

Uncertainty Effects from an Asteroid Risk Assessment Perspective for the PDC25 Impact Scenario

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Asteroid Threat Assessment Project (ATAP)

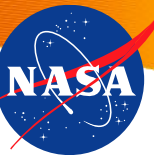
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Big Picture for Uncertainty

- **Three main sources of uncertainty** in the Probabilistic Asteroid Impact Risk (PAIR) model:
 - Properties/Parameters we can improve ← **This Study**
 - Properties/Parameters we can't measure
 - Model uncertainty

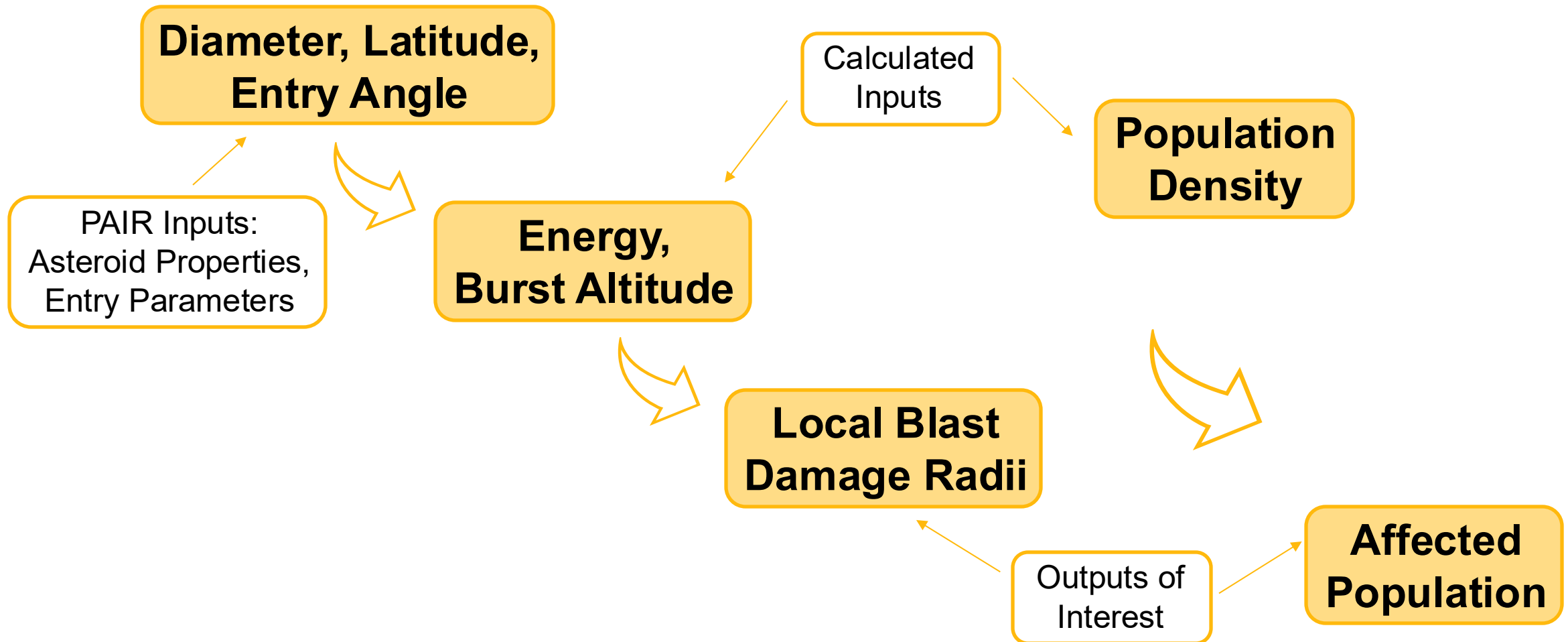
Big Picture Goal: Understand the expected benefit to our risk knowledge from gaining additional sources of information, using the PDC25 Exercise Scenario as a case study

Highlight PAIR model input refinements between scenario epochs

Evaluate effect of uncertainty refinements on PAIR model outputs

Analyze overall knowledge gain from JWST observations and flyby reconnaissance

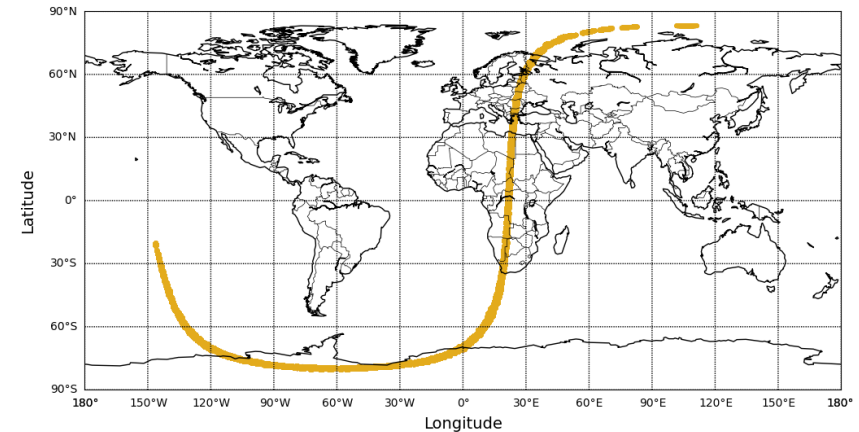
PAIR Inputs and Outputs



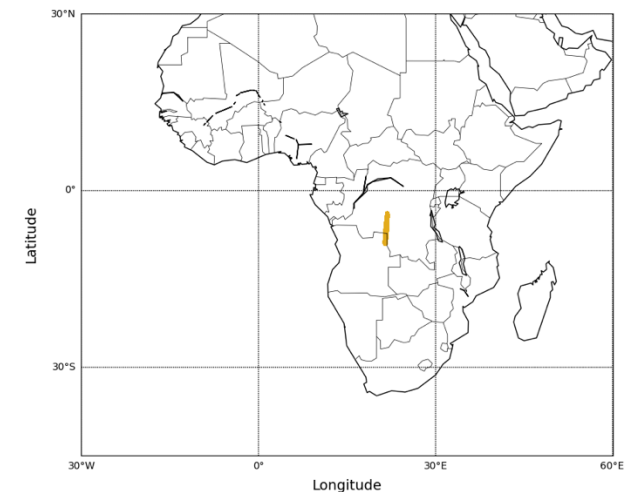
Exercise Scenario

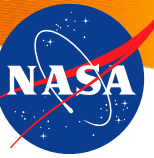
- Asteroid Properties
 - **Baseline/Epoch 0:** Initial ground-based observations estimated size based on brightness; Large ranges, all classes, limited constraining information
 - **Epoch 1:** JWST observation refined diameter estimates and identified type S taxonomy
 - **Epoch 2:** Flyby mission obtained direct size measurement and confirmed type S taxonomy
- Entry Parameters
 - **Epoch 1:** August 2024 swath, determined from astrometric observations, spanned Antarctica, South Atlantic, Africa, the Mediterranean, and Eastern Europe
 - **Epoch 2:** April 2028 swath, refined by ongoing ground-based astrometric observations and flyby orbital tracking, spanned Angola and Democratic Republic of the Congo

August 2024
Potential Earth Impact Points

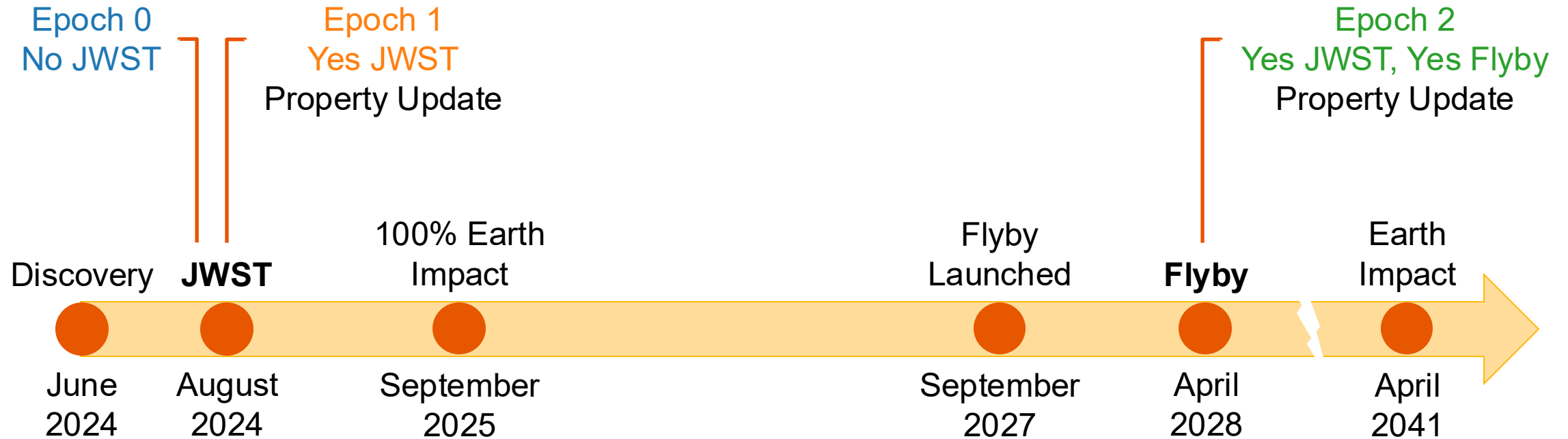


April 2028
Potential Earth Impact Points





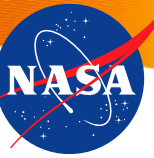
Timeline



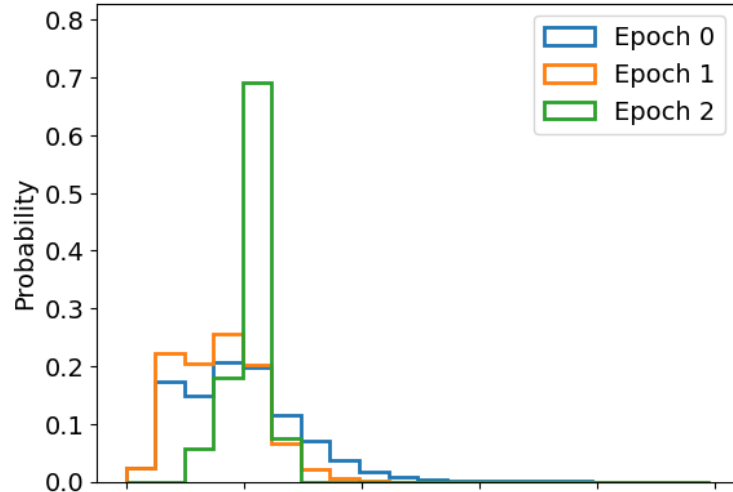
Entry Updates Ongoing →



DAMAGE RADIUS



Damage Radius – Yes JWST, Yes Flyby

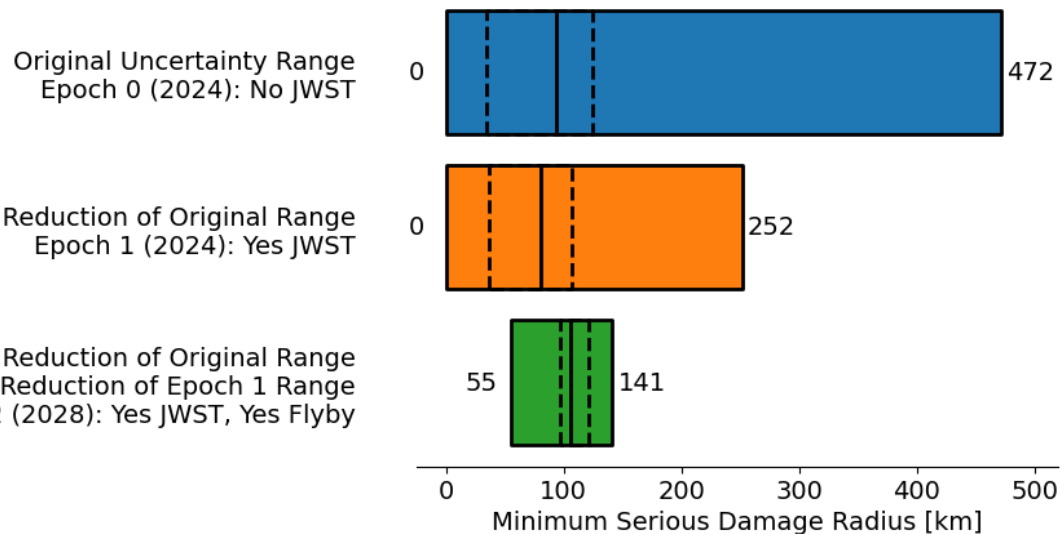


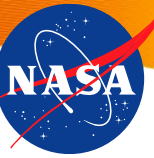
Epoch 0 to Epoch 1 to Epoch 2

Diameter	↓	98%	→	Energy	↓	99%
Entry Angle	↓	95%		Burst Altitude	↓	62%

For every ~1% asteroid property input refinement,
 ~0.8% damage radius output refinement
 For every ~1% entry parameter input refinement,
 ~0.3% damage radius output refinement

Overall ~47% damage radius output refinement from Epoch 0 to Epoch 1
 Overall ~82% damage radius output refinement from Epoch 0 through Epoch 2

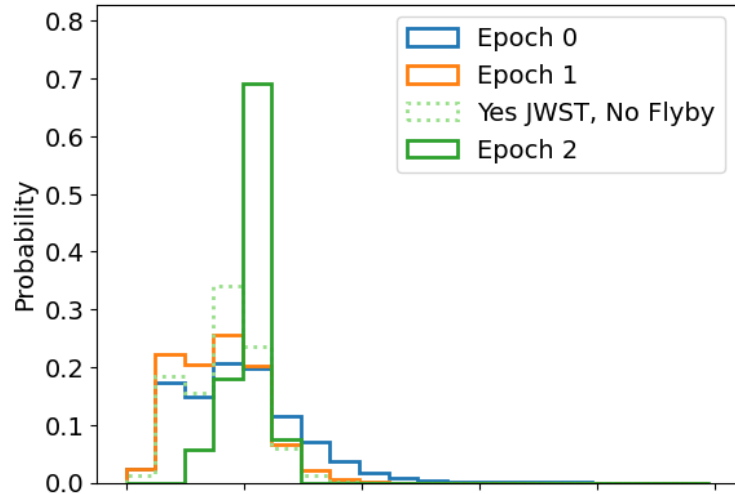




Timeline



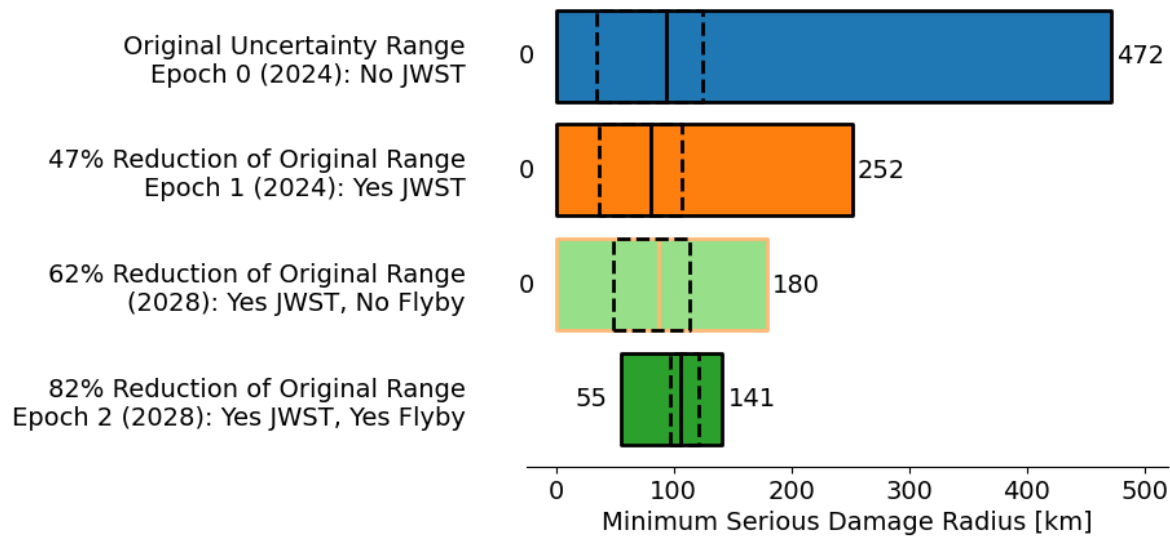
Damage Radius – Yes JWST, No Flyby



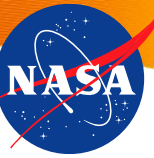
Epoch 0 to Epoch 1 to Yes JWST, No Flyby

Diameter ↓ 73% **Energy** ↓ 97%
Entry Angle ↓ 95% **Burst Altitude** ↓ 38%

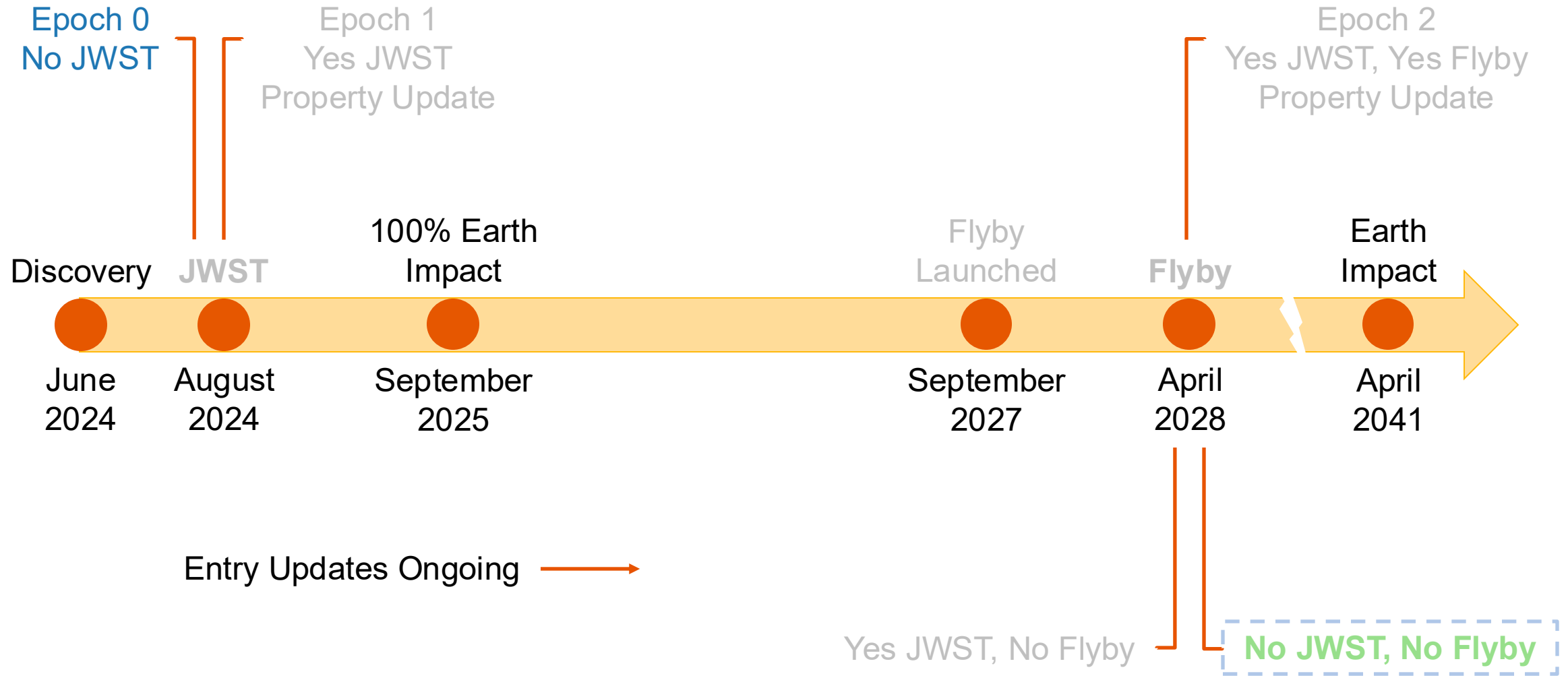
For every ~1% asteroid property input refinement,
 ~0.6% damage radius output refinement
 For every ~1% entry parameter input refinement,
 ~0.3% damage radius output refinement



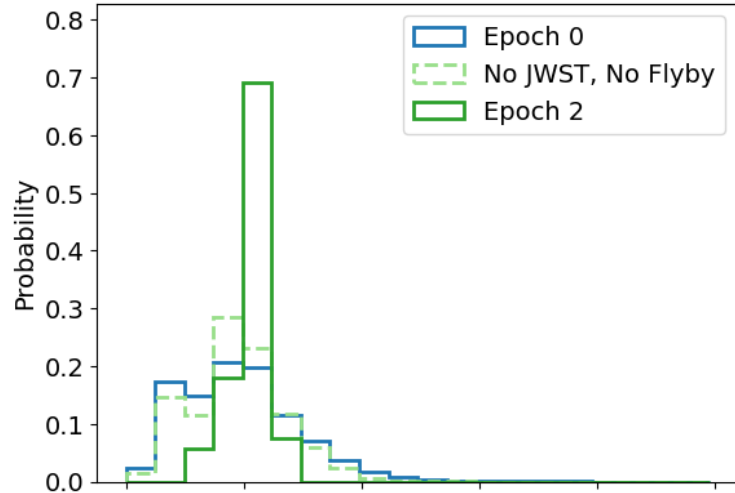
Forfeiting ~57% damage radius output refinement for every ~100% asteroid property input refinement lost by forgoing Flyby
Overall ~20% forfeit



Timeline



Damage Radius – No JWST, No Flyby



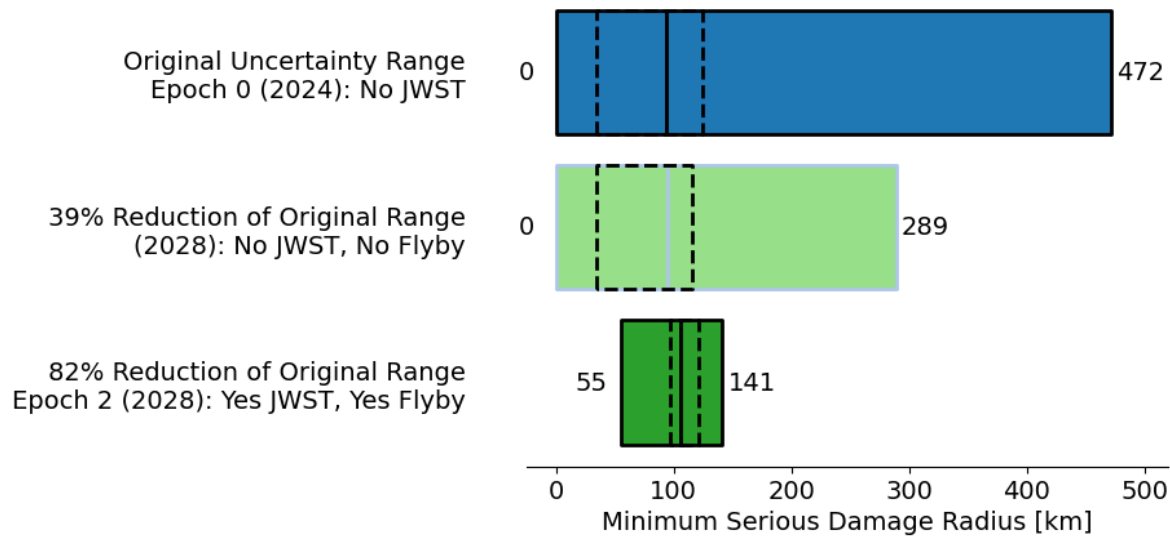
Epoch 0 to No JWST, No Flyby

Diameter	↓ 0%	→	Energy	↓ 1%
Entry Angle	↓ 95%		Burst Altitude	↓ 39%

For every ~1% entry parameter input refinement, ~0.4% damage radius output refinement

Forfeiting ~72% damage radius output refinement for every ~100% asteroid property input refinement lost by forgoing JWST, Flyby

Overall ~43% forfeit

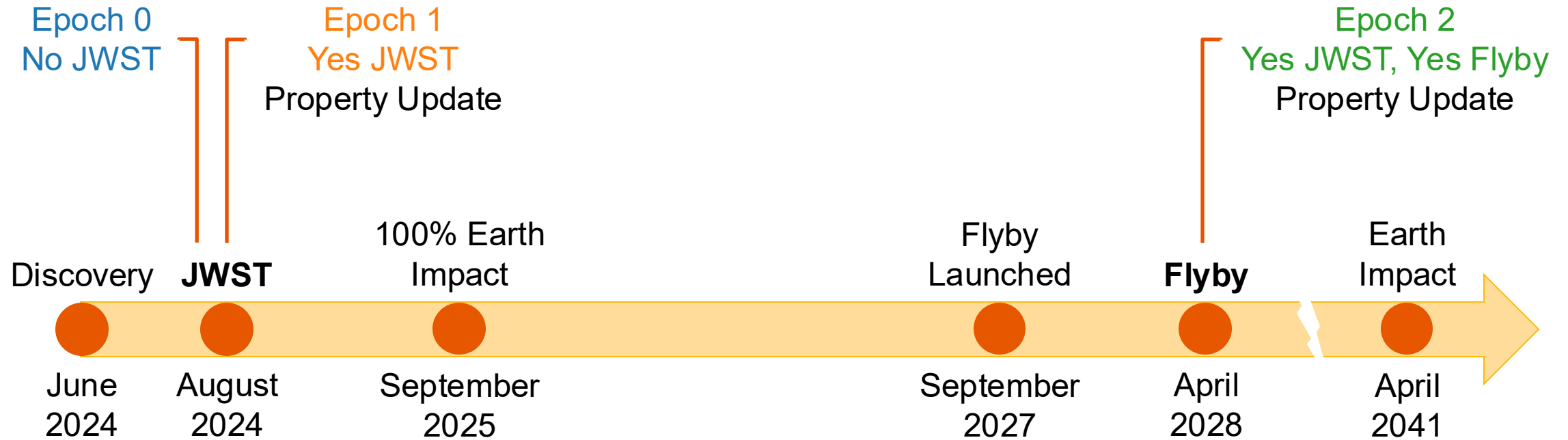




AFFECTED POPULATION

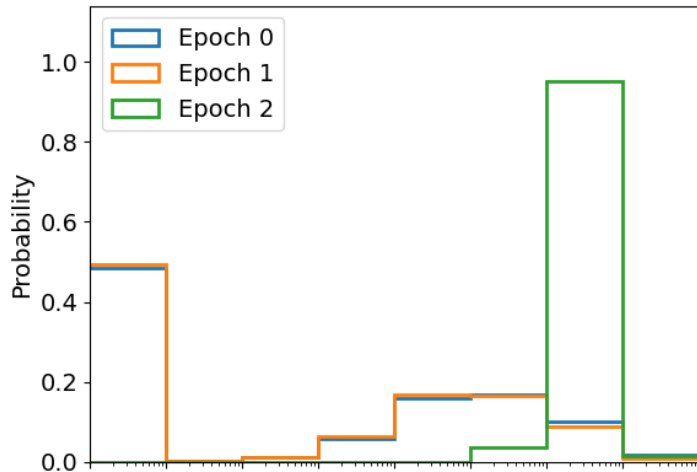


Timeline



Entry Updates Ongoing →

Affected Population – Yes JWST, Yes Flyby



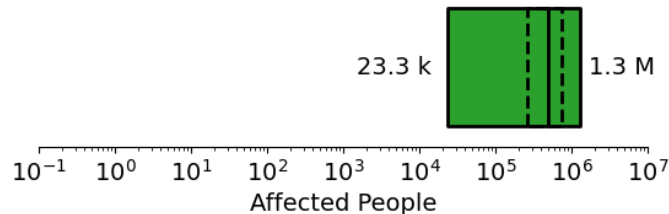
Original Uncertainty Range
Epoch 0 (2024): No JWST



23% Reduction of Original Range
Epoch 1 (2024): Yes JWST



81% Reduction of Original Range
75% Reduction of Epoch 1 Range
Epoch 2 (2028): Yes JWST, Yes Flyby



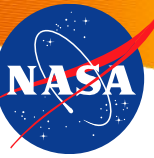
Epoch 0 to Epoch 1 to Epoch 2

Diameter	↓ 98%	→	Damage Radius	↓ 78%
Latitude	↓ 97%		Pop. Density	↓ 100%

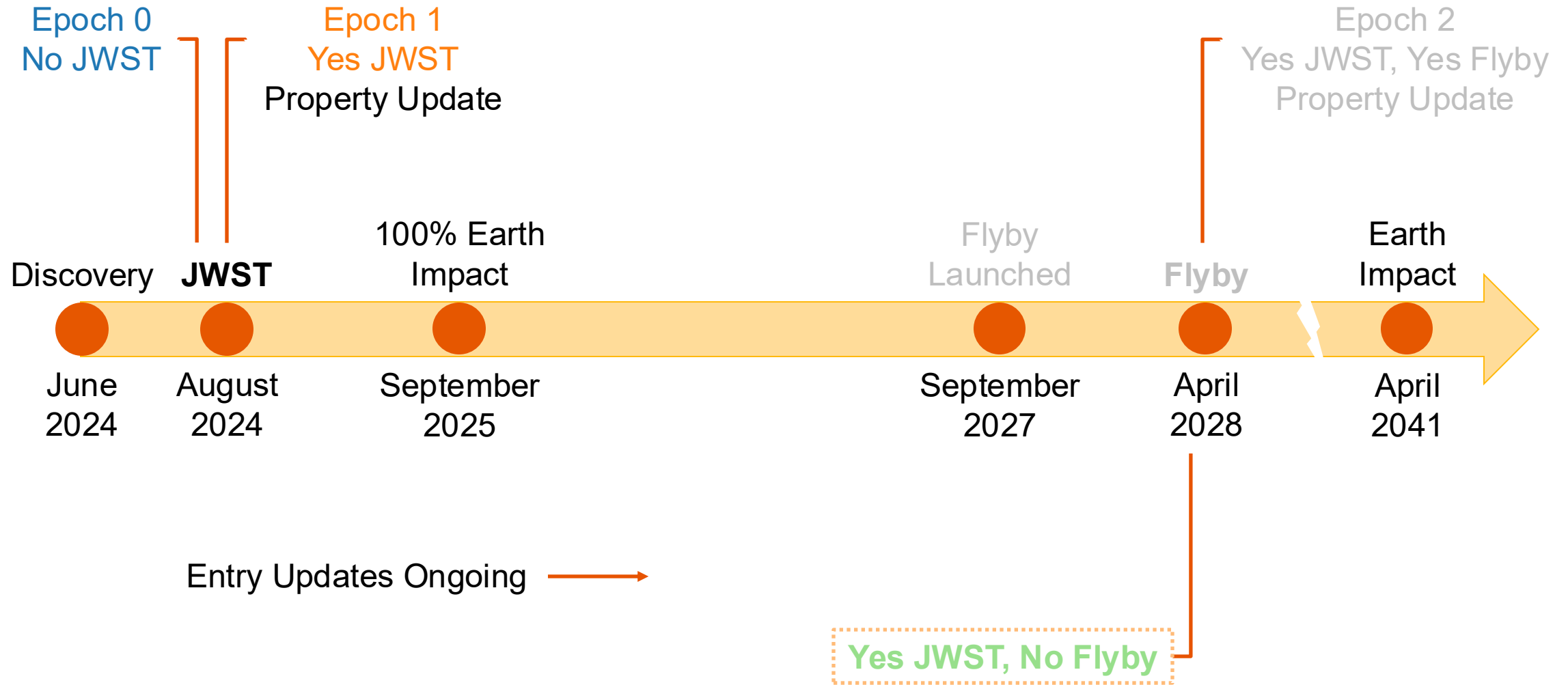
For every ~1% asteroid property input refinement,
~0.3% affected pop. output refinement
For every ~1% entry parameter input refinement,
~0.6% affected pop. output refinement

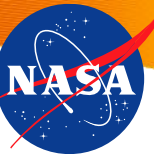
Overall ~23% affected population output refinement from Epoch 0 to Epoch 1

Overall ~81% affected population output refinement from Epoch 0 through Epoch 2

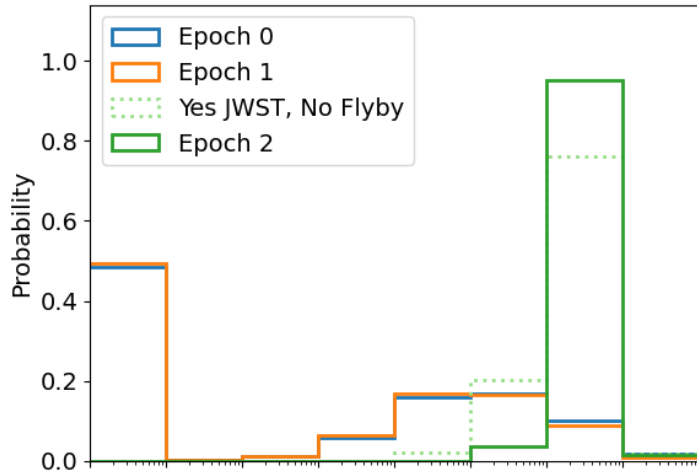


Timeline





Affected Population – Yes JWST, No Flyby



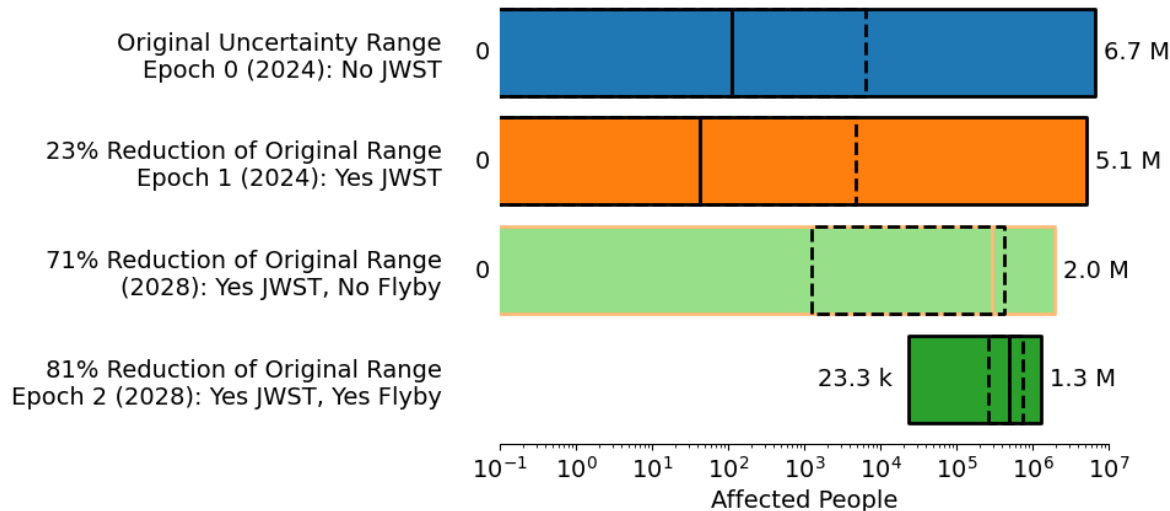
Epoch 0 to Epoch 1 to Yes JWST, No Flyby

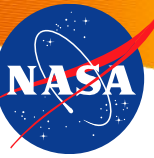
Diameter ↓ **73%** → **Damage Radius** ↓ **57%**
Latitude ↓ **97%** → **Pop. Density** ↓ **100%**

For every ~1% asteroid property input refinement,
 ~0.3% affected pop. output refinement
 For every ~1% entry parameter input refinement,
 ~0.6% affected pop. output refinement

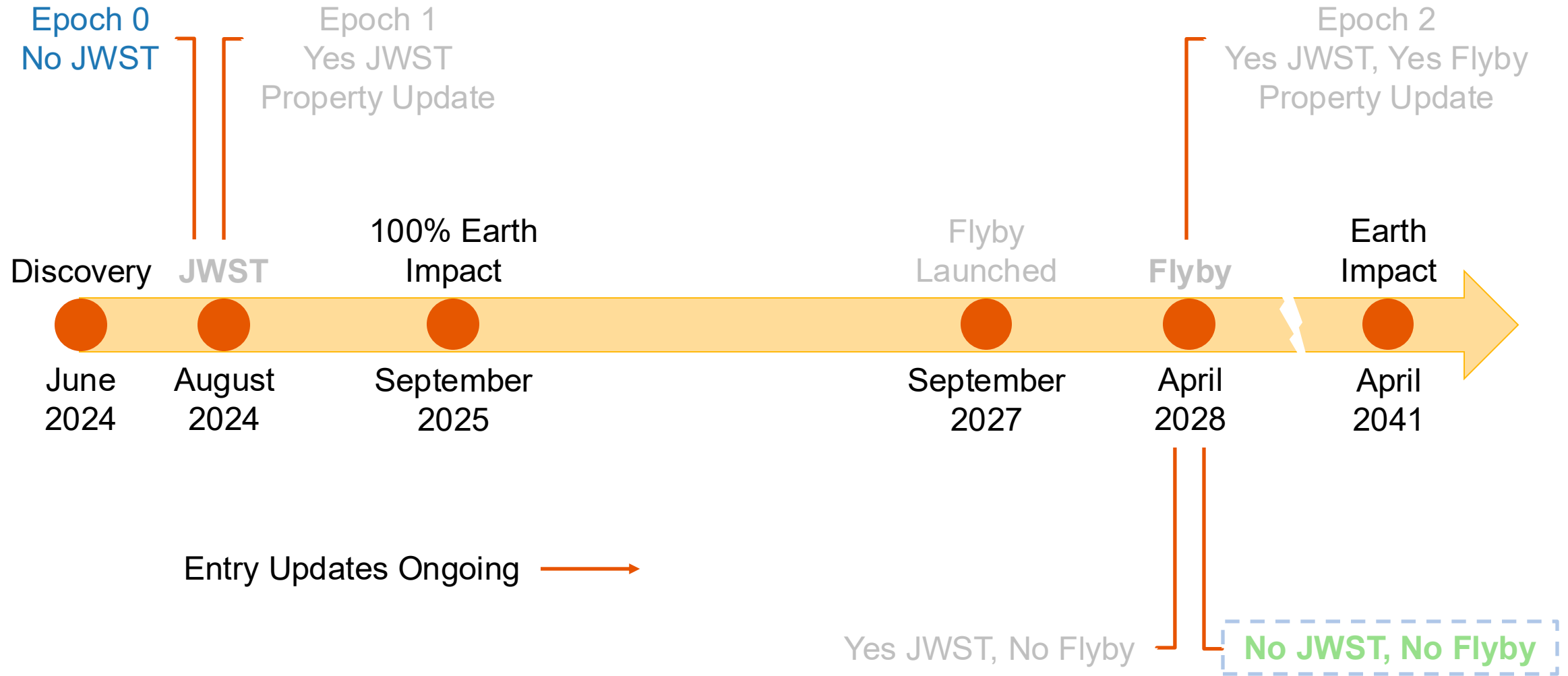
Forfeiting ~40% affected population output refinement for every ~100% asteroid property input refinement lost by forgoing Flyby

Overall ~10% forfeit

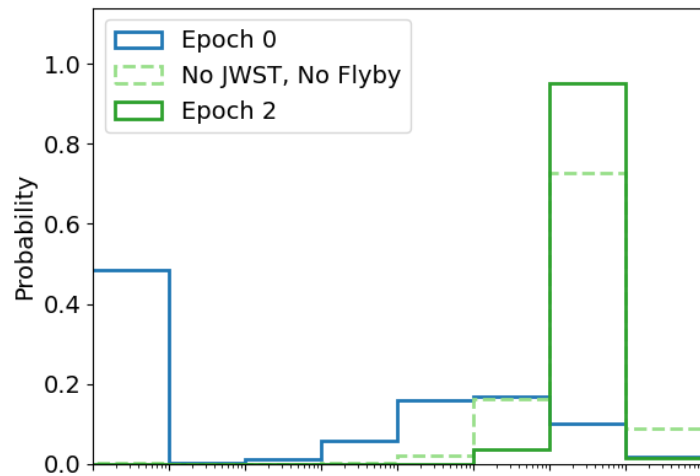




Timeline



Affected Population – No JWST, No Flyby



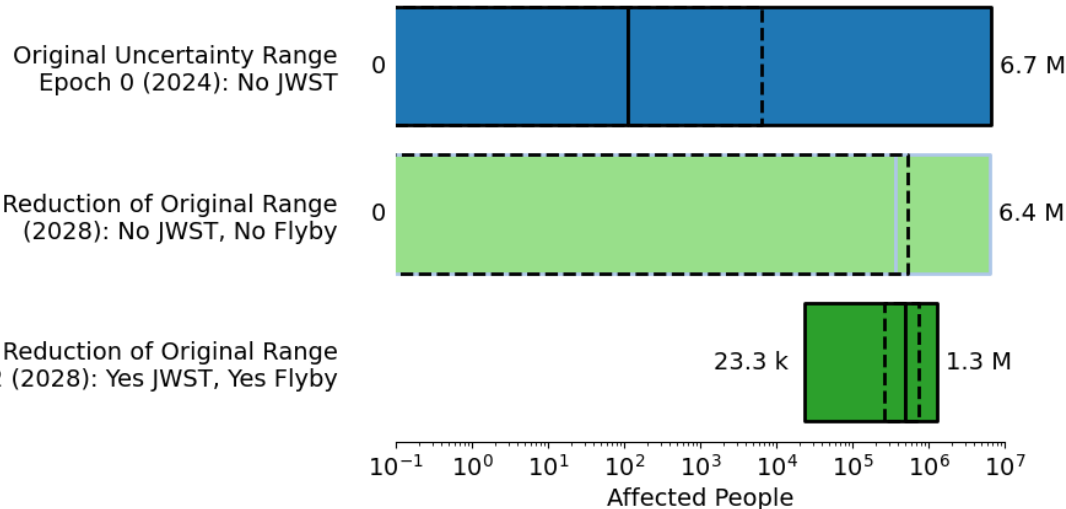
Epoch 0 to No JWST, No Flyby

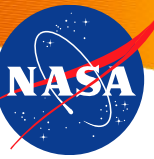
Diameter	↓ 0%	→	Damage Radius	↓ 12%
Latitude	↓ 97%		Pop. Density	↓ 100%

For every ~1% entry parameter input refinement, ~0.04% affected pop. output refinement

Forfeiting ~80% affected population output refinement for every ~100% asteroid property input refinement lost by forgoing JWST, Flyby

Overall ~77% forfeit

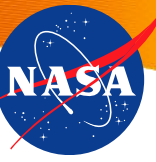




Looking Forward

Big Picture Goal: Understand the expected benefit to our risk knowledge from gaining additional sources of information, using the PDC25 Exercise Scenario as a case study

- Conducting more general study to map out expected benefits across size regimes, from additional information sources, order of information, etc.
- Provide options to decision makers, allow them to decide how much risk information they want and/or need and when they need it within context of the larger problem
 - 150 m vs 900 m asteroid makes a difference for mitigation efforts
 - 150 km vs 300 km or 1M people vs 6M people makes a difference for evacuation efforts



Thank you

Other Relevant PDC25 Technical Talks

- Earth Impact Effects & Consequences Session
 - Lorien Wheeler et al. “Airburst & Blast Damage Risk Modeling Trends for the PDC25 Impact Scenario”
- Hypothetical Threat Exercise Technical Session
 - Jessie Dotson et al. “The effect of prior knowledge on planetary defense scenario risk assessments”

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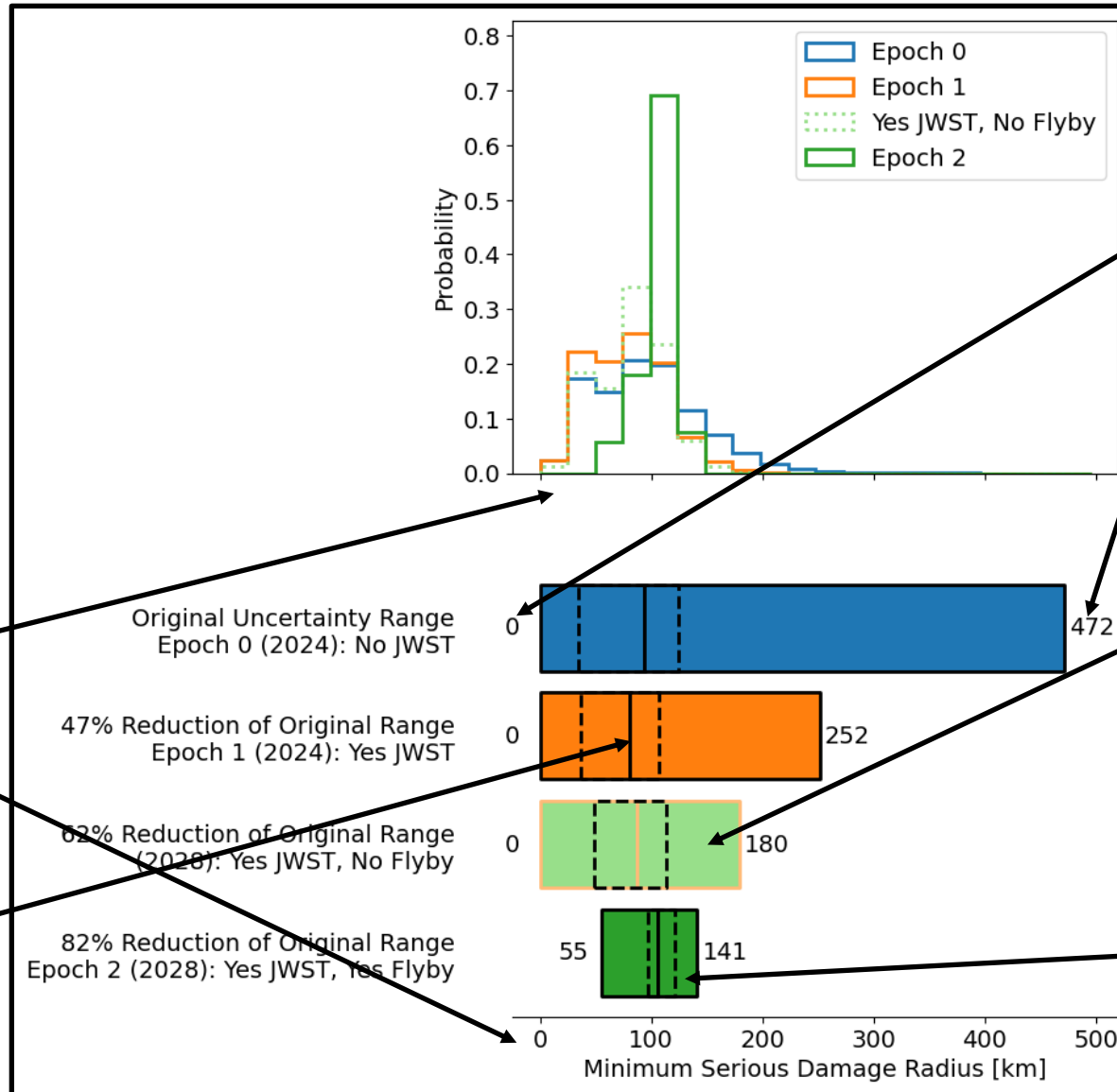
BACKUP

Plot Details

Serious damage radius is shown in the plots, results for other severity levels are in the associated paper

Common x axis between plots

Solid line represents the median



Listed values are the min and max modeled, not the theoretical absolute min/max

Green interior to signify Epoch 2 time point (2028), orange outline to signify Epoch 1 property refinement (just JWST)

Dashed box highlights the most likely range (68% HPDI)