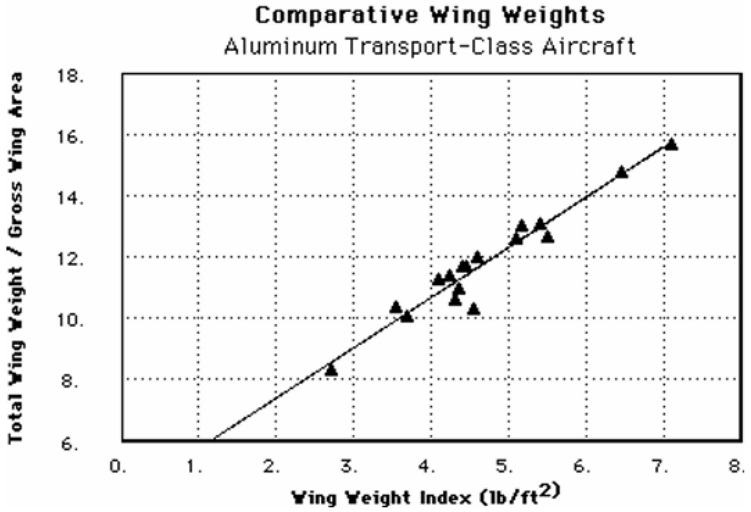
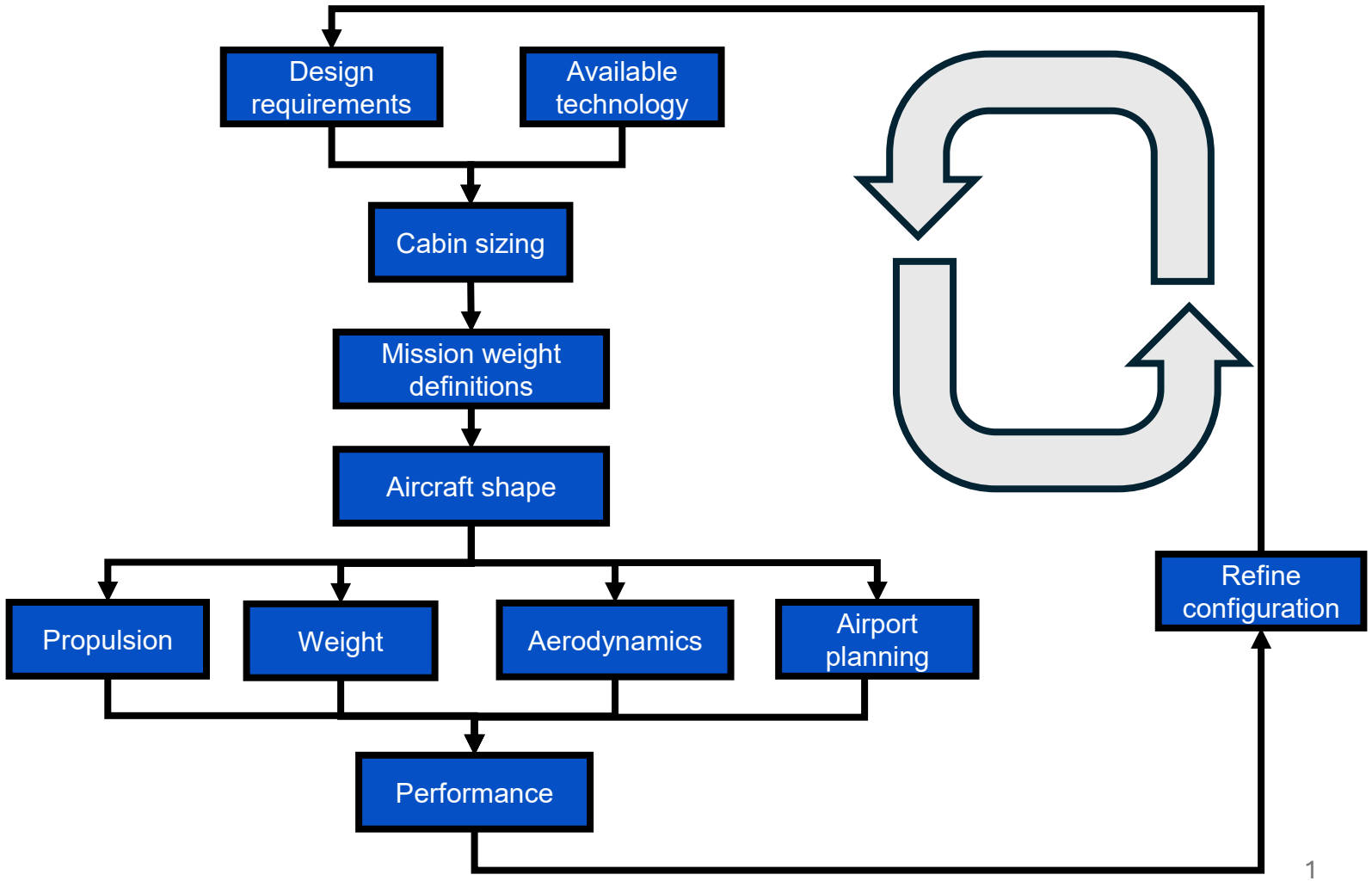
What is conceptual aircraft design?

$$W_{wing} = 4.22\,S_{wg} + 1.642 \times 10^{-6}\,\frac{N_{ult}\,b^3\,\sqrt{TOW\ ZFW}\,(1+2\lambda)}{(t/c)_{avg}\,\cos^2\Lambda_{ea}\,S_{wg}\,(1+\lambda)} \quad \text{(lbs)}$$





Airbus, Raymer, Ilan Kroo

Novel configurations

- Large range of designs
- No data for similar novel aircraft
  - Simulation and optimization is required

NASA

Boeing

Airbus Helicopters

“Do Diffusion Models Dream of Electric Planes?”

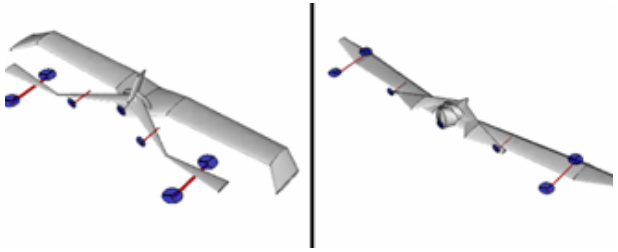
Aurelien Ghiglino, Daniel Elenius, Anirban Roy, Ramneet Kaur, Manoj Acharya, Colin Samplawski, Brian Matejek, Susmit Jha, Juan J. Alonso, Adam D. Cobb

ICML 2026
6th – 11th July 2026, Seoul, Republic of Korea

Representing requirements as probabilities

Question

What is the design that leads to a range of 4150 nm?



τ

Single wing

θ

Wingspan

Simulator

$z \sim p(z|\theta, \tau)$

$x \sim p(x|z, \theta, \tau)$

Range

Goal

Given x infer input parameters θ and topology τ

=> **S**imulation **B**ased **I**nference

Why is this a challenging SBI problem?

- Mixed discrete (topology) and continuous (parameters) variables
- Variable-dimensional parameter space
- Large-scale design space (**144 topologies**, up to **136 parameters**)

- Challenge: **narrowing design space efficiently**

Key idea for mixed SBI

We factorize the posterior:

$$p(\theta, \tau \mid x) = p(\theta \mid \tau, x) \cdot p(\tau \mid x)$$

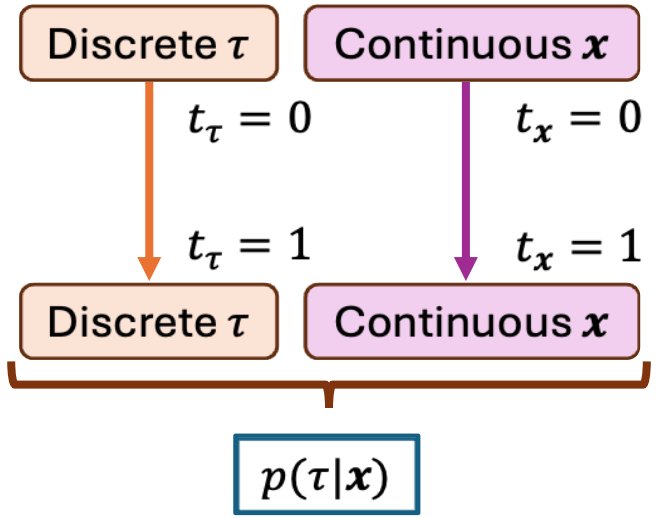
Hierarchical sampling:

1. Sample topology τ conditioned on x
2. Sample parameters θ conditioned on τ and x

Enables **tractable modeling** of variable-dimensional design spaces.

MixeDiT: Topology from Performance

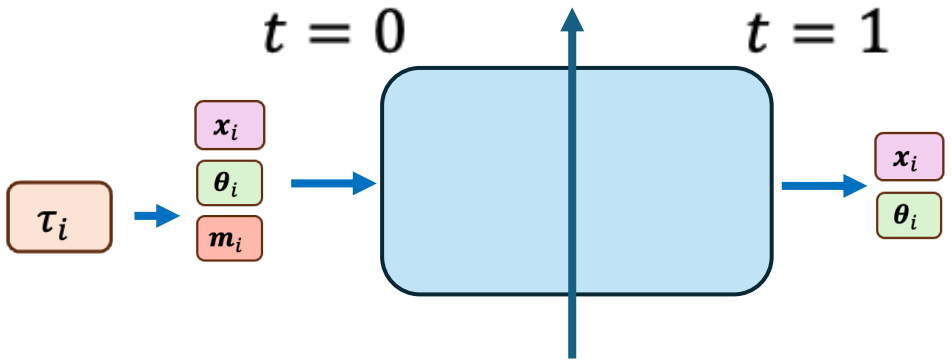
- Joint discrete-continuous modeling based on Unified World Models
- Uses Riemannian Diffusion for discrete variables
- Captures distribution over 144 topologies



$$\ell = \gamma \ell_{discrete} + (1-\gamma)\ell_{continuous}$$

MaskeDiT: From Topology and Performance

- Handles variable-dimensional inputs via masking
- DiT-based Simformer (*Gloeckler et al.*)
- Enables a single model across all topologies

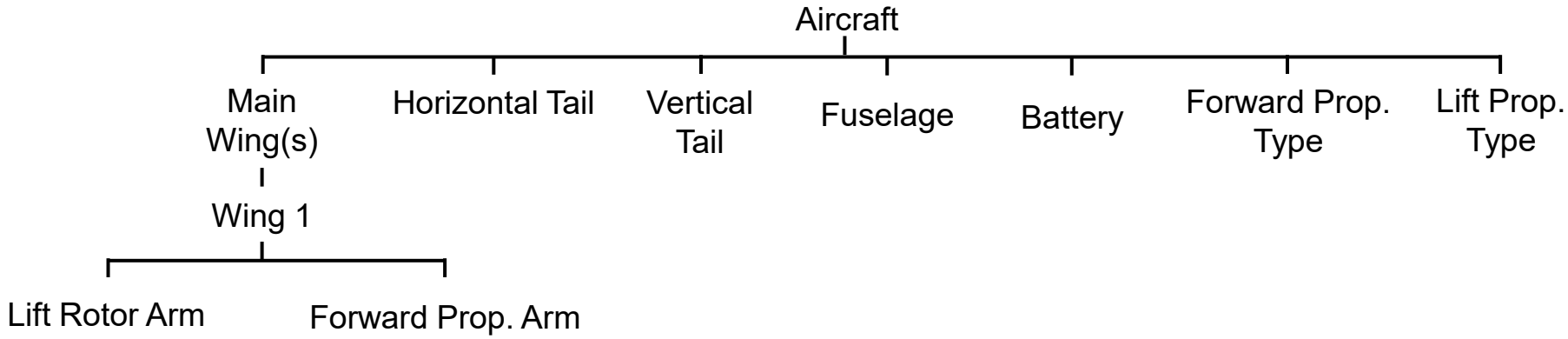


Data generation

- **Tree-structured** probabilistic program
- **SUAVE simulator** for performance evaluation

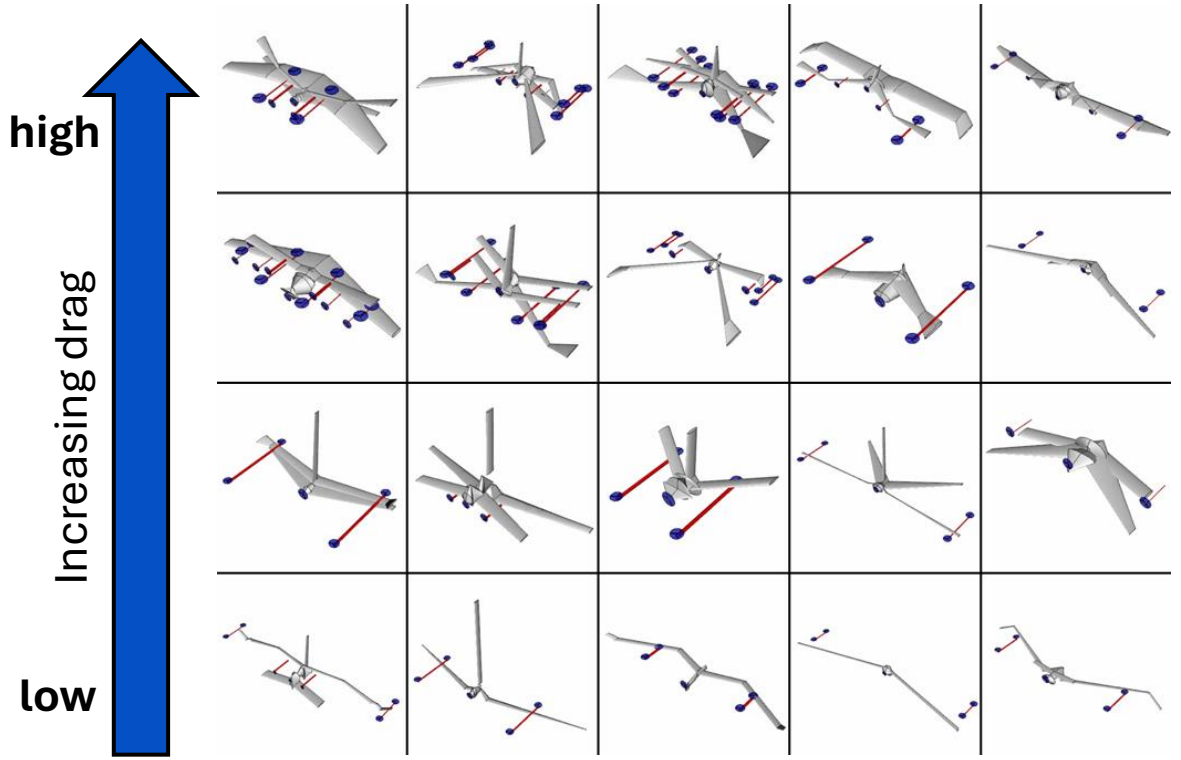
gov.br

Final dataset: **30,276** valid aircraft designs



Case study Increasing Drag (All Other Observations Fixed)

Hypothesis: Higher drag designs will have smaller wingspans and more components to increase induced and profile drag.



Key Contributions

- Hierarchical diffusion for **mixed discrete-continuous** SBI
- Handles **variable-dimensional** parameter spaces
- Scales SBI to complex engineering system: **x10 typical SBI benchmarks**
- **Large dataset** publicly released to benchmark practical SBI