Solar Probe Plus

A NASA Mission to Touch the Sun

Integrated Science Investigation of the Sun Energetic Particles

Preliminary Design Review

05 – 06 NOV 2013

Risk Status

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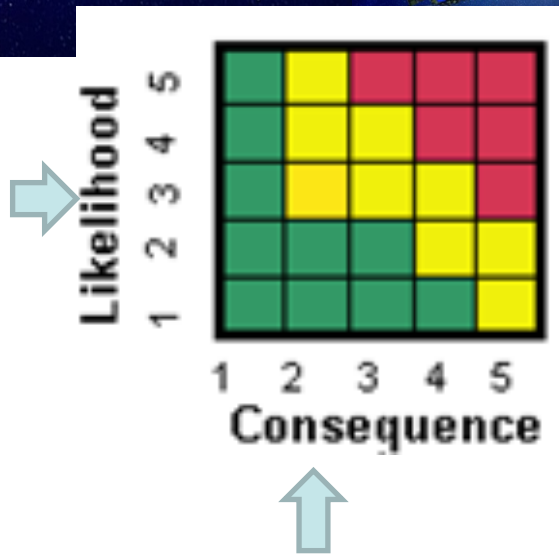
Outline

- Risk Analysis Score Card
- Likelihood/Consequence implementation for ISIS
- Risk Summary
- Top Risks
- Risk Description
  - Autonomy Concerns
  - Technical Risks
  - Risks with Likelihood and Consequence < 2
  - Mitigated Concerns
  - New Risks

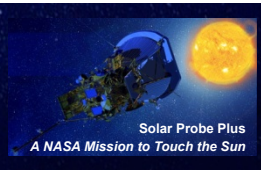
Risk Analysis Score Card

Likelihood Bins	Safety (likelihood of safety event occurrences)	Technical (Estimated likelihood of not meeting mission technical performance requirements)	Cost/schedule (Estimated likelihood of not meeting allocated Cost/ Schedule requirements or margin)
5 Very High	($P_s > 10^{-1}$)	($P_T > 50\%$)	($P_{CS} > 75\%$)
4 High	($10^{-2} < P_s \leq 10^{-1}$)	($25\% < P_T \leq 50\%$)	($50\% < P_{CS} \leq 75\%$)
3 Moderate	($10^{-3} < P_s \leq 10^{-2}$)	($15\% < P_T \leq 25\%$)	($25\% < P_{CS} \leq 50\%$)
2 Low	($10^{-6} < P_s \leq 10^{-3}$)	($2\% < P_T \leq 15\%$)	($10\% < P_{CS} \leq 25\%$)
1 Very Low	($P_s \leq 10^{-6}$)	($0.1\% < P_T \leq 2\%$)	($P_{CS} \leq 10\%$)



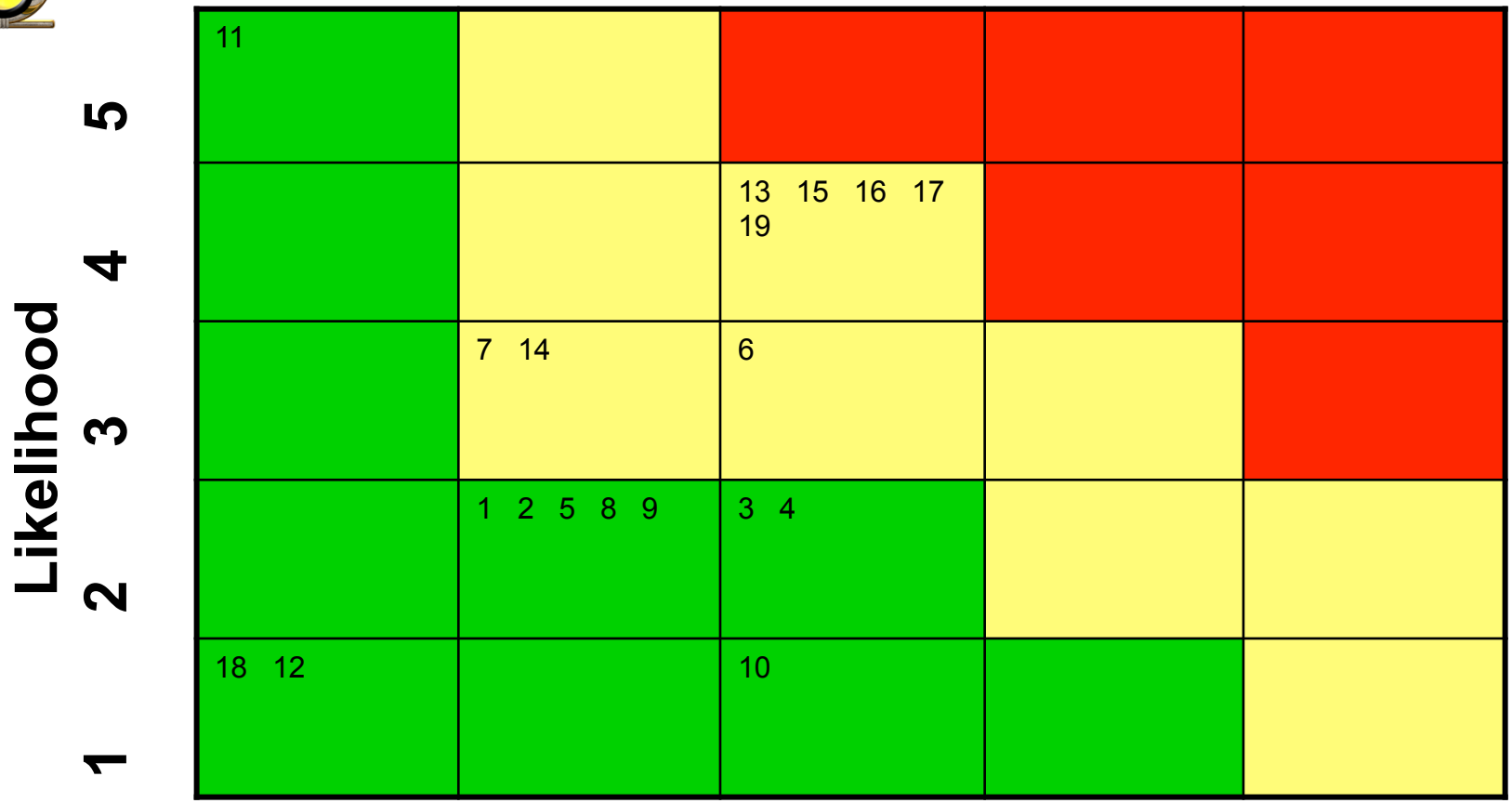
LEVEL	Minimal (1)	Minor (2)	Medium (3)	Major (4)	Very High (5)
Safety	Negligible safety impact	Minor injury with no lost work time	Injury with lost work time	Severe injury	Death or permanent disabling injury
Technical	Negligible technical impact	Decrease in instrument capability/margin. But all instrument requirements met, or need for requirement definition or design/implementation workaround	Major loss of instrument capability	Loss of Instrument (EPI-Hi or EPI-Lo)	Loss of one or more Level-1 science requirements
Cost	ISIS Project cost overrun of less than 1% of allocated	ISIS Project cost overrun between 1% to 3% of allocated	ISIS Project cost overrun between 3% to 10% of allocated	ISIS Project cost overrun between 10% to 20% of allocated	ISIS Project cost overrun of greater than 20% of allocated
Schedule	Negligible schedule slip	Schedule slip not on critical path	Schedule slip affecting critical path but not launch or post-launch critical event	Schedule slip of 1 to 3 months	Schedule slip of greater than 3 months

Likelihood/Consequence for SPP Plans/Risks

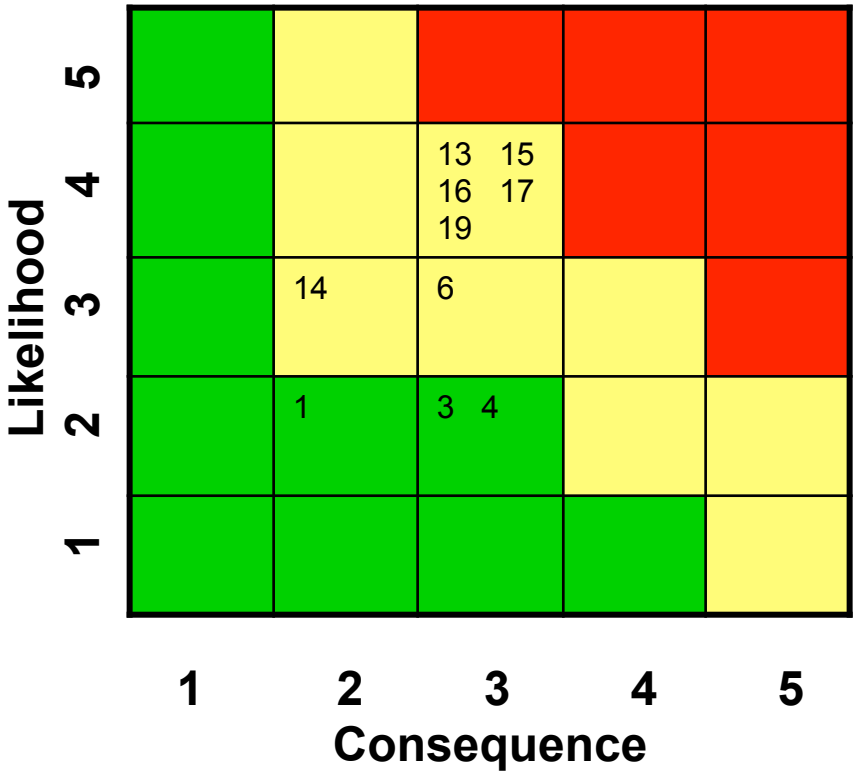


- SPP Plans:
  - Likelihood: The likelihood the project will implement the plan x the likelihood the plan will affect ISIS
  - Consequence: If the plan were to be realized, how much would it impact ISIS.
- Risks:
  - Likelihood: The likelihood the risk will affect ISIS
  - Consequence: If the risk were to be realized, how much would it impact ISIS.
- A note on Plans Mitigation Strategy
  - Every SPP Plan can be accomplished by adding resources (mass/power, cost, schedule). These are quantified in the threats/liens spreadsheet, not as mitigations in the risks.

Risk Summary



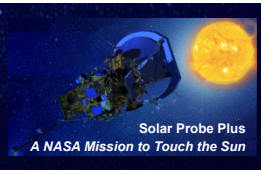
Progression of Top Risks



Criticality	L x C Trend	Approach
High	⇩ Decreasing (Improving)	M - Mitigate
Med	⇧ Increasing (Worsening)	W - Watch
Low	⇨ Unchanged	A - Accept
	□ New Since Last Period	R - Research

Rank	Trend	Risk ID	Approach	Risk Title
1	□	13	R	SPP PLANS: ISIS Time Tagged Commands
2	□	15	R	SPP PLANS: ISIS Increased Ground Software Demands Due to Autonomy
3	□	16	R	SPP PLANS: ISIS Increased Instrument FSW Demands Due to Autonomy
4	□	17	R	SPP PLANS: Configuring ISIS Based on Solar Distance
5	□	19	R	SPP PLANS: ISIS Increased Autonomy
6	⇨	6	R	RISK: ISIS Vibration Levels
8	⇩	3	R	RISK: EPI-Hi LET Thin Windows and Dust Impact Susceptibility
9	⇩	4	R	RISK: EPI-Lo Dust Impact Susceptibility
10	⇩	1	R	RISK: EPI-Hi Thin Detector Availability
7	⇨	14	R	RISK: ISIS Shock Testing

Autonomy Risks (Top 5 ISIS Risks)



- As a result of the lack of heritage in the ISIS predecessor instruments implement instrument level heritage, ISIS has elevated several specific areas in which more work will be required:
  - Implementation of Time Tagged Commands
  - Ground software autonomy handling demands
  - Flight software autonomy handling demands
  - The ability to configure the instrument based on solar distance
  - General concern about loss of science data due to autonomous operations
- All of these issues will be high priority for clarification during phase C
- Planned mitigations include:
  - Analyzing scenarios and brain-storming operation conditions
  - Working with autonomy experts to explore all conditions
  - Updating the design concept to accommodate instrument autonomy implementation
  - Peer reviewing our updates with autonomy experts
  - Test potential autonomy conditions thoroughly
- This accounts for our top 5 risks as a Project
  - All items are Likelihood: 4, Consequence: 3
- This is a testament to the experience of the instrument teams, the firm grasp on technical challenges to the instruments, and the firm grounding in heritage instruments

Risk: ISIS Vibration Levels

Description ID: 6	**Given that SPP random vibration is a challenging requirement; there is a chance that instruments will not be capable of meeting the requirements,**
Consequence	which will result in a late re-design of the instruments.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 3
Status Message	**Waiting on Project for more conclusive Coupled Loads Analysis results; also looking for sine vibe environment to be better defined by Project.**
Mitigation Plan 1 Status: Expired Trigger Date: 02 Apr 2012	Title: Deliver FEM Model to Project Description: Develop and deliver an FEM model to Project to enable Project analysis of vibration levels and iterate vibration requirements.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 May 2013	Title: Mechanical Design, Analysis, and Testing Description: Prioritize mechanical design and analysis critical to ensuring the sensors survive vibration testing. Early Phase B vibration testing with the bracket and instrument mass models will validate the designs early enough to make changes if necessary.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 May 2014	Title: Increase Structure Description: Increase structure of instruments to meet vibration levels.

Update mitigations/dates

RISK: EPI-Hi LET Thin Windows and Dust Impact Susceptibility

Description ID: 3	**Given that thin windows are fragile and the mission dust environment could be harsher than initially expected; there is a risk that dust impacts could result in damage to the windows during flight,**
Consequence	which will result in a compromise in the resolution of the EPI-Hi telescopes.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 2
Status Message	**EPI-Hi windows survived Heidelberg dust testing and showed stacked window configuration is effective at mitigating dust penetration to detectors. Even holes produced by penetrating particles result in very limited access of UV light to detectors.**
Mitigation Plan 1 Status: Completed Trigger Date: 01 May 2013	Title: Perform Dust Testing Description: The integrity of the windows in a stacked configuration will be tested in a dust environment to determine the efficacy of the windows in protecting the detectors from dust and maintaining structural integrity to block UV light.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Nov 2013	Title: Baffling for Dust Protection Description: If risk of catastrophic damage due to dust impacts does not appear acceptably low, EPI-Hi could increase the baffle size to limit the affected angle of dust on the detectors. Trade: mass is used to buy down damage risk.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2014	Title: Significant Thickness Increase Description: If risk of catastrophic damage due to dust impacts does not appear acceptably low, EPI-Hi could use significantly thicker window for LET2 (single ended) telescope. Trade: measurement quality is reduced to buy down catastrophic damage risk.

RISK: EPI-Lo Dust Impact Susceptibility

Description ID: 4	**Given that foils, SSDs, and MCPs are fragile and the mission dust environment could be harsher than initially expected; there is a risk that dust impacts could result in damage to the foils, SSDs, or MCPs during flight,**
Consequence	which will result in a compromise of the FOV of the EPI-Lo instrument.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 2
Status Message	**EPI-Lo collimators limit FOV of dust particles to the foils. A second foil has been added to reduce likelihood of penetrating particles. UTEP environmental model completed with angular dependence and extension to smaller dust sizes. Foils received, foil sample holders being fabricated for dust tests at dust beam in Colorado, expected in November. More analysis on background due to dust-produced holes in foils (e.g., light, solar wind electrons).**
Mitigation Plan 1 Status: In Process Trigger Date: 01 Apr 2012	Title: Improved Analysis Description: Analysis will determine the expected rate of impact and damage, and if necessary, an outer shield can be added and additional design effort will ensure the instrument is fault tolerant to impacts on an individual wedge.
Mitigation Plan 2 Status: In Process Trigger Date: 01 Nov 2013	Title: Double Foils Description: Double foils with half the original thickness each could be used behind the collimators to act as a whipple shield to avoid detector damage due to dust. Trade: complexity in foil design is increased to buy down susceptibility to dust damage.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2014	Title: Increase Structure Description: Possible mass and/or power increase to design the instrument to be more fault tolerant.

Risk: ISIS Shock Testing

Description ID: 14	**Given that the project plans to shock test the SPP instruments and no shock testing has ever been performed on any of the ISIS heritage instruments, there is a chance that additional structural support will be required by ISIS to endure the [rigorous] qualification test environment without damage;**
Consequence	which will result in an increase in mass requirement.
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 3
Status Message	**This level, though reduced, is still very high if it is meant to be applied at the instrument base. ISIS requests levels at the instrument mounting deck. Shock level in excess of 1000 g's at (in this case, at high frequencies) the instrument location are of concern.**
Mitigation Plan 1 Status: In Progress Trigger Date: 27 May 2013	Title: Define Shock Environment Description: Work with project to determine the actual shock environment and work towards determining acceptable levels to which the shock test may be performed without significant design change. Trade: analysis is used to buy down the consequence of the risk.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2013	Title: Increase Structure Description: Increase the structure of the ISIS instrument to withstand the testing without concern for failure. Trade: mass is used to buy down the consequence of the risk.

RISK: EPI-Hi Thin Detector Availability

Description ID: 1	Given that improved detectors have to date not been produced reliably with adequate yield; there is a risk that the energy threshold of the detectors will be increased,
Consequence	which will result in a compromise in the resolution of the EPI-Hi telescopes.
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 2
Status Message	**Two manufacturers have successfully fabricated L0 and L1 detectors. Test records to date have revealed no concerns with either manufacturer.** **Accelerator and lab tests have shown the L1 detectors from both Micron and LBNL and L0 detectors from Micron perform as required for measurements of energetic heavy ions. These tests did not yet include any L0 detectors from LBNL.** **L0 detectors from LBNL are awaiting back-side ion implantation at LBNL. A thin detector (L0) in thermal-vacuum life test at GSFC has had stable leakage current over more than a week at 40C.** **Total doses tests of L1 detectors from both manufacturers have been carried out at JPL up to 1.1 Mrad with no observable degradation of detector performance. Additions radiation doses on these detectors are planned.**
Mitigation Plan 1 Status: Not Started Trigger Date: 01 Nov 2013	Title: Increase Detector Thickness Description: If thinnest detectors (10 micro-meter) were found to be too fragile to give an acceptable yield, would increase the thickness as appropriate and accept an increase in energy threshold.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2014	Title: Use STEREO Detectors Description: If neither development were to yield flight-quality detectors, would fall back to thicker detectors of conventional design (as on STEREO).

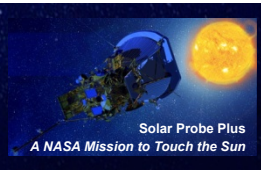
RISK: EPI-Lo Stray Light Impact Susceptibility

Description ID: 7	**Given that stray light exists in the SPP environment as both background coronal light and reflected glint from the spacecraft itself; there is a risk that stray light could enter through the optics and impact the detectors,**
Consequence	which will result in a biasing of the desired measurements from the instrument.
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 3
Status Message	**Updated FOV obstruction analysis conducted. More analysis on light attenuation in foils and impact on false start signal and on background solid state detector counts.**
Mitigation Plan 1 Status: In Process Trigger Date: 01 May 2013	Title: Environmental Stray-Light Analysis Description: Model background light environment, specifically light reflecting off of electrons and dust, across all wavelengths of light and accounting for variations in the direct spectrum of the sun as a blackbody.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Nov 2013	Title: Ray-Tracing Analysis Description: Model light reflected off of spacecraft and scattered back to instruments, specifically to instrument apertures, using ray tracing techniques.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2014	Title: Optics Baffling Description: Increase size of collimators and/or foil thickness above sensitive aperture areas on instrument to limit entrance of light and light impacting detectors. Possibly block off affected apertures.

RISK: EPI-Lo Wedge Technology Development

Description ID: 10	**Given that the as proposed EPI-Lo wedge design based on two sensor wedges per anode board has a long start delay line; there is a risk that the mass resolution performance may result in poor 3He/4He separation because of reduced timing performance.**
Consequence	which will result in the EPI-Lo design failing to meet the instrument species separation requirements at high energies (>1MeV) for high ratios (100:1 or 1000:1).
Overall Status: Accepted(Retired) Consequence: 3 Likelihood: 1	
Status Message	**TRL6 demonstration on quadrant wedge architecture has reduced risk likelihood. New CFDs are showing better performance. End-to-end testing on a full wedge has not yet occurred. We fully expect the new CFDs to perform better with the wedge. Upon successful testing, risk may be retired.**
Mitigation Plan 1 Status: In Progress Trigger Date: 20 Sep 2012	Title: Quadrant Design Description: The baseline plan is to use the 4 anode boards with 3 preamplifiers per board. Advantage is that this would require less resources (power/mass), but TOF measurement has not been adequately demonstrated.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Sep 2013	Title: Accept lower mass resolution Description: If the Quadrant design does not perform as expected, we can use the lower mass resolution, as long as the loss of performance does not affect the L1 requirements.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2013	Title: Octant Design Description: A backup plan is to use 8 separate anode boards with 3 preamplifiers per board. This option provides the cleanest measurement and separation of the ions, but adds power and mass.

Risks with Likelihood/Consequence < 2

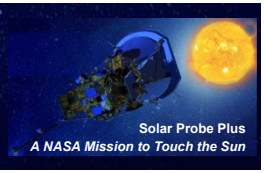


- **Given that** design and fabrication of a new Rad-Hard PHASIC could prove prohibitively challenging, **there is a risk** that existing STEREO chips would need to be used; **which will result** in an increase in mass for spot shielding.
  - Good linearity and low thermal noise of new Rad-Hard PHASIC prototypes means that the targeted improvement in dynamic range has been met.
- **Given that** design and fabrication of an EPI-Lo TOF ASIC could prove prohibitively challenging; **there is a risk** that EPI-Lo will be required to use existing TOFAs, **which will result** in an increase in mass and power resources required and a decrease in performance.
  - EPI-Lo has selected test house for final qualification and working with test house to develop tests and test procedures.
- **Given that** EPI-Lo has a max operating temperature of 30C and the Project expects EPI-Lo to operate at this temperature at Perihelion (prime science); **there is a risk** that operating at the max op temp will result in reduced resolution of the solid state detectors, **which will result** in a reduction in performance of the detector
  - EPI-Lo has received SSDs from Canberra, mounted them into Ultem carrier, and completed fabrication and assembly of the energy board. Testing has begun.
- **Given that** the spacecraft is planning to cant the spacecraft at 1AU in order to warm the radiators behind the heat shield; **there is a risk** that EPI-Hi windows will be facing the sun, **which could result** in thin windows covering LET telescopes to overheat and fail, possibly causing damage to the EPI-Hi detectors.
  - Goddard solar simulator will work for EPI-Hi solar illumination test. In Process: Determine correct thermal coating for aluminized polyimide windows and run thermal analysis.

SPP Plans that have been mitigated

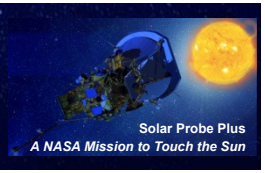
- **Given that** the SPP Project is considering updating EMI requirements for Deep Dielectric Discharge, **there is a chance** that the Project will require all instrument box walls to be 54 mils thick; **which would result** in a significant mass increase to the ISIS instrument.
  - Deep Dielectric Discharge requirements were released that did not require box wall thickness increases
- **Given that** the SPP Project is considering updating EMI requirements to exclude switching circuits in power supplies, **there is a chance** that portions of the ISIS LVPS will have to be redesigned; **which would result** in a significant power increase due to loss of efficiency in non-switching supplies and a schedule delay in the delivery of the EM LVPS to EPI-Hi and EPI-Lo.
  - LVPS design moved away from the use of POL
- **Given that** the project is requiring worst case circuit analysis to be performed on all circuits in the design, **there is a chance** that the ISIS team will be required to perform more analysis than was originally budgeted; **which will result** in increased cost and schedule delays.
  - Worst case analysis required on safety critical circuits only

Recent Risks (1 of 2)



- **Given that** the SPP spacecraft is dynamic and movement of spacecraft components can affect instrument parameters, such as FOV; **there is a chance** the spacecraft could move or change something on the spacecraft into the ISIS FOV, **which would result** in reduction in quality of science data and could compromise satisfaction of mission science requirements.
  - Consequence: 3 (technical), Likelihood: 2 (2% - 15%)
  - Mitigation #1: Carefully track configuration control with the spacecraft
  - Mitigation #2: Ensure all changes to position of spacecraft components are vetted with instrument teams
- **Given that** the SPP Spacecraft can not send commands to the instrument; **there is a chance** that the spacecraft will remove power from the instrument in the case of certain fault conditions, **which will result** in the loss of forensic data in volatile memory required to diagnose the problem.
  - Consequence: 3 (technical), Likelihood: 2 (2% - 15%)
  - Mitigation #1: Explore fault conditions
  - Mitigation #2: Enable low level commands to reboot instruments
- **Given that** EPI-Hi is very sensitive to noise in it's measurements and the power supply has switching low voltage conversion; **there is a chance** that noise from the power supply could increase the instrument noise floor, **which will** result in the reduction in quality of science data.
  - Consequence: 2 (technical), Likelihood: 2 (2% - 15%)
  - Mitigation #1: Emphasize noise reduction in power supply design
  - Mitigation #2: Plan rigorous testing between instrument and power supply

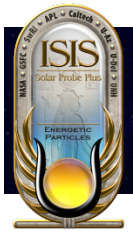
Recent Risks (2 of 2)



- **Given that** the demand for the calibration facility that EPI-Hi was planning to use has been updated and grown in popularity, **there is a chance** that scheduling the facility will be challenging, **which will result** in a slip in the date for full calibration or an increase in cost to go to a different facility.
  - Consequence: 1 (cost, schedule), Likelihood: 3 (15% - 25%)
  - Mitigation: Schedule facility well in advance
- **Given that** the cost for the calibration facility that EPI-Lo was planning to use has increased, **there is a chance** that scheduling the facility will be challenging, **which will result** in a slip in the date for full calibration or an increase in cost to go to a different facility.
  - Consequence: 1 (cost, schedule), Likelihood: 3 (15% - 25%)
  - Mitigation: Schedule facility well in advance
- **Given that** [SOMETHING], **there is a chance** that EPI-Lo will require two sets of carbon foils where one was budgeted, **which will result** in an increase in instrument cost.
  - Consequence: 1 (cost, schedule), Likelihood: 3 (15% - 25%)
  - Mitigation:
- **Given that** the allocated time for on-orbit instrument calibration is less than what was initially requested, **there is a chance** that EPI-Lo will have inadequate calibration time to collect statistics prior to the first encounter phase, **which will result** in a reduction in the usefulness of the first encounter data.
  - Consequence: 2 (technical), Likelihood: 2 (2% - 15%)
  - Mitigation: Work with Project to utilize other available time for calibration (week before combined calibration)

Summary

- ISIS risk process is effective and active
- ISIS has made tremendous progress in driving down and mitigating risks
- The ISIS instruments are technically sound, well understood, and corroboration with the spacecraft team is effective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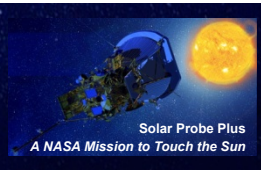
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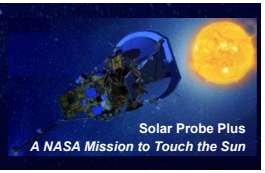
Backup

SPP PLANS: ISIS Time Tagged Commands

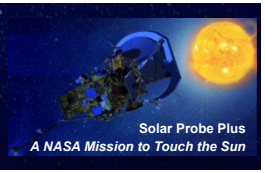
Description ID: 13	**Given that the SPP Project is considering devolving the implementation of Time Tagged Commands to the Instruments, there is a chance that implementing a feature that has historically been performed by the spacecraft would require extra technical, financial, and schedule resources and might also incur extra IV&V scrutiny on the part of all instruments on the SPP spacecraft;**
Consequence	which would result in duplication of effort, inconsistency of design, incompleteness of coordinating testing, and excessive expenditures of precious resources.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 4
Status Message	ISIS is working with the Project to better understand the impact instrument autonomy as implemented on SPP will have. ISIS must implement a command handler to enable execution of commands at specific. This function was implemented in the spacecraft on ISIS heritage instruments.
Mitigation Plan 1 Status: In Progress Trigger Date: 30 Jan 2013	Title: Analyze and Quantify Impact Description: Work with Project to see if this normally available service can still be provided to the Instruments
Mitigation Plan 2 Status: In Progress Trigger Date: 01 July 2013	Title: Implement Design Change Description: Design new software and add extra coding and testing time.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Jan 2014	Title: Test Description: Reduce risk of lack of well-coordinated and tested time-tagged commands by adding additional spacecraft and instrument ground testing resources.

SPP PLANS: ISIS Increased Ground Software Demands Due to Autonomy



Description ID: 15	**Given that the project is planning to operate the spacecraft autonomously during most mission phases with minimal S/C FSW oversight of the instruments, there is a chance that the instrument ground software will be required to perform more rigorous vetting and error checking and experience more oversight than was original planned;**
Consequence	which will result in an increase in ground software cost, complexity, and/or schedule slip.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 4
Status Message	ISIS is working with the Project to better understand the impact instrument autonomy as implemented on SPP will have. ISIS must implement various error checking that is above our experience on heritage instruments. This will affect both ground and flight software.
Mitigation Plan 1 Status: In Progress Trigger Date: 30 Jan 2013	Title: Project Assistance Description: Work closely with the project to understand and implement autonomy and help deter increased oversight. Aid from project will help instrument teams anticipate challenges with which they have not had to deal in the past.
Mitigation Plan 2 Status: In Progress Trigger Date: 01 July 2013	Title: Work with Autonomy Experts for Assistance Description: Hire expert consultants who have experience with spacecraft autonomous operations in order to aid design instrument autonomous operations to handle unforeseen conditions.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Jan 2014	Title: Autonomy Peer Reviews Description: Hold peer reviews on the instruments planned autonomy measures to vet instrument autonomous operations.

SPP PLANS: ISIS Increased Instrument FSW Demands Due to Autonomy



Description ID: 16	**Given that the project is planning to operate the spacecraft autonomously during most mission phases with minimal S/C FSW oversight of the instruments, there is a chance that the instrument FSW will be required to perform more rigorous vetting and error checking and experience more oversight than was original planned;**
Consequence	which will result in an increase in ground software cost, complexity, and/or schedule slip.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 4
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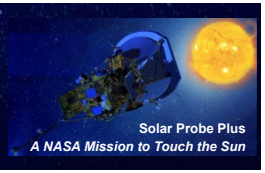
SPP PLANS: Configuring ISIS Based on Solar Distance



Description ID: 17	**Given that the project is planning to operate the spacecraft autonomously during most mission phases with uncoordinated instrument commanding and the instruments need to be able to configure themselves at power-up and to change their operational mode without spacecraft commanding, there is a chance that the instruments will have to increase their flight software capabilities or rely on a promising, but low-heritage concept of self-configuration based on solar distance;**
Consequence	which could result in increased flight software complexity, increased cost, and delayed the schedule.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 4
Status Message	ISIS is working with the Project to better understand the impact instrument autonomy as implemented on SPP will have.
Mitigation Plan 1 Status: In Progress Trigger Date: 27 May 2013	Title: Project Assistance Description: Work closely with the project to understand and implement autonomy and help deter increased oversight. Aid from project will help instrument teams anticipate challenges with which they have not had to deal in the past.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Nov 2013	Title: Work with Autonomy Experts for Assistance Description: Hire expert consultants who have experience with spacecraft autonomous operations in order to aid design instrument autonomous operations to handle unforeseen conditions.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Jan 2014	Title: Autonomy Peer Reviews Description: Hold peer reviews on the instruments planned autonomy measures to vet instrument autonomous operations and configuration based on solar distance.

SPP PLANS: ISIS Increased Autonomy

Description ID: 19	**Given the relatively few real-time contacts, the need for autonomy, and the fact that instruments will be turned off repeatedly during data downlink activities, there is a chance that there will be an interruption in the operation of the instrument**
Consequence	which results a loss of primary science data.
Overall Status: Accepted(Active)	Consequence: 3 Likelihood: 4
Status Message	ISIS is working with the Project to better understand the impact instrument autonomy as implemented on SPP will have.
Mitigation Plan 1 Status: In Progress Trigger Date: 27 May 2013	Title: SC capability to send commands to the instruments Description: Having the capability of the SC computer to send a few commands to the instruments (less than a dozen commands needed) would mitigate the risk.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Nov 2013	Title: More testing Description: All autonomy algorithms will need to be tested extensively.

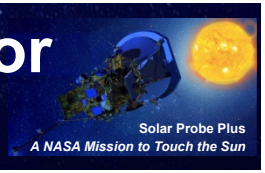
SPP PLANS: ISIS DDD EMI Requirement

Description ID: 11	**Given that the SPP Project is considering updating EMI requirements for Deep Dielectric Discharge, there is a chance that the Project will require all instrument box walls to be 54 mils thick;**
Consequence	which would result in a significant mass increase to the ISIS instrument.
Overall Status: Accepted(Active) Consequence: 1 Likelihood: 5	
Status Message	Updated analysis demonstrates that mitigation is only required on external cables with restrictions on floating connectors in E-Box, per Rich Conde: "Deep dielectric discharges are possible on harnesses on the exterior of the spacecraft. Therefore any electrical interface to a harness that is fully or partially on the exterior of the spacecraft must satisfy the survival and operational requirements previously presented... Deep dielectric discharges in the external harness can be prevented with total shielding of 13 mils Al equivalent, which could be provided by an additional 3 wraps (with 50% overlap) of Neptape. There is an additional DDD-related requirement on the maximum allowable volume of floating dielectric or conductive material within a shielded enclosure such as a chassis." Information forthcoming
Mitigation Plan 1 Status: In Progress Trigger Date: 30 Jan 2013	Title: Analyze and Quantify Impact Description: Work with the Project to fully analyze DDD environment and meter conservancy to reduce the requirement. ISIS team to quantify mass impact.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Nov 2013	Title: Implement Design Change Description: Increase wall thickness or spot shield to mitigate DDD dose.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2013	Title: Discharge Protection Description: Add additional ground straps to mitigate surface charging and implement discharge protection methods.

SPP PLANS: ISIS POL EMI Requirement

Description ID: 12	**Given that the SPP Project is considering updating EMI requirements to exclude switching circuits in power supplies, there is a chance that portions of the ISIS LVPS will have to be redesigned;**
Consequence	which would result in a significant power increase due to loss of efficiency in non-switching supplies and a schedule delay in the delivery of the EM LVPS to EPI-Hi and EPI-Lo.
Overall Status: Accepted(Active)	Consequence: 1 Likelihood: 1
Status Message	The LVPS design does not use POL circuits
Mitigation Plan 1 Status: In Progress Trigger Date: 30 Jan 2013	Title: Analyze and Quantify Impact Description: Work with the Project to fully analyze EMI environment and meter conservancy to reduce the requirement. ISIS team to quantify power/schedule impact.
Mitigation Plan 2 Status: Not Started Trigger Date: 01 Nov 2013	Title: Modify Design Description: Modify design to avoid use of POL converters.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2014	Title: Quantify Signature Description: Test and quantify ISIS frequency signature to correlate with FIELDS measurements on orbit.

SPP PLANS: ISIS Worst Case Analysis Required for All Circuits



Description ID: 18	**Given that the project is requiring worst case circuit analysis to be performed on all circuits in the design, there is a chance that the ISIS team will be required to perform more analysis than was originally budgeted;**
Consequence	which will result in increased cost and schedule delays.
Overall Status: Accepted(Active) Consequence: 1 Likelihood: 1	
Status Message	ISIS Worst Case Analysis reduced to only safety critical circuits.
Mitigation Plan 1 Status: Not Started Trigger Date: 27 May 2013	Title: Negotiate a Reduced Set of Analyses Description: Perform analyses on mission and safety critical circuits in order to reduce the total cost of the analyses.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Nov 2013	Title: Cost and Schedule Relief Description: Receive cost aid and schedule relief from project in order to implement worst case analysis on all circuits. This could result in engineers executing to a modified schedule and spend plan and/or the addition of new engineering resources.

RISK: EPI-Hi Development of New PHASIC

Description ID: 2	**Given that design and fabrication of a new Rad-Hard PHASIC could prove prohibitively challenging; there is a risk that existing STEREO chips would need to be used,**
Consequence	which will result in an increase in mass for spot shielding.
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 2
Status Message	**Linearity of both low and high gain channels of prototyped PHASICs was verified to be "good" (max deviation from straight line fit is less than about 1 channel out of 2000, or 0.05% of full scale). Thermal noise appears to be somewhat lower than predictions, allowing low threshold goals to be met. This together with the good linearity in low gain means that the targeted improvement in dynamic range has been met.** **The remaining PHASIC mods that need to be checked are** **1) that the matching of peak detector thresholds has been improved and 2) that the new preamp compensation scheme allows proper preamp gain/phase control and linearity for all detector configurations. Finally, we still need to check the performance over temperature.**
Mitigation Plan 1 Status: In Progress Trigger Date: 01 May 2012	Title: Radiation Hardened STEREO Design Description: Redesign STEREO PHASIC for new implementation with Aeroflex as a Rad-Hard ASIC. Assuming development progresses as expected, no severe delay in schedule is expected.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Oct 2014	Title: Spot-Shield STEREO PHASIC Description: If problems arise with radiation-hardening the STEREO design, would use existing spare STEREO chips with spot shielding to reduce radiation dose to a tolerable level.

RISK: EPI-Lo TOF ASIC Development

Description ID: 5	**Given that design and fabrication of an EPI-Lo TOF ASIC could prove prohibitively challenging; there is a risk that EPI-Lo will be required to use existing TOFAs,**
Consequence	which will result in an increase in mass and power resources required and a decrease in performance.
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 2
Status Message	**EPI-Lo has selected test house for final qualification and working with test house to develop tests and test procedures.**
Mitigation Plan 1 Status: In Progress Trigger Date: 02 Apr 2012	Title: Assist APL with Requirements Definition Description:
Backup Mitigation Plan Status: Not Started Trigger Date: 01 May 2014	Title: Utilize Heritage Design Description: Ensure enough TOFAs are available for EPI-Lo. Potential mass/power increase and possible loss of performance.

RISK: EPI-Lo Hot-Op Performance Impact

Description ID: 8	**Given that EPI-Lo has a max operating temperature of 30C and the Project expects EPI-Lo to operate at this temperature at Perihelion (prime science); there is a risk that operating at the max op temp will result in reduced resolution of the solid state detectors,**
Consequence	which will result in a reduction in performance of the detector
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 2
Status Message	**EPI-Lo has received SSDs from Canberra and mounted them into Ultem carrier. Completed fabrication and assembly of energy board. Started testing SSD with energy board, but don't have test results yet.**
Mitigation Plan 1 Status: Expired Trigger Date: 01 May 2012	Title: Continued Analysis Description: Further analyze and quantify EPI-Lo's performance at elevated temperatures to determine if expected temperatures pose a threat to instrument performance.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 May 2013	Title: Add isolation to reduce temperature Description: Add thermal isolation between instrument electronics and instrument sensors to allow sensors to run at lower temperature. Could also operate instrument colder by using more heater power.

RISK: EPI-Hi solar illumination

Description ID: 9	Given that the spacecraft is planning to cant the spacecraft at 1AU in order to warm the radiators behind the heat shield; there is a chance that EPI-Hi windows will be facing the sun,
Consequence	which could result in thin windows covering LET telescopes to overheat and fail, possibly causing damage to the EPI-Hi detectors.
Overall Status: Accepted(Active)	Consequence: 2 Likelihood: 2
Status Message	Finished: Goddard solar simulator will work for EPI-Hi solar illumination test. In Process: Determine correct thermal coating for aluminized polyimide windows and run thermal analysis.
Mitigation Plan 1 Status: Implemented Trigger Date: 01 Aug 2012	Title: Define Exposure Scenario Description: Obtain definition of planned illumination conditions (directions, durations) from project and work with project to determine if there is an approach that can be used to avoid excessive illumination of LET windows.
Mitigation Plan 2 Status: Expired Trigger Date: 01 Feb 2013	Title: Thermal Analysis and Test Description: Do a thermal analysis of the window, once the window material and thickness are chosen. Do test of EM windows using a solar simulator at GSFC.
Backup Mitigation Plan Status: Not Started Trigger Date: 01 Oct 2013	Title: Thicker Windows and Test Description: Make thicker windows that are in line with experience base of solar exposure at 1 AU. Do test of thicker EM windows using a solar simulator at GSFC.