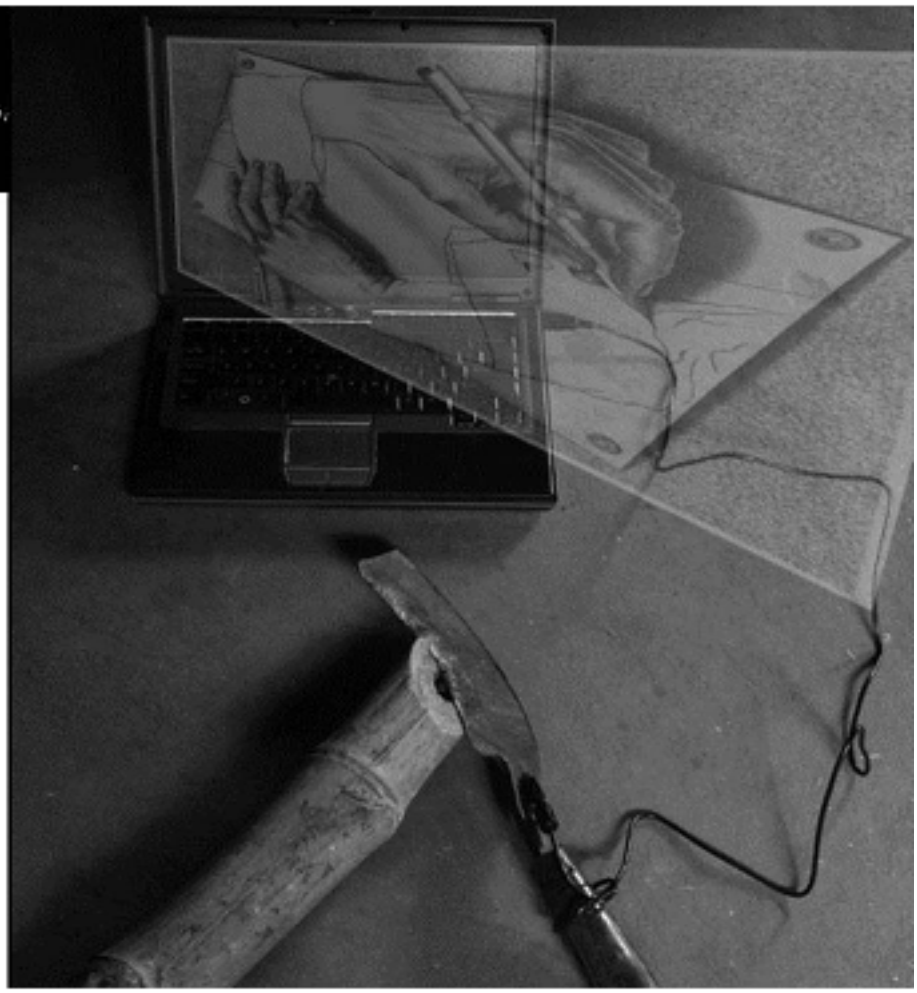
KAMATH DESIGN STUDIO
Architecture Planning and Environment



CRAFT AND THE COMPUTER
Theory and Practice

MIT Design Computation Lecture Series

9th December 2011

Introduction: Craft & Industry

Craft

- Products are **never identical**
- Variations are **unpredictable**
- **Complexity is unplanned**

Industry

- **Predictable output** through mechanical operations
- **Complexity can be designed**

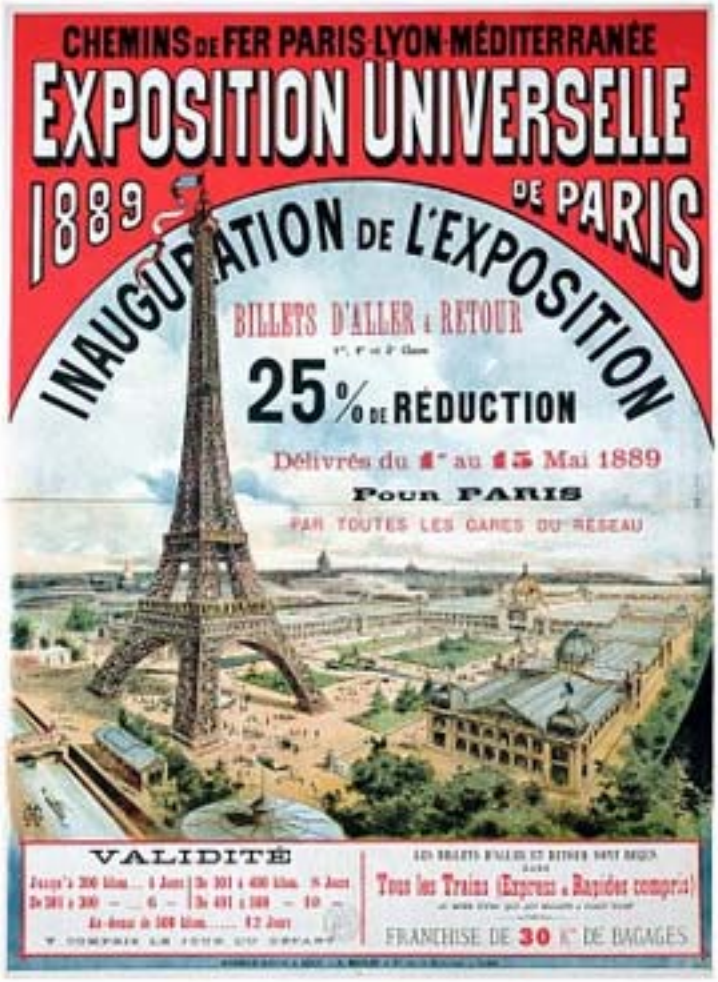
Top: Mumbai Indian, Flickr.com
Bottom:
http://www.continentalplastic.com/industrial_buckets.htm

Introduction: Craft & Industry

Industrial processes are

- Efficient only at **high volumes**
- Required a mass **consumer culture** to support them.

Image:
http://en.wikipedia.org/wiki/File:Paris_1889_plakat.jpg



Introduction: Craft & Industry

Industrial processes require

- Input materials with **predictable** properties

Such **materials** are

- Naturally **rare**
- Require extensive **processing**

This makes industrial processes

- **Energy** intensive
- **Resource** intensive

Image:
http://en.wikipedia.org/wiki/File:Philippe_Jacques_de_Loutherbourg_the_Younger_-_Coalbrookdale_by_Night_-_1801.jpg

Coalbrookdale by Night is an 1801 painting by Philip James de Loutherbourg. It depicts the Madeley Wood (or Bedlam) Furnaces, which belonged to the Coalbrookdale Company from 1776 to 1796. The picture has come to symbolize the birth of the Industrial Revolution in Ironbridge, England. It is held in the collections of the Science Museum in London.

http://en.wikipedia.org/coalbrookedale

Introduction: Context

"Discussions about sustainability in the globalising world have also been pre-empted by high technology; consequently, **craft**, or the new craft of **architecture** (especially in the West), **builds on the idea of the complete disappearance of traditional skills**. In India's context, craft is a continuous and living tradition."

Rahul Mehrotra, "Architecture In India Since 1990", 2011, p. 203

Introduction: The Role of the Computer

Digital fabrication allows

- The same machine to produce **varied outputs**
- High **precision**

Digital design and **digital fabrication** allow architects to

- Design **non-standard building forms**
- Fabricate **non-standard building components**
- **Minimize in-situ fabrication**

Introduction: The Role of the Computer

The **ability to produce variation** through digital design and digital fabrication has elicited

- **Comparisons with craft processes**
- **Comparisons between craftspersons and designers** using digital design and digital fabrication tools.

Top: http://www.jewelry-model.com/

Bottom: http://asatha.com/blog/wp-content/uploads/2011/07/kutch-silver-kada.jpg

3D printed rapid prototypes for jewelry design

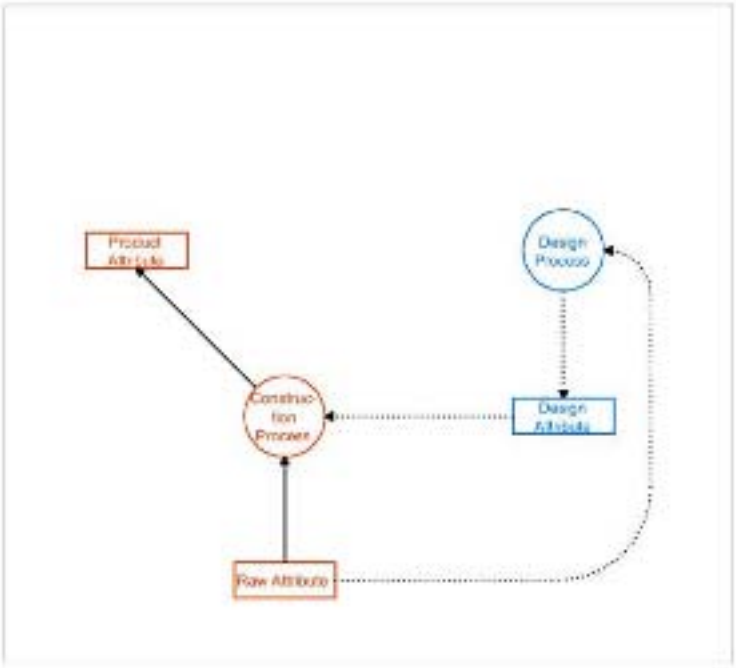
Hand crafted silver jewelry from Kutch

Framework

- Design Attributes: define a design
- Product Attributes: describe a finished product
- Raw Attributes: characterize raw materials

Goal:

- **To convert Raw Attributes into Product Attributes**



Adapted from: Papanikolaou, Dimitrios. [2006]. *Activity process methodology : feasibility assessment of Digital Fabrication Production Systems for planar part assemblies using network analysis and System Dynamics.* (Thesis, Massachusetts Institute of Technology).

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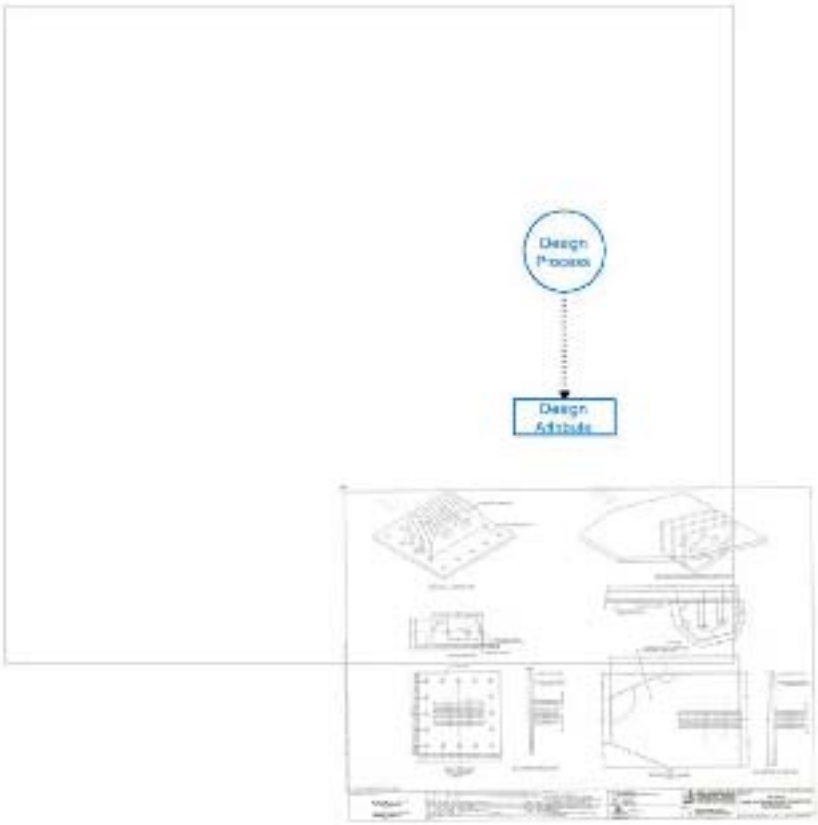

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Framework

Natural materials have

- Predictable properties
- Unpredictable properties

Image:
http://upload.wikimedia.org/wikipedia/commons/thumb/8/8e/Metal_yield.svg/500px-Metal_yield.svg.png

Framework

Scientific Processes give **indirect knowledge of predictable material** properties.

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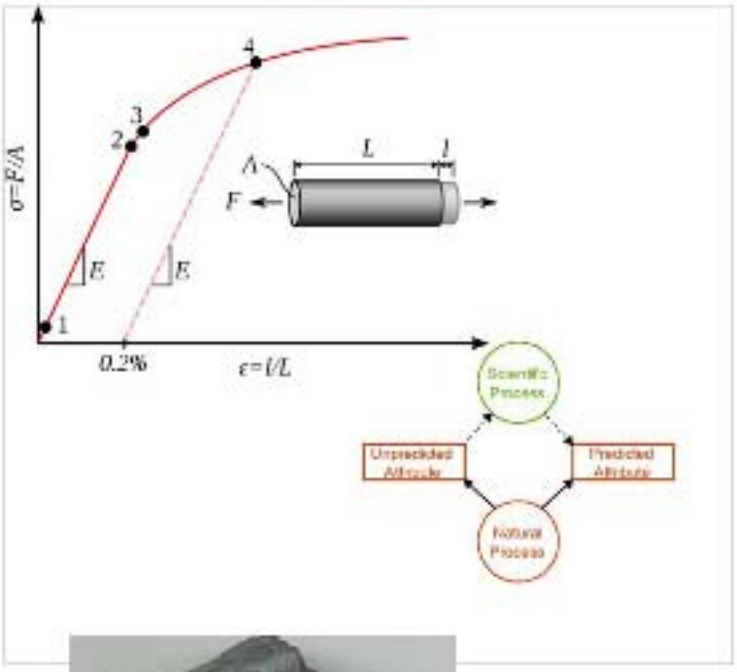

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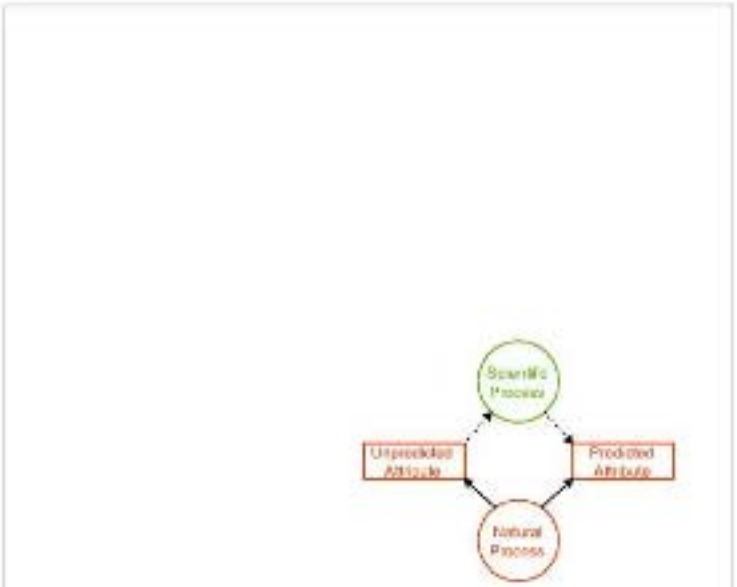

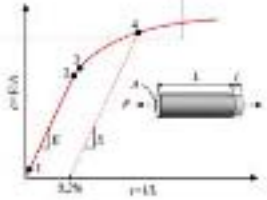

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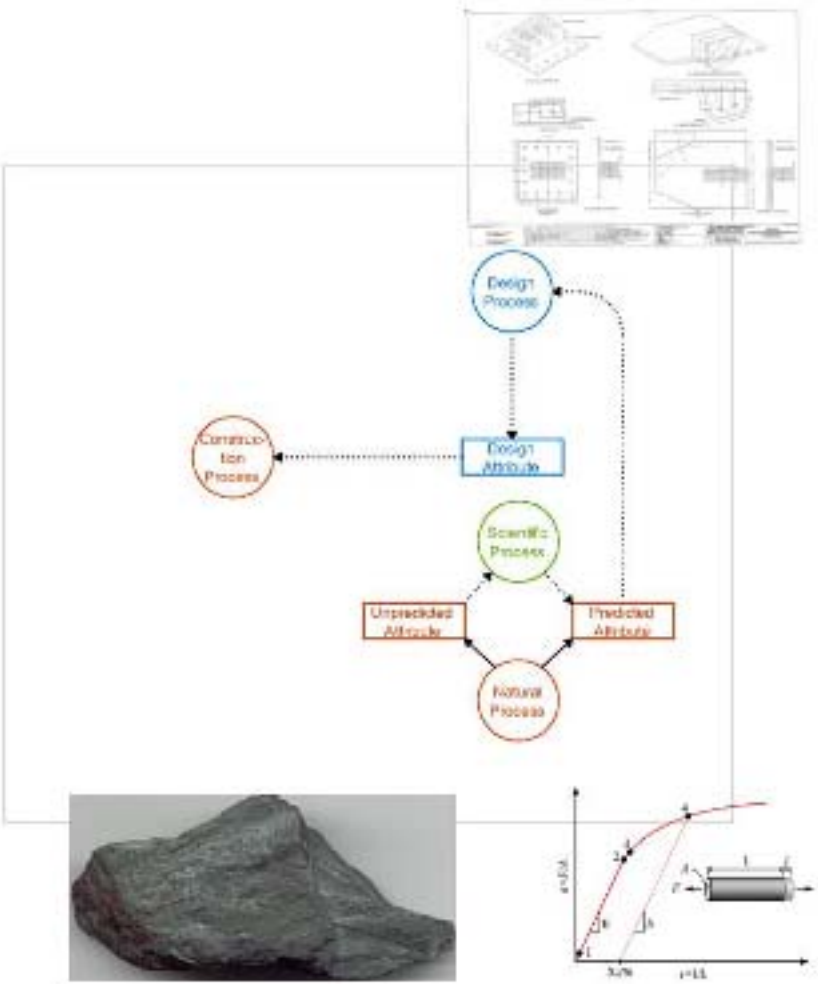

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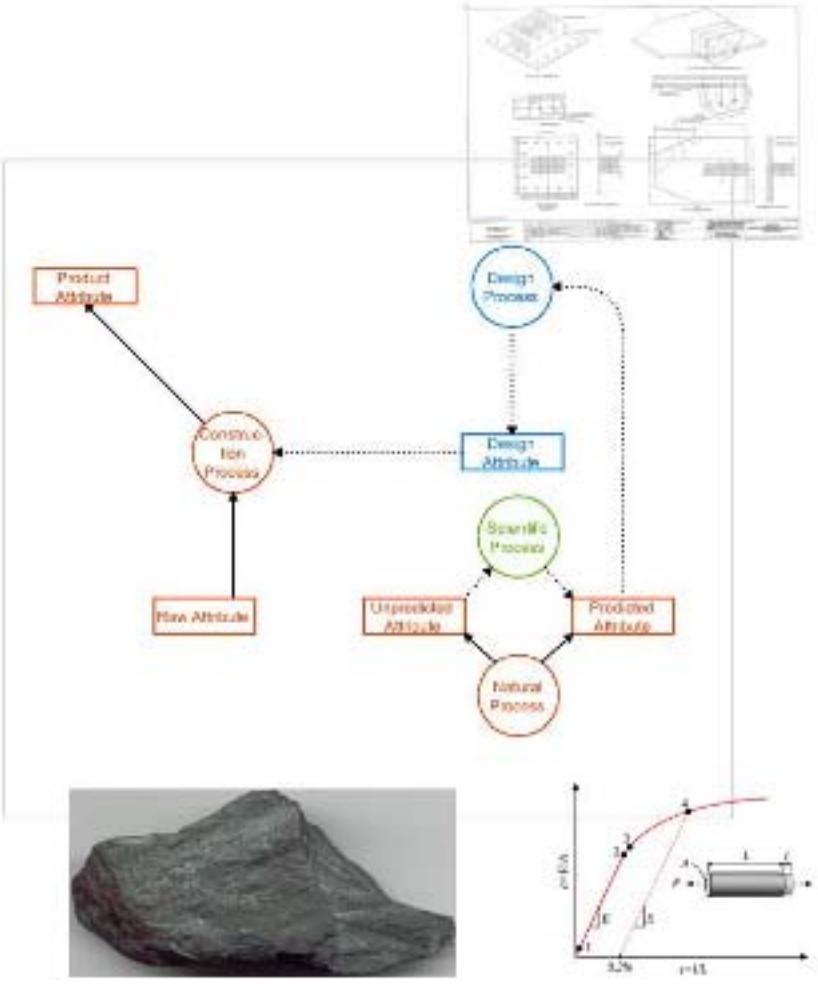
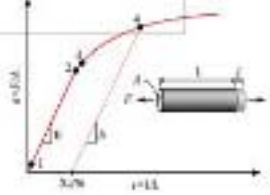


Framework

Scientific Processes give **indirect knowledge of predictable material** properties.

Unpredicted material properties result in

- **Unforeseen** design **consequences**
- **Incorrect results** of mechanical processes

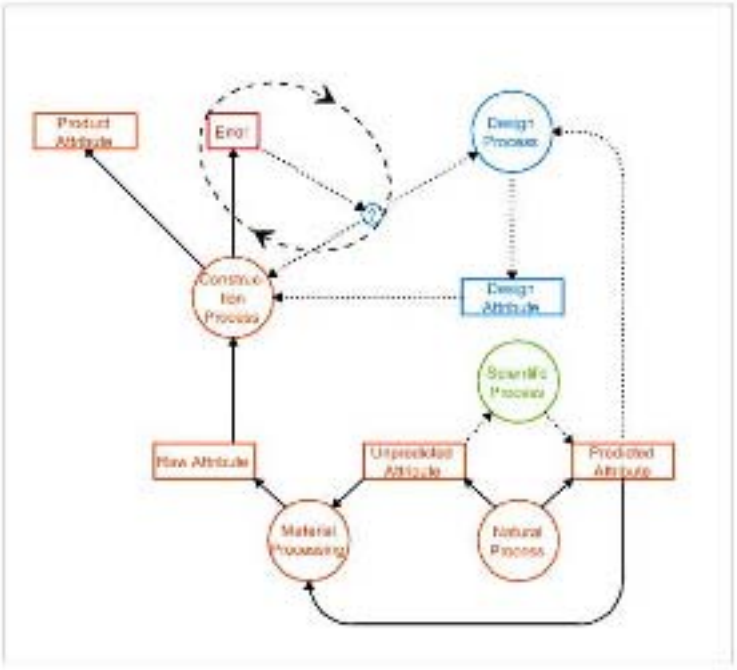


Middle:
http://upload.wikimedia.org/wikipedia/commons/thumb/8/8e/Metal_yield.svg/500px-Metal_yield.svg.png

Framework

Errors are caused by

- Design flaws
- Mechanical flaws
- Material flaws



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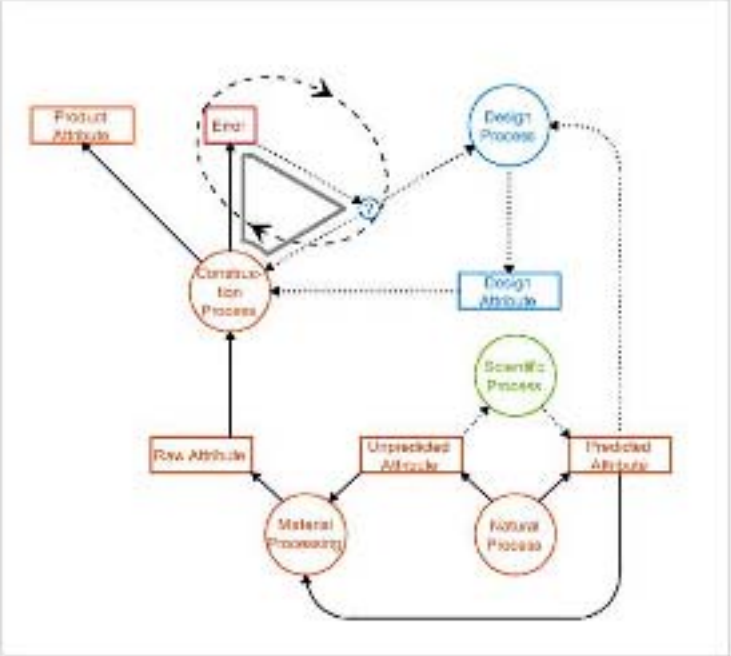
Framework

Error correction:

- Re-produce
- Re-design



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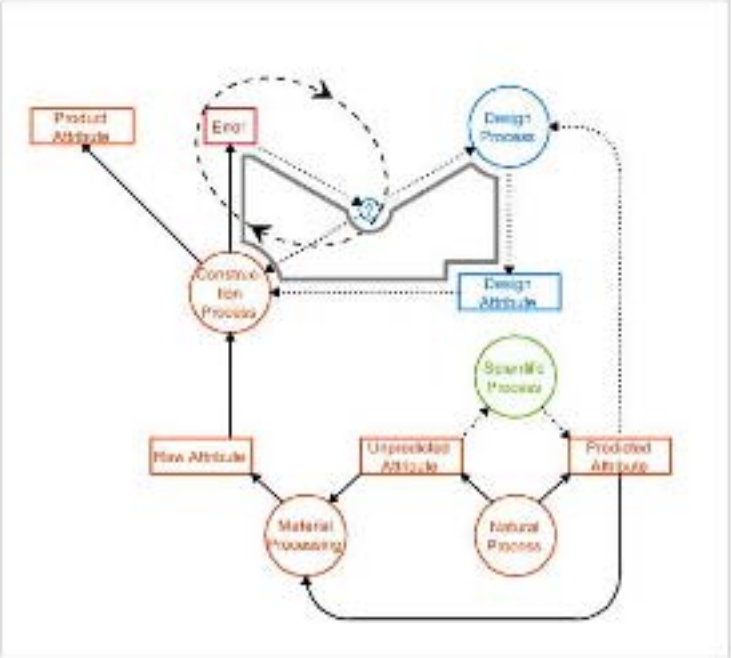

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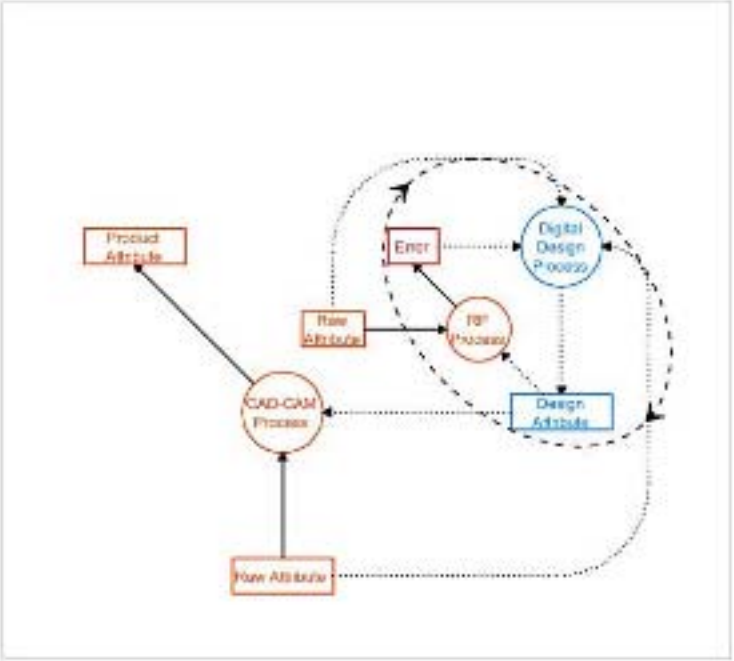
Generative design produces

- **Many design solutions**



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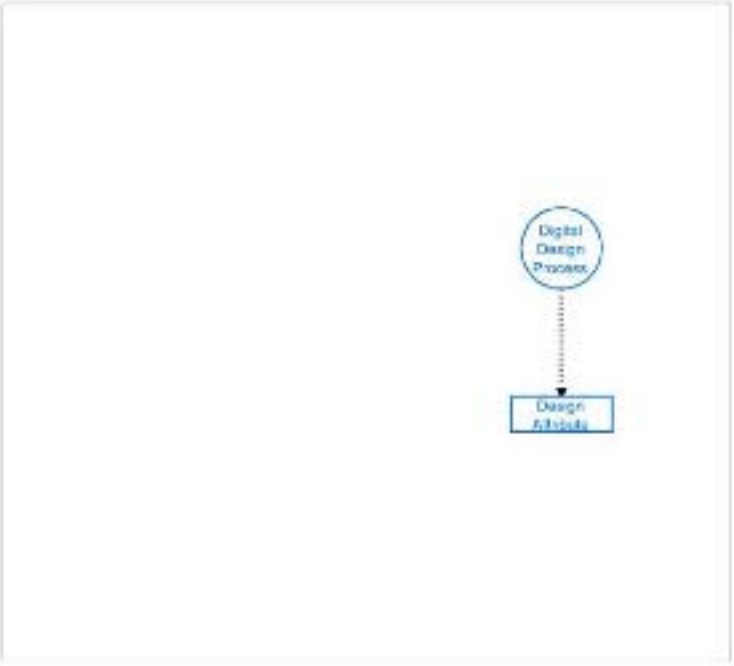

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Generative design produces

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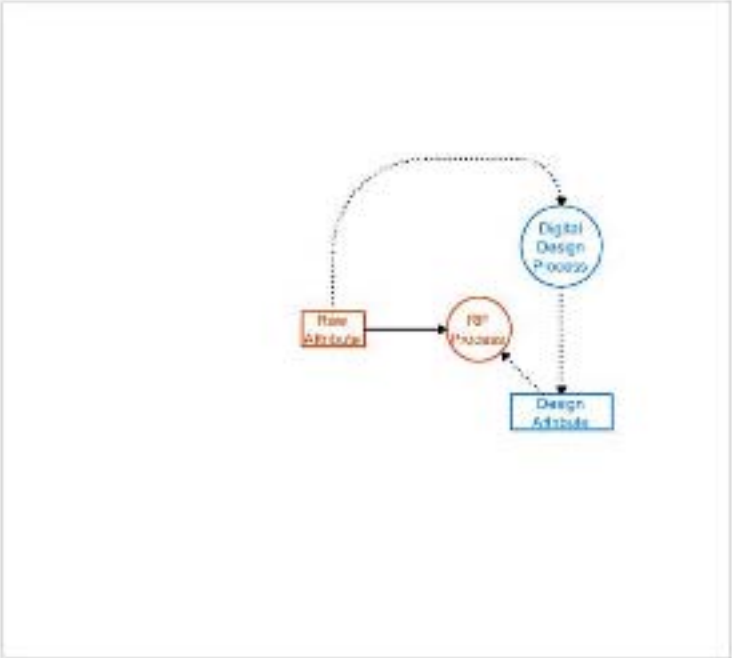
Rapid Prototyping (RP) enables

- Seamless transition from **digital to physical**
- **Evaluation of physical** prototypes



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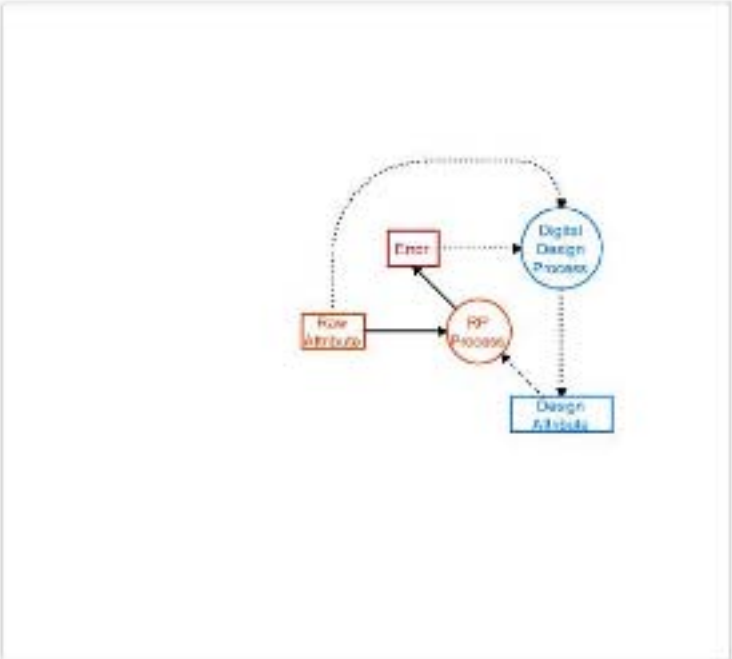

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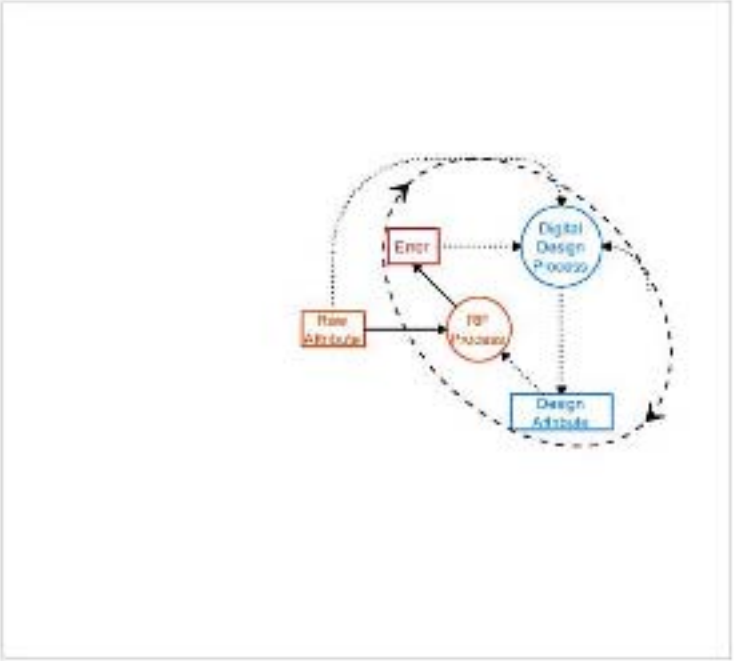

Framework

Generative design produces

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Rapid Prototyping (RP) enables

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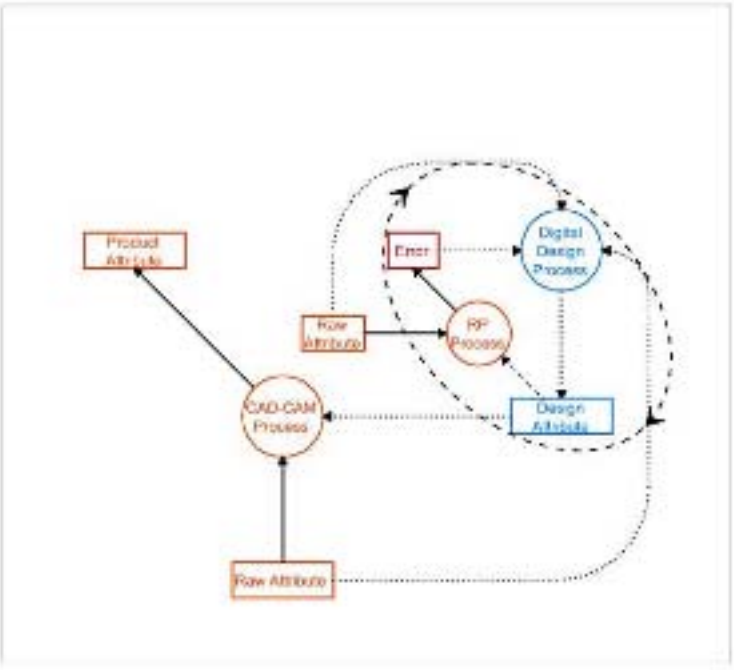
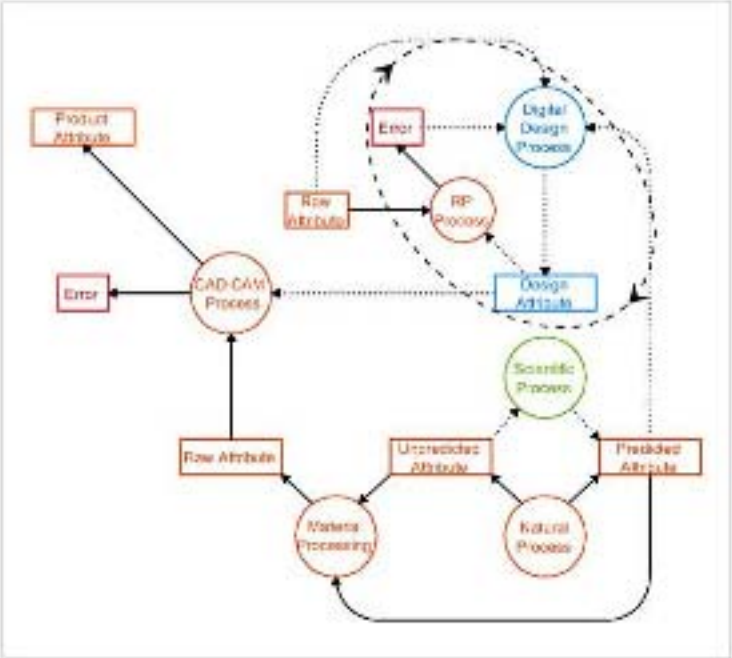
CAD CAM manufacturing allows

- Production of **non-standard** components
- **High tolerances**



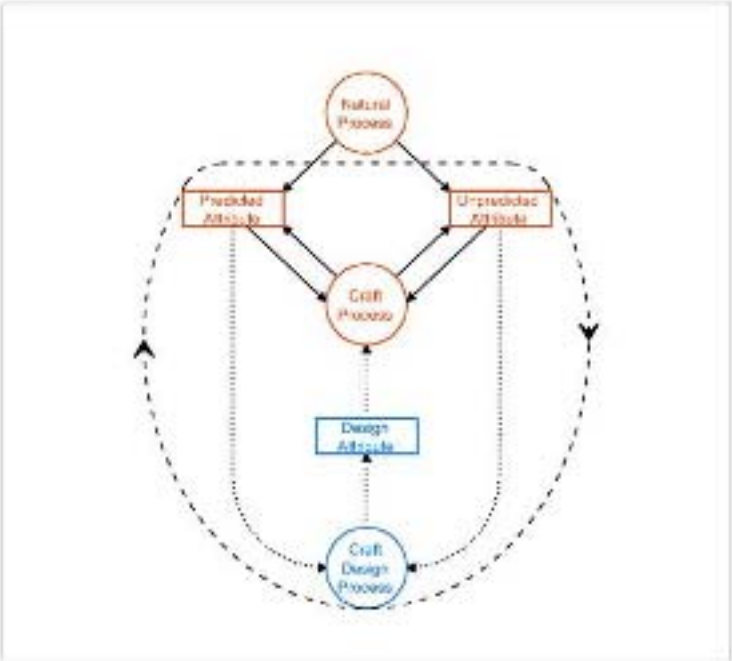
Framework

- Correlation between the prototypes and the product requires **materials with predictable properties**
- Only **highly processed materials** can be used, ex. plywood, plastics and metals
- **Unpredictability leads to error**



Framework

Design in craft



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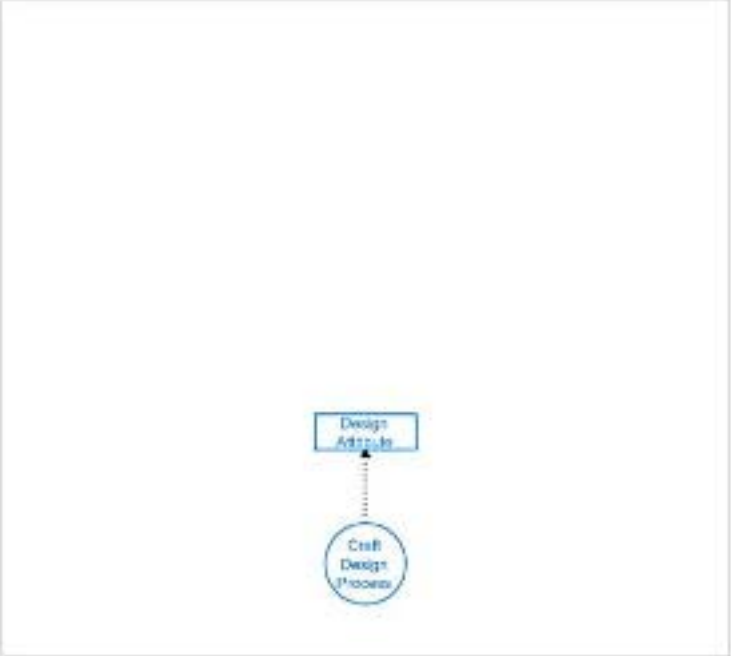
Design in craft

- Is **not explicit**
- **Does not simulate** the product before production



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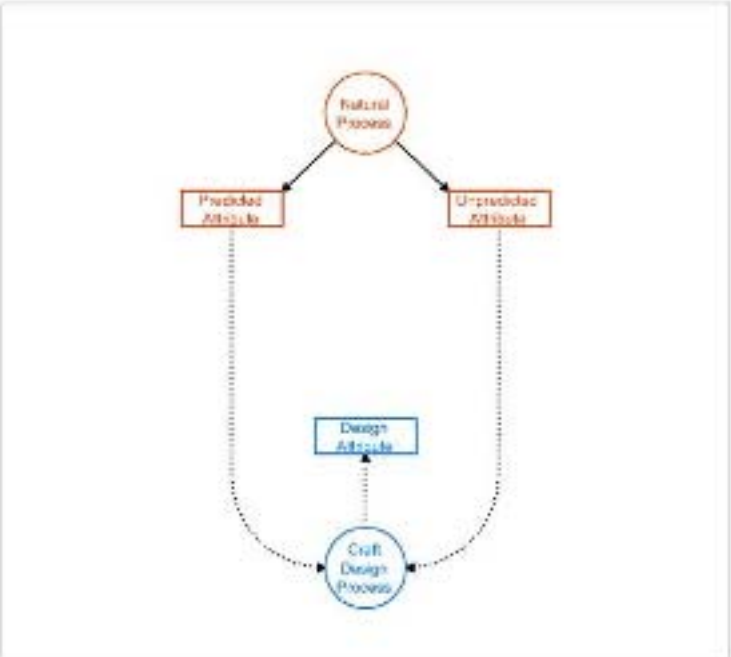
- **Absorbs Unpredicted Attributes** in materials



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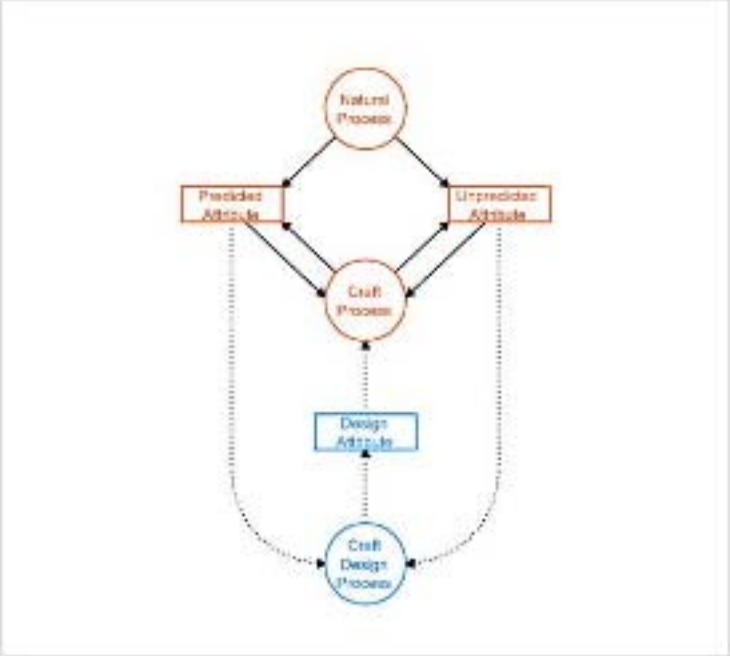

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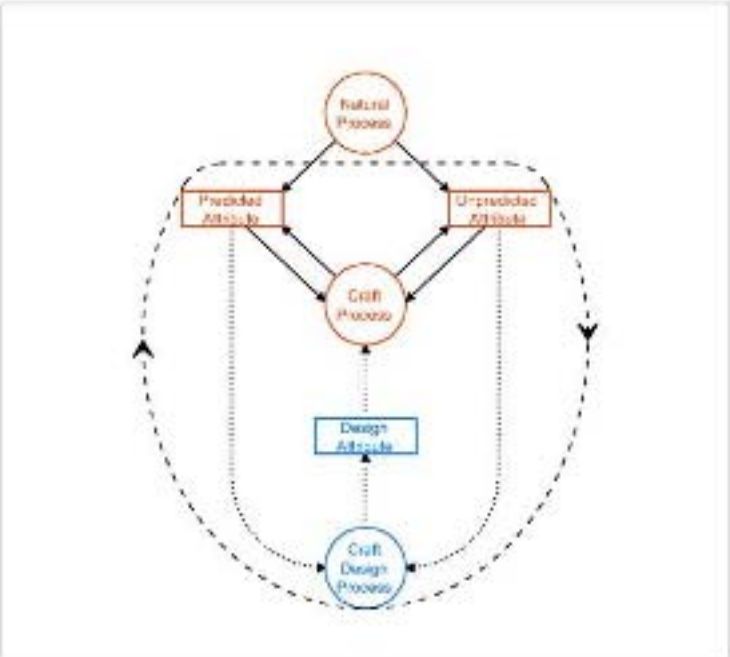
- **Incrementally** bring the product to its final form



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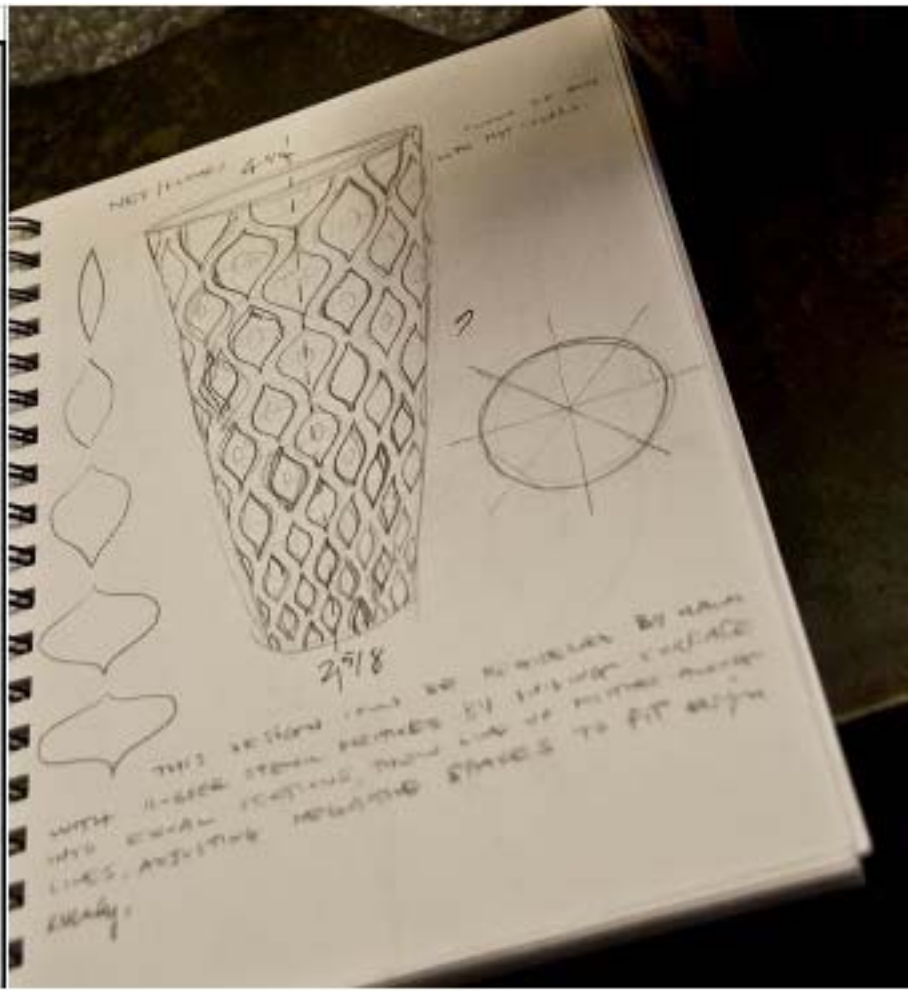

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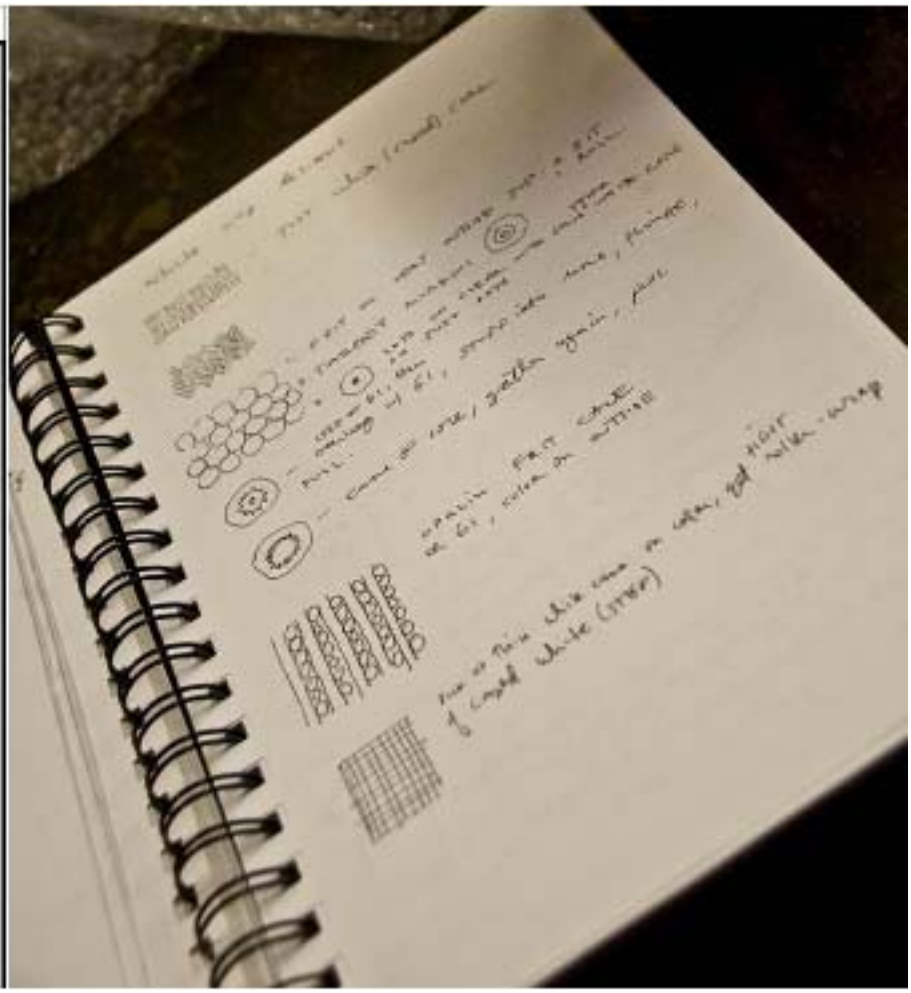

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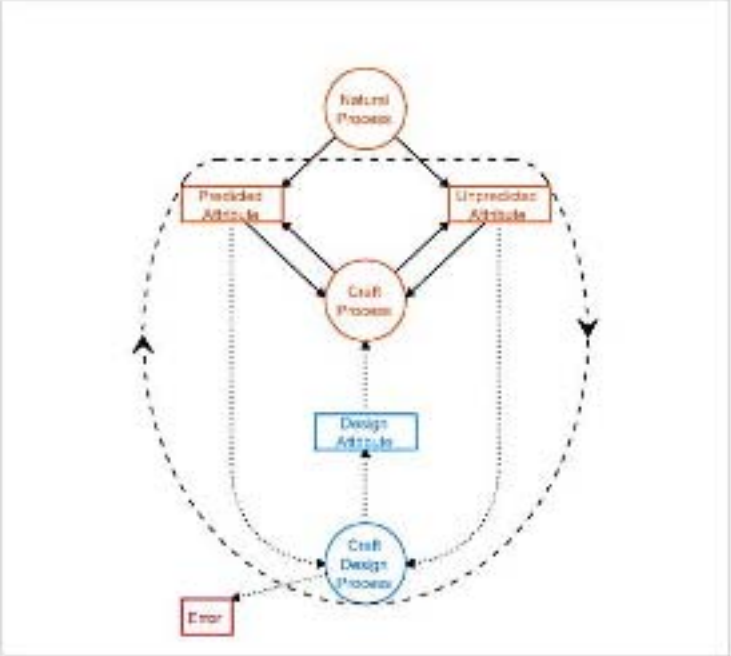
Framework

Craft involves **"workmanship of risk"**

Error in craft occurs

- When an **Unpredicted Attribute can not be incorporated** into the design
- **During design** not production



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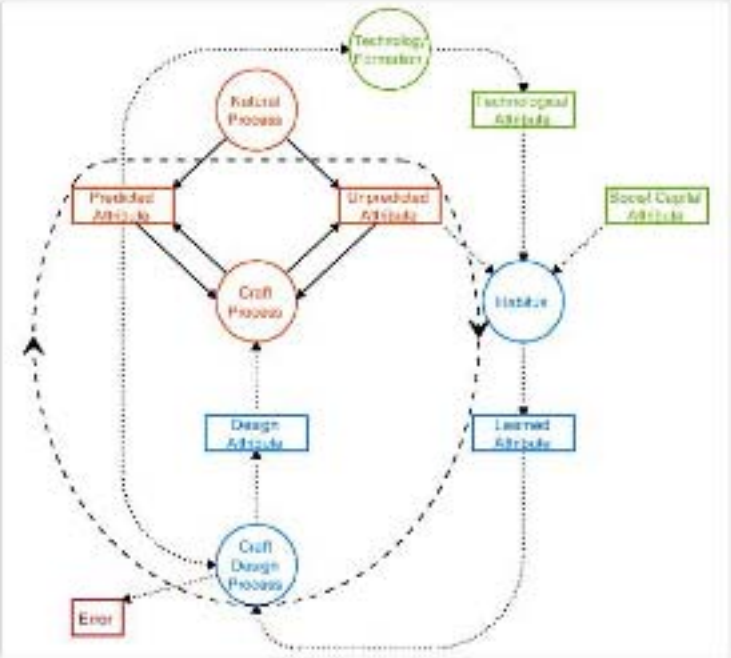
- **Skills minimize unpredictability** in craft



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- **Skills minimize unpredictability** in craft
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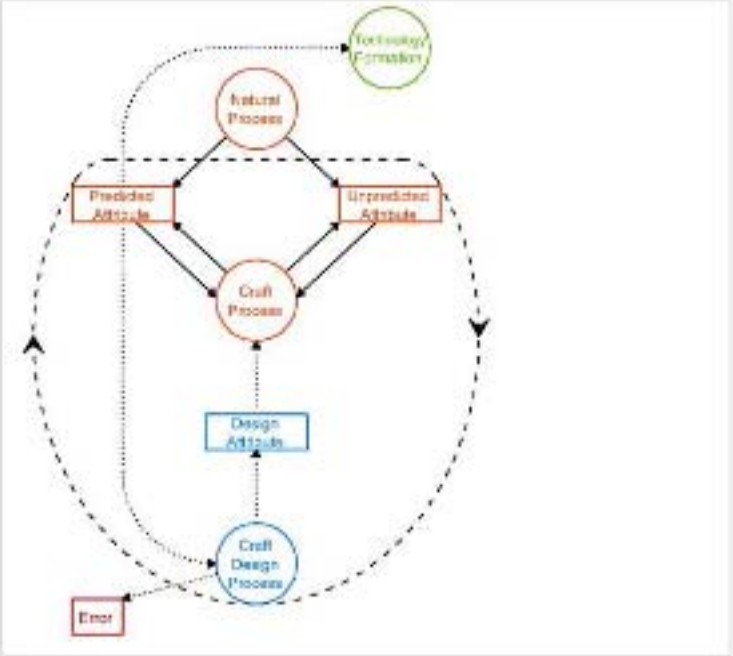

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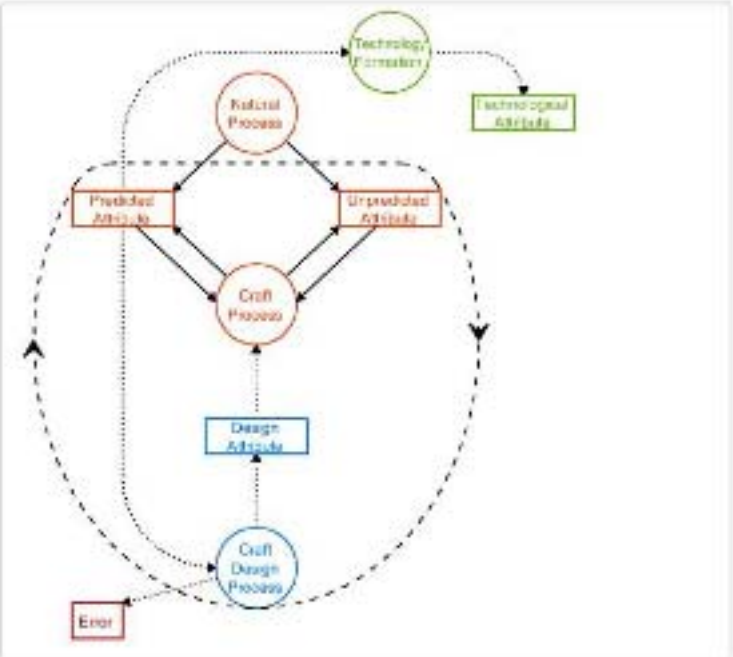

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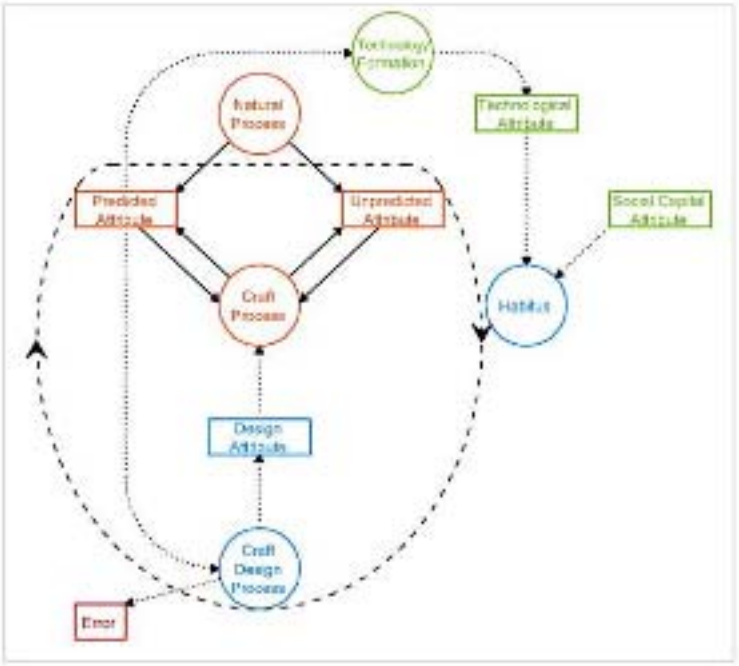

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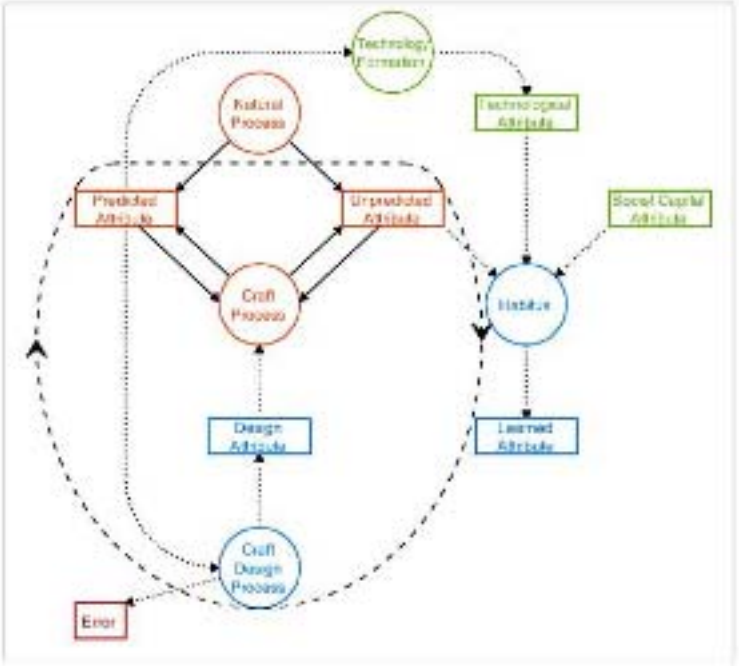

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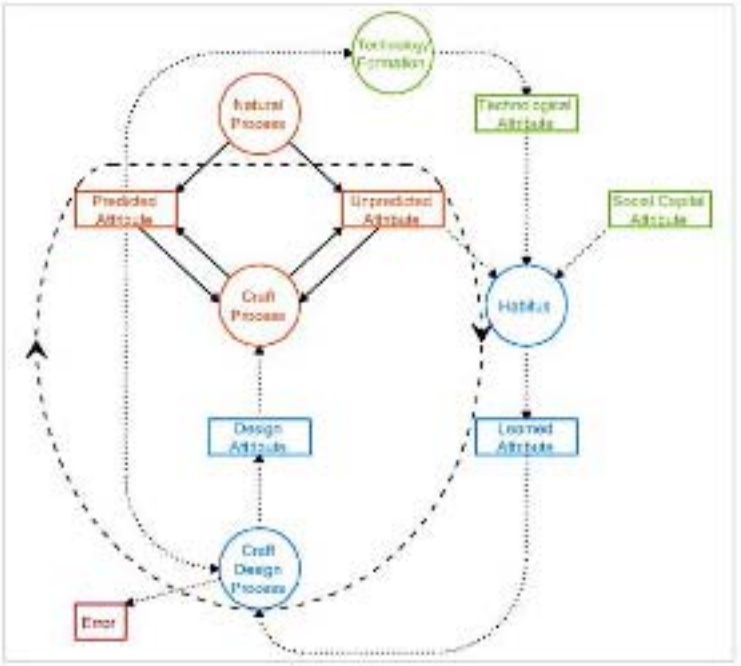

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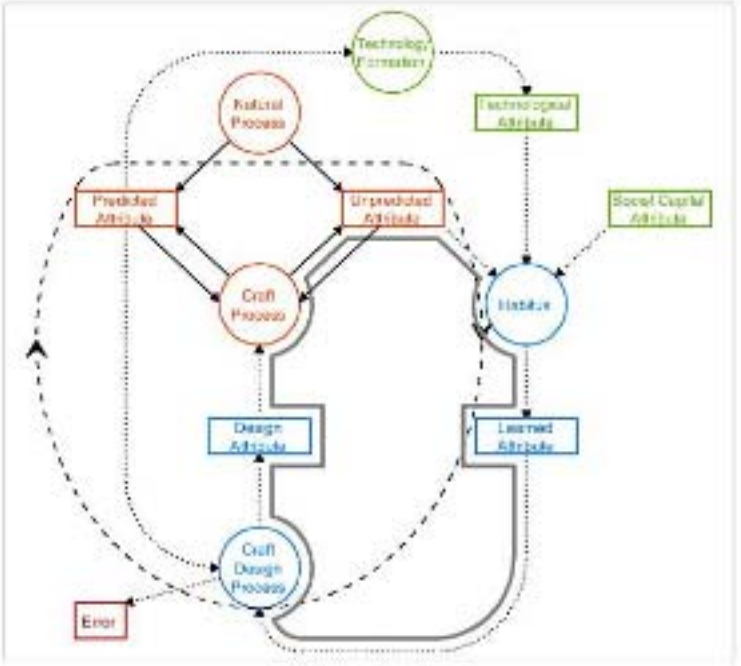

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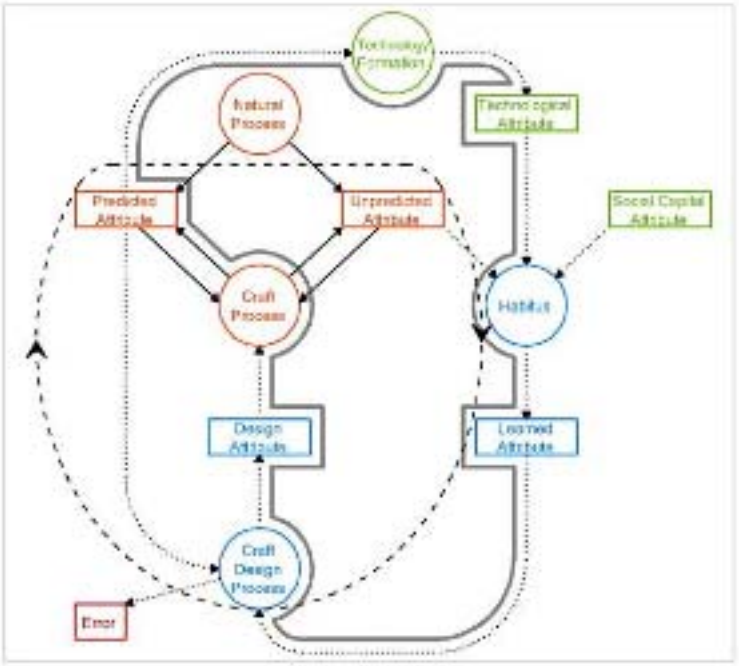

Projects: Parametric Pavillions

- **Parametric family** of hyperbolic paraboloid based **bamboo pavilions**

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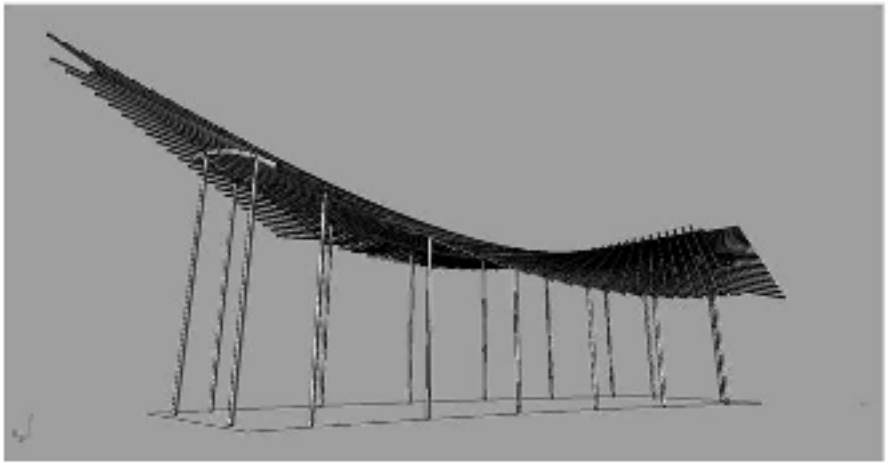

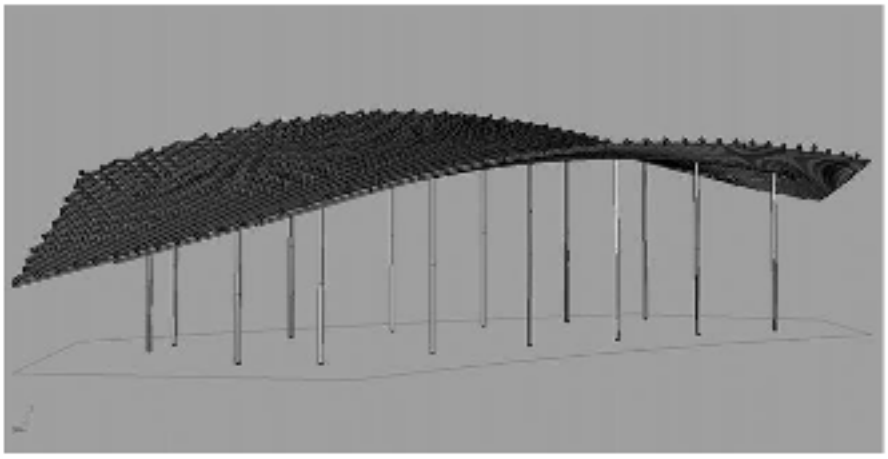

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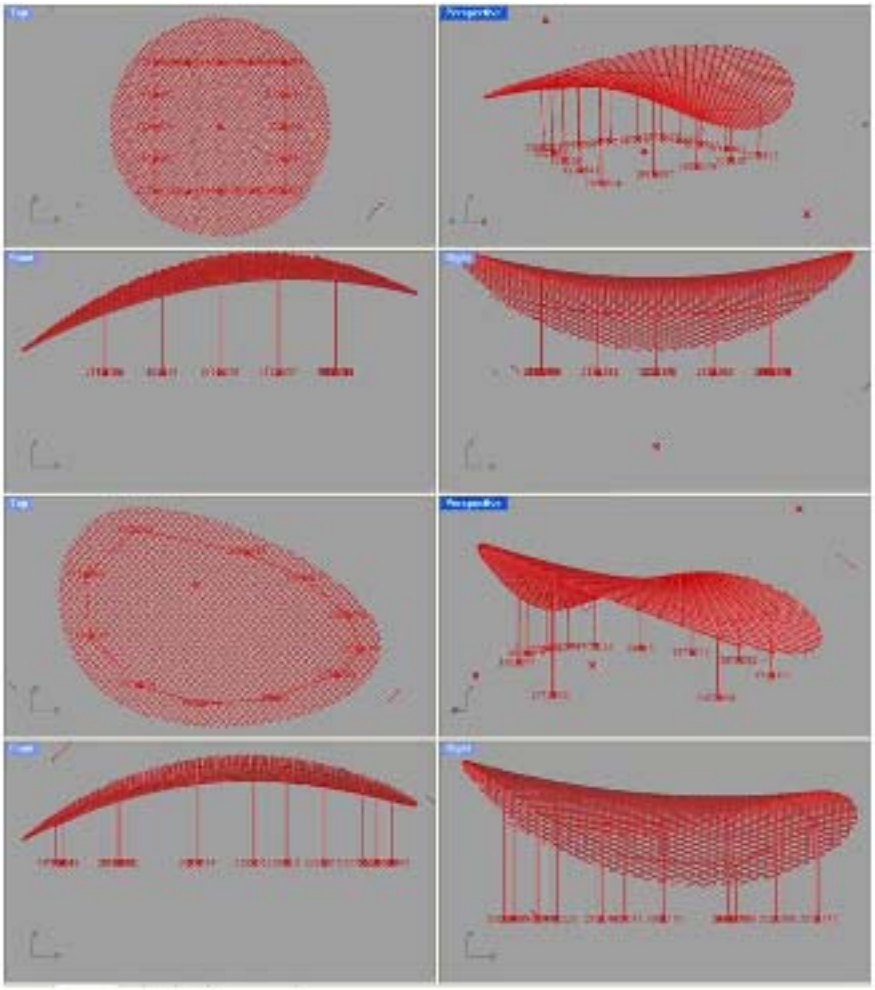
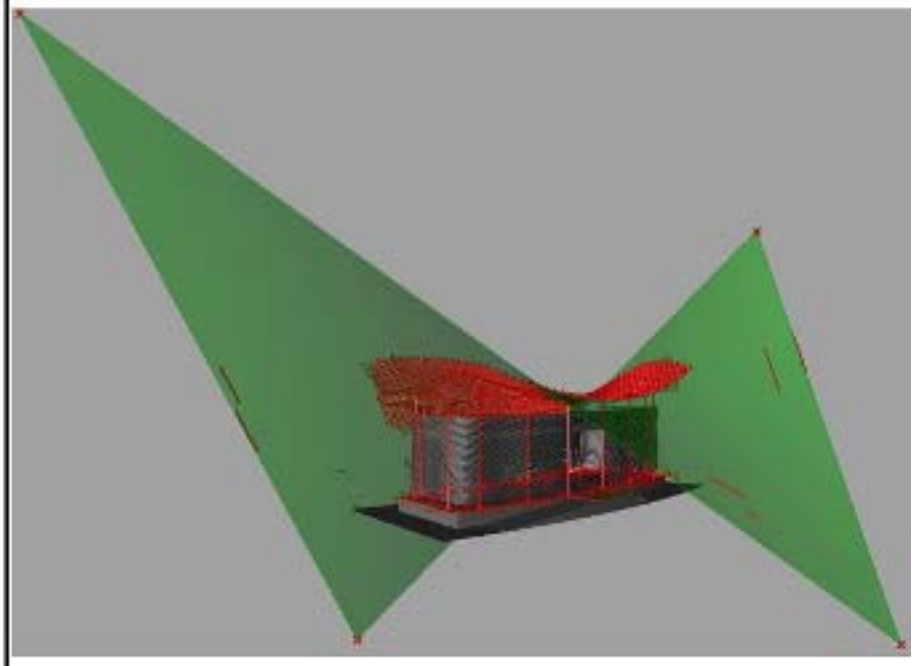


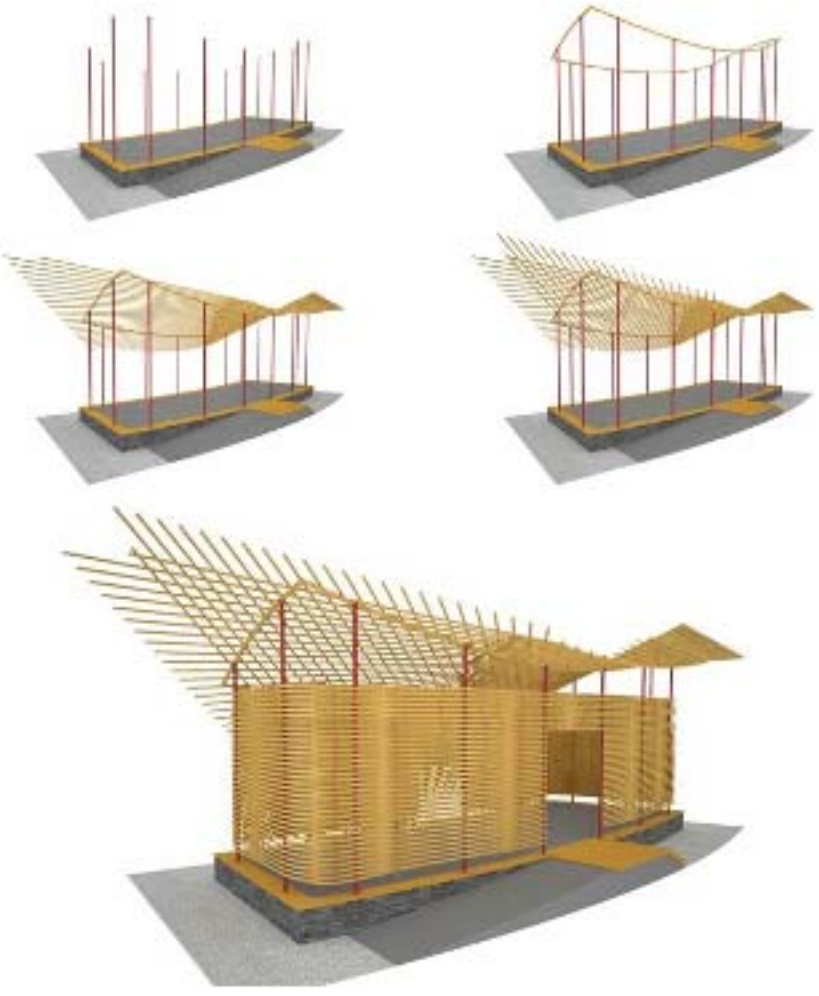
Projects: Parametric Pavillions

- Geometry used to **negotiate digital design with manual fabrication**



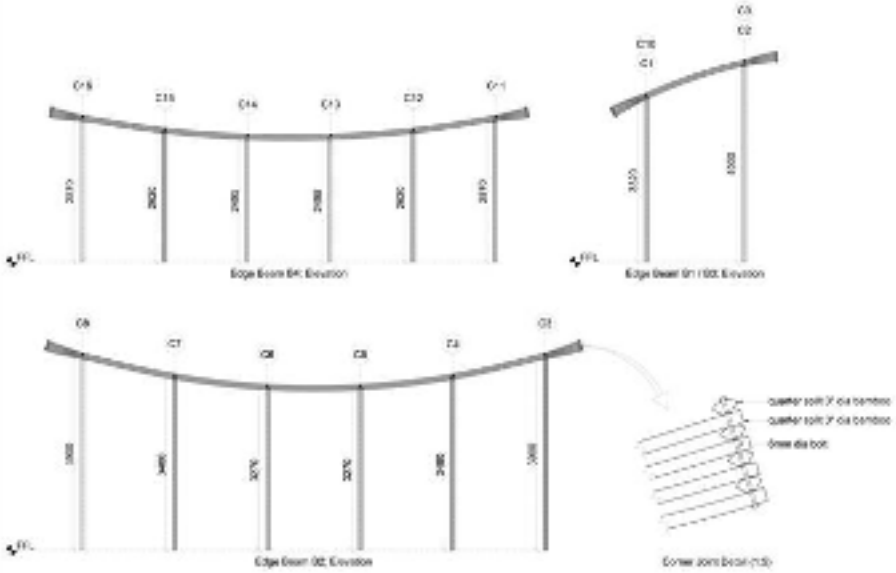
Projects: Parametric Pavillions

- The **ruled surface** enabled the use of **straight members** to produce curvature



Projects: Parametric Pavillions

- The construction drawings for the pavilion included **linear dimensions only**



Projects: Parametric Pavillions

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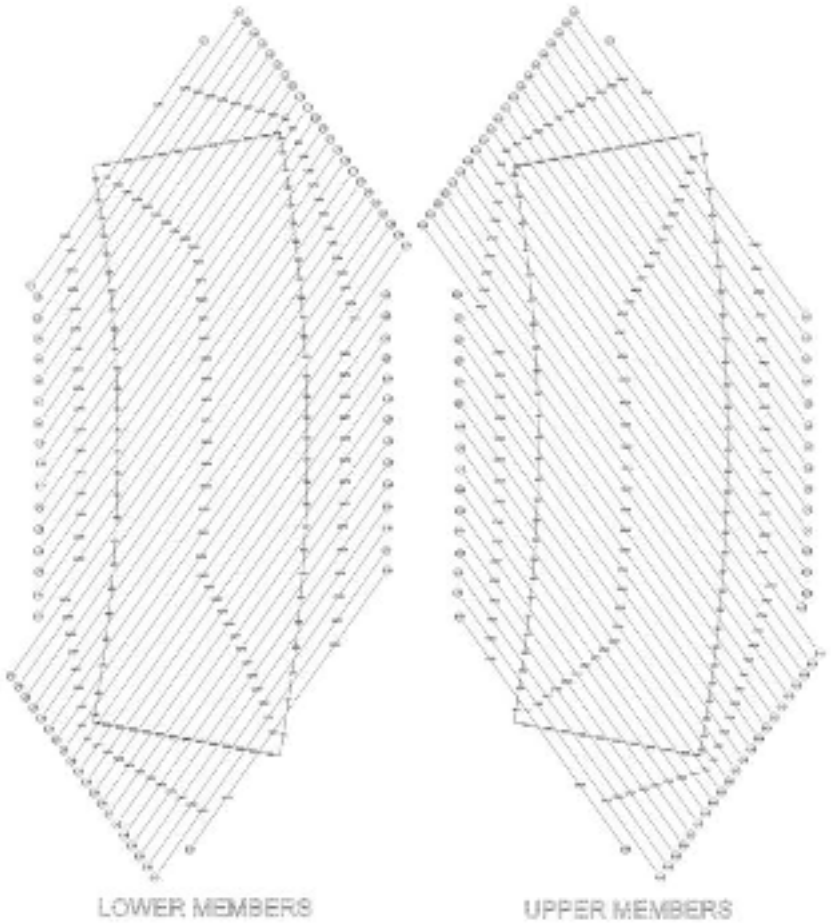
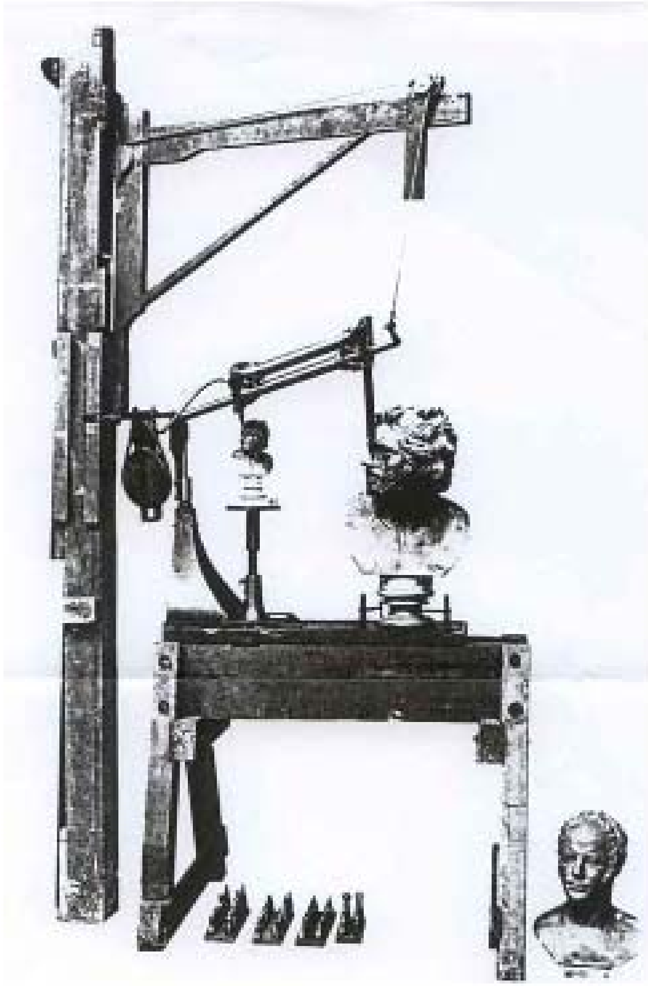


Projects: Parametric Pavillions

- The digital design produces **linear measurements**
- Linear measurements from the **digital design informs the craft**

Image:
http://www.the[illegible].net/forum/index.php?showtopic=1278



Projects: Parametric Pavillions

The craftspersons

- **Negotiated unpredictable variations** in materials and building processes
- Adhered as closely as possible to **digitally derived linear dimensions**

Projects: Parametric Pavillions

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The craftspersons

- **Negotiated unpredictable variations** in materials and building processes
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Projects: Solar Cooker

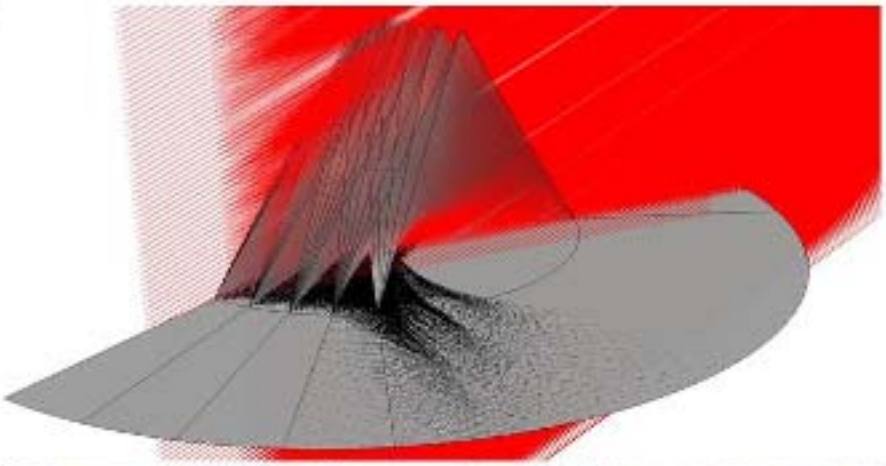
The reflector can be **customized** based on

- Geographical location
- Orientation
- Time of use

Linear dimensions specify the shape.

The **materials** used are

- Bamboo
- Twine
- Hessian
- Mud
- Broken mirror



Projects: Nest Roof

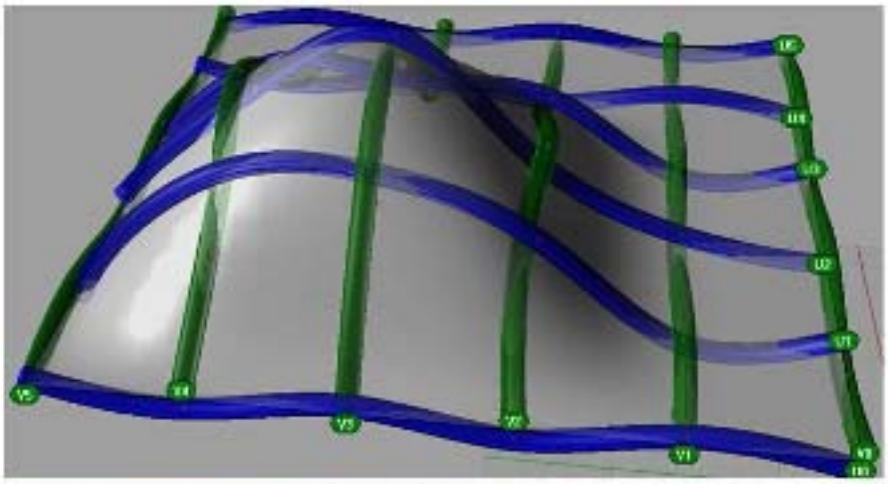
- Explores a **greater role for generative design** in informing craft
- Digitally derived linear measurements to guide a **weaving based craft process**
- **Not limited to ruled surfaces**

Projects: Nest Roof

The **flexibility** of linear materials is used to produce **curvature.**

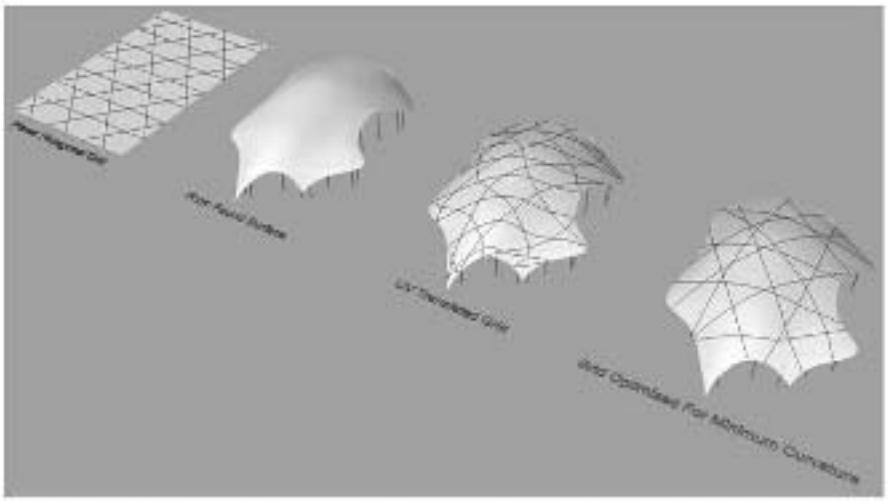
Projects: Nest Roof

A **network** of intersecting **linear members** produces a **curved surface.**



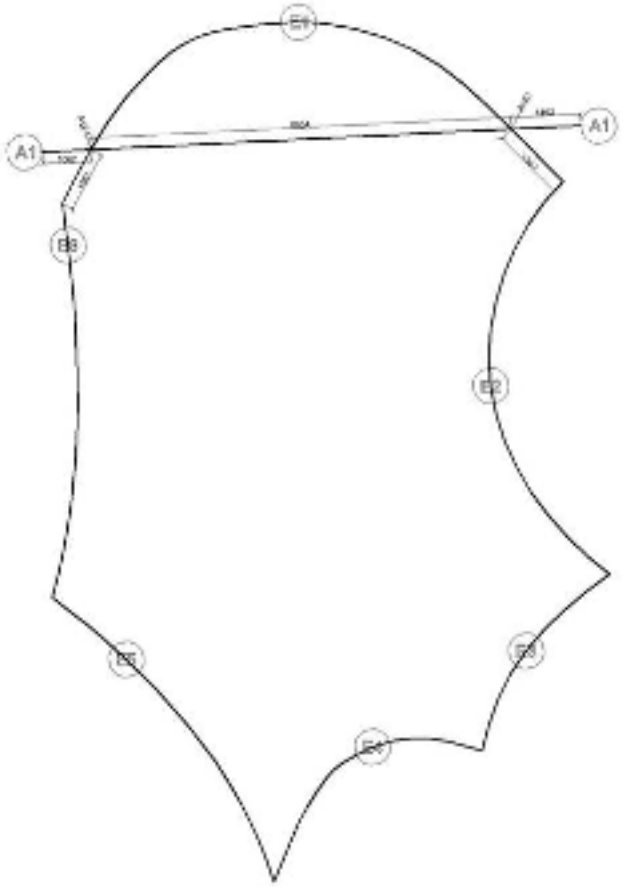
Projects: Nest Roof

- The roof is a **form-found** compressive **shell** that forms a **double curved** surface
- The network of **surface paths with minimum curvature** is found
- They are woven with **half-split bamboo** members for **maximum strength**



Projects: Nest Roof

A sequence of **linear measurements** specify the weaving.



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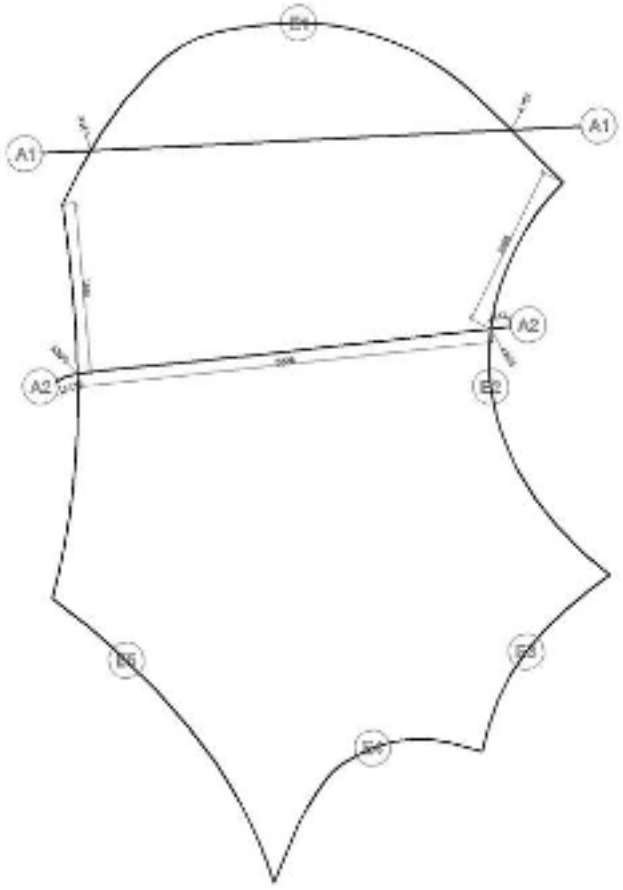

Projects: Nest Roof

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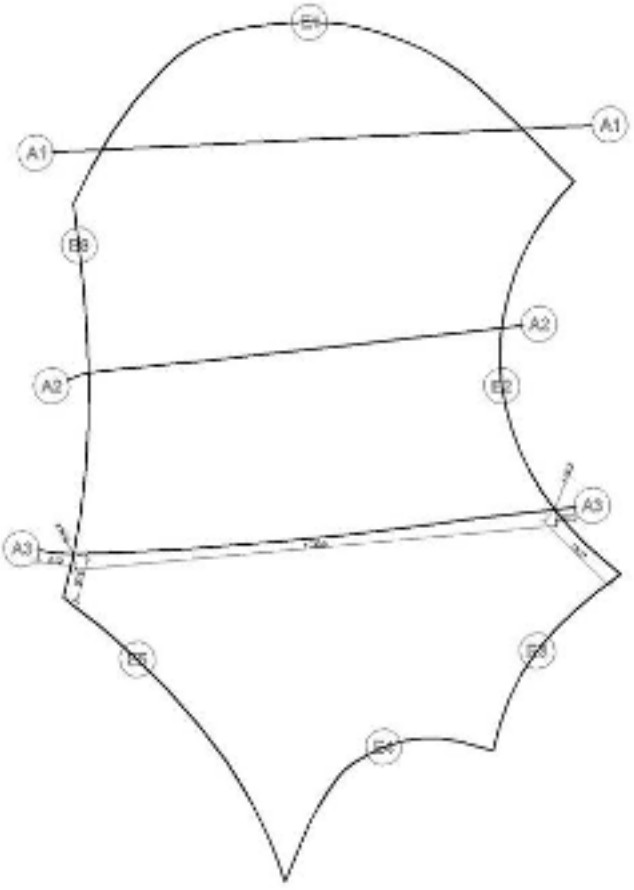

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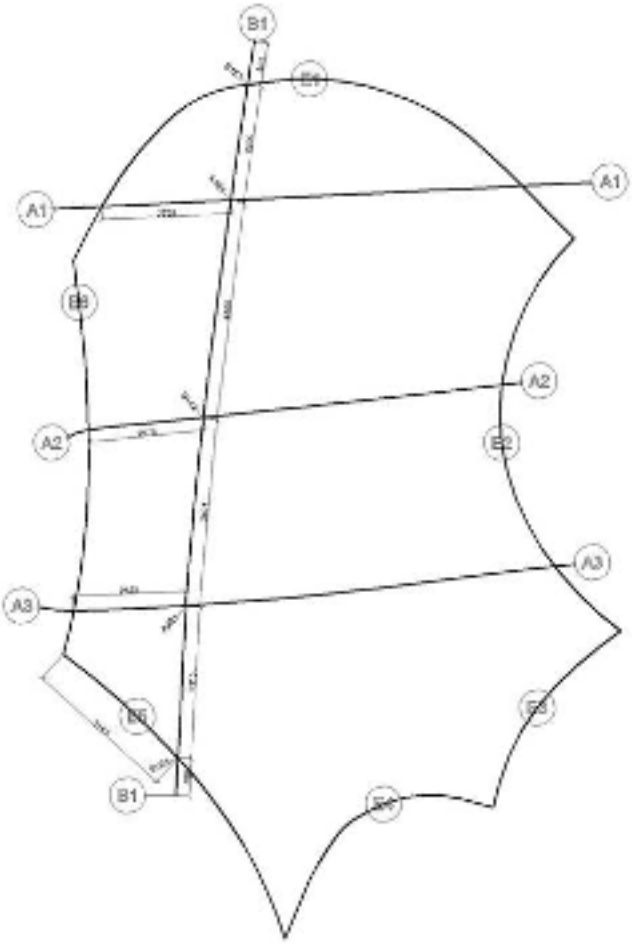

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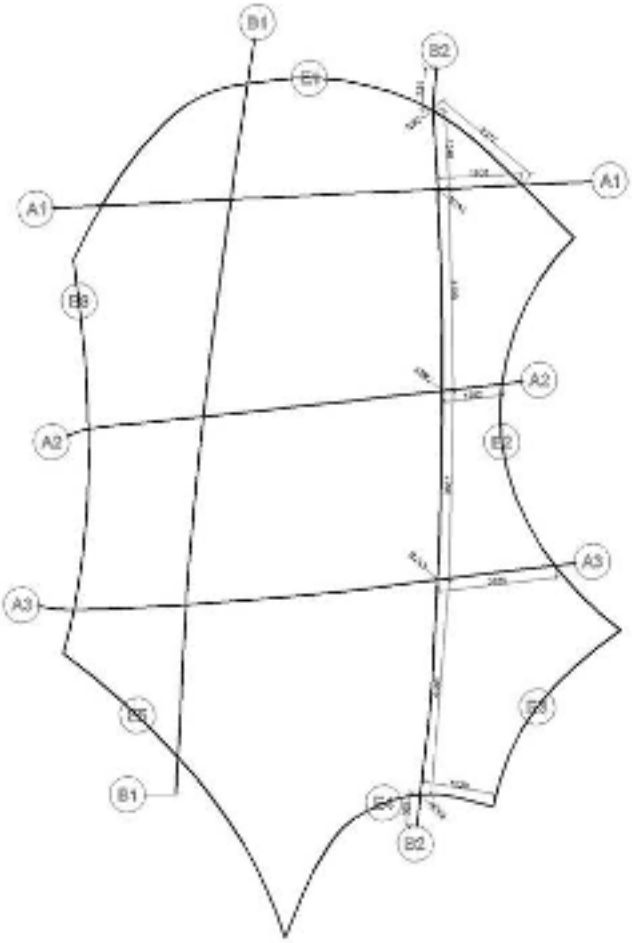

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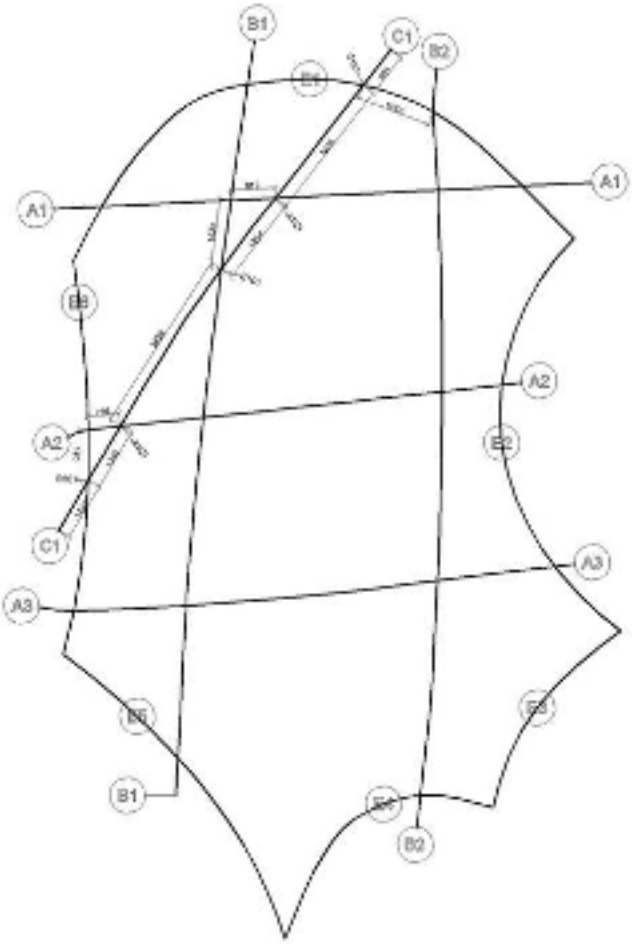

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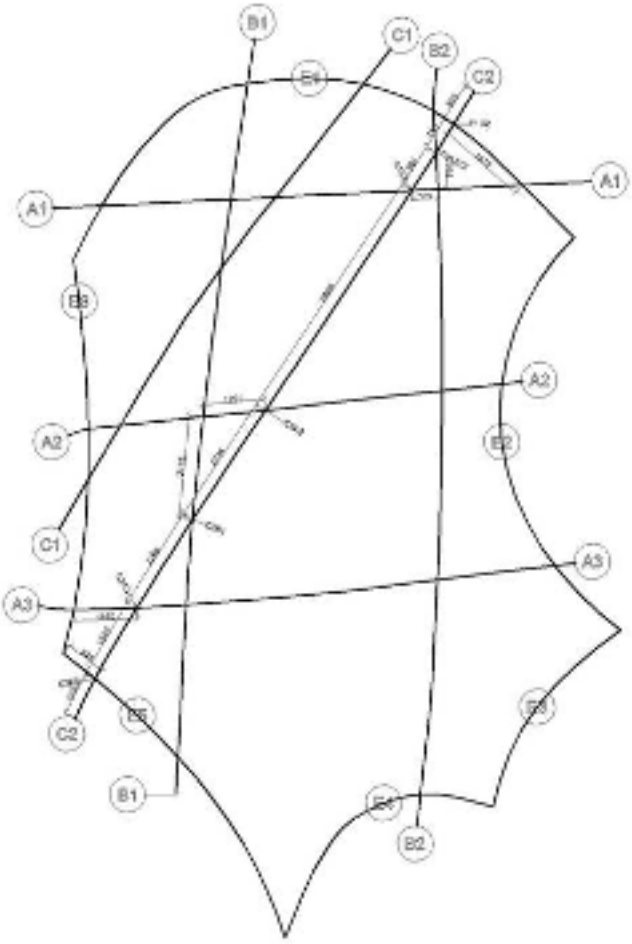

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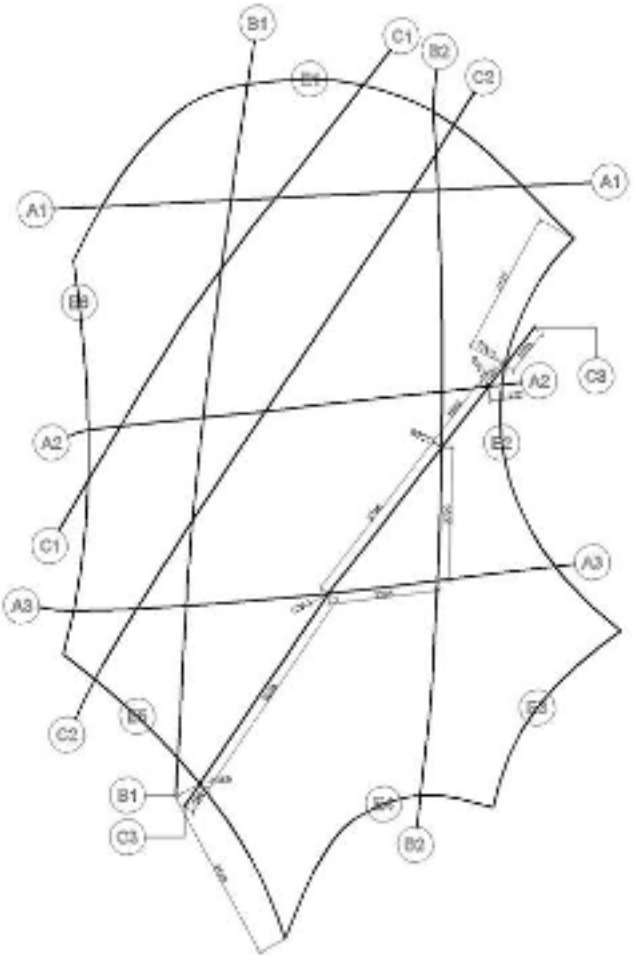

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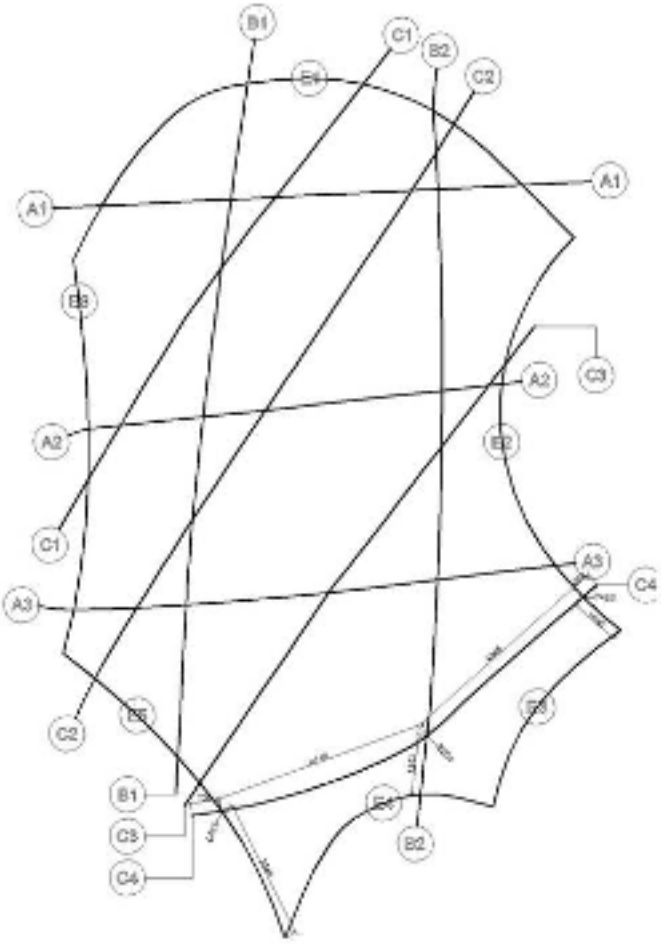

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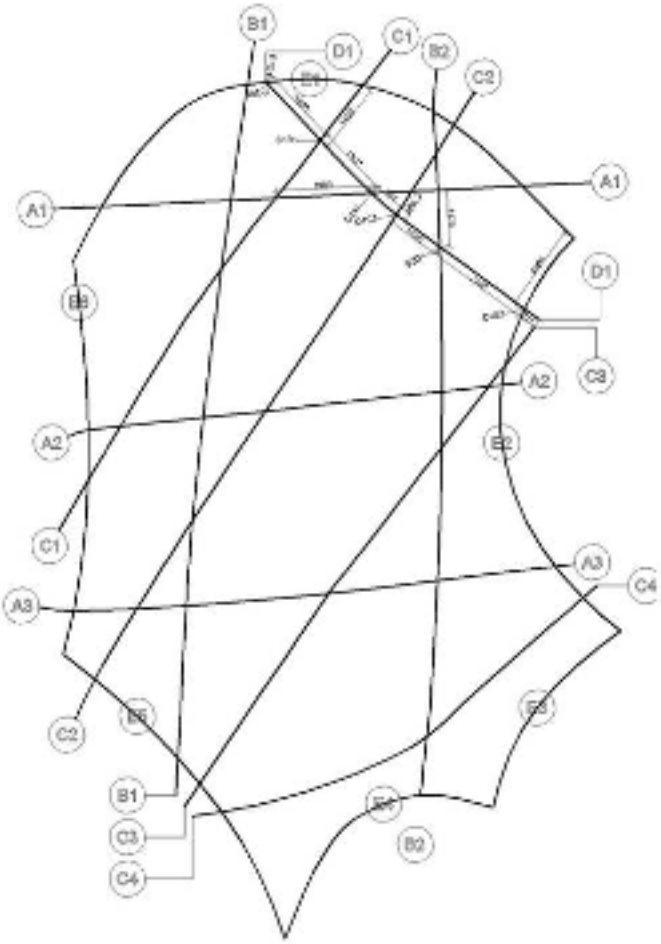

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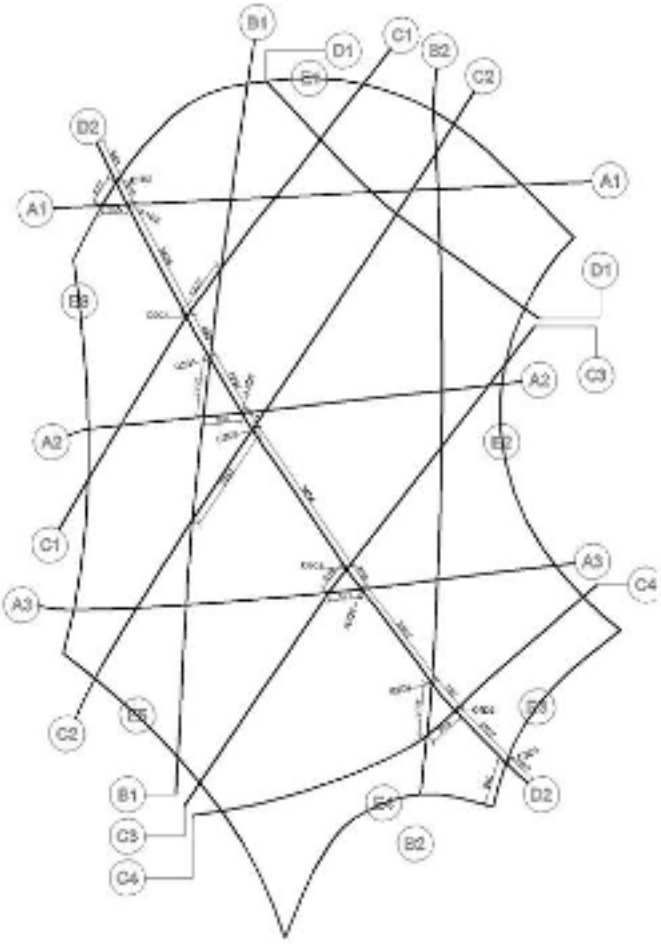

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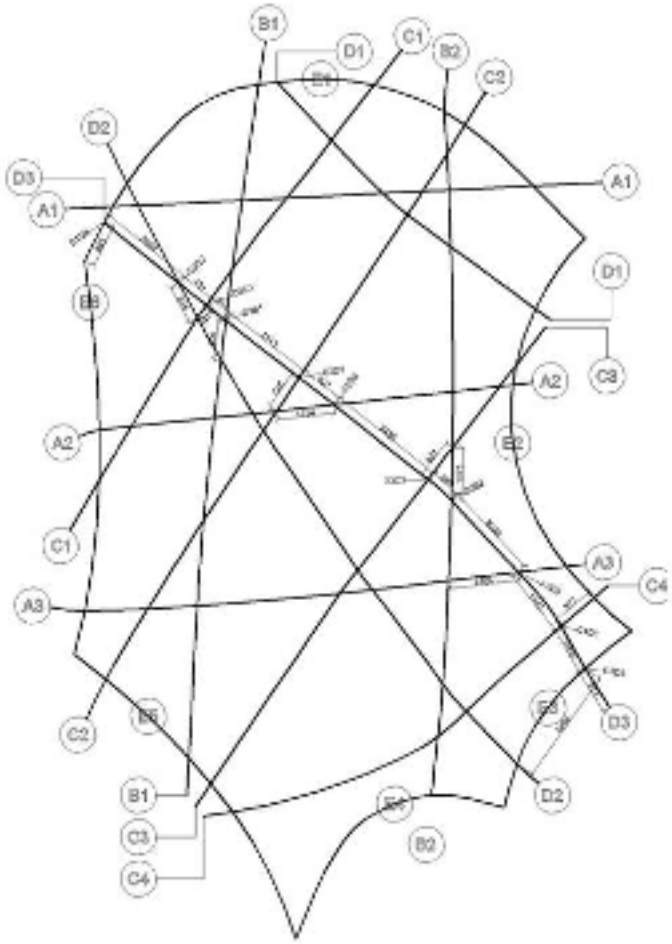

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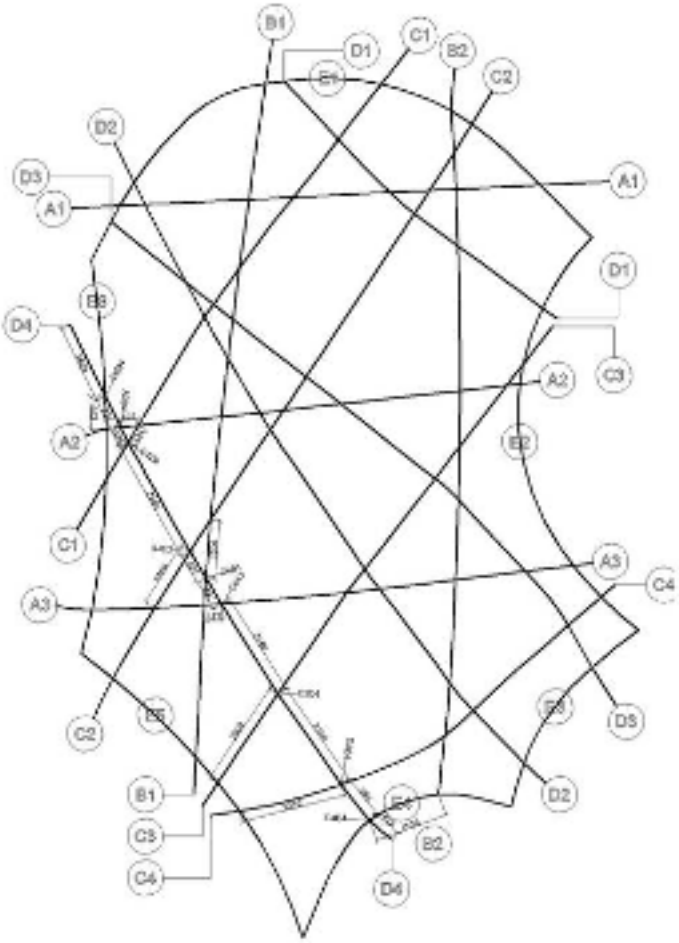

Projects: Nest Roof

The prospective construction team built a scale model of the roof using the linear dimensions

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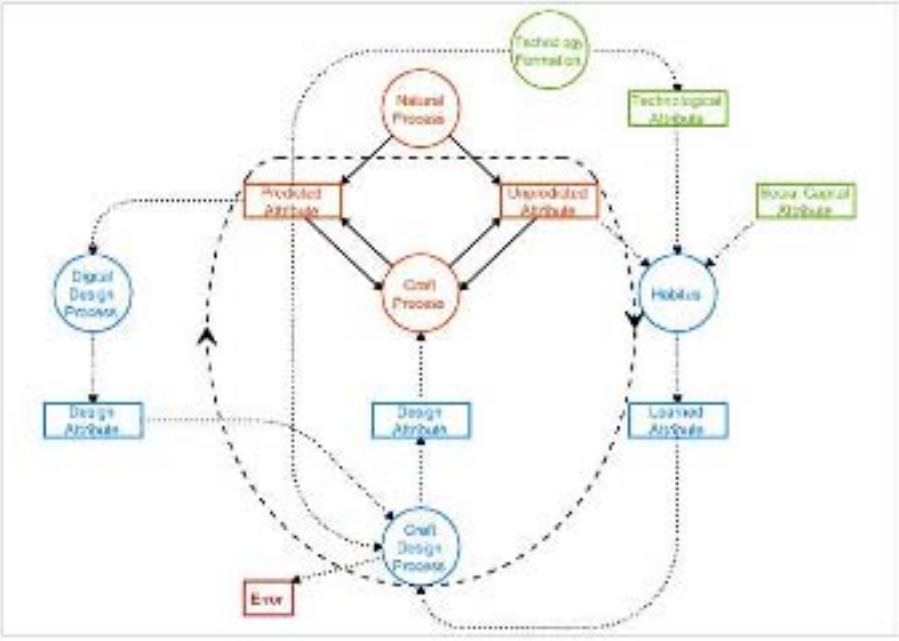
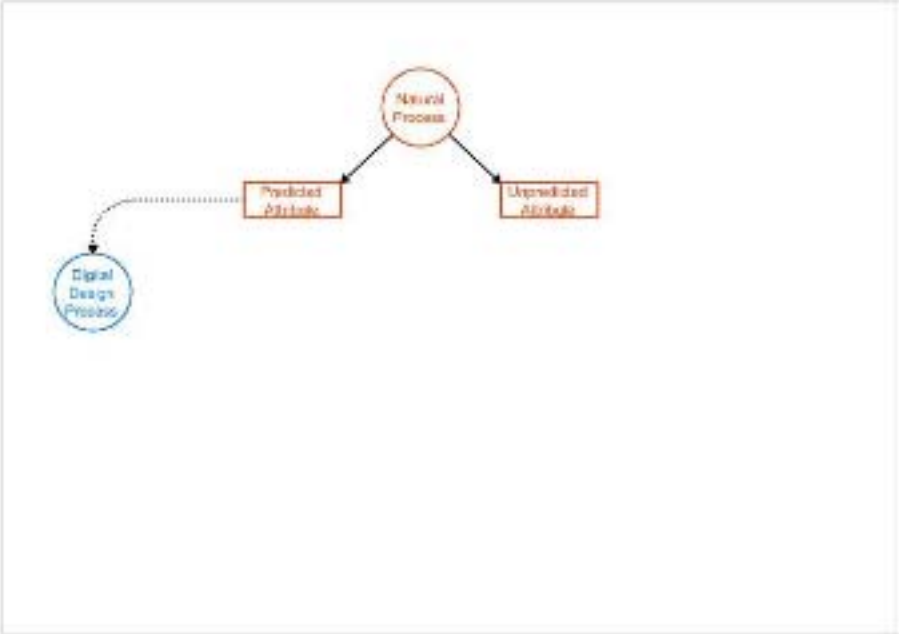
The prospective construction team built a scale model of the roof using the linear dimensions

Projects: Analysis



Projects: Analysis

- **Predictable** properties of the materials **inform the digital** design



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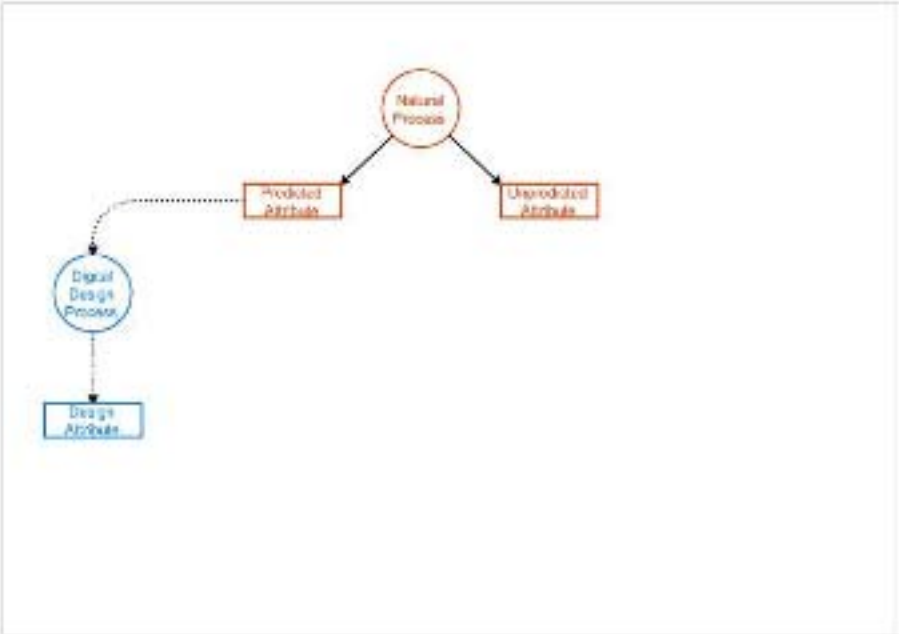
- **Predictable** properties of the materials **inform the digital** design
- The digital design produces **linear measurements**



Projects: Analysis

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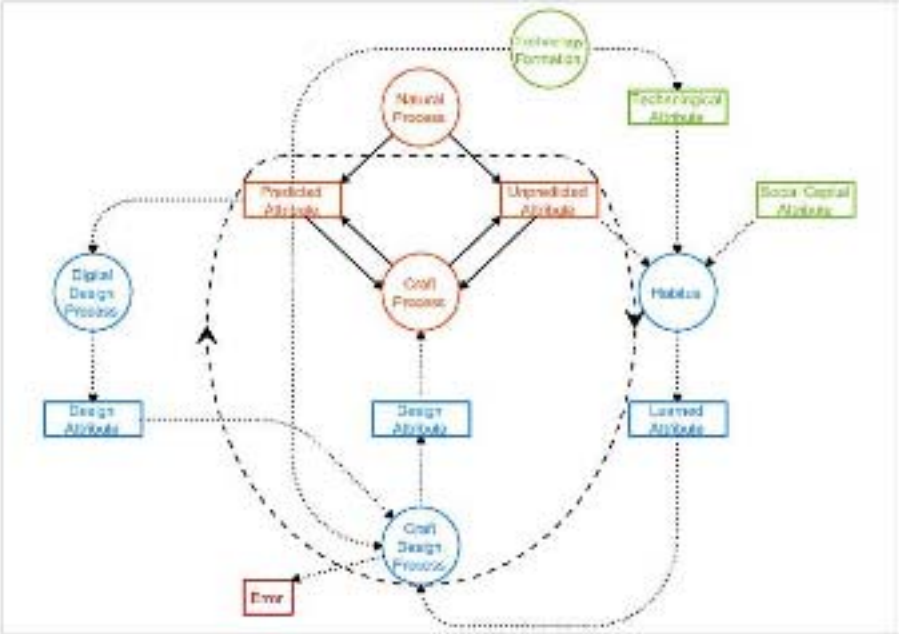
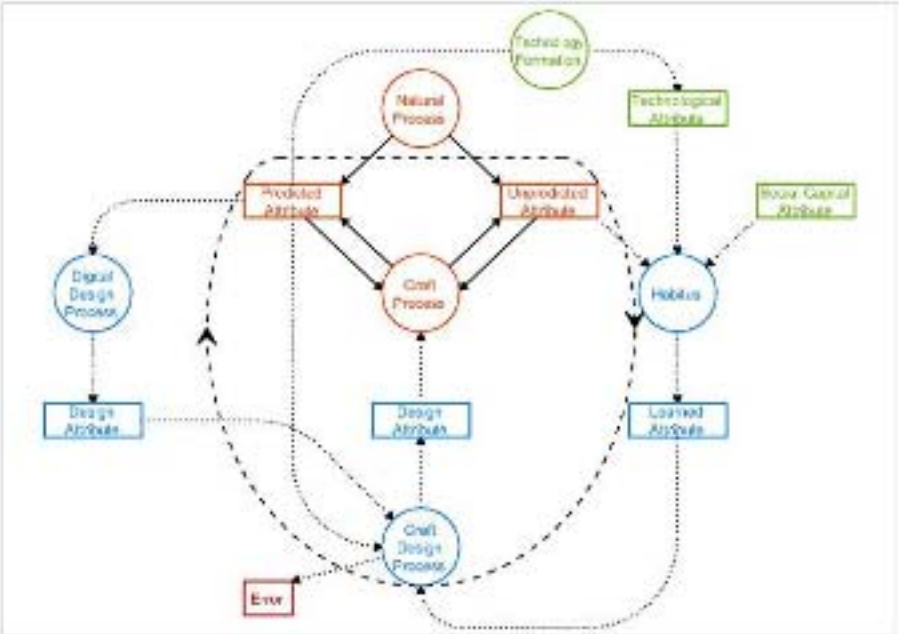
- The digital design produces **linear measurements**
- Linear measurements from the **digital design informs the craft**



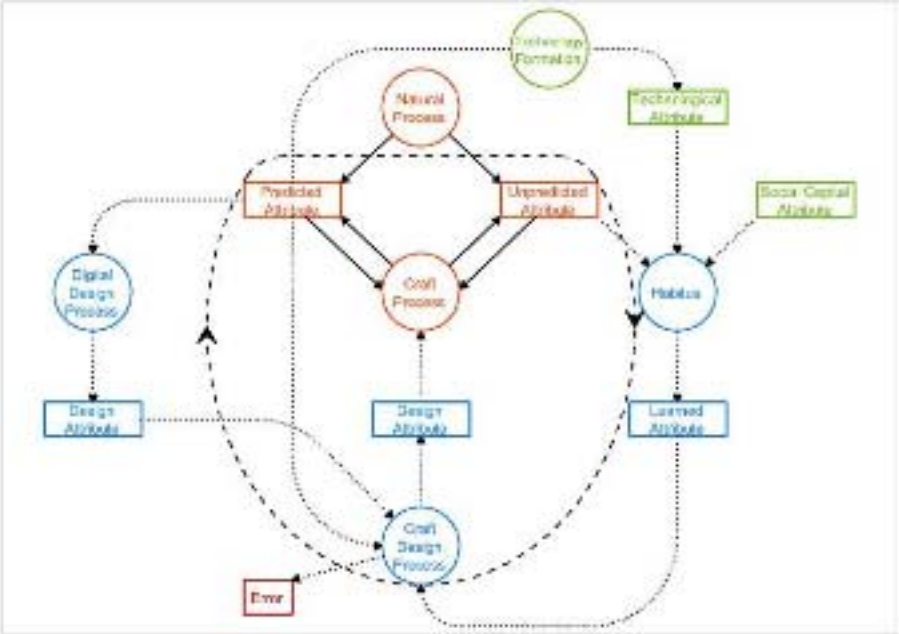
Projects: Analysis

- The design process moves beyond the iterative loop of craft allowing the **planning of complexity**
- The **ability to negotiate Unpredictable Attributes** through craft is maintained



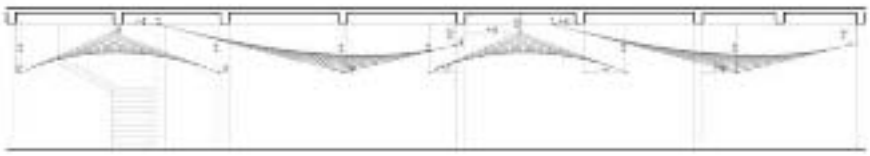
Projects: Analysis

- The **Digital Design** Process is **not informed by Unpredicted Attributes**
- The **Digital Design** Process **does not contribute to Habitus** Formation



Projects: Multi-Purpose Hall

Suspended bamboo hyperbolic paraboloid ceiling



HEALTH VILLAGE MULTI-PURPOSE HALL
D-30, SECTOR 62, NOIDA
HYPERBOLIC PARABOLOID LEVELS
SCALE 1:75 @A3 SIZE
DATE 25.11.2011

Projects: Multi-Purpose Hall

Linear dimensions specify the hyperbolic paraboloid

Projects: Multi-Purpose Hall

The technology of the craft does not include:

- The ruled surface geometry of the hyperbolic paraboloid
- Structurally suspending objects from the roof

Projects: Multi-Purpose Hall

- The **trabeated system** of the Parametric Pavilions is **familiar** to the craftspersons
- The **geometry of ruled surfaces emerges** from the trabeated construction






Projects: Multi-Purpose Hall

The technology of the craft does not include:

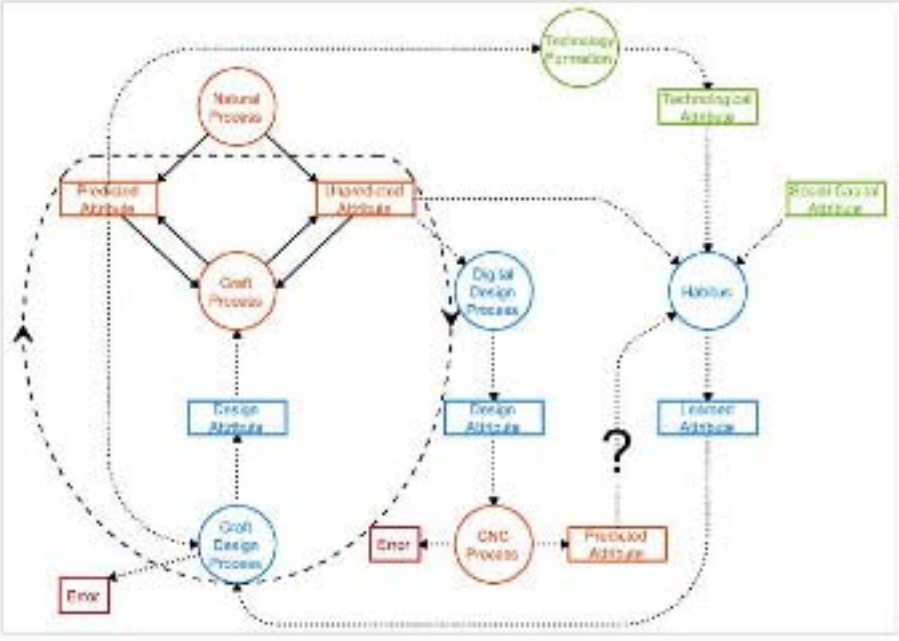
- The **ruled surface geometry** of the hyperbolic paraboloid
- **Structurally suspending** objects from the roof


Experiment

- The **Digital Design** Process is **informed by Unpredicted Attributes**

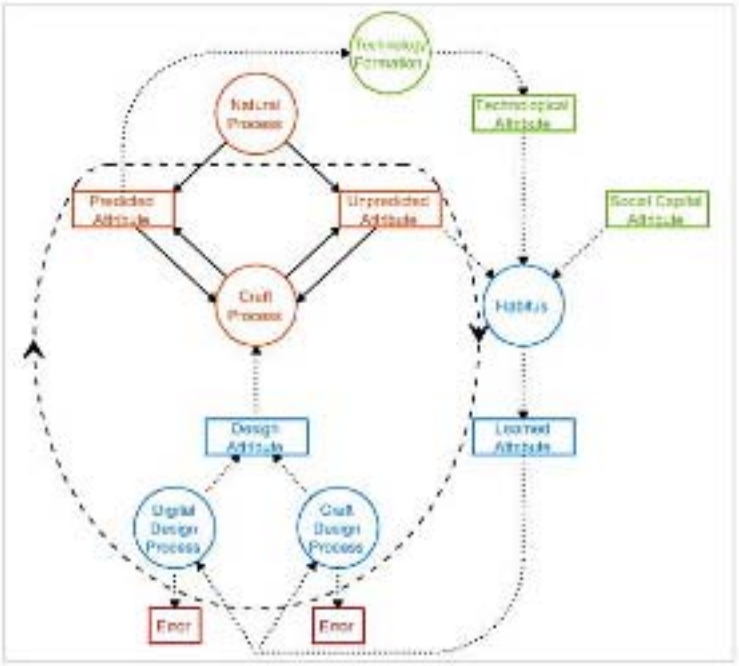
Experiment

- **Unpredicted Attributes do not feedback** into the Digital Design Process
- The **Digital Design** Process is **not a part of** the iterative loop of **craft**
- The **Digital Design** Process may **indirectly contribute** to **Habitus** Formation



Theoretical Speculation

- The **technology** of DDF is **not inherently limited to the DDF system** of design and fabrication
- DDF is able to **generate non-standard variation**
- Can DDF tools be made to **incorporate unpredicted variation?**
- **Planning and incorporating complexity** can occur **within the iterative loop**
- DDF tools can **influence Habitus**



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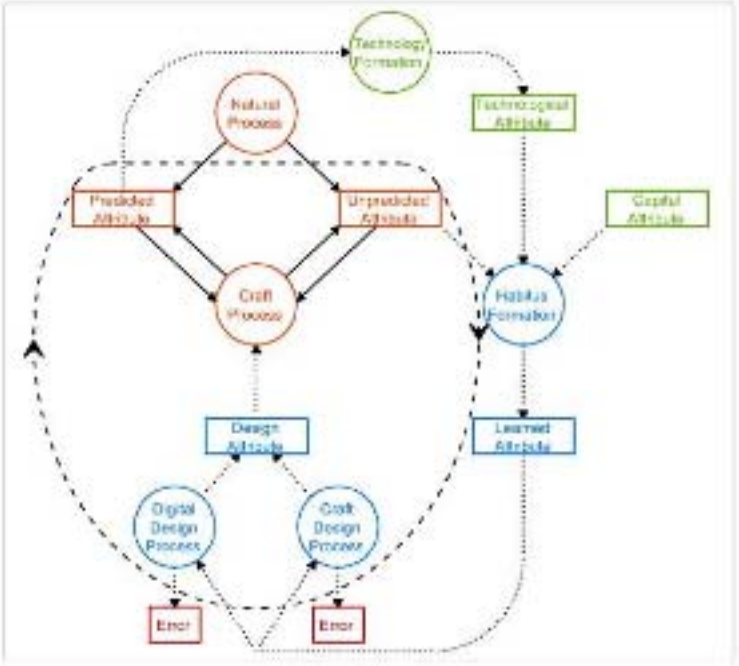
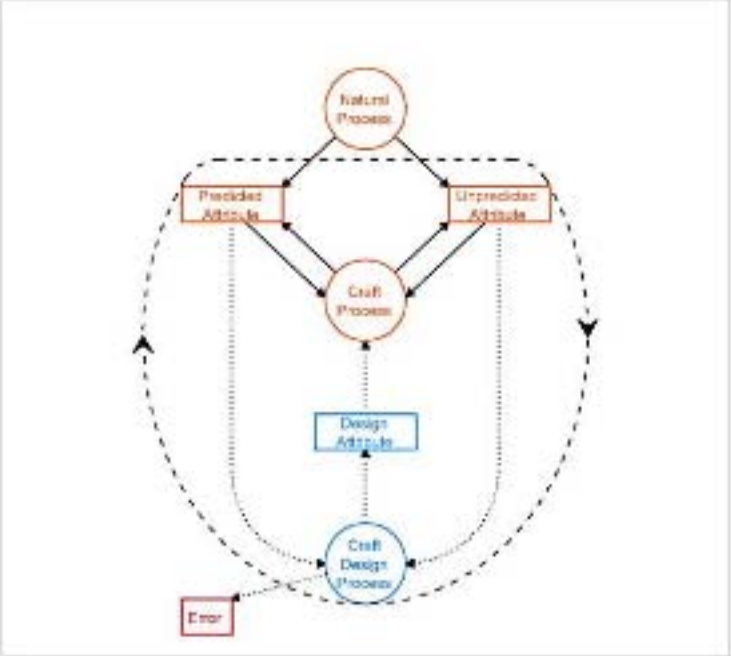


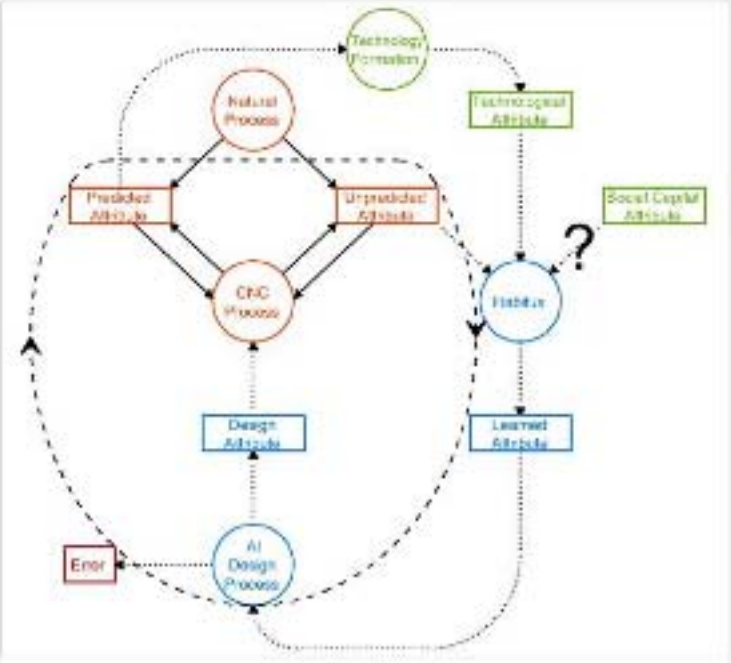
Theoretical Speculation

Craftspersons may be **predicting** the results of computationally unpredictable processes **by executing those process**



Theoretical Speculation

Can habitus be automated?

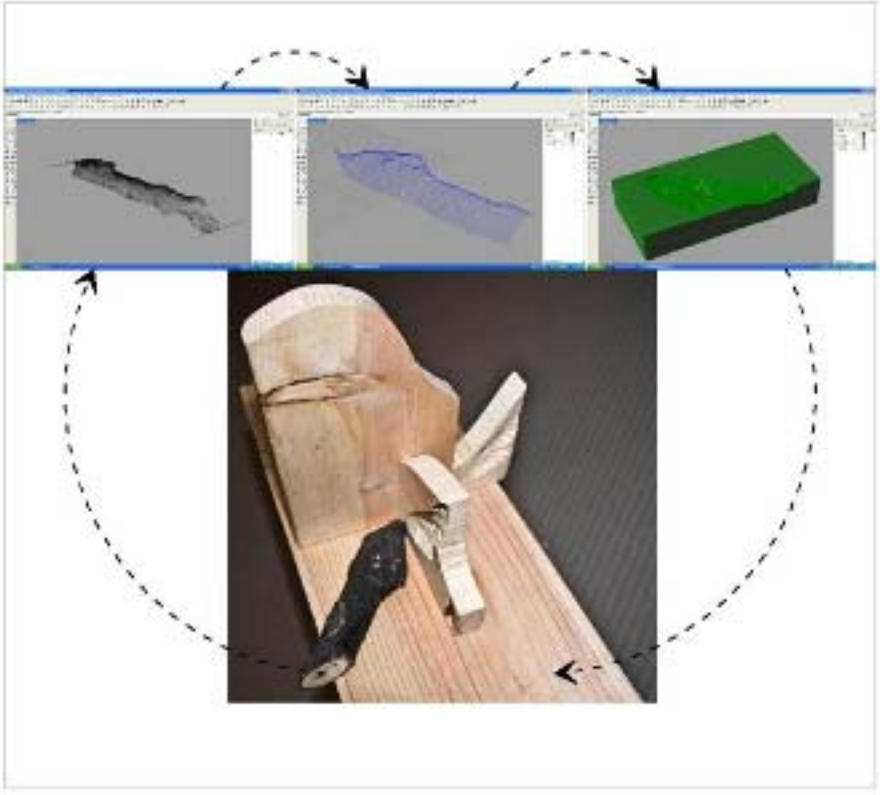


Experiment

CNC **friction fit** with irregular, **unpredicted forms**

Experiment

An **unpredicted** form was **integrated into the digital** design process



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