Elec 4309 Senior Design

Wendell H Chun

Sept. 7, 2017

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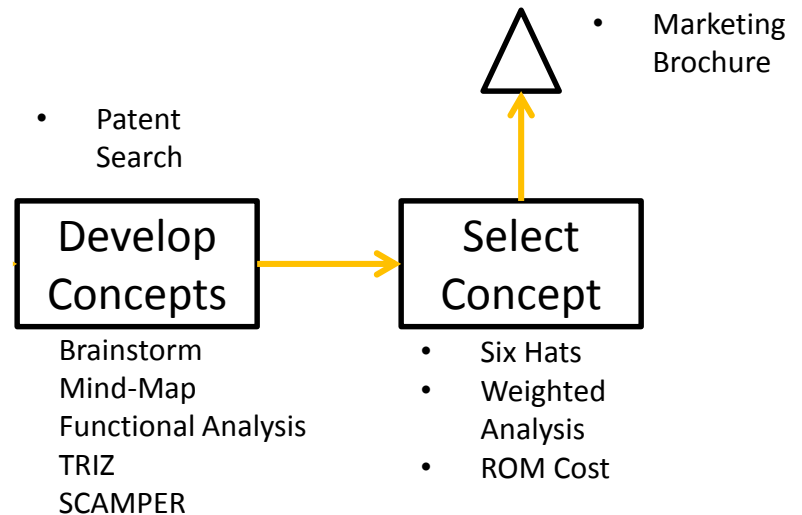
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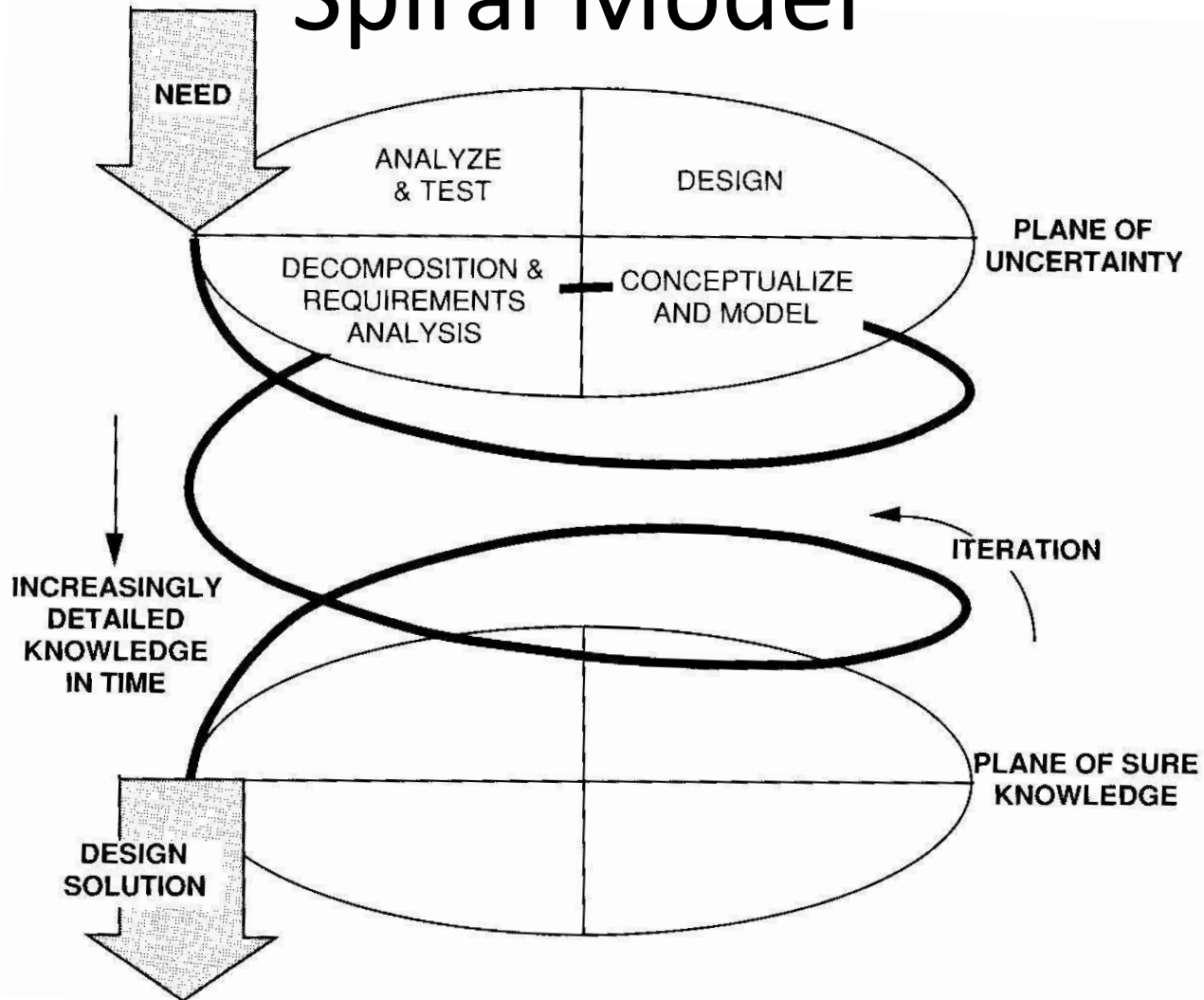
The "General" Design Process

1. Identify the problem
2. Define the working criteria/goals
3. Research and gather data
4. Brainstorm ideas
5. Analyze potential solutions
6. Develop and test models
7. Make decision
8. Communicate decision
9. Implement and commercialize decision
10. Perform post-implementation review

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Next Step

Develop Concepts

- Patent Search

Brainstorm
Mind-Map
Functional Analysis
TRIZ
SCAMPER

Select Concept

- Six Hats
- Weighted Analysis
- ROM Cost

- Marketing Brochure

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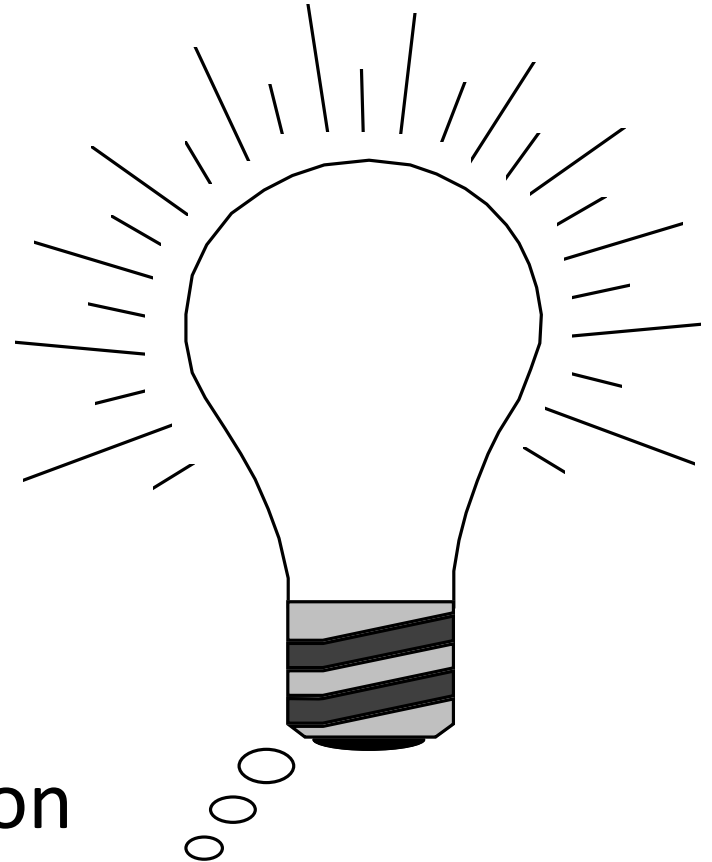DENVER | ANSCHUTZ MEDICAL CAMPUS

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To Think

- To form or <u>conceive</u> in the mind
- To meditate, ponder, <u>analyze</u> or examine
- To have in mind as a plan, intent, or purpose; <u>intend</u>
- To hold as an opinion; <u>believe</u>; suppose
- To <u>reflect</u> upon the matter in question
- To <u>anticipate</u> or expect
- To <u>make a mental discovery</u>

An Idea

- Any conception existing in the mind as a result of <u>mental understanding, awareness or activity</u>
- A <u>thought</u>, conception or notion
- An <u>impression</u>
- <u>A plan </u>of action; an intention

Lateral Thinking

Many problems require a different perspective to solve successfully

Edward de Bono

Lateral Thinking

Four critical factors associated with lateral thinking:

1. Recognize dominant ideas that polarize the perception of a problem
2. Search for different ways of looking at things
3. Relaxation of rigid control of thinking
4. Use of chance to encourage other ideas

Lateral Thinking: Avoidance

Keep an idea from dominating thinking as it always has in the past by asking avoiding questions.

- Ask "Is there another way of looking at this?"

- Ask "Why?"

- Focus on an aspect of the problem other than the "logical" one.

- List all possible alternatives to every aspect of the analysis.

- Break apart aspects (concepts) of the problem, or combine them to create even more concepts.

Some Creative Stimuli Words

- Guest stars
- Alphabet
- Truth
- Outer space
- Charity
- His and hers
- Style
- Nation
- Family
- Videotape

- Photography
- Testimonials
- Decorate
- Fantasy
- Hobbies
- Holidays
- Weather
- Calendar
- Push button
- Snob appeal

Use of Ridiculous

- How can you join two wires together?
  - Hold them with your teeth.
  - Use chewing gum.
- Can you think of others?
- Do any of these ridiculous ideas suggest a not-so-ridiculous solution?

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Conceptual

- Pertaining to concepts or the forming of concepts
- CONCEPT--

  a general notion or idea; conception
  an idea of something formed by
  <u>mentally combining all its</u>
  <u>characteristics or particulars</u>: a construct
  a directly conceived or intuited object

Why Conceptual Thinking is Difficult

- We emphasize analysis
  - taking things apart
- Need to emphasize synthesis
  - putting things together
- Must think <u>both</u> ways
- Otherwise, we are "half wits"
- We don't emphasize it, reinforce it, reward it and practice it

Utility and Value

- Concepts should be broad enough to be useful
- Concepts should be specific enough to be of value
- The "Goldilocks Problem"
- Like programming
- Able to be amended and modified
- Not limited by time and place

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Blink

- ***Blink: The Power of Thinking Without Thinking*** is a 2005 book by Malcolm Gladwell

- Mental processes that work rapidly and automatically from relatively little information

- "thin-slicing"- our ability to gauge what is really important from a very narrow period of experience

- Gladwell contends is an age of information overload, he finds that experts often make better decisions with snap judgments than they do with volumes of analysis

- Premise is that intuitive judgment is developed by experience, training, and knowledge

Brain Writing

- **Objective:** To generate as many ideas as possible.

- **Rules:** It's quantity not quality that counts.

- **In groups:** Each person has a sheet of paper. Everybody writes down two good ideas/solutions. Once it's done you pass the paper to the person next to you. Again write two good ideas and pass on the sheet. Continue like this for a set amount of time.

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Common Statements

- "I'm not creative."

- "I wish I could be more creative, but I don't have it in me."

- "Why are some people creative and others aren't?"

- **The truth is almost everyone has creative potential.**

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10 Questions to Encourage ideas

1. What if…?

2. How can we improve…?

3. How will the Optimist Member and/or the community benefit?

4. Are we forgetting anything?

5. What's the next step?

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10 Questions to Encourage ideas

6. What can we do better…?

7. What do you think about…?

8. What should we add?

9. What should we eliminate?

10. What other ideas do you have…?

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Problem Solving Techniques

- Brainstorming

- Mind maps

- Cause-and-Effect diagrams

- Failures Mode and Effects Analysis

- Fault Tree Analysis

- Design of Experiments

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Brainstorming

- Proposed by Alex Osborn "for the sole purpose of producing checklists of ideas"
- Technique to identify causes and develop solutions to problems
- "Seeking the wisdom of ten people rather than the knowledge of one person" [Kaizen Institute]

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Tools & Techniques

BRAINSTORMING

Purpose:

To generate a large number of ideas in a short period of time.

Brainstorming

Rules for Brainstorming:

- The more ideas the better!
- No discussion
- No idea is a bad idea
- Build on one another's ideas
- Display all ideas

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Brainstorming

- No criticism is permitted
  - "only stupid question is one that is not asked"
- Wild ideas are encouraged
  - often trigger good ideas from someone else
- Each person contributes one idea
  - further single ideas on second circuit
  - repeat until no further ideas
- All contributions are recorded in view

Brainstorming Exercise

How Do We Motivate Our Senior Design Team Members?

Ideas: Freely record your ideas as they come to your mind.

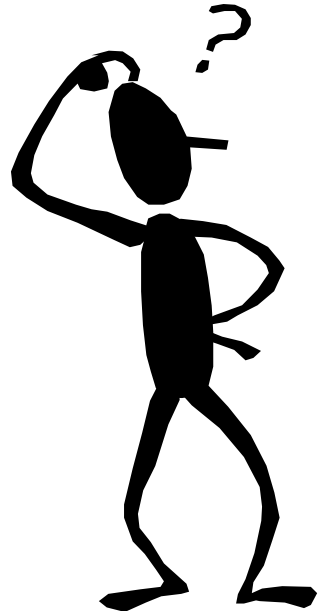
Brainstorming Guidelines

Remember Creative Thinking

1. Practice question: How Do We Motivate Our Senior Design Team Members?

Re-state the question to keep the process going

What did you mean by that?!!!

2. Clarify understanding. Once all the ideas have been generated (it may take approximately 5 to 6 minutes), review ideas offered.

Brainstorming Guidelines

Let's combine ideas!!!

Are we done yet?

3. Combine items that are similar and/or eliminate duplicates.

4. Completion.

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Brainstorming

- Brainstorming emphasizes right-brain activity.
  - Rules for brainstorming:
    - Put judgment and evaluation aside temporarily.
    - Turn imagination loose, and start offering the results.
    - Think of as many ideas as you can.
    - Seek combination and improvement.
    - Record all ideas in full view.
    - Evaluate at a later session.

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Brainstorming

- Osborn proposed 75 fundamental questions

- Can be reduced to:
  - ∗ seek other uses?
  - ∗ modify?
  - ∗ minify?
  - ∗ rearrange?
  - ∗ combine?

  - ∗ adapt?
  - ∗ magnify?
  - ∗ substitute?
  - ∗ reverse?

Seven Secrets for Better Brainstorming

1. Sharpen the focus

2. Playful rules

3. Number your ideas

4. Build and jump

5. The space remembers

6. Stretch your mental muscles

7. Get physical

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Brainstorming

- Brainstorming is a *lateral thinking* process.
- Brainstorming encourages open and random thinking and communications

Some Pitfalls

- Most people mess up their creative process **is in the first two steps**

- Part of preparation is working on things of interest (which some people have no idea)

- Another place where things go wrong is by not being aware of how social the creative process is

- Few great ideas come from a person sitting and thinking by oneself

- Creative People tend to be attracted to areas with a high density of other creative people

More Pitfalls

- Creative People throughout history have always spoken against working for someone else because doing so has a tendency to stop your own incubation process

- For most people, it's not because they don't have the capacity to be creative and has everything to do with their creative process being buggy

- Fixing the creative process is not that hard to do

- All it takes is one or two good ideas, well-executed, for you to live the life of greatness

Before you Start too far down the path of Brainstorming various Design Alternatives

- Determine the primary functions that are required.
  - Show these on the top level of the tree
- List various means by which each function may be implemented.
  - Show these on the next level of the tree
- Determine secondary functions that would result from implementing each of the means.
  - Show these on the next level of the tree
- The tree continues to alternate between means and functions until you reach a reasonable termination point.
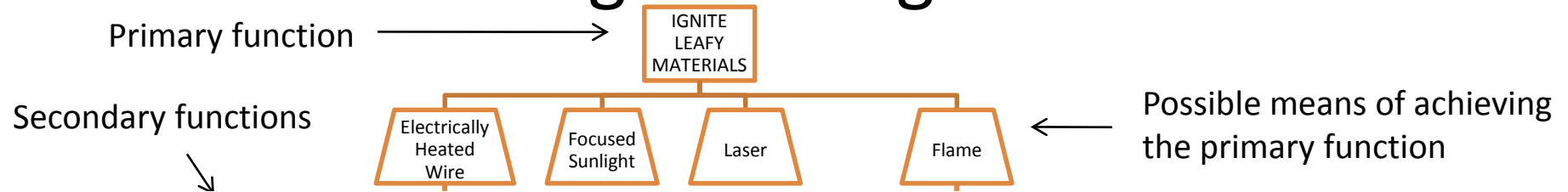
It helps to go Beyond the terminology and what you're Trying to Do

- Think of the "functions" as *what* you must do.

- Think of the "means" as *how* you might do it.

- The Function-Means Tree is a tool for listing the primary functions of a design and various means of achieving those functions.

- The Function-Means Tree should flow out of the Attributes List, PCC, Objectives-Constraints Tree, and Design Specifications.

Here is a Partial Function-Means Tree for a Cigarette Lighter

Primary function →

IGNITE LEAFY MATERIALS

Secondary functions ↘

| Electrically Heated Wire | Focused Sunlight | Laser | Flame |

← Possible means of achieving the primary function

Function

Means

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Strengths and Weaknesses of the Function-Means Approach

Strengths

- Helps break down the design problem into features or functions

- Systematic manner of deriving possible means

- Avoids possible bias toward certain means

- Helps identify and consider novel/unusual combinations

Weaknesses

- Applicable only to design problems where the features or functions of the design solution are well understood

- Quickly leads to too many possible combinations

- No valuation attached to individual means

Alternative Brainstorming

- Alternative Brainstorming Techniques
  - *Random Input*
  - *Reframing*
  - *Professions approach*
  - *Provocation*

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Alternative Brainstorming

- Alternative Brainstorming Techniques
  - SCAMPER system

S=substitute

C=combine

A=adapt

M=modify

P=put to another use

E=eliminate

R=reverse

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Concept Generation

- Substitute – new elements

- Combine – existing elements

- Adapt – different operation

- Modify – size, shape, function

- Put to other use – other app domains

- Eliminate – parts or whole

- Rearrange or reverse – work better

SCAMPER

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Morphological Chart

- Morphological chart is the process of generating ideas in an analytical and systematic manner

Procedure

- List the features or **functions** that are essential to the product

- For each feature or function, list the **means** by which it might be achieved

  - derive these systematically

- Identify feasible combinations

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Example: List the Features or Functions …

Engine
Shifting
Drive
Brakes
Steering
…
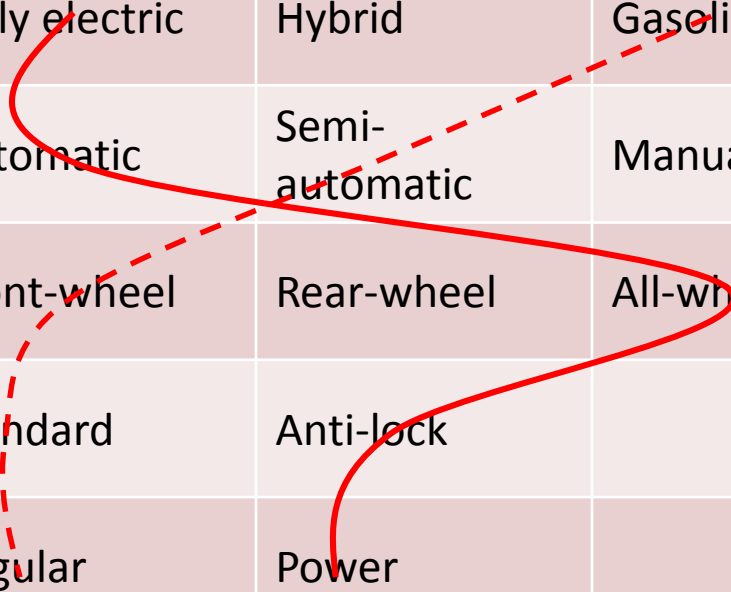
Example: List the Means by which …

Engine	Fully electric	Hybrid	Gasoline	Diesel
Shifting	Automatic	Semi-automatic	Manual	
Drive	Front-wheel	Rear-wheel	All-wheel	
Brakes	Standard	Anti-lock		
Steering	Regular	Power		
…	…	…	…	

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Example: Identify Feasible Combinations

Engine	Fully electric	Hybrid	Gasoline	Diesel
Shifting	Automatic	Semi-automatic	Manual	
Drive	Front-wheel	Rear-wheel	All-wheel	
Brakes	Standard	Anti-lock		
Steering	Regular	Power		
…	…	…	…	

Typical Notation: Morphological Chart

Functions	Technological Options							
Capture/Collection	Wind	Solar	Micro-Hyrdo	River Energy (Underwater turbines)	Piezoelectric (Capture vibration energy)	Thermoelectric	Sound Energy	Algae
Storage	Kinetic Energy in a Flywheel	Compressed Air	Thermal (water or molten salts)	Lead-Acid battery	Nickel Metal Hydride Battery	Lithium Ion Battery	Ultra-capacitors	Hydrogen
Conversion	AC/DC Converter	Alternator	DC/DC	AC/AC	Fuel Cell			
Location/Transmission	Power Lines	Pick-up and carry	Water					
Consumption	AC Power	DC Power	Thermal					
Management/Control	Limit Switch	PLC Display	Constant Monitoring					

Criteria for Successful Use

- The various features or functions of the eventual design solution must be well understood

- The various features or functions of the eventual design solution must be relatively independent

- The various means per feature or function must not be infinite, and principally relate to one another so a systematic articulation can uncover all of them

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TRIZ

- Teorija Reshenija Izobretatel'skih Zadach
- Loosely translates as Theory of Inventive Problem Solving (TIPS)
- 40 Inventive Principles
- TRIZ is a methodology, tool set, knowledge base, and model-based technology for generating innovative ideas and solutions for problem solving.
- TRIZ provides tools and methods for use in problem formulation, system analysis, failure analysis, and patterns of system evolution (both 'as-is' and 'could be').
- Aims to create an algorithmic approach to the invention of new systems

TRIZ Process
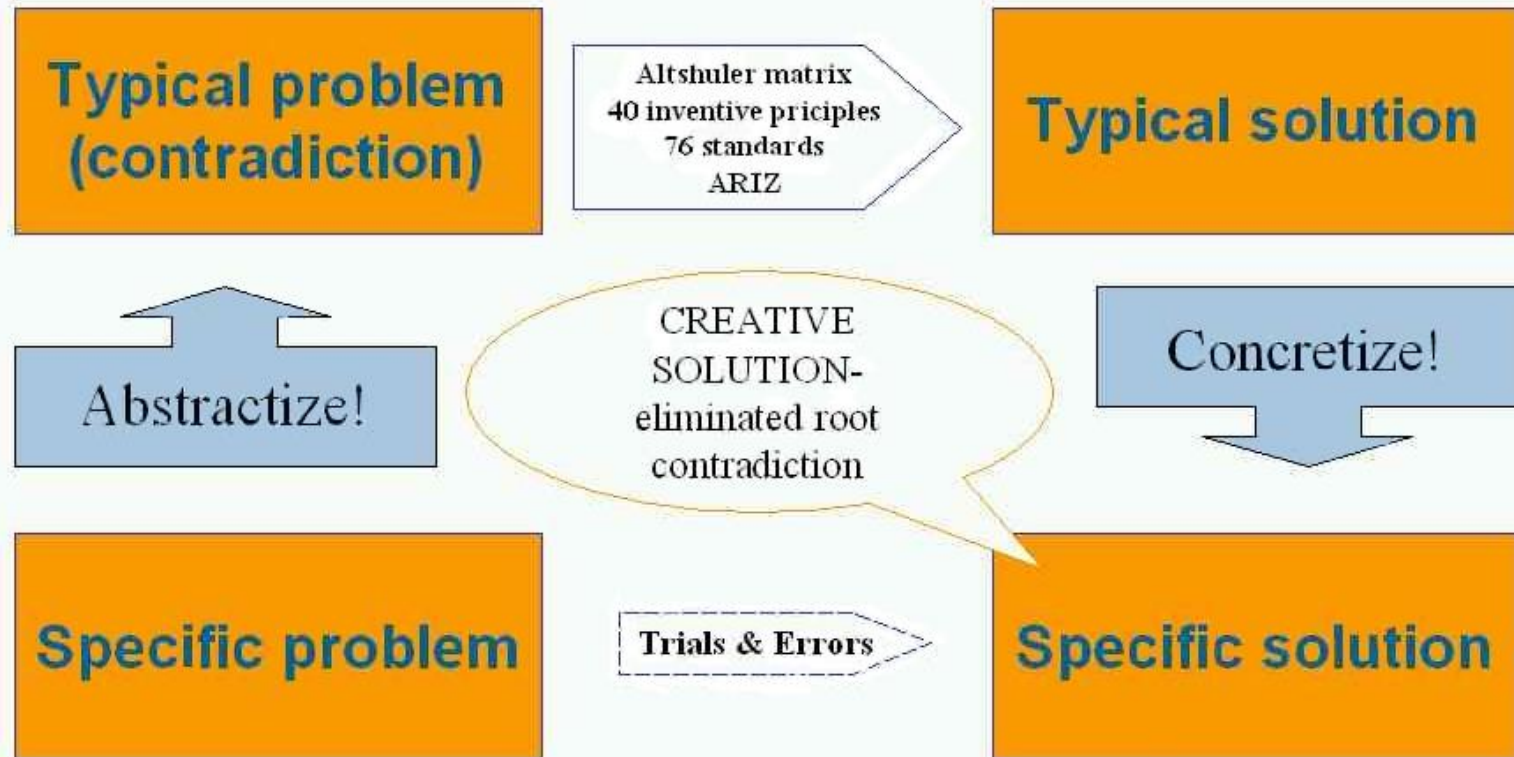
40 Inventive Principles of TRIZ

IP 01: Segmentation

IP 04: Asymmetry

IP 07: Nested doll

IP 10: Preliminary action

IP 13: The other way round

IP 16: Abundance

IP 19: Periodic action

IP 22: Blessing in disguise

IP 25: Self-service

IP 28: Mechanics substitution

IP 30: Flexible shells and thin films

IP 33: Homogeneity

IP 36: Phase transition

IP 39: Inert atmosphere

IP 02: Taking out

IP 05: Merging

IP 08: Anti-weight

IP 11: Prior cushioning

IP 14: Spheroidality or curvature

IP 17: Another dimension

IP 20: Continuity of useful action

IP 23: Feedback

IP 26: Copying

IP 29: Pneumatics and hydraulics

IP 31: Porous materials

IP 34: Discarding and recovering

IP 37: Thermal expansion

IP 40: Composite materials

IP 03: Local quality

IP 06: Universality

IP 09: Preliminary anti-action

IP 12: Equipotentiality

IP 15: Dynamics

IP 18: Mechanical vibration

IP 21: Rushing through

IP 24: Intermediary

IP 27: Cheap short-lived objects

IP 32: Color change

IP 35: Parameter change

IP 38: Strong oxidants

Mind Maps

- Attributed to Tony Buzan
  - classic book "Use Your Head"
- A **mind map** is a diagram used to represent words, ideas, tasks, or other items linked to and arranged around a central key word or idea.
- Mind maps are used to generate, visualize, structure, and classify ideas, and as an aid in study, organization, problem solving, decision making, and writing.
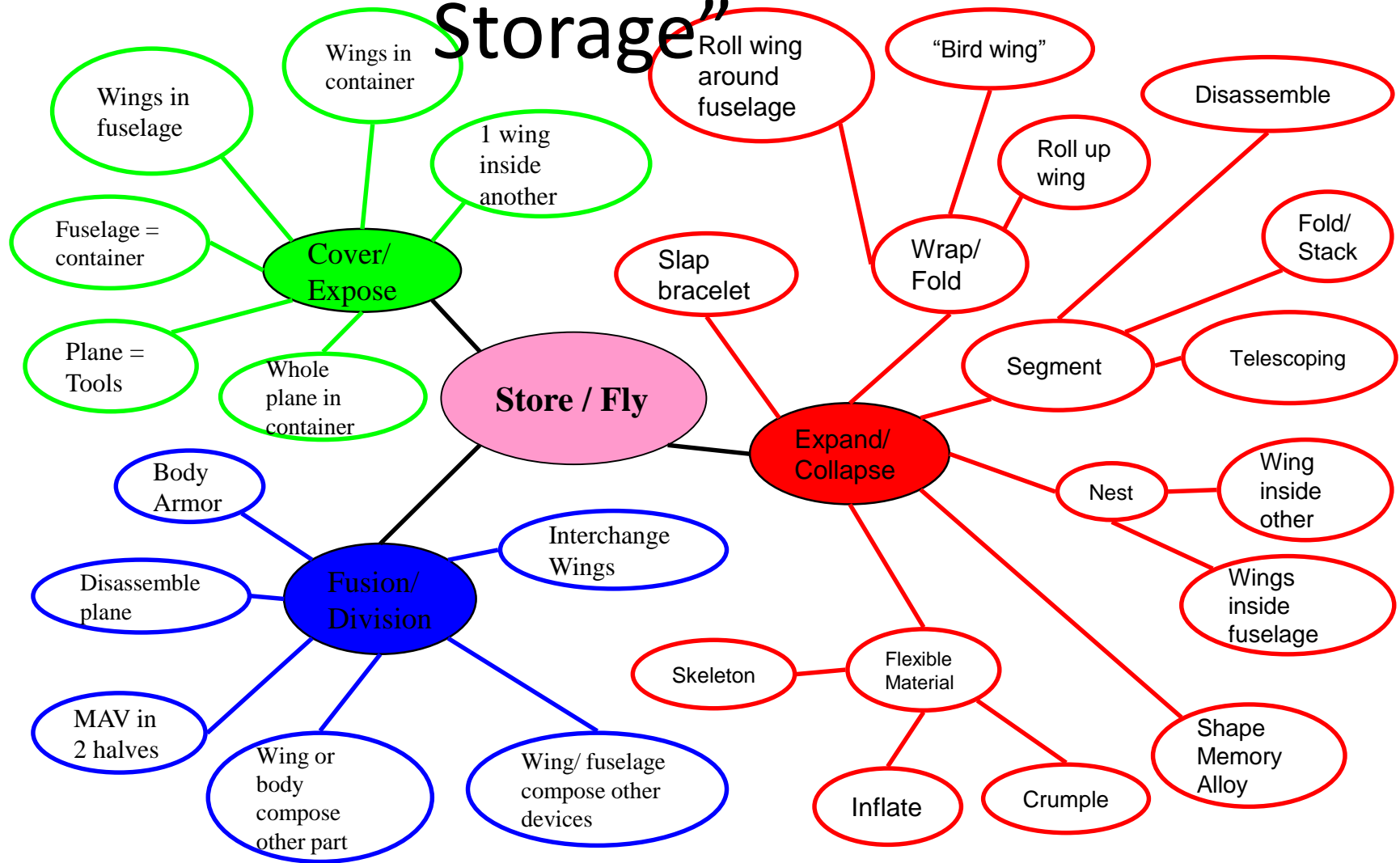- A mind map is often created around a single word or text, placed in the center, to which associated ideas, words and concepts are added.
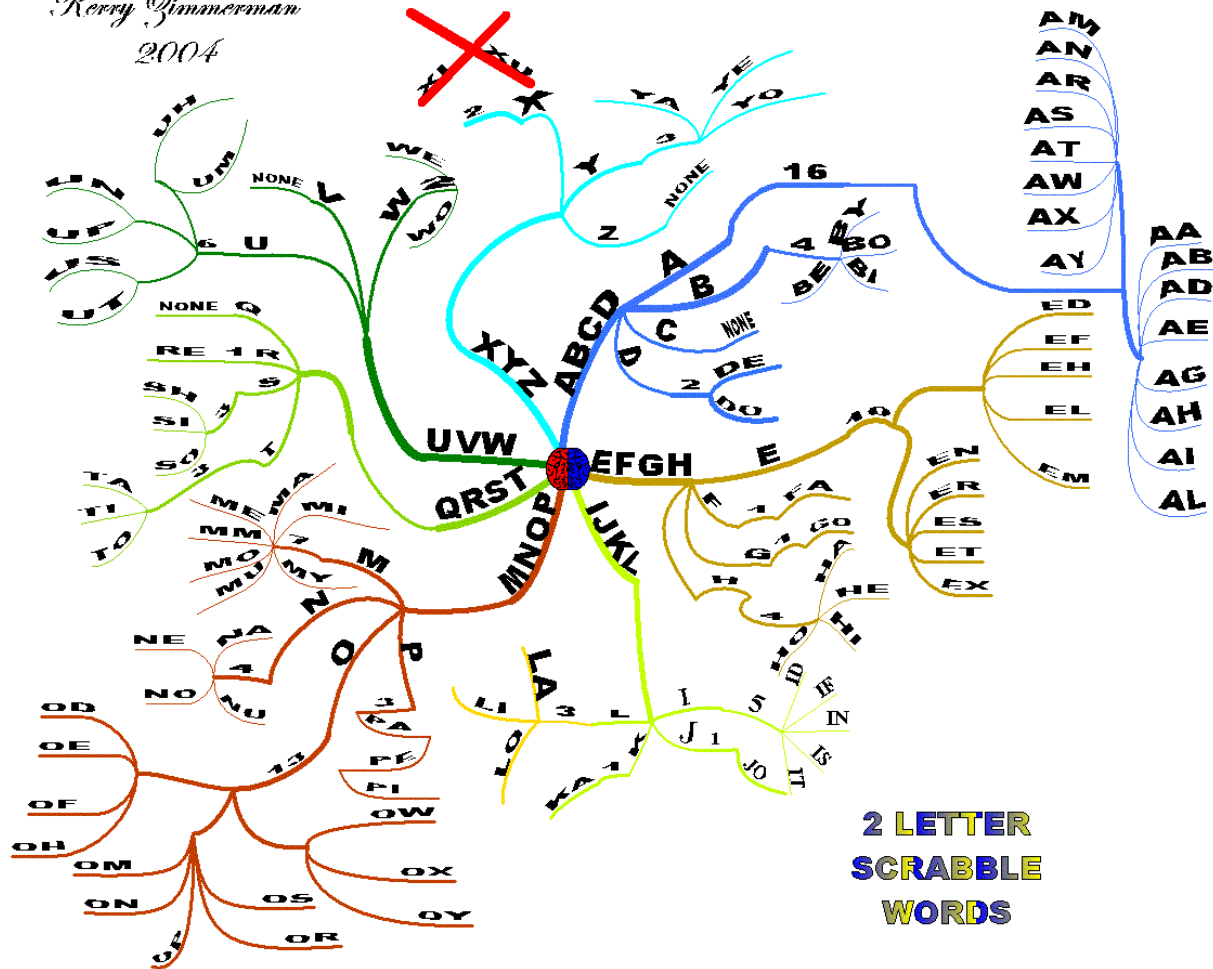
Mind Maps

Mind Map Example: UAV "Compact Storage"

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Lateral Thinking: Four Step Process

Edward de Bono's
Creative Thinking process

GET STARTED

Results: New Ideas

Select & Define Focus

Capture & Work with Output

Generate Ideas

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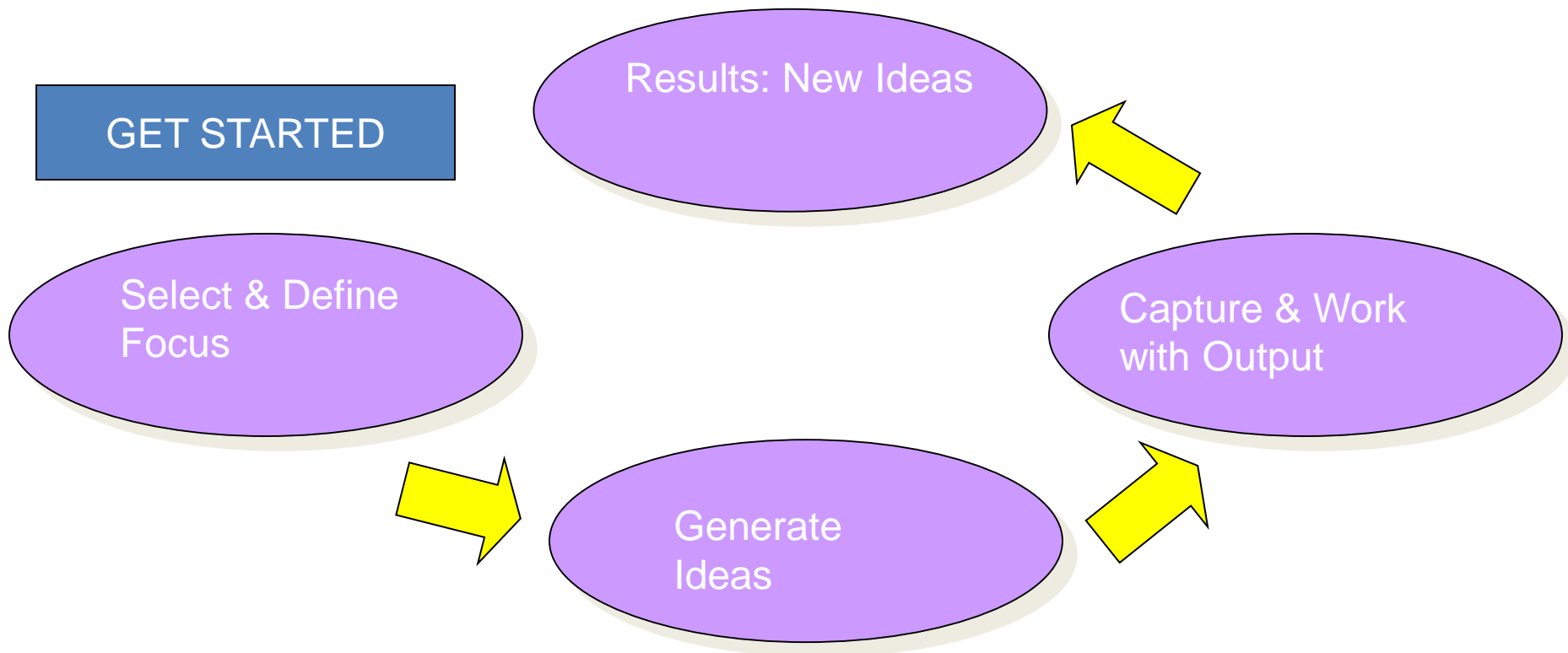
Bono's Six Hats

- Questions (White) - considering purely what information is available, what are the facts?

- Emotions (Red) - instinctive gut reaction or statements of emotional feeling (but not any justification)

- Bad points judgment (Black) - logic applied to identifying flaws or barriers, seeking mismatch

- Good points (Yellow) - logic applied to identifying benefits, seeking harmony

- Creativity (Green) - statements of provocation and investigation, seeing where a thought goes

- Thinking (Blue) - thinking about thinking

Edward de Bono's Lateral Thinking Random Word List

soap	coal	eagle
mouse	camel	taxi
cloud	diary	soup
hair	lawyer	prison
ice-cream	cigarette	shark
rocket	toy	diamond
tax	snow	gun
bed	parachute	train
wheel	door	picture
frog	tap	beer
farm	hurricane	kitchen
computer	watch	nose
jazz	balloon	elephant
hat	party	wine
credit card	shoe	rose
church	root	saw
shop	knife	hospital
hamburger	smoke	camera
book	president	banana
scales	button	snail

Edward de Bono's Six Thinking Hats:

Information

Feelings

Caution

Benefits

Creativity

Managing the thinking

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Six Hats

Information

- What information do we have?
- What are the objectives?
- What information do we need?
- How do we acquire the needed information?

Feelings

- I once read an article where...
- That reminds me of an episode where...
- It is my impression that...
- What if we tried to...?

Caution

- That is a bad idea because...
- Drilling in the reservoir is problematic because...
- The risk of going forward on this is too high because...
- The implementation will be difficult because...

Benefits

- It would be a good idea to...
- The project is running well but it could run even better if...
- The idea certainly has qualities in the area of...
- The potentials of this idea are so great that we should attempt to...

Managing the thinking

- This has been thoroughly covered. Next item is...
- Will the yellow hat please elaborate on the subject...?
- What is the documentation for the idea that...?
- We need to involve these stakeholders to ensure that...

Creativity

- The basics of this venture are similar to...
- This is comparable to...
- There is a likeness between this platform and...
- The synergies between what your saying and what he is saying is...

Strategy

- Having identified the six states that can be accessed, distinct programs can be created, these are sequences of hats which encompass and structure the thinking process toward a distinct goal

- Sequences always begin and end with a blue hat

- The group agrees together how they will think, then they do the thinking, then they evaluate the outcomes of that thinking and what they should do next

- Sequences (and hats) may be used by individuals working alone or in groups

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6 Hat Programs

- Initial Ideas - Blue, White, Green, Blue
- Choosing between alternatives - Blue, White, (Green), Yellow, Black, Red, Blue
- Identifying Solutions - Blue, White, Black, Green, Blue
- Quick Feedback - Blue, Black, Green, Blue
- Strategic Planning - Blue, Yellow, Black, White, Blue, Green, Blue
- Process Improvement - Blue, White, White (Other peoples views), Yellow, Black, Green, Red, Blue
- Solving Problems - Blue, White, Green, Red, Yellow, Black, Green, Blue
- Performance Review - Blue, Red, White, Yellow, Black, Green, Red, Blue

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Example: Initial Ideas

- Initial Ideas - Blue, White, Green, Blue

Managing the thinking

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Information

- What information do we have?
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Managing the thinking

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Lateral Thinking (LT)

- In normal thinking, each step that we take is firmly based on the preceding step (vertical thinking). When we arrive at a solution, the validity of that solution is proved by the validity of every proceding step.

- Lateral thinking gets us out of the normal way and we create somthing new.

- **Methods for lateral thinking**

  - Provocation :: Random Word :: Pressure – 90 ideas in 10 minutes :: Steal from a previous idea on the list

This is Where we are on Teams

Jeffrey Redmond
Julia Redmond
Walter Emery
Joshua Moyers

Randal Butler
Ryan Heifferon
Nathan Schram

Logan Noll
Dre Llewellyn
Kidist Getu
Endalk Zewdie

Yuriy Komlev
Mulbah Dolley
Brandon Nguyen
Anthony J Smith

Mousa Akhmri
Abdulla Alobaidly
Mansoor Al-Zeyara
Abdulrahman Al-sulaiti
Morad Hazim

Daniel Pavlovsky

Class Schedule

MID-TERM PRESENTATION

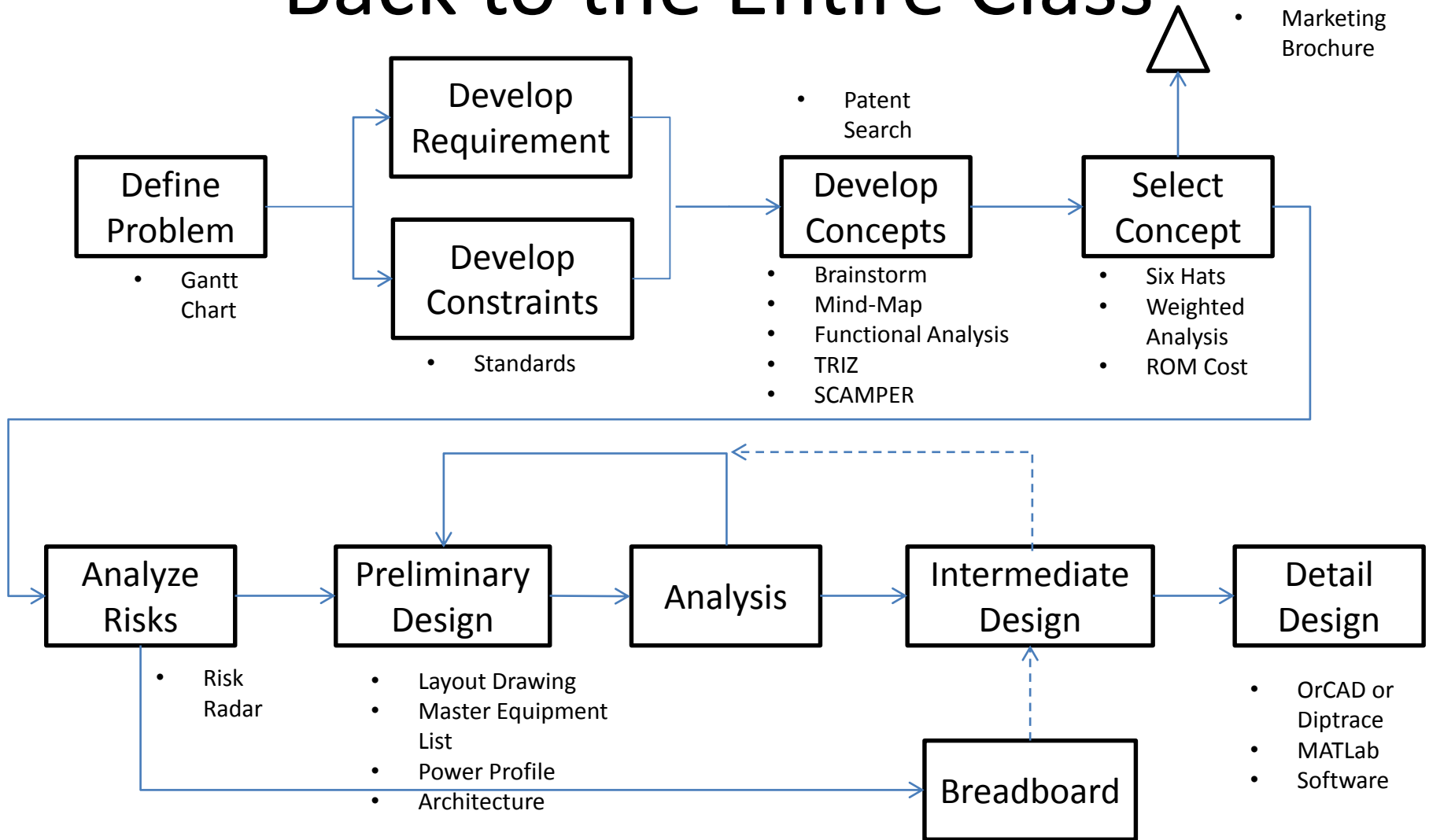OTHER CLASS PRESENTATION

Milestone is October 3 or October 10:
1. Marketing Brochure (one pager)
2. Conceptual Design In-class Presentation

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Back to the Entire Class

```
Define                Develop                                        Develop                    Select
Problem               Requirement                                    Concepts                   Concept
                      Develop
                      Constraints
```

• Marketing Brochure

• Patent Search

Define Problem
• Gantt Chart

Develop Constraints
• Standards

Develop Concepts
• Brainstorm
• Mind-Map
• Functional Analysis
• TRIZ
• SCAMPER

Select Concept
• Six Hats
• Weighted Analysis
• ROM Cost

```
Analyze        Preliminary                    Intermediate        Detail
Risks          Design        Analysis         Design              Design
                             Breadboard
```

Analyze Risks
• Risk Radar

Preliminary Design
• Layout Drawing
• Master Equipment List
• Power Profile
• Architecture

Detail Design
• OrCAD or Diptrace
• MATLab
• Software

Deliverables for this Class

- Project/Team Status Report - September
- Project/Team Status Report - October
- Project/Team Status Report - November

- Marketing Brochure – Oct 3 or Oct 10 class
- Mid-term Presentation – Same as Marketing Brochure class (10-12 minute team presentation. Everyone speaks)
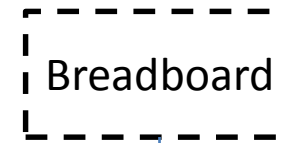
- Ethics Homework – End of October

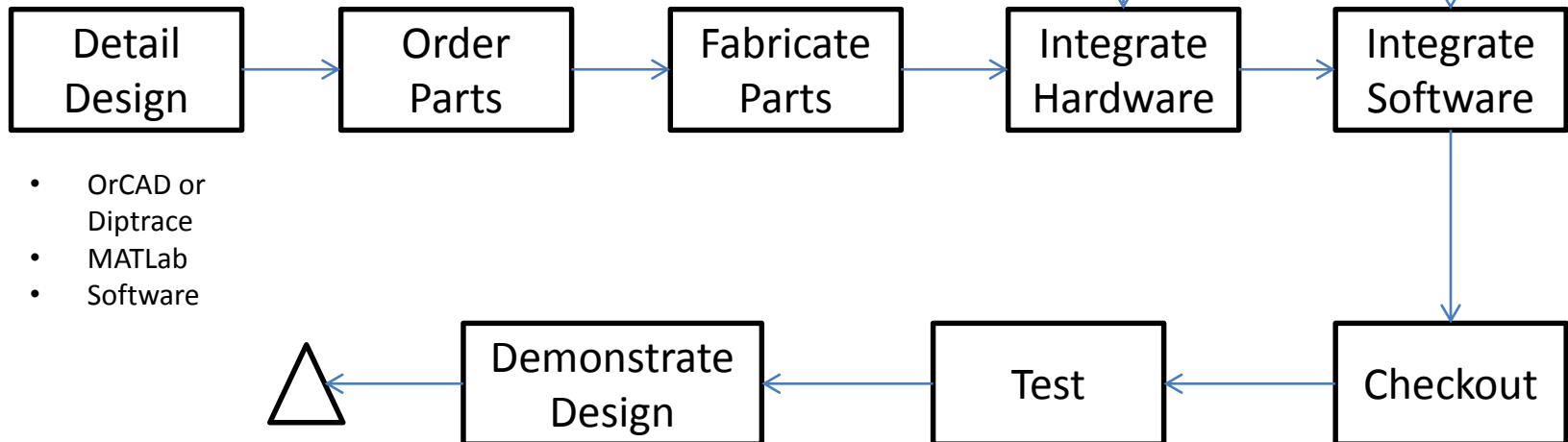- Final Presentation – Dec 5 or Dec 7
- Design Book – Dec 17

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Plan For EE4319