The Positive Value of Negative Design

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- *As engineers we focus upon what the answer is*
- *For decision-makers it may be equally useful to know what the answer is not*

In art this called "Negative Space"

- *Draw a picture of a mug and a chair…*

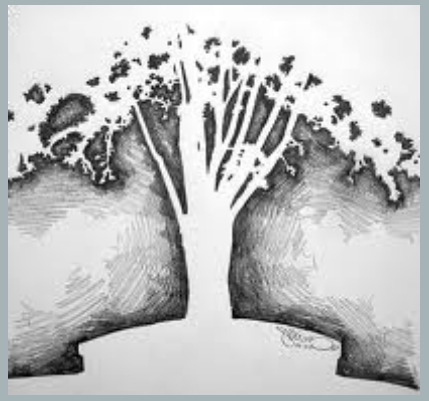
In art this called "Negative Space"

- *Draw everything that is NOT the mug and chair…*

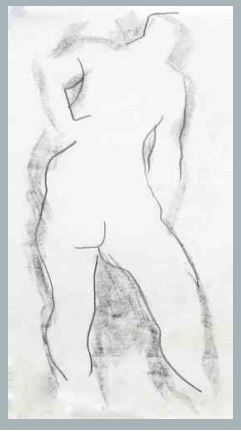
In art this called "Negative Space"

- *Draw everything that is NOT the mug and chair…*

Negative Tree



Negative Figures



Negative Space in the Value Equation

- *Purpose of a value equation is to guide design decisions*
- *It might be equally useful to use a negative approach: Anti-Value*

Decision Making and Measures of Effectiveness

- *Value Equation*

vs

- *Decision Parameters*

Decision Making and Measures of Effectiveness

- ~~*Value Equation*~~

vs *Measure of Effectiveness (MOE)*

- *Decision Parameters*

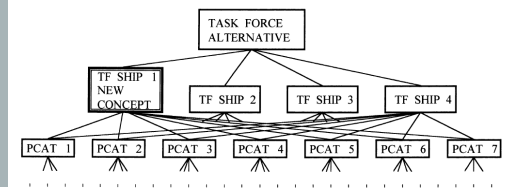
Decision Making and Measures of Effectiveness

- *A Measure of Effectiveness*

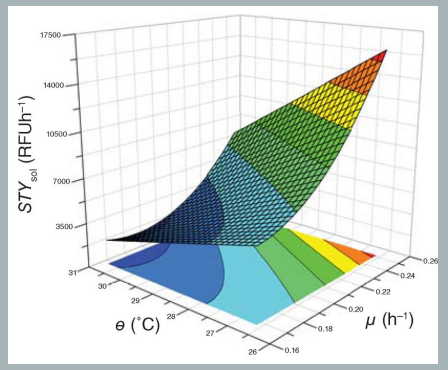
vs

- *Decision Parameters*

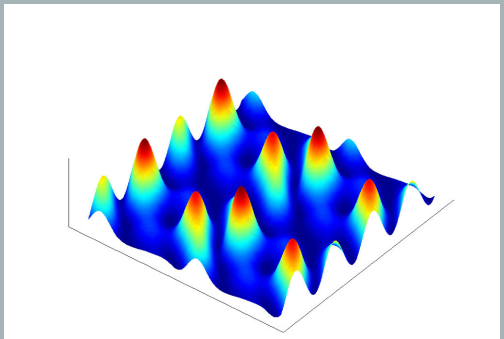
- *Hockberger (1996):*



Measures of Effectiveness: The Ideal



Measures of Effectiveness: The Real



Measures of Effectiveness: The Real

- *Multiple peaks may exist*
  - *Due to discrete variables*
  - *Due to discrete missions*
- *User can't identify a single peak as goal*
- *Location of peak is subject to uncertainty*

Real Effectiveness

- *The engagement model is not perfect*
- *The ship design model is not perfect*
- *Tomorrow's weapons are unknown*
- *Tomorrow's threat is unknown*

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Maxims

- *"No plan survives contact with the enemy"*

  Helmuth von Moltke the Elder
- *"Change is the only constant"*

  Heraclitus of Ephesus

Real Effectiveness

- *The engagement model is not perfect*
- *The ship design model is not perfect*
- *Tomorrow's weapons are unknown*
- *Tomorrow's threat is unknown*

- ***How to handle uncertainty?***

Michelangelo's David

- *"It's easy. All I do is chip away everything that is not David."*

Michelangelo's David

- *"It's easy. All I do is chip away all the marble that is not David."*
- *Can we identify everything that's not the ship?*

What part of the design space is not the solution?

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- *A good ship design:*
  - *Doesn't sink*
  - *Doesn't roll over*
  - *Doesn't break in half*
  - *…*

What part of the design space is not the solution?

- *A good ship design:*
  - *Doesn't sink*
  - *Doesn't roll over*
  - *Doesn't break in half*
  - *Doesn't get defeated by the bad guy*
  - *…*

Engineering Negative Space

Axiom (a):

- *"Succeed" is a subset of "Don't Fail"*

Engineering Negative Space

Axiom (a):

- *"Succeed" is a subset of "Don't Fail"*

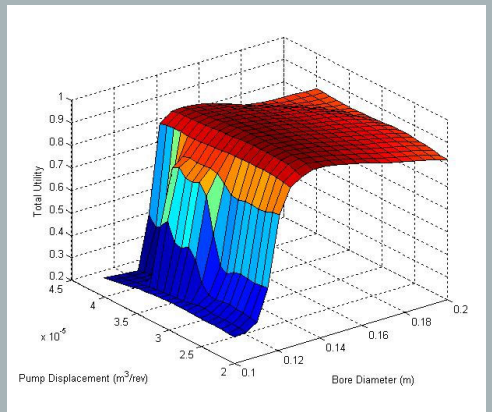
Corollary:

- *Failure may be a lot easier to find than success*

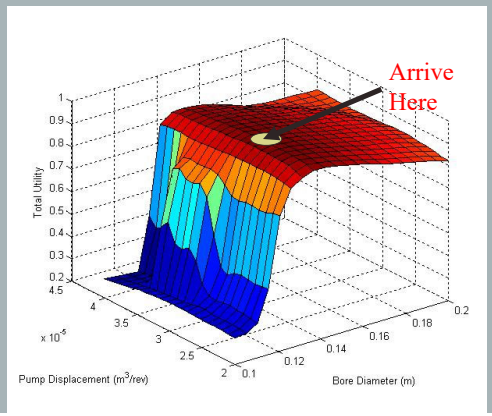
A return to naval architecture

- *A good ship design:*
  - *Doesn't sink*
  - *Doesn't roll over*
  - *Doesn't break in half*
  - *Doesn't get defeated by the bad guy*
  - *…*
- *Ship design requirements can be expressed in the language of Negative Space*

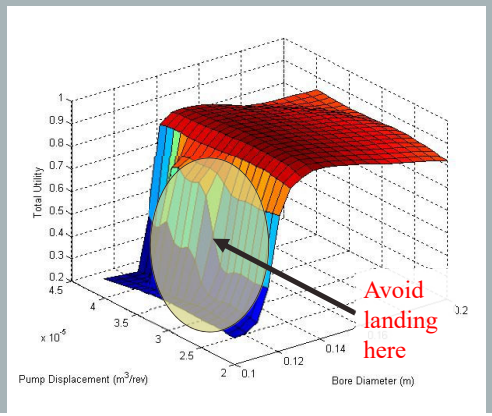
Measures of Effectiveness



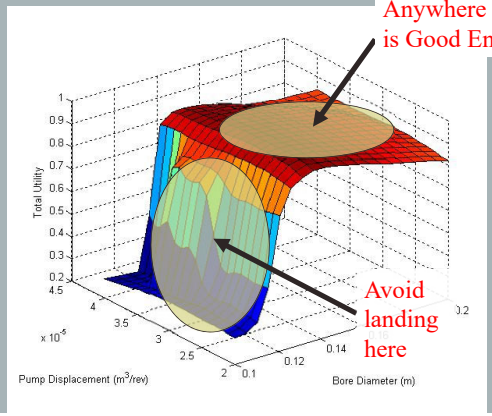
Measures of Effectiveness
In the language of Optimization



Measures of inEffectiveness



Measures of inEffectiveness



Good enough…

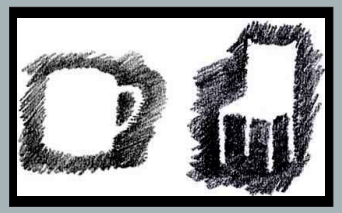
- *I started the discussion with art.*
- *Now let me try philosophy…*

Maxims

- *"Better is the enemy of Good Enough"*
  Sergei Gorshkov
- *"The perfect is the enemy of the good"*
  Voltaire
- *"Good enough, is."*

Find the Solution Space for the Mug and Chair

Find the Solution Space for the Mug and Chair

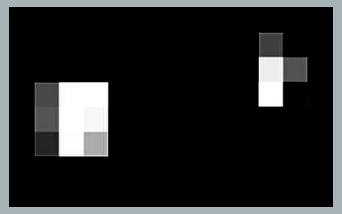


- *This is what we want to find*
  1 mega-pixel

Find the Solution Space for the Mug and Chair

- *This is where we start*

Find the Solution Space for the Mug and Chair



- *Generation 1 – 104 pixels*

Find the Solution Space for the Mug and Chair

- *Generation 2 – 416 pixels*

Find the Solution Space for the Mug and Chair

- *Generation 3 – 1664 pixels*

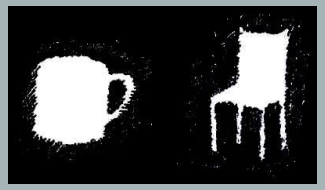
Find the Solution Space for the Mug and Chair

- *Generation 4 – 6656 pixels*

Find the Solution Space for the Mug and Chair

- *Generation 5 – 26624 pixels*

Find the Solution Space for the Mug and Chair



- *Generation 5 – 106496 pixels*

If the best solution is in the middle of the object…

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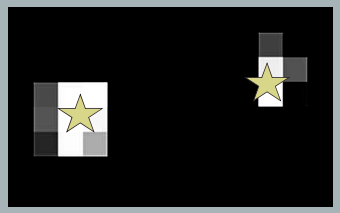

…then actually we found it in the first generation

Conclusion

- *Negative Design*
  - *May be faster than positive design*
  - *Avoids over-optimization*
  - *May be a technique for accommodating uncertainty*

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