# *SOHO*

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Presentation to the Heliophysics Senior Review
*2013 April 23*

- Summary of prioritized science goals
- Situational awareness as science
- Budget
- Backup slides, if of interest, on:
  - *Relation to Roadmap research focus areas*
  - *Mission ops staffing*
  - *Archive status*
  - *Consumables*
  - *NOAA NWS letter to SMD AA*
  - *DSN contact time, by year*
  - *Anomaly statistics*

# Prioritized Science Goals

# SOHO Prioritized Science Goals

1. *Provide Sun-earth line, visible light coronagraphy for the Heliophysics System Observatory*
2. *Continue to enable long-baseline and space weather-related science with European-funded investigations*
3. *Continue to offer robust solar wind proton and EUV irradiance measurements*

# Situational Awareness as Science

# *Situational Awareness as Science (I)*

- There are good *scientific* reasons to keep a Sun-earth line, visible light coronagraph capability
    - initiation of dynamic events in the heliosphere
    - magnetic helicity budget of the outer solar atmosphere
    - energetic particle acceleration
    - propagation in heliolongitude (“sympathetic” events)

# *Situational Awareness as Science (II)*

- And there are also significant *societal / national interest benefits*
  - early warning of potentially geoeffective events
  - unambiguous identification of events propagating toward earth before closer-in assets are saturated with SEP effects
  - at least through 2019, in conjunction with STEREO, situational awareness of events propagating toward any NASA asset anywhere in the solar system

# *Situational Awareness as Science (III)*

- A modest proposal:
  - Monitoring space weather – being able to use coronagraph measurements to predict, with < 6 hour arrival time accuracy, CME arrival at 1 AU, and having the data with which to improve the models – *is science*
  - Testing what 360° space weather situational awareness can tell us about the heliosphere's and individual planets' responses to ICMEs *is science*
- On this basis, *SOHO* LASCO remains at the forefront of heliophysics *science*

# *Uptake of SOHO data*

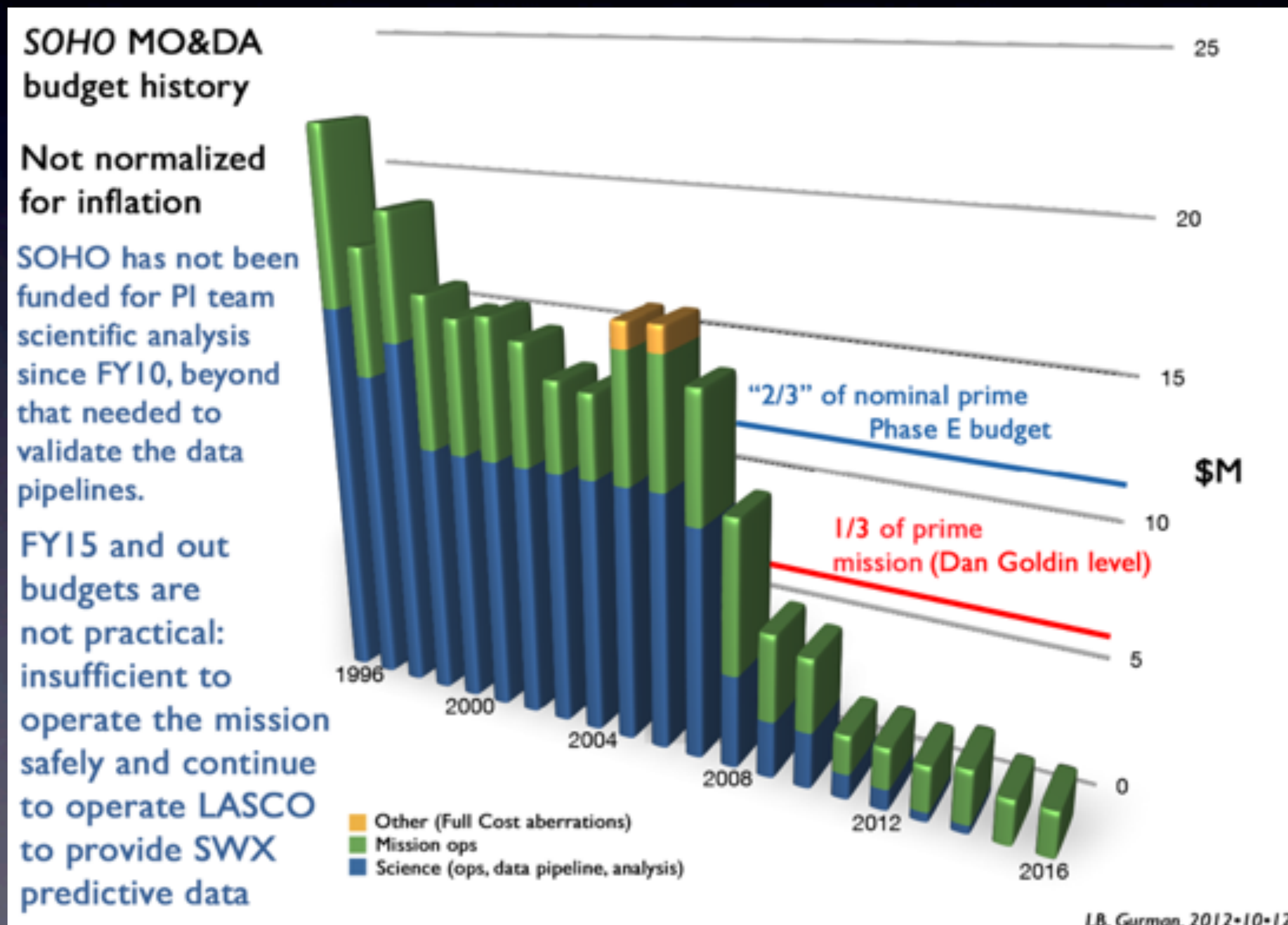
- *SOHO* Website: > 279 Tbyte of downloads in 2012/04 - 2013/03 (vs. 99 Tbyte 3 years ago)
- > 165 Gbyte of *SOHO* data (FITS or CDF) downloaded *via* the VSO Web interface in 2012 (most users now employ IDL)
- > 2,200 comets discovered through the end of 2012, over half by amateurs, using freely downloadable *SOHO* LASCO coronagraph images (FITS files), since 1996 (well over half of all the comets for which orbital elements are known)
- LASCO CME measurements used as inputs for NOAA SWPC forecasting models, GSFC CCMC modeling efforts

| Calendar Year | Refereed Journals only |
|---|---:|
| 1996 | 31 |
| 1997 | 125 |
| 1998 | 174 |
| 1999 | 297 |
| 2000 | 295 |
| 2001 | 210 |
| 2002 | 289 |
| 2003 | 305 |
| 2004 | 332 |
| 2005 | 330 |
| 2006 | 272 |
| 2007 | 360 |
| 2008 | 320 |
| 2009 | 321 |
| 2010 | 275 |
| **2011** | 297 |
| **2012** | 240 |
| **2013 (to Feb. 28)** | 39 |
| **Total** | 4505 |

*SOHO papers in the refereed literature*

# Budget

# *Operating a (former) Great Observatory on a SMEX Budget*



# *Proposed Mission, FY14 - FY18*

- Not really *SOHO* as we knew it: the "Bogart" mission, since 2008
    - Operating a Great Observatory as a SMEX
    - Have already automated all operations except orbit trim, momentum management, and rolls (4 each per year)
    - *The national and scientific need for SOHO operations is to continue the LASCO earth-Sun line coronagraphy not available on SDO*
- MDI ceased observing in 2011 April (SDO/HMI)
- UVCS operations ended in 2013 January (detector issues)
- SUMER operations severely limited by hardware issues
    - Will cease after campaign with IRIS in 2013 summer
- CELIAS MTOF and PM operations last only ~ 1 year under current guidelines

# *Current Year Budget and FY14-18 Guidelines ($M)*

| | FY14 | FY15 | FY16 | FY17 | FY18 |
|---|---|---|---|---|---|
| Mission Ops | 1.54 | 1.58 | 1.63 | 1.67 | 1.67 |
| Science Ops | 0.64 | 0.52 | 0.53 | 0.54 | 0.55 |
| **Total** | 2.19 | 2.10 | 2.16 | 2.22 | 2.22 |
| **Guideline** | 2.19 | 1.87 | 1.90 | 1.90 | 1.90 |
| **Needed** | | 0.23 | 0.26 | 0.31 | 0.32 |

- These figures *do not* include IT security-essential upgrades of MOC strings and spacecraft simulator; both are obsolete and mission-critical
- Estimated additional costs for development: $331K in FY14, $271K in FY15.

# Costs including Development Efforts

| | FY14 | FY15 | FY16 | FY17 | FY18 |
|---|---|---|---|---|---|
| Mission Ops | 1.54 | 1.58 | 1.63 | 1.67 | 1.67 |
| Science Ops | 0.64 | 0.52 | 0.53 | 0.54 | 0.55 |
| Development | 0.33 | 0.27 | | | |
| **Total** | 2.52 | 2.37 | 2.16 | 2.22 | 2.22 |
| **Guideline** | 2.19 | 1.87 | 1.90 | 1.90 | 1.90 |
| **Needed** | 0.33 | 0.50 | 0.26 | 0.31 | 0.32 |

- Both MOC “strings” of workstations and simulator are currently on obsolete platforms, for which even reliable spares are beginning to become unavailable
- Not upgrading is not a reasonable risk posture

# Under Current Guidelines

- If we have to operate under these guidelines, we will need to:
  - Eliminate the only SW plasma data stream with > 8 hr/day of near-realtime coverage, ~ 10 hour (maximum) turnaround for recorded data, and little or no SEP saturation
  - forego IT security- and longevity-critical updates of MOC strings, spacecraft simulator: mission critical
  - reduce the size of the FOT yet further: will endanger the mission

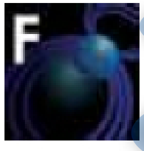
End

# Supporting Material

- Relation to Roadmap research focus areas (RFAs)
- Mission ops staffing
- Archive status
- Consumables
- NOAA NWS letter to SMD AA
- DSN contact time, by year
- Anomaly statistics

# *Roadmap:* "*Frontier*"

## Research Focus Areas




**F1** Magnetic reconnection

**F2** Particle acceleration and transport

**F3** Ion-neutral interactions

**F4** Creation and variability of magnetic dynamos

## Open the Frontier to Space Environmental Prediction

The Sun, our solar system, and the universe consist primarily of plasma. Plasmas are more complex than solids, liquids, and gases because the motions of electrons and ions produce both electric and magnetic fields. The electric fields accelerate particles, sometimes to very high energies, and the magnetic fields guide their motions. This results in a rich set of interacting physical processes, including intricate exchanges with the neutral gas in planetary atmospheres.

Although physicists know the laws governing the interaction of electrically charged particles, the collective behavior of the plasma state leads to complex and often surprising physical phenomena. As the foundation for our long-term research program, we will develop a comprehensive scientific understanding of the fundamental physical processes that control our space environment.

The processes of interest occur in many locations, though with vastly different magnitudes of energy, size, and time. By quantitatively examining similar phenomena occurring in different regimes with a variety of techniques, we can identify the important controlling mechanisms and rigorously test our developing knowledge. Both remote sensing and in situ observations will be utilized to provide the complementary three-dimensional, large-scale perspective and the detailed small-scale microphysics view necessary to see the complete picture.

Note: Refers to *SOHO* Bogart mission, not the "classic" *SOHO* mission

# Roadmap: "Home"

### Research Focus Areas

- **H1** Causes and evolution of solar activity
- **H2** Earth's magnetosphere, ionosphere, and upper atmosphere
- **H3** Role of the Sun in driving change in the Earth's atmosphere
- **H4** Apply our knowledge to understand other regions

### Understand the Nature of Our Home in Space

Humankind does not live in isolation; we are intimately coupled with the space environment through our technological needs, the solar system bodies we plan to explore, and ultimately the fate of our Earth itself. We regularly experience how variability in the near-Earth space environment affects the activities that underpin our society. We are living with a star.

We plan to better understand our place in the solar system by investigating the interaction of the space environment with the Earth and the effect of this interaction on humankind. We plan to characterize and develop a knowledge of the impact of the space environment on our planet, technology, and society. Our goal is to understand the web of linked physical processes connecting Earth with the space environment.

Even a casual scan of the solar system is sufficient to discover that habitability, particularly for humankind, requires a rare confluence of many factors. At least some of these factors, especially the role of magnetic fields in shielding planetary atmospheres, are subjects of immense interest to heliophysics. Lessons learned in the study of planetary environments can be applied to our home on Earth, and vise versa, the study of our own atmosphere supports the exploration of other planets.

# Roadmap: "Journey"

### Research Focus Areas


**J1** Variability, extremes, and boundary conditions

**J2** Capability to predict the origin, onset, and level of solar activity

**J3** Capability to predict the propagation and evolution of solar disturbances

**J4** Effects on and within planetary environments

### Safeguard the Journey of Exploration

NASA's robotic spacecraft continue to explore the Earth's neighborhood and other targets in the heliosphere. Humans are expected once again to venture onto the surface of the Moon and one day onto the surface of Mars. This exploration brings challenges and hazards. We plan to help safeguard these space journeys by developing predictive and forecasting strategies for space environmental hazards.

This work will aid in the optimization of habitats, spacecraft, and instrumentation, and for planning mission operation scenarios, ultimately increasing mission productivity. We will analyze the complex influence of the Sun and the space environment, from origin to the destination, on critical conditions at and in the vicinity of human and robotic spacecraft. Collaborations between heliophysics scientists and those preparing for human and robotic exploration will be fostered through interdisciplinary research programs and the common use of NASA research assets in space.

# Mission Ops Staffing

- FY96 "great observatory" model: ~ 22.5 FTE
- FY13 Bogart model: 7.8 FTE + 1.1 FTE for development
  - 4.45 FTE for Flight Ops (8 x 5 plus contingencies)
  - 0.67 FTE for DSN scheduling
  - 0.61 FTE for orbit (FDF) and attitude (FOT)
  - 1.28 for sys admin, h/w support, db admin
  - 0.73 for mission data collection, distribution
  - &c. for logistics, property, &c.

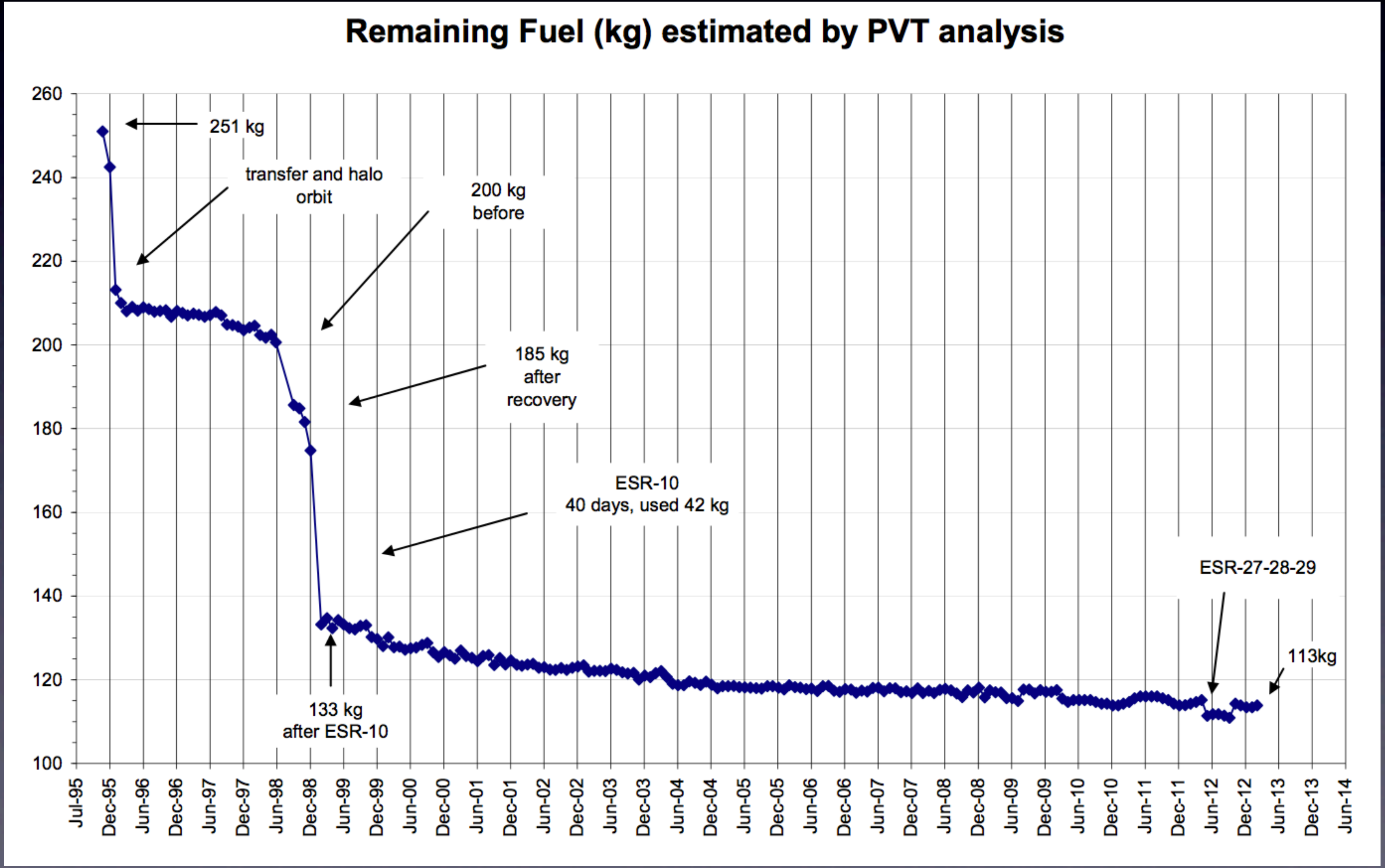
# *Archive Status (I)*

http://soho.nascom.nasa.gov/data/archive/index_gsfc.html

**Available Data as of March 20, 2013**

| INSTRUMENT | LATEST DATA | UPDATED ON |
|---|---|---|
| CDS | 2013-03-14 | 2013-03-17 |
| CELIAS | 2012-12-05 | 2013-03-17 |
| COSTEP | 2012-06-18 | 2012-08-29 |
| EIT | 2013-03-06 | 2013-03-17 |
| ERNE | 2013-03-07 | 2013-03-11 |
| GOLF | 2013-03-11 | 2013-03-20 |
| LASCO | 2012-12-30 | 2013-03-18 |
| MDI | 2011-04-11 | 2012-08-24 |
| SUMER | 2011-11-18 | 2012-08-24 |
| SWAN | 2013-03-05 | 2013-03-11 |
| UVCS | 2012-06-16 | 2012-11-09 |
| VIRGO | 2013-03-01 | 2013-03-11 |

# Fuel



Remaining Fuel (kg) estimated by PVT analysis
260
240
220
200
180
160
140
120
100
251 kg
transfer and halo orbit
200 kg before
185 kg after recovery
ESR-10 40 days, used 42 kg
133 kg after ESR-10
ESR-27-28-29
113kg
Jul-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
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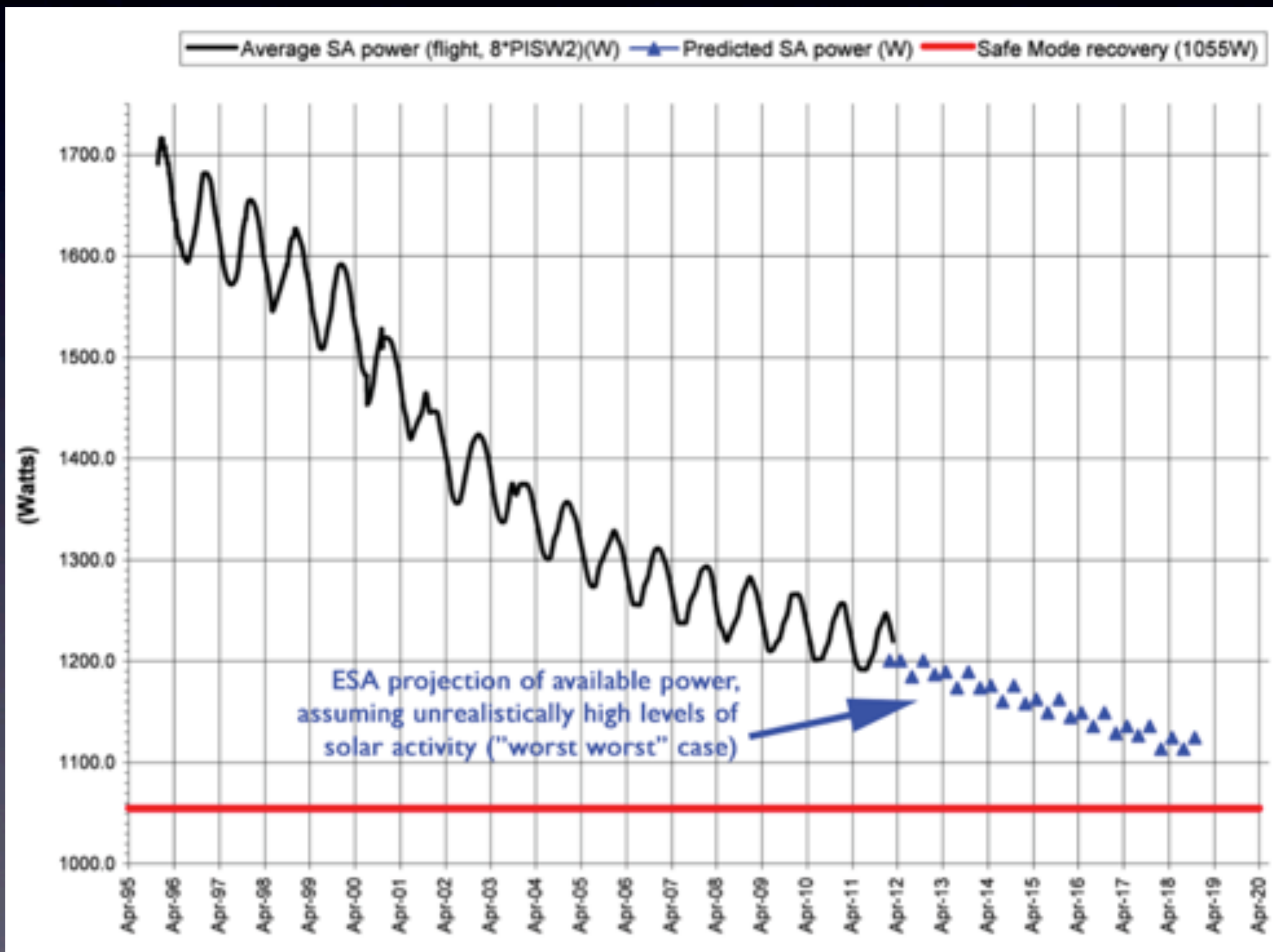
Jun-14

# Solar Array Output




ESA Technical Study: SOHO/PRG/TN/741, April 2012

- Conclusion: Even without the remarkably low levels of solar activity in Cycle 24, we have more than adequate margin through FY18

**U.S. DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
NATIONAL WEATHER SERVICE
1325 East-West Highway
Silver Spring, Maryland 20910-3283
THE DIRECTOR

Dr. John M. Grunsfeld
Associate Administrator
for the Science Mission Directorate
National Aeronautics and Space Administration
300 E Street, S.W.
Washington, DC 20546

DEC 18 2012

Dear Dr. Grunsfeld:

I am writing you to request dedicated support for the operation of the ground systems that provide SOHO/LASCO and STEREO/SECCHI coronagraph data to the National Oceanic and Atmospheric Administration (NOAA).

The threat an extreme geomagnetic storm poses to the Nation's critical infrastructure is well-recognized throughout our community and throughout the highest levels of government, including the Executive Office of the President. One key to protecting the Nation's critical infrastructure is the accurate prediction of geomagnetic storms. To better warn the Nation of impending geomagnetic storms, and as a result of collaborative efforts between NSF, NASA, and NOAA, the WSA-Enlil model was transitioned into operations at NOAA in 2012. Coronagraph observations provide the optimal input parameters to properly initialize the WSA-Enlil model with the solar events that cause geomagnetic storms. Today, the only reliable source of coronagraph data comes from the NASA SOHO/LASCO and STEREO/SECCHI research missions. It is of vital importance to NOAA that coronagraph observations continue to be available to support this critical function for the Nation.

NOAA has specific operational requirements for the SOHO/LASCO and STEREO/SECCHI instrument data. Our base requirements are that they be available at an approximate 15 minute cadence, with gaps between real-time contacts of no greater than 8 hours.

NOAA recognizes the value coronagraph data have to its mission and we are actively working to secure funding for an operational replacement. In the meantime, NOAA is requesting NASA's dedicated support to ensure the availability of the existing coronagraph data for our operational use and ensure that the Nation's interests are adequately protected.

I am confident that we can help keep the momentum of our agencies' partnership moving forward. If you have any questions please do not hesitate to have your staff contact Mr. Brent Gordon, Space Weather Services Branch Chief, at (303) 497-4468 or brent.gordon@noaa.gov.

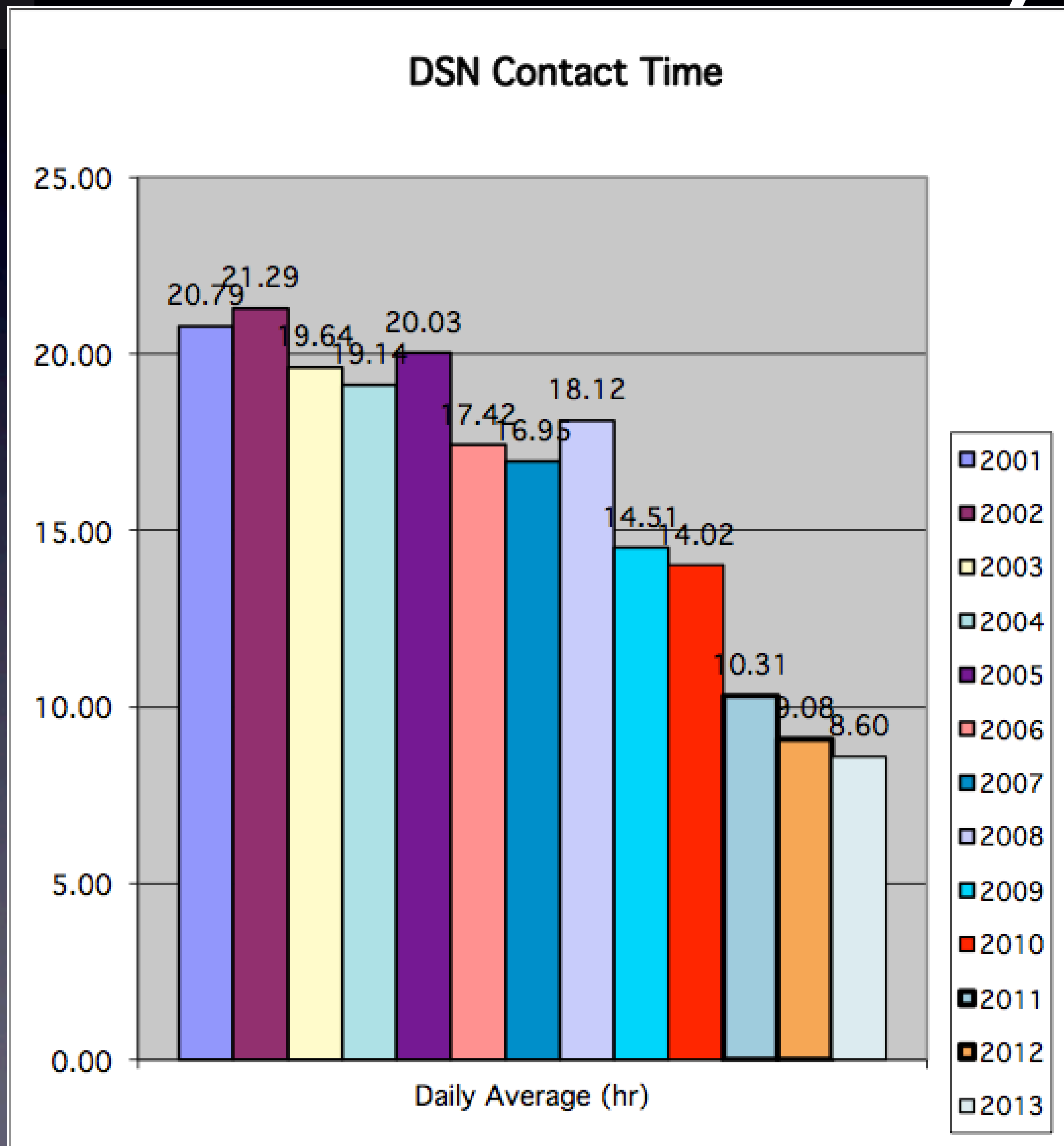
Respectfully,

Laura K. Furgione

Laura K. Furgione
Acting Director

THE ASSISTANT ADMINISTRATOR
FOR WEATHER SERVICES

# Mean Daily DSN Contact Time, by Year




2013 figure will probably approach 2012 value

# SOHO DSN Statistics

### 4.4 PLM anomalies by year

Synthesis of PLM anomalies counted by year and by instrument:

| | Total | SVM | PLM | CDS | CELIAS | CEPAC | GOLF | LASCO | EIT | MDI | SUMER | SWAN | UVCS | VIRGO | FOT | DSN | POCC | FDF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 79 | 28 | 17 | 0 | 0 | 1 | 0 | 2 | 0 | 2 | 6 | 0 | 6 | 0 | 28 | 3 | 2 | 1 |
| 1996 | 250 | 134 | 76 | 17 | 5 | 5 | 2 | 5 | 0 | 4 | 6 | 2 | 20 | 10 | 34 | 2 | 0 | 4 |
| 1997 | 232 | 74 | 145 | 87 | 3 | 21 | 0 | 7 | 1 | 2 | 7 | 5 | 10 | 2 | 6 | 0 | 5 | 2 |
| 1998 | 126 | 41 | 71 | 29 | 2 | 11 | 0 | 3 | 0 | 5 | 5 | 2 | 12 | 2 | 8 | 0 | 6 | 0 |
| 1999 | 124 | 37 | 85 | 23 | 4 | 26 | 0 | 2 | 3 | 4 | 4 | 5 | 13 | 1 | 2 | 0 | 0 | 0 |
| 2000 | 95 | 30 | 64 | 22 | 5 | 18 | 1 | 1 | 3 | 3 | 1 | 3 | 7 | 0 | 1 | 0 | 0 | 0 |
| 2001 | 90 | 29 | 60 | 12 | 3 | 27 | 0 | 0 | 4 | 3 | 4 | 1 | 3 | 3 | 0 | 1 | 0 | 0 |
| 2002 | 79 | 28 | 51 | 18 | 2 | 18 | 0 | 1 | 0 | 3 | 3 | 1 | 3 | 2 | 0 | 0 | 0 | 0 |
| 2003 | 70 | 24 | 46 | 11 | 2 | 22 | 2 | 3 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| 2004 | 52 | 25 | 27 | 9 | 2 | 9 | 0 | 1 | 0 | 1 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| 2005 | 100 | 46 | 54 | 21 | 1 | 11 | 9 | 3 | 0 | 2 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| 2006 | 85 | 40 | 45 | 9 | 0 | 18 | 0 | 3 | 0 | 8 | 4 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2007 | 71 | 31 | 40 | 3 | 3 | 19 | 0 | 1 | 2 | 3 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2008 | 60 | 24 | 36 | 7 | 3 | 13 | 2 | 3 | 0 | 1 | 4 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| 2009 | 56 | 24 | 32 | 15 | 0 | 2 | 2 | 2 | 0 | 2 | 5 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| 2010 | 48 | 27 | 21 | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 3 | 4 | 1 | 0 | 0 | 0 | 0 |
| 2011 | 41 | 19 | 22 | 10 | 2 | 4 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| 2012 | 45 | 26 | 19 | 3 | 1 | 11 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | |
| Total | 1703 | 687 | 911 | **306** | 38 | 236 | 19 | 37 | 15 | 43 | 70 | 28 | 82 | 37 | 79 | 6 | 13 | 7 |

Some of the PLM anomalies are related to a spacecraft reconfiguration or monitoring. Over the past year:

- 2011 December: PLM thermal reconfiguration caused by CEPAC/ERNE;
- 2011 March: CELIAS/CTOF switched OFF

Since 2009, there has been:

- less CEPAC anomalies thanks to a CEPAC SW upgrade allowing the instrument to recover by itself a CEPAC ESU data request error; but in 2012, due to higher temperatures, CEPAC ERNE was switched OFF several times.
- less LASCO/EIT anomalies by using 2 COBS Standard Monitorings to provide automated resets of LASCO Electronics Box (LEB).