TEXAS
The University of Texas at Austin

EDUCATING DESIGNERS FOR GENERATIVE ENGINEERING

LEARNING GOAL 2

Chapter: Traditional Design, *The Design and Objective Spaces*

Learning Objectives: 1) Design direction; 2) the design space; 3) the objective space.

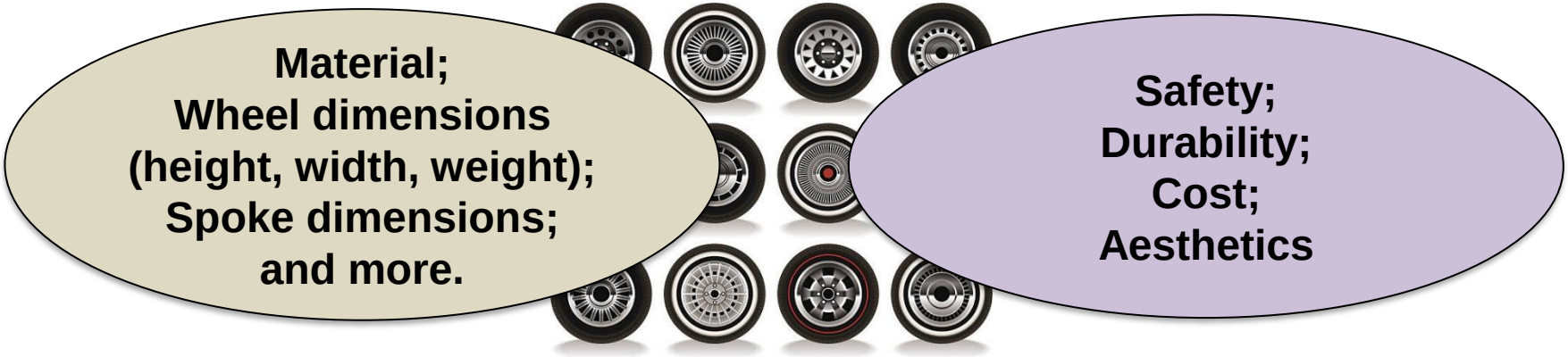
Design Space and Objective Space

Space – abstract representation of the relationships between variables.

Design Space – all possible design solutions; i.e., each possible configuration of the design variables.

Objective Space – performance criteria used to evaluate/compare designs.

Example Design Problem – Car wheel



Car Wheel Design Space

Car Wheel Objective Space

Design Space and Objective Space **Activity**

Real world problem – traveling across a body of water.
Goal – Design and build a structure to enable travel
Solution – A bridge!

Activity 1. List the variables in the bridge Design Space,

Activity 2. List **Safety** evaluation metrics in the bridge Objective Space.

Material;
What else?

Bridge Design Space

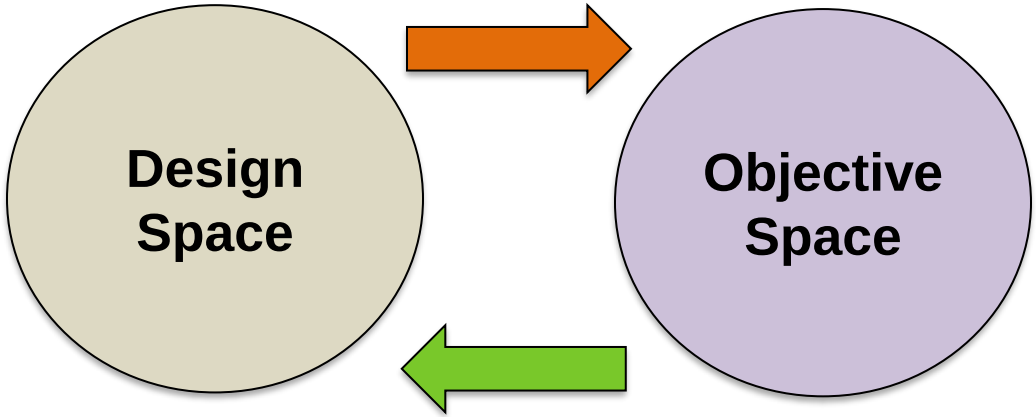
Safety;
How to measure?

Bridge Objective Space

Design Direction

Design Direction – key difference between design paradigms is the direction the design takes while moving between the **Design Space** and **Objective Space**.

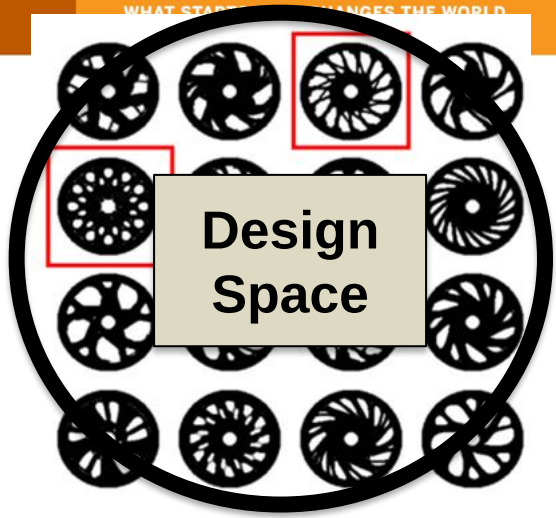
in Traditional Design – Design Space -> Objective Space
in Parametric Design – Design Space -> Objective Space
in Generative Design – Objective Space -> Design Space



Design Space – all possible design solutions.

Objective Space – performance criteria used to evaluate/compare designs.

Forward Design



Forward Design – when the designer works from the Design Space to the Objective Space. Common in *Traditional* and *Parametric Design*.

A designer in Forward Design will –

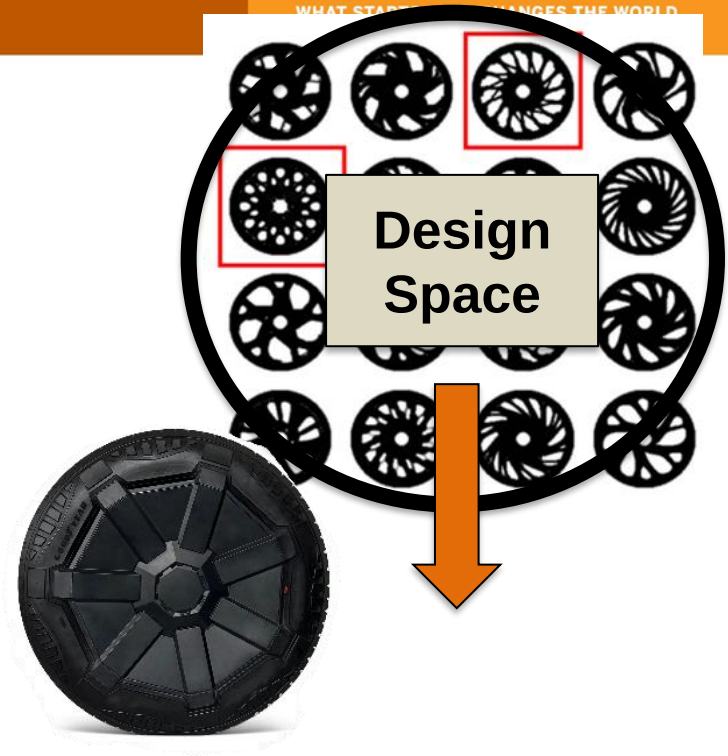
1. Arrange the parameters in the Design Space
    i. **Car Wheel example**
        a) Spoke # = 7
        b) Inner-spoke covering = full cover

Forward Design

Forward Design – when the designer works from the Design Space to the Objective Space. Common in *Traditional* and *Parametric Design*.

A designer in Forward Design will –

2. to create a design solution, and then

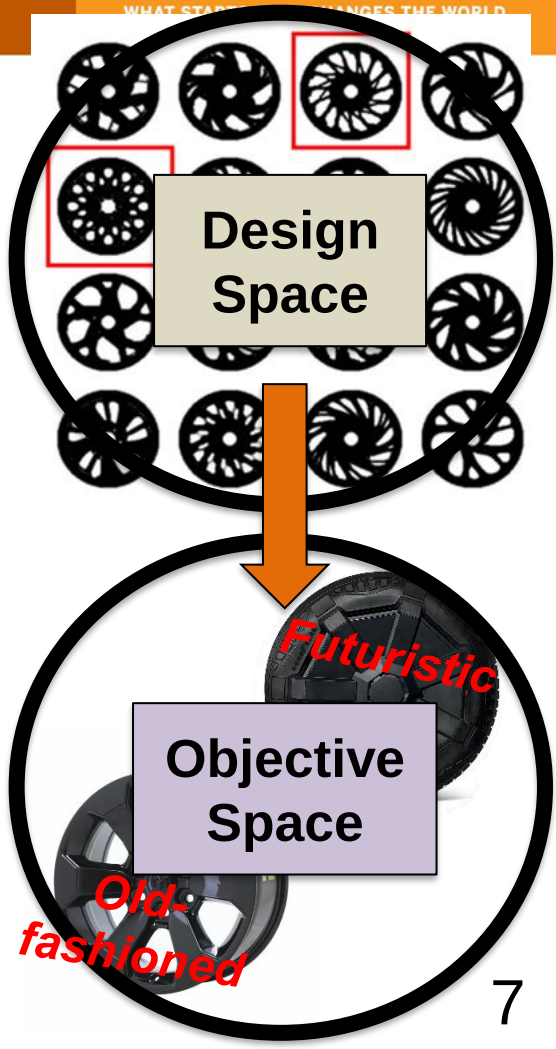


Forward Design

Forward Design – when the designer works from the Design Space to the Objective Space. Common in *Traditional* and *Parametric Design*.

A designer in Forward Design will –

3. Evaluate design performance in the Objective Space.
    - **i. Car Wheel example**
        - a) Spoke # = 7; *conveys futuristic aesthetic*
        - b) Inner-spoke covering = full cover; *conveys futuristic aesthetic*

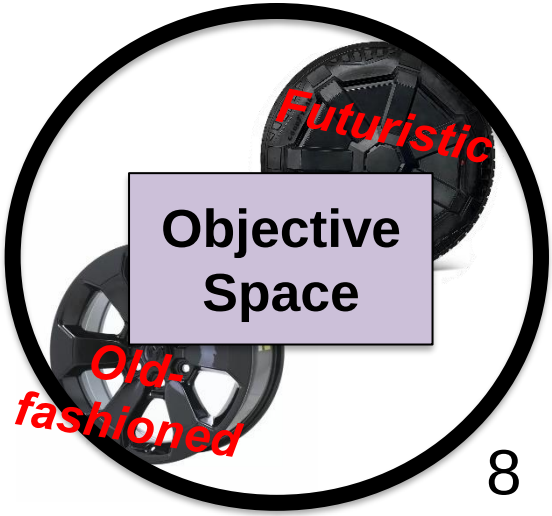


Backward Design

Backward Design – when the designer works from the Objective Space to the Design Space. Common in *Generative Design*.

A designer in Backward Design will –

1. Define the Objective Space for a generative design software,
    i. **Car Wheel example**
        a) To ChatGPT - “Give me a sketch of a futuristic car wheel design.”

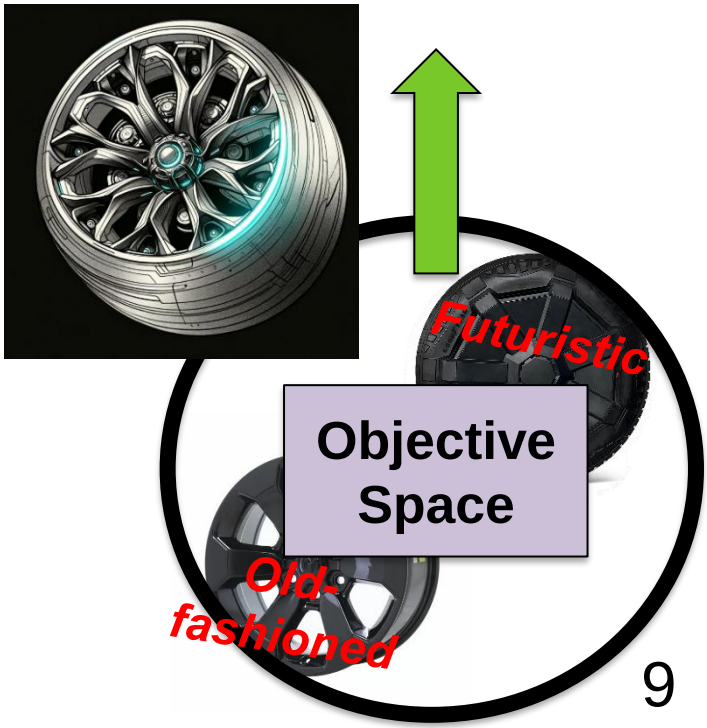


Backward Design

Backward Design – when the designer works from the Objective Space to the Design Space. Common in *Generative Design*.

A designer in Backward Design will –

2. For the AI to consider as it fully explores the Design Space,

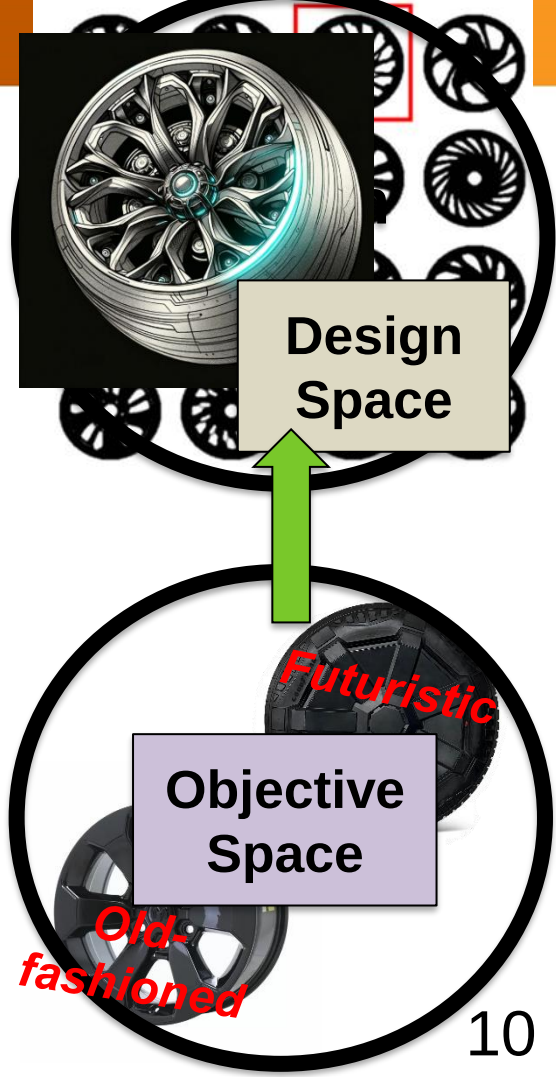


Backward Design

Backward Design – when the designer works from the Objective Space to the Design Space. Common in *Generative Design*.

A designer in Backward Design will –

3. Evaluate AI created designs and edit parameters in the Design Space.
    i. **Car Wheel example** – Selecting one out of a set of AI-designed car wheel CAD models and (potentially) changing the spoke width for aesthetic (i.e., qualitative) reasons.
        a) Spoke # = 8
        b) Inner-spoke covering = some cover



Forward Design: Solar Energy Home Design

Design Space → **Objective Space**

Design Option 1

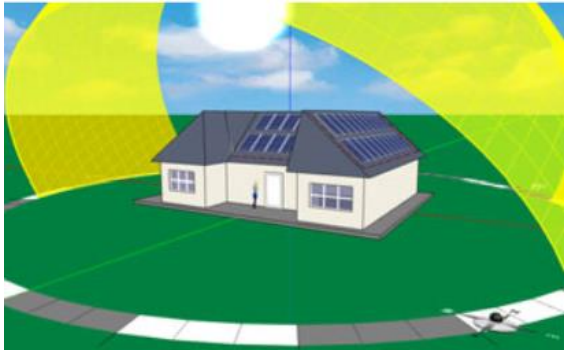
Design Option 2

Design Option 3

Evaluated by

Components	Requirements
Story	1
Number of windows	> 4
Size of windows	>1.44 m^2
Number of doors	≥1
Size of doors (Width × Height)	>1.2 m × 2m
Height of wall	>2.5m
Distance between ridge to panel	>0

1



2

The human designer arranges the variables based on the constraints to create a solution in the objective space which can be objectively evaluated via the upfront budget and annual energy output.

Backward Design: Solar Energy Home Design

Design Space

Objective Space

"I want a design that falls under a budget of $*x* And has an annual energy output of *y* kW."

Components	Requirements
Story	1
Number of windows	> 4
Size of windows	>1.44 m^2
Number of doors	≥1
Size of doors (Width × Height)	>1.2 m × 2m
Height of wall	>2.5m
Distance between ridge to panel	>0

The human designer can input a prompt for the generative AI to consider as it explores the design space and generates a solution that meets the goals.

END