Overview of Graphical User Interface for ARRBOD (Acute Radiation Risk and BRYNTRN Organ Dose Projection)

Myung-Hee Y. Kim,1 Shaowen Hu,1 Hatem N. Nounu,1 and Francis A. Cucinotta2

1USRA, Division of Space Life Sciences, Houston, TX 77058, USA
2NASA Johnson Space Center, Houston, TX 77058, USA

F23, 38th COSPAR, 18-25, July 2010, Bremen, Germany
Brief Overview

- Acute Radiation Risk (ARR) and BRYNTRN with SUMDOSE codes are developed at NASA JSC.
- BRYNTRN is a Baryon transport code with an output data processing module of SUMDOSE written in FORTRAN; and ARR in C.
- A future version to estimate cancer risks will use FORTRAN/C++.
- The risk models (Organ dose, ARR, & Cancer) take the output from BRYNTRN as input for the calculations.
- BRYNTRN code operation requires extensive input preparation.
  - With GUI to handle input and output for BRYNTRN, the response models can be connected easily and correctly to BRYNTRN in friendly way.
Objectives

- Support of mission/spacecraft design and operational planning to manage radiation risks in space missions.
- NASA trade studies of mission scenarios, shielding materials, masses and topologies for protection of astronauts from space radiation.
- Proper shielding solutions to avoid ARR symptoms and to stay within the current NASA Dose limits.
- Quantified evaluation of dose and ARR severity to guide alternative solutions for the determined objectives set by mission planners.
The integration of risk projection models of organ doses and acute radiation risk has been a key problem for human space applications.

Baryon transport (BRYNTRN) code operation requires extensive input preparation.

Only a graphical user interface (GUI) can handle input and output for BRYNTRN to the risk response models easily and correctly in a friendly way.

A GUI for the Acute Radiation Risk and BRYNTRN Organ Dose (ARRBOD) projection code provides seamless integration of input and output manipulations, which are required for operations of the ARRBOD modules: BRYNTRN, SUMDOSE, and the ARR probabilistic response model.

A proof-of-concept for future integration of other risk projection models for human space applications.
Applicability

- Mission and spacecraft designers
- Aerospace engineers
- Space operations in the Mission Operations Directorate (MOD)
- Space biophysicists
Release History

- Beta version released to the testers in May 2009.
- Version 1 released to US citizens and ISS partner nations in March 2010.
- NASA TP-2010-216116 distributed to the managers and researchers at NASA centers and to the researchers at US academia/research institutes in March 2010.
Development of Graphical User Interface for ARRBOD
(Acute Radiation Risk and BRYNTRN Organ Dose Projection)

Myung-Hee Y. Kim,¹ Shaowen Hu,¹ Hatem N. Nounu,¹ and Francis A. Cucinotta²

¹Universities Space Research Association, Houston, TX  77058, USA
²NASA Johnson Space Center, Houston, TX  77058, USA
Future Plans for Development and Use

- Add functionalities
  - Shield file supplied by user
  - SPE spectra data files supplied by user
- Add blood kinetics to ARR model.
- Add cataract risk project based on NASA Study of Cataracts in Astronauts (NASCA) and NASA Space Radiation Laboratory (NSRL) data.
- Add Probabilistic Risk Assessment (PRA) approach to SPE protection (Hazard function).
- The deterministic method of ARRBOD to be evolved to GCR Event-based Risk Model (GERM) Space code for the description of time-dependent biophysical events with reduced uncertainty.
- Overall I/O Sequences of Risk Calculations
- Output of ARR Sickness Severity Levels
- Output of Organ Dose for SPE Exposure
- References
Overall I/O Sequences of Risk Calculations

ARR directly? y n

Whole body exposure

Acute dose

Protracted dose

Total BFO dose in Gy-Eq?

Total BFO dose in Gy-Eq? Exposure time, hr?

BRYNTRN input file for SPE exposure

BRYNTRN

Dosimetry output

Physics output

SUMDOSE

Organ dose

Gender

Male

Female

BFO\text{Male}(EVA)

BFO\text{Female}(EVA)

EVA duration in hr?

EVA duration in hr?

Pull down menu for Spacecraft:

BFO_{\text{craft}} = BFO\text{Male}(x)

Pull down menu for Spacecraft:

BFO_{\text{craft}} = BFO\text{Female}(x)

directly or

Organ dose

More ARR y n

Severity/dose summary

Go to Main y n

End

Page No. 10
## ARR Sickness Severity Levels

<table>
<thead>
<tr>
<th>Severity level</th>
<th>Upper Gastrointestinal Distress (UG)</th>
<th>Fatigability and Weakness (FW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td>2</td>
<td>Upset stomach, clammy and sweaty, mouth waters</td>
<td>Somewhat tired with mild weakness</td>
</tr>
<tr>
<td>3</td>
<td>Nauseated, considerable sweating, swallows frequently to avoid vomiting</td>
<td>Tired with moderate weakness</td>
</tr>
<tr>
<td>4</td>
<td>Vomited once or twice, nauseated, and may vomit again</td>
<td>Very tired and weak</td>
</tr>
<tr>
<td>5</td>
<td>Vomited several times, including the dry heaves, severe nauseated, and will soon vomit again</td>
<td>Exhausted with almost no strength</td>
</tr>
</tbody>
</table>
**NASA limit for organ dose**

<table>
<thead>
<tr>
<th>Exposure limit by NASA*</th>
<th>Organ dose, Gy-Eq</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-d limit at Skin</td>
<td>1.5</td>
</tr>
<tr>
<td>30-d limit at Eye</td>
<td>1.0</td>
</tr>
<tr>
<td>30-d limit at BFO</td>
<td>0.25</td>
</tr>
<tr>
<td>Min BFO dose for ARR</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*National Research Council/National Academy of Sciences (NRC/NAS), Committee on the Evaluation of Radiation Shielding for Space Exploration. Managing space radiation risk in the new era of space exploration, the National Academies Press; 2008.*

---

**Graph: Shield thickness vs. Organ dose, Gy-Eq**

- **SKIN**: 30-d limit at Skin (1.5 Gy-Eq)
- **EYE**: 30-d limit at Eye (1 Gy-Eq)
- **BFO**: 30-d limit at BFO (0.25 Gy-Eq)
- **Min BFO dose for ARR**: 0.5 Gy-Eq

---

Page No. 12
References