OVERVIEW OF FLIGHT RULES

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Purpose :

Flight Rules provide a structure for pre-determined actions to address potential in-flight issues. Pre-determination of action levels facilitates time critical decision-making to meet mission objectives.

Primarily these rules define the interfaces between the Radiation Operations team and Flight Management (Flight Director).

Due to many factors influencing exposures some actions are not listed as mandatory. SRAG will submit recommendations for evaluation consistent w/ALARA. Flight Director will determine actions taken if any.

Flight Rule - Notes

There are two sets of rules: One for Shuttle operations and one for Station operations.

More operational flexibility exists on station. Shuttle is constrained by On-Orbit Time

Currently the Flight Rules are being upgraded. When completed, the shuttle rules will also be up graded.

The Flight Rules presented today represent the direction being developed for Station. The primary focus will be on Crew Exposure Management

Flight Rule Organization:

Section 14 Space Environment Section

General Definitions

Defines event conditions (e.g. artificial events, Major X-ray event, SPE, energetic SPE, Geomag Storm, ALARA etc.)

Radiation Subsystem Loss Definitions

Defines what determines equipment to be out of service

Crew Exposure Management

Most important section, defines actions to assist in management of the crew exposures. Rules are in place to maintain exposure ALARA as well as below legal limits

Radiation Subsystem Management

Special rules for radiation equipment operation

DMI (Designated Maintenance Items)

Additional criteria that hardware may be inoperable.

Maximum Exposure Limits

Joint Exposure Limits (REM)			
	BFO	Eye	Skin
30 Days	25	TBD (50)	150
Annual	50	TBD (100)	300

Note: Joint limits are used in flight rules as mission termination limit. International Partners must agree. Proposal to cut eye limit in half compared to US Legal limit

Note: US legal limits are based on NCRP 98 recommended limits. These are used as a basis for the Joint Exposure Limits.

US Legal Limit Exposure Limits (REM)			
	BFO	Eye	Skin
30 Days	25	100	150
Annual	50	200	300

Alert / Mission Control Manning Levels

SRAG WARNING AND ALERT CRITERIA	
EVENT	**THRESHOLD**
Warnings	
SPE:	≥ 10 pfu @ ≥ 10 MeV
Major Geomagnetic Storm:	A_B = 50-100
Severe Geomagnetic Storm:	A_B ≥ 100
Alerts	
Major X-Ray Flare:	≥ M5
SPE:	≥ 10 pfu @ ≥ 10 MeV
Energetic SPE:	≥ 1 pfu @ ≥ 100 MeV
Major Geomagnetic Storm:	A_B=50-100 or K_B=6
Severe Geomagnetic Storm:	A_B≥100 or K_B=7

: **SRAG recall.**

: **SRAG on-console.**

Warnings:

Notification on projected levels

Alerts:

Notification of actual levels

ALERT Definitions

Major X-ray Flare		> M5
Solar Particle Event		> 10 pfu for > 10 MeV protons > 1 pfu for > 100 MeV protons
Geomag Storm (major)	K_B	> 6
	A_B	= 50 to 100
(Severe)	K_B	> 7
	A_B	$\geq$ 100
Radiation Belt Enhancements		
Artificial Events		

EVENT ACTIONS

Environmental Conditions

Respond to changes in the environment to assess the impact to crew radiation safety. When the environment changes there are certain actions that can be taken by the crew and ground to address the increase or potential increase in exposure to the crew. ALARA recommendations as dictated by environmental conditions.

Classification	Definition	Actions
Normal	No additional adverse environmental condition exists	1. Provide routine crew exposure monitoring: Nominal operations: 4 Hour daily support plus EVA coverage 2. Perform EVA Exposure management Normal Ground Rule planning for ALARA
Alert	Conditions for a significant change are present. Actual increase may or may not occur. If increase occurs may not be "large"	1. SRAG Ops monitoring support increases, as required. 2. Ensure radiation monitoring hardware is at maximum capacity and telemetry is enabled 3. Restrict/reschedule EVA's as required by the EVA Go/No-Go rule.
Contingency	A confirmed increase in radiation exposure levels that may require active intervention to minimize the effects from the enhanced environment.	1. SRAG Ops to 24 hrs. 2. Active seeking of shielded areas during at risk orbital alignments. 3. No EVA except for emergencies –Careful timing recommended if EVA is necessary.

ACCUMULATED EXPOSURE ACTIONS

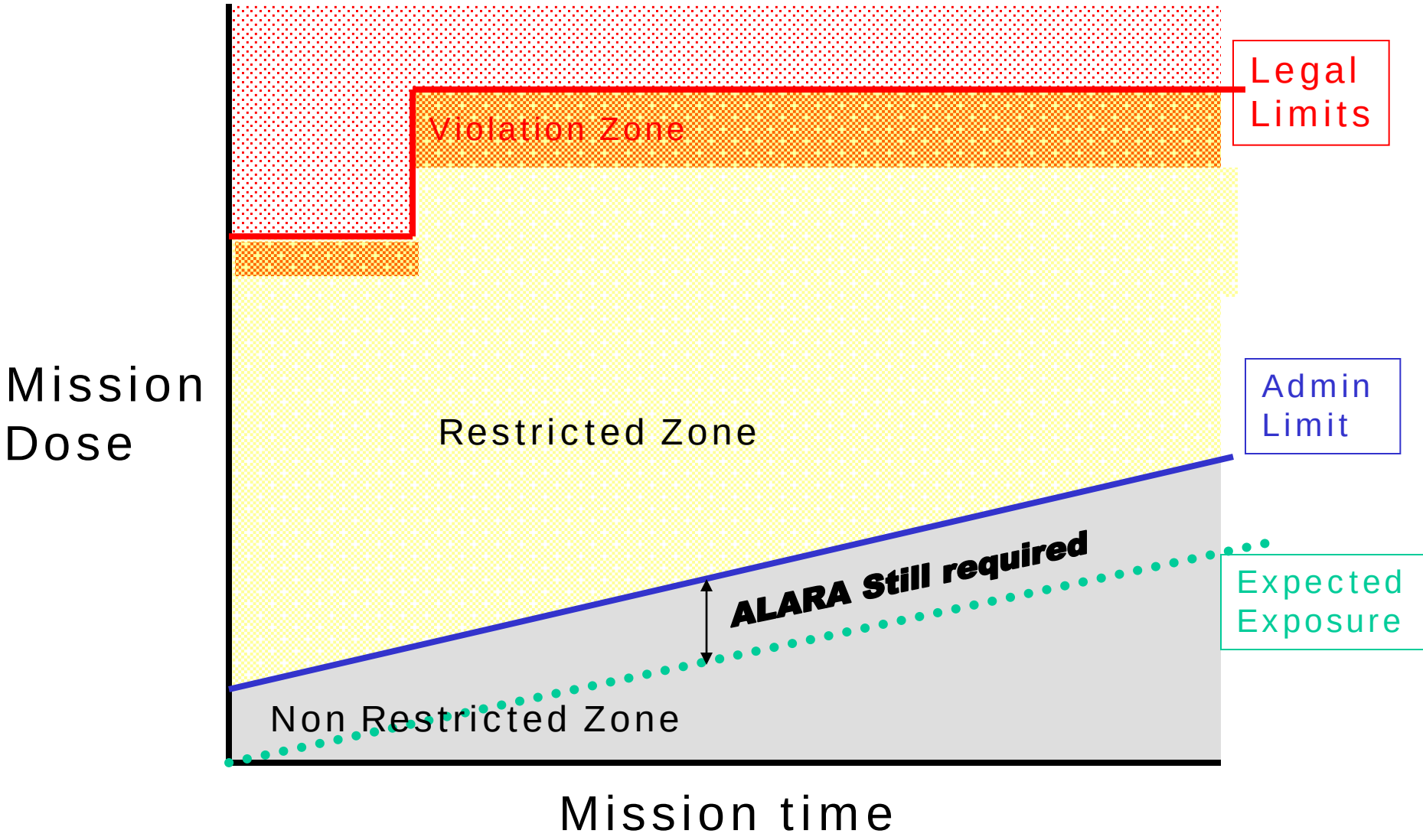
Exposure (History) Status

A reflection of how the exposure of the crew has progressed during the mission relative to the limits.
For ALARA, the higher the exposure history the greater the radiation safety restrictions.

Exposure Status	Definition	Action required
Non-restricted	Cummulative crew radiation exposure is within pre-flight projections.	1. Provide routine crew exposure monitoring 2. Perform EVA exposure management Ground Rule planning for ALARA (typically SAA avoidance)
Restricted	Cummulative crew radiation exposures have exceeded administrative limits Internally derived administrative limits are used to base intermediate actions	Dose management actions are required. Non restricted actions plus: 1. Review EVA schedules and update end of mission exposures. 2. **Consider** positive actions to reduce the risk of exceeding the exposure limits such as having affected crewmember sleep in more heavily shielded locations and limiting/rescheduling EVAs
Violation	A radiation dose extrapolation that violates a legal limit based on analytical projections with accumulated rates confirmed by onboard dosimetry readout.	Restricted Plus: 1. **Take** positive actions to reduce the risk of exceeding the exposure limits, Such as having affected crew member remain in more heavily shielded location, limiting EVAs or returning to the ground at the earliest opportunity

Administrative Limits

DRAFT CONCEPT



Basis for Administrative Limit

A certain amount of daily exposure is unavoidable.

A small margin is applied to the expected exposure levels as a buffer to allow for some contingency dose to accumulate (i.e. exposure above normal quiescent projections). This level defines where additional actions will be required.

This margin corresponds roughly to the exposure inside the station during one of the largest events under quiet magnetic conditions.

It is expected that only 2 or 3 events per cycle could trigger crossing the threshold.

International Concurrence required to implement as Station Rule

Preliminary Implementation:

.5 rad/month background (instrument measured dose)

.5 rad/mission margin for additional exposures (on instruments)

EVA RULE PART I

Conditions: Below Administrative Limit
(non-restrictive)

Actions:

Scheduled EVA:
Consider Delay up to 2 days
Consider Adjust Egress 1- 2 revs
(up to ± 3 hours)

Inherent risks of performing an EVA accept risk of additional exposure in below the admin limit. Reduce exposures if practical (ALARA)

EVA In progress:
Continue in EVA progress
Consider not adding unscheduled items
(if resulting in additional exposure)

Risk has already been incurred to perform EVA. Allowed to continue below admin limit. Exposures for an event commencing growing to large level before EVA unlikely.

Additional tasks not added for ALARA

EVA RULE PART 2

Conditions: Projected to Exceed Administrative Limit (restrictive)

Note:
14 days for Station is satisfactory, but not for the shuttle. The Shuttle-only rule will have to have different requirements.

Actions:

Scheduled EVA:
Delay up to 14 days
Adjust Egress 1- 2 revs
(up to ± 3 hours)

Radiation Risk has risen to higher levels. If effective, time shifting will be done to reduce exposures, otherwise it will be replanned.

EVA In progress:
Consider expediting EVA progress
Delete tasks not required for primary mission objectives
(if resulting in additional exposure)

Risk has already been incurred to perform EVA. Allowed to continue but, if practical, expedite by deleting tasks not required for primary mission objectives.

Additional tasks not added for ALARA

EVA RULE PART 3

Conditions: Projected to exceed High Dose Rate Limit (an additional admin limit)

NOTE

High dose rate limit is:
5 rad/day
instrument reading
Based on NCRP Rpt 98 threshold for high dose rate

Actions:

Scheduled EVA:
Rescheduled to be less than the limit

Risk levels have increased so the EVA is replanned to lower the exposures

EVA In progress:
Expedite EVA progress
Delete tasks not required for primary mission objectives
(if resulting in additional exposure)

EVA is expedited and extra tasks deduced to limit risk.

EVA RULE PART 4

Conditions: Projected to exceed Joint Exposure Limits (Legal Limit)

Actions:

Scheduled EVA:
Rescheduled to be less than the limit

EVA In progress:
Terminate an EVA

Legal Exposure limit is:

BFO	25 Rem /30 day
Eye	Joint TBD
Eye	100 Rem/ 30 day (legal)
Skin	300 Rem / 30 day

Risk levels have increased so the EVA is replanned to lower the exposures

EVA is terminated to limit exposures below legal exposure guidelines.

Space Weather Metrics: EXPOSURES

Chest X-ray	0.01 rads	
A day on orbit solar max (no events, ballpark number)	0.02 rads	
A poorly timed EVA could easily be (normal conditions)	0.4 rads	
During a severe electron belt enhancement	40.0 rads	
Oct 89 event inside shuttle (no mag storm, skin)	0.8 rads	
Oct 89 event inside Station (no mag storm, skin, calc only)	0.4 rads	No verification of ISS levels
Oct 89 event Shuttle worst 6 hrs (Skin)	0.6 rads	
Oct 89 EVA (Worst 6 hours, no mag storm, skin)	0.9 rads	
Oct 89 EVA (Whole event, no mag storm, skin)	1.0 rads	
Oct 89 IVA Mir total dose estimated by crew dosimeters (mag storm)	1.5 - 3.0 rads	

Oct 89 event projections seem low because a stable geomagnetic field was used to project. Newer tools are becoming available to estimate during altered magnetic conditions. In reality, one of the stormy periods coincided with the Oct 89 event so projected levels should be higher