Deterministic Design

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Today

The design process explained

Designing for developing countries
The Design Process

Break down problems into manageable chunks
The Design Process

Break down problems into manageable chunks

Works in any system and across disciplines
Deterministic Design

Designing with a purpose
Deterministic Design

Designing with a purpose

And justifying it!
Metrics

Evaluate a design’s performance
Metrics

Evaluate a design’s performance

Time
Cost
Risk
Manufacturability
...

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Choosing Metrics

What is important to you?
Choosing Metrics

What is important to you?
What is important to the user?
Choosing Metrics

What is important to you?

What is important to the user?

Can’t have it all: maximize what is important.
Tradeoffs

Not all dreams can come true.
Tradeoffs

Not all dreams can come true.

Cost vs. Performance
Innovation vs. Risk
Precision vs. Manufacturability
Design

Creating something new...
Design

Creating something new...
Design

Creating something new...

methodically.
Creativeeering

Channel creativity with a deterministic process.
Creativeering

Channel creativity with a deterministic process.
Creativeeering

Channel creativity with a deterministic process.

Use your creativity to come up with new ideas.
Creativeering

Channel creativity with a deterministic process.

Use your creativity to come up with new ideas.
Use your engineering skills to assess and develop them.
Design Process

Start vague and become more specific
Design Process

Start *vague* and become more *specific*

- Strategy
- Concept
- Module
- Component
Strategy

A plan of how to do something.
Strategy

A plan of how to do something.
Strategy

A plan of how to do something.

How will you go accomplish your design goals?
Strategy

A plan of how to do something.

How will you go accomplish your design goals?
Don’t sweat the details.
Concept

A device that will meet your design goals.
A device that will meet your design goals.
Concept

A *device* that will meet your design goals.

How does it stack up (*metrics*)?
Concept

A device that will meet your design goals.

How does it stack up (metrics)?
Don’t sweat the details.
Module

A chunk of your device.
Module

A chunk of your device.
Module

A chunk of your device.

Focus on most important modules first.
Module

A chunk of your device.

Focus on most important modules first.
Start sweating the details.
Component

A specific engineered part.
Component

A specific engineered part.
Component

A specific engineered part.

All of the details are figured out.
Deterministic Design

Evaluate with your metrics at every stage
Deterministic Design

Evaluate with your metrics at every stage

Strategy
Deterministic Design

Evaluate with your metrics at every stage

Strategy

Concept
Deterministic Design

Evaluate with your metrics at every stage

Strategy
Concept
Module
Deterministic Design

Evaluate with your metrics at every stage

Strategy
Concept
Module
Component
Notebooks!

Put all of your designs and analysis in a design notebook.
Notebooks!

Put all of your designs and analysis in a design notebook.
Sturdy bound notebook (composition is fine).
Notebooks!

Put all of your designs and analysis in a design notebook. Sturdy *bound* notebook (composition is fine).
Notebooks!

Put all of your designs and analysis in a design notebook. Sturdy **bound** notebook (composition is fine).

This is **super** important!
Design Evaluation

FRDPAARC technique
Design Evaluation

FRDPAARC technique

\textbf{FR} = Functional Requirements
Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters
Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

A = Analysis
Design Evaluation

FRDPAARC technique

**FR** = Functional Requirements

**DP** = Design Parameters

**A** = Analysis

**R** = Research
Design Evaluation

FRDPAARC technique

FR = Functional Requirements

DP = Design Parameters

A = Analysis

R = Research

R = Risk
Design Evaluation

FRDPAAR C technique

**FR** = Functional Requirements

**DP** = Design Parameters

**A** = Analysis

**R** = Research

**R** = Risk

**C** = Countermeasures
Design Problem

Design a pump to help farmers irrigate their fields in developing countries
Design Problem

Design a pump to help farmers irrigate their fields in developing countries
Functional Requirements

**What** does the design have to do?
Functional Requirements

What does the design have to do?
Functional Requirements

What does the design have to do?

Pump:

Pump water out of well 10m deep
Operated by a single person
Can be made out of local materials
Design Parameters

How are you going to meet your functional requirements?
Design Parameters

How are you going to meet your functional requirements?
Design Parameters

How are you going to meet your functional requirements?

Pump:

- Archimedes screw
- Buckets
- Chamber pump
Design Parameters

This is where you can be creative!
Design Parameters

This is where you can be creative!
Design Parameters

This is where you can be creative!

What are your design freedoms?
Design Parameters

This is where you can be creative!

What are your design freedoms?

What are your design constraints?
Analysis

For each design parameter, is it feasible?
Analysis

For each design parameter, is it feasible?
Analysis

For each design parameter, is it feasible?

Pump:

What power is needed to operate?
What are the costs?
What are the component stresses?
What are the fluid dynamics?
Research

Don’t reinvent the wheel!
Research

Don’t reinvent the wheel!
Research

Don’t reinvent the wheel!

Pump:

Look at other pumps in developing countries
Risks
Risks

What will bite you in the ass?
Risks

What will bite you in the ass?
Risks

What will bite you in the ass?

Each design parameter will have specific risks
Risks

What will bite you in the ass?

Each design parameter will have specific risks
Risks

What will bite you in the ass?

Each design parameter will have specific risks

Pump (chamber pump):
  Seals don’t work
Countermeasures

When it hits the fan, how will you recover?
Countermeasures

When it hits the fan, how will you recover?
Countermeasures

When it hits the fan, how will you recover?

Pump (chamber pump DP):
  Use better seals
  Tighten tolerances
  Use a fluid as the seal
Treadle Pump

“Money-Maker Pump”
Treadle Pump

“Money-Maker Pump”

Chamber-pump
Treadle Pump

“Money-Maker Pump”

Chamber-pump

Uses water around the pistons as a seal
Developing Countries

Present some delightful design constraints
Developing Countries

Present some delightful design constraints
Have some tremendous design opportunities
Developing Countries

Present some delightful design constraints
Have some tremendous design opportunities
Developing Countries

Present some delightful design constraints
Have some tremendous design opportunities

Biggest difficulty: frame of reference
Frame of Reference

You do not live in a developing country.
Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?
Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?
How do you select your goals?
Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?

How do you select your goals?
Frame of Reference

You do not live in a developing country.

How do you determine what is important to the design?
How do you select your goals?

Community Partners!
Community Partners

Do live in developing countries!
Community Partners

Do live in developing countries!
Community Partners

Do live in developing countries!

Know their customers
Community Partners

Do live in developing countries!

Know their customers
Know their capabilities
Community Partners

Do live in developing countries!

Know their customers
Know their capabilities
Can provide incredible feedback
Community Partners

Do live in developing countries!

Know their customers
Know their capabilities
Can provide incredible feedback

Need to know how to ask
Design Constraints

What *limits* your designs?
Design Constraints

What limits your designs?
Design Constraints

What limits your designs?

Mild steel only
Design Constraints

What limits your designs?

Mild steel only

Limited manufacturing precision
Design Constraints

What limits your designs?

Mild steel only
Limited manufacturing precision
Lack of machine tools
Design Constraints

What limits your designs?

Mild steel only

Limited manufacturing precision

Lack of machine tools

Cultural risk aversion
Design Constraints

What *limits* your designs?

- Mild steel only
- Limited manufacturing precision
- Lack of machine tools
- Cultural risk aversion
- Harsh use conditions
Design Opportunities

What can you exploit?
Design Opportunities

What can you exploit?

Bicycle components
Design Opportunities

What can you exploit?

Bicycle components
Local repairmen
Design Opportunities

What can you **exploit**?

- Bicycle components
- Local repairmen
- Make-do culture
Become a Ninja
Become a Ninja of design!
Become a Ninja

of design!
Become a Ninja of design!

develop your creativity and analytical skills
Become a Ninja of design!

develop your creativity and analytical skills

practice
Become a Ninja

of design!

develop your creativity and analytical skills

practice

enjoy the process
Summary
Summary

Metrics to guide your design.
Summary

Metrics to guide your design.

Broad to focused approach.
Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!
Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!

Use FRDPARRC to evaluate your design.
Summary

Metrics to guide your design.
Broad to focused approach.
Notebooks!
Use FRDPARRC to evaluate your design.
Seize design opportunities, know design constraints.
Summary

Metrics to guide your design.

Broad to focused approach.

Notebooks!

Use FRDPARRC to evaluate your design.

Seize design opportunities, know design constraints.

Use your community partners!
Summary

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