Summary

Third Workshop of the Coordination Group for Meteorological Satellites
Socioeconomic Benefits Tiger Team (SETT)

October 7, 2015
Paris, France

Prepared by M.Kutny & M.Storaas
October 2015

Acknowledgements
The CGMS SETT would like to acknowledge the contributions of the Organisation for Economic Development and Cooperation (OECD) Space Forum who generously hosted the workshop and associated webinar at the OECD headquarters in Paris, France. In particular, the SETT would like to thank Claire Jolly and Anita Gibson.

EXECUTIVE SUMMARY

The purpose of the Coordination Group for Meteorological Satellites (CGMS) Socioeconomic Benefits Tiger Team (SETT) is to develop credible methodology and common terminology for articulating the socioeconomic benefit of satellite observing systems, and explore the most effective ways to communicate this information to desired stakeholders. On 7 October 2015, representatives of CGMS member organizations were joined by and representatives of the OECD Space Programme and invited guests for the Third CGMS SETT Workshop in Paris, France. The goal of the workshop was to further discuss CGMS SETT case study and develop a plan for execution of the study. The objective of the case study is to demonstrate the approaches and best practices for conducting socioeconomic benefit studies for CGMS members. Some of these approaches were outlined in the findings of the first and second CGMS SETT Workshop.

The workshop participants:

- Received introductions to both the CGMS SETT and the OECD Space Programme,
- Heard an update from the NOAA Joint Polar Satellite System program on the status of their economic benefit analysis,
- Reviewed the case study design, identified opportunities and constraints to case study progress, and identified timeline for a concept note, and noted the need to identify CGMS Members contributions to the study and an agree upon timeline for case study major milestones and completion;
- Reviewed and discussed the draft guidance document and recommend changes; and
- Determined the next steps for the SETT.

This workshop summary captures key outcomes and discussions from the workshop. It is not intended to be a transcript of every point made. Links to speaker presentations are provided in the Annex 2: Workshop Agenda.

The summary is organized into the following sections:
- Executive Summary
- Workshop Introduction
- Case Study Introduction and Discussion
- Guidance Document Introduction and Discussion
- Action Plan and Recommendations
- Annex 1: Agenda
- Annex 2: Participant List
- Annex 3: Case Study as proposed for the workshop
- Annex 4: Preliminary Draft of Guidance Document as shared in advance of the workshop

WORKSHOP INTRODUCTION

The Workshop began with welcome remarks and introductions to both the SETT and the OECD Space Program that set the stage for the discussions that would shape the SETT's path forward.

Chuck Wooldridge, SETT Chair & Deputy Director, National Oceanic and Atmospheric Administration (NOAA) Satellite & Information Service (NESDIS) International & Interagency Affairs Division, introduced the participants to the

Coordination Group on Meteorological Satellites, whose 16 members exchange technical information on geostationary and polar-orbiting meteorological satellite systems and research and development missions; coordinate, to the extent possible meteorological satellite mission parameters; and encourage complementarity, compatibility, and possible mutual back-up in the event of system failure through cooperative mission planning and compatible meteorological data products and services. For example, CMGS has successfully implemented its backup plans among EUMETSAT, Japan, and the United States.

Recognizing that CGMS members are increasingly asked to justify and defend public investments in meteorological satellite missions, the CGMS established a Socioeconomic Tiger Team (SETT) during the 43rd CGMS Plenary Meeting in 2013 to develop a credible methodology and common terminology for articulating the socioeconomic benefit of satellite observing systems, and to explore the most effective ways to communicate this information with stakeholders.

Mr. Wooldridge explained that, to date, the SETT has:

- Reviewed and compiled relevant socioeconomic benefit and return on investment studies and made those available on the CGMS website and via a Google Drive folder that is available to all SETT members;
- Identified relevant socioeconomic expertise in CGMS members, the WMO and related institutions, noting that in-house expertise was limited and seeking to broaden the participation in the SETT to a larger community of practice including other partners and interested economists;
- Identified key application areas and gather examples, case studies that illustrate benefit; and
- Evaluated approaches and methodologies used to understand the value of satellite observing systems among all observing systems and understand the role of satellite observing systems in the entire value chain.

He then noted the outstanding tasks of the SETT which include reviewing the terminology for accuracy, consistency and accessibility to non-technical audiences; and how to best communicate the SETT efforts with the broader CGMS community.

Chuck Wooldridge highlighted the studies reviewed to date, noting that they ranged from macroeconomic approaches such as how to optimize investment in global observing systems to microeconomic approaches such as the impact of Earth observation on specific application areas, such as malaria early warning systems and volcanic ash advisories. In addition to the studies reviewed, the key findings of the first SETT workshop held in April 2013, outlined in Figure 1, helped clarify the overall approaches available as shown in Figure 2.

Finally, Mr. Wooldridge introduce the two main topics of the day's discussions including the CGMS SETT Guidance Document and the proposed case study, and he outlined the next steps for the SETT including:

- Increase participation by CGMS Members;
- Finalize the case study design and identify necessary resources for completion;
- Complete the guidance document;
- Coordinate, as appropriate, with related efforts at the WMO, OECD and other partners; and
- Host the next workshop in Asia in late 2016/early 2017.

Replying to questions, Mr. Wooldridge clarified that the CGMS SETT is not tasked with undertaking socioeconomic benefits study on behalf of, or evaluating, the CGMS system as a whole, and that CGMS has no resources or funding dedicated to the SETT efforts.

Next, the Head of the OECD Space Programme Claire Jolly introduced both the OECD and its Space Programme to participants. She noted that the OECD is an international economic organization, but not a space organization. The OECD was established in 1961 with 34 member states and 2,500 staff and nearly 300 expert committees and working groups with participation from more than 100 countries. The OECD serves a:

- forum in which governments can work together to share experiences and seek solutions to common problems;
- understand what drives economic, social and environmental change;
- measure productivity and global flows of trade and investment;

- analyze and compare data to predict future trends; and
- set international standards on a wide range of things, from taxes to space.

The OECD Space Forum arose from the OECD Futures project ten years ago to look at the potential value of investing in space programmes, such as the value of GPS in cars and Earth observation data use by non-meteorological organization. The OECD issued two reports, Space 2030: Tackling Society's challenges, and Space 2030: Exploring the Future of Space Applications.

She explained that the two main missions of the OECD Space Programme are to:
- Develop comparable statistics and indicators and exchange lessons learned and best practices; and
- Assess the contributions of space technologies to addressing major challenges the world faces including socioeconomic impacts.

The Space Forum activities are managed by the OECD Secretariat with analytical inputs from the Forum's Steering Group. The Steering group, composed of 10 space-related administrations and or ministries, is helping to identify what work should be undertaken.

The Space Forum contributes to different OECD Missions as well including innovation policy country reviews, impact of public support for business R&D and innovation, innovation, inclusiveness, and development, and higher education institutions in the knowledge triangles. In additional they coordinate with different directorates such as environment, trade, agriculture, and fisheries.

OECD Space Forum achievements to date include:
- Highlighting the economic significance of space activities – including their best-selling report, the Space Economy at a Glance;;
- Bringing together experts and building a community of practitioners – including a major workshop next March on geospatial information and such as this workshop today;
- Making progress on key methodological issues in indicators and statistics; and
- Making progress on evaluation/impact assessments of space investments.

For the OECD it starts with the numbers – how do you collect them, compare them, and determine their meaning. OECD publications include the Space Economy at a Glance 2014 and the OECD Handbook on Measuring the Space Economy, which help define the space sector and downstream activities; provide comparable data across time and countries; set international methods; and undertake thorough research. The handbook includes a chapter on examining socioeconomic impacts, for example as show on Slide 9 of Ms. Jolly's presentation. In addition, OECD also maintains a database of 70 to 80 studies on the space economy.

Next, Ms. Jolly outlined selected economic impacts across different sectors as shown on slide 10 of her presentation. They noticed commonalities across the results and methodologies, and also explored the value of monitoring sea routes with satellites with interesting results - though primarily qualitative rather than quantitative.

She provided some pointers on evaluation and impact assessments as follows:
- Growing demand,
- Evaluation culture and practices uneven across countries,
- Fuzziness of basic concepts,
- Mismatch between theory and reality,
- Ignorance of evaluation guidelines, and the
- Need to be aware of unreasonable expectations.

Additionally, the OECD Space Forum found that some of the best impact assessments on space applications include:
- The earlier the better when launching assessments, to create a "history" of case studies and time series;

- Higher quality, when technology/scientific impacts are also provided;
- Survey method or peer review, rather than black box method with too many assumptions, noting the OECD has found value of information to be very relevant; and
- Open tender process for assessments (competition pays off).

Finally, Ms. Jolly concluded with the way forward for the OECD Space Programme. She noted that more effort is needed to build the international knowledge base regarding assessments of space investments to help avoid reinventing the wheel by providing know-how and lessons learned to practitioners, and providing evidence-based information to decision-makers on the benefits of space applications.

In addition, the OECD Space Forum contributes to the field by bringing together communities of practice such as the IAF Space Economy Technical Committee, and delivering outputs to facilitate international discussions and knowledge transfer.

She concluded by highlighting and encouraging participation in the March Workshop "Data to Decisions: Valuing the Societal Benefit of Geospatial Information" organized by the socioeconomic benefits community of practice in collaboration with the OECD, NASA and the U.S. Geological Survey. The workshop will be held 10-11 March 2016 at the OECD in Paris, France. The Deadline for abstract submission is November 15, 2015.

CASE STUDY INTRODUCTION & DISCUSSION

Mary Ann Kutny from NOAA/NESDIS International and Interagency Affairs Division presented the case study for the workshop, explaining how it is not the study's results that are important for the CGMS SETT, but the process it depicts. For this purpose, Operational Sea Ice Information and Product was the topic that generated the most interest among CGMS members. The polar region is relevant for CGMS since it is an area of responsibility for a number of CGMS members and because of the heavy reliance on satellite data for sea ice products and information. She noted that the audience for the case study is CGMS members, with the case study serving as an example and source of lessons learned for future SEB studies.

Pablo Clemente-Colón, Chief Scientist for the U.S. National Ice Center (NIC), provided a background briefing on the NIC, whose information services are the results of interagency and international cooperation including the NOAA, the U.S. Navy, the U.S. Coast Guard and Canadian counterpart agencies. Dr. Colón's presentation is included in the presentation on the case study and outlined the products issued by the NIC and its partners and the data inputs required for the creation of those products. In addition, he provided anecdotal evidence of the value of the products based on unsolicited feedback received from users.

Since the Second Workshop, the case study has focused on systematically capturing the use and its impact on decision making:

- Who benefits from the services?
- What is the basis for these benefits?
- How is the provided information used?
- Are we missing users?

During the discussion period, participants noted the small number of operators in the Arctic. Further they raised the need to collect information on private users and the challenges gathering that information can entail depending on a country's policies.

As a result of the discussions participants agreed to adjust the study objective to focus more generally on the benefits of remote sensing observations via sea ice information products used by ship operators in the Arctic rather than for rapid response to adverse events alone.

In addition, Jeff Lazo from the National Center for Atmospheric Research (NCAR) gave a presentation outlining his comments on the proposed case study and future SETT activities. He reviewed how the type of economic analysis will depend on the purpose of the study; shared resources for conducting socioeconomic benefit studies; provided an overview of the conceptual framework for the weather information value chain; and outlined key economic concepts including value of information, decision making under uncertainty, and public goods.

Specifically, Dr. Lazo identified the following resources for CGMS Members undertaking SEB studies:

- Primer on Economics for National Meteorological and Hydrological Services,
- USAID/WMO/World Bank Socioeconomic Benefits book,
- The WMO Working Group on Societal and Economic Research Applications (SERA), and
- "Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services - noting Chapters 5-8 are most relevant for this group.

In addition, he noted that the SETT is not developing new methods, but applying existing, well-established methods to the value of Earth observations. He recommended moving away from bench marking studies (secondary) to benefits-transferrable economic (primary) studies.

Finally, Dr. Lazo shared some thoughts on the SETT including the following points.

- The SETT has identified key aspects of doing a good study and provided good findings from their literature review though a broader review of studies where the end "value" may seem unrelated to satellites (e.g. value of statistical life, time saved, improved energy production costs) could be useful.
- The guidance document needs to distinguish between primary and secondary studies.
- Not all economists are created equal and CGMS Members should be sure to employ those who are experts in the type of study they wish to undertake.
- Simply being peer reviewed does not make a study good.
- He recommended a case study on values to the public since the primary mission of most National Meteorological and Hydrological Services is to save lives and they are important to policy makers and likely to generate large economic values. This could include a case study on the value to households.
- Regarding the identification of end users he noted the SETT need only identify one or a few key users to focus on, consider a questionnaire linked to a key website, and noted the long term process of working with customers to identify user needs.
- He suggested the SETT consider focusing on potential cost savings from improved transportation decision making, and examine the quantity of data available and determine feasibility of data analysis versus an anecdotal case study.

Finally, after some discussion the SETT members identified the following next steps for the case study:

- Develop a concept note for the Case Study
- Identify CGMS member resources to conduct case the study, including required data sets, other in-kind contributions, and financial commitments
- Conduct Solicitation for Case Study
- Conduct the Study
  Communicate results of the case study to both the end users who contributed information on their decision making processes, and the intended audience (CGMS members) in a relevant and meaningful fashion.

GUIDANCE DOCUMENT DISCUSSION & RECOMMENDATIONS

During the Second SETT Workshop, the participants agreed the SETT should develop a Guidance Document on the conduct of socioeconomic benefit studies. They noted the document must meet three key criteria to ensure its value and use by CGMS Members. The guidance document must be:

- Brief;

- Specific to the challenges of measuring the benefits (quantitatively or qualitatively) of space-based observing instruments and/or systems; and
- General enough to address the range of motivations that may drive a CGMS member to undertake a socioeconomic benefit analysis

Mary Ann Kutny presented the preliminary draft of the SETT Guidance Document, noting that during the Second SETT Workshop, participants agreed the SETT should develop a Guidance Document to support CGMS members sponsoring, rather than conducting an in-house SEB study. Principle authors of the draft document also included Stephan Bojinski of the World Meteorological Organization (WMO) Space Programme. She noted that the authors strove to ensure the document meets the three key criteria set forward during the Second SETT Workshop for ensuring its value and use by CGMS Members. The criteria included that the guidance document be:

- Brief;
- Specific to the challenges of measuring the benefits (quantitatively or qualitatively) of space-based observing instruments and/or systems; and
- General enough to address the range of motivations that may drive a CGMS member to undertake a socioeconomic benefit analysis

The draft Guidance Document drew on existing resources including the WMO/ World Bank Publication "Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services," and the NASA publication "Measuring Socioeconomic Impacts of Earth Observations: A Primer" among others.

Lessons learned at the completion of the proposed case study will also be incorporated into a subsequent revision of the Guidance Document.

During the discussion, participants raised questions regarding the relevance of prospective versus retrospective studies. It was noted that any SEB study compares a baseline to a change whether a past or future change the process is similar. Securing funding for retrospective studies has been challenging; however, it was agreed that retrospective studies should be conducted as they provide lessons learned and allow for inclusion of costs and/or benefits not anticipated during the prospective study. In addition, questions were raised about how to address to whom and where the benefits accrue. It was noted that the study would specify the geographic region, typically the country of the host agency.

ACTION PLAN AND RECOMMENDATIONS

Two key next steps were identified:

(1) Develop Draft Concept Note for the Case Study
Lead(s): Mary Ann Kutny, NOAA/NESDIS
Deadlines: 13 November 2015
Develop a draft concept note for the Case Study for review by SETT members.

(2) Refine the Guidance Document
Lead(s): Workshop participants, and Guidance Document Authors (S.Bojinski, M.Kutny, M.Storaas)
Deadlines: 30 October 2015 for Workshop participant comments

In addition, the workshop participants recommended the SETT consider holding the next Workshop in Asia, and request SETT members identify if they are interested in hosting the workshop and propose potential dates for consideration.

The next SETT meeting will be a teleconference in mid-January 2016.

ANNEX 1:

AGENDA

WEDNESDAY, OCTOBER 7, 2015

OECD Headquarters, Paris, France

8:30 a.m.	**Welcome & Introductions** ***Meeting Logistics & Overview of Agenda,*** *Mary Ann Kutny, NOAA/NESDIS*
8:45 a.m.	**Welcome Remarks & Introduction to the SETT** Chuck Wooldridge, SETT Chair
9:00 a.m.	**Introduction to the OECD Space Programme** Claire Jolly, Head, OECD Space Programme
9:30 a.m.	**Review of Proposed Case Study Design: Understanding and Assessing the Value of Improved Satellite Data for the Users of Operational Sea Ice Products and Information,** Mary Ann Kutny, NOAA/NESDIS & Pablo Clemente Colon, NOAA/NESDIS National Ice Center
10:15 a.m.	**Break**
10:30 a.m.	**SETT Member Update:** JPSS Economic Benefit Study, John Furgerson, NOAA/NESDIS/JPSS
11:00 a.m.	**SETT Guidance Document Discussion,** Mary Ann Kutny, NOAA/NESDIS on behalf of herself and Stephan Bojinski, WMO *[Discussion of document, discussion of communication/distribution strategy]*
Noon	**Working Lunch**
1:30 p.m.	**Case Study Design & Future Work Plan [PART 1]** • *Case Study design discussions* • *Identify required resources, data, and expertise*
2:30 p.m.	**Presentation: Economist Perspective on Case Study Design + Discussion** Jeff Lazo, UCAR
3:30 p.m.	**Break**
3:45 p.m.	**Case Study Design & Future Work Plan [PART 2]** • *Finalize Case Study design* • *Discussion/assignment of roles/responsibilities* • *Set Timeline*
4:45 p.m.	**Next Steps for SETT** Chuck Wooldridge, SETT Chair
5:15 p.m.	**Workshop Summary & Actions** Mary Ann Kutny, NOAA
5:30 p.m.	**Adjourn for the Day**
7:30 p.m.	**Happy Hour & No Host Dinner**

ANNEX 2: PARTICIPANT LIST

SETT MEMBERS

Chuck Wooldridge, NOAA, and SETT Chair
Stephan Bojinski, WMO (Virtual)
Molly Brown, University of Maryland (Virtual)
Pablo Clemente-Colon, NOAA National Ice Center
Vanessa Escobar, NASA (Virtual)
John Furgerson, NOAA (Virtual)
Toshiyuki KURINO, JMA (Virtual)
Mary Ann Kutny, NOAA
Jeff Lazo, University Corporation for Atmospheric Research (UCAR)
Jiashen Zhang, CMA

INVITED PARTICIPANTS

Patrick Besha, Office of Strategy & Policy, Office of the Administrator, NASA
Joon-Min CHOI, Principal Researcher, Space Test Division, Korea Aerospace Research Institute (KARI)
Luca Del Monte, Office for Relations with Industry, Industry, Procurement and Legal Directorate, European Space Agency
Simona Di Ciaccio, Strategic Perspectives & European Affairs, Italian Space Agency
Hendrik Fischer, Space Strategy & Program Space Administration, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany
Anita Gibson, Project Co-ordinator, OECD Space Forum
Sungwook HUR, Counsellor, ICCP, CSTP, NEA, SPAM Task Force, E-Commerce, Permanent Delegation of Korea to the OECD
Claire Jolly, Head, OECD Space Forum
Eunjeong KIM, Space Policy Team, KARI
Anne-Marie Lan Phan, Policy Branch, Canadian Space Agency
Marit Undseth, Research Analyst, OECD Space Forum
Margrethe Storaas, Intern, American Meteorological Society Policy Program (Virtual)

ANNEX 3: CASE STUDY (AS PRESENTED AT WORKSHOP)

DESIGNING A CASE STUDY: Understanding and Assessing the Value of Improved Satellite Data for the Users of Operational Sea Ice Products & Information

Coordination Group for Meteorological Satellites (CGMS)
Socioeconomic Tiger Team (SETT)

Introduction

The importance of attributing socioeconomic benefits of the data collected by meteorological satellite – the value derived from the practical application the data and data products - is increasingly important to CGMS members as they seek to defend public investments in existing and planned meteorological satellite programs.

This case study is intended to serve as an example for CGMS of the process of sponsoring a socioeconomic benefits study (SEB) and to identify best practices and lessons learned for the CGMS community. The absolute value (quantified value) is of less interest than the process itself.

Objectives

(1) Quantify the socioeconomic benefits of remote sensing observations on the sea ice products and information used by operators in the Arctic [for rapid response to adverse events.]
(2) Identify the qualitative benefits (e.g. national/international policy drivers) that could influence investment in advanced remote sensing to improve operational sea ice products (e.g. Arctic Council priorities).

Rationale

Ship traffic and other economic activity (e.g. oil exploration) in the Arctic is rising and Arctic sea ice melts. The Northern Sea Route (also known as the Northeast Passage) follows Russia's northern border and typically has less ice buildup than the Northwest which is nearer to Canada. Climate Change is lengthening the short season from late summer to early fall during which both routes are navigable. The Arctic route can shorten the trip from China to Europe by approximately two weeks.

The Arctic Institute reports that in 2013, 71 ships carried 1.35 million tons of goods through the Northern Sea Route. However, there is significant variability in sea ice conditions on both routes, and information on sea ice conditions, especially thickness and extent, are important for safe and efficient operations in the region.

"The remoteness of the Polar Regions limits the amount of direct observation of sea ice. Hence, more than 95% of the data used in sea ice analyses are derived from the remote sensors on polar-orbiting satellites. Sea ice analyses and forecasts are primarily prepared using satellite imagery and ice reconnaissance." (U.S. National Ice Center)

CGMS members and/or their affiliated government agencies are primarily responsible for sea ice observations, analysis, and products.

Audience

The principal audience for this study is CGMS members as a means of understanding the process of undertaking a SEB study. However, for the purposes of this exercise the SETT will 'assign' an intended audience as the funding entities of the US National Ice Center and the Canadian Ice Service.

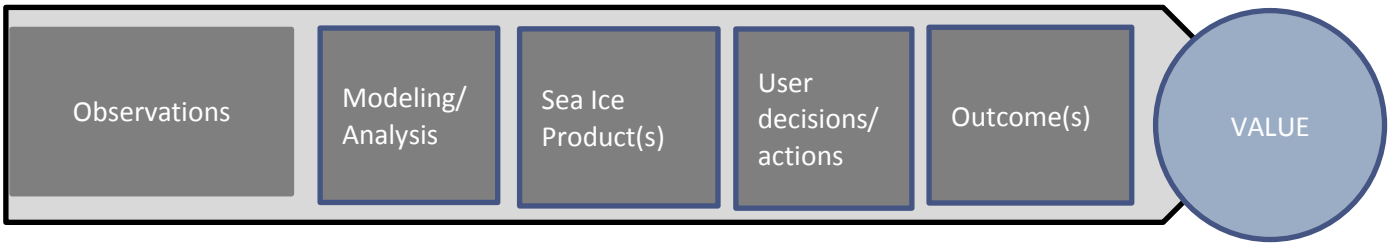
Framing

(1) Assess and characterize how sea ice product(s) are used by operators in the Arctic to make decisions and how outcomes change a result.
    a. Who benefits from sea ice product(s)?

i. Users identified by NOAA include the US Navy, the US Coast Guard, the National Science Foundation, the international maritime community (e.g. BIMCO, International Association of Arctic Tour Operators - IAATO), tribal communities (e.g. walrus hunters), and the research community (e.g. Norway, Italy, etc.) for calibration/validation of other products/services.
ii. Users identified by the Canadian Ice Service include the Canadian and US Coast Guards, commercial shipping, fishing, and ferry operators, port corporations, riparian interests, and northern residents.

b. Which products are used by the operators in the Arctic?
c. What is the nature and basis of the benefit? (OUTSTANDING QUESTION)

(2) Identify the data used in the development of the sea ice product(s), and diagram the information flow from satellite to decision process.
   a. Which piece(s) of remote sensed data (type, frequency, resolution) contribute to the product(s)?
   b. Develop the value chain



(3) Identify which remote-sensed data (input) to evaluate & quantify impact of the data on the product(s).
   a. Determine the baseline (pre-VIIRS, pre-sentinel)
   b. Identify the change to be measured and how it will be measured

(4) Identify the qualitative benefits (policy drivers) which might influence decisions to invest in the remote sensing data.
   a. Arctic Council thematic pillar: Arctic Ocean safety, security, and stewardship

(5) Identify the benefit measurement approach to determining the socioeconomic benefit of the remote sensed data.
   a. Possible approaches to consider include: value-in-use

Concept Note/SOW

Conduct of study
Roles, responsibilities, timelines

Communicate Study

ANNEX 4: PRELIMINARY DRAFT OF GUIDANCE DOCUMENT

A copy of the preliminary draft of the guidance document that was distributed in advance of the third workshop follows.

Coordination Group for Meteorological Satellites

Socioeconomic Benefits Tiger Team (SETT)

October 2015

Valuing Meteorological Satellite Programs:
Guidelines for Socioeconomic Benefit Studies

CONTENTS

Introduction 1

1. Context 2

Identifying Motivation/Drivers 2

Identifying Audiences 3

2. Framing an SEB study 3

Identifying Impacts to measure 4

Resource Availability 5

3. Methodologies 6

Choosing a Quantitative or Qualitative Approach 8

Communicating Study Results 8

4. General Framework 10

5. Lessons Learned 11

Appendix A: Key Terminology 11

Appendix B: Socioeconomic Impact Assessment Methods 1

APPENDIX C: Examples 2

C.1 Cost-Benefit Analysis for GMES 2

C.1 Volcanic Ash Advisories & Aviation Safety 2

C.# TEMPLATE Study Title 4

APPENDIX D: SETT Documentation List 5

FROM NASA PRIMER (RESOURE) Socioeconomic Benefits Analysis Flow 7

INTRODUCTION

CGMS established the Socioeconomic Benefits Tiger Team (SETT) to develop credible methodology and common terminology for articulating the socio-economic benefit of satellite observing systems, and explore the most effective ways to communicate this information to desired stakeholders. The SETT developed this document to provide initial guidance to CGMS Members seeking to undertake a socioeconomic benefit study on a current or planned satellite system.

To that end, SETT members agreed this document must meet three key criteria to ensure its value for CGMS Members, specifically it must be:

- Brief;
- Specific to the challenges of measuring the benefits (quantitatively or qualitatively) of space-based observing instruments and/or systems; and
- General enough to address the range of motivations that may drive a CGMS member to undertake a socioeconomic benefit analysis.

The SETT recognized that most CGMS members would be contracting out their study. In order to guide the sponsor/agency in this process, the guidance document offers a structural construct for how to frame a SEB study, formulate the statement of work, choose methodology, assess one's resource requirements and communicate the study results. Also, insights into challenges typically experienced by study executors are explored. The provided guidance is derived from analyses of existing socio-economic studies and meteorological and environmental satellite systems, from where the Team has taken note of lessons learned in addition to considering numerous other resources and primers on the subject.

This guidance document does not attempt to duplicate existing resources, but rather to highlight the most relevant aspects of those resources for CGMS members. In addition, several CGMS-relevant examples are examined to provide concrete examples from which CGMS members can learn.

1. CONTEXT

Prior to undertaking a socioeconomic benefit study, the sponsor must identify the drivers (motivation) of the study, the primary audience for the study, what questions face that audience and how they will use the study's results to make decisions. This context will inform the study question, needed resources including data, and any time constraints.

IDENTIFYING MOTIVATION/DRIVERS

There can be many motivations for a sponsor/satellite agency to value its activities through a "socio-economic benefit" study. The main driver is usually to provide a sound justification for planned activities, such as a future satellite programme, to policymakers, governing bodies, user communities, and the general public. Many CGMS members face increasing pressure to ensure that their resources are efficiently and effectively utilized. "Socio-economic benefit" can be assessed in many ways, in both qualitative and quantitative terms, as outlined below.

Subject of an SEB study could be satellite datasets, instruments, missions, or programmes ("satellite assets"). Although benefit studies usually target planned assets, there can be value in estimating the benefit of past or present satellite assets, for example when the case for sustaining a series of satellites needs to be made. Indeed, planned assets are often evaluated using existing data as a proxy.

Socio-economic benefit of satellite assets can be expressed in terms of:

- monetary value (to a national economy, economic sector, individual actor; includes both added value and avoided costs)
- reduced error in satellite-based products (e.g., NWP forecast, ice charts)
- ability to monitor compliance (e.g., with a global protocol, environmental regulation)
- the value of a consistent, long-term data record for climate monitoring and prediction
- national capacity and security
- support to policy formulation and implementation (e.g., agricultural policy)
- other sector-specific or anecdotal benefits

The value of partnerships between satellite operators (e.g., the NOAA-EUMETSAT Joint Polar System) can also be subject of study, for example to highlight the benefits of mutual back-up agreements and sharing of data.

Based on a survey of CGMS Members conducted in April 2015, the SETT identified three primary drivers for socioeconomic benefit studies for CGMS Members:

1. Evaluating the value of a future satellite programme for environmental monitoring and security,
2. Evaluating the societal benefit of a future polar-orbiting meteorological satellite, with a focus on its impact on numerical weather prediction capabilities, and
3. Evaluating the value of remote-sensing data to a specific application (e.g. volcanic ash advisories).

IDENTIFYING AUDIENCES

Knowing the intended audience also drives decisions about the analytical methodology and communication strategy for the study. Understanding the audience for the study and how they may use the study results to make decisions will help CGMS members in framing the study question, and in estimating the appropriate level of resource allocation and the time frame for the study. Figure 1 provides an overview the possible interests of particular audiences in the results of a SEB study on a CMGS member asset/programme.

Figure 1. Primary audiences for socioeconomic benefit studies for the three key questions facing CGMS members as identified by the CGMS SETT poll conducted in April 2015

Audiences	*Purposes*		
	Evaluating a future satellite programme for environmental monitoring and security	*Evaluating the societal benefit of a future polar-orbiting meteorological satellite, with focus on its impact on NWP*	*Evaluating the value of remote-sensing data to a specific application*
Political (ministry, treasury, boards of directors, etc)	✓	✓	
Technical (Agency Leadership)		✓	
User communities			✓

2. FRAMING AN SEB STUDY

Framing the SEB study is critical to its success. Success depends on the ability to understand and to articulate how the information product is used in a decision and how the outcome can be improved (e.g. In terms of spatial, spectral, temporal resolution) with its addition relative to without the information (e.g. increased accuracy or precision, improved confidence, decreased uncertainty, etc.). Framing the SEB study correctly takes time and should be an iterative process between the satellite agency or study sponsor, the intended audience (those who will use the remote sensed data to make decisions), and the contractor carrying out the study.

The following assumptions and parameters should be considered:

- Baseline (against which to evaluate benefits)
- Timeframe over which benefits accrue
- Geographic area where benefits accrue

- Information value chain (where do benefits accrue)
- Methodology to establish impact (see below)
- Bottom-up vs. top-down approach: to what extent is scaling possible (over time, area, case-to-sector)
- Context (is the value of a satellite asset estimated considering other EO assets, or standalone?)
- Availability of socio-economic data (for example, what percentage of a national economy (GDP) is "weather-sensitive" economy; are ship tracks available to assess the value of more precise ice charts?)
- Data policy (e.g., potential limitations on data value due to data availability constraints)

In addition, several questions can help determine whether the proposal has the attributes of a strong case study including:

- Is the economic model generalizable enough to be useful in other contexts?
- Does sufficient data exist to conduct an empirical analysis?
- Is the case study meant to inform a near-term decision? If so, that may adversely impact the timeline and scope of the SETT case study or lead to inappropriate application of the results. It may also introduce challenges due to political sensitivities.
- Can it be simplified through a set of tenable, defensible assumptions, and can it be subjected to a sensitivity test(s)?

IDENTIFYING IMPACTS TO MEASURE

As part of the framing of a SEB study, the agency must determine which impacts to measure and which impacts will best meet the agency's goals in undertaking the study and resonate most effectively with the intended audience.

For example, the impacts of a new satellite program, instrument or application could be measured relative to:

- monetary value (to a national economy, economic sector, individual actor; includes both added value and avoided costs)
- reduced error in satellite-based products (e.g., NWP forecast, ice charts)
- ability to monitor compliance (e.g., with a global protocol, environmental regulation)
- the value of a consistent, long-term data record for climate monitoring and prediction
- national capacity and security
- support to policy formulation and implementation (e.g., agricultural policy)
- other sector-specific or anecdotal benefits

Measuring impact in terms of monetary value will resonate most effectively with

Agency leadership and customers may prefer to see the value measured in terms of product (e.g. forecast accuracy,

Understanding relative impact of satellite observations is crucial. The WMO and the operational agencies are placing great efforts in using Observing System Experiments (OSE) or Forecast Sensitivity to Observations (FSO) to understand the role of satellite observations in the context of all observing systems and their relative impact on NWP (See Figure 1). Analysts can use this information to extrapolate the socio-economic benefits derived from a particular observing system. For example, an indicative "impact per cost" ranking can be generated by dividing the impact by the estimated annual cost for an observing system.

[INSERT: NEED Discussion of the challenges of measuring the downstream impacts of a large programme. Recongize – not easy to "sum" benefits. NEEDN'T be only one measure (natl value + NWP error reductions + monetary). Part of Audience assessment – if qualitative will suffice for audience, other cultural considerations)]

Policy makers and environmental stakeholders….

Researchers, policy makers, decision makers…

RESOURCE AVAILABILITY

$, time, data, experts/expertise

The value of perfect information may not be worth the cost of acquisition. Cost benefit analyses are increasingly time-consuming and costly as you move down the value chain. A decision about the scope and methodology of a proposed study must factor in the cost of conducting the study.

Study planning should examine the need for ancillary data, and determine if the data needed to undertake a socioeconomic study is publicly available or commercially restricted. Building relationships with user communities can help facilitate access to ancillary data sets. For example, calculating the costs attributable to Volcanic Ash Advisories requires data from the airline industry, and estimating the contribution of earth observations to a Malaria Early Warning System requires access to public health data. Developing relationships with end users are an important aspect of planning and completing a study.

The most robust studies bring together experts from across the physical and social sciences over the lifetime of the project allowing for repeat analyses, and recalculation of benefits. For example, the study represented in Figure 3 shows the breadth of expertise – including social scientists and public health experts - required to undertake a socioeconomic analysis of the value of Earth observation information to a Malaria Early Warning System (MEWS) in Botswana.

3. METHODOLOGIES

Recreate a version of table 6.2 (Valuation Methods) from new WMO Report??? And or use the table from the NASA primer (Appendix B – here) delete and move up – combine? Think I like the WMO one better?

Benefit–cost analysis: The quantification of the total social costs and social benefits of a policy or a project, usually in money terms. The costs and benefits concerned include not only direct pecuniary costs and benefits, but also externalities, meaning external effects not traded in markets. These include external costs, for example, pollution, noise and disturbance to wildlife, and external benefits such as reductions in travelling time or traffic accidents. Benefit–cost analysis is often used to compare alternative proposals. If the total social benefits of an activity exceed total social costs, this can justify subsidizing projects that are not privately profitable. If the total social costs exceed total social benefits, this can justify preventing projects even when these would be privately profitable (Black et al., 2012; from cost–benefit analysis).

Retrospective or prospective?

Some common methodologies are defined below.

Avoided cost method: A valuation method that assesses actual or imputed costs for preventing environmental deterioration by alternative production and consumption processes, or by the reduction of or abstention from economic activities (OECD, 2008); for example, measuring the benefits of reduced air pollution by assessing the cost of installing indoor air purifiers.

***Benefit transfer*:** Transferring benefit estimates developed in one context to another context as a substitute for developing entirely new estimates (Tietenberg and Lewis, 2009).

Market Values: There may be a "market value" for the impact quantities under study. That is, people may have bought or sold items that are used to quantify impacts. For example, if the impacts are increased agricultural yields, the prices paid for the agricultural products in relevant markets (such as local retail purchases or international commodities markets) can be used to place a market value on the increased yields. (NASA Primer)

> ***Government or International Agency Standard Monetary Equivalents:*** Some governments and international agencies have established standard monetary values for impact quantities under analysis. The U.S. DOT cost per minute for traffic congestion is an example of this. As another example, some governments have developed a "value of a statistical life" to monetize mortality data. (NASA Primer)
>
> ***Industry and Non-Governmental Organization Standard Monetary Equivalents:*** Some industries and non-governmental organizations have established standard monetary values for

the unit under analysis. For example, there are often industry wage rate and standard costs for com-mon operations that can be used. (Nasa Primer)

Monetary Equivalence Estimates from the Literature: Socioeconomic impact analysis is a mature discipline. Previous analytic work has been done on many impacts of interest to develop reasonable conversion methods from physical to monetary terms. This work can be mined to develop simple conversion factors or methods. Some of these methods may include non-use approaches, which are discussed below. The adaption of existing studies to monetize similar, but not identical, benefits in new studies is known as benefits transfer. (Nasa Primer)

Non Market Valuation: Stated-preference methods: Methods for valuating non-market goods and services in which respondents are directly asked about their WTP for a good or service, such as the preservation of a species. These methods can be direct (such as contingent valuation surveys) or indirect (such as contingent ranking or conjoint analysis) (Tietenberg and Lewis, 2009, p. 39).

Contingent valuation: A survey method used to ascertain WTP for services or environmental amenities (Tietenberg and Lewis, 2009).

Conjoint analysis: A survey-based technique that derives WTP by having respondents choose between alternate states of the world where each state of the world has a specified set of attributes and a price (Tietenberg and Lewis, 2009).

***Non Market Valuation: Revealed-preference methods*:** Methods for valuating non-market goods and services based on actual observable choices and from which actual resource values can be directly inferred. These methods can be direct (such as market prices or simulated markets) or indirect (such as travel costs and hedonic pricing) (Tietenberg and Lewis, 2009, p. 39).

Averting Behavior

Travel cost method: A pricing method that seeks to estimate a money value on the basis of the amount that people actually pay (in money and time) to gain access to beautiful sites, wilderness and so on, or to avoid various forms of damage and degradation. The costs incurred by visitors to a site are used to determine a demand curve for the recreational value they place upon that site. This can be the basis for estimates of the value of the site, and hence of the significance in monetary terms of benefit or damage to or loss of availability of the site (OECD, 2008).

Hedonic pricing: The method of pricing a good for estimating the value of the individual characteristics that form the good. For example, a house would be seen as comprised of a number of rooms, a garden, and a location. The values of the characteristics are summed to derive a price for a good (Black et al., 2012).

Choosing a Quantitative or Qualitative Approach

While a quantitative approach may be more convincing, there are caveats. When employing a quantitative approach, the sponsor must ensure the analysis is sufficiently rigorous to withstand scrutiny by economists and social scientists. In addition, sponsors of quantitative studies must balance the need for economic rigor with the ability to represent the full value of a system recognizing conservative estimates of benefits may lead to undervaluing of the data or products.

The sponsors must able to communicate the results along with any underlying socio-economic assumptions or limitations so that decision makers understand the findings and their context. It is important to state which factors are measured and which excluded as well as to state any assumptions.

Communicating Study Results[1]

Figure 2.

Audience	Opportunities	Engagement Options
Political (ministry, treasury, boards of directors, and the like)	Governing decision makers are influential advocates for improved infrastructure and/or national policy priorities (e.g. becoming a technological leader) Public fund investment decision makers are interested in service efficiency. An SEB study can help balance pressures to excessively commercialize Earth observations; it provides information on the overall economic benefits to society	Finance ministry – Numbers, graphs, visuals. Emphasize economic benefit – Politicians – Respond to voters, and politics is local. Run local campaigns in tandem
Technical (Agency leadership, National Meteorological & Hydrological Services (NMHs))	NMHSs are influential users and advocates for continuing or improving services from meteorological satellites	WMO Other Annual meetings or specially convened seminars Science funding agencies – Scientific quality and evidence of economic benefit crucial. - Formal presentations
USER COMMUNITIES		
Regulators	Regulators review the NMHS service provisions, especially aviation	Partner with NMHS to communicate with relevant industry (e.g. Aviation industry) – Annual meetings or specially convened seminars
Service Users	Service users and taxpayers expect efficiency, so publicize realized benefits and potential benefits	Business leaders – Media, conferences, and professional clubs
Emergency Managers	Emergency managers have a	Emergency management users,

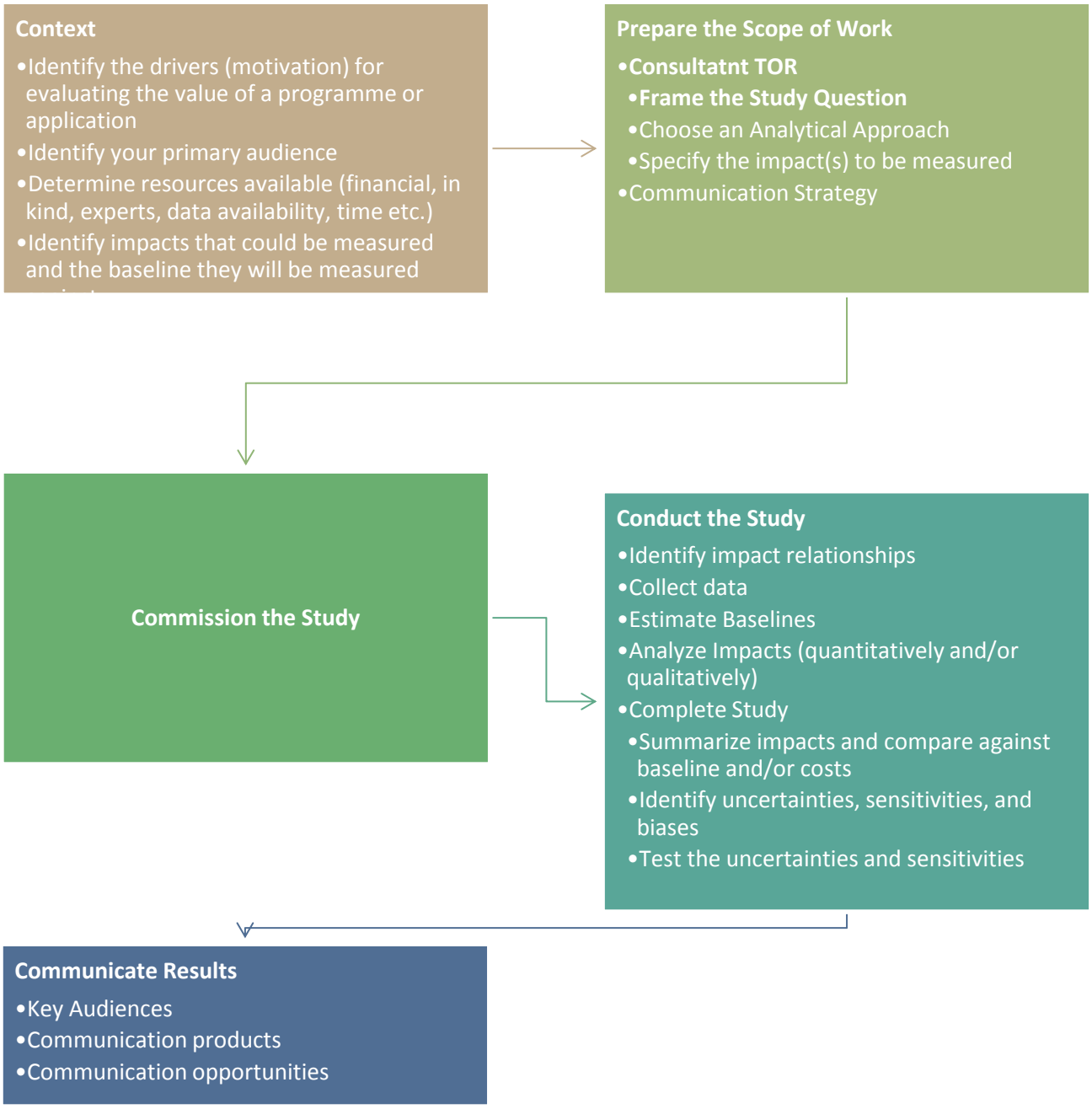
[1] Drawn from the WMO Valuing Wx & climate

	strong interest in the resilience of weather services generally and improved severe weather forecasts in particular. Their voice carries considerable weight with decision makers – especially investment in meteorological infrastructure	stakeholders – One-on-one meetings, conferences. Publication of articles in trade journals
Researchers/Academia	Scientists value continuity of data as well as increasing volumes, accuracy, resolution, and reliability of data	Scientific Conferences & workshops - Scientific quality and evidence of economic benefit crucial. - Formal presentations - journal articles
Development Banks & other funding agencies	**Development banks may support investment in Earth Observing technologies to facilitate applications (e.g. malaria early warning systems) that contribute to their goals**	**- Scientific quality and evidence of economic benefit crucial.** **- Formal presentations**

Liberally adapted from the WMO [Insert Doc Reference]

4. General Framework

Figure 3. Steps for Undertaking a Socioeconomic Benefit Study



(Adapted from WMO)

5. Lessons Learned

- SEB studies an important contribution to secure public commitment to satellite assets
- SEB studies necessary but not sufficient to secure satellite assets
- Often, largest SEBs accrue outside the constituency that pays for assets (e.g., in developing countries; global protocol monitoring)
- Often, most realistic results are qualitative (but less convincing to financial auditors etc)
- Benefits of environmental/climate programmes mostly lie in avoided costs rather than wealth creation and jobs/competitiveness
- Credibility in SEBs often judged by who performs it (e.g., large auditor firm) rather than content
- No-one (perhaps except Korea) publishes an SEB that shows the asset is not "worth" funding…

Appendix A: Key Terminology

Every discipline has its own language. We've provided a glossary of key terminology to assist CGMS members in understanding the language of economics and other related social sciences. These definitions have been compiled from the resources listed in Appendix E.

Baseline: A reference case, assuming no changes in historical trends, that can be compared to actual outcomes or impacts to measure changes due to both project outputs and confounding factors.

Benchmarking: A process in which a business evaluates its own operations (often specific procedures) by detailed comparison with those of another business (especially a competitor), in order to establish best practices and improve performance; the examination and emulation of other organizations' strengths (Oxford English Dictionary).

Benefit: A quantified gain of an action (Tietenberg and Lewis, 2009; from benefit–cost analysis).

Cost: The value of the inputs needed to produce any good or service, measured in some units or numeraire, generally money (Black et al., 2012).

***Cost-effectiveness*:** The achievement of results in the most economical way. This approach assesses efficiency by checking whether resources are being used to produce any given results at the lowest possible cost. Cost-effectiveness is most relevant as a concept of efficiency in cases such as the provision of defence, education, health care, policing or environmental protection, where it is sometimes difficult to measure the monetary value of the results achieved (Black et al., 2012).

Demand: The desire and ability to acquire a good or service, or the quantity of a good or service that economic agents are willing to buy at a given price (Black et al., 2012).

Discounting: Placing a lower value on future receipts than on the present receipt of an equal sum. The fundamental reason for discounting the future is impatience: immediate consumption is preferred to delayed consumption (Black et al., 2012; from "discounting the future").

Expenditures: Spending, by consumers, investors or the government. Consumer expenditure is restricted to purchasing real goods and services; acquiring assets of making transfers to others by individuals does not count as expenditure. Government expenditure is treated differently; some government expenditure is on real goods and services, but government interest payments and transfer payments to individuals, such as pensions, are counted as government expenditure, and government spending is not clearly divided between current and capital account items, possibly because these are hard to distinguish. National expenditure is what a country spends (Black et al., 2012).

Impact: A positive or negative benefit.

Loss: The result of a business operation where expenditures exceed receipts. Business losses may arise internally, through failure to produce enough of anything the market will buy to cover production expenses, or externally, through failure of others to pay bills due, or to repay debts. (Black et al., 2012).

Tangible impact: A directly quantifiable impact. Example: Reduced timber losses due to more timely detection of wildfires.

Intangible impact: An impact that is difficult to quantify directly. Example: Happiness due to lower old-growth forest destruction from wildfires.

Macroeconomics: The macro aspects of economics, concerning the determination of aggregate quantities in the economy. Macroeconomics considers what determines total employment and production, consumption, investment in raising productive capacity, and how much a country imports and exports. It also asks what causes booms and slumps in the short run, and what determines the long-term growth rate of the economy, the general level of prices, and the rate of inflation. Macroeconomics considers how these matters can and should be influenced by government through monetary and fiscal policies (Black et al., 2012).

Marginal benefit: The additional benefit from an increase in an activity. This is the addition to total benefit resulting from a unit increase if it varies discretely, or the addition to total benefit per unit of the increase, if it varies continuously. Marginal private benefit is marginal benefit accruing to the person or firm deciding on the scale of the activity, excluding any external benefits; marginal social benefit includes external benefits as well as private benefits accruing to the decision taker (Black et al., 2012).

Marginal cost: The additional cost from an increase in an activity. This is the addition to total cost resulting from a unit increase in output if it varies discretely, or the addition to total cost per unit of the increase, if it varies continuously. Marginal cost may be short run, when only some inputs can be changed, or long run, when all inputs can be adjusted. Marginal private cost is marginal cost falling on the person or firm deciding on the scale of the activity, excluding any external costs; marginal social cost includes external costs as well as private cost falling on the decision maker (Black et al., 2012).

Microeconomics: The micro aspects of economics, concerning the decision making of individuals. Microeconomics analyses the choices of consumers (who can be individuals or households) and firms in a variety of market situations. Its aim is to explore how choices should be made, and to provide an explanation of the choices that are made. Microeconomics also considers economics composed of individual decision makers, and studies the existence and properties of economic equilibrium. The

effect of government choices upon consumers and firms is also analysed, with the aim of understanding economic policy (Black et al., 2012).

Monetized impact: An impact that has been converted into the equivalent amount of money. This usually represents the maximum amount of money that a person or group would be willing to pay to obtain or avoid the impact.

Monte Carlo method: A method of investigating the behaviour of economic models which are too complicated for analytical solutions to be possible. A system is started off at a large number of initial positions chosen at random, and followed through a numerical simulation to see how it evolves. Monte Carlo methods can be used to check whether a system has an equilibrium, and whether this is stable for any starting point, or some limited region of possible starting points (Black et al., 2012).

Net benefits: The excess of benefits over costs resulting from some allocation (Tietenberg and Lewis, 2009).

Net present value: The present value of a security or an investment project, found by discounting all present and future receipts and outgoings at an appropriate rate of discount (see discount rate). If the NPV calculated is positive, it is worthwhile investing in a project (Black et al., 2012).

Non-excludability: A property of a good or service that exists when no individual or group can be excluded from enjoying the benefits that good or service may confer, whether they contribute to its provision or not (Tietenberg and Lewis, 2009).

Non-market goods and services: Goods and services not distributed through markets(Black et al., 2012, from "non-marketed economic activities"), for example, clean air and water, scenic vistas and beach visits.

Non-market valuation: The economic valuation of goods and services not distributed through markets (Black et al., 2012; from "non-marketed economic activities"). Methods can be based on either revealed-preference or stated-preference methods, and assessed either directly or indirectly.

Non-rivalry: A property of a good or service that exists when consumption by one consumer does not reduce the quantity available for consumption by any other (Black et al., 2012; from "public good").

Opportunity cost: The cost of something in terms of an opportunity forgone. Opportunity cost is given by the benefits that could have been obtained by choosing the best alternative opportunity. For example, for a farmer the opportunity cost of growing wheat is given by what they would have earned if they had grown barley, assuming barley is the best alternative (Black et al., 2012).

Pareto efficiency: A form of efficiency for an economic allocation. An allocation is Pareto efficient if there is no feasible reallocation that can raise the welfare of one economic agent without lowering the welfare of any other economic agent. The concept of Pareto efficiency can be applied to any economic allocation whether it emerges from trade, bargaining, strategic interaction, or government imposition (Black et al., 2012).

Present value: The value today of a future payment, or stream of payments, discounted at some appropriate compound interest – or discount – rate (Downes and Goodman, 2010). See also discount rate.

Price elasticity: The ratio of a proportional change in quantity supplied or demanded to a proportional change in price. The price elasticity of supply is Es= (p/q)(dq/dp), where p is price and q is quantity. The price elasticity of demand is often defined as Ed = – (p/q)(dq/dp) so that it is positive, but the minus sign is not universally used (Black et al., 2012).

Proxy: A tangible quantity used to infer information about a related intangible impact. Example: Contributions to charities that work for species preservation might be a proxy for happiness due to biodiversity.

Public good: A good that no consumer can be excluded from using if it is supplied and for which consumption by one consumer does not reduce the quantity available for consumption by any other. The first property is referred to as non-excludability, whereas the latter is termed non-rivalry. As a consequence of these properties, public goods cause market failure (Black et al., 2012).

Social benefit: The total benefit from any activity. This includes benefits accruing directly to the person or firm conducting the activity, as well as external benefits outside the price system accruing to other people or firms (Black et al., 2012).

Socioeconomic: Concerning the use of resources belonging to a group of people.

Social welfare function: (a) The level of welfare in an economy or society expressed as a function of economic variables. Social welfare is expressed as a function of the aggregate consumption levels of goods. Alternatively, an individualistic social welfare function is a function of individual utility levels. (b) A process for aggregating individual preferences into social preferences (Black et al., 2012).

Supply: The amount of a good or service offered for sale. The supply function relates supply to the factors which determine its level. These include the price of the good, the prices of factor services and intermediate products employed in producing it, the number of firms engaged in producing it, and their levels of capital equipment (Black et al., 2012).

Trade-off: The requirement that some of one good or one objective has to be given up to obtain more of another. The need to trade off goods or objectives against one another is a sign of economic efficiency; if it is possible to get more of one good without accepting less of another, or to achieve one objective without sacrificing another, the economy is not Pareto efficient (Black et al., 2012).

Transaction costs: The costs incurred in undertaking an economic exchange. Practical examples of transaction costs include the commission paid to a stockbroker for completing a share deal, and the booking fee charged when purchasing concert tickets. The costs of travel and time to complete an exchange are also examples of transaction costs. The existence of transaction costs has been proposed as the explanation for many of the economic institutions that are observed. For example, it has been argued that production occurs in firms rather than through contracting via the market because this minimizes transaction costs. Transactions costs have also been used to explain why the market does not solve externality problems (Black et al., 2012).

Value added: The amount by which the value of information, services or goods is increased at each stage of its production (Oxford English Dictionary).

Value chain: The process or activities by which value is added to information, services or goods, from production to final use or consumption (Stevenson and Waite, 2011).

Value of information: The value of the outcome of action taken with the information less its value without the information (West and Courtney, 1993, p. 230).

Willingness to pay: The maximum amount that an economic agent is willing to pay to acquire a specific good or service. The WTP is private information but may be obtained using revealed-preference methods or stated-preference methods (Black et al., 2012).

APPENDIX B: SOCIOECONOMIC IMPACT ASSESSMENT METHODS[2]

Approach	Focus	Considerations	Examples
Impact Assessment			
Time-Series/ Statistical Analysis	Comparing historical trends before and after project completion	Retrospective; based primarily on objective data; therefore data-intensive and dependent upon availability of data	
Expert Opinion	Using expert judgment or prior analyses to estimate project impacts	Can be retrospective or prospective; feasible in situations with limited data, but based on subjective or proxy data	
Value of Information	Analyzing decisions under uncertainty with and without information from project	Usually prospective; requires availability and cooperation of decision maker; mix of subjective and objective basis	
Cost-Based Assessment			
Benefit-Cost Analysis	Comparing monetized impacts with financial costs of project	Allows financial comparison of projects with different objectives; requires both impact and cost analyses; monetizing impacts can be difficult and controversial	
Cost-Effectiveness Analysis	Comparing costs of achieving desired impacts	Allows financial comparison of projects with similar objectives; requires both impact and cost analyses; does not require monetizing impacts	
Impact Monetization			
Market Valuation	Using prices paid in open markets for goods and services related to project impacts	Objective; requires market data; applicable only if markets exist for goods and services related to the project impact	
Standards-Based Valuation	Using standardized prices from government or industry for project impacts in lieu of market data	Can be controversial, depending on standardizing source; simplifies monetization process; available for only a limited number of impacts	
Benefits Transfer from Prior Research	Adapting existing studies to monetize impacts similar to those from the project	Can be controversial, depending on relative similarity of project benefits to those in prior research	
Stated Preferences Valuation	Using surveys, augmented by analysis, to estimate stakeholders' willingness to pay for project impacts (e.g., conjoint analysis)	Tendency for biased responses by stakeholders who are only conceptually spending money for the impacts; requires survey development and analysis	
Revealed Preferences Valuation	Using stakeholder behavior to estimate willingness to pay for project impacts (e.g., travel cost analysis, hedonic analysis)	Based on actual behavior rather than conceptual surveys; relationship between priced item and project impact may be indirect and thus controversial	

[2] Derived from *Measuring Socioeconomic Impacts of Earth Observations: A Primer* published by NASA

APPENDIX C: EXAMPLES

C.1 COST-BENEFIT ANALYSIS FOR GMES

DATE OF COMPLETION: 2006
COMMISSIONED BY: European Commission: Directorate General for Enterprise & Industry
AUTHORED BY: Booz&co.
DURATION: ???
APPROXIMATE COST OF STUDY: ????
METHODOLOGY: Cost-Benefit Analysis

Principle Audience:

Study Description:

Study Question(s):

- *TBD*
- *TBD*

Principle Finding(s)*:*

- *TBD*
- *TBD*

Methods:

- *TBD*
- *TBD*

Lessons Learned:

C.1 VOLCANIC ASH ADVISORIES & AVIATION SAFETY

DATE OF COMPLETION: 2011
COMMISSIONED BY: NASA, Earth Science Division, Applied Sciences Program
AUTHORED BY:
DURATION: ???
APPROXIMATE COST OF STUDY: ????
METHODOLOGY: Impact Analysis

Principle Audience: NASA, NOAA, FAA, Airline Industry

Study Description: The case study uses a specific event—the eruption of Iceland's Eyjafjallajökull volcano in 2010—to assess the impact of the observations in avoided costs and losses. In a retrospective analysis, this example uses a combination of time-series and VOI approaches. This case also presents a prospective extrapolation for a global estimate of aver-age annual benefits to civil aviation.

Principle Question(s):

If better VAAC information and more reliable predictions on the location and movement of the volcanic ash clouds results in better decision making by air traffic control authorities and airlines regarding the closure of

airspace, the cancellation of flights, and route adjustments, how much could airlines reduced revenue losses through more-targeted flight cancellations, and (b) avoid or reduce aircraft damages from better route adjustments and ash cloud avoidance.

Principle Finding(s)*:*
Overall, the team estimated that use of the data following the Eyjafjallajökull eruption saved $24 million to $72 million in avoided revenue losses due to unnecessary delays and avoided aircraft damage costs. If the data had been used from the beginning of the eruption, the total potential impact in avoided losses and costs could have been around $200 million.

Methods:

- *Combined time series and VOI approach were used to determine how much the introduction of Aura data would reduce the uncertainty about the level of ash threat.*
- two impact metrics: avoided revenue losses and avoided aircraft dam-ages.

Lessons Learned:

The number of potential impacts of a project may be large and may require prioritization for analysis. There were many different potential impacts for this project, including multiple benefits in terms of time and safety to both the traveling public and the airline operators. A full, comprehensive socioeconomic impact analysis would quantify each separately and add them together. Otherwise, if resources for the analysis are limited, analysts may be required to assess and prioritize the impacts so those that are most likely to be greatest in magnitude are addressed first. Additional analyses can be done in priority order until the resources are exhausted. In this case, the sum of the benefits analyzed would be a floor for the total benefits.

Historical data alone may not be sufficient to develop a single baseline case; it may be necessary and appropriate to examine multiple baselines. The historical record on volcanic ash events and the European regulators' past actions was somewhat limited. As such, the analytic team was constrained in making a strong supposition about how the regulators would have behaved in the absence of the Earth observations data—whether they would have reopened the airspace more quickly or more slowly. Thus, the analysis considered two different baseline cases, and it estimated the benefits in each case.

Impacts that accrue during infrequent events may be more difficult to estimate statistically than impacts that occur broadly in time. Time-series retroactive analyses typically require data series of reasonable lengths to generate baselines and make statistical inferences. Because of the relatively small number of major volcanic eruptions that influence air flight operations, the analytic team had to use several assumptions and proxies in the Eyjafjallajökull case to get sufficient information to complete the analysis.

Impacts during specific, infrequent events may not necessarily be representative of the steady state; impact analyses should consider the frequency of the event in conveying impacts appropriately to the audience. Events with the magnitude of Eyjafjallajökull are not common occurrences, yet they tend to occur at least every decade. Smaller eruptions and disruptions occur more frequently. For event-driven analyses, the impact assessment report should be upfront about the frequency of such events so that the audience is not misled. Where possible, the impact assessment should analyze and articulate the expected value for an annual basis (or appropriate timeframe) to indicate how representative the event's impacts are of the more routine, steady-state condition.

C.# TEMPLATE STUDY TITLE

DATE OF COMPLETION: Month Year
COMMISSIONED BY: Agency Name
AUTHORED BY:
DURATION:
APPROXIMATE COST OF STUDY:
METHODOLOGY:

Principle Audience:

Study Description:

Study Question(s):

- *TBD*
- *TBD*

Principle Finding(s)*:*

- *TBD*
- *TBD*

Methods:

- *TBD*
- *TBD*

Lessons Learned:

APPENDIX D: SETT DOCUMENTATION LIST

European Commission Directorate-General for Enterprise & Industry (Prepared by Booz&Co): Cost-Benefit Analysis for GMES

European Commission Directorate-General for Enterprise & Industry (Prepared by PricewaterhouseCoopers LLP): Main Report Socioeconomic Benefits Analysis of GMES

EUMETSAT: The Case for EPS/METOP Second Generation Cost Benefit Analysis
http://bit.ly/EPS-METOP_CostBenefit

European Space Policy Institute: EUMETSAT-NOAA Collaboration in Meteorology form Space: Review of a Longstanding Trans-Atlantic Partnership. Report 46 September 2013
http://bit.ly/ESPI_EUMETSAT-NOAAPartnership

Thomas Frei, MeteoSwiss: Economic and social benefits of meteorology and climatology in Switzerland

IOCCG: "Why Ocean Colour? The Societal Benefits of Ocean-Colour Radiometry" Published by the International Ocean-Colour Coordinating Group. Publication sponsored by the Canadian Space Agency
http://bit.ly/WhyOceanColour

Macauley: "Ascribing societal benefit to applied remote sensing data products: an examination of methodologies based on the Multi-angle Imaging SpectroRadiometer experience" Molly K. Macauley, David J. Diner, Journal of Applied Remote Sensing, Vol. 1, 013538 (27 September 2007)
http://bit.ly/RemoteSensing_Macauley_2007

Macauley: "The value of information: Measuring the contribution of space-derived earth science data to resource management" Molly K. Macauley, *Space Policy* 22 (2006) 274–282
http://bit.ly/SpacePolicy22_Macauley

Macauley: "The Value of Information: A Background Paper on Measuring the Contribution of Space-Derived Earth Science Data to National Resource Management" Molly K. Macauley, May 2005 Discussion Paper 05-26, Resources for the Future
http://bit.ly/RFF_Maucauley_2005

NASA: Measuring Socioeconomic Impacts of Earth Observations: A Primer
http://bit.ly/NASA_SocioeconomicPrimer

NASA: 2012 Annual Report NASA Applied Sciences Program
http://bit.ly/2012NASAAppliedSciences

NASA: 2011 Annual Report NASA Applied Sciences Program
http://bit.ly/2011NASAAppliedSciences

NASA: "Evaluating the use of remote sensing data in the U.S. Agency for International Development Famine Early Warning Systems Network" Molly E. Brown and Elizabeth B. Brickley, Journal of Applied Remote Sensing 063511-2, Vol. 6, 2012
http://bit.ly/USAID_FEWSNet_Evaluation

NASA: "Policy for robust space-based earth science, technology and applications" Molly E. Brown et al. Space Policy (2012) 1-7
http://bit.ly/SpacePolicy_Brown2012

USGS: What is the Economic Value of Satellite Imagery? Fact Sheet - January 2013
http://bit.ly/USGS_ValueSatelliteImagery

USGS: An Economic Value of Remote-Sensing Information – Application to Agricultural Production and Maintaining Groundwater Quality. Professional Paper 1796, 2012
http://bit.ly/USGS_RemoteSensingApplication

WMO: "Observing System Studies: Cost Benefit Studies for Observing Systems" WMO Document CBS/OPAG-IOS/IPET-OSDE1/Doc 8.4 (03-12-2014)
http://bit.ly/WMO_CostBenefitStudies

WMO: Climate Exchange (case studies in GFCS across various application areas)
http://bit.ly/WMOClimateExchange

WMO: Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services, WMO-No. 1153, 2015

WMO Side Meeting Presentations, EUMETSAT 2014

- Alain Ratier: Socio-economic benefits of satellite data
- Lars Peter Riishojgaard: Cost-benefit analysis of satellite observing systems
- Stephan Bojinski: Raising the benefits of meteorological services and satellites

WMO: **TECO PART2: "Understanding and Communicating the Return on Investment through Basic Systems and Services**" CBS-15/Doc.8(1)
(PDF Provided)

FROM NASA PRIMER (RESOURE) SOCIOECONOMIC BENEFITS ANALYSIS FLOW[3]

[3] Derived from *Measuring Socioeconomic Impacts of Earth Observations: A Primer* published by NASA