Work Product	Product Design Lecture (from [redacted] Human Factors & Design)	
Date Work Completed	February 2017	
Employer	[redacted]	
Applicant's Role	Course Co-Instructor	
Industry Sector and Context	Lesson on Product Design was incorporated into the syllabus for the Human Factors & Design course. The purpose of the lesson was to tie together previous lessons on anthropometry, systems analysis, and human factors assessment tools	
Page No.	**Competency**	**Description of how Competencies are met**
12	3 & 12	Taught students that in design projects you will work alongside professionals from other disciplines in a supportive or assisting role. Often this relationship is that of a consultant whereby other professionals require your assessment, input, or report to feed into their design decisions (e.g., size, material, weight, etc)
2-4	4	Taught students the different stakeholders (developers, regulators, consumers) that are impacted and important to consider, consult, and include during the systems design process
12	5	Stressed the importance of involving end-users in the systems design process given their activities, careers, and well-being are affected by the product. Taught students that users can be leveraged from informal focus groups to formal user testing in order to gauge and measure their wants, needs, capabilities, and limitations
7-11	10	Taught students important characteristics that make up effective and applicable requirements to be used in design projects
12	11	Taught students that empathy for, and collaboration with, other professionals and backgrounds is essential in developing requirements as they must be able to understand and interpret requirements/specifications to develop a working system
17, 24	17	Emphasized the importance of developing realistic and executable project milestones for optimal design and project management

[redacted]

Week 9: Product Design

Fundamental Human Factors Fallacies

(adopted from Pheasant 1986)

1. The design is satisfactory for me; therefore it is satisfactory for everyone else.
2. The design is satisfactory for the average person; therefore it is satisfactory for everyone else.
3. The variability of humans is so great, it is impossible to accommodate in design.
4. Humans are so highly adaptable, accommodating a population is not necessary.
5. Designing for human factors is an excellent idea. I can do it intuitively and don't need the expertise of a human factors professional

Additional fallacies:

- *Human factors is a waste of resources as humans prefer appearance and styling above all else*
- *The time to characterize human factors is after the design is complete.*

Ergonomics
Vol. 55, No. 4, April 2012, 377–395

A strategy for human factors/ergonomics: developing the discipline and profession

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(*Received 7 December 2011; final version received 22 January 2012*)

The Value of HFE for Stakeholders

- Four main stakeholder groups of systems design:

1. **System Actors** – employees & product users
2. **System Experts** – professionals such as engineers and psychologists who contribute to a design and collaborate with HFE
3. **System Decision Makers** – managers who make decisions regarding the design, implementation, and use of a system
4. **System Influencers** – media, governments, standardization organizations, regulators

The Value of HFE for Stakeholders

- System Actors
  - Employees:
    - Improved physical, psychological, and social well-being
    - Higher motivation, growth, and job satisfaction
    - Improved performance (intrinsic or extrinsic rewards)
  - Product Users:
    - Better experience
    - Shorter time to learn / familiarize
    - Fewer mistakes
    - Greater efficiency

The Value of HFE for Stakeholders

- System Experts
  - Better acceptance by users of designed systems
  - Better fit with legal standards (health & safety, accessibility)
  - Improved development process

The Value of HFE for Stakeholders

- System Decision Makers
  - Better productivity by reduced time for performing work procedures
  - Better quality and reliability of production processes and produced goods
  - Lower operating costs due to lower level of health problems, motivational deficits, accidents, absenteeism, etc.
  - More innovation through increased creativity
  - Better decision making through improved information of system

The Value of HFE for Stakeholders

- System Influencers
  - Social wealth

    (through improved *well-being*)
  - Economic wealth

    (through improved *performance*)

Strategy for the Future

(1) **Strengthening the demand for high-quality HFE** by enhancing the awareness of stakeholders' need for high-quality HFE (in particular, for system experts and system decision makers, emphasising performance) by:
   (a) *Communicating* with specific stakeholders about the value of high-quality HFE in the language of the stakeholder.
   (b) *Building partnerships* with these stakeholders and their representing organisations.
   (c) *Educating* stakeholders to raise awareness of high-quality HFE and its contributions to system design.
(2) **Strengthening the application of high-quality HFE** by:
   (a) *Promoting the education of* HFE specialists to apply high-quality HFE.
   (b) *Ensuring high quality standards* of HFE applications and HFE specialists.
   (c) *Promoting HFE research excellence* at universities and other organisations.

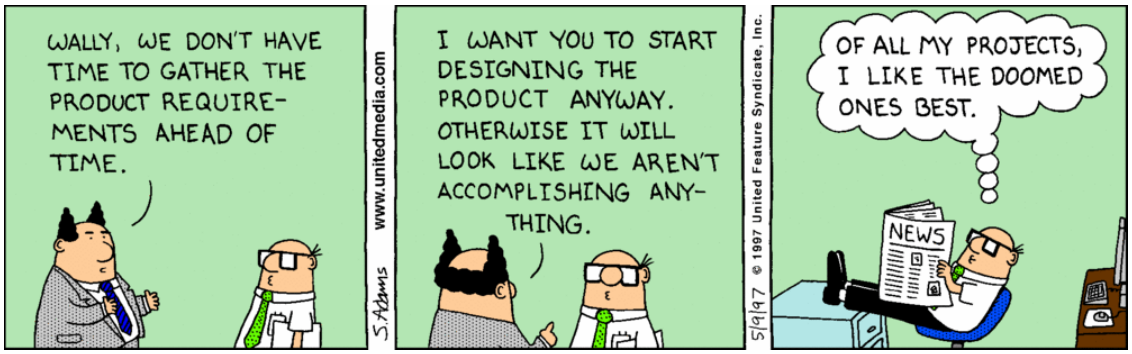
Strategy Implementation

- Strengthening demand for high-quality HFE by enhancing awareness of a need for high-quality HFE:
  - Communicate with dominant stakeholders (system experts & system decision makers) by emphasizing key characteristic benefits of HFE in <u>their</u> language (cost-benefit analysis, productivity, quality)
  - Build strategic partnerships
  - Educate future stakeholders by showing the value of HFE at all educational levels within other field (business, engineering, design, etc.)

Strategy Implementation

- Strengthening the application of high-quality HFE
  - Formulating high standard for HFE specialists
  - Bridging the gap between well-being & performance
  - Accreditation and certification
  - Promoting HFE research excellence at universities and institutions

Developing Requirements



The 8 Characteristics of Good Requirements

1. **Verifiable**
2. **Clear & Concise**
3. **Complete**
4. **Consistent**
5. **Traceable**
6. **Viable**
7. **Necessary**
8. **Implementation Free**

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Verifiable

A **verifiable** requirement …

- Is stated in such a way that it can be tested by inspection, analysis, or demonstration
- Makes it possible to evaluate whether the system met the requirement

Bad Example	Good Example
The system must be user friendly	*The user interface shall be menu driven and provide dialogue boxes, help screens, radio buttons, and dropdown list boxes for user inputs*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Clear & Concise

A **clear & concise** requirement …

- Must consist of a single requirement, be easily read and understood, be ambiguous, not contain definitions, and avoid subjectivity

Bad Example	Good Example
All screens must appear on the monitor quickly	*When the user accesses any screen it must appear on the monitor within two seconds*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Complete

A **complete** requirement …

- Contain all the information needed for system function, leaves no one guessing, and includes measurement units

Bad Example	Good Example
On loss of power the battery backup must support normal operations	*On loss of power the battery backup must support normal operations for 30 minutes*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Consistent

A **consistent** requirement must …

- Not conflict with other requirements, use same terminology, and not be redundant

Bad Example	Good Example
- *The overhead hatches must be compliant to MIL-STD-1472G* - *NASA strength guidelines must be adhered to in designing the overhead hatches*	- *The overhead hatches must be compliant to MIL-STD-1472G* - *MIL-STD-1472G strength guidelines must be adhered to in designing the overhead hatches*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Traceable

A **traceable** requirement …

- Has a unique identity number, has change control, and can be easily traced

Bad Example	Good Example
The system must generate a batch end report when a batch is aborted	*SSPS-108:The system must generate a batch end report when a batch is aborted*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Viable

A **viable** requirement must …

- Be met using existing technology, achieved within the budget, met within the schedule, and is helpful to build the system

Bad Example	Good Example
The replacement control system shall be installed with no disruption to production	*The replacement control system shall be installed causing no more than two days of production disruption*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Necessary

A **necessary** requirement …

- Is one that must be present to meet system objectives
- Leads to deficiency if it is removed

Bad Example	Good Example
All computers used on the project must be configured with 16GB memory, NVIDIA graphics card, and 24" display	*All computers used by developers on the project must be configured with 16GB memory, NVIDIA graphics card, and 24" display*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Implementation

An **implementation free** requirement …

- Defines what functions are provided by the system
- Does not specify how the function is implemented

Bad Example	Good Example
After three unsuccessful attempts to log on a Java Script routine must lock the user out of the system	*After three unsuccessful attempts to log on the user must be locked out of the system*

https://www.slideshare.net/guest24d72f/8-characteristics-of-good-user-requirements-presentation

Requirements Exercise

- In small groups, write a requirement that pertains to principles taught in the last two weeks for a hypothetical system or product:
  - Anthropometry
  - Strength
- Consider the 8 Characteristics of Good Requirements

1. **Verifiable**
2. **Clear & Concise**
3. **Complete**
4. **Consistent**
5. **Traceable**
6. **Viable**
7. **Necessary**
8. **Implementation Free**

Integrated Product Teams

- No successful or effective product is developed in isolation
- Multidisciplinary teams are critical to ensure a product, system, or process is well-rounded, usable, affordable, safe, marketable, etc.
- When developing requirements it is important to consider and include the Integrated Product Team as different professionals will rely on those specifications throughout the design and development stages

Maintainability | Logistics | Schedule | Cost
Safety | Weight | Manufacturability | Supply Chain
Human Factors | Reliability | Quality | Structural

The Importance of User Input

- The false-consensus effect is the tendency of people to assume that others share the same beliefs and will behave similarly in any given context or scenario
- You can't be all of these things simultaneously:
  - Large & Small
  - Experienced & Inexperienced
  - Strong & Weak
  - Able-Bodied & Disabled
  - Old & Young

Where Did Homer Go Wrong?

Maintainability	Logistics	Schedule	Cost
Safety	Weight	Manufacturability	Supply Chain
Human Factors	Reliability	Quality	Structural

The Edsel

- Heavily advertised but was a wide-scale failure that lost Ford approx. $250 Million (1950s), equivalent of ~ $2 Billion today
- The public had difficulty understanding what it was supposed to be based on the price point relative to other products in the Ford line and comparable models from competitors
- “Edsel” has become synonymous with product failure
- It also came with a host of usability issues

Where Did The Edsel Go Wrong?

- Teletouch transmission was overly complex, requiring drivers to shift P-R-N-D to avoid overloading the motor
- Drivers would inadvertently shift gears when trying to use the horn
- Speedometer was difficult to decipher

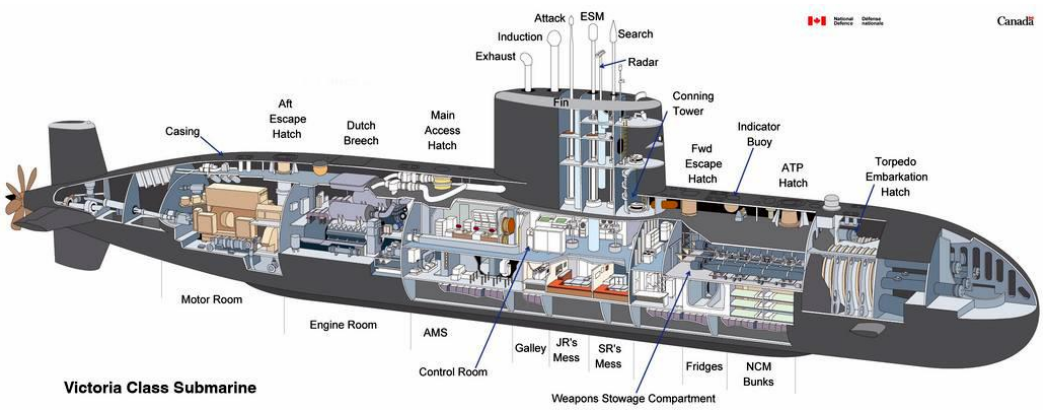
- From a distance and in the dark, the rear turn indicator lights were deceiving as they are shaped as arrows that aim the opposite way

The Negativity Bias in Product Design

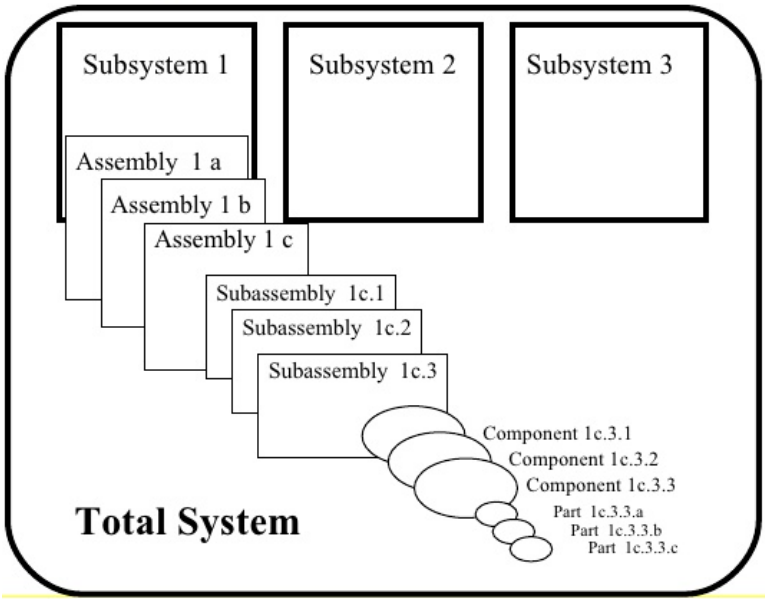
- **The negativity bias** is the tendency for **humans to pay more attention, or give more weight to negative experiences** over neutral or positive experiences
- This is true even when negative experiences are inconsequential, humans tend to focus on the negative
- Research has indicated that we tend to avoid choosing options that might result in loss
  - The bad feeling of losing $20 outweighs the good feeling of winning $20

System Breakdown

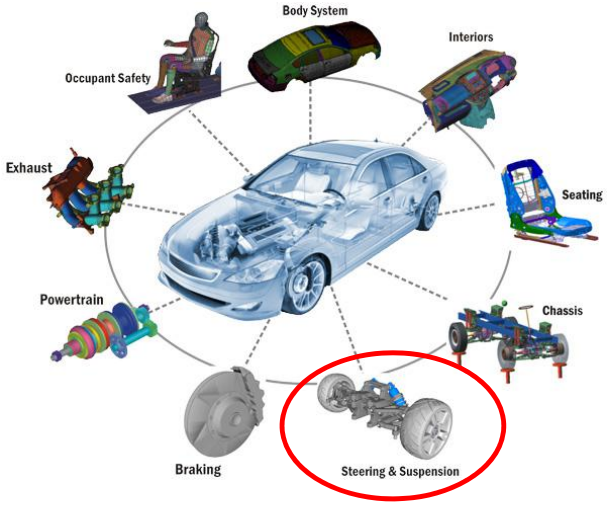
- A set of connected parts that form a whole to fulfill an objective
- Can be a product, process, or an organization

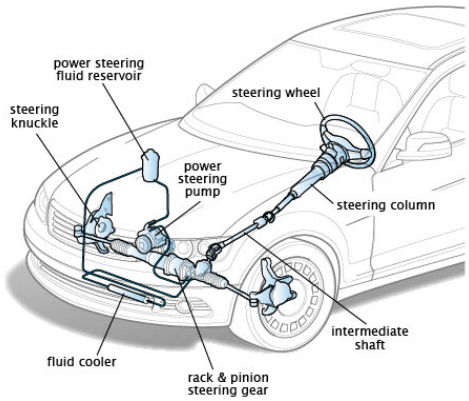


System Breakdown



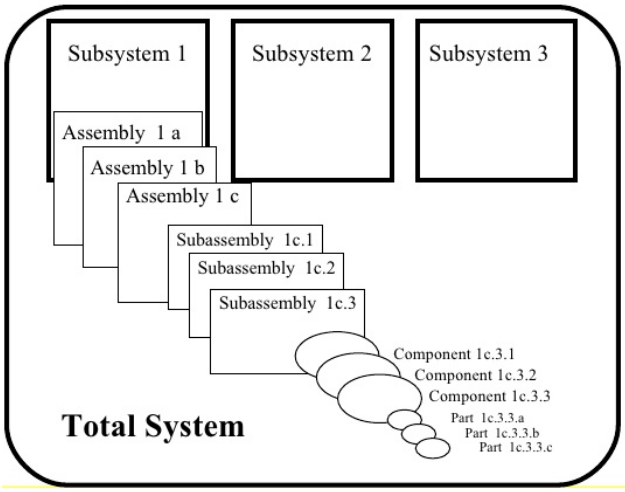
System Breakdown





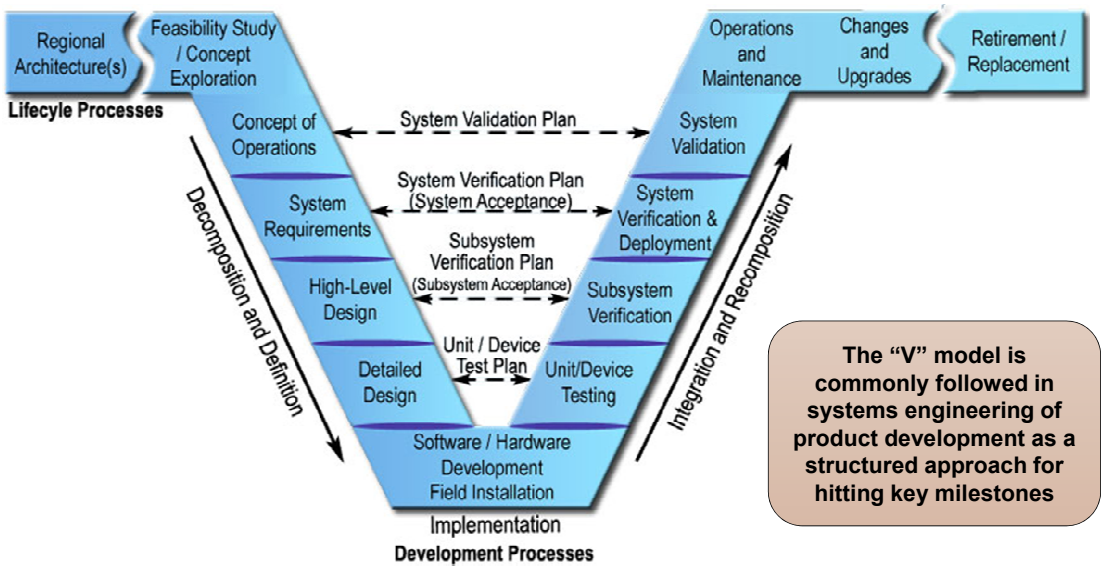
System Breakdown

- In small groups, pick a system from the list and decompose

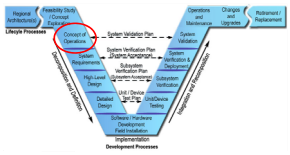


- Refrigerator
- ATM
- Laptop
- Cell Phone
- Photocopier
- Windmill
- Satellite

Systems Engineering "V" Model

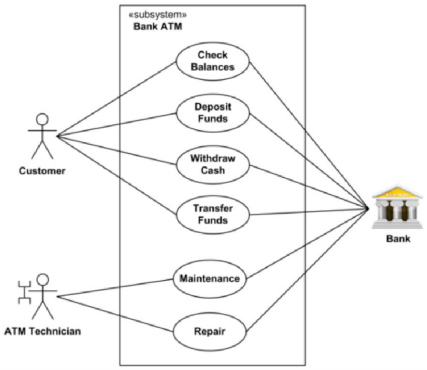


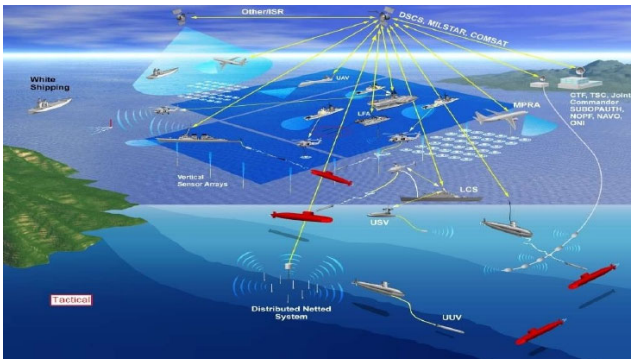
The "V" model is commonly followed in systems engineering of product development as a structured approach for hitting key milestones

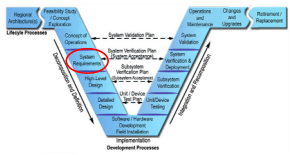


Concept of Operations

- Describes the characteristics of a system from the standpoint of end-users
- Develop use-cases to breakdown the tasks by each stakeholder of a system/product

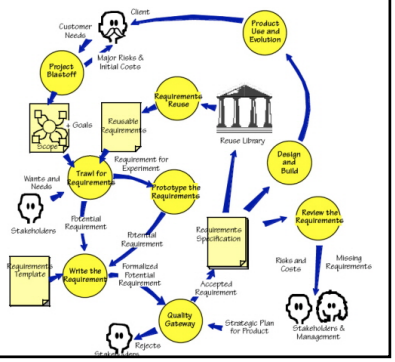


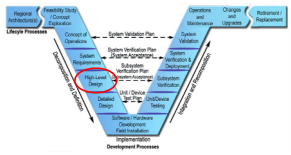




System Requirements

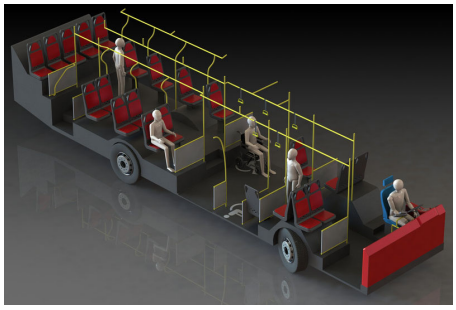
- Leveraging the Concept of Operations, begin to develop requirements that pertain to human factors criteria
- Start big (system) and then decompose to smaller (subsystem) and smallest (part)
- Human factors specific requirements likely to include:
  - Physical Attributes
    - ✓ Anthropometry ,Strength, Field of View
  - Cognitive Attributes
    - ✓ Error, Performance, Memory, Reliability
  - Environmental Attributes
    - ✓ Temperature, Noise, Vibration, Light

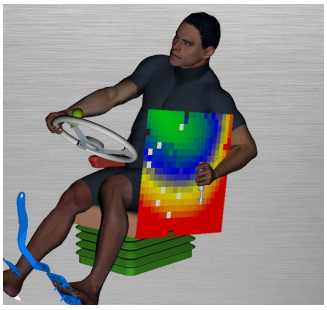


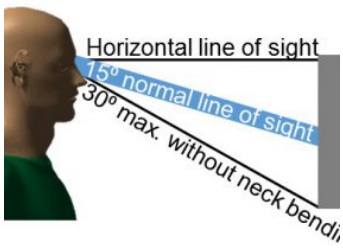


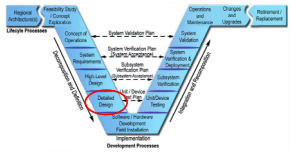
High-Level Design

- Can be done using digital human modeling in CAD or simple concept sketches
- Using rough models and basic geometries to account for space claims that will be maintained (reach envelopes, line of sight, shoulder clearances, hand access)







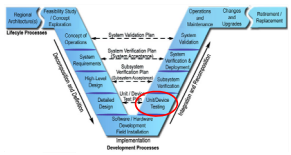


Detailed Design

- Will be done exclusively in digital human modeling in CAD at this point
- Verify accommodation, access, vision, force application (and so on) in high fidelity

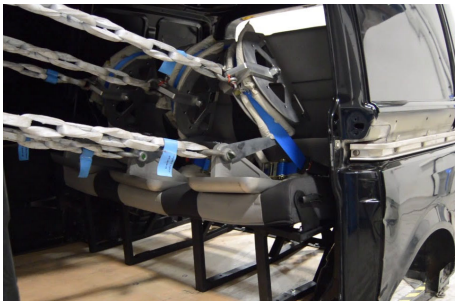
Software/Hardware Installation

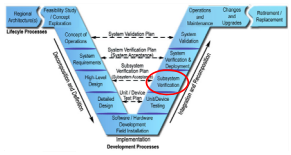
- Once designed parts are built it offers the first chance to verify assessments
- Physical mock-ups or prototype builds are common at this stage



Unit/Device Testing

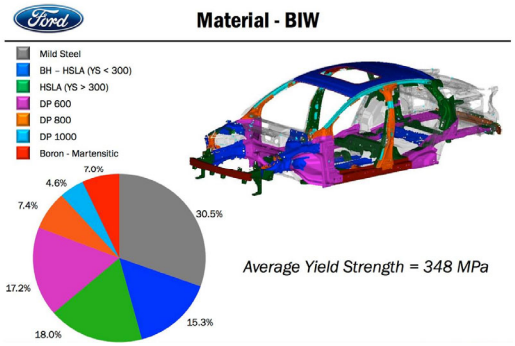
- Depending on requirements and intended output, testing may occur at part level where the entire assembled product is not necessary
  - Seats often require isolated stress / pull tests for crashworthiness
  - Individual components can be tested in environmental chambers (temperature) or shaker tables (WBV)





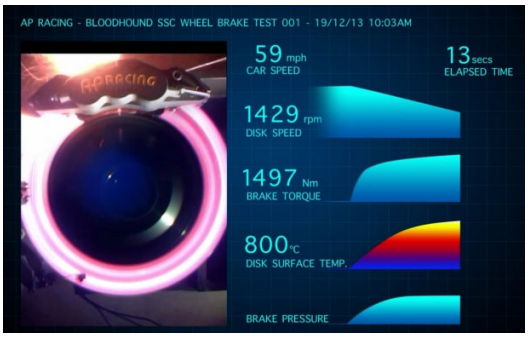
Subsystem Verification

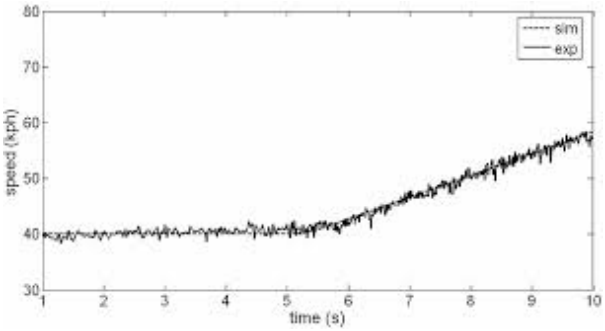
- Human factors verification at the subsystem level is not common, generally, requirements are assessed against human factors criteria at the part or system level
- Other subsystem verification may be related to weight roll-up or structural testing

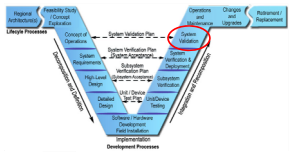


System Verification

- **Verification** ensures that a system or product meets the required specifications
- Proven by analysis and formal testing





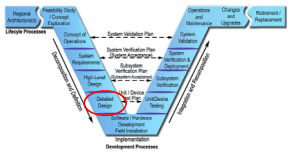


System Validation

- **Validation** ensures that a system or product meets the customer's needs
- Proven by demonstration in a representative environment
- Allows end-users to confirm if the product will operate as necessary

Operations and Maintenance

- Human factors is integrated in this process by way of training operators and maintainers of a system
- Early HFE involvement ensures that human factors professionals are aware of all the required steps as well as potential hazards



Changes and Upgrades

- Common in systems with longer lifecycles
  - Average ownership of commercial vehicles is ~5 – 7 years
  - Average commercial vehicle life before retirement is ~12 years
  - Average military vehicle life before retirement is ~35 years
- Upgrades often include integration of more sophisticated modernizes parts and technologies that did not exist when first built
- Same “V” process is followed when a project is initiated

Trade-Offs

- Competing requirements can occur in the design of products and systems, generally more often than we would like
- Leads to a balanced decision to achieve two (or more) incompatible features through compromise
- Once attempts are exhausted, a trade-study should occur where multiple design concepts are compared:
  - Importance of each metric is ranked
  - Each metric is assigned a value percentage (out of 100)
  - Both concepts are then assessed against metrics and winner is determined objectively

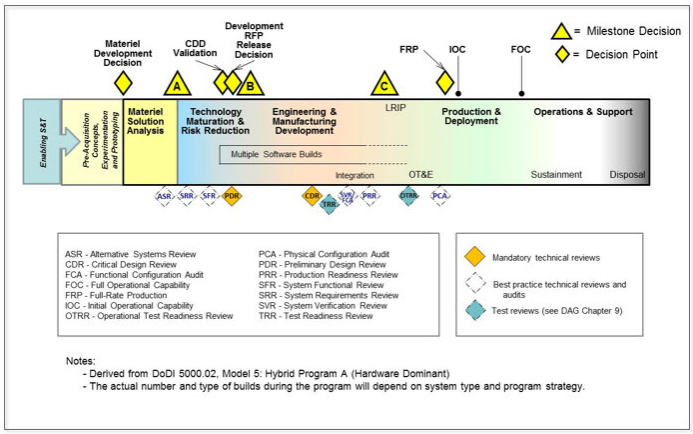
Pugh Matrix

Pugh Matrix											2005-08-22
Evaluation criterias		Reference Design		Concept 1		Concept 2		Concept 3		Concept 4	
	Priority - 5 is high	Rating	Weighted	Rating	Weighted	Rating	Weighted	Rating	Weighted	Rating	Weighted
Product Cost	5	1	5	3	15	2	10	2	10	1	5
Tooling Cost	2	5	10	4	8	2	4	3	6	1	2
Development time	3	4	12	2	6	1	3	1	3	1	3
Ease of customer use	5	1	5	1	5	3	15	3	15	3	15
Viewability	2	0	0	1	2	3	6	2	4	3	6
Customer physical attributes	4	1	4	1	4	4	16	4	16	1	4
Interface acceptance	5	3	15	4	20	2	10	3	15	1	5
Mounting space	3	4	12	4	12	1	3	1	3	4	12
Auxilliary system inputs	1	2	2	2	2	1	1	2	2	2	2
Ergonomics	3	2	6	3	9	4	12	1	3	2	6
Clinic rating	5	3	15	3	15	3	15	3	15	1	5
Ease of diagnostics	3	2	6	2	6	1	3	1	3	1	3
Number of new parts	1	2	2	2	2	1	1	1	1	1	1
Total Score			94		106		99		96		69
Selected/Rejected/Maintained alternative											

Responsible for Pugh	
Leader:	
Engineering:	
Engineering:	
Advanced Engineering:	
Aftermarket:	
Product Planning:	
Product Planning:	
Marketing:	
Eng. PM:	

Milestones

- Milestones are important events that help track the progress in terms of design maturity, schedule, and budget
- They typically work as “gates”, in that you must pass one milestone before starting the next. This keeps design teams working towards a common goal and mitigates costly rework



Conclusion

- Any outstanding questions?
- Reading for next week’s class:
  - [redacted]