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

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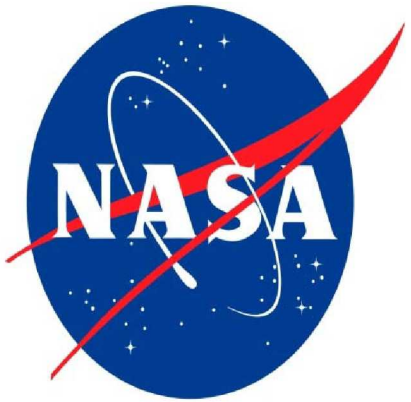

NASA Policy & Practices

- **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

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  - 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

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

Dose Computation

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

Male :		Female:	
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 %

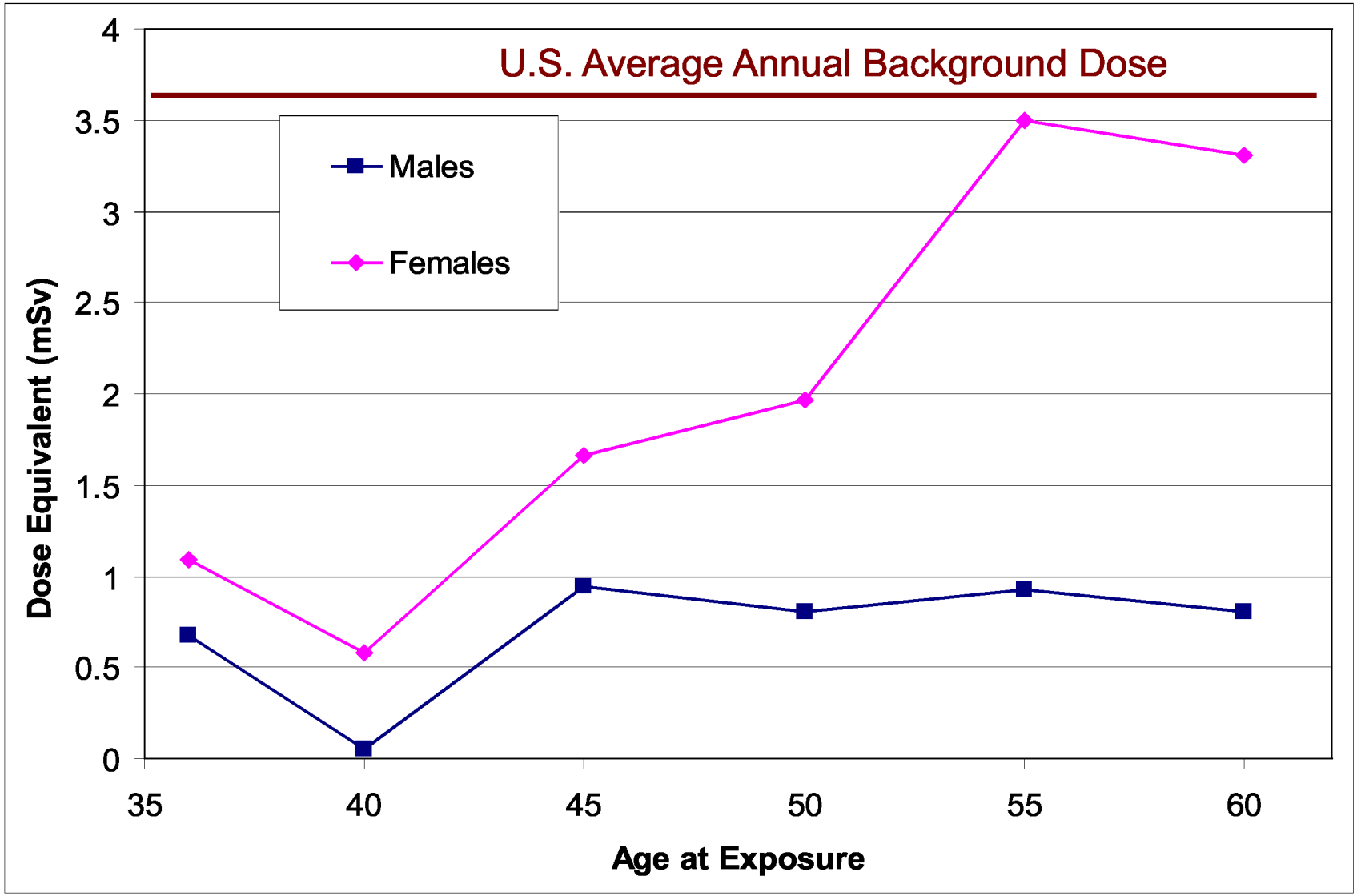
Females

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 ≈ 360 mrem / year

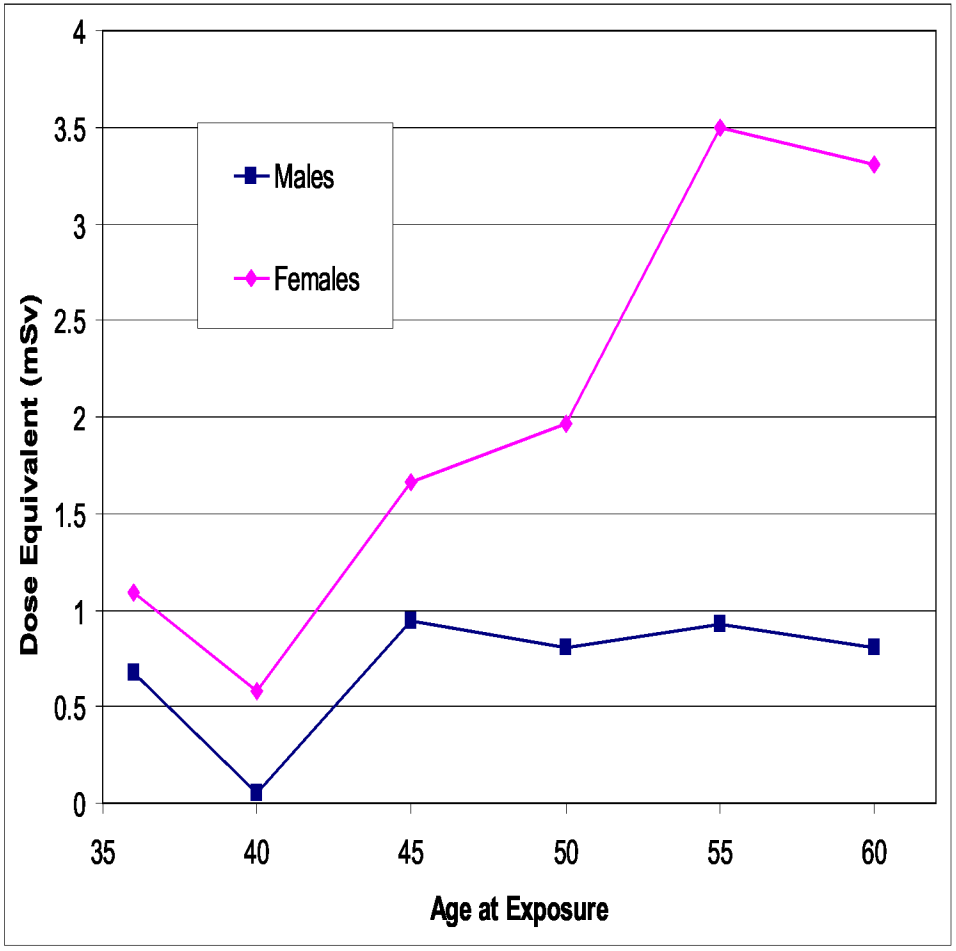
Dose Results

Annual Dose from Required Medical Exams

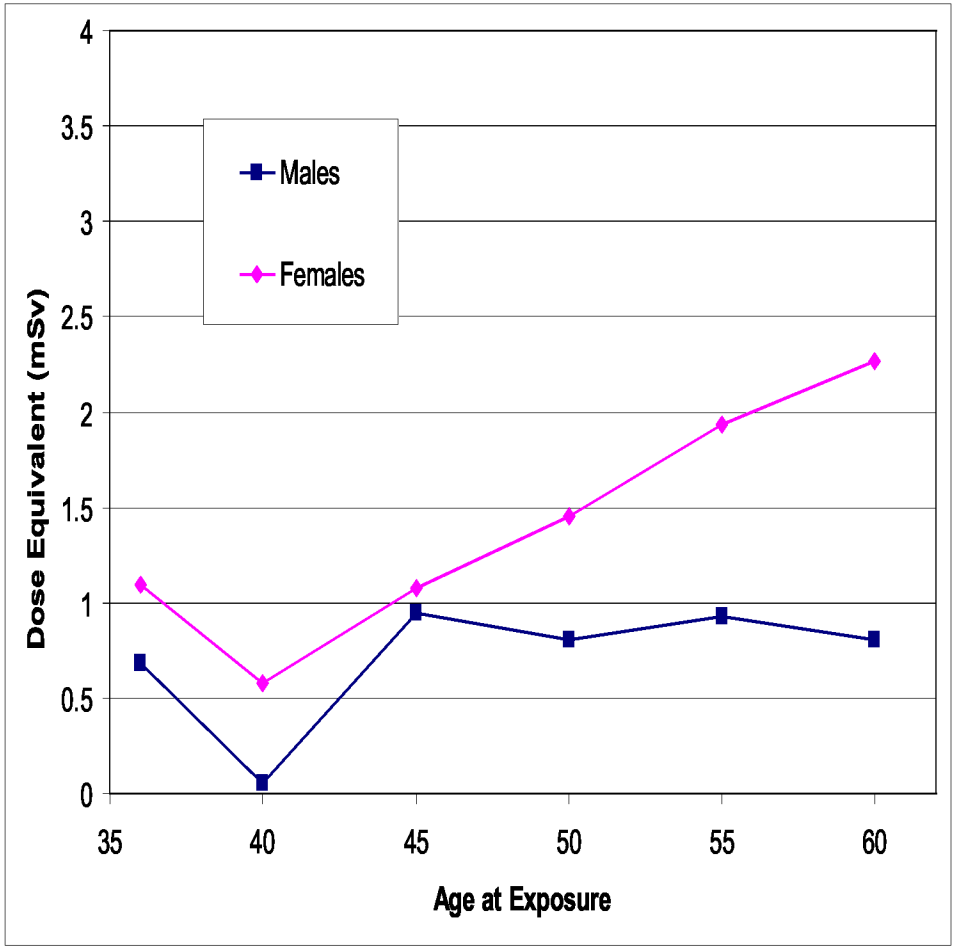


Dose Results

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** – **R**isk of **E**xposure **I**nduced **D**eath
  - 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.

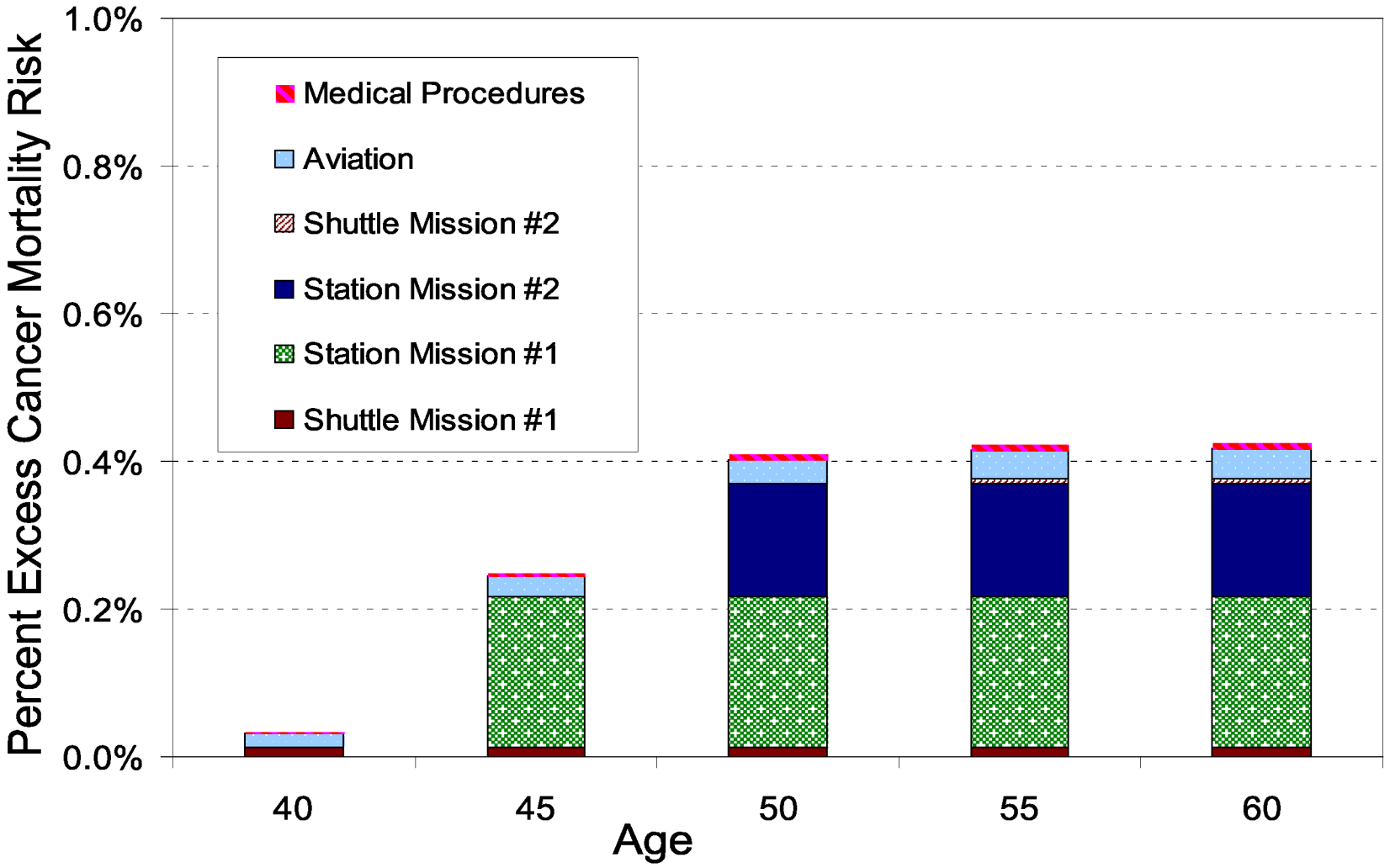
Currently

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

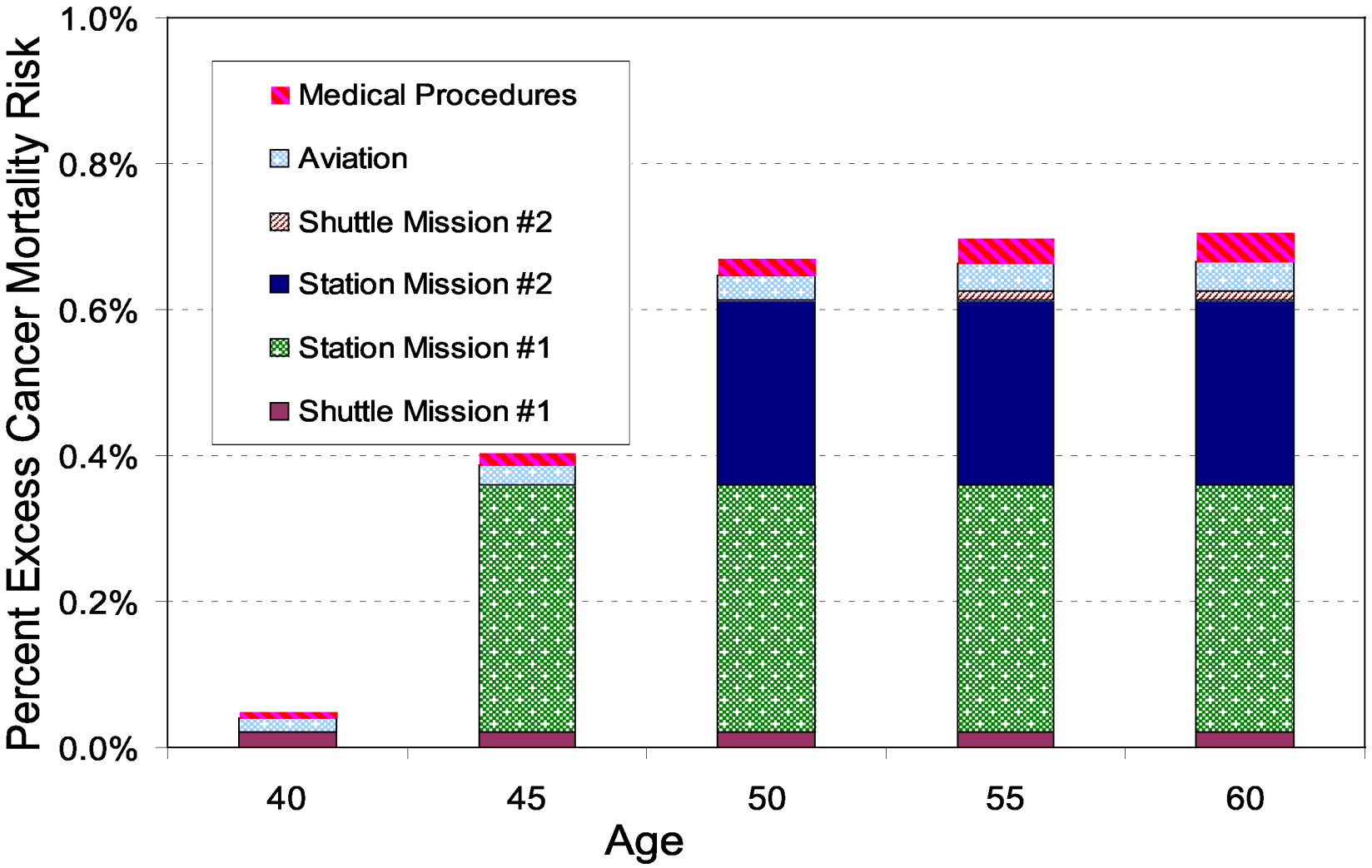
Typical Station mission – 300-400 km – 6 months – 80 mSv (8000 mrem)

Cumulative Excess Mortality Risk

Male



Cumulative Excess Mortality Risk
Female



Conclusions

- Medical has a very low overall contribution
  - 1 day in space ≈ 2.5 chest x-rays (0.10 mSv)
  - 1 day in space ≈ 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 ?