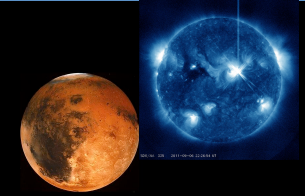# SRAG – CCMC Partnership

Applications for Human Spaceflight

D. Fry
Johnson Space Center
Space Radiation Analysis Group

Target Areas

Focus on Missions Beyond LEO

Mission Planning/ Design

- Probabilistic model of worst-case SEP spectra at give confidence
  - Single event
  - Peak flux
  - Mission cumulative

Forecasting

- All-Clear
  - SEP
  - Flare
  - CME

- CME/Shock arrival (ensemble methods)

- Impact assessment via magnetic connectivity

Environmental Status

- Quick-look products
  - Particle fluence
  - X-ray flux
  - CME characteristics

- Historical event comparison
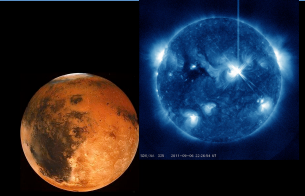 - Calculation and projection of total SEP event fluence

'In-Event' Dose Projection

- Event starts
  - What is the expected cumulative event dose?

Goal: develop prototype operational toolset that will provide robust products covering timeline from mission planning through event contingency.
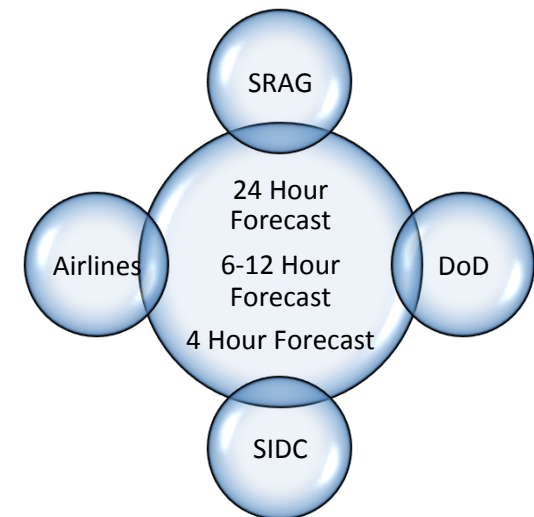
ISEP Technical Origins

First All-Clear Workshop (2009)

- Focus on bringing operations and research community together
- Funded by Living With a Star program
- Brought together NASA, NOAA, DoD, United Airlines and research community
- Goal:
  - Get operations and research community on same page – understand model maturity and understand operational needs
  - Rack-and-stack models based on "quantified" maturity (skill score), complexity (run time, number of input data streams, post-processing, etc)
  - Determine overlap in operational needs between NASA, NOAA, DoD and Airlines
  - Agree on set of metrics for future testing of models
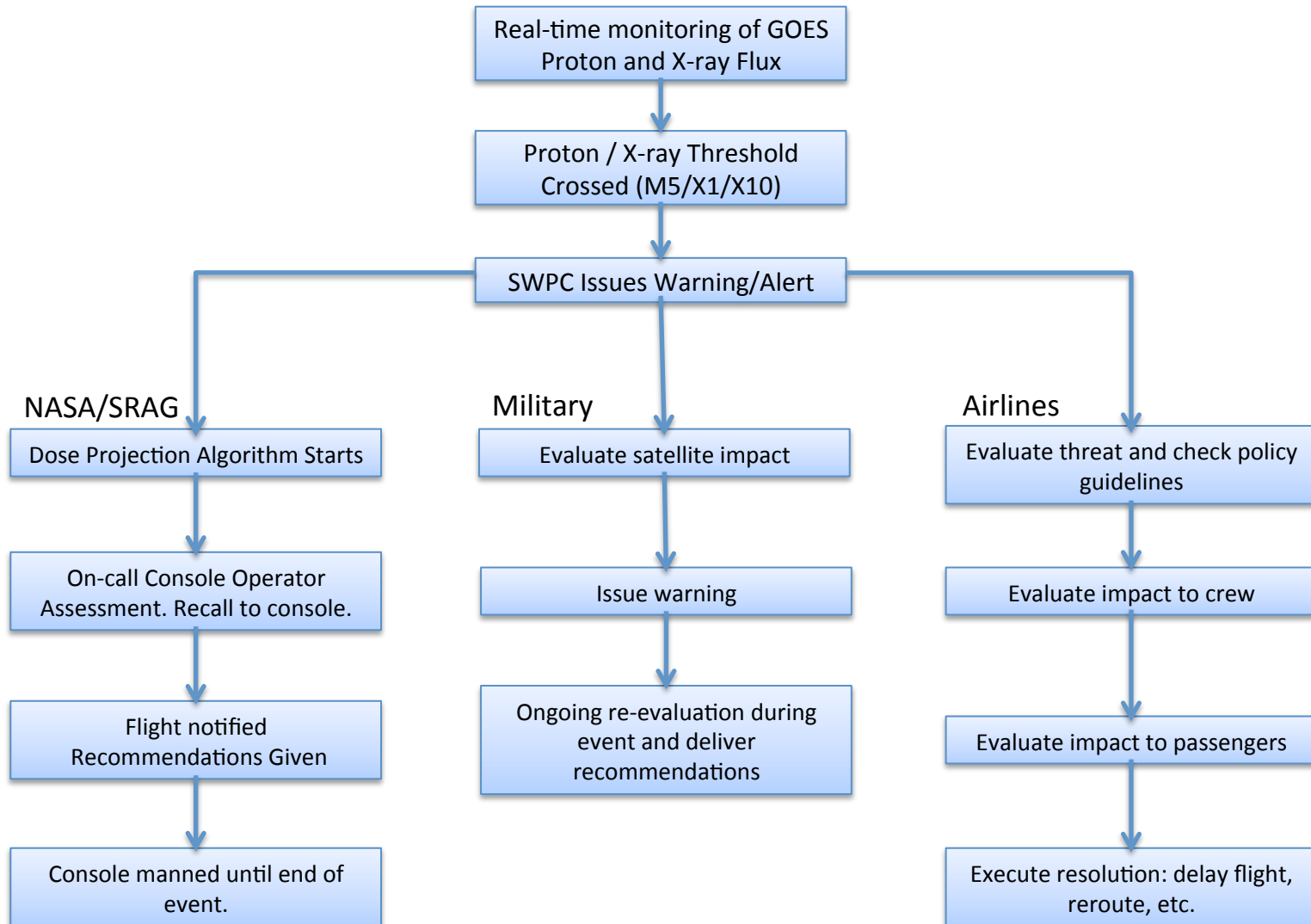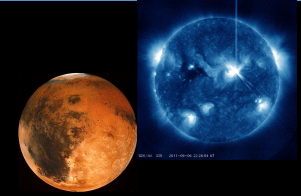
ISEP

- Leveraged assessment of model maturity, operational need to select starting point.
- Leveraged identification of metrics to formulate V&V approach.
- In addition, leveraged past work on probabilistic modeling (Xapsos/Adams), work funded by SRAG on dose projection (Townsend/Utenn)
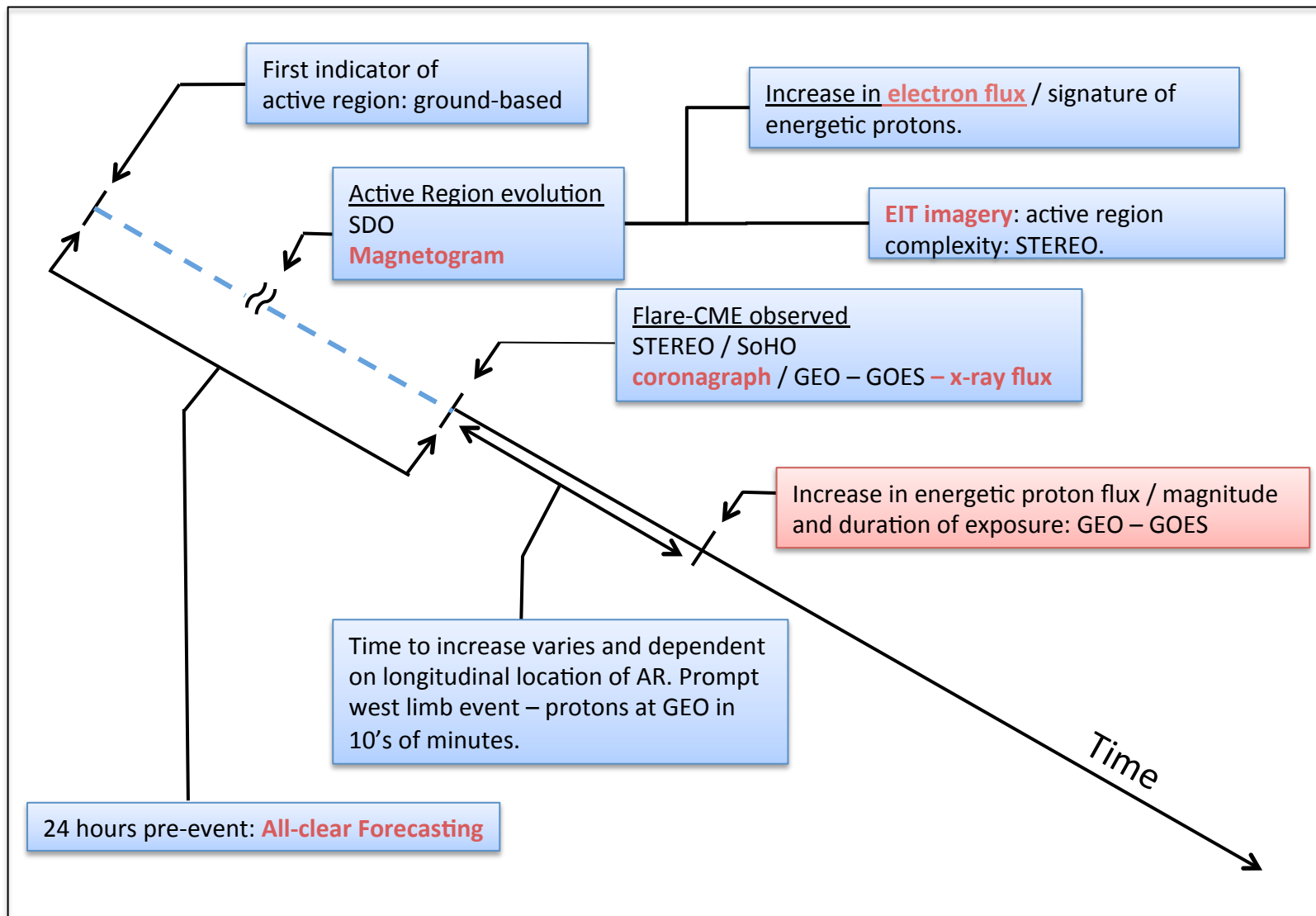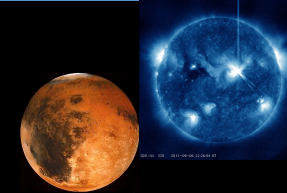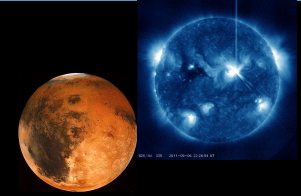
SRAG

24 Hour Forecast

6-12 Hour Forecast

4 Hour Forecast

Airlines

DoD

SIDC

ISEP Technical Origins

Real-time monitoring of GOES Proton and X-ray Flux

↓

Proton / X-ray Threshold Crossed (M5/X1/X10)

↓

SWPC Issues Warning/Alert

NASA/SRAG

Dose Projection Algorithm Starts

↓

On-call Console Operator Assessment. Recall to console.

↓

Flight notified Recommendations Given

↓

Console manned until end of event.

Military

Evaluate satellite impact

↓

Issue warning

↓

Ongoing re-evaluation during event and deliver recommendations

Airlines

Evaluate threat and check policy guidelines

↓

Evaluate impact to crew

↓

Evaluate impact to passengers

↓

Execute resolution: delay flight, reroute, etc.

ISEP Technical Origins

First indicator of
active region: ground-based

Active Region evolution
SDO
Magnetogram

Increase in **electron flux** / signature of
energetic protons.

EIT imagery: active region
complexity: STEREO.

Flare-CME observed
STEREO / SoHO
coronagraph / GEO – GOES **– x-ray flux**

Increase in energetic proton flux / magnitude
and duration of exposure: GEO – GOES

Time to increase varies and dependent
on longitudinal location of AR. Prompt
west limb event – protons at GEO in
10's of minutes.
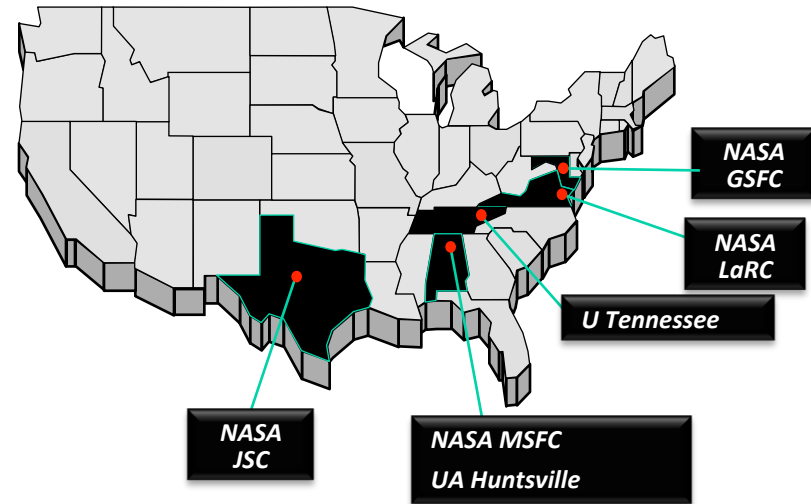
Time

24 hours pre-event: **All-clear Forecasting**

ARP Team

Core Team

Nasser Barghouty (MSFC)
James Adams (Univ. Alabama Huntsville)
Zachary Robinson (Univ. Alabama Huntsville)
Michael Xapsos (GSFC)
Craig Stauffer (GSFC)
Michael Hesse (GSFC)
Peter MacNeice (GSFC)
Marlo Maddox (GSFC)
Rick Mullinix (GSFC)
Antti Pulkkinen (GSFC)
Maria Kuznetsova (GSFC)
Aleksandre Taktakishvili (GSFC)
Martha Clowdsley (LaRC)
Larry Townsend (Univ. of Tennessee)
Hanna Mousa (Univ. of Tennessee)
David Falconer (Univ.of Alabama Huntsville)
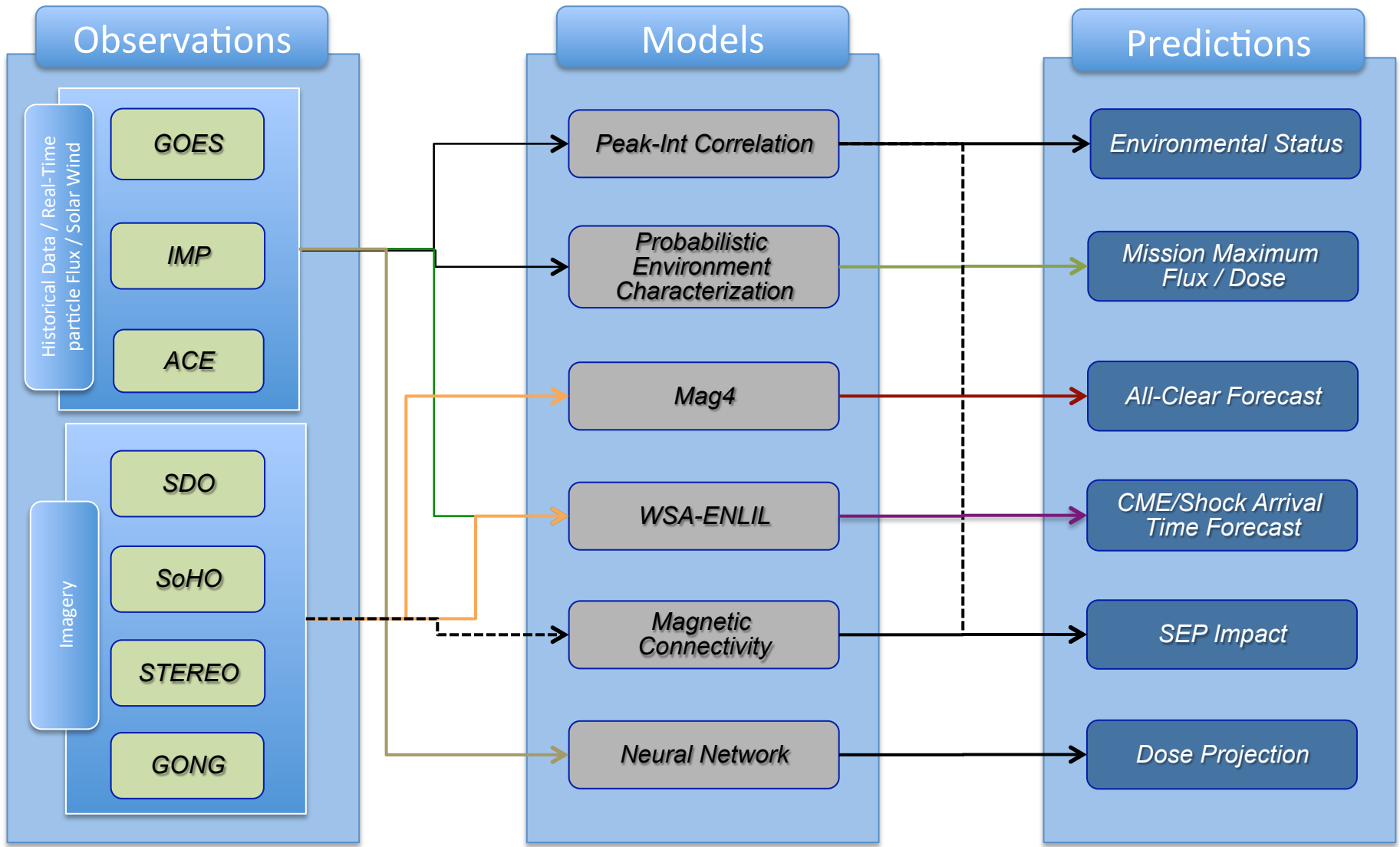Igor Khazanov (Univ.of Alabama Huntsville)
Janet Barzilla (JSC)

- NASA GSFC
- NASA LaRC
- U Tennessee
- NASA JSC
- NASA MSFC / UA Huntsville

Stakeholders

Intra-Agency:
  HEOMD
  Robotic Operations

Potential Extra-Agency:
  NOAA / SWPC
  DoD (AFWA)
  Commercial Airlines

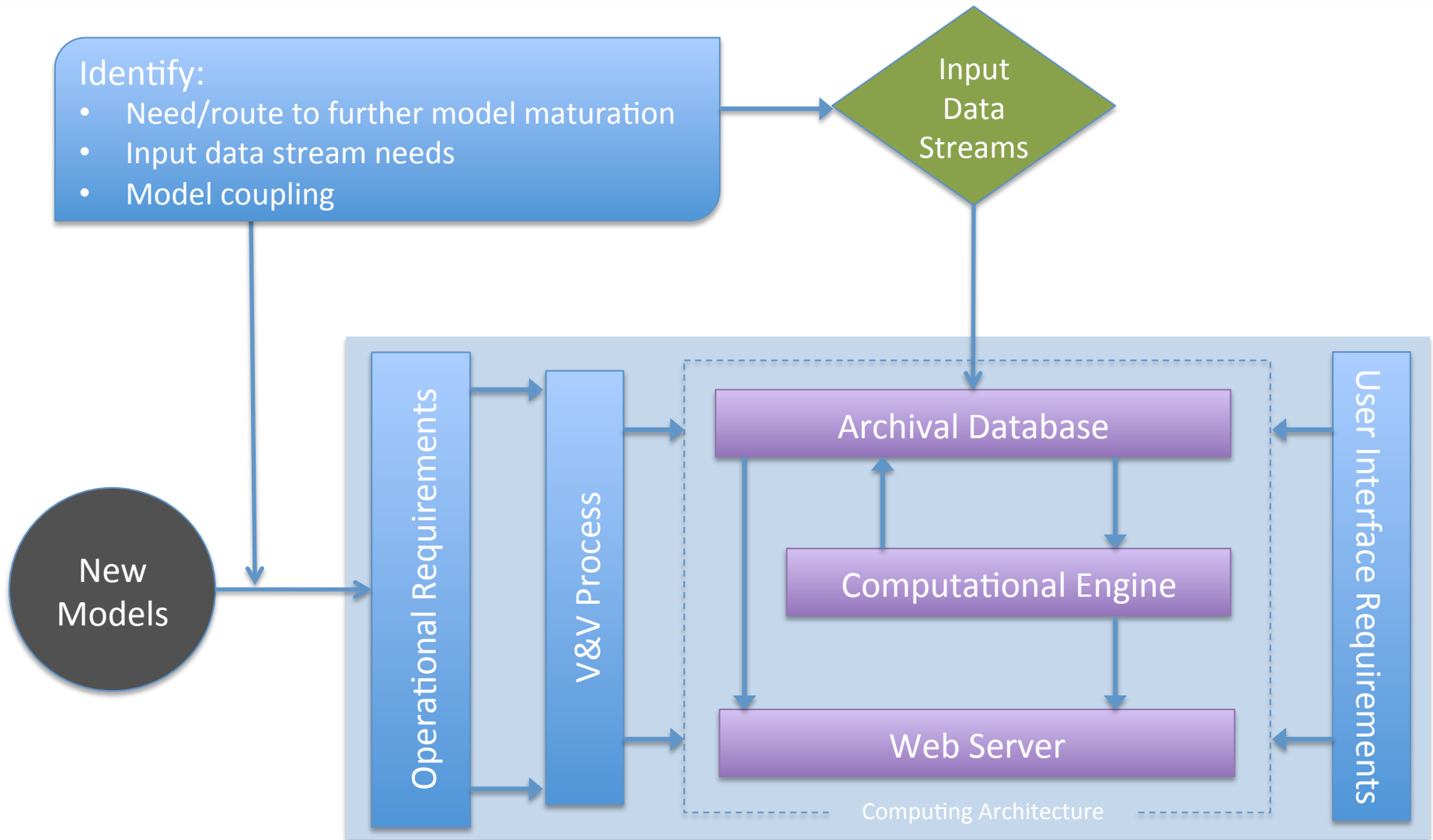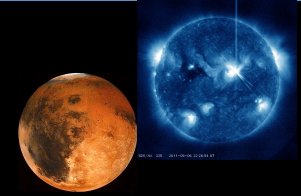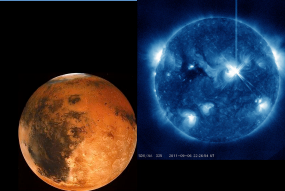## Observations

Historical Data / Real-Time particle Flux / Solar Wind

- GOES
- IMP
- ACE

Imagery

- SDO
- SoHO
- STEREO
- GONG

Models

- Peak-Int Correlation
- Probabilistic Environment Characterization
- Mag4
- WSA-ENLIL
- Magnetic Connectivity
- Neural Network

Predictions

- Environmental Status
- Mission Maximum Flux / Dose
- All-Clear Forecast
- CME/Shock Arrival Time Forecast
- SEP Impact
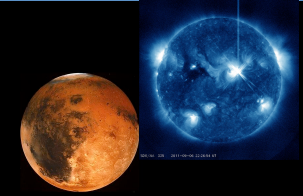- Dose Projection

Composite Products

- Often times there isn't much lead time to pass information back to flight control team
- Need tools that integrate forecasting with information needed to kick-off mitigation in real-time
- Combine All-Clear forecast with impact assessment via magnetic connectivity
- First of it's kind for human operations
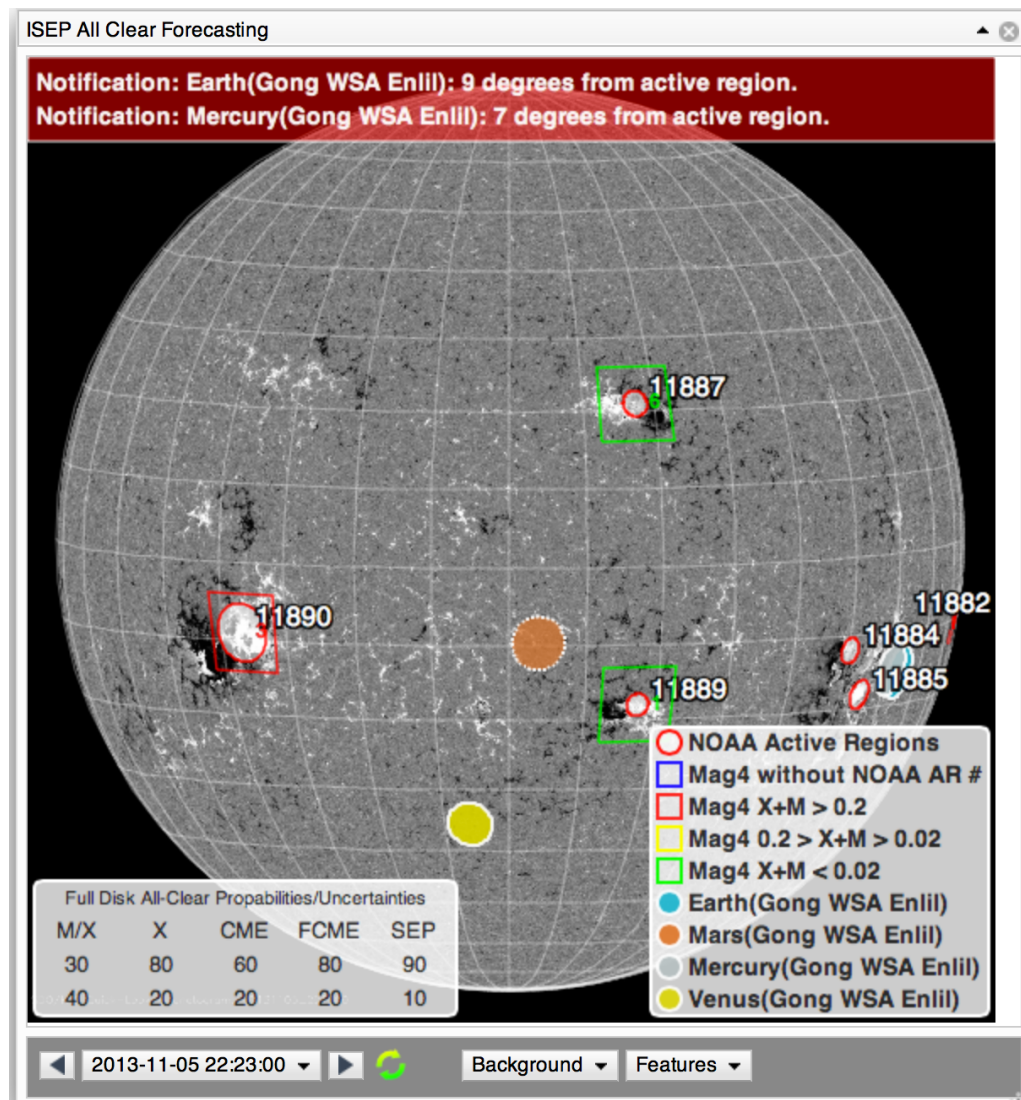
Web Displays

Leverage iSWA System Architecture

- Modular
- Real-time data stream pull
- Model code integrated and running on backend server
- Dedicated ISEP interface deployed across multiple systems for redundancy with full iSWA capabilities and features.
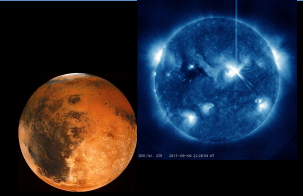- Operators will be able to pull up and configure interface analogous to iSWA.
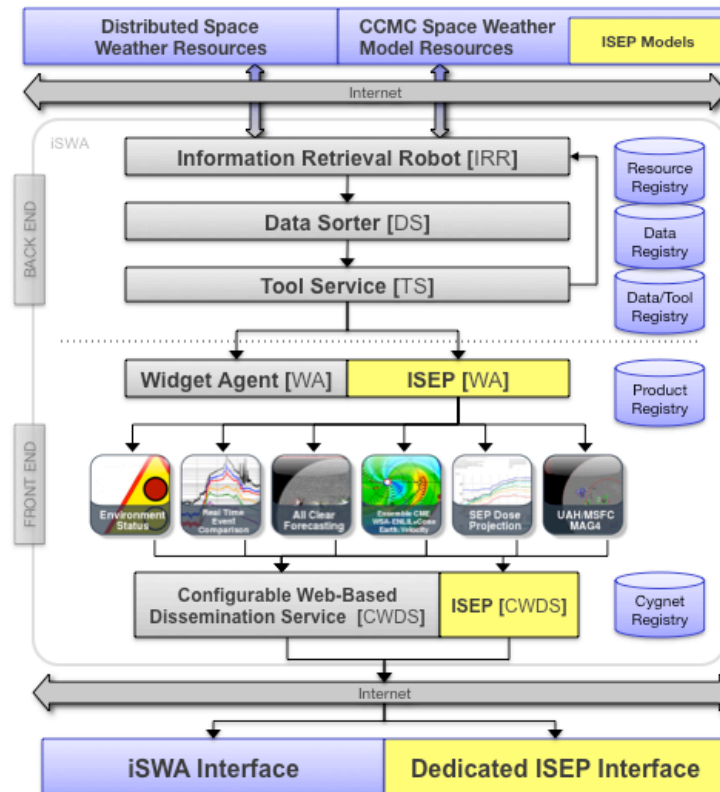
ISEP System

ISEP components are integrated into the iSWA system framework providing a solid development and operational platform. A modular architecture ensures new models, data, features, and functionality can be added to the system.

Summary

- Finishing up end of year three of project

- Focused on transitioning several models to operational tools
  - Not all-inclusive but a reasonable starting point from an operational perspective

- Performance metrics will be available through end-of-year report

- CCMC partnership has been an important piece and will continue