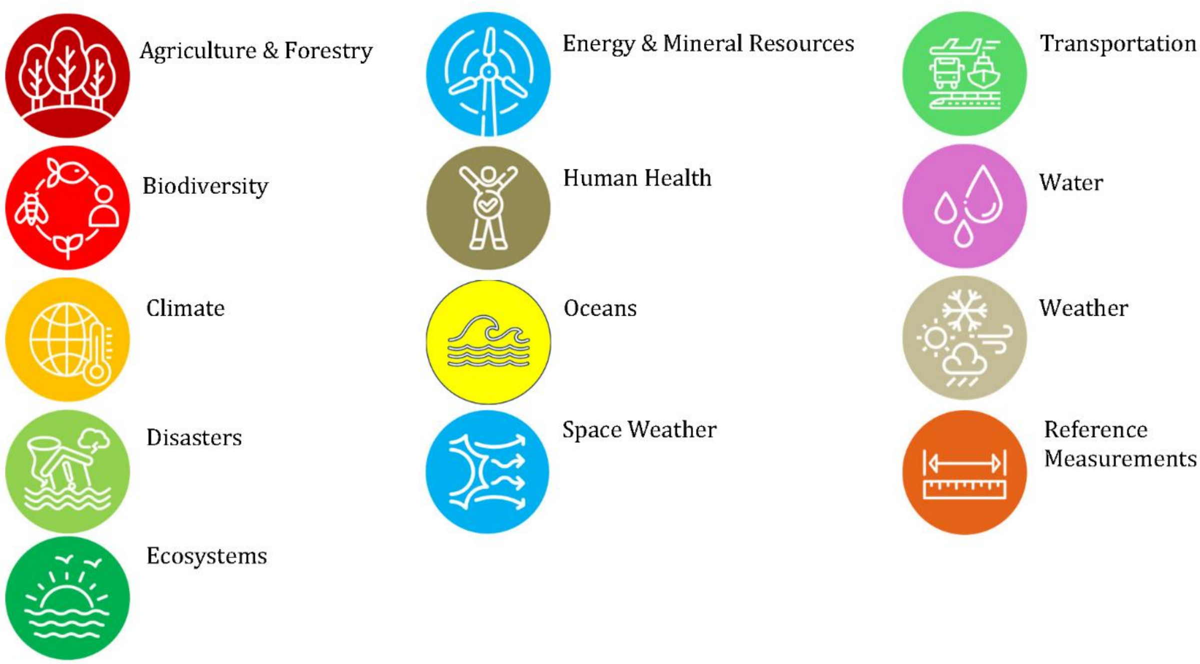

Figure 1. ***The 13 SBAs That Make up the EOA.***

Societal Benefit Area Value Tree Hierarchy

Structure

Each of the 13 SBAs that make up the full EOA dataset are organized into a hierarchical structure, or value tree. A value tree is a hierarchical model containing top-level SBAs and sub-areas, and respective functionally aligned products and services. It represents the relationship between data sources and SBAs, and can therefore be used to assess the impact of observing systems and their products on all levels of the value trees.

Each value tree consists of multiple levels (Table 1) At the top, the SBA is divided into natural thematic subdivisions, or SBA sub-areas. KOs are further subdivisions of the sub-areas that describe the activities that support national rather than agency-specific goals, and can be clearly linked to Earth observation systems, data, or products derived from Earth observations. The bottom of the tree includes KPSOs. These are the data, information, or analytical products that directly support progress toward meeting KOs. The inputs to KPSOs are the Earth observations or intermediate products needed to produce KPSOs. KPSOs that belong to the same category or class of information products or research area are organized into KPSO groups.

Top of the Value Tree: Defining an SBA Value Tree

The EOA is coordinated by SBA teams consisting of Federal experts guided by the USGEO Subcommittee's AWG and supported by an assessment team of technical experts. Each SBA team defines and organizes the structure of its value tree and assigns weights to the top levels where applicable. The weights are used to differentiate the relative importance of elements that make up each level of the value tree. SBA team members also identify relevant subject matter experts (SMEs) for the data collection portion of the EOA that describes the bottom of the value tree. The final structure and weighting of each SBA value tree is used to generate a quantitative assessment of the contribution of each Earth observation input to delivering societal benefit as captured within each SBA.

This assessment ultimately determines the extent to which the top five levels of the value tree (the SBAs, sub-areas, KOs, KPSOs, and KPSO groups) rely upon each input. By defining the structure of the value tree and assigning weights at the KPSO group level and above (determined by the SBA teams), and by defining criticality and satisfaction of each input for each KPSO (based on the elicitation sessions with KPSO producers), the value tree represents as accurately as possible the flow of benefit from each input to any element in any level in the tree above it. The value tree can then be evaluated to determine the impact of removing an input from the tree on any level of the tree. The EOA dataset captures all these linkages. Figure 2 illustrates the types of connections captured in an EOA.

Table 1. ***Table of Value Tree Structure, Descriptions, and an Example.*** *Each SBA is organized in the same way. For every level of the value tree, there are multiple contributors to the element above. For example, there are multiple sub-areas that contribute to the Agriculture & Forestry SBA and multiple Earth observation inputs that contribute to the KPSO. This example shows a single pathway (out of many) of how Landsat contributes to the Agriculture & Forestry SBA.*

Value Tree	Elements	Description	Example
Top	SBA	Societal Benefit Area	Agriculture & Forestry
	SBA Sub-Area	Natural thematic subdivisions of the parent SBA	Enhance Food Supply
	KO	An activity within a sub-area that is clearly supported by and can be linked to Earth-observing systems, data, and products	Support forage assessment and management for animal production
	Key Product, Service, or Outcome (KPSO) Group	A group of KPSOs that belong to the same category or class of information products or research outcomes	Indicators of grazing conditions
Bottom	KPSO	A primary or important information product, service, or outcome required to make progress toward or meet a KO	Rangeland Condition Monitoring Assessment and Projection (RCMAP)
	Data Source (Surveyed Product and/or Earth Observations Input)	The data, information, and Earth-observing systems needed to produce KPSOs	3DEP, LCMAP, NLCD, CDL, Landsat
	Earth Observations Input	An observing system or database that is the lowest level of disaggregation in the value tree	Airborne lidar

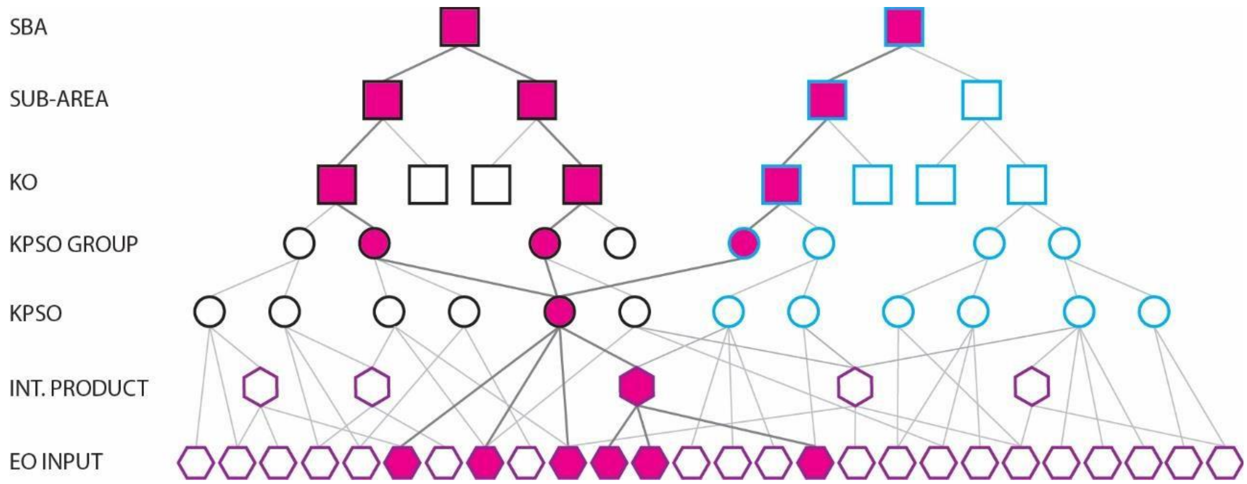

Figure 2. ***Schematic Illustration of Linkages among Elements in the EOA Dataset.***

Defining and Organizing the Value Tree Levels

To define an SBA value tree, an SBA team made up of cross-agency SMEs reviews the current tree, including definitions, scope, and overlap with other SBAs. The team:

- Updates the SBA sub-areas to reflect the current understanding of and approach to the SBA,
- Describes key Federal objectives through which agency Earth observation activities and programs contribute to delivering societal benefit,
- Identifies an initial set of KPSOs that support each KO and rely on Earth observations,
- Categorizes KPSOs into KPSO groups if they belong to the same category of information products or research area, and
- Identifies SMEs for each KPSO to facilitate the process for collecting data for the bottom of the value tree. SMEs are selected based on their knowledge of the KPSO and the data, information, and Earth observation inputs required to develop and deliver the KPSO.[1]

Assigning Weights to Value Tree Levels

Sub-areas and KOs may contribute different amounts of societal benefit from one another. Some sub-areas play a larger role in supporting an SBA than others within the same SBA. Similarly, some KOs make a larger contribution to a sub-area than others. To fully assess the relative contribution of each Earth observation input to the provision of societal benefit, SBA teams assign weights to each of the sub-areas and KOs within an SBA to capture the relative differences in contribution to the next level up. Weights are applied so that the total weight of all sub-areas in an SBA sum to 100%, and the total weight of all KOs within a sub-area also sum to 100% (Figure 3).

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[1] Because the underlying Earth observation inputs may be sensors, systems, databases, fieldwork or other sources that provide input to the KPSOs, they are collectively referred to in this report as "inputs."

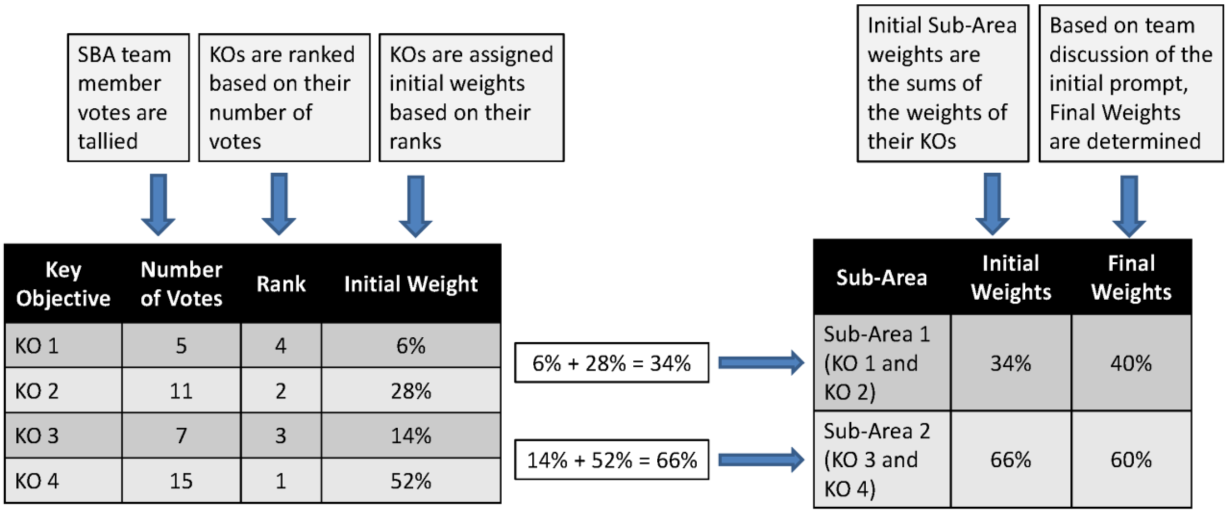


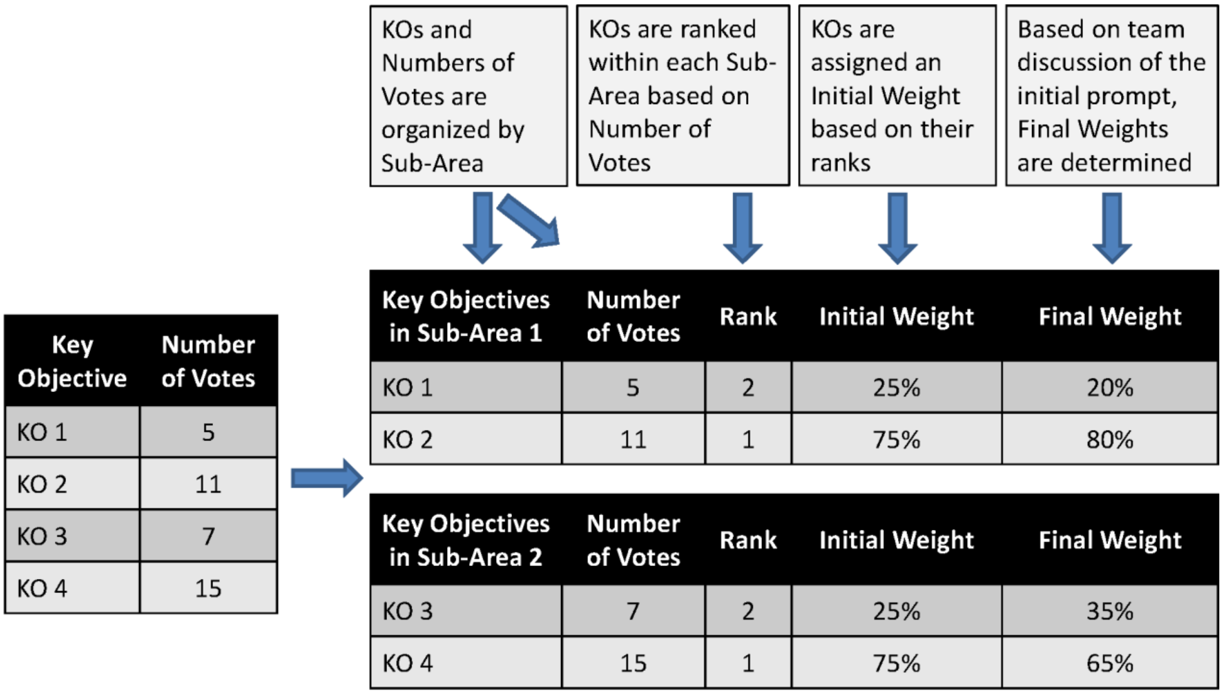
Figure 3. ***Example of SBA Sub-Area Weighting.***

SBA team members use a rigorous and reproducible process to determine initial weights for sub-areas and KOs of each SBA. To help the SBA team members estimate the relative weights of the different objectives, the assessment team uses an elicitation method based on the Simple Multi-Attribute Rating Technique Exploiting Ranks (SMARTER) system.[2] SBA team members are given an alphabetized list of the KOs within their SBA and are presented with the following prompt: “Earth observations are critical for realizing many societal benefits. In the value tree for your SBA, the key objectives reflect the various ways Earth observations currently contribute to societal benefits.” The team members are asked to vote for the top 50% of KOs in an SBA that, in their view, provide the most societal benefit from Earth observations. The assessment team sums the votes from each team member to calculate the total number of votes for each KO, and KOs are then ranked across and within sub-areas (Figure 4).

The Rank Order Centroid (ROC) model is used to convert the SBA teams’ ranks into weights. For an SBA with a total number of K key objectives, the weight of the k^{th} key objective w_k across all sub-areas is calculated as follows:

$$w_k = \left(\frac{1}{K}\right)\sum_{i=k}^{K}\left(\frac{1}{i}\right)$$

[2] W. Edwards and F. H. Barron, “SMARTS and SMARTER: Improved Simple Methods for Multiattribute Utility Measurement,” *Organizational Behavior and Human Decision Processes* 60 (1994): 306–325.



Key Objective	Number of Votes
KO 1	5
KO 2	11
KO 3	7
KO 4	15

Key Objectives in Sub-Area 1	Number of Votes	Rank	Initial Weight	Final Weight
KO 1	5	2	25%	20%
KO 2	11	1	75%	80%

Key Objectives in Sub-Area 2	Number of Votes	Rank	Initial Weight	Final Weight
KO 3	7	2	25%	35%
KO 4	15	1	75%	65%

Figure 4. ***Example of Key Objective Weighting.***

Because of the large number of KPSOs within each SBA, SBA teams place KPSOs into thematic KPSO groups. SBA team members with expertise in the relevant science area assign weights to the KPSO groups. The guiding weighting metric is that those KPSO groups that contribute more to achieving the KO should receive a higher weight than those that contribute less. Following the survey, each SBA team member's vote is averaged, and both the average and standard deviation of the weights are sent to the SBA team leads for final determination of the KPSO group weights. The KPSOs within each KPSO group are weighted equally. An example of what the full process looks like is seen in Figure 5.

Bottom of the Value Tree: Evaluating the Key Products, Services, and Outcomes and Their Inputs

Earth Observation Inputs

Hundreds of interviews with SMEs are conducted for each SBA in order to identify the relevant Earth observation data that serve as inputs for the full assessment. The ultimate list of inputs is not a comprehensive inventory of all possible inputs; instead, it identifies a snapshot of representative inputs that currently support the SBAs.

There are many types of EOA inputs, including human, mechanical, and electronic instruments; in situ stationary and mobile devices; and remotely sensed (via satellite, balloon, and piloted and unmanned aircraft) data and imagery. They span a range of geographic scales (local, regional, hemispheric, global). They also include a number of inputs that may not automatically come to mind when a person thinks about "observing" the planet: things like historical maps, human observers, permit databases, and sets of publications that provide crucial context and calibration without which new observations are less meaningful.

While all inputs are used to meet Federal objectives, the inputs are not limited to Federal observing systems. EOA inputs may also include resources from international, State, Tribal, Territorial, or local governments; commercial companies; and nonprofit organizations.

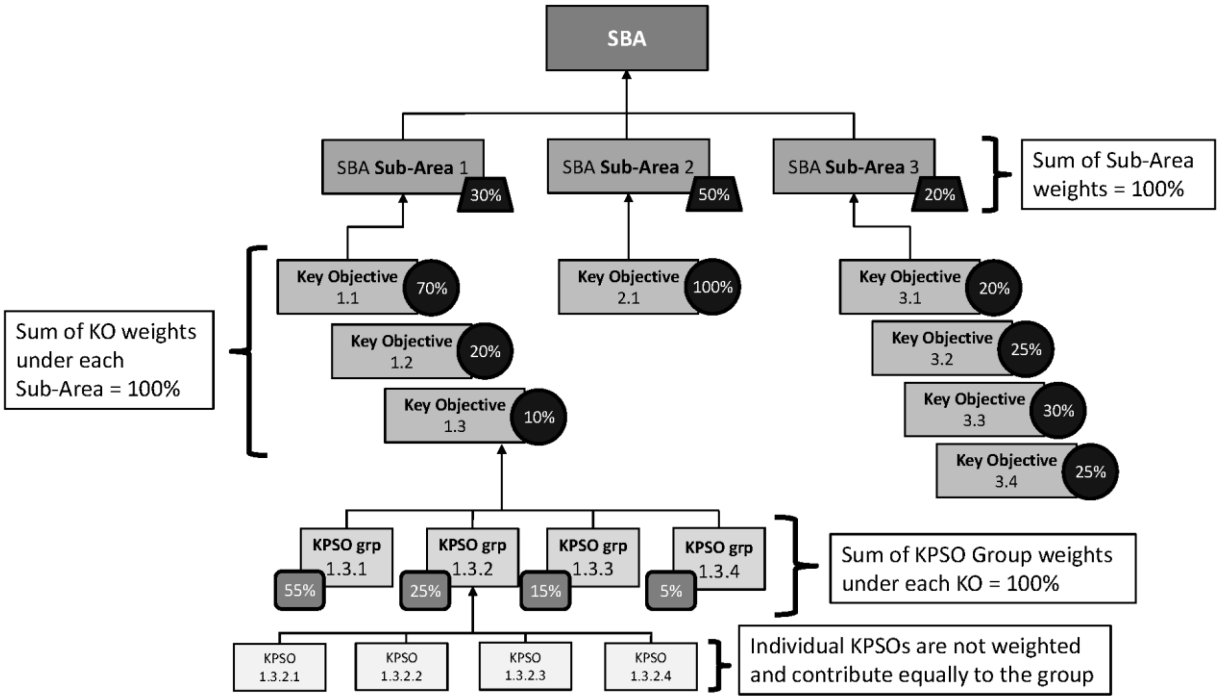


Figure 5. ***Example of Value Tree Weighting Results.***

Method for Determining the Impact of Earth Observation Inputs

During the EOA data collection process, structured elicitation sessions with SMEs are held to gauge the relative importance of Earth observation data, and thereby the systems or surveys providing the data, to producing an identified KPSO. In each KPSO elicitation session, SMEs are asked to:

1. Quantify how well the KPSO is meeting its mission requirements or research goal,
2. Identify the inputs they rely on to produce the KPSO, including direct inputs and intermediate products,
3. Quantify the criticality of individual data inputs, and
4. Quantify their overall satisfaction with each data input.

The assessment team asks SMEs to quantify, on a scale of 1–100 (Figure 6), how well a KPSO meets its mission requirements or research goal. This is referred to as the "status quo score" because it represents the current state of the KPSO. They are then asked how well each input meets the requirements for producing the KPSO. These scores are referred to as "satisfaction scores," representing how satisfied the SME is with the input to the KPSO.

Performance / Satisfaction Scale		
100	Ideal	Meets all requirements and exceeds some
90	Fully Satisfied	Meets all requirements
80	Good	Meets all major requirements with minor limitations
70		
60	Fair	Meets most major requirements, with significant limitations
50		
40	Poor	Fails to meet many major requirements, but provides some value
30		
20	Very Poor	Fails to meet most major requirements, but provides minor value
10		
1	No Capability	Provides no value

Figure 6. ***Scale for Determining Status Quo and Satisfaction Scores.***

The criticality of each Earth observation input is determined using a technique called swing weighting.[3] With swing weighting, the SME quantifies how much the status quo score would drop if the SME no longer had access to each of the individual inputs to a KPSO. The change in the status quo score reflects the reliance of the KPSO on each input. See Figure 7 for an example.

Impact Scores

The assessment team uses swing weighting information and satisfaction scores to calculate the impact of each input on the KPSO. The impact scores reflect the extent to which an input contributes to the KPSO's performance (or ability to meet requirements or goals). The SMEs review the initial impact scores and verify that the scores represented their responses.

Because the value tree represents as accurately as possible the flow of benefits from each input to any element in any level in the tree above it, the value tree can be evaluated to determine the impact of removing any given input from the tree at any level of the tree. The impact of each input is determined by calculating the difference in the status quo score with and without each input for each element at each level in the value tree. This allows for the calculation of the impact of each input for SBAs, sub-areas, and KOs. The impact that an input has on any given element in any of the top five levels is the ratio of each element's status quo score without the input present to the element's original status quo score, expressed as a percentage.

Tables of Earth Observation Inputs

Each SBA annex shows the inputs supporting the SBA and SBA sub-areas, and the relative contribution of each input. These tables offer managers and policy makers a comprehensive view of the Earth observation inputs that contribute to major SBA sub-areas. For example, a reader can see the full suite of Earth observation inputs that contribute to Enhancing Food Supply under the Agriculture & Forestry SBA. The tables offer a starting point for use of the assessment. To derive full benefit from the EOA data, agencies can work through the USGEO Subcommittee to query the EOA relational dataset for further information about agency KPSOs, their usage, and inputs.

[3] This technique is described in C. W. Kirkwood, *Strategic Decision Making: Multi-objective Decision Analysis with Spreadsheets* (Belmont, CA: Duxbury Press, 1997), and G. S. Parnell, P. J. Driscoll, and D. L. Henderson, eds., *Decision Making in Systems Engineering and Management* (Hoboken NJ: John Wiley & Sons, 2011).

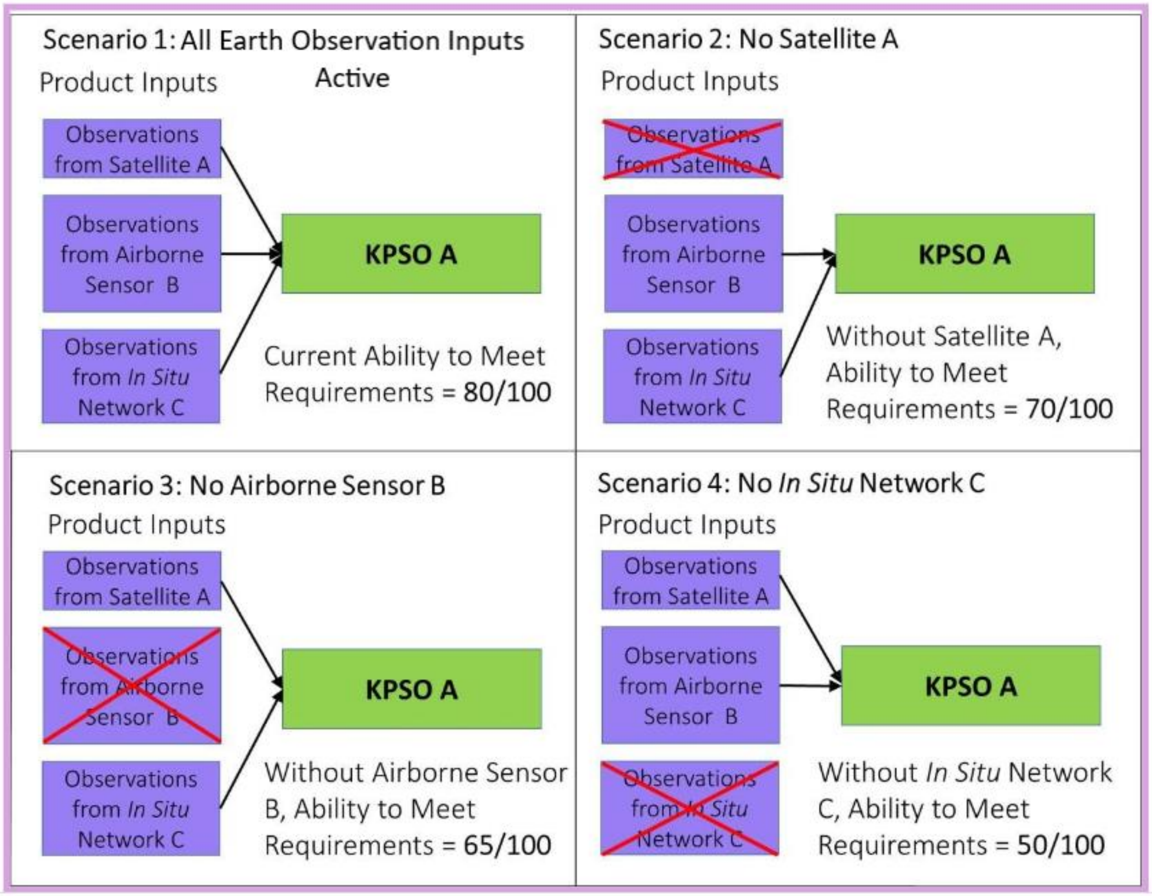


Figure 7. ***Simplified Depiction of How Different Inputs Affect KPSO Status Quo Score.*** *In this swing weighting example, three Earth observation inputs are needed to make KPSO A, which has a status quo score of 80 when all inputs are available (scenario 1). When input A is removed, the status quo score drops by 10 points to 70 (scenario 2). When input B is removed, the status quo score drops by 15 points to 65 (scenario 3). Finally, the removal of input C drops the status quo score by 30 points to 50 (scenario 4).*

Table 2 provides an abbreviated version of an EOA results table. The table lists the first 15 (alphabetically) inputs to the Agriculture & Forestry SBA and its sub-areas. A colored cell under the SBA and sub-area columns indicates that the input has some degree of impact on a given part of the value tree; a white cell indicates no impact. Airborne High-Resolution Visible Imagery, for example, was ranked in the 95th percentile based on its impact on the Agriculture & Forestry SBA, as compared to all other Earth observation inputs. By contrast, the Advanced National Seismic System (ANSS) ranked below the 50th percentile in the list. The range of inputs that matter to the SBA or sub-area is seen by reading down the relevant column in the table. Airborne Synthetic Aperture Radar (SAR)/Interferometric SAR (IfSAR) ranks in the 95th percentile in both the SBA and all sub-areas.

Table 3 shows the SBA and sub-area-level impact scores for the 50 inputs with the highest overall impact scores in the Agriculture & Forestry SBA. A full version of these tables is available in the annex that accompanies each SBA report.

Table 2. ***Alphabetical List of the Inputs to the Agriculture & Forestry SBA and Their Impacts at the SBA and Sub-Area Levels.***

Key	SBA	Sub-Area			
99th Percentile					
95th Percentile and Above					
90th Percentile and Above					
75th Percentile and Above					
50th Percentile and Above					
Below 50th Percentile					
Blank Cells Indicate Input Does Not Contribute to Area					
Earth Observation Inputs	Agriculture & Forestry [AF]	Enhance Food Supply [AF-1]	Maximize productivity and conservation of ecosystem condition [AF-2]	Improve resilience to disasters and disturbance events [AF-3]	Support regulatory requirements and evidence-based decision-making [AF-4]
1-Minute Refresh	0.04%	< 0.01%	< 0.01%	0.11%	< 0.01%
5-Minute Refresh	0.25%	0.01%	0.01%	0.73%	0.01%
Advanced Land Observing Satellite-2 (ALOS-2) Phased Array L-band SAR [JAXA]	0.01%	< 0.01%	0.01%	0.01%	0.05%
Advanced National Seismic System (ANSS)	< 0.01%			< 0.01%	
Ag Economic Data (crop prices, econ reports, cost of production, etc.)	< 0.01%	0.02%			
Agriculture and Agri-Food Canada (AAFC) Data	< 0.01%	< 0.01%	< 0.01%		< 0.01%
Agrimet (USBR, Pac NW Agricultural Sfc Weather Network)	0.03%	0.05%	0.04%	0.02%	0.03%
Air Resources Lab Observing Capabilities	< 0.01%	< 0.01%	< 0.01%	< 0.01%	< 0.01%
Air Resources Lab Observing Capabilities Nevada Test Site	< 0.01%	< 0.01%	< 0.01%	< 0.01%	< 0.01%
Air Resources Lab Observing Capabilities WDC Network	< 0.01%	< 0.01%	< 0.01%	< 0.01%	< 0.01%
Airborne Gamma Ray Surveys	0.01%	0.03%	0.01%	0.01%	0.02%
Airborne High-Resolution Visible Imagery	0.48%	0.07%	0.52%	0.50%	0.90%
Airborne Obs USCG	< 0.01%	< 0.01%	< 0.01%	< 0.01%	< 0.01%
Airborne Synthetic Aperture Radar (SAR)/Interferometric SAR (IfSAR)	1.34%	2.68%	1.10%	1.03%	1.35%
Aircraft Meteorological DAta Relay (AMDAR)	0.07%	0.06%	0.05%	0.11%	0.04%

Although impact scores are expressed in percentages, it is important to note that the impact scores in any column of any of the tables do not sum to 100 percent. This is because inputs are not fully independent in each KPSO in the value tree model. Still, because a given impact score is a percentage of any given SBA's total score, the impact scores for a given input can be compared across the 13 SBAs.

Using the Global Positioning System (GPS) as an example, Table 3 shows the overall impact score is 3.01 percent for Agriculture & Forestry SBA. This indicates that if GPS were removed from the dataset (i.e., from the Earth observations portfolio), the overall Agriculture & Forestry score would fall by more than 3 percent.

In addition to providing the numeric scores, Table 3 and the tables in the annexes enable readers to appreciate the relative impacts of inputs at a glance because the tables use colors to denote the percentiles into which the impact scores fall relative to the ranked list of all inputs. Continuing the GPS example from above, Table 3 shows GPS (line 10) impact scores fall in at least the 95th percentile across all Agriculture & Forestry sub-areas and in the 99th percentile in two (Maximize productivity and conservation of ecosystem condition; Support regulatory requirements and evidence-based decision-making).

*Table3. **Fifty of the Most Impactful EO Systems to the Agriculture & Forestry SBA.***

Key:
- 99th Percentile
- 95th Percentile
- 90th Percentile
- 75th Percentile
- 50th Percentile
- Below 50th Percentile
- Blank Cells Indicate Input Does Not Contribute to Area

Key	Earth Observation Inputs	SBA: Agriculture & Forestry [AF]	Sub-area: Enhance Food Supply [AF-1]	Sub-area: Maximize productivity and conservation of ecosystem condition [AF-2]	Sub-area: Improve resilience to disasters and disturbance events [AF-3]	Sub-area: Support regulatory requirements and evidence-based decision-making [AF-
1	Aqua Moderate Resolution Imaging Spectroradiometer (MODIS)	9.04%	8.56%	8.96%	9.84%	7.26%
2	Terra Moderate Resolution Imaging Spectroradiometer (MODIS)	8.99%	8.42%	8.96%	9.77%	7.24%
3	Field Work - Visual Surveys/Lab Samples Collection	8.54%	11.22%	14.68%	1.98%	1.68%
4	Landsat Operational Land Imager (OLI)	6.76%	5.81%	7.41%	6.98%	4.76%
5	JPSS Polar Constellation Visible Infrared Imaging Radiometer Suite	4.49%	2.47%	3.83%	6.39%	3.75%
6	DEM Output - Shuttle Radar Topography Mission (USGS)	4.22%	4.06%	4.32%	4.33%	3.64%
7	Sentinel-2 Multi-Spectral Imager [ESA]	3.65%	3.81%	2.66%	5.36%	1.52%
8	National Agriculture Imagery Program (NAIP)	3.45%	5.10%	2.76%	2.01%	8.96%
9	Landsat Thermal Infrared Sensor (TIRS)	3.08%	3.21%	3.14%	2.94%	3.07%
10	Global Positioning System (GPS)	3.01%	1.48%	3.90%	1.35%	7.49%
11	Database: National Elevation Dataset (NED)	2.92%	3.95%	3.33%	2.10%	2.44%
12	Field Work - Ground Surveys, Field Measurements	2.86%	0.17%	4.17%	1.05%	8.00%
13	Database: State/Local Parcel Data	2.57%	0.14%	3.68%	0.98%	7.33%
14	Database: Landsat archives	2.54%	1.30%	3.13%	1.75%	4.75%
15	Commercial Airborne Lidar	2.41%	4.53%	1.58%	2.53%	2.19%
16	Global Land Survey Digital Elevation Model (GLSDEM)	2.41%	2.24%	2.46%	2.55%	1.92%
17	Citizen Reporting - Phenology	1.98%	0.23%	4.32%	0.54%	
18	Database: USGS Topographic Maps	1.59%	0.14%	2.13%	0.78%	4.48%
19	SNOwpack TELemetry (SNOTEL)	1.51%	1.98%	0.91%	2.19%	0.86%
20	GOS Basic Surface Synoptic Network	1.39%	0.52%	0.14%	3.45%	0.67%
21	Field Work - Visual Surveys	1.34%	1.69%	0.34%	1.19%	5.53%
22	NEON Airborne Observation Platform (AOP) Imaging Spectrometer	1.32%	1.93%	2.51%	< 0.01%	< 0.01%
23	ISS Global Ecosystem Dynamics Investigation (GEDI) Lidar	1.31%	0.08%	1.48%	0.64%	4.88%
24	Airborne Synthetic Aperture Radar (SAR)/Interferometric SAR (IfSAR)	1.31%	2.65%	1.06%	0.99%	1.33%
25	Database: Historical FIA Forest Inventory Data	1.29%	0.07%	1.88%	0.45%	3.71%
26	Geostationary Operational Environmental Satellite - R Series ABI	1.28%	0.52%	0.48%	2.77%	0.55%
27	Field Work - Visual Inspections	1.09%	1.99%	0.37%	0.82%	3.68%
28	USGS Streamgages	1.07%	1.98%	0.70%	1.22%	0.62%
29	WorldView 3 Commercial Earth Observation Satellite	1.01%	1.08%	0.33%	1.53%	1.93%
30	National Ecological Observatory Network (NEON)	0.99%	0.12%	2.16%	0.27%	
31	Database: National Hydrography Dataset (NHD) Data	0.98%	1.43%	1.26%	0.41%	1.11%
32	Database: Integrated Reporting of Wildland-Fire Information (IRWIN)	0.90%	0.07%	0.30%	1.92%	1.11%
33	WorldView 2 Commercial Earth Observation Satellite	0.88%	0.88%	0.33%	1.23%	1.92%
34	Database: Google Earth	0.83%	0.11%	1.22%	0.43%	1.69%
35	Database: STATSGO Database	0.82%	1.22%	0.82%	0.65%	0.75%
36	NWS Cooperative Observer Program (COOP)	0.81%	0.97%	0.49%	1.20%	0.49%
37	Database: ArcGIS Imagery	0.80%	0.04%	1.09%	0.45%	2.06%
38	US National Imagery Systems (USNIS)	0.78%	< 0.01%	< 0.01%	1.70%	2.01%
39	State & Local Air Monitoring Stations (SLAMS)	0.76%	0.01%	1.59%	0.31%	0.01%
40	Interagency Remote Automated Weather Stations (RAWS)	0.74%	0.64%	0.45%	1.17%	0.57%
41	Database: VIIRS Land Cover Product	0.72%	0.31%	1.51%	0.18%	< 0.01%
42	Database: Google Earth Engine (GEE)	0.68%	0.55%	1.04%	0.14%	1.29%
43	Database: Canadian Digital Elevation Model	0.68%	0.66%	0.67%	0.75%	0.53%
44	Database: FAA Airport Diagrams	0.66%	0.03%	0.97%	0.22%	1.89%
45	Database: Avenza Maps	0.66%	0.03%	0.97%	0.22%	1.89%
46	Database: USDA FSA Form 578 Database	0.65%	1.76%	0.59%	0.33%	0.30%
47	Field Work - Field Experiments	0.65%		1.59%		
48	Database: Hydrologic Unit Codes (HUC)	0.65%	1.33%	0.62%	0.48%	0.27%
49	State Geologic Survey Maps	0.61%	1.47%	0.49%	0.28%	0.94%
50	Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)	0.60%			1.34%	1.46%

Linkages

The EOA dataset, capturing the links between inputs and their uses, can support a number of queries of potential interest to Federal agencies. For example, it is possible to identify the KPSOs that rely on a particular input, along with the producing agency. The EOA dataset also includes information about user satisfaction levels for individual inputs. Thus, by querying the dataset, the providers of Earth observation inputs, products, and services can better identify their Federal communities of use, user areas of concern, and potential enhancements.

Exploration of the EOA can illuminate the breadth of users of an individual input. As an example, the Geostationary Operational Environmental Satellite (GOES) Imager is an input to the Global Forecast System (GFS) model, and the output of that model is used, in turn, to produce local forecasts at airports across the United States. The EOA can identify direct and indirect uses of the GOES Imager across the SBAs.

Variation in Impact Scores

Most impact scores may seem low. This is in part due to the large number of inputs contributing to the many KPSOs, and in part due to planned redundancy for some systems. Inputs used in many KPSOs tend to have the largest overall impact, while most other inputs tend to have a smaller overall impact.

Caution must be exercised when comparing small impact scores and small differences between impact scores to avoid attributing more precision to the results than is appropriate when programmatic or budgetary decisions are under consideration. Still, the EOA is useful for framing analyses to support such decisions.

Interpreting Lower Impact Scores

Every Earth observation input assessed in the EOA supports and is useful for some portion of the Federal Earth observation enterprise, even if it is only a significant input to one KO within a single SBA. Thus, when viewing the overall SBA tables, great care must be taken when considering inputs with lower impact scores, because lower scoring inputs may still be crucial for specific sub-areas or KOs.

For example, the USGS Streamgages Network measures streamflow and water level in rivers and streams across the country. While it was ranked 28th overall in the 2023 Agriculture and Forestry SBA, it was ranked 4th within the KO *Increase the efficiency of irrigation, fertilizers, and pesticides by encouraging sustainable and precision agriculture*, demonstrating its importance for meeting that KO. In the overall Agriculture and Forestry SBA, USGS Streamgages are not near the top, and would not necessarily appear to be prominent, but their importance is apparent at the KO and KPSO levels.

Using the EOA Data

Immediate lessons about the scope of the portfolio and which particular inputs have more or less relative impact in which areas can be gleaned directly from the tables in the SBA annexes to this report. More detailed insight about the data collected in the assessment is available in the SBA reports, and the tableau viewer that was developed for this assessment (link).

Provisos

When interpreting EOA materials, it is helpful to keep the following provisos in mind.

Comprehensiveness

The list of inputs includes all inputs mentioned during elicitations for all KPSOs. Because the list of inputs is driven by the SBA-oriented elicitations, the list is not a comprehensive inventory of all Earth observation inputs. Additionally, it is limited by the availability of experts to participate in the process.

Current Focus

Because the EOA is a snapshot of the inputs that are relied upon to meet KOs at the time of the survey, the inputs represent data from current Earth observations and existing data. Future observing systems or capabilities may be discussed in the SBA annexes but are not included in the EOA results.

Impact versus Value

As the EOA does not include cost data or estimates of economic contributions associated with each Earth observation input, the results convey their impacts, not their economic value. The assessment is meant to provide useful information to the program planning process and to complement, but not substitute for or replace, information and methods traditionally used in agency or government budget planning processes.

Satellites

Federal agencies often need to make decisions about managing platforms that house multiple Earth observation inputs, not just single inputs. Satellites, for example, are platforms that may house multiple sensors that perform varied functions. To make decisions about managing satellites and constellations of satellites, users need information about entire sets of inputs.

The EOA dataset and individual SBA reports also provide information at the satellite-platform level by aggregating information about individual inputs into information about the entire set that resides on that platform. Reports about uses and impacts can be generated that correspond to those sets.

Glossary

Data Source: The data, information, and Earth observation systems needed to produce KPSOs.

Earth Observation Inputs: The Earth observation systems needed to produce KPSOs.

Intermediate Product: A product that is a data source for other products.

Impact Score: A relative measure of an observing system's contribution to performance at a given node in the value tree, typically the top node representing overall performance. In contrast to criticality, impact accounts for all of the contributions made by the observing system at all nodes in the tree below the node of interest.

Key Objective (KO): An activity within a sub-area that is clearly supported by and can be linked to Earth observation systems, data, and products.

Key Product, Service, or Outcome (KPSO): A primary of important information product, service, or outcome required to make progress toward or meet a KO.

Key Product, Service, or Outcome Group: A group of KPSOs that belong to the same category or class of information products or research areas.

Satisfaction Score: A score that represents how well the input meets the SME's needs for the KPSO.

Societal Benefit Area (SBA): A framework for assessing how specific Earth observations support the achievement of broader societal objectives.

Societal Benefit Area Sub-Area: The major thematic component within an SBA; natural subdivisions of the parent SBA.

Status Quo Score: Refers to the impact an observing system or database has on an SBA, a sub-area, a KO, or a data source if the observing system or database were removed from the Value Tree or survey product. It is an SME's assessment of how well their product meets users' and stakeholders' needs and expectations.

Swing Weight: Describes how much the status quo score would change if the SME no longer had access to the individual inputs to a KPSO.

Value Tree: An approach that establishes the connection from the top-level, societal benefit inherent in the SBA down through sub-areas, KOs, data sources and tools, and ultimately to the set of Earth-observing systems that contribute to the SBA.