Radiological Contingency Planning

Health Physics Support For The Ground Processing of The Mars Science Laboratory

(Assembly to Launch/May – Nov 2011)
RPS Ground Flow Processing

- Receipt of Radioisotope Power Source (RPS) Unit at Storage Facility
- RPS Unit Checkout at Storage Facility
- Transfer RPS to Payload Processing facility for fit check on Spacecraft
- Transfer RPS back to storage facility
- Loading of science instruments on Rover containing radiation sources
  - X-ray
  - Instrument radioisotope sources
  - Laser source
  - RF Sources
- Transfer RPS to launch pad processing facility
- Installation of RPS unit on spacecraft mounted on top of launch vehicle
Programmatic Aspects

- Maintain personnel radiation exposures as low as reasonably achievable
- Implement work specific radiation permitting system
- Provide appropriate level of worker radiation safety training
- Set up and administer radiation dosimetry monitoring program
- Conduct comprehensive worksite radiation safety oversight
Radiological Safety Aspects of Ground Processing RPS Missions

Maintain personnel radiation exposures as low as reasonably achievable

- Rehearse RPS handling procedures with high fidelity mockup to streamline handling procedures which help reduce time and maximize distance from the source
- Develop a document that summarizes by specific task the location and duration personnel are near RPS units to calculate an expiation dose estimate for a particular ground processing operation
- Install RPS unit on spacecraft as late in the ground processing flow as possible
Radiological Safety Aspects of Ground Processing RPS Missions

- Implement work specific radiation permitting system
  - Who is cleared to work on it
  - What are the required radiation safety requirements to implement
  - What procedures will be followed
  - Where will the work take place
  - What type of personnel radiation dosimetry is required
What is an RPS

- Generates electricity (with no moving parts) and can provide extra heat to keep spacecraft subsystems warm in cold environments
- Uses plutonium dioxide fuel as its long-lived heat source (MSL 10.6 lbs, 60,000 Ci)
- Designed, built and tested to contain its fuel in a wide range of accident conditions
Receipt of RPS Unit at Storage - June 2011
Receipt of RPS Unit at Storage
Receipt of RPS Unit at Storage
Receipt of RPS Unit at Storage
Receipt of RPS Unit at Storage
Receipt of RPS Unit at Storage
### Radiological Safety Aspects of Ground Processing RPS Missions

<table>
<thead>
<tr>
<th>DISTANCE</th>
<th>Neutron mrem/hr</th>
<th>Gamma mR/Hr</th>
<th>Total mrem/Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge of Fintip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Feet</td>
<td>85.2</td>
<td>11</td>
<td>96.2</td>
</tr>
<tr>
<td>3 Feet</td>
<td>39.6</td>
<td>4.7</td>
<td>44.3</td>
</tr>
<tr>
<td>4 Feet</td>
<td>23.6</td>
<td>2.8</td>
<td>26.4</td>
</tr>
<tr>
<td>5 Feet</td>
<td>17.6</td>
<td>1.7</td>
<td>19.3</td>
</tr>
</tbody>
</table>
Radiological Safety Aspects of Ground Processing RPS Missions
RTGF Radiation

2 mr/hr

6 mr/hr

2 mr/hr

2 mr/hr

2 mr/hr

2 mr/hr
RPS to Spacecraft Processing Facility for Fit Check Testing - July 2011
RPS to Spacecraft Processing Facility for Fit Check Testing
RPS to Spacecraft Processing Facility for Fit Check Testing
RPS Fit Testing at Spacecraft Processing Facility
RPS Fit Testing at Spacecraft Processing Facility
RPS Fit Testing at Spacecraft Processing Facility
RPS Fit Testing Back Out & Return to RPS

Storage Facility
RPS Fit Testing Back Out & Return to RPS

Storage Facility
RPS Fit Testing Back Out & Return to RPS

Storage Facility
RPS Fit Testing Back Out & Return to RPS

Storage Facility
Other Radiation Sources on Curiosity

- **Radioactive Material**
  - Alpha X-Ray Spectrometer
    - Curium-244 Plated Alpha Sources – 30 mCi
    - Curium-244 Sealed Gamma Sources - 30 mCi
  - DAN Neutron Pulse Generator for Back Scatter studies
    - Tritium Plated Foil – 2.0 Ci

- **Machined Produced Radiation**
  - CheMin x-ray machine
    - 28 kVp/0.1 mA

- **Laser**
  - ChemCam laser analyzer
    - Nd:KGW (1067nm, 17 mJ Peak Power, 8nsec pulse duration, 1-10 Hz PRF, 1.3 mrad Beam Divergence, with NODH of 1270 meters and Safety Goggle O.D. 5)
Loading Science Instrument Sources and Laser Testing
Loading Science Instrument Sources and Laser Testing
Loading Science Instrument Sources and Laser Testing
RPS Installation on Spacecraft at Launch Pad
Integration Facility - Nov 16, 2011
RPS Installation on Spacecraft at Launch Pad Integration Facility

PLEASE CHECK IN WITH THE HEALTH PHYSICS DESK ON LEVEL 5 BEFORE STARTING YOUR SHIFT.

DAYSHIFT HP: JAMES SHERER AND DAVID LAM
MIDNIGHT HP: CHRIS MILLER AND JOE DEVOR

If you are entering a Radiation Area, you will need a TLD. PICK UP TLD at HP Desk.

BEFORE YOU LEAVE SHIFT – Drop TLD off at HP DESK. DO NOT TAKE HOME!

DID YOU REMEMBER TO TURN IN YOUR TLD?
RPS Installation on Spacecraft at Launch Pad

Integration Facility

[Images of RPS installation process at the Kennedy Space Center Integration Facility]
Radiological Contingency Planning

Kennedy Space Center
Radiation Protection Program

RPS Installation on Spacecraft at Launch Pad Integration Facility
RPS Installation on Spacecraft at Launch Pad Integration Facility
RPS Installation on Spacecraft at Launch Pad Integration Facility
RPS Installation on Spacecraft at Launch Pad

Integration Facility
Ground Operations Radiation Safety Support Summary

- **Radiation Safety Training**
  - ✓ 950 Non-handler (Including personnel in the area) trained
  - ✓ 75 Handlers personnel trained by their organizations

- **Dosimetry**
  - ✓ 125 per month Issued TLD’s with 220 issued during last month
  - ✓ 12-20 Issued EPD’s per day

- **Center Permits**
  - ✓ 8 Radiation Use Authorizations Issued

- **HP Surveys**
  - ✓ 220 Radiation Safety Surveys Performed during 6 month ground operations
MSL RPS Handler Personnel Radiation Exposure Results

Number of Handlers monitored with a TLD.

* Minimum Threshold of Detection = 10 mRem
MSL RPS Non-Handler Personnel Radiation Exposure Results

Number of Non-Handlers monitored with a TLD

* Minimum Threshold of Detection = 10 mRem

Total Dose for Non-Handlers

Number of Non-Handlers received dose above threshold value of 10 mrem

Highest Dose to an Individual Non-Handler
Launch Vehicle Roll Out – Nov 25, 2011
Mars Science Laboratory (MSL)
Radiological Contingency Planning & Launch Support

Feb 2006 – Nov 2011
Radiological Contingency - Concept of Operations

- Presidential Directive HSPD-5 requires Federal agencies follow the National Response Framework (NRF)
- NRF Annex for radiological incidents specifies the role and responsibility for the Coordinating Agency
- For accidents involving the release (or potential release) of nuclear/radioactive materials from NASA spacecraft, NRF specifies that NASA is the Federal Coordinating Agency
  - NASA provides the leadership, expertise, and authority to implement nuclear/radiological aspects of the response
  - NASA is the primary Federal source for information of a technical nature regarding the onsite and offsite radiological effects
  - State and County of Brevard have primary responsibility for implementing protective measures for the public
Radiological Contingency Response Goals

- Notify appropriate agencies in the event of an accident involving potential release of radioactive material
- Generate public information messages on any mishap that are accurate, timely, consistent, and easily understood
- Assess whether a release of radioactive material has occurred
- Quantify and predict the dispersion of any radioactive material released
- Formulate & recommend appropriate protective actions to be taken onsite and offsite
- Support smooth transition to a Unified Command if needed
- Address out-of-launch area accidents resulting in sub-orbital or orbital reentry
Emergency Response Support to Launch

Radiological Control Center (RADCC)
- Technical Monitoring and Assessment Team
- Coordinating Agency Representative Management Group (CMG)
- Joint Information Center (JIC)

Pre-deployed Field Monitoring Capabilities on and off-site
- Environmental Continuous Air Monitoring System – ECAMS
- Field Radiation Monitoring Teams

Consequence Management Home Team – CMHT
- Virtual DOE technical advisory center established in 2010 – functioned as additional technical expertise to backup primary assessment team located in the RADCC
On-Site Radiological Contingency Control Organizations

Radiological Control Center (RADCC)

- Staffed by technical and radiological assessment personnel from NASA, DOE, 45 SW, and State of Florida
- Performed the data collection and assessment function supporting deployment for launch site and field data collection activities
- Evaluated field measurements and data from automated monitoring systems to determine if a radioactive material release has occurred
- Evaluated data collected and develops recommended actions for review by the Coordinating Agency Representative (CAR)
On-Site Radiological Contingency Control Organizations

- Staffed by management authority from NASA, DOE, DHS/FEMA, EPA, State of Florida and Brevard County
- Performed the management decision making activities governing the overall radiological response
- Coordinated NASA response to out-of-launch area accidents through NASA HQ Office of Protective Services (OPS) Rep in CMG
On-Site Radiological Contingency Control Organizations

Joint Information Center (JIC)

➢ Staffed by public information and risk communication specialists from NASA, 45th Space Wing, DOE, FEMA, EPA, State of Florida and Brevard County to provide informational releases to the media on the status of radiological monitoring & assessment actions and conditions post accident.
Organizational Construct-Joint Information Center

JIC Manager PTP to Launch Commentator to be installed at end of table, as space allows

Universal Projection Station for JIC participants. VGA interface available for plug in.

 projection screen
 COPIER
 FAX
 IN
 FAX
 OUT

Presentation Easel
 White Board

NWS REP
 16

USCG PAO
 15

LV ADVISOR
 17

KSC PAO REP
 7

42" Monitor
(Alg-Place Display)

Universal Projection Station for JIC participants. VGA interface available for plug in.

Project Station

JIC MANAGER

Conf Phone

Speaker

OIS-52D

OIS-52D

42" Monitor
(Mtg-Place Display)

FEMA PAO
 11

USAJ PAO

STATE
 OF FL PAO

BREVARD
 CTY PAO

10

DOE PAO

4

DOE JIC REP

2

JPL JIC ACTION MONITOR

24

FEMA PAO

SHREDDING
 CAN

42" Monitor
(Mtg-Place Display)

FEMA PAO

FEMA PAO

LEADERSHIP

BCDS

Selector

Rack

FEMA PAO

SHREDDING
 CAN

42" Monitor
(Mtg-Place Display)
Radiological Contingency Planning

Kennedy Space Center
Radiation Protection Program

Joint Information Center Process

- JIC had preplanned information releases for the following phases
  - Pre-Launch Accidents
  - Early Ascent Initial Announcements
  - Follow-up to Early Ascent Announcements
  - Follow-up to Sheltering Announcements
  - Follow-up to Rad Mon Announcements
  - Late Ascent Accident Initial Announcements
  - Sub Orbital/Orbital Accident Initial and Follow-up Announcements
  - Special Topics (Ag warnings, FRMAC deployment, etc)
- 30+ pages of pre-scripted announcements
- 150 pages of frequently asked questions and responses to queries
- Social media experts driving the instant message process
Overall Data & Communications Architecture
Environmental Continuous Air Monitor (ECAM)

Developed and tested at National Labs
Technology utilized in support of Pluto New Horizons (PNH) launch in 2006
Weather-Resistant
Available and active 24/7
Continuous telemetry data stream to RADCC via satellite (upgraded from PNH line-of-sight configuration)
Direct measurement of breathing zone concentrations
- Selects for respirable particle sizes
- Alpha spectrometer
- Very low minimum detectable activity
- Can distinguish plutonium air concentrations at near-background levels
Generator or AC powered
On-site & Off-Site deployment of field monitoring teams equipped with FIDLER detectors, Alpha survey meters, and hi volume air samplers. Field teams made up of personnel from NASA KSC, DOE, Air Force, and State of Florida Bureau of Radiological Health. Instrument readings were electronically sent to the RADCC & CMHT RAMS servers via use of DOE Tablets and Multi-path Communication Devices (MPCD’s).
Dispersion Modeling Capabilities

- NOAA Wind Data
- Toxics Plots
- NARAC Dispersion Predictions
Launch Modeling

- At L-2 draw shelter in place box around 100 mrem contour
- On-Site EOC’s alert potentially affected areas
- Off-Site BEOC sets up Reverse 911 call list & TV ticker tape messages
Contingency Planning Readiness Activity

Exercises and Verification Tests
- Command Post Exercise with DOE evaluation March 4, 2011
- System Verification Test in conjunction with JUNO countdown August 2, 2011

Multi-agency Integration Activity
- Held 6 fully integrated planning meetings (all participating agencies) July 6-7, 2011
- Hosted FEMA Unified Command assessment team

Readiness Reviews/Presentations
- NASA Administrator (PMC) March 25, 2011
- Presidents Science Advisor (OSTP) June 1, 2011
- Florida Director of Emergency Management October 14, 2011

Miscellaneous
- Mock Press Conference August 2, 2011
- Countdown practice 8 sessions
- On-orbit contingency drills multiple dates
- Field team/resource deployment drills July & Oct 2011
- ECAM testing and satellite communications validation July 2011
- 45 SW Command staff orientations May 18/ June 14/Oct 18
- Editorial Boards Sept 26-29, 2011
- Local Hospital REACTS training October 10-15, 2011
- Brevard County Commission March 1, 2011
- Brevard County League of Cites Board of Directors October 10, 2011
ECAM Field Testing - April 2011

Radiation Protection Program

Radiological Contingency Planning
ECAM Deployment - Oct 2011
Three Days of Radiological Contingency Team Training and Deployment Drill - Nov 10-13, 2011
Launch Day Action - Nov 26, 2011
(RADCC/JIC)
Launch Day Action (RADCC/JIC)
Launch Day (Mobile ECAM Teams)
Launch Day (Field Radiation Monitoring Teams)
Radiological Contingency Planning

Representative MSL Launch Monitoring Locations

- **30 ECAMS (≥65 mile span)**
  - 9 on-site
  - 17 off site
  - 4 mobile (L-2 hr deployment in down wind corridor)

- **16 RADMON Teams**
  - 11 on site (25 personnel)
  - 5 off site (10 personnel)
  - Advanced field instrumentation

- **1 Medical DECON team (clinic)**

- **2 Operational DECON (field)** with specialized instruments
Combined NASA, DOE, 45 SW, State & County assets & personnel worked together to insure a robust deployment was in place to make prompt & comprehensive radiological assessments and insure prompt coordinated protective actions would be taken to protect onsite workforces at KSC & CCAFS, and any offsite areas potentially affected.
Launch - Nov 26, 2011
Show Launch & Animated Landing Videos
Launch Video
Landing
Landing

Sky crane
Curiosity
Back shell
Parachute
Heat shield
Landing
Landing
Landing
Landing
Landing
Landing