NASA and Space Weather: Nominal Impacts and Mitigations

Neal Zapp, Ph.D.
NASA, Office of the Chief Engineer

NASA And Space Weather

When we say “Space Weather”, we usually seem to mean:

A relatively focused, nearly independent operational capability representing awareness, and hopefully some foresight of the space environment.

Perhaps we’re learning that it’s more:

An end-to-end, system-of-systems-wide capability set supporting multiple large-scale programmatic endeavors, encompassing the life cycles of multiple asset missions and associated ground systems, ingesting the activities of multiple internationally active, broad, and diverse scientific communities dealing with both source and effect(s), supporting intrinsic transition of science to operations, and helping to refine architectural/mission/systems design – all of which in turn ultimately help to enable the more familiar mission execution.

NASA Space Weather Impacts

- Air and Space Systems
  - Avionics
  - Communications
  - Env. Control and Life Support Systems (ECLSS)
  - Guidance and Navigation (G&C)
  - Vehicle, air-or-spacecraft charging
  - Orbital and trajectory impacts in LEO/MEO
  - Instrumentation (science missions)
  - Data management
  - Power
  - SoS (System of Systems) impacts (e.g. TDRSS effects on ISS ops)
- Crews
  - Radiation risks
  - EMU-as-system impacts for EVA

Mitigations

- Components selections or developments
- Architecture, mission, and element/vehicle design
  - Mission planning
  - Vehicle design/layout/materials
  - Redundancies
  - Software controls
  - Gracefully-failing systems
- Operations
  - Environmental awareness, characterization
  - In situ monitoring
  - Forecasting
  - Mission or timeline manipulation
  - Mission truncation
  - Execution of real-time mitigation plans

Space Weather Is Not Limited To Mission Execution In Scope
Accelerating Development In Forecasting Ability

NASA And Space Weather

HELIOPHYSICS

Fundamental Science – the engine

Assets and Measurements

LWS

Targeted Transition to Operations – TR&T

Space Weather Research Center

Community Coordinated Modeling Center

Model stable hosting

Facilitation of collaborative research

Transition to operations, both intra-and-inter-agency

Direct support of NASA missions

Radiation Protection

Real-Time HEO Operations, MCC-H

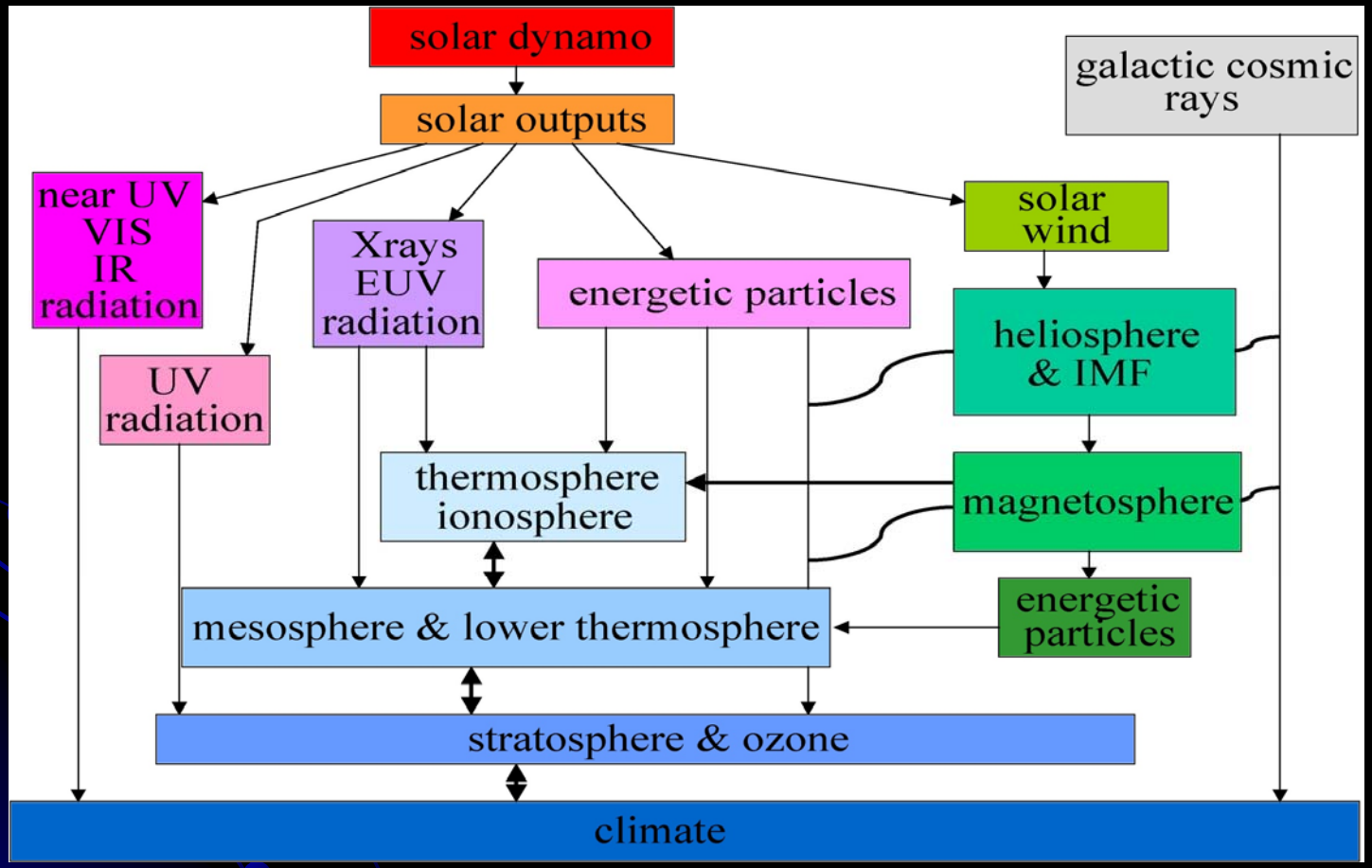
Architecture, Vehicle, H-W Design

In-Situ Measurements

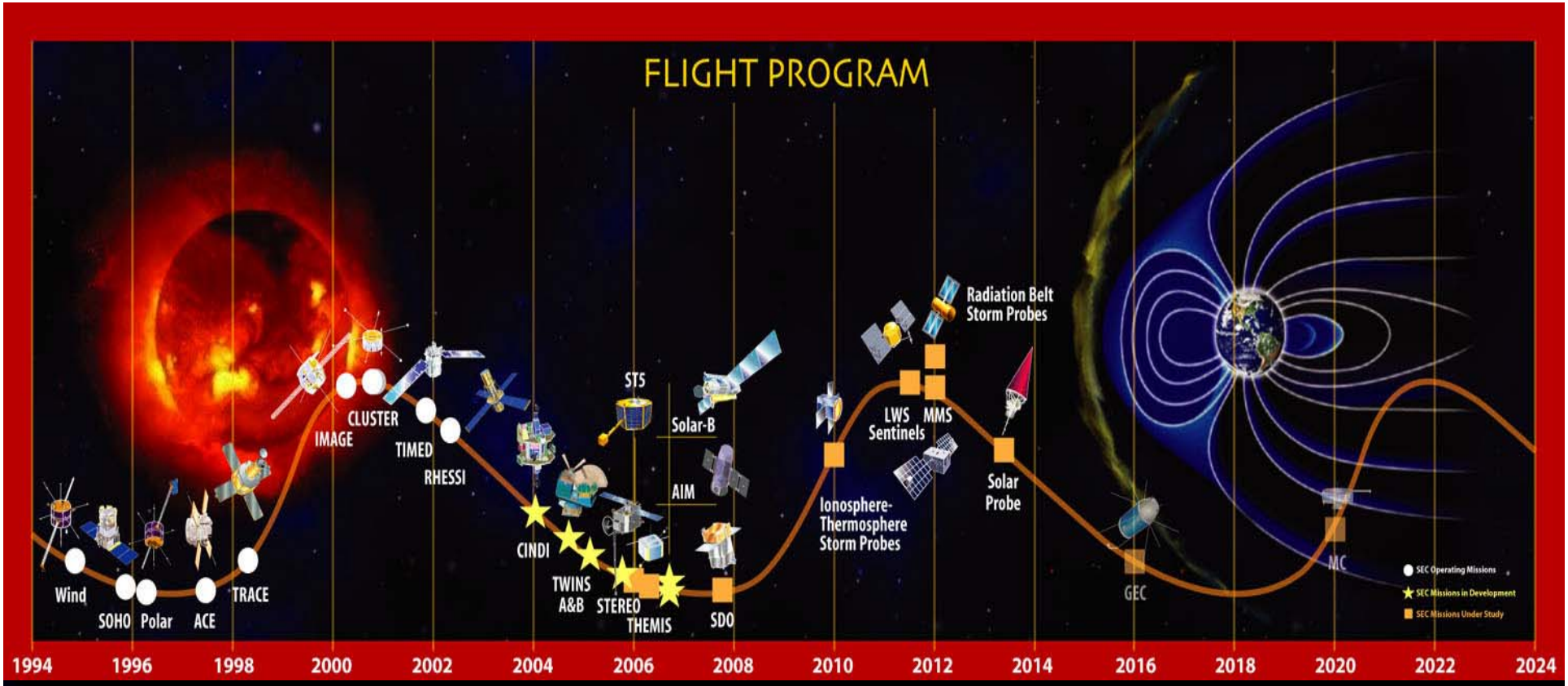
Technology Development

LWS: Systems Approach

LWS focuses not on any one region of space, but rather on our Sun Earth Region as one system.



A very important part is the study of the connection between the regions and how one drives a response in another.



STP Program

Solar -B (with Japan)

STEREO Nominal mission

LWS Program

SDO Nominal mission + 5 yr Extended mission

Ionospheric-Thermospheric Storm Probe mission

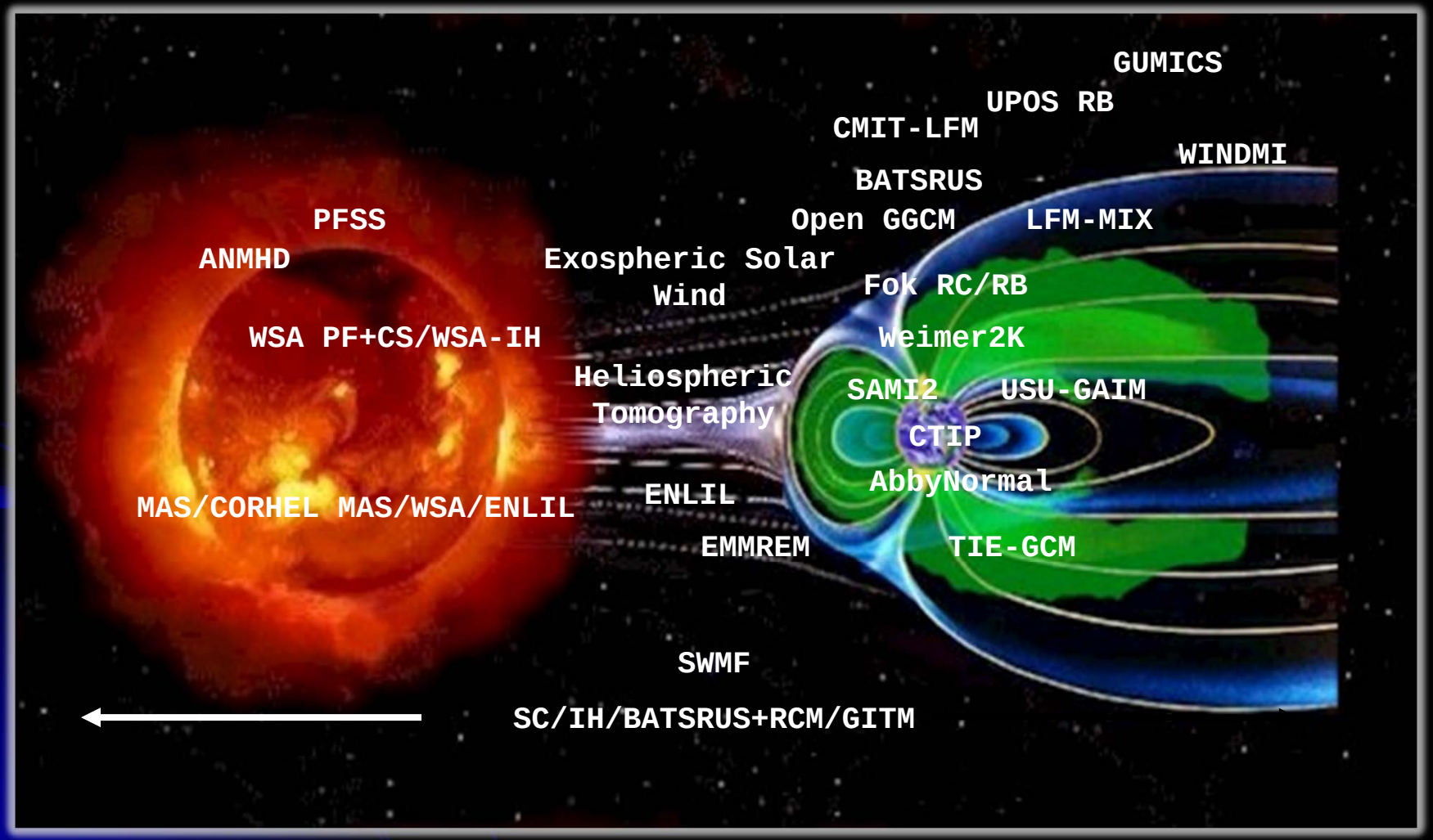
Radiation Belt Storm Probe mission

Heliospheric Sentinel Mission

Solar Probe Mission (Augmentation under study)

Development
Formulation
Under Study

Community Coordinated Modeling Center

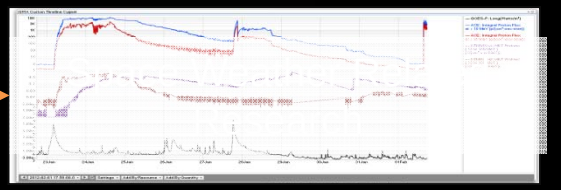


Space Weather Research Center

Space Weather Research Center

Partnering

Johnson Space Center
NOAA
ASTRA
EPRI
NiCT
esa
Met Office
KASI
JAXA
KMA
Meteorological Administration

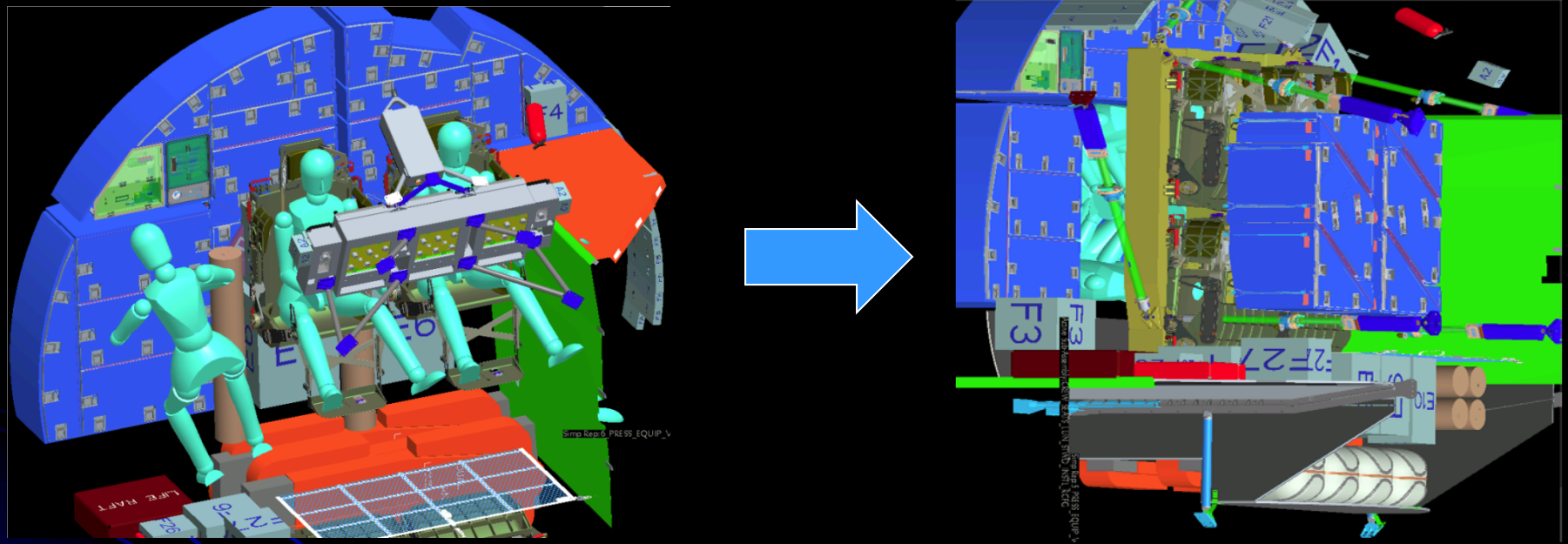


Space Radiation Analysis Group - SRAG

- Programmatic support for radiological health in human spaceflight
  - Architecture definition
  - Program requirements definition
  - Crew risk estimation
  - Risk leveling
  - Heritage beginning with Mercury

- Broad functions
  - Real-time console support, MCC-H
  - Design, provision, operation and sustenance of in-situ measurements
  - Crew badging
  - Vehicle and on-board hardware design support
  - Space weather linkage to vehicle hardware owners
  - Interface and partnership with elements of DoD – artificial event ops

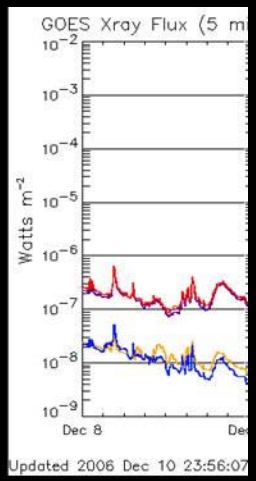
Provision of Systems Capability

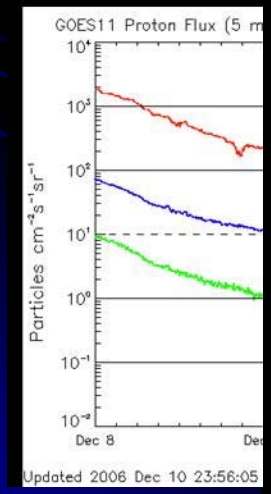


Lines are increasingly blurred between “science-operations”, and “design-execution”

Why?

Probability? – STS-116





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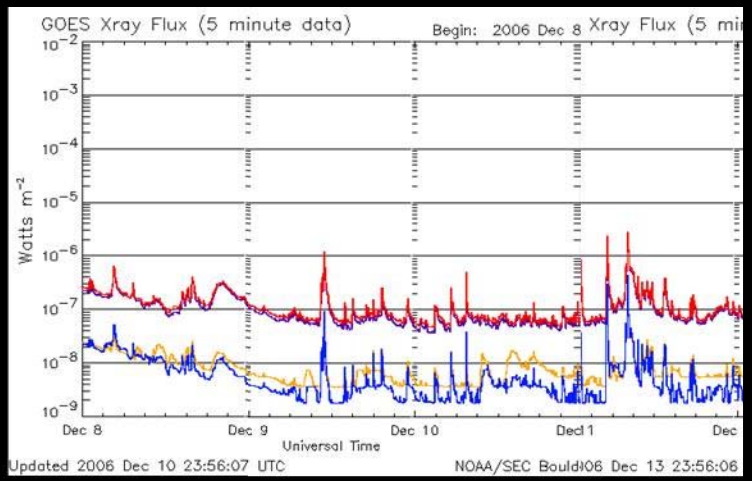
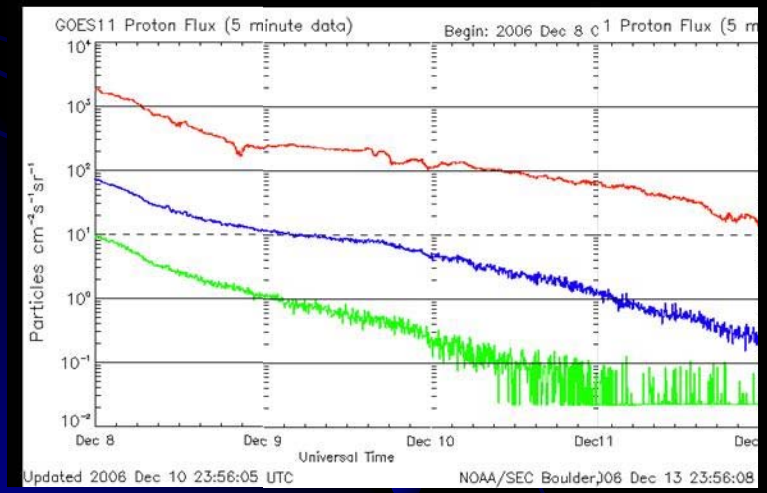
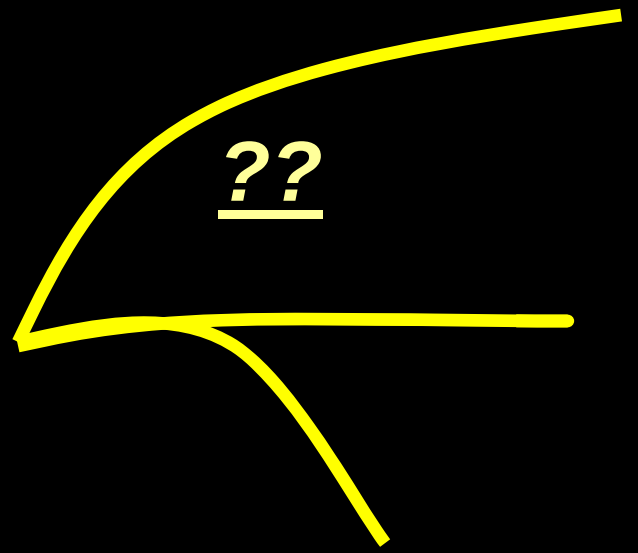
STS-116 Launch

Why?

Probability? – STS-116



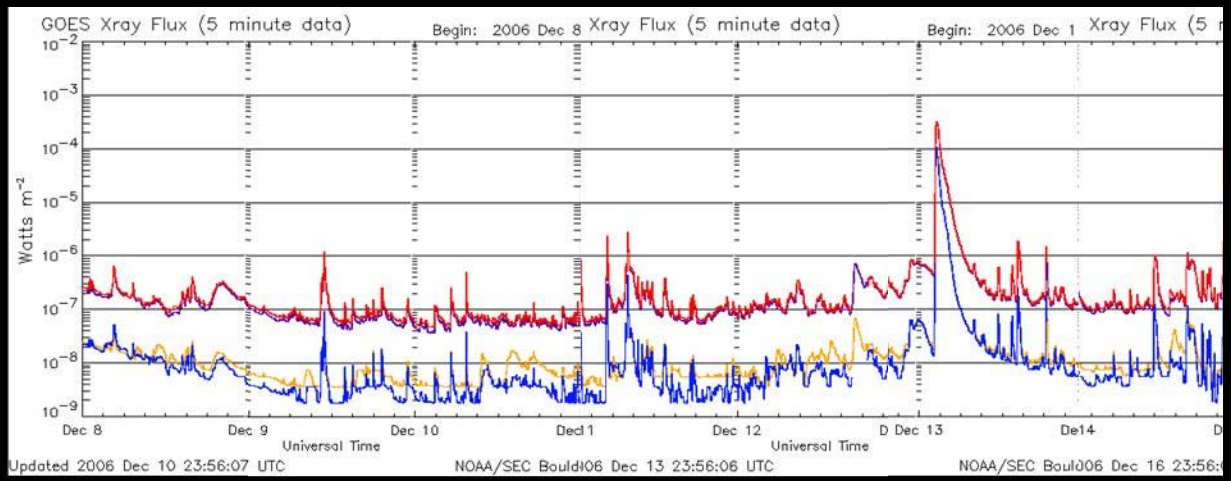


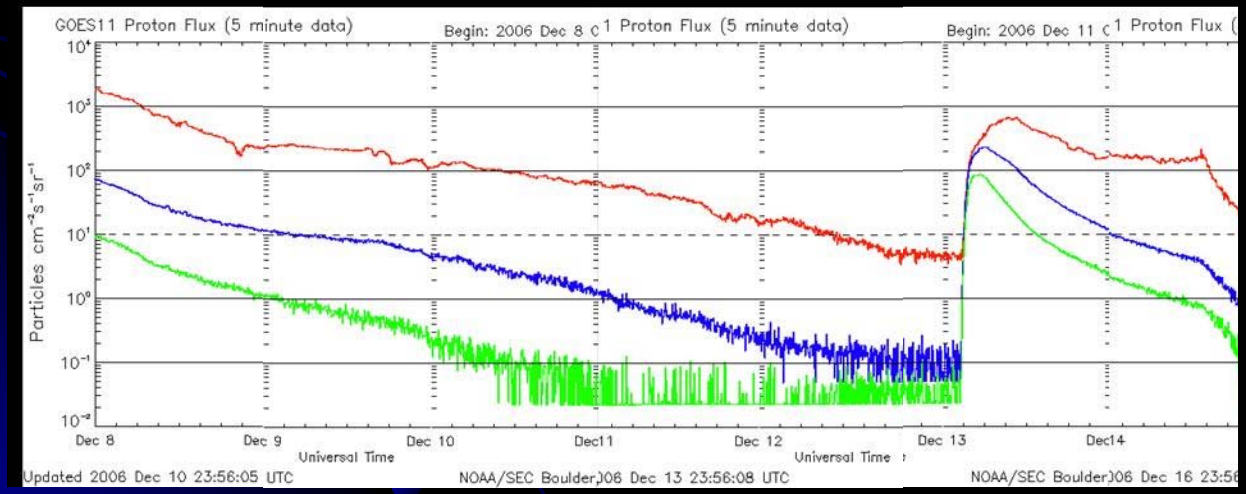


EVA 1 Ingress

Why?

Probability? – STS-116





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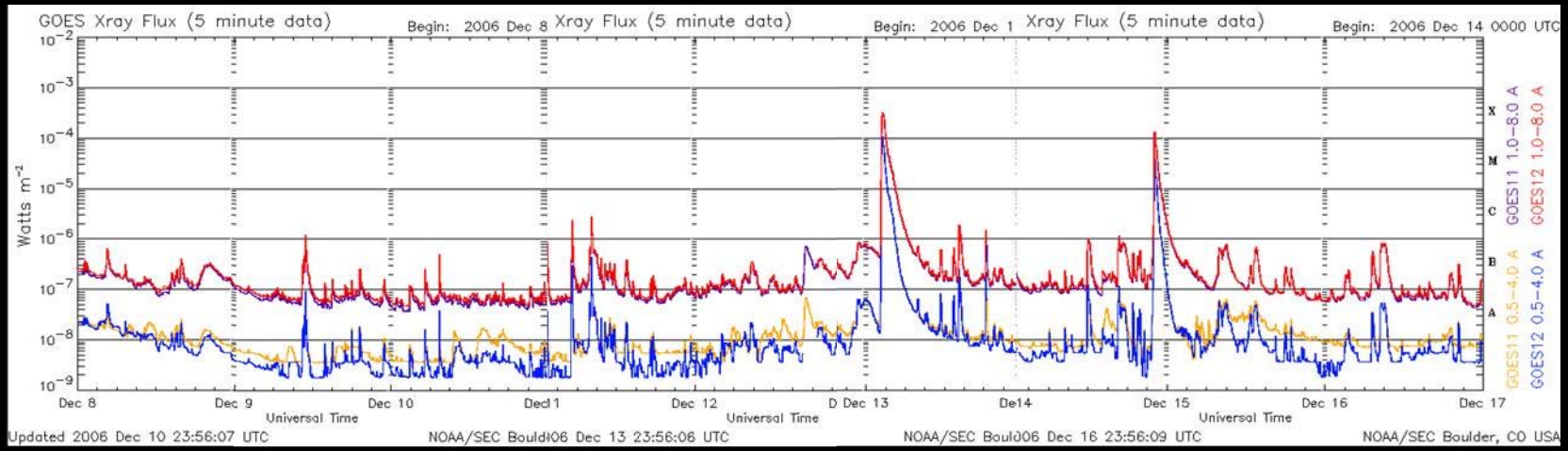
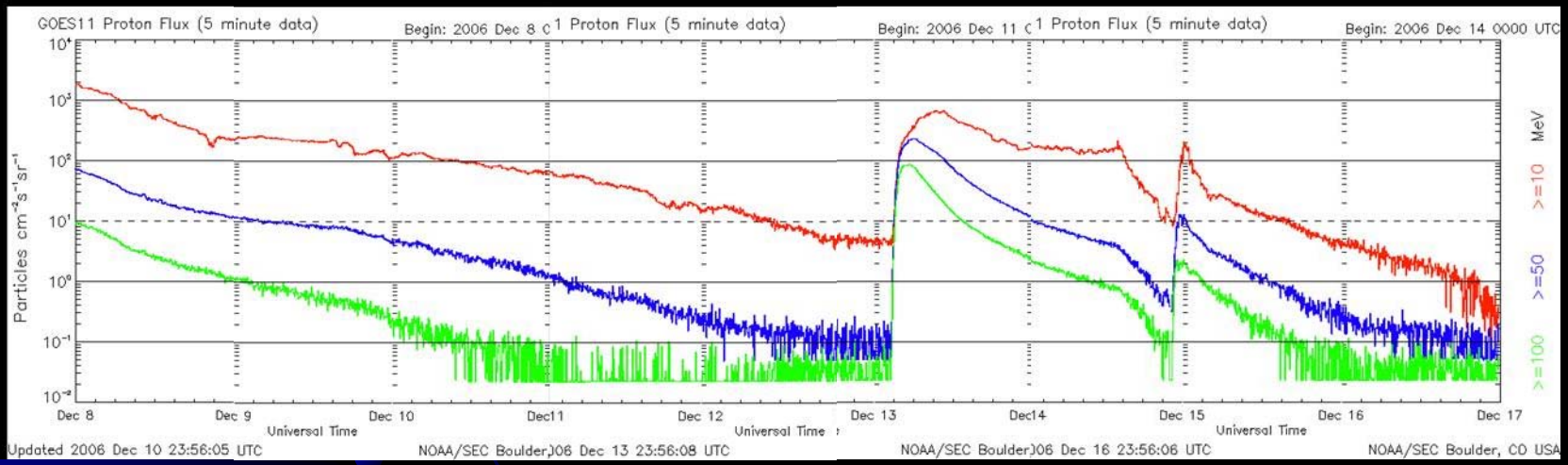
EVA 2 Egress

Why?

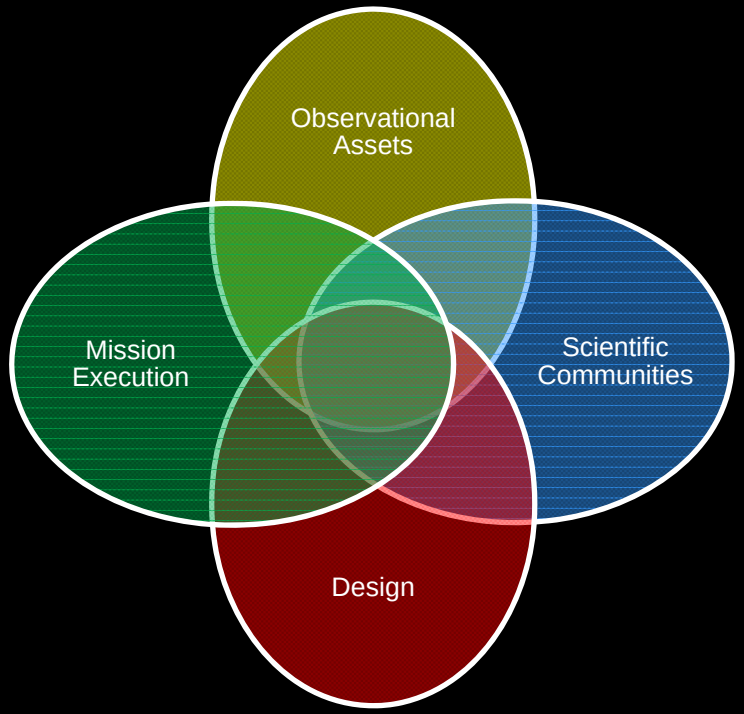
Probability? – STS-116





What's Next?

- Continued commitment to evolution of our fundamental understanding.
  - NASA Heliophysics, Living With a Star Program
  - Human Research Program
- Technology Development
  - Advanced Exploration Systems (AES)
  - Space Technology Mission Directorate
  - Science to Operations
- "Cradle to grave" character
- Meaningfully embrace collaboration
  - "intra-" and "inter-"

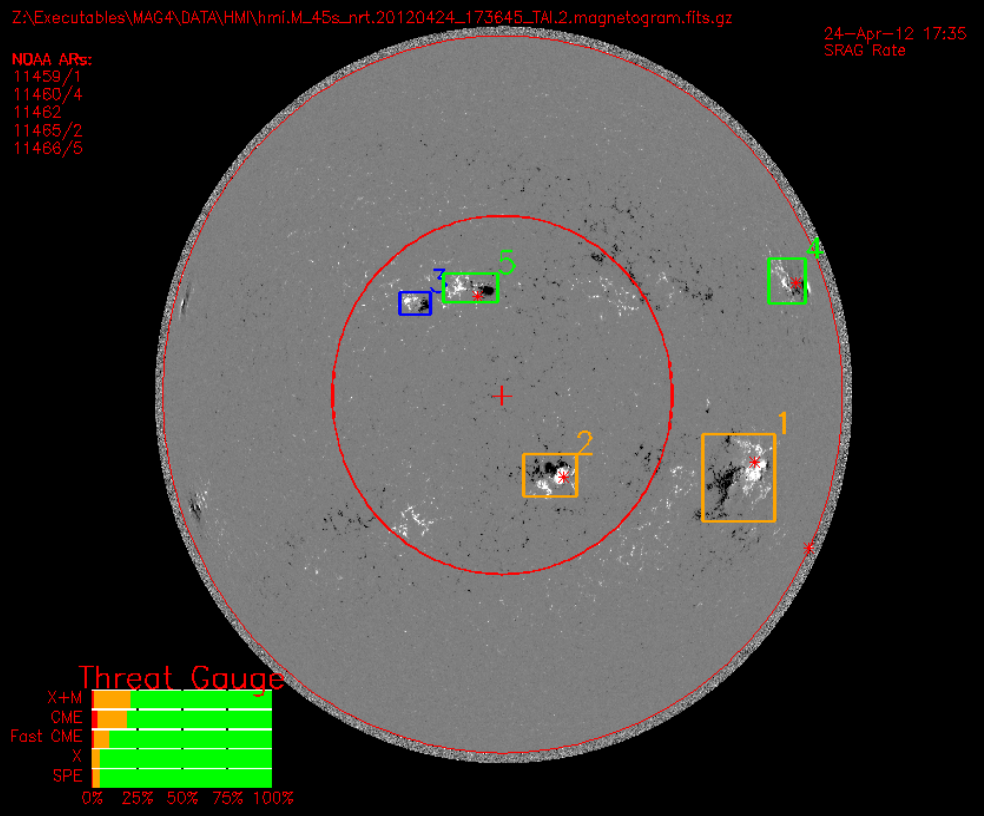


Thematically, the world is becoming a more integrated place.
Necessity has helped to lead us here – efficacy will keep us here.

What's next - SPE Forecasting

- Historical database for identification of event trending/characteristics
- Probabilistic modeling for operational mission planning
- ISEP: integration of probabilistic spectral and SEP dose modeling
- Dose projection for in-event risk mitigation
- Forecasting of event onset and impact outside of low-earth orbit.

MAG4 Model



David Falconer University of Alabama

All-Clear Modeling

All-clear probability is cumulative over disk. However, time dependence of single-region growth correlates with region identified as producing flares and SEP.