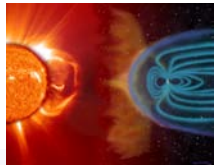


Solar Dynamics Observatory (SDO) Project Continuous Risk Management Implementation

Presented By:

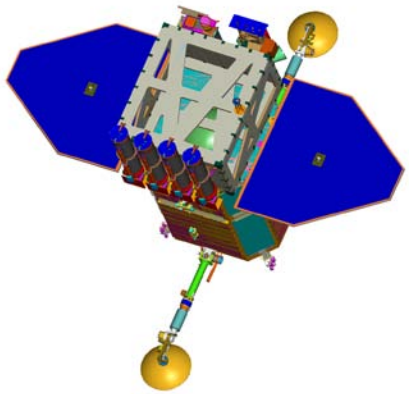
Gerald (Jerry) A. Klein, Jr.

NASA Goddard Space Flight Center
Stinger Ghaffarian Technologies (SGT), Inc.

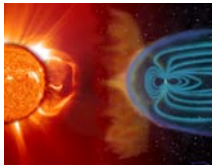
Joint Polar Satellite System (JPSS) Program
Risk Manager

SDO Mission/Project Overview

- **SDO is a NASA Category 1 mission (High Priority, Life Cycle Cost > $500 M), first Living With a Star (LWS) Mission, part of Sun-Earth Connection theme**
- **Characterizing the dynamic state of the Sun, enhancing the understanding of solar processes and space weather. Viewed as SOHO follow-on.**
- **NASA GSFC:**
  - Manages the mission
  - Built the S/C in-house
  - Managed and integrated the instruments
  - Developed/manages the Ground System and Mission Operations
  - Performed Observatory environmental testing at GSFC
- **Principal Investigators were responsible for development of their respective Instrument & Science Operations Centers**
- **Launched February 11, 2010 on an Atlas-V from KSC into a GEO-Sync Orbit, inclined 28.5 degrees**
- **Design Drivers:**
  - Continuous high data rate/volume
  - Geosynchronous orbit (mass to orbit, radiation)
  - 5 year mission life
  - Instrument pointing and stability

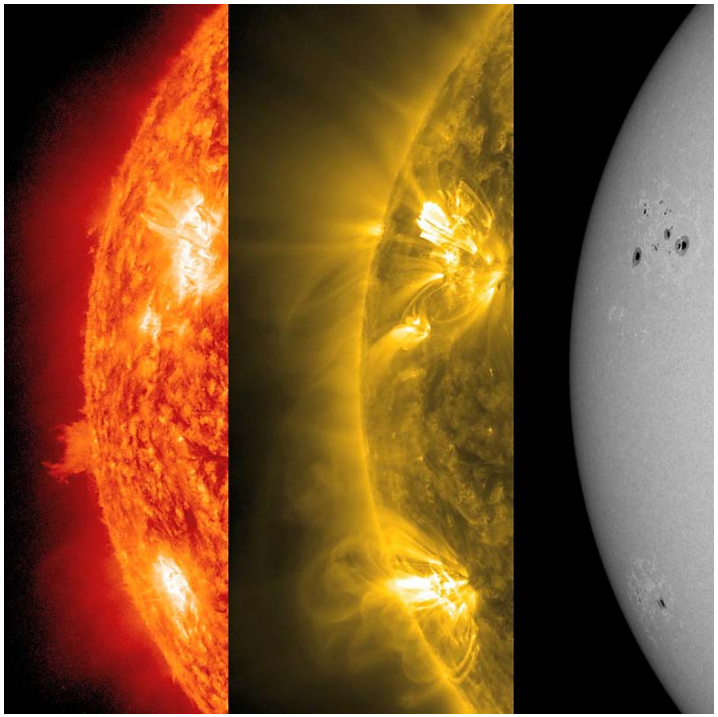


SDO Investigations



- **Helioseismic and Magnetic Field Investigation (HMI, Stanford University):**

HMI *observes "filtergrams" of the Sun which are used to produce dopplergrams and magnetograms. Analysis of these measurements allow us to understand the interior processes governing the transition from solar minimum to solar maximum, allow us to probe the dynamics of the near-surface shear layer to observe local strong flux regions before they reach the photosphere, and measures the highly variable magnetic field.*



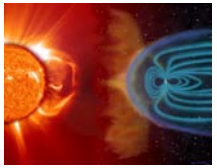
- **Atmospheric Imaging Assembly (AIA, Lockheed-Martin Solar and Astrophysical Laboratory):**

AIA *captures the initiation and progression of dynamic processes, with the spatial resolution necessary to understand their connection to the magnetic field and the spectral coverage to infer the processes at multiple temperatures.*

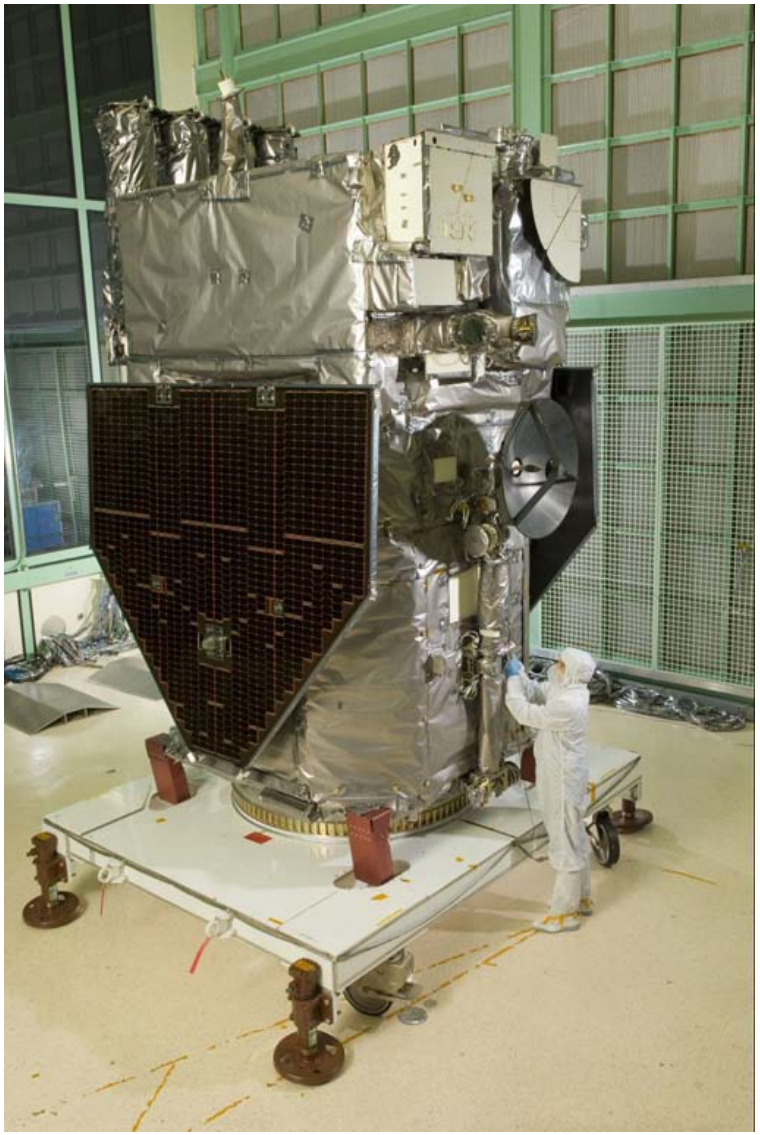
- **EUV Variability Experiment (EVE, University of Colorado, Laboratory for Atmospheric and Space Physics):**

EVE *specifies the spectral irradiance with a sensitivity that allows us to gauge the energy input into the complex processes of the Earth's atmosphere and near-Earth space. Its temporal resolution allows us, for the first time, to understand the flare-induced impacts on these processes.*

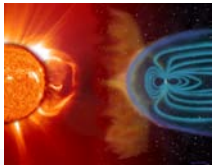
Solar Dynamics Observatory Facts



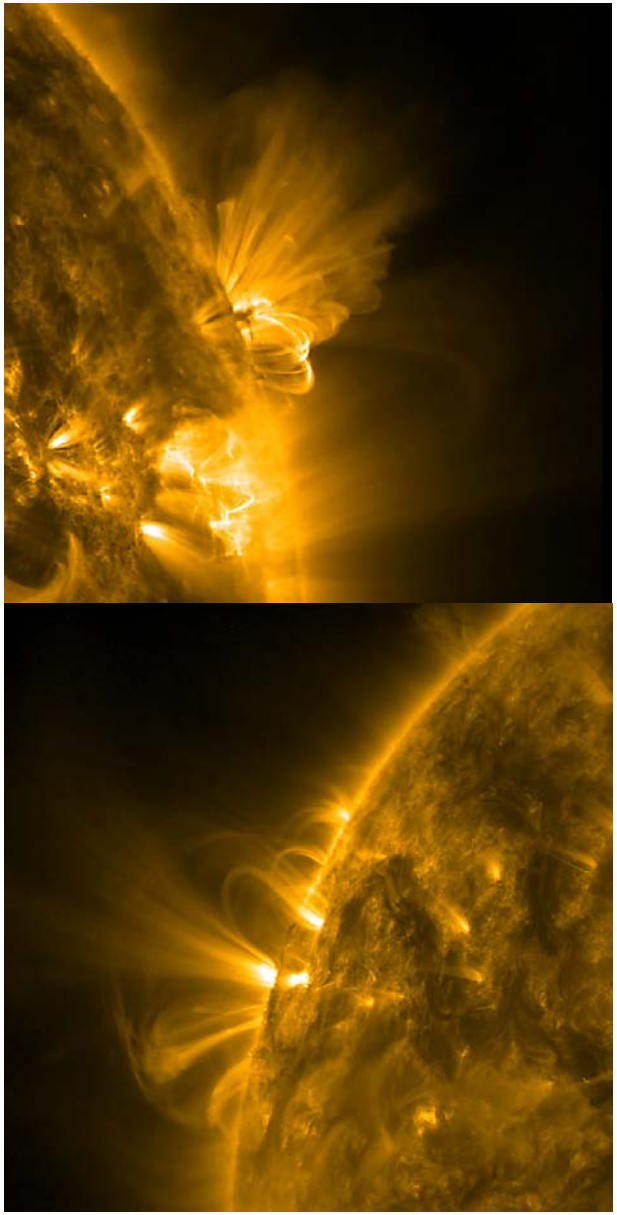
- **Total mass at launch: 3000 kg (6620 lb)**
  - Instruments 300 kg (660 lb)
  - Spacecraft 1300 kg (2870 lb)
  - Fuel 1400 kg (3090 lb)
- **Overall length: 4.5 m (14.76 ft); each side is 2.22 m (7.28 ft)**
- **Span of extended solar panels: 6.25 m (20.5 ft)**
- **Available power: 1500 W from 6.6 m^2 (71 ft^2) of solar arrays operating at an efficiency of 16%**
- **High-gain antennas rotate once each orbit to follow the Earth**



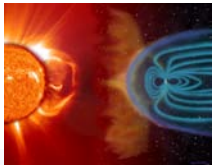
SDO Risk Management Strategy



- **Significant participation by the functional teams**: Instrument providers, suppliers and other affiliated organizations; process encouraged *all* team members to identify risks
- **Emphasis on individual team members:** Assumption made that the expertise required to identify, rank, prioritize, and develop mitigation strategy typically resides at the “grass-roots” level
- **Communication is always the key factor:** Open communication of risks was encouraged at all project levels
- **Risks were discussed monthly:** All risks were tracked on a monthly basis by the SDO Risk Management Review Board (RMRB), comprised of SDO Senior Staff and Product Development Leads (as req.) until retired
- **Constant mitigation adjustment:** RMRB adjusted mitigation activities and resource assignments monthly (or “Out-of-Board” when necessary)
- **SDO Project utilized a Risk Management Coordinator**
  - Actively solicited risk input from team members (new and existing risks)
  - Facilitated RMRB meetings, updated database, provided training



SDO Project Monthly RM Cycle



Continuous Loop

Week 1

Leads meet with team members
Review existing risks, identify new risks

Week 2

Risk Coordinator meets with Leads
Capture new risks, update risk status

Week 3

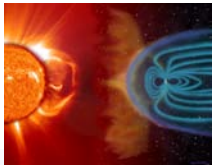
Risk Management Review Board
Review new and existing risks, adjust mitigations, adjust ranking

RMRB periodically reviewed all Open and Accepted risks. Assumptions still valid?

Week 4

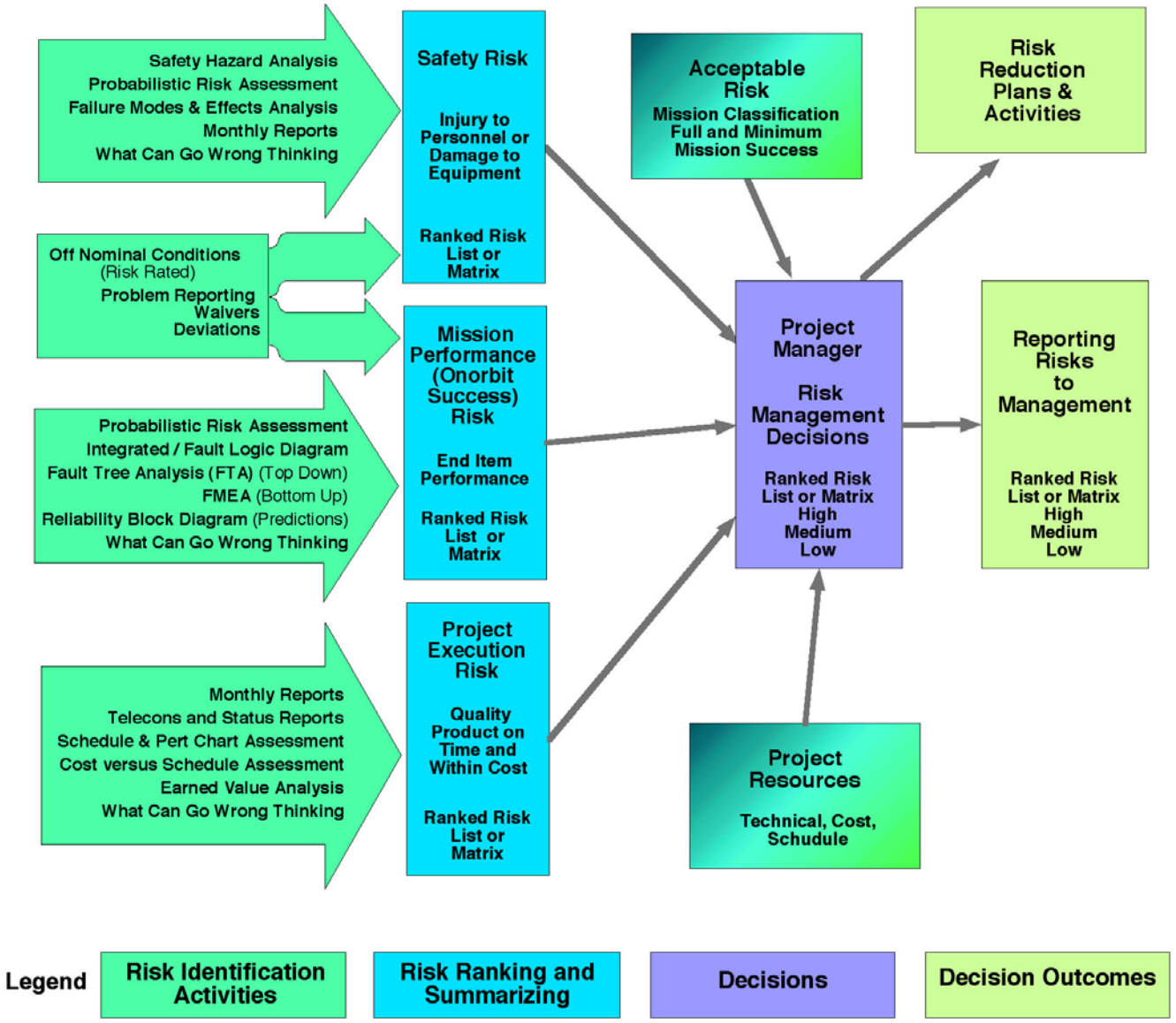
Report Risks to Management and all Stakeholders

SDO Risk Types

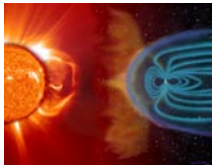


- **SDO Separated Risks Into Three Categories:**
  - **Safety**
    - Potential problem that includes the possibility of personnel injury and/or catastrophic damage to hardware/facilities
    - SDO risk management process was *not* intended to replace the existing system safety process; safety related risks continued to be addressed and documented in hazard analyses
  - **Mission Performance**
    - Potential problem that includes the possibility of impact to flight/ground segments during on-orbit operations (i.e., “end products" performing their desired functions in their operational environments)
    - Addresses the potential of not meeting mission requirements, possibly resulting in degraded science or total loss of mission
  - **Project Execution**
    - Potential problem that could impact to the ability to deliver the required product within the allocated budget, schedule, and technical resources
    - Addresses programmatic risk related to delivering a fully functioning observatory to the launch site, on time, and within budget

SDO Risk Management Flow

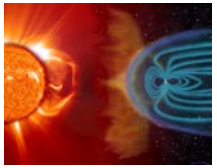


SDO CRM Process Implementation



- **Process Calibration Period:** Once the SDO Risk Management Review Board monthly meetings began, it took a while to work out the Board philosophy (about six months)
  - What needed to be tracked in the database
  - Who should attend the risk meetings
  - How long should discussions be allowed to go
  - When it was appropriate to write both a technical and programmatic risk for the same potential problem
  - When it was appropriate to write a risk after a problem had already occurred and was reported as an Issue
  - When it was appropriate to close a risk
  - When it was appropriate to accept a risk
  - When it was appropriate to reject a risk
  - When lower-level risks (subsystems, Instrument providers, contractor) were added to the Project-level risk database
  - When Project-level risks are promoted to the Program

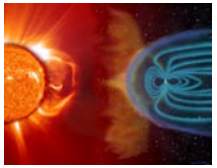
SDO Risk Management Focus



- **What did *not* belong in the SDO risk management database:**
  - **Problems** - (something that has already gone wrong) are tracked separately from risks (e.g., Issues, Problem Reports, Action Items)
  - **Concerns** - uncertainty who's likelihood cannot be assigned with confidence
  - **Worries** - have no basis in fact

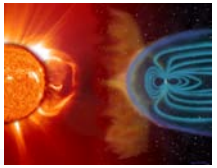
- **What *did* belong in the SDO risk management database:**
  - **<u>Potential</u> Problems, aka Risks**
    - *Fact-based* potential problem with a Condition and Consequence
    - Likelihood can be assigned with confidence
    - Credible, and therefore *actionable*

SDO CRM "Value Added"



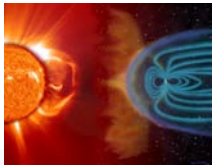
- **Integrated Management:** Risk Management became an integral Project Management tool, consistent with the project culture and philosophy
  - Brought project groups (e.g., science, finance, engineering, operations) together toward a common goal
  - Communicated the project's management vision and philosophy to *all* levels
- **Teamwork and Communication:** *Entire* project understood all the potential problems, consequences and options
  - Everyone worked together as part of a team, toward a common goal
  - Common understanding of project strategy and decision rationale
  - Talent, skills and knowledge were brought together monthly
- **Continuous Process:** Risk Management became a daily activity
  - Project established and *sustained* constant vigilance
  - Once established during Formulation, Risk Management became routine, continually identifying and managing risk throughout all project life cycle phases

SDO CRM "Value Added" cont.



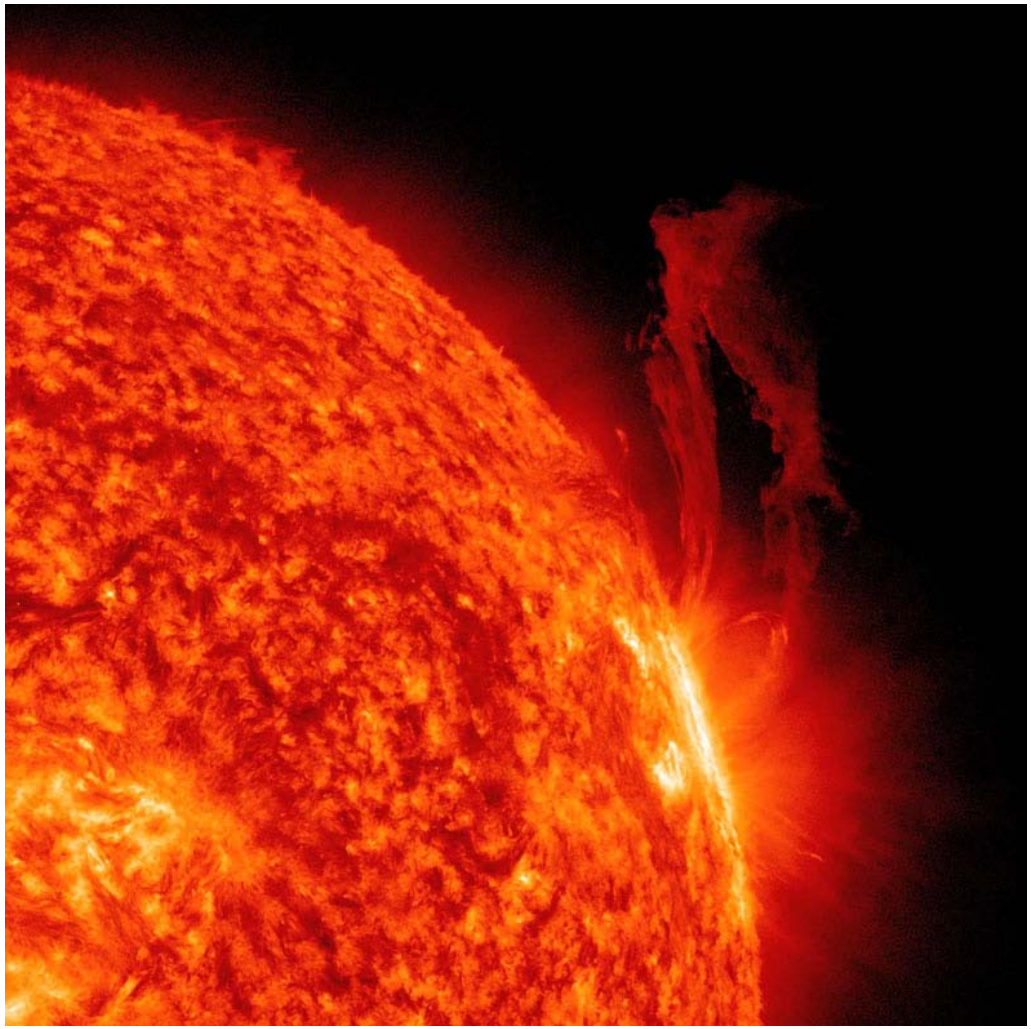
- **Forward-looking View:** SDO Team learned to look beyond today's crisis, and to the current crisis' future consequences
  - Constantly thought ahead to identify uncertainties; anticipating possible outcomes
  - Allocated project resources and managed activities with an eye on the future
- **Shared Product Vision:** SDO Team become attuned to the project objectives and the *overall* product it was producing (bigger picture)
  - Common understanding of how each piece integrated to become an Observatory
  - Fostered a shared vested interest in the outcome; mutual commitment
- **Global Perspective:** People began to look beyond their specific interests, goals and tasks, and reached a common view of what was important to the project/organization
  - Better understanding of the higher-level systems requirements, design and implementation
  - Clearer appreciation for the scope of potential impacts (ripple effect)

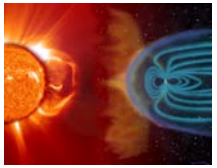
SDO CRM Lessons Learned



- **Success Relies On Project Personnel:**
  - SDO Project Management determined the RM process; SDO managers, engineers, and project support people, made it work
  - Regardless of the tool(s) you use to automate your RM process, it helps to have a “human in the loop” (RM Coordinator) to guide the project folks during day-to-day activities
  - All projects rely on each individual to point-out new risks as soon as they’re known

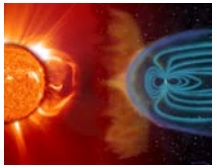
- **Projects Are Not Static; Neither Was The RM Process:**
  - As the project evolved, the RMRB made adjustments to the CRM process to ensure continued effectiveness
  - As NASA CRM requirements evolved, the RMRB reviewed the changes and adjusted the SDO CRM approach accordingly





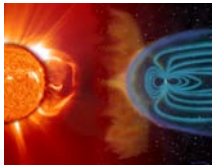
Backup

SDO Risk Consequence Ranking



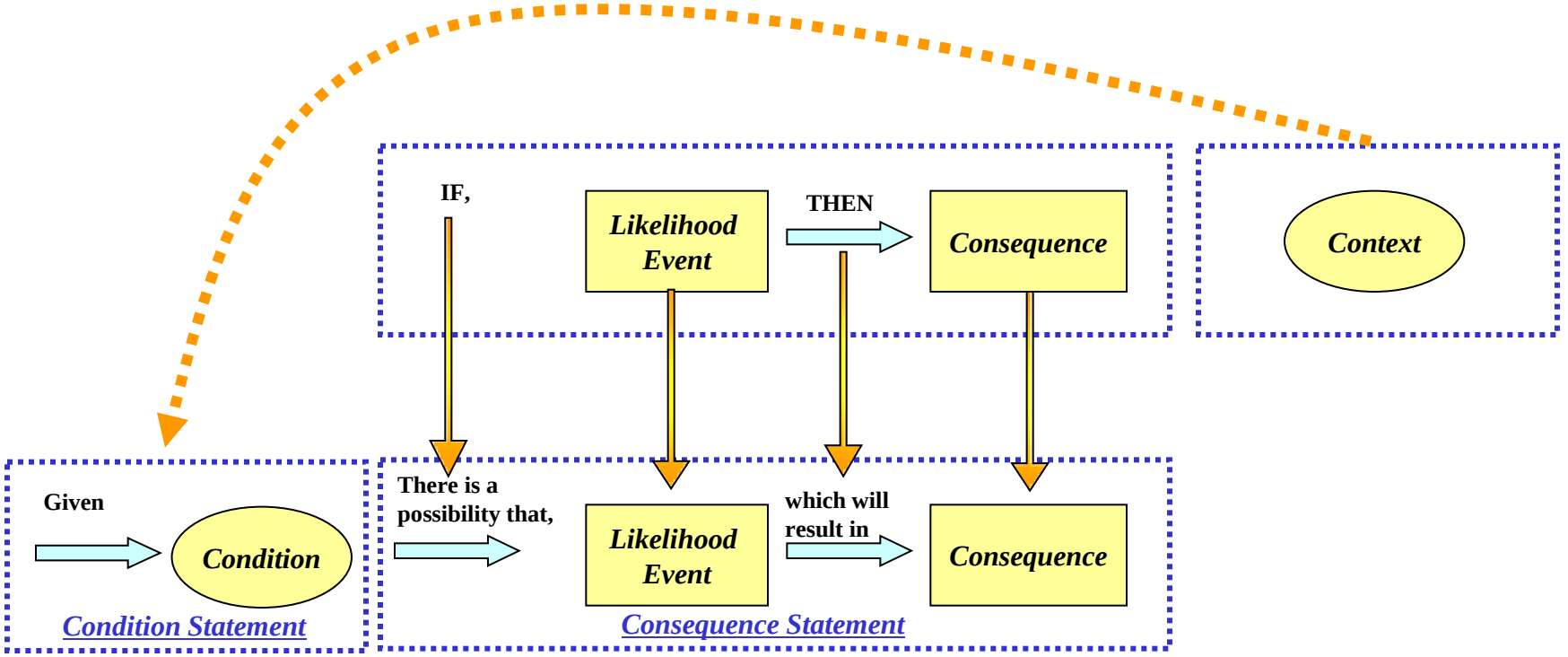
Rank	Impact	Safety (NPG 8715.3)	Mission Performance	Project Execution
5	**Very High**	**I Catastrophic** - A condition that may cause death or permanently disabling injury, facility destruction on the ground, or loss of crew, major systems, or vehicle during the mission.	**Total Loss of Mission**	**Technical** – Threatens ability to meet minimum mission success criteria, estimates exceed established margins (mass, power, volume) **Cost** – Greater than 10% increase over that allocated and/or exceeds available reserves **Schedule** – Major impact to critical path and cannot meet major milestone.
4	**High**	**II Critical** - A condition that may cause severe injury or occupational illness, or major property damage to facilities, systems, equipment, or flight hardware.	**Loss of Science** - (Does Not Meet Minimum Success Criteria)	**Technical** –Threatens established margins **Cost** – Between 7% and 10% increase over that allocated, and/or threatens to reduce reserves below prudent levels **Schedule** – Significant impact to critical path, and cannot meet established lower-level milestone. Level 2 milestone slip of > 1 month, or Project critical path impacted.
3	**Moderate**	**III Moderate** - A condition that may cause minor injury or occupational illness, or minor property damage to facilities, systems, equipment, or flight hardware.	**Degraded Mission** - (Does Not Meet Full Success Criteria, Meets Minimum Success Criteria)	**Technical** –Can handle within established margins. **Cost** – Between 5% and 7% increase over that allocated, and can be handled within available reserves. **Schedule** – Impact to critical path, but can handle within schedule reserve, no impact to milestones. Level 2 milestone slip of < 1 month.
2	**Low**	**IV Negligible** - A condition that could cause the need for minor first aid treatment though would not adversely affect personal safety or health. A condition that subjects facilities, equipment, or flight hardware to more than normal wear and tear.	**Not Used**	**Technical** –Can handle within established margins. **Cost** – Between 2% and 5% increase over that allocated, and can be handled within available reserves. **Schedule** – Minor schedule impact, but can handle within schedule reserve; no impact to critical path. Some additional activities may be required.
1	**Very Low**	**Not Used**	**Loss of Non-Critical Function** - (Loss or Degradation of Redundancy)	**Technical** – No impact on margins. **Cost** – Less that 2% increase over that allocated, and can be handled within available reserves. **Schedule** – Minimal or no impact to schedule, no impact to schedule reserve; no impact to critical path.
0	**Extremely Low**	**Not Used**	**Negligible Risk –** (Meets Full Success Criteria, Negligible or Minor Impact)	**Not Used**

SDO Risk Likelihood Ranking



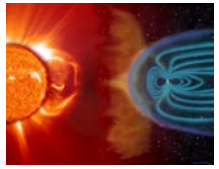
Rank	Likelihood	Safety	Mission Performance	Project Execution
5	Very High	$> 10^{-1}$	>50%	80-99%
4	High	$10^{-1} > X > 10^{-2}$	<50%..-.. >10%	60-80%
3	Moderate	$10^{-2} > X > 10^{-3}$	<10%..-.. >1%	40-60%
2	Low	$10^{-3} > X > 10^{-6}$	<1%..-.. >.1%	20-40%
1	Very Low	$<10^{-6}$	<.1%	1-20%
0	Extremely Low	Not Used	Extremely Unlikely	Not Used

SDO CRM Lessons Learned

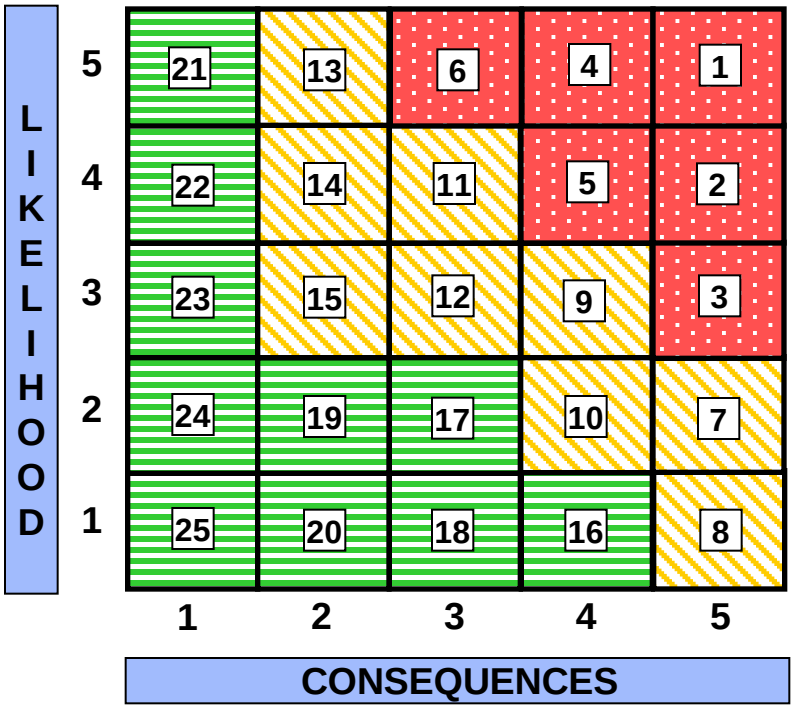


Both statements supply the same risk information, the difference is that the condition/consequence statement forces you to provide the context (condition) of the current scenario.

SDO Risk Exposure Ranking



SDO Risk Ranking Approach
Consequence Weighted



To illustrate the SDO Consequence-weighted ranking approach, the 5x5 matrix has numbered squares from 1 to 25, with 1 having the highest exposure and 25 having the lowest exposure.

Within each of the colored zones (red, yellow, and green), the risks are ranked from highest Consequence and highest Likelihood ranking to lowest Consequence and Likelihood ranking.

For example, within the red zone, the three risks with a Consequence of 5 have the highest exposure and are ranked in order of Likelihood. The next-highest exposure risks have a Consequence of 4, again ranked in order of Likelihood, followed by the C3, L5 risk.