

# Increased Cancer Mortality Risk for NASA's ISS Astronauts: the Contribution of Diagnostic Radiological Examinations

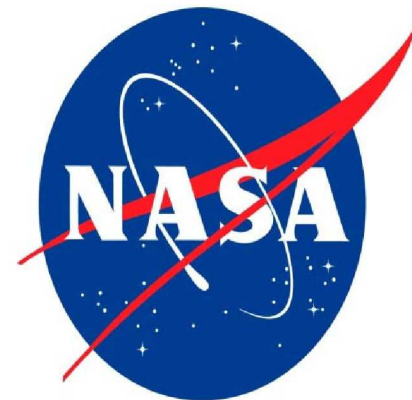
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# NASA Policy & Practices

- **NASA Standard 3001 – NASA SPACE FLIGHT HUMAN SYSTEM STANDARD VOLUME 1: CREW HEALTH**
  - Career exposure to radiation is limited to not exceed 3 percent Risk of Exposure Induce Death for fatal cancer.
  - Short-term dose limits are imposed to prevent clinically significant non-cancer health effects including performance degradation, sickness, or death in-flight
    - Limited by specific organ, i.e. Blood forming organs, lens of the eye, skin, etc
- For limitation of astronaut risks, NASA monitor all exposures to radiation from spaceflight, occupationally related aviation, and medical exposures required for flight certification
  - The monitoring of aviation and medical exposures is a departure from accepted practices within the ground based radiological protection community

**Note: this presentation focuses on radiation exposure risks incurred by the Astronaut Corp**

# Motivation

- The NASA Radiation Health Officer found a need to educate physicians and astronauts on the radiation exposures and relative risks from various procedures
  - Particularly at a time when new monitoring requirements were being considered
  - This information can also be useful for counseling astronauts reluctant of x-ray exams for fear it may limit their flight career

# Required X-rays

Diagnostic X-ray images are required for:

- Acceptance into the Astronaut Corps.
- Screening for mission impacting health issues
- Monitoring of physiological changes due to long-term spaceflight
- Verification of recovery to pre-flight health following long-term spaceflight

# Currently Required X-rays

<u>Monitored X-ray Exams</u>	<u>Frequency</u>
<b>Bone Density (DEXA)</b>	<b>Upon selection into Corps Tri-annual 6 months post flight until density recovery</b>
<b>Chest x-ray</b>	<b>Annual</b>
<b>Coronary Calcification (EBCT)</b>	<b>Upon selection Males 40+ every 5 years Females 50+ every 5 years</b>
<b>Dental     Bitewing     Panoramic</b>	<b>Once per year Every 5 years</b>
<b>Mammogram</b>	<b>Upon selection 40-50 years old every two years 50+ years annual exams</b>

# Dose Computation

Doses were computed on the average male and female astronaut using commercially available software\*:

<u>Male :</u>		<u>Female:</u>	
Height	177 cm	Height	169 cm
Weight	82.7 Kg	Weight	63.1 Kg

**Average age at entry into the Corps      36**

**Average age at first mission                      42**

**Average age at second mission                    52**

\* PCXMC and ImPACT

# Dose Results

## Males

Exam Type	Effective dose per series (mSv)	Percent of average U.S. annual dose
Chest	0.1	3.0 %
EBCT	0.3	8.3 %
Dental Bitewing (4) or Panoramic	0.028 0.03	0.78 % 0.83 %
DEXA series (7)	0.013	0.4 %

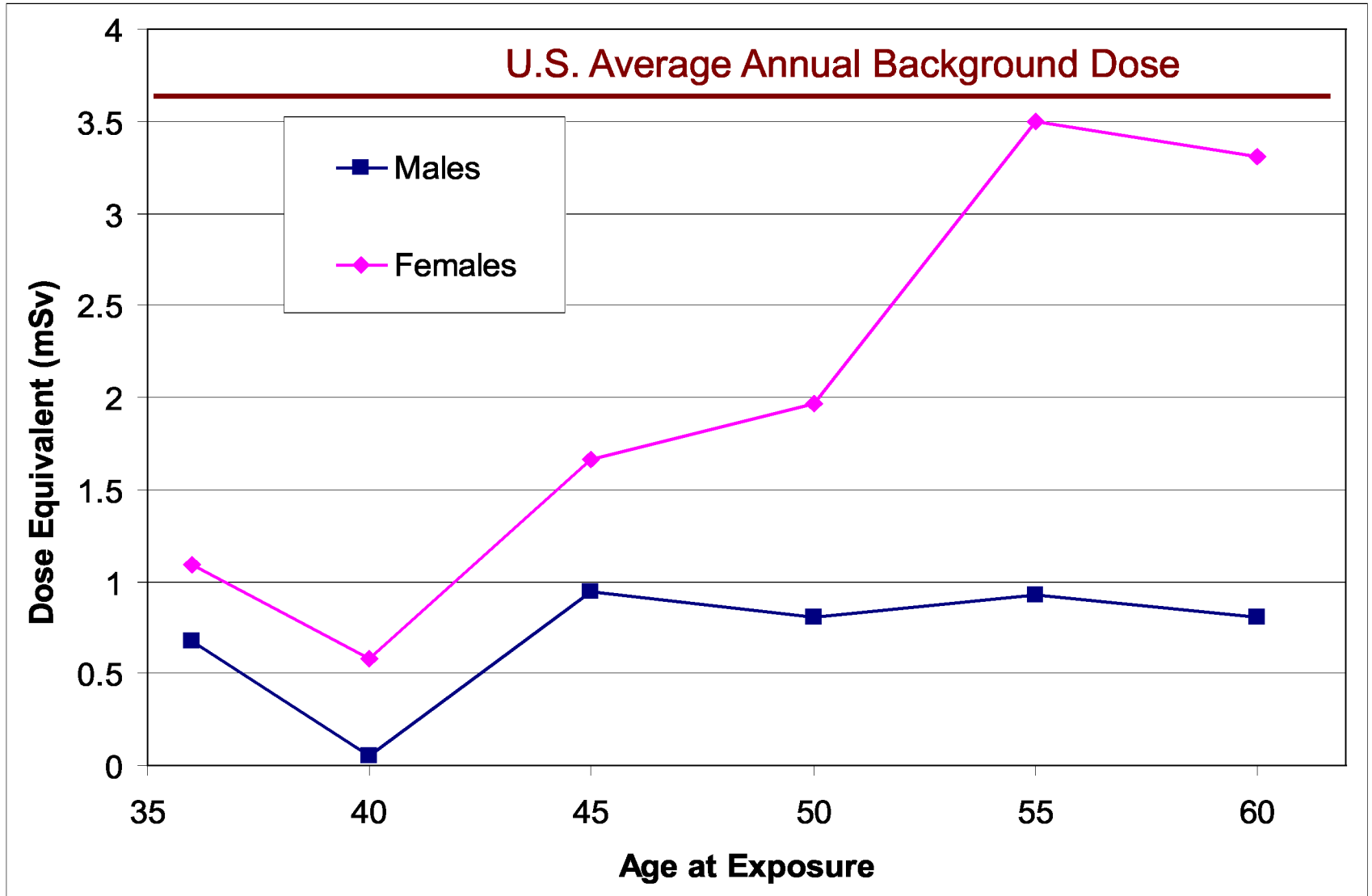
## Females

Exam Type	Effective dose per series (mSv)	Percent of average U.S. annual dose
Chest	0.1	3.0 %
EBCT	0.3	8.3 %
Dental Bitewing (4) or Panoramic	0.028 0.03	0.78 % 0.83 %
DEXA series (7)	0.025	0.7 %
Mammogram	0.52	14.4 %

U.S National Average Background Dose  $\approx$  360 mrem / year

# Dose Results

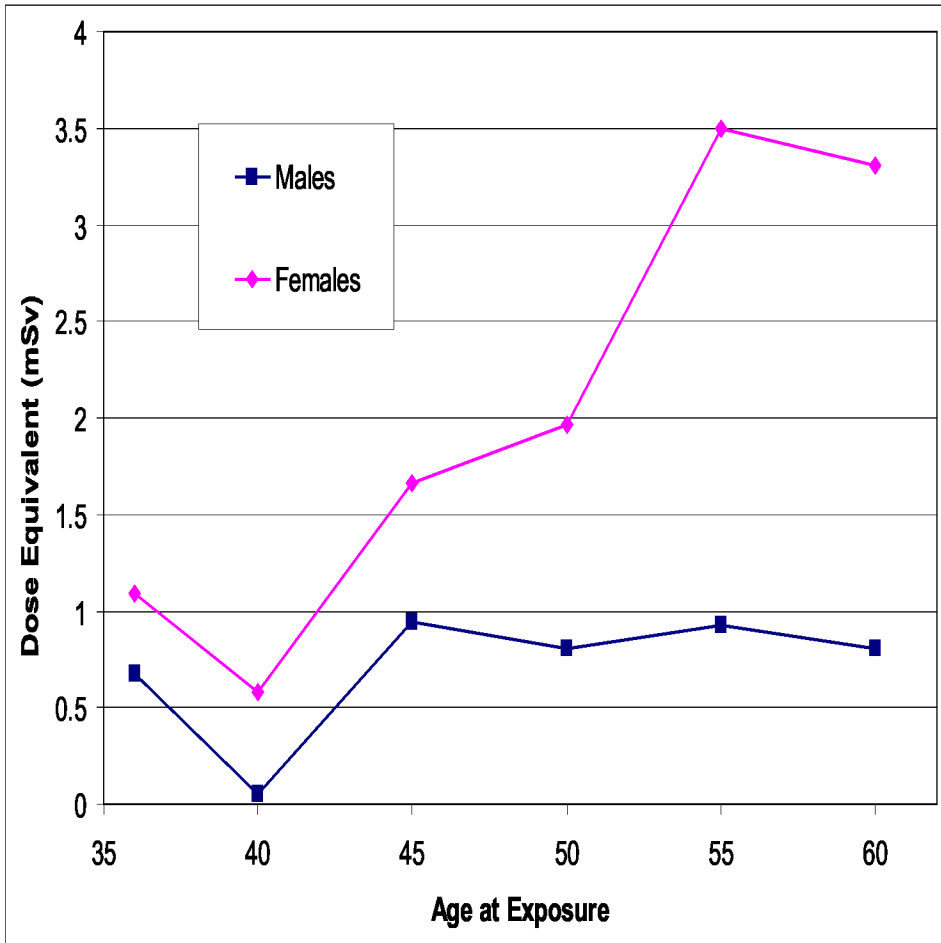
## Annual Dose from Required Medical Exams



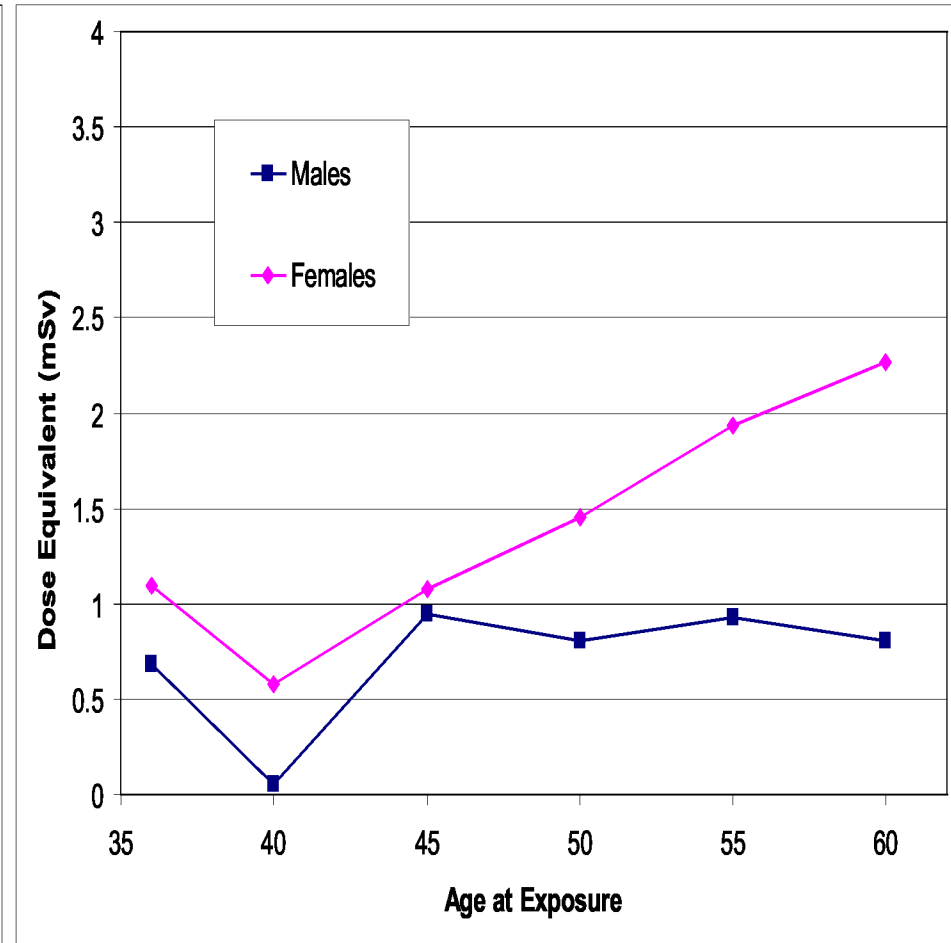


# Dose Results

## Annual Dose from Required Medical Exams



All Breast exams from X-rays



Breast exams Alternating between X-rays and MRIs

# NASA's Risk Model

- **REID – Risk of Exposure Induced Death**
  - Cancer induction is believed to be the most significant health impact from radiation exposure
  - In current model risk varies with the age and sex of the astronaut
  - Non-cancer mortality not currently included
- **NASA is required to manage to below a 3% excess risk of death**
  - Uncertainties in the risk projection are large enough that NASA manages to the 95% Confidence Interval
- **Data on non-cancer mortality are being accumulated and should be reflected in NASA's next risk model**

# Risks in Perspective

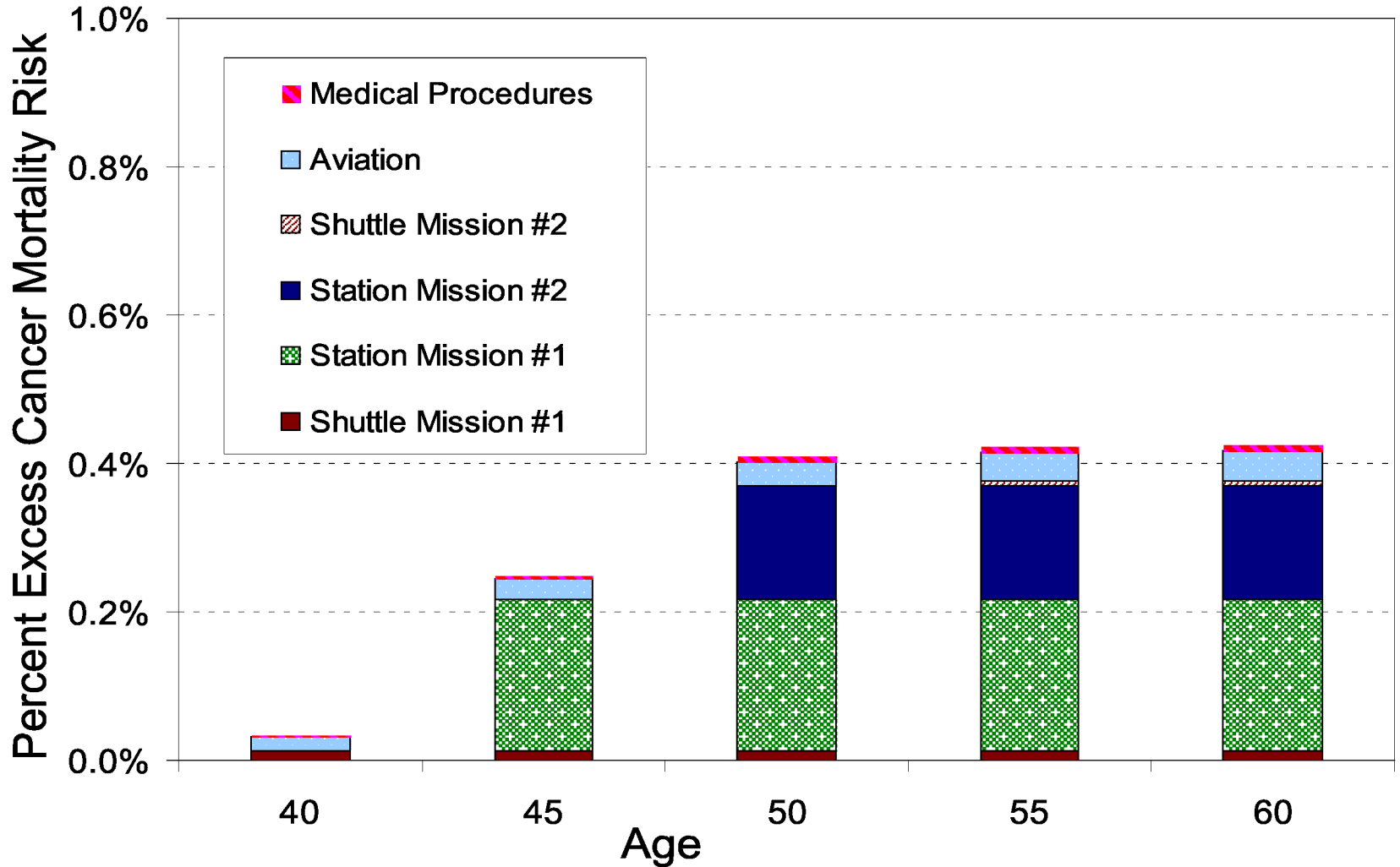
- To compare doses from medical exposures the risks were compared to a long astronaut career
  - Continuing availability for spaceflight is the main concern for most astronauts
  - Medical doses were compared to a male and female astronaut with a total of 2 typical shuttle missions **and** 2 typical space station missions.

## Currently

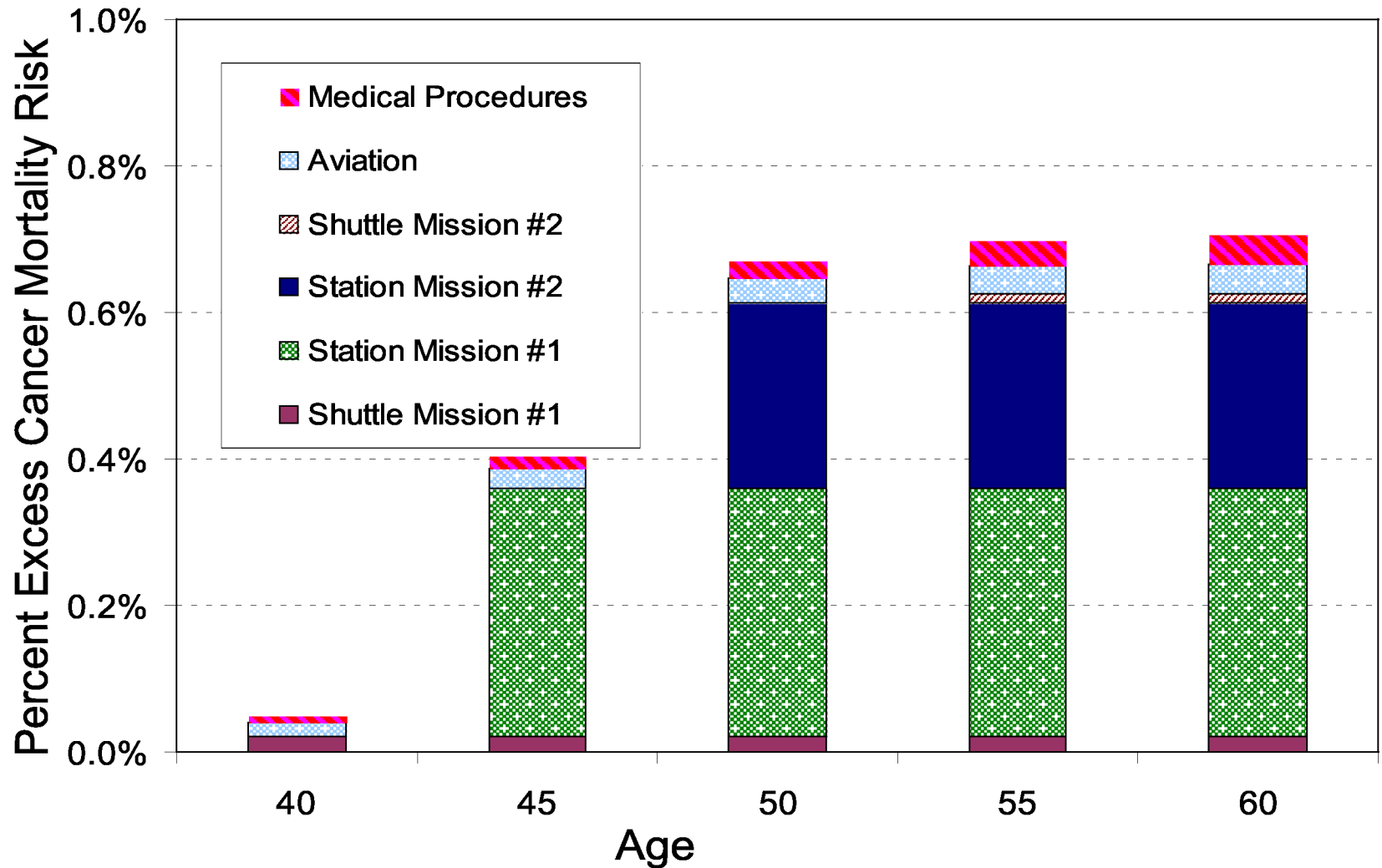
Typical Shuttle mission – 300-400 km – 2 weeks – 8 mSv (800 mrem)

Typical Station mission – 300-400 km – 6 months – 80 mSv (8000 mrem)

# Cumulative Excess Mortality Risk Male



# Cumulative Excess Mortality Risk Female



# Conclusions

- Medical has a very low overall contribution
  - 1 day in space  $\approx$  2.5 chest x-rays (0.10 mSv)
  - 1 day in space  $\approx$  43 days on earth (3.6 mSv / yr)
- Career cumulative mortality risk from diagnostic x-rays
  - Males 0.014 % or 1.4 in 10,000
  - Females 0.046 % or 4.6 in 10,000
- Medical x-rays will not prohibit an astronaut (male or female) with an long career from additional missions

**Questions ?**