Columbian Mechanical Engineering Department Head Forum

organized by

Colombian Network of Mechanical Engineering Programs (REDIMEC)

Practice-based Curriculum Transformation: Strategies-Tactics-Resources

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Process for Curricular Change

- Department Retreat-August 2009: Proposed to faculty the Major Initiative to “Prepare our Students for a Complex and Changing World” (delayed to 2011 due to charter revision)
  - Wrote 2 NSF curriculum proposals in ‘09 & ’10 – not successful
- Motivation
  - Friedman’s book “The world in flat”
  - Unprecedented & Unpredictable changes in last 20 years (’89-’09)
  - Next 20 years? Not prepared for the last 20
  - 10 years since last curriculum revision
- Break Out Groups:
  - Using NAE Grand Challenges brainstorm
  - what our students need to meet these challenges, and
  - near & long term research issues to meet these challenges

Process for Curricular Change

- Resources: "Preparing engineers for the next 10- 20 years"
  - ASME Vision 2030
  - The Engineer 2020
  - Duderstadt Report
  - NAE Grand Challenges
- Start: Fall 2011: Established a Curriculum Revision Committee through the Executive Committee
  - Curriculum Revision Fund Raising Campaign
  - Supported invited speakers (workshop format)
    - ASME Vision 2030 Report
    - Curriculum development process
  - Funded faculty in summers, release time, and equipment

CRC establishes vision (AY 2011-12)

- Employers will aggressively compete for our graduates, who have extensive **hands-on training in solving engineering problems**.
- Graduate programs will aggressively compete for our graduates, who, in addition to practical problem solving skills, have developed **expertise in a sub-specialty of mechanical engineering**.
- Students have a passion to solve problems that **make a difference in their communities**, and they take ownership of their learning.
- The curriculum enables faculty and students to engage in **cross-disciplinary projects** that strengthen critical, creative, and interdisciplinary thinking.
- Faculty are committed to doing whatever it takes—including pushing beyond boundaries, **working collaboratively**, adjusting course content and adopting **new teaching approaches**—to best realize the rest of the vision.

Faculty provide input on learning objectives (AY 2011-12)

- CRC establishes curriculum "threads"
  - Application of thermal fluids
  - Application of design & manufacturing
  - Application of solid mechanics
  - Application of dynamic systems
  - Programming, modeling & simulation
  - Instrumentation, measurement, data acquisition, controls
  - Structured design process
  - Making & tinkering
  - Communication
- Faculty assign learning objectives to practice courses via "sticky note" process

New course development (2012-2014)

- Established learning objectives for new courses
- Developed ABET syllabi for new courses
- Faculty voted to approve new curriculum
- New courses become official
- Detailed development of new courses

New curriculum courses

Old course sequence (credits)	New course sequence (credits)	Δ credits
Dynamics (3) Mechanical Vibrations (3) Dynamic Systems & Controls (4)	Dynamics (3) Dynamic Systems (4)	-3
Thermodynamics (3) Fluid Mechanics (3) Heat Transfer (3)	Energy-Thermal-Fluids I (3) Energy-Thermal-Fluids II (4)	-2
Product Realization I (3) Product Realization II (3)	Mechanical System Design & Analysis (3)	-3
Integrated Design & Manufacturing (4)	Manufacturing (3)	-1
Engineering design processes (3) Energy lab (1) Mechanical Engineering lab (2)	Mechanical Engineering Practice I (2) Mechanical Engineering Practice II (3) Mechanical Engineering Practice III (2) Mechanical Engineering Practice IV (3)	+4
Technical electives (9) – 3 courses	Technical electives (15) – 5 courses	+6

New curriculum starts

- Taught 1st and 2nd practice courses for the first time (AY 2014-2015)
- Taught remaining new courses for the first time (AY 2015-2016)
- Legacy courses transitioned out (AY 2014-2016)
- All Students on revised curriculum Spring 2017

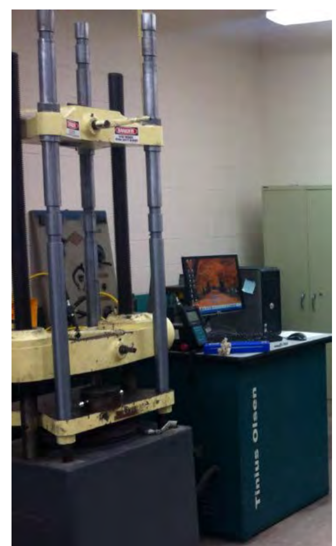
ME Practice 1

- **Data acquisition** – Sensors, sampling rate, signal processing
- **Mechanical testing** – Tension and bending
- **Reverse engineering** – Scenario: students work for consumer reports and have to study an existing product
- **Elevator modeling and testing** – Scenario: Company evaluates use of new software package to use in an elevator improvement project
- **Bridge modeling and 3D printing** – Scenario: Company wants to explore 3D printing of a truss member in a scale bridge
- **CNC lathe manufacturing** – Chess pieces










ME Practice 2

The objective of ME Practice 2 is to introduce concepts of inertia, stability and control and demonstrate the ME connection between dynamics, thermodynamics, solid mechanics, controls, and manufacturing. Heavy emphasis on

- **critical thinking, synthesis, and interpretation,**
- **reader-centered communication,** and
- **independent learning.**

Activities include:

- Experimenting with physical and simulated control systems
- Use of advanced computational engineering tools
- Data analysis, processing and interpretation; uncertainty in measurements
- Use of standards
- Application of theory (cons. mass & energy) to components and systems
- Connection between mechanical and thermal-fluid inertia
- Use of PID for stability and control

MEP 2 Communications

- Throughout the course students are given scenario-specific communication exercises related to the practice sessions:

  e.g., You are working as an engineer for a company that builds laboratory test equipment used for training technicians on control of air heating systems in commercial buildings. One particular test stand uses an RTD as a temperature sensor and for control of an air heater. Your supervisor would like to replace the RTD with a thermocouple in this test stand because the thermocouple is much less expensive. You are tasked with determining which, if any, thermocouple will be suitable as a replacement.

  The intent is **teach and reinforce a reader-centric approach** across all forms of communication: email, graphical, memos, short reports, stand-alone presentation and calibration certificates.

- During the semester there are **four independent communication exercises** that are created and monitored by N. Barr. This is a continuation of communication exercises from ME Practice 1.

  Week 3: Communication via resume and interviews. This corresponds to the university Career Fair.

  Week 6: Reader-centered approach to document structure.

  Week 9: Reader-centered approach to paragraph and sentence structure.

  Week 12: Reader-centered research: Gathering, analyzing, and thinking critically about information.

MEP 2 Dynamic Systems Module

Control Systems: Introduce via model jib crane shown. Testing affect of PID control gains on position accuracy.

Critical Thinking: Affect of gains on position accuracy and stability.

Sensors: Dynamic force in boom via strain gage.

Simulation: Simulink model of jib crane.

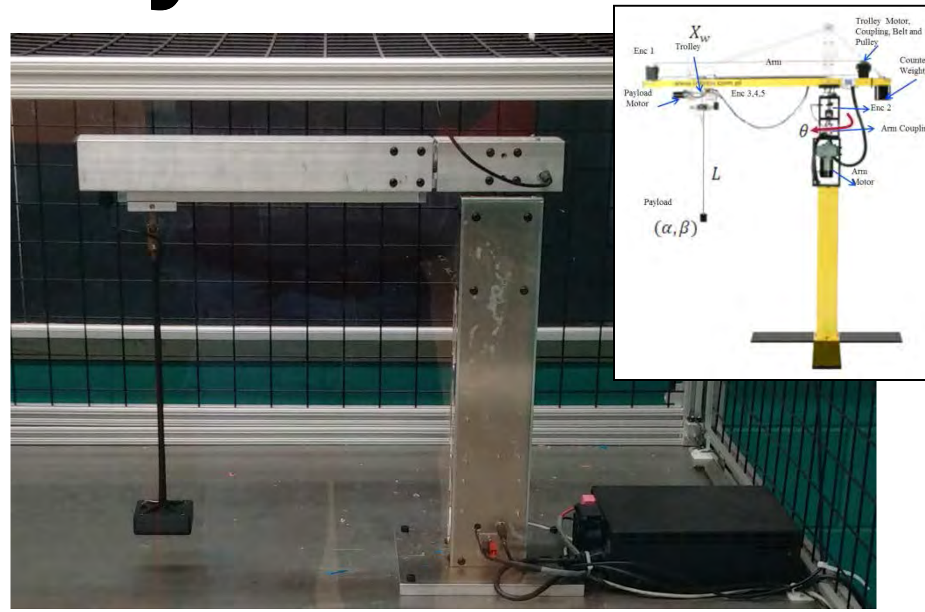
Calibration: Calibration of Simulink model using data from crane.

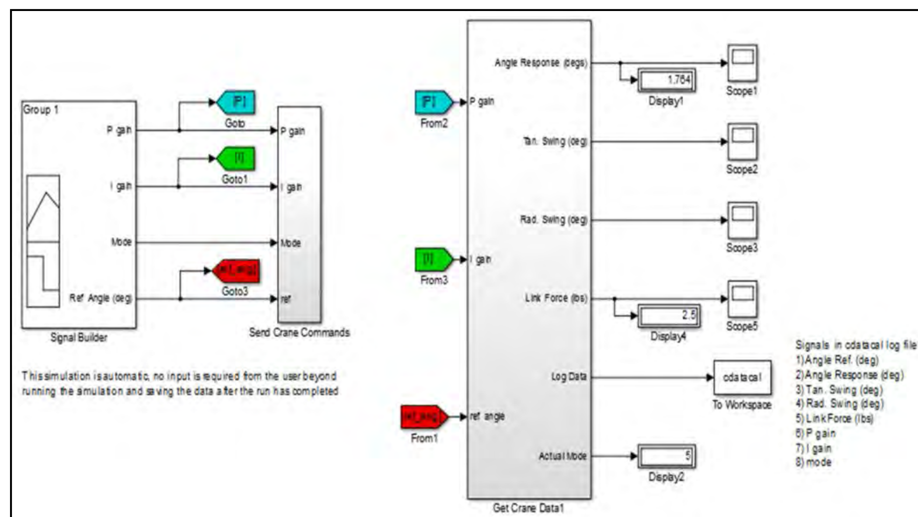
Stability Testing: Using calibrated model, students test stability limits of crane and range of dynamic force with respect to control gains.

2D FEA Analysis: Students design new link for crane boom. Require the link to fail at specified PID control gains. **Self-learning exercise.**

Manufacturing: 3D printing of new link. Conversion of FEA to m-code for manufacturing.

Failure Testing: Did the link fail at the predicted control gains.





MEP 2 Energy-Thermal-Fluids Module

Experimental Methods: Data processing, regression analysis, graphical communication, and uncertainty propagation. Dynamic response and determination of time constants.

Critical Thinking: Analysis of ideal and actual experimental data, data extraction and “goodness” testing. Open ended sessions.

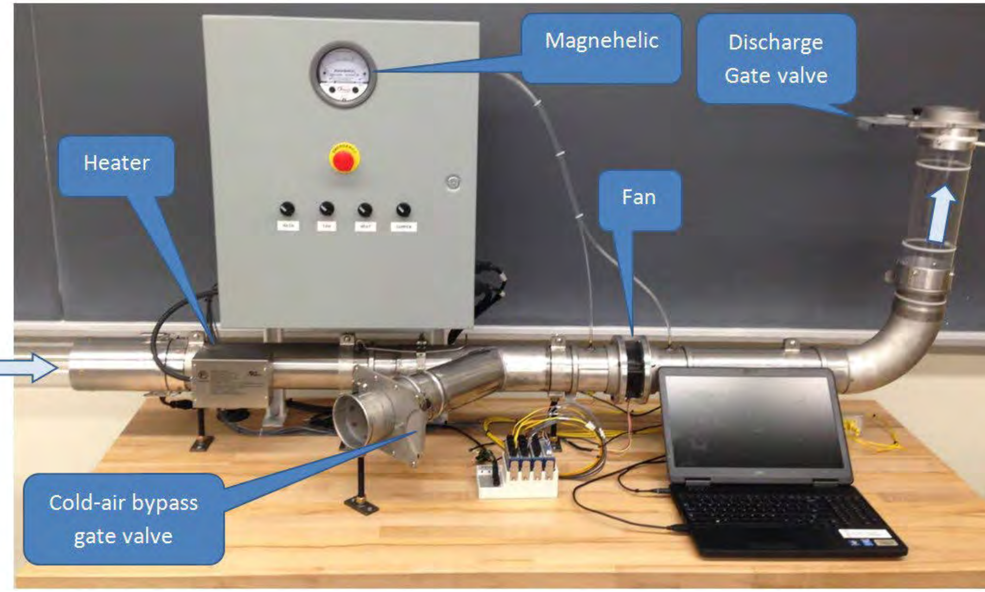
Sensors & Calibration: Measuring pressure & temperature, sensor calibration using primary & secondary standards, precision & accuracy.

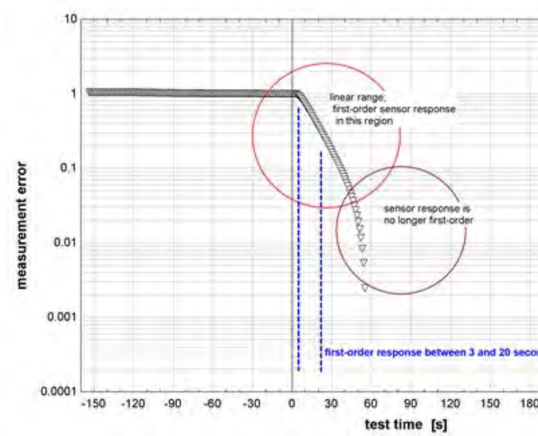
Use of Standards: Measurement of flow. Students purchase ASME MFC-3M-2004 and use extensively (5 weeks).

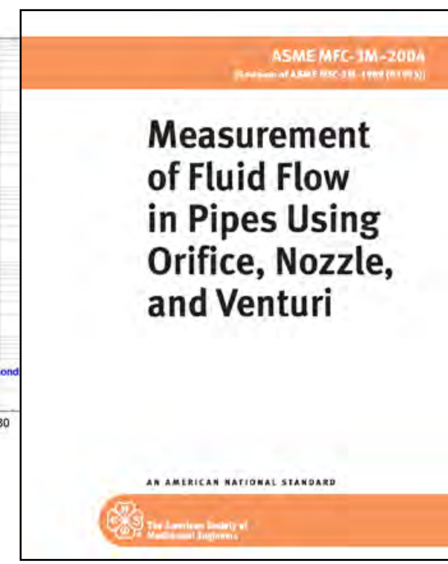
Dimensional Analysis: Prediction of fan performance in air handling system.

Cons. Mass & Energy: Application of theory to air handling system (shown) with uncertainty.

Control Systems & Stability: Reintroduce PID control using air handling system (shown). Test stability of air temperature. **Relates thermal-fluid inertia to mechanical inertia from week 1.**







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Department of Mechanical Engineering - Engineering Mechanics

MEP3 – Model Based Design

Design Goal: Safely move people and goods point to point along a specified route

Use a series of models to guide design decisions

Student Teams:

- Self select specific application
- Research applicable standards and codes
- Determine performance requirements

Focus is on passenger safety resulting in requirements for fatigue, maximum acceleration and maximum jerk.

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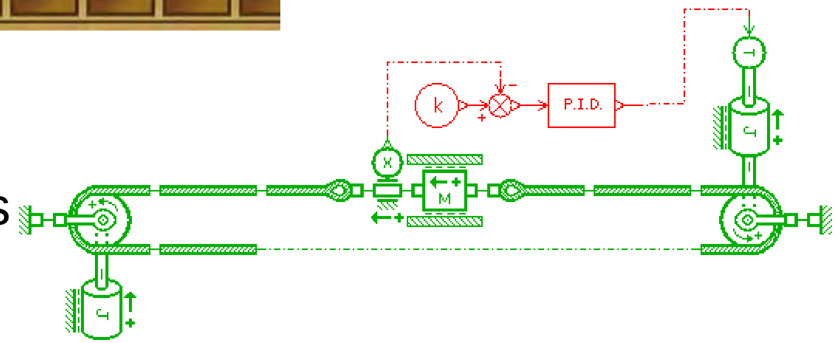
MEP3 – Model Based Design

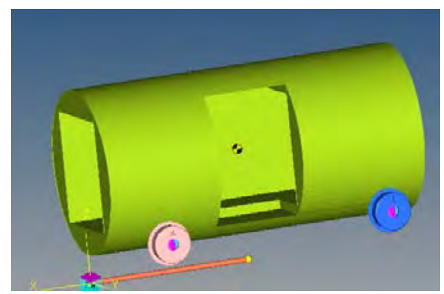
1) Basic Physics Models
- Software: *PhET*
- Verify fundamentals

http://phet.colorado.edu/

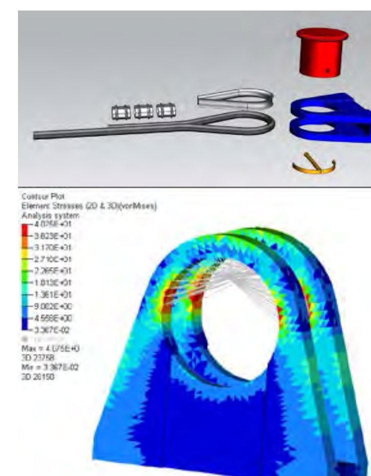
2) Energy Models
- Software: *Siemens AMESim*
- Explore options and parameters



3) Multi-Body Dynamics Models
- Software: *Altair MotionView*
- Add components



4) Finite Element Models
- Software: *Altair: Inspire, HyperMesh, OptiStruct*
- Refine design and validate requirements



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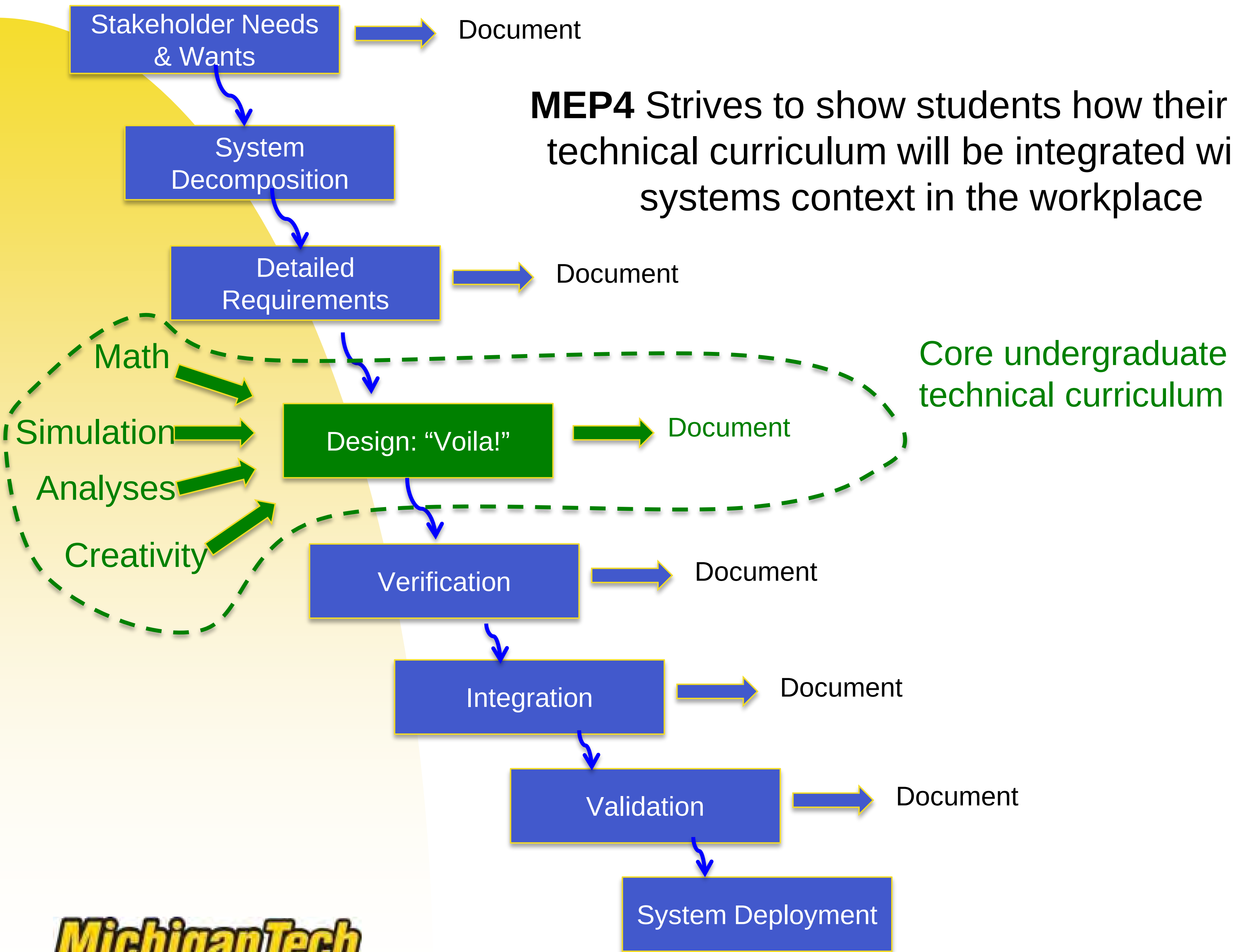
J.P. De Clerck and C.D. Van Karsen

ME Practice 4

MEP4 Strives to show students how their core technical curriculum will be integrated with a systems context in the workplace



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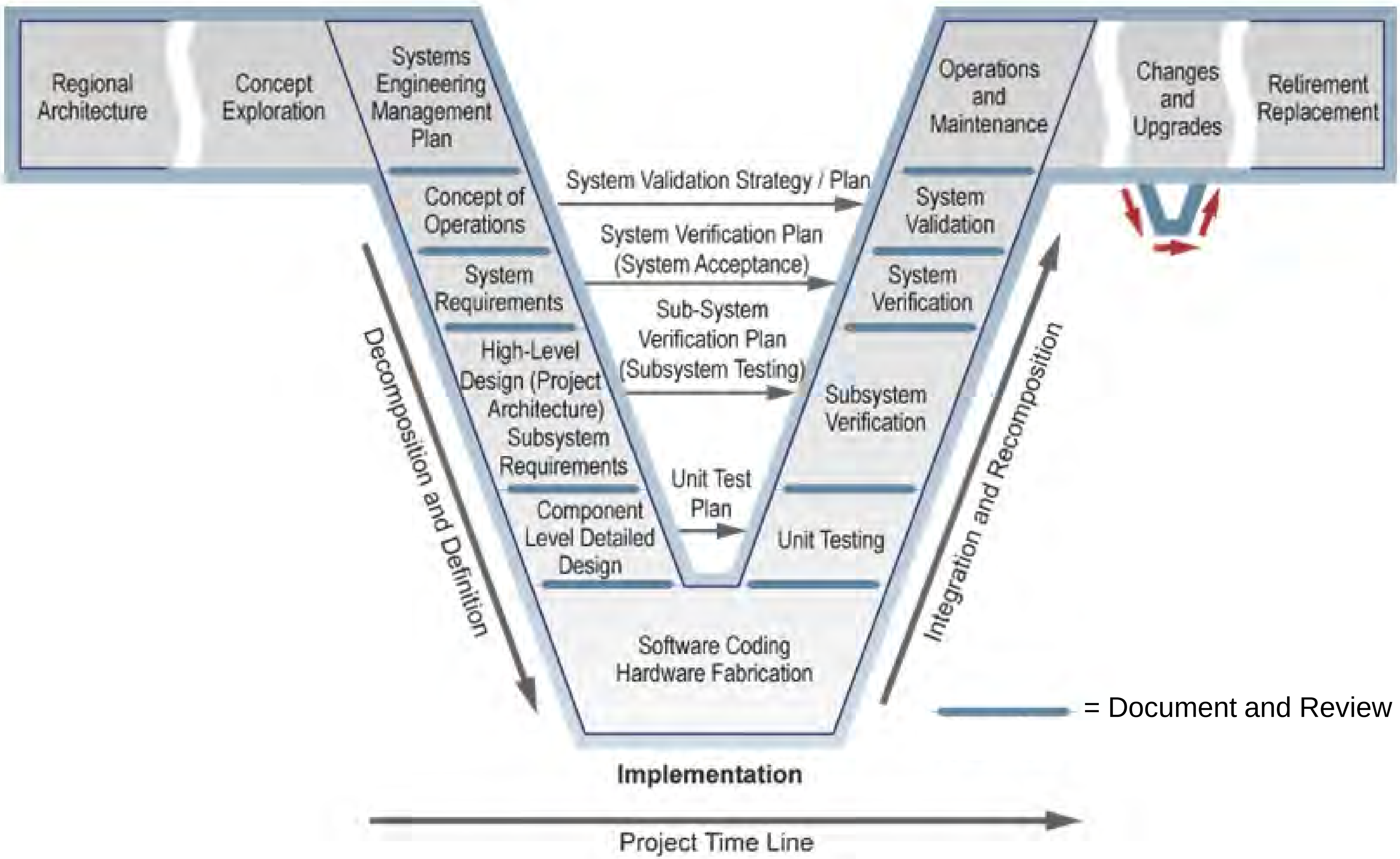
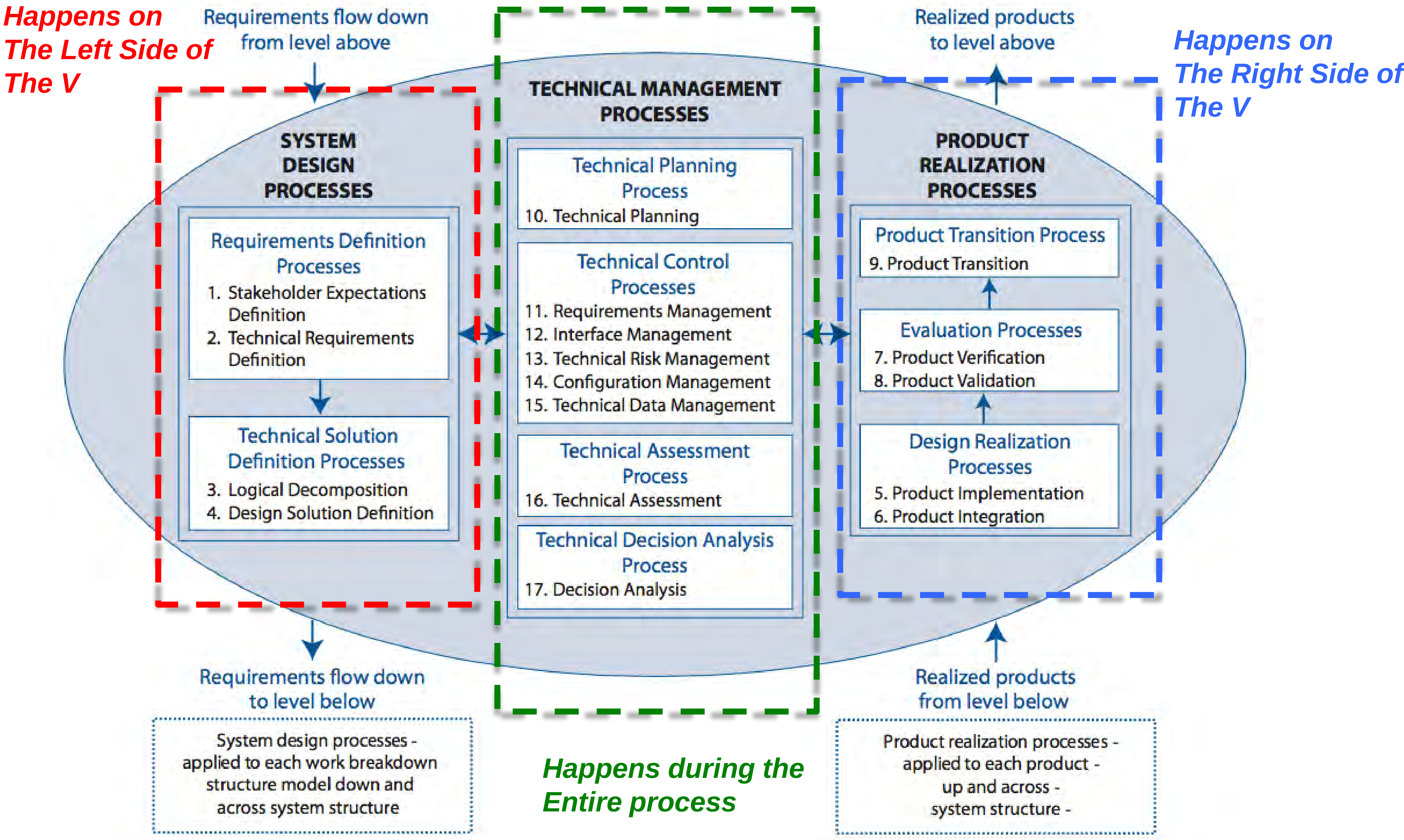
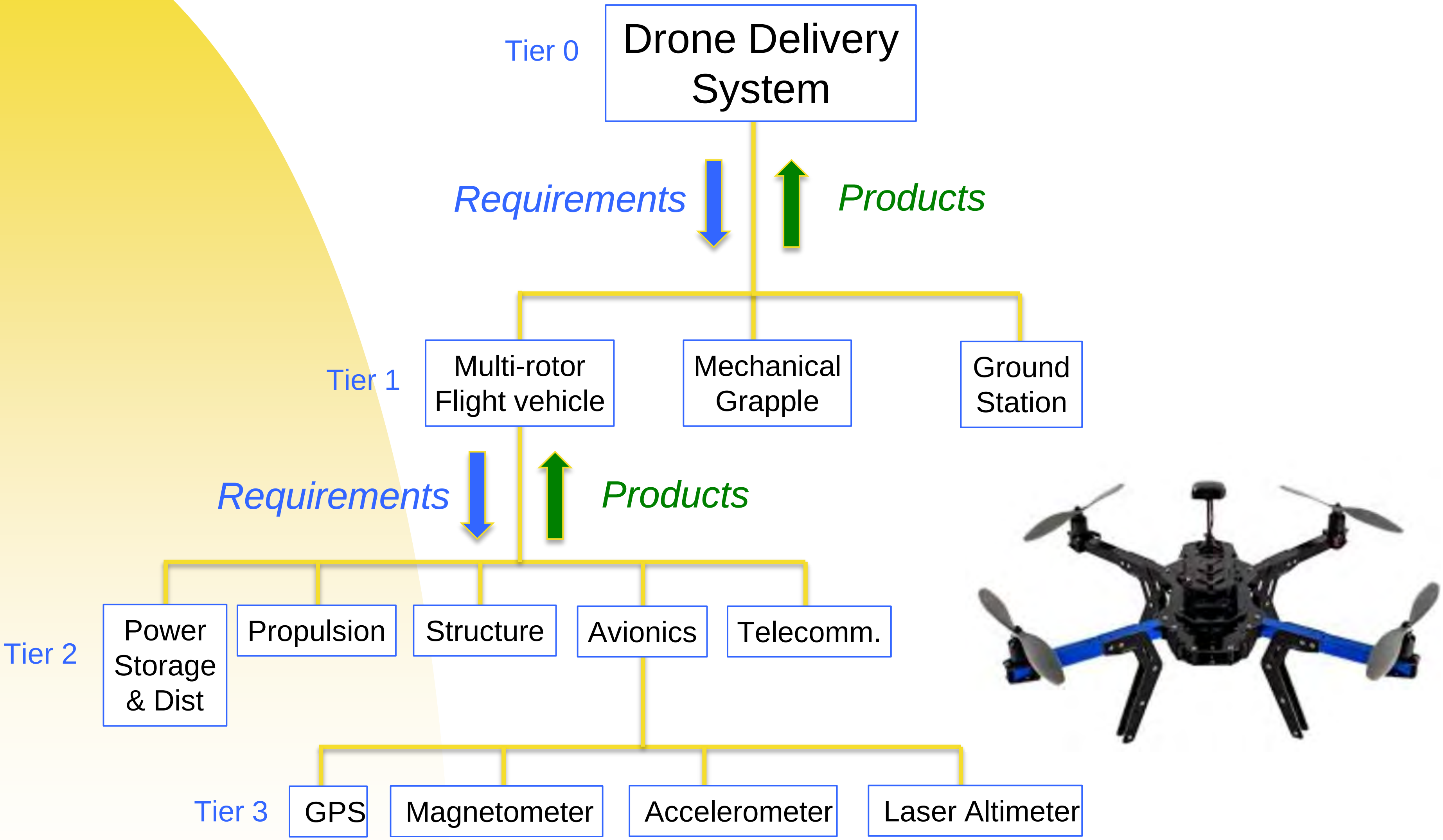
The "V" model of Systems Engineering



The Systems Engineering "Engine"



System Under Study: Rotary-wing Drone Package Delivery



Test / Simulation Sequence of System Re-composition

Mechanical Efficiency of DC Motor

- Dynamometer measures mechanical power
- Current & voltage measure electrical power

Fluid Control Volume Analysis

- Anemometer measures velocity profile from propeller
- CV analysis yields thrust and power in flow
- Compared to direct thrust & power measurement

Structural Dynamics

- Concept of Frequency Response Function
- Modal analysis of copter frame
- Effect of fixturing and damping

System Control

- Feedforward and feedback via Simulink
- HWIL to test integration of software with hardware
- Flight performance test-bed for copter study

Optimization

- Energy-optimal altitude change analyzed via simulation
- Test bed used to evaluate simulated profiles in hardware