Heliophysics Senior Review briefing to HPAC

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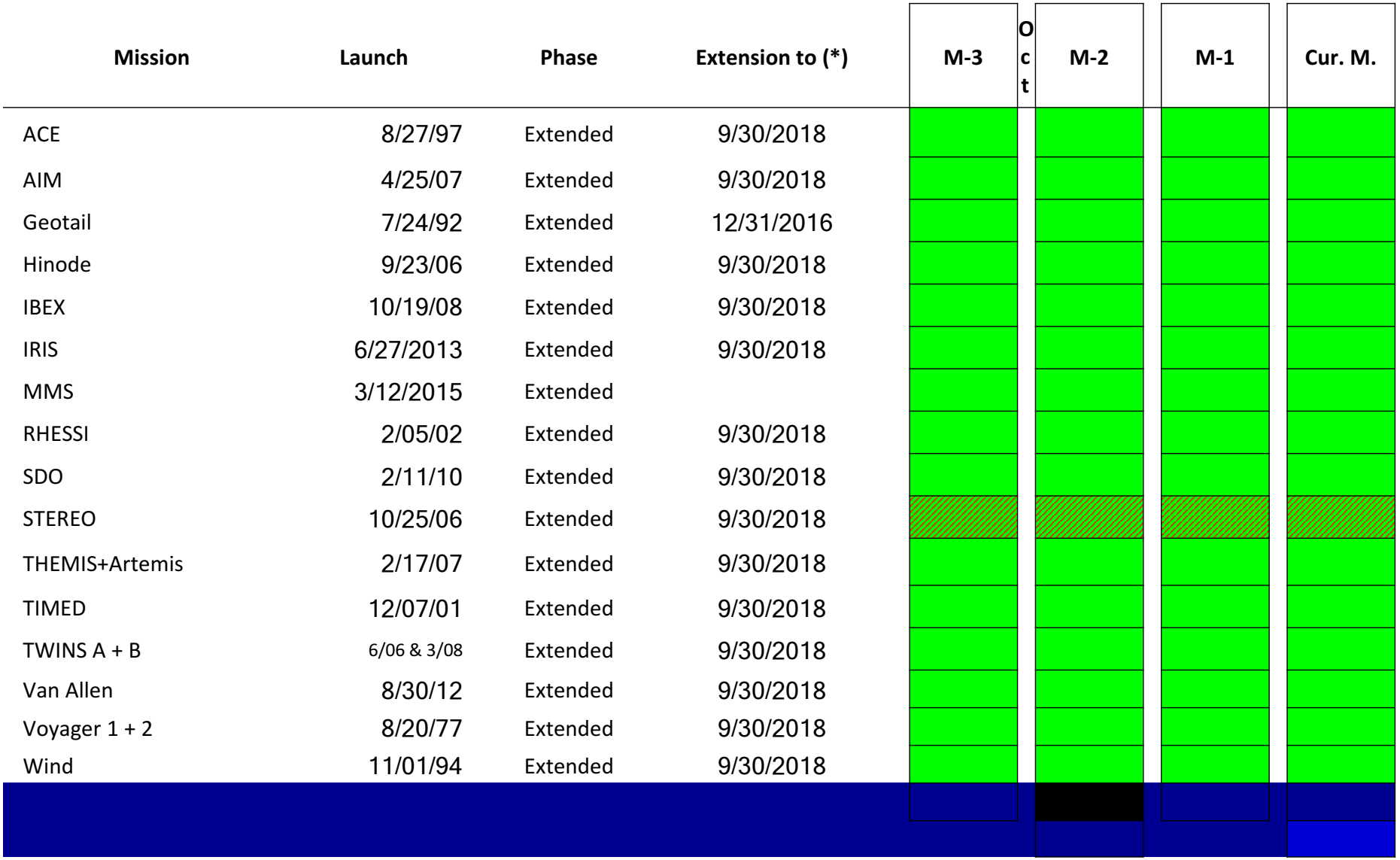
Proposed Heliophysics Operational Mission Suite

Mission	Launch	Phase	Extension to (*)
ACE	8/27/97	Extended	9/30/2018
AIM	4/25/07	Extended	9/30/2018
Geotail	7/24/92	Extended	12/31/2016
Hinode	9/23/06	Extended	9/30/2018
IBEX	10/19/08	Extended	9/30/2018
IRIS	6/27/2013	Extended	9/30/2018
MMS	3/12/2015	Extended	
RHESSI	2/05/02	Extended	9/30/2018
SDO	2/11/10	Extended	9/30/2018
STEREO	10/25/06	Extended	9/30/2018
THEMIS+Artemis	2/17/07	Extended	9/30/2018
TIMED	12/07/01	Extended	9/30/2018
TWINS A + B	6/06 & 3/08	Extended	9/30/2018
Van Allen	8/30/12	Extended	9/30/2018
Voyager 1 + 2	8/20/77	Extended	9/30/2018
Wind	11/01/94	Extended	9/30/2018



(*) Extended mission end dates subject to upcoming Senior Reviews.

(+) Terminates at date.

Mission proceeding to meet science requirements

Area of concern - possible reduction in capability

Significant problem - possible or probable loss of mission

Heliophysics Missions Invited to the SR 2017

The objectives of the 2017 Heliophysics Senior Review for MO&DA were to assess the science merits and performance of the 16 missions invited to participate in the review. These missions are (in alphabetical order): **ACE, AIM, Geotail, Hinode, IBEX, IRIS, MMS, RHESSI, SDO, STEREO, THEMIS, TIMED, TWINS, Van Allen Probes, Voyager, and Wind.**

The Joint NASA/ESA **SoHO** mission was not invited to the 2017 Senior Review on the basis of the recommendation of both the 2010 and 2013 panels. In the case of SoHO, the mission and its NASA portion were found to be of limited intrinsic scientific value as a standalone mission, but the mission is an essential component of the Heliophysics System Observatory. SoHO has the only white light coronagraph at the Sun-Earth L1 Lagrange point, and so provides required context for space weather observations for NASA's projects and missions, as well as meeting National needs by providing data to other federal agencies. To insure oversight of SoHO in lieu of the Senior Review, a programmatic review will be done in conjunction with the annual PPBE process.

The Senior Review Paradigm

NASA's Science Mission Directorate (SMD) periodically conducts *comparative* reviews of Mission Operations and Data Analysis (MO&DA) programs to maximize the scientific return from these programs within finite resources. The acronym MO&DA encompasses operating missions, data analysis from current and past missions, and supporting science data processing and archive centers.

NASA uses the findings from these *comparative* reviews to define an implementation strategy and give programmatic direction and budgetary guidelines to the missions and projects concerned for the next 5 fiscal years (matching the Federal government's budget planning cycle). Additionally, from the *National Aeronautics and Space Administration Transition Authorization Act of 2017 (PL 115-10; Sec 513 (a) 1)):*

- *"...The Administrator shall carry out triennial reviews within each of the Science divisions to assess the cost and benefits of extending the date of the termination of data collection for those missions that exceed their planned missions' lifetime."*

Mission Extension Paradigm

Under this call, the budgets for mission extensions beyond the prime mission lifetime (in NPR 7120.5 parlance, Prime Phase E) will support, at a lower level, the activities required to maintain operations and continue to produce meaningful and significant science data, which is adequately described and accessible to the non-specialist researcher.

- When a mission has completed its **Prime Phase E**, NASA will accept higher operational risk, lower data collection efficiency, and instrument/mission degradation due to aging.

- It is assumed that, along with this greater risk, the cost to implement will be at a lower level than that of Prime Phase E.

As a corollary to the above direction, priority will be given to maintaining an understanding of the instrument performance, monitoring progress toward accomplishing the objectives of science observations, and to involving the science community in formulating the mission observing program to make the best scientific use of NASA's missions.

Charge to Panel

Venue: Hyatt Place, 400 E St SW. October 30 to November 3, 2017

From the proposals submitted by the projects, the panel was charged to make their assessments in four broad areas.

- In the context of the research objectives and focus areas described in the SMD Science Plan, rank the **scientific merits** of the expected returns from the projects reviewed during the period FY16 through FY20. The scientific merits include relevance to the research objectives and focus areas, scientific impact, and promise of future scientific impact, as well as contributing to the system science of heliophysics. It is understood that predicting the science productivity of a mission over such a long period is speculative, but missions are asked to assume the *status quo* operationally; hence, the need for *Prioritized Science Goals* (PSGs) in the proposal.

Charge to Panel

- Assess the **cost efficiency, data availability and usability, and the vitality** of the mission's science team as secondary evaluation criteria. Assess how the missions did in meeting their PSGs (where applicable).
- From the assessments above, **provide findings** on an implementation strategy for the MO&DA portfolio for FY18 through FY22, based on the Extension Paradigm (described elsewhere), which could be one of the following:
  - *Continuation of projects as currently baselined;*
  - *Continuation of projects with either enhancements or reductions to the current baseline;*
  - *Project termination.*
- Provide on **overall assessment of the strength** and ability of the MO&DA portfolio to meet the expectations of the HSO from FY18 through FY22, as represented in the 2014 SMD Science Plan and in the context of the recent Heliophysics decadal survey.

Senior Review Proposal Content

The SMD Science Plan incorporates the Heliophysics System Observatory as integral element of strategic plan of the Heliophysics science area. The 2014 Roadmap provided a series of open science questions that could be addressed by the continuation of specific assets of the System Observatory. The proposals need to discuss each mission's potential for elucidating such answers during FY18 to FY22 in each of these areas:

- Relevance to the stated Heliophysics research objectives and focus areas
- Impact of scientific results as evidenced by citations, press releases, etc.
- Spacecraft and instrument health
- Productivity and vitality of the science team (e.g., publishable research, training younger scientists, etc.)
- Promise of future impact and productivity (due to uniqueness of orbit and location, solar cycle phase, etc.)
- and broad accessibility and usability of the data.

Senior Review Proposal Content

The proposal shall contain a science section, a technical/budget section, a mandatory legacy science data archiving and migration plan to a final archive, a list of acronyms, and a budget supplied on a standard spreadsheet (provided). The scientific, the technical/budget, and legacy mission archive plan should be no more than 35 pages of writing and graphics.

Note that under this Call for Proposals, HQ asked for consequences of in-guide budgets.

Missions were to identify appropriate and reasonable over-guides.

Heliophysics Panel Deliberations

This presentation summarizes the content of the 2017 Heliophysics Senior Review Report that is being finalized. The recommendations and findings formulated by the panel help to prioritize the budget profile for the next 3 years, and set guidelines for the 5-year budget horizon (out to FY22).

In addition to recommendations and findings, the panel was charged to come up with two prioritized lists: 1) science value of the individual mission; and 2) contribution to the System Observatory as a whole.

- This latter list allows NASA to assess a mission's contribution to the ensemble of our observations and hence our understanding of the system science of Heliophysics.

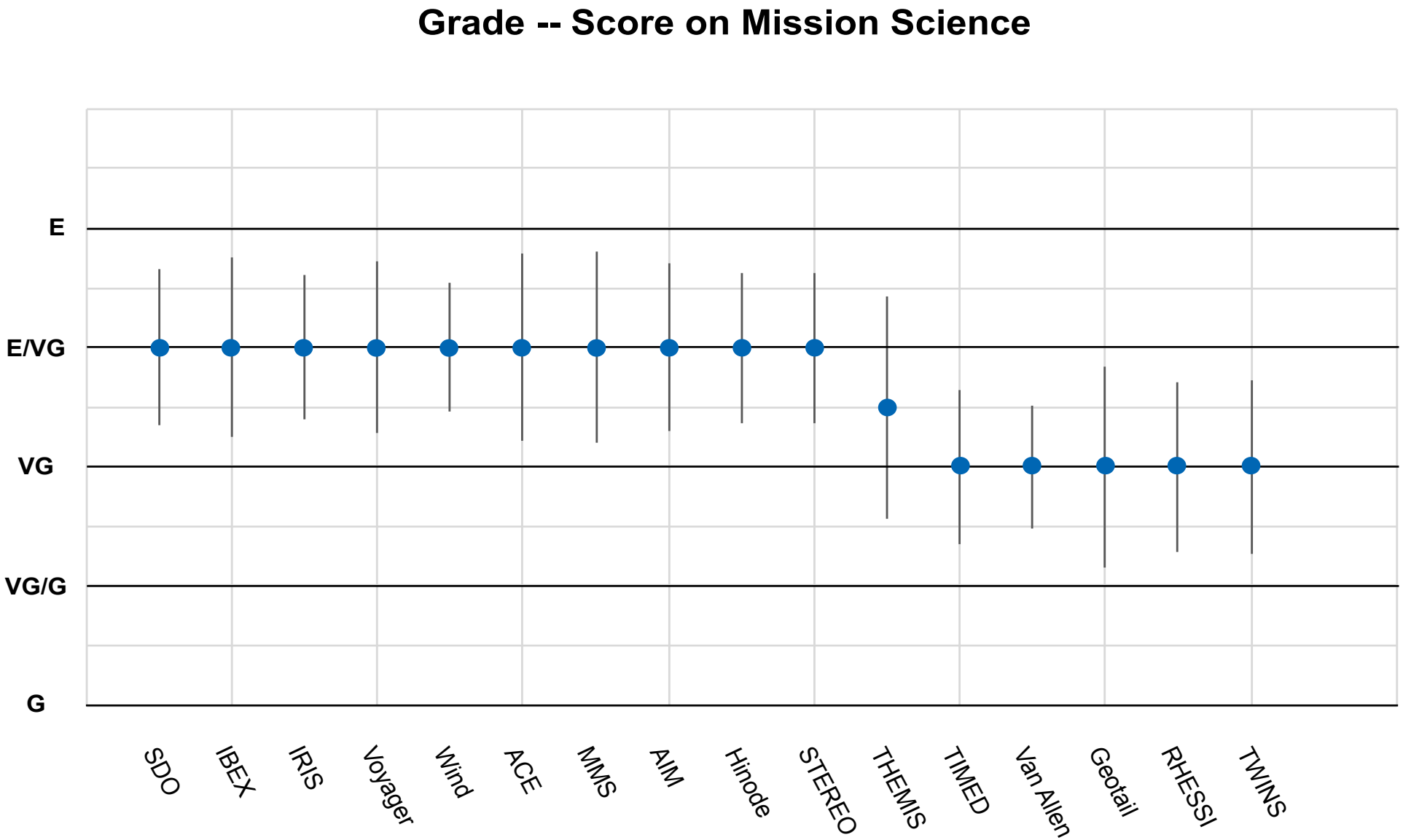
The Chair was James Spann of NASA/MSFC.

The full report will be published as a PDF on science.nasa.gov after this briefing and finalization of the report, as will the Heliophysics Division's disposition of the findings.

Mission Grades and Ranking

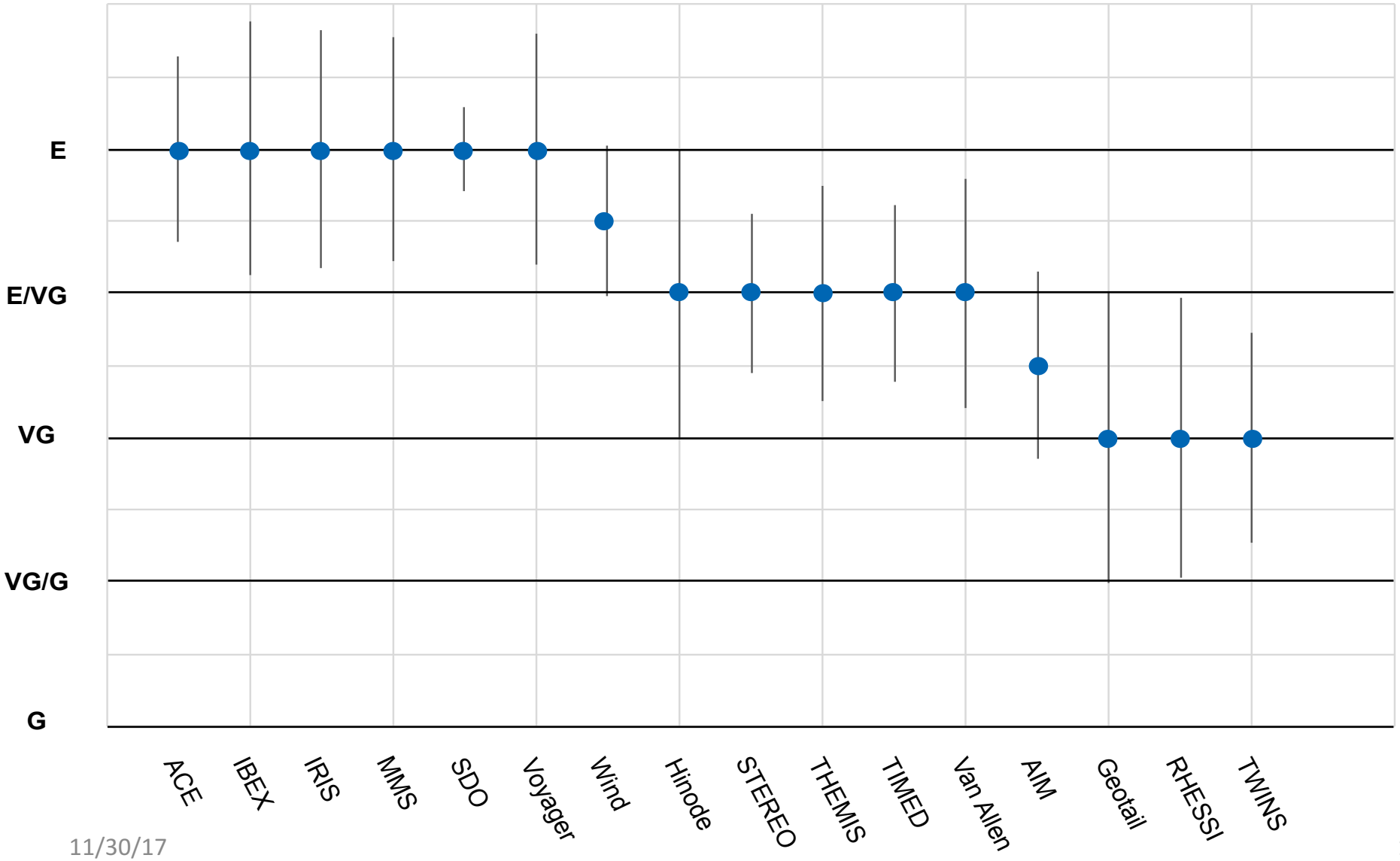
- Each mission was assessed and graded from two perspectives: (1) on its scientific merit, relevance and responsiveness to NASA Heliophysics research objectives, and technical capability & cost reasonableness, and (2) on its impact to the coupled Heliophysics System Observatory science. The panel considered criteria A, B, C for first perspective. The grades for each are provided in the plots below. The plots show the median and the standard deviation of the votes. The number of votes ranged from 14 to 11 depending on the number conflicted panelists.

Mission Science Grades and Standard Deviation



Mission HSO Grades and Standard Deviation

Grade -- Score on HSO Contribution



Senior Review Recommendations (General)

Title	Recommendation	Context
Extend Prime Mission Phase	Assess extension of prime mission phase up to 5 years far large strategic missions, and 3 years for PI lead missions	The large strategic missions are going into extended phase with only a portion of their mission value and science output realized. Frequently their major prime mission goals are still being actively investigated at the time they enter into the extended phase, but now expected to operate with reduced resources. This causes the mission to not fully achieve its science potential and to struggle with resource reductions at the very time when it is reaching its peak performance and science output. The same is true for the PI lead missions, but to a lesser extent. This recommendation will result in substantially more science return at a cost that is likely less than would be incurred if the resources are doled out piecemeal after prime mission phase. Consideration of mission reliability costs for a prolonged prime phase should be considered to ensure that the benefit of increased science is realized.

Senior Review Recommendations (General)

Title	Recommendation	Context
Heliophysics System Observatory Mission Campaign	Create an opportunity for the community to propose a coordinated HSO observing campaign	Several individual missions proposed adjustments to their mission operations in order to better coordinate with other missions to effectively address a science question. Currently, a few missions coordinate observations, but this is only made possible by members of those missions. The community at large does not have the opportunity to coordinate campaigns, and undoubtedly innovative and important ideas go unfulfilled. There is no opportunity for the community to propose a coordinated campaign-mode science study in which specific missions in the HSO would operate in a given fashion to maximize science return. Creating such an opportunity to propose an HSO Campaign Team to address system level science would be justified by compelling science. It would be coordinated with and employ appropriate HSO missions. Appropriate resources would be made available for mission operations for each participating mission, and for data analysis for the HSO Campaign Team.

Senior Review Recommendations (General)

Title	Recommendation	Context
Mission Archive	Establish a team to prepare the Mission Archive presentation	For the past several Senior Reviews, a single individual has expertly prepared the Mission Archive presentation. While this has been accomplished in a remarkable way, it would be appropriate to have a team compile the content and presentation materials to ensure that archival efforts are evaluated from a broader perspective, that experience with the full range of data sets and types of data can be brought to bare by the team, and that diverse inputs needed for future directions are included,.
Data Compatibility	Establish a community-wide, cross-agency workshop to assess options for broad solar and space physics data retrieval	Data access and usability of HSO data was an issue for several missions being reviewed. A common theme that emerged during the assessment was the lack of data compatibility, and a cross-referenced and coordinated retrieval system for solar and space physics data. There are pockets of data that are cross-referenced and easily retrievable, but these data are focused. There does not exist an overarching data retrieval system for Heliophysics data. This recommendation would enable an assessment of whether such a system could be developed and the level of resources required for such an investment.

Senior Review Recommendations (General)

Title	Recommendation	Context
Mission Data Archival Requirement	Establish a requirement for future Heliophysics AO's that the archived data will be the responsibility of NASA and the responsible mission institution (PI or NASA Center) is required to provide archival mission data in a timely fashion in an appropriate format.	During the review of the missions and associated archival data, it became apparent that there is no set process to ensure that the data is properly archived and made accessible. This is particularly true of longrunning missions and those missions that are near their end-of-life. Some mission data is in jeopardy of being lost because host institutions are not willing to continue to be responsible for data distribution and archival.
In-guide and Over-guide Science Output	Require in the next Senior Review call for proposals, a table that articulates (1) what science will be accomplished with the in-guide budget, and (2) what science will be accomplished with a proposed over-guide budget.	Proposed efforts for the senior review frequently elaborate on the great science that will be conducted for the over-guide budget, and have little to no discussion on what will be done if only the in-guide budget is awarded. This leaves the review panel with very little information on how to assess and rank each proposal, and what to recommend to the Heliophysics Division. This could be done with a table and associated text discussion in the body of the proposal

Finding on Heliophysics Missions of Least Impact

The panel conducted an assessment of the value of individual missions to the Heliophysics System Observatory and ranked them as shown in Charts 12 and 13 . This finding identifies those missions, when considered from a heliophysics system-science perspective, that would have the least impact should future data from those missions were not available. These are RHESSI, Wind, TWINS, and TIMED. Note that these are not necessarily the lowest ranked missions for science or HSO impact. The panel was very intentional and deliberate in assessing the overall system science impact for the HSO, which is distinct from individual mission impact. Consideration by the panel of various aspects was taken into account, such as data usefulness and availability, end-of-mission outlook, and uniqueness of system contribution in the HSO.

Finding on Heliophysics Missions of Least Impact

The summary rationale for identifying this set of missions is:

- The RHESSI mission provides unique information on hard x-rays of solar events and is complimentary to other solar imaging missions. However, relative to other solar observing missions, its contribution is very focused. Furthermore the instrument is near its end-of-life with thermal issues that are trending in a worsening direction.
- The Wind mission provides complimentary to and overlapping observations with ACE and NOAA's Deep Space Climate Observatory (DSCOVR) mission, but is the not cited as often as source of solar wind data as ACE in system level science investigations and space weather studies.

Finding on Heliophysics Missions of Least Impact

The summary rationale for identifying this set of missions is:

- The TWINS mission produces long-term observations of the global magnetosphere, however the data is not used as widely as other magnetospheric missions, and it is difficult for the community to access and use the data without significant involvement of the TWINS science team. Furthermore, one of the two instruments suffered an anomaly over a year ago and has not provided data since. The failure is still under investigation.
- TIMED continues to produce valuable data of the ITM system. However, once the GOLD and ICON are launched in 2018, much of the unique value of the TIMED observations will go away.

Mission Findings/Recommendations

ACE and Hinode

None

AIM

Finding: Although the AIM mission is providing quality data products and documentation, it would be beneficial for these be served directly from the SPDF Final Archive.

Geotail

Finding: It would be beneficial for the Geotail team to present a plan to NASA HQ that would enable US investigators to engage more heavily in the scientific potential of the HSO.

IBEX

Finding: The panel finds that most recent skymaps are not easily accessed. The IBEX should ensure that skymaps are easily accessed and useable by the science community.

Mission Findings/Recommendations

IRIS

Finding: The Panel is aware that the majority of the IRIS over-guide request is based on the uncertainty in the continued support of ESA.

MMS

Recommendation 1: That the MMS mission work towards a lower operating cost scenario. As MMS moves through extended mission phases, and new HSO missions come on line, current requested costing levels for MMS operations will increasingly become less sustainable.

Recommendation 2: As MMS moves more deeply into extended mission operations, a new operating paradigm employing more autonomous operations should be considered. The MMS team is encouraged to begin now to implement strategies that will move MMS operations in that direction sooner rather than later in order to smooth the transition.

RHESSI

Recommendation: Based on the mission evaluation the panel recommends to (1) develop an end-of-life plan and present to HQ in 2019 prior to the next Senior Review call, and (2) begin archiving data now in anticipation of end-of-life.

Mission Findings/Recommendations

SDO

Finding: SDO is a valuable asset to the Heliophysics System Observatory. It provides a breadth of observational information that will enable cutting-edge investigations; the data are presently used by many NASA Heliophysics missions, as well as for near-real-time space-weather forecasting by other US and international agencies.

Recommendation 1: It is recommended that for the next Senior Review the team provide a separate number for publications that derive scientific discoveries principally from SDO data, as opposed to papers in which SDO is referenced in general or as context. While the total number of annual publications associated with SDO project is impressive, the Panel feels that in order to better evaluate the impact of SDO data on research in Heliophysics that this recommendation should be implemented.

Recommendation 2: The Panel recommends that an assessment of the mission requirements, including operations and data timeliness, be made with the intent of reducing mission costs. The panel expresses a concern regarding stated negative impacts of flat funding profile on spacecraft operations, data acquisition, data calibration and data processing described in the proposal under in-guide funding levels. This recommendation if implemented will alleviate the impact of the funding profile.

Mission Findings/Recommendations

STEREO

Finding: Many STEREO websites do not spell out acronyms, making it sometimes difficult to get the big picture. The link to the EUVI page does not work:

https://stereo.gsfc.nasa.gov/instruments/instruments.shtml

THEMIS

Finding: the panel recognizes that the full potential of HSO science as proposed by THEMIS will likely not be possible if in-guide budget is awarded.

TIMED

Finding 1: The overall assessment of the TIMED mission is positive. The mission will continue to provide valuable ITM data and will support the upcoming GOLD and ICON missions.

Finding 2: There are still issues with the TIMED NetCDF formats and with the final archive strategy. Ongoing discussions with SPDF on these topics should be continued.

Recommendation: The panel recommends that the TIMED mission team calibrate the new TIDI Thermospheric Wind product with ground-based wind measurements.

Mission Findings/Recommendations

TWINS

Recommendation: It is recommended that images be posted online for the community two weeks after completion. The most recent image found online by the panel was January 2015. As an example, if images take a month to process and 6 months of data are required for each, then each image should be available online to the community within 7.5 months.

Van Allen Probes

Recommendation: The panel recommends that an assessment of the budget profile be conducted to reconcile the planned and executed 2015 Senior Review budget. If needed, this should be followed by a reformulation of the 2018-2019 budget profile that enables mission operations at a level consistent with the current operational level.

Mission Findings/Recommendations

Voyager

Recommendation 1: Succession Plan. Given the state of the mission, the panel recommends that a personnel succession plan be developed and presented to HQ and be implemented in near term to ensure that appropriate early career personnel will be trained. This training should occur not only on the science side but on the engineering side, given that the spacecraft currently experience some engineering new challenges (e.g., decreasing power and thermal margins). The Voyager mission is an ageing yet invaluable space research asset, taking *in-situ* data in a region that likely will not be visited for decades to come. The panel is aware of the fragility of the data (some of the instruments operate at the limit of sensitivity) requiring hands-on handling by the PI's and co-I's, and is aware of the ageing workforce on this mission. The panel was surprised to find that for such an important and iconic mission, there was no succession plan.

Recommendation 2: Timeliness, Availability and Archival of Data. A data processing and archival plan should be developed and implemented for all the instruments. The panel recognizes that the magnetometer data access and timeliness is being addressed. However, attention should be continued on the magnetometer data and the other data streams. The Voyager data processing and archive require extra care given its legacy approach to managing the data and the ageing instrument/spacecraft coupled with weak signal/noise ratio.

Mission Findings/Recommendations

The above mentioned Voyager succession plan and archive plan should have the expressed and intentional focus on reduced cost and improved timeliness and availability of the data. The Voyager team should work closely with NASA HQ to ensure that they possess the necessary support (cost associated) to perform such task. Both of these plans should be presented to NASA HQ for approval in the Spring 2018.

Finding 1: While the panel commends the Voyager team for addressing last Senior Review concerns and making the magnetic data available in a timely fashion, one area for improvement of Voyager data handling is the provision of more background corrected data sets from the LECP instruments. Timeliness of data availability and independent insight and validation of data leaves much to be desired.

Finding 2: Voyager relies heavily on interpretation by global models. These global models require the use of supercomputing facilities such as Pleiades. The increased need for supercomputing facilities puts pressure on their time allocation usage. Use of supercomputing facilities should be fully supported.

Finding 3: We note that Voyager and IBEX are highly complementary missions exploring the outer edges of the heliosphere. Voyager 1 and 2 are taking in-situ data in two distinct spatial locations while IBEX is taking global Energetic Neutral Atoms maps of the heliosphere. The panel encourages mutual synergetic activities such as joint conferences and collaborations.

Mission Findings/Recommendations

Wind

Finding: Wind continues to provide unique, robust, and high-resolution solar wind measurements, important for new science as well as support of other missions in the Heliophysics Observatory. It is unparalleled for low energy particle and radio wave observations of the solar wind by near-Earth spacecraft. Further, it serves as the 1 AU reference for Solar Probe Plus and Solar Orbiter and provides cross-calibration for the DSCOVR and ACE missions. Wind's continues high scientific productivity and high use of its data by other researchers (almost 2 million data access requests in two years).

Mission In-Guide FY18 Budgets

Mission	Launch	FY18 In-guide	FY18 Request	Delta
ACE	1997	3.000	3.000	0.000
AIM	2007	2.982	3.302	-0.320
Geotail	1992	0.222	0.531	-0.309
Hinode	2006	6.835	6.835	0.000
IBEX	2008	3.400	3.400	0.000
IRIS	2013	6.834	6.834	0.000
MMS	2015	14.555	25.836	-11.281
RHESSI	2002	1.855	1.855	0.000
SDO	2010	12.000	12.908	-0.908
STEREO	2006	8.250	7.800	0.450
THEMIS	2007	5.400	5.400	0.000
TIMED	2001	2.551	2.551	0.000
TWINS	2008	0.604	0.604	0.000
Van Allen	2012	13.000	17.584	-4.584
Voyager	1977	5.587	5.884	-0.297
Wind	1994	2.168	2.168	0.000
Total:		89.243	106.492	-17.249

Conclusion

A executable set of missions can be maintained in the current near-term budget environment. **However, the ability of a number of the individual missions to maintain their current productivity is questionable if inflation is not allowed for in the post-FY18 timeframe.**

The next Senior Review for operating missions is anticipated to be in the Spring 2020 timeframe.