



# Risky business: The science and art of radiation risk communication in the high risk context of space travel



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Successfully communicating complex radiation exposure outcomes within the high-risk context of space travel presents a unique challenge. A majority of the potential risks of space radiation will be realized later in life; it is hard to draw comparisons between these events and more acute spaceflight risks such as hypoxia and microgravity-induced bone loss. Additionally, unlike other spaceflight risks, there is currently no established mechanism to mitigate the risks of incurred radiation exposure such as carcinogenesis. Despite these challenges, it is the duty of the Space Radiation Analysis Group (SRAG) at NASA's Johnson Space Center to effectively convey to astronauts the risks associated with exposure to the space radiation environment. To this end, astronauts and their flight surgeons are provided with an annual radiation risk report documenting the astronaut's individual radiation exposures from space travel, medicine, and internal radiological procedures. In an effort to improve communication of radiation risk, the current report style is reviewed and an alternative is explored to better communicate risk to astronauts, flight surgeons, and management.

What about medical? We're talking about only including research studies in the REID

Get these off the front page since they don't go in to the REID "Safe Days" NEEDS to go! See below

These values should reflect the 95% confidence interval rather than a central estimate because that's what NASA standard 3001 uses

Use "out of 100" rather than %REID to avoid percents of percentages

Let's add a "Total REID" category that includes "Total Space" and relevant Medical

Is effective dose the right metric to use? We will need to combine with medical for a total

Do we even want to include REIC here?

Scale to reflect NASA Limit and other relevant values

How about the new LxC values? Management would like to see that

We need better explanations of what these values mean and where they come from

Can we PLEASE come up with a new metric? "Safe Days" implies that if you spend a single day more in space, you are no longer safe, as though the limit is a threshold. Maybe incorporate values for current and future risk?

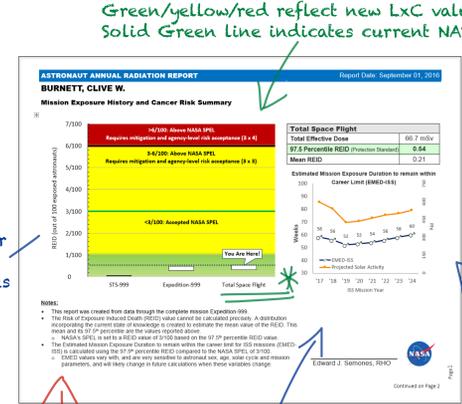
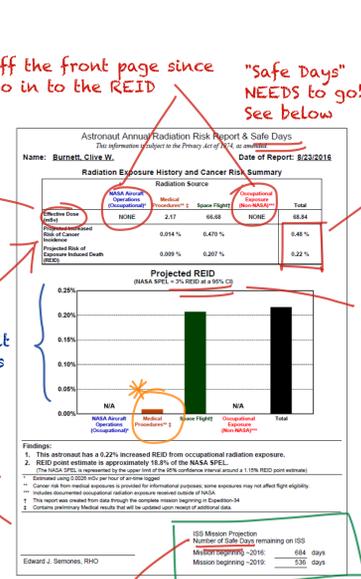
Crew and Surgeon really focus on this information for career planning, but the value will likely change with time. Can we do a calculation for more years? Maybe include solar cycle parameter(s) to show how these values can change?

Please take a post-it note and leave your feedback in the white space!

First page focuses on space exposures, everything else relegated to following pages

How about this color scheme?

Or do we want a more temporally defined metric?

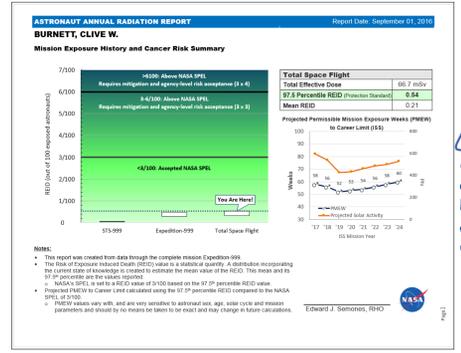


That solid RED BLOCK might suggest that over 6/100 you go from safe to NOT safe Maybe we should avoid that?

Color reflects where you stand within the limit

Use Phi as solar cycle surrogate

New metric defined (EMED) to replace Safe Days reported in any duration - weeks, months, etc. (days reflects granularity we just don't have)



Space Radiation Exposures table with columns: Mission Name, Period, Duration (hr), Dose Rate (mSv/hr), REID, REIC, and Projection of Component.

Put these on the front page

Medical Radiation Exposures table with columns: Exam Date, Type, Asympt, Projection, Purpose, MED/REID, Effective Dose (mSv), REID, REIC, and Preliminary/ Final.

Streamline: there's a lot of information here that's not necessary

Good for record-keeping, but since diagnostic medical isn't included in the REID let's only display doses

REID/REIC values should not be calculated for individual medical exposures

Diagnostic medical

Space for anything that needs to be defined

Astronaut Annual Radiation Report for Burnett, Clive W. Other Radiation Exposures Summary. Includes a table for Medical Radiation Exposures and a table for Other Radiation Exposures.

Medical likely needs to be broken into diagnostic (not included in the REID) and research (included in the REID)

Careful review of the current report style reveals many opportunities to improve exposure and cancer risk communication to stakeholders. The first page of the report is dedicated to space exposures. For career planning purposes, a highly important aspect of the report to crew and flight surgeons is the remaining duration an astronaut has until the NASA limit is reached. Because this value is not fixed, a range is now given that reflects how this limit might vary with environmental parameters and astronaut age and sex. Reported REID values reflect the 95<sup>th</sup> percentile of the distribution since this value is defined as the risk limit in NASA Standard 3001. A condensed format of additional exposures is included in subsequent pages for record keeping purposes. The NRC recommends that NASA no longer include diagnostic medical exposures in the REID calculation as the benefits from these diagnostics outweigh the risks from radiation. If implemented, only elected medical research studies which contain an ionizing radiation component will be included in the REID calculation. Thus, flight surgeons and their crew are empowered to make decisions regarding medical care without being constrained by the NASA risk limit. While medical exposure doses will be presented in the report, risk estimates from these will not be individually calculated. Each medical exposure that does contribute will be included in the occupational exposure total. More adjustments can likely be made to further improve risk communication. Feel free to contact the authors with any feedback.