

**P1.28 NPOESS ECONOMIC BENEFIT ESTIMATION IN A DYNAMIC POLICY ENVIRONMENT**

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The debate over how much farther to go with restoration of demanifested sensors originally planned for the National Polar Orbiting Environmental Satellite System (NPOESS) and how much reliance to place on other satellite systems makes understanding of the nature and value of benefits of the program and components essential. Decisions rest on priorities given to continuity of weather records, the importance of new climate records, technical issues and economic considerations.

The study for the tri-agency NPOESS Integrated Program Office reported on here developed order of magnitude estimates of benefits before and after the 2006 Nunn-McCurdy changes and subsequent program changes.<sup>1</sup> The Extended Abstract and presentation also discuss a recommended approach to assessing choices among measurements and sensors as a follow on to the July 2008 National Research Council study.<sup>2</sup> The recommended approach uses expert opinion based on values instead of using rankings and explicitly recognizing differences in priorities between weather experts and climate experts.

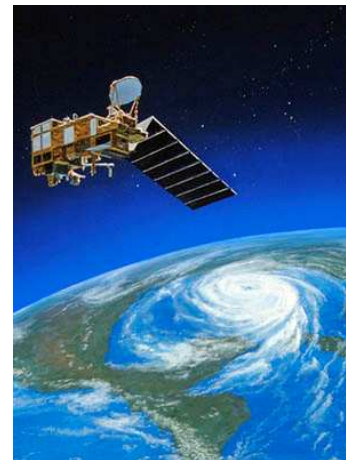
**1. NPOESS PROGRAM CHANGES AND ISSUES**

The legislatively required review in response to cost increases resulted in the following changes:

**Table 1. Summary of Nunn-McCurdy Changes to the NPOESS Program<sup>3</sup>**

Key area	Program before the Nunn-McCurdy decision	Program after the Nunn-McCurdy decision
Life cycle range	1995-2020	1995-2026
Estimated life cycle cost	\$8.4 billion	\$12.5 billion
Launch schedule	NPP by October 2006 First NPOESS by November 2009 Second NPOESS by June 2011	NPP by January 2010 First NPOESS by January 2013 Second NPOESS by January 2016
Management structure	System Program Director reports to a tri-agency steering committee and the tri-agency Executive Committee Independent program reviews noted insufficient system engineering and cost analysis staff	System Program Director is responsible for day-to-day program management and reports to the Program Executive Officer Program Executive Officer oversees program and reports to the tri-agency Executive Committee
Number of satellites	6 (in addition to NPP)	4 (in addition to NPP)
Number of orbits	3 (early morning, midmorning, and afternoon)	2 (early morning and afternoon; will rely on European satellites for midmorning orbit data)
Number and complement of instruments	13 instruments (10 sensors and 3 subsystems)	9 instruments (7 sensors and 2 subsystems); 4 of the sensors are to provide fewer capabilities
Number of EDRs	55	39 (6 are to be degraded products)

In January 2008, NASA and NOAA announced they would restore the Clouds and Earth Energy Systems (CERES) instrument on NPP. Subsequently, the Ozone Mapping and Profiler Suite Limb (OMPS-limb) was restored to NPP. It is possible it will be restored on NPOESS in the future. The instrument has the capability to determine ozone profiles below the peak concentration in the stratosphere. In May 2008 the decision was announced to remanifest the Total Solar Irradiance Sensor (TSIS) on the first NPOESS satellite C1. The MIS sensor replaces CMIS with a less complex instrument. As a result of the initial and subsequent changes, the configuration of instruments to be on NPOESS as of April 2008 is:<sup>4</sup>



C1: VIIRS, CrIS, ATMS, OMPS, CERES, SEM, TSIS, Search and Rescue, A-DCS.

C2: VIIRS, MIS, Search and Rescue, A-DCS.

Changes to the NPOESS program subsequent to the Nunn-McCurdy review have been influenced by the release of interim materials from National Academies study: "A Strategy to Mitigate the Impact of Sensor Descopes and Demanifests on the NPOESS and GOES-R Spacecraft," along with pressures from the study's participants.<sup>5</sup> Also, NASA added two missions in response. Other changes proposed by the National Academies have fallen prey to budget limitations. Still others are being discussed for possible restoration to NPOESS or other missions if funding can be obtained. At the same time, there may be greater opportunities to rely on information from satellites of other nations.

**2. BENEFIT ESTIMATES**

Benefits are broadly defined to include those to the civilian economy and society. They include both economic benefits and non-economic benefits — such as those to life, health, safety and the environment. The core consideration is weather related benefits.

Calculations from a national econometric model of effects of weather on the economy by Harrod *et. al.*<sup>6</sup> are adapted to obtain an estimate of the value of weather effects that largely reflects impacts on businesses and governments. Part of the effect of adverse weather and short term climate change is assumed to be reduced by the availability of forecasts, warnings and information to obtain a value of weather information to these sectors. The results are combined with values based on a study of households' "willingness to pay" for weather services by Lazo and Chestnut<sup>7</sup> to derive a more complete estimate of the benefits of weather information.

A portion of the combined gain is then attributed to NPOESS to remove the contributions of other satellites, other measurement platforms and the myriad activities of the weather enterprise.

Adjustment is made for underestimation and unmeasured economic and environmental impacts. Possible benefits associated with climate change are discussed and illustrative calculations are made, drawing on recent economic studies. The methods and assumptions are described in the Appendix.

The central values of the estimates are:

- The present value of NPOESS benefits before the Nunn-McCurdy modifications is

\$18.1 billion with a discount rate of 5%. With a 7% discount rate the value decreases to \$14.5 billion and at 3% it is \$22.9 billion.

- The present value of benefits is reduced to \$11.2 billion after the Nunn-McCurdy and subsequent modifications with a discount rate of 5%. With a 7% discount rate the value is \$8.9 billion and at 3% it is \$14.1 billion.
- A one year delay reduces the value of benefits with a 5% discount rate from \$11.2 billion to \$10.0 billion and a two year delay reduces it to \$9.6 billion.
  - These values assume that the delay does not cause service to extend beyond 2026. If it did, with a one and two year delay the benefits would be somewhat higher, at \$10.6 billion and 9.6 billion in year 2008 dollars.
- A one year greater length of service increases the value of benefits in the central case with a 5% discount rate from \$11.2 billion to \$11.8 billion and a two year delay increases it to \$12.5 billion.

Possible benefits with varying degrees of restoration (beyond the restoration that took place prior to release of the NAS final report) are illustrated by taking percentages in between the pre-Nunn-McCurdy benefits (100% of sensors) and the benefits with the planned configuration (61.8% of sensors). Examples of the added present values of benefits for the central case with a 5% discount rate are presented in Table 2 for various percentages of the pre- and post-Nunn-McCurdy estimates. Full restoration would increase benefits by \$6.9 billion in the example.

Table 2 also can be used to calculate how much of the benefits would be offset by a cost escalation of a particular magnitude.

<b>Table 2. Present Value of Restoration of Benefits at 5% Discount Rate</b> (billions of 2008 dollars)	
<b>percentage of reduction in benefits restored</b>	<b>benefits added in central case</b>
25%	\$1.7
50%	\$3.4
75%	\$5.2
100%	\$6.9
Source: Tables 4 and 5. Numbers vary due to rounding.	

**3. A RECOMMENDED APPROACH FOR COMPARING PROGRAM ALTERNATIVES**

Next, an approach is recommended for comparing program alternatives using a

consensus of expert opinion based on values of measurements and sensors, instead of using rankings as was done in the NRC study. The approach explicitly takes account of the differences in priorities of weather experts and climate experts.

There also is a need for more explicit consideration of relationships among weather, climate and environmental programs. This should take into account programs and plans of both the U.S. and other nations. The approach can be used for this purpose as well.

The NPOESS and related programs will continue to undergo considerable change based on resolution of technical issues with sensors, the timing of satellite launches, increased interest in climate change and budget considerations. The stakes are high, both in terms of expenditures and contributions to society. The analysis described can contribute to improved decisions about future program modifications.

Specifically, the July 2008 National Research Council study that ranked measurements and sensors should be followed by analysis for decision support that:

- Continues to rely on expert opinion but takes fuller advantage of that knowledge.
  - Elicits relative values, not just rankings.
  - Compares values assigned by weather and by climate experts separately to avoid uncertain effects of the mix of priorities, and combines the sets of values with explicit alternative weights.
- Makes explicit adjustments based on risks associated with differences in complexity.
- Uses costs together with values to make determinations.

The approach has many advantages.

- Finding common ground.
- Facilitating identifying where sensors or measurements do not meet the needs of both weather and climate scientists and additional provision for data collection has to be made.
- Separating differences in priorities from differences in selections (weights) made to achieve priorities.

- Allowing users of the information to combine the sets of valuations of the two groups of experts in explicit ways.
- Making it possible to compare relative values for a given priority with estimates of economic and social value

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<sup>1</sup> The main analysis: Irving Leveson, *NPOESS Economic Benefits*, prepared for the NPOESS Integrated Program Office, June 18, 2008, is available at <http://www.economics.noaa.gov/bibliography/npoess-report.doc>

<sup>2</sup> Benefits of adding the three instruments whose restoration was decided prior to the release of the NAS report are already included in the estimates in this study.

<sup>3</sup> Source: United States Government Accounting Office, *Environmental Satellite Acquisitions: Progress and Challenges*, GAO-07-1099T, July 11, 2007, Table 3.

<sup>4</sup> Benefits of adding the three instruments whose restoration was decided prior to the release of the NAS report are already included in the estimates in this study.

<sup>5</sup> National Research Council, *Ensuring the Climate Record from the NPOESS and GOES-R Spacecraft: Elements of a Strategy to Recover Measurement Capabilities Lost in Program Restructuring*, Washington, D.C.: National Academies Press, July 10, 2008. Also see Space Studies Board, National Research Council, *Options to Ensure the Climate Record from the NPOESS and GOES-R Spacecraft: A Workshop Report*, Washington: The National Academies Press, 2007

[http://www7.nationalacademies.org/ssb/SSB\\_NPOESS2007\\_Presentations.html](http://www7.nationalacademies.org/ssb/SSB_NPOESS2007_Presentations.html)

<sup>6</sup> Megan Harrod, *et al.*, "Sensitivity of the U.S. Economy to Weather Variability," paper presented at the annual meeting of the American Economic Association, January 5, 2007 [http://www.aeaweb.org/annual\\_mtg\\_papers/2007/0105\\_0800\\_0201.pdf](http://www.aeaweb.org/annual_mtg_papers/2007/0105_0800_0201.pdf)

<sup>7</sup> Jeffrey K. Lazo, and Lauraine G. Chestnut, *Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector*, Stratus Consulting, November 22, 2002.

## APPENDIX: SUMMARY OF BENEFIT METHODS AND ASSUMPTIONS

### Weather and Short term climate benefits

Adaptation and update of estimates from national econometric model of effects of weather on the economy.

Addition of half of benefits determined in household study of willingness to pay to reflect benefits not captured in national econometric model.

### Weather and climate assumptions

Adverse weather and short term climate impacts (as estimated based on the national econometric model) are assumed to be reduced by 10% by the availability of forecasts, warnings and information.

10% of the gain from the forecasts, warnings and weather information (1% of the weather impacts) is attributed to NPOESS, the rest being the share of other public and private efforts at measurement, analysis and dissemination of weather information and also the cost of responses to reduce weather impacts.

Benefits are reduced by 30% to allow for the contribution of non-NPOESS satellites (MetOp and DSMP) to the NPOESS program.

An allowance of \$50-\$100 million per year is added for long term climate-related benefits prior to Nunn-McCurdy.

### Explanation of adjustment for underestimation and unmeasured economic, environmental and climate impacts

A reduction is applied for Nunn-McCurdy and subsequent changes to 61.8% of what the benefit would have been with the configuration prior to Nunn-McCurdy. The reduction is based on number of EDRs, with those having reduced capability counted at half.

An alternative calculation illustrates what benefits would be if removed capabilities were half as important to the economy and society as those retained. It results in a reduction in benefits to 80.9% of pre-Nunn-McCurdy values.

The benefit estimate for NPOESS is raised by 30% to roughly account for 1) incompleteness of available estimate of weather effects on economy in the econometric model due to using a limited number of measures of weather, 2) exclusion of intra-year variation in the econometric model, and 3) environmental and safety benefits beyond those reflected in households' willingness to pay.

10% of the gain from the forecasts, warnings and weather information attributed to NPOESS is based on:

Assuming the benefits of NPOESS and GOES account for equal shares of the benefits.

Assuming that platforms other than satellites account for benefits equal to those of satellites.

Assuming the NPOESS satellites and their instruments account for 40% of the NPOESS benefits and the other 60% is attributable to data assimilation, modeling, dissemination and other downstream efforts. (benefits are equal to  $\frac{1}{2}$  of 50% x .4)

Benefits of NPOESS associated with climate change are illustrated for the United States at \$50-\$100 million (centered on \$75 million) starting in 2013, for the configuration before the Nunn-McCurdy changes. This is based conservatively on a review of the literature on economic effects of climate change contained in the study report.

### Alternative benefits are calculated if satellites were delayed or lasted longer, based on shifting benefits among years. Estimates are for:

A one year and a two year delay in operation.

A one year and a two year additional useful life.

Benefits are in present discounted values of dollars of 2008 purchasing power.

Beyond the initial years, benefits are shown as present discounted values and not annually because year-to-year variation is not calculated beyond the initial buildup of capabilities. The initial phase in through 2017 is calculated based on the number of EDRs by year used in the NDE Cost Effectiveness Analysis.

Effects of using alternative discount rates of 7%, 5% and 3% are shown.

## IRVING LEVESON

Dr. Leveson has strong analytical skills in the fields of economics and social science. He has extensive experience in strategic and economic consulting and research in government, non-partisan think tanks, and private industry. He has been an independent consultant since 1990. He currently is a consultant to the U.S. Department of Commerce and the Aerospace Corporation, and is an Adjunct Fellow at the Hudson Institute.



Dr. Leveson has provided NOAA with assistance, advice and analytic support on a wide range of economic and social science issues for the last seven years, both working independently and as a member of teams with NOAA personnel. His activities include:

- Conducting a comprehensive examination of external trends affecting NOAA, including technology, business models and public/private sector roles.
- Assisting NOAA in incorporating social science into its planning through a series of briefing books and workshops with mission goal teams and program and budget offices.
- Examining NOAA programs and plans.
- Assisting with social science study development.
- Examining policies and guidelines for NOAA partnership policy.
- Assisting in the development of a social science plan for weather and water.
- Assessing benefits of the CORS and gravimetric height measurement programs.
- Analyzing economic impacts of high impact weather.

In these activities he has gained familiarity with NOAA plans, programs and processes and the customers and constituencies with which NOAA is engaged.

His work on satellite-related issues includes:

- Conducting a strategic cost-benefit analysis of modernization of the Global Positioning Satellite system with a focus on evolving applications, markets and benefits of the new L2C signal.

- A major GPS financial analysis study.
- Participating the National Security Space Office GPS architecture study.
- Examining opportunities for utilizing a modernized GPS system in NOAA.
- Estimating the loss of benefits if the P(Y) signal were turned off or rendered unusable by phasing out or use of flexpower.
- Estimating benefits of the NPOESS weather satellite system.

Dr. Leveson holds a Ph.D. in economics from Columbia University. He previously served as Director of Economic Studies of the Hudson Institute, Senior Vice President and Director of Research of Hudson Strategy Group, Assistant Administrator for Health Systems Planning for the New York City Health Services Administration and as a research director for the New York City Planning Commission. He also served as an economist for the RAND Corporation and the National Bureau of Economic Research. Dr. Leveson is a member of the American Meteorological Society, the Institute of Navigation, the American Economic Association and the National Association for Business Economics.