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An Evaluation of the Boeing Diamond Process Model's Effectiveness for T-7A Red Hawk Development

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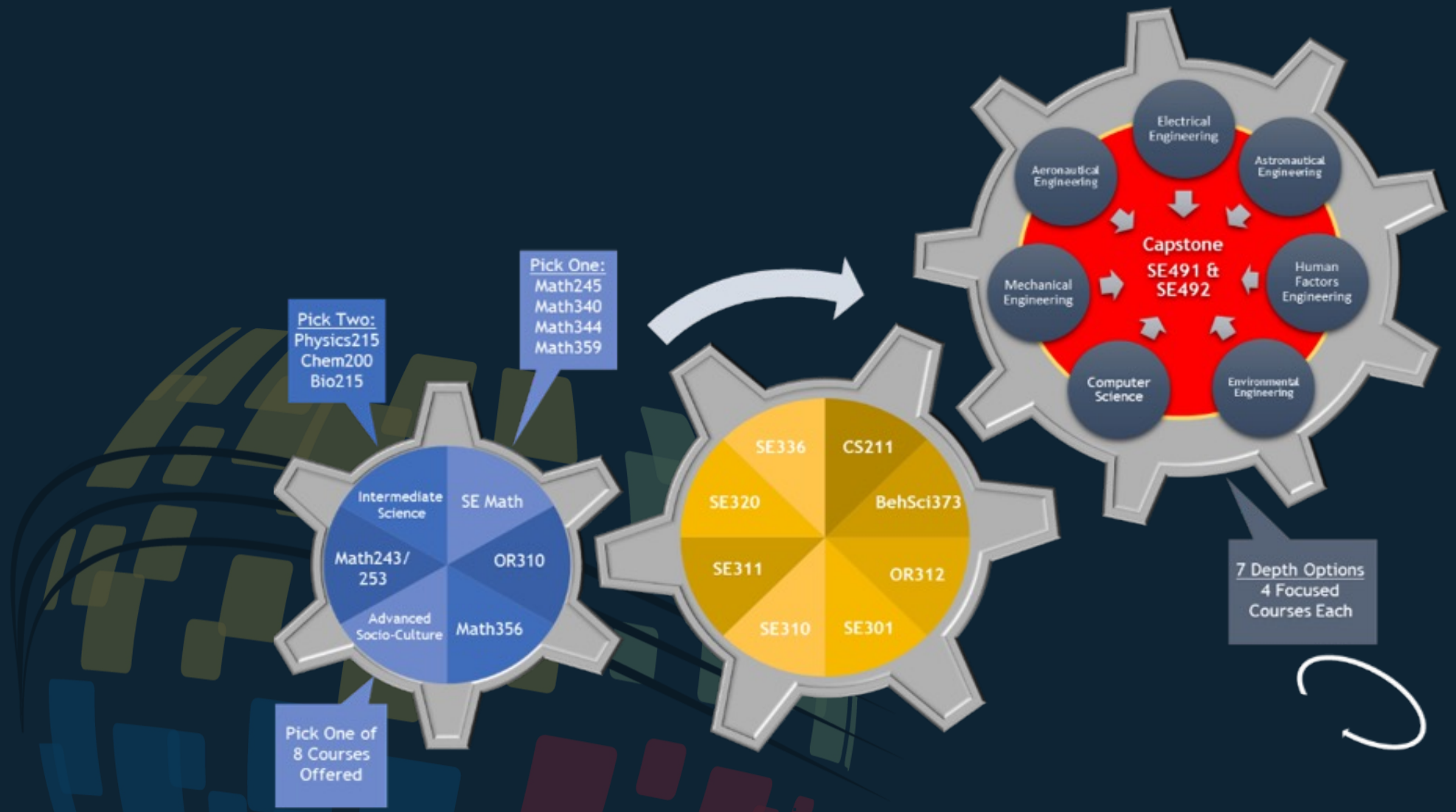
United States Air Force Academy (USAFA)

USAFA Systems Engineering Program



USAFA Systems Engineering Program

- **ABET accredited BS in Systems Engineering (all programs grant Bachelor of Science)**
- **144 Semester Hours Total**
- **SE Core Curriculum Includes:**

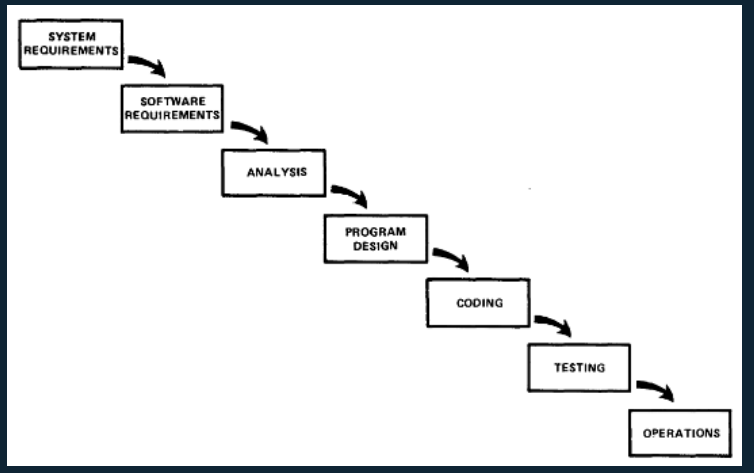
SE 301: Project Engineering	CS 211: Intro to Programing for Scientists/Engineers
SE 310: Intro to Systems Engineering	OR 312: Probabilistic Models
SE 311: Intermediate Systems Engineering Methods	BehSci 373: Intro to Human Factors Engineering
SE 320: Optimization Theory with Design Applications	SE 405 / 406: Systems Engineering Colloquium I/II
SE 336: Engr Economics and Financial Management	SE 491 / 492: Systems Engineering Capstone Design I/II

- **Depths: Mech, Electrical, Aero, Astro, Human Factors, Environmental, Comp Sci**
  - **4-course discipline-specific track**
  - **2-course capstone sequence is in cadet's depth area**

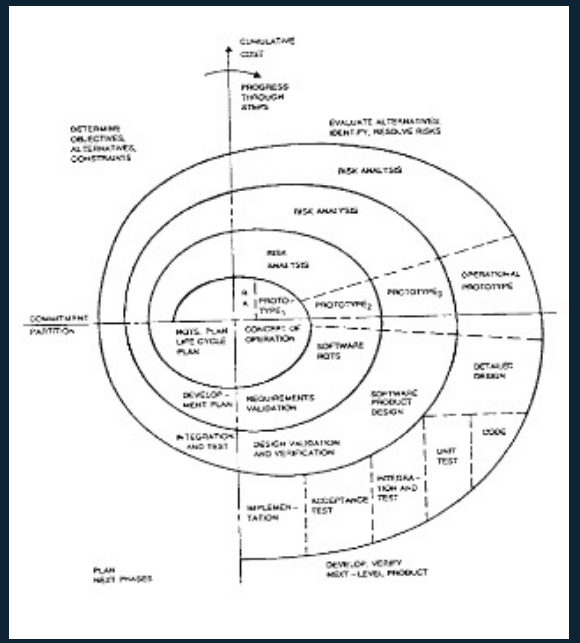
Process Models and Model Based Systems Engineering

- Systems engineers require process models in order to assist them in all aspects of lifecycle processes.
- Model Based Systems Engineering (MBSE) includes the use of digital models to represent aspects of complex systems.

Waterfall Process Model



Spiral Process Model



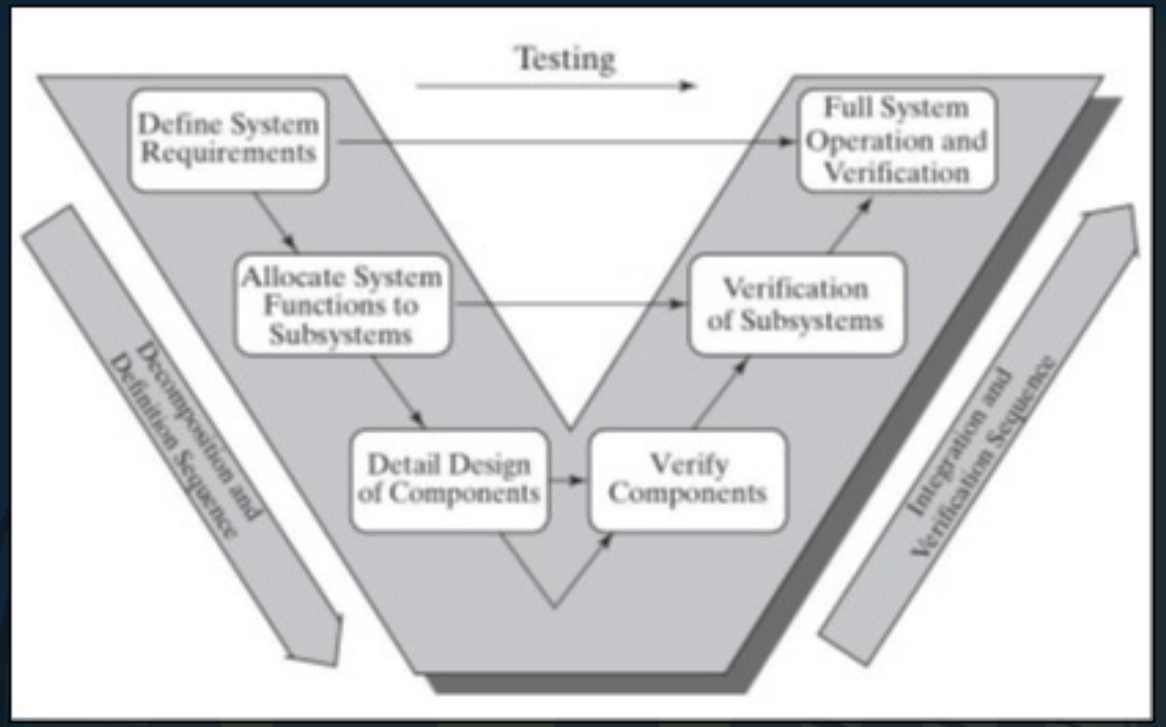
Vee Process Model

Boeing Diamond Process Model?

Focusing on the Vee Process Model

- The Vee started appearing in literature around 1991 when Kevin Forsberg and Harold Mooz published their landmark paper about relating roles and responsibilities within a systems context.
- Their idea encouraged a repetitive process for engineers to follow when designing advanced systems.
- Numerous other process models have been developed, both before and after Forsberg and Mooz's work.

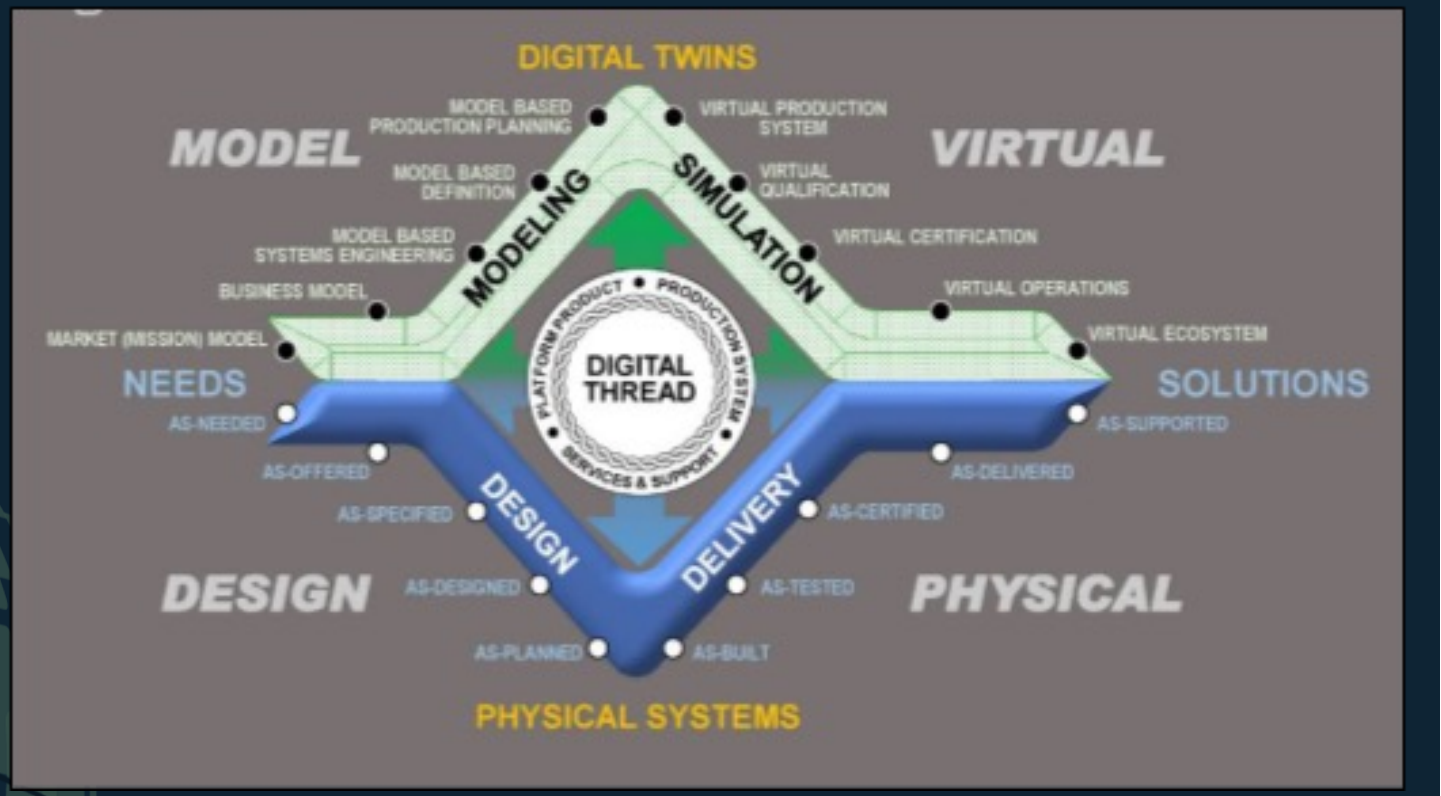
Focusing on the Vee Process Model



- One of the most common process models is the Vee Model.
- This model follows left to right, starting with the customer needs and breaking them down into requirements.
- Up the right side, evaluation and verification are performed.

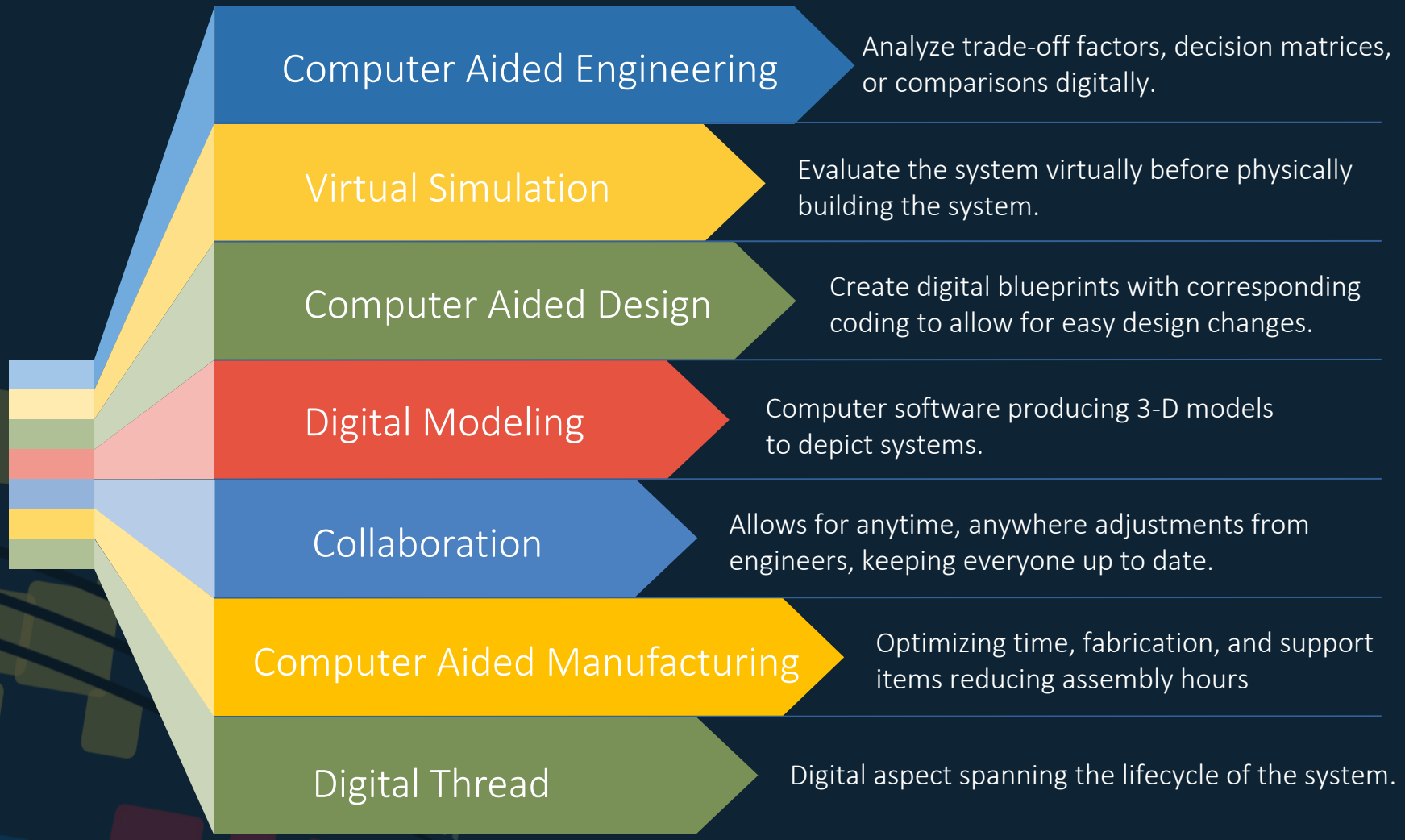
Boeing Diamond Process Model

- Boeing engineers created the Boeing Diamond Process Model.
- It is essentially the vee Model with a second vee inverted on the top.
- This model allows for simultaneous development in both the virtual and physical domains.
- The second vee accounts for the digital twin that models and evalutes the system.



The Digital Design Process

Digital DNA



Boeing/Saab T-7A Red Hawk

T-7A Red Hawk livery rendering by Boeing

Why a New Trainer?

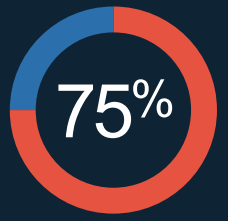
- This aircraft was dedicated to the Tuskegee Airmen, who were founded almost eight decades ago. The T-7A mimics the coloring of the P-51 Red Tail, the aircraft the Tuskegee Airmen flew during World War II.
- The T-38 Talon, the current undergraduate pilot training aircraft, has been in use since 1961.
- New fighter pilots in the 1960s learned how to fly using the same training platform as pilots today learn.
- The Boeing-Saab T-7A Red Hawk is defined as groundbreaking for not only the United States Air Force, but for engineers throughout the world.

T-38 Talon at Sheppard AFB

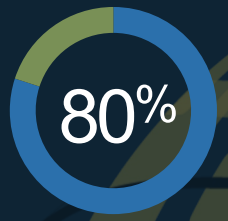
Boeing/Saab T-7A Red Hawk

T-7A Red Hawk livery rendering by Boeing

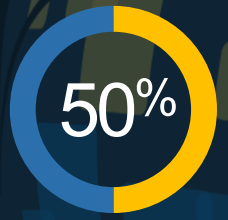
T-7A Red Hawk Digital Design



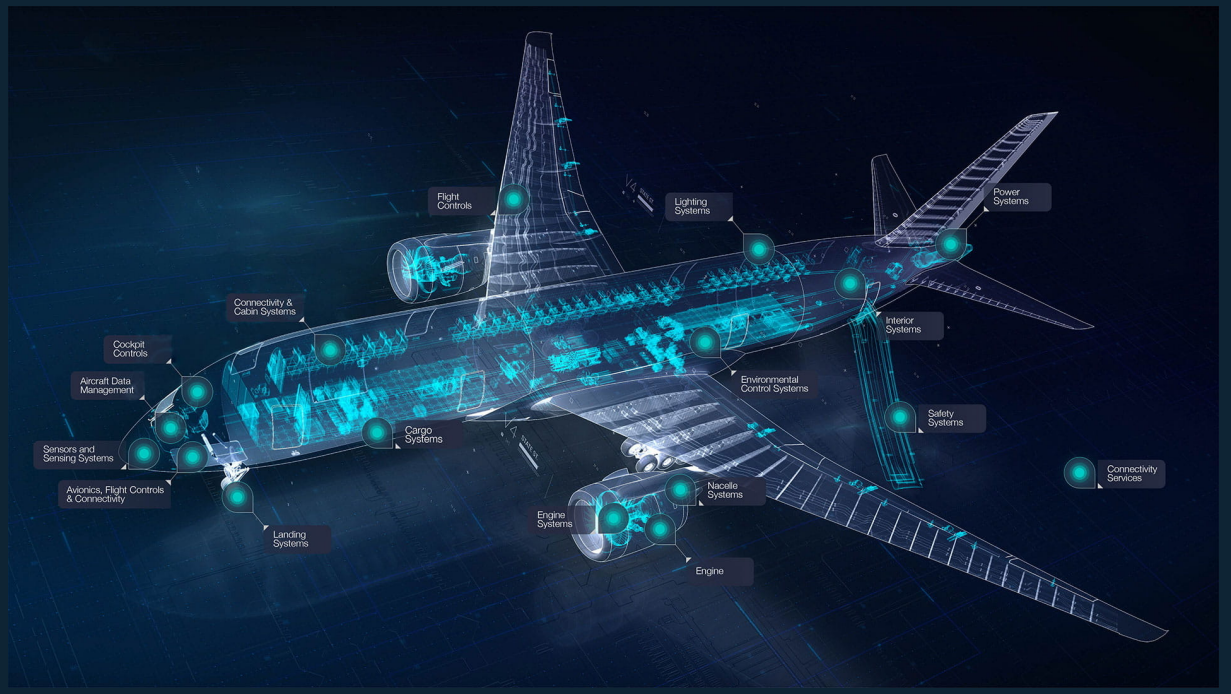
Improvement in first iteration quality



Reduction in assembly hours



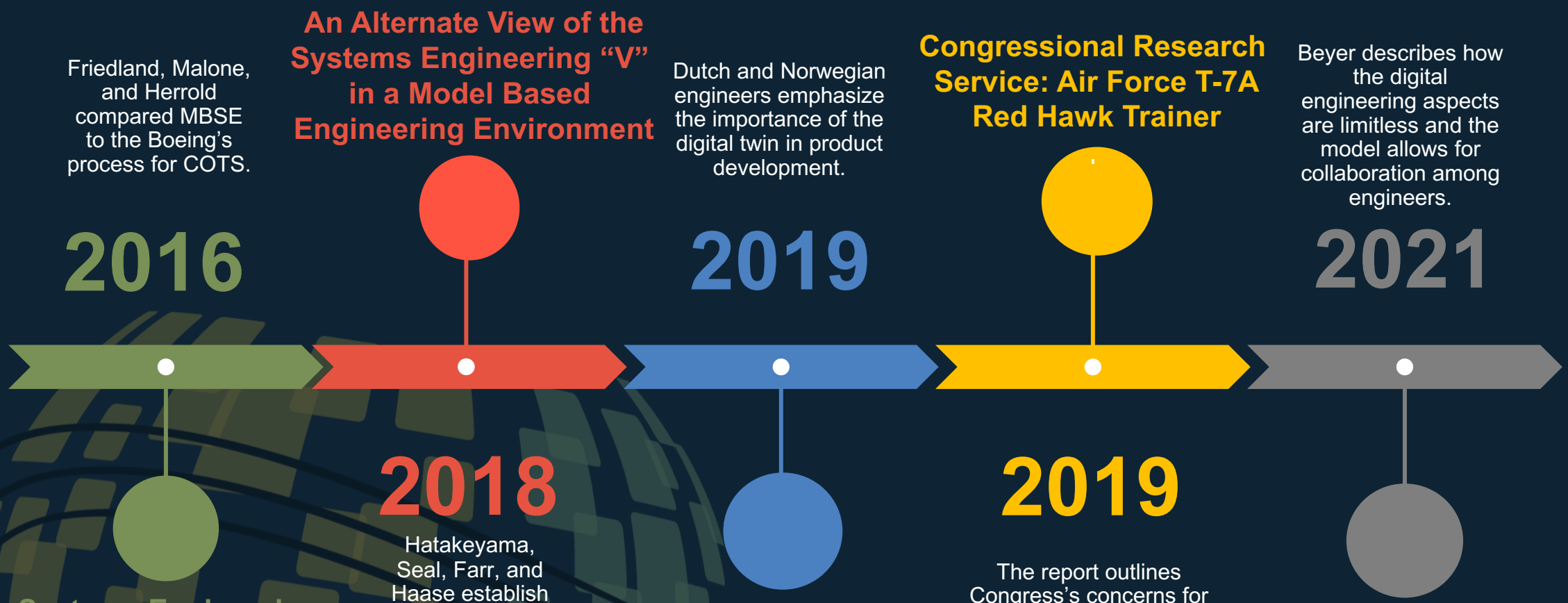
Reduction in software development and verification time



Why is this Important?

- Systems engineers require process models in order to assist them with all aspects of lifecycle processes.
- The Boeing Diamond Process Model brings the idea of process models into the digital age
- This model reduces engineering time, cost, and increases efficiency when designing a large system, such as an aircraft.

Literature Review



Boeing Diamond vs. Vee

- It is made very clear that the Boeing Diamond Process Model has more capabilities that support the systems engineering realm.
- The Vee Process Model is lacking in the modeling and simulation aspects of engineering.

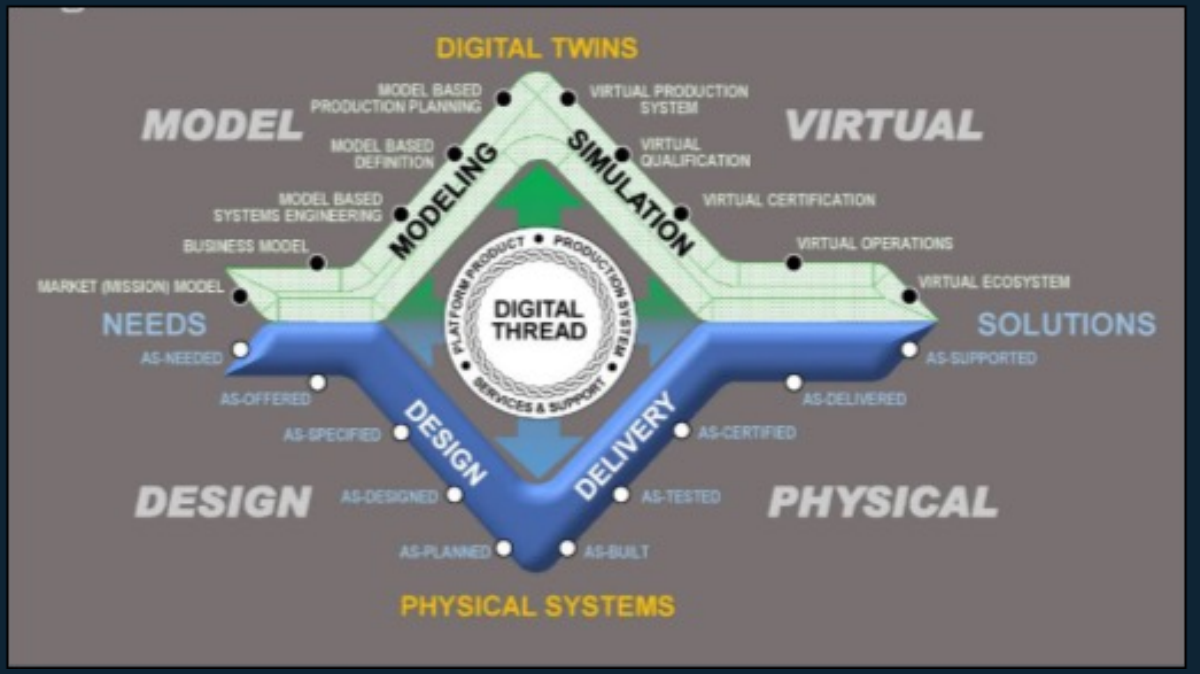
	Boeing Diamond Model	Vee Model
Verification of Requirements	✓	✓
Validation of the System	✓	✓
Function Begets Form	✓	✓
Replication through Modeling	✓	
Evaluation of the System in Simulation	✓	
Improves Overall Engineering Process	✓	✓

So Which Model is Better?

It depends…

Conclusions

- The research concluded that the Boeing-Saab Diamond model for Systems Engineering was effective for the case study of the T-7A Red Hawk.
- The T-7A Red Hawk case study determined how the model's top-down design process allowed for an improved the first engineering process by eliminating failures in the system early.
- The technology Boeing introduced allowed for more collaboration among engineers and an efficient design process.



Recommendations

- The United States Air Force should consider implementing the Boeing double diamond process model into other acquisition programs.
- Other OEMs should investigate creating their own process model.
- Future research on this subject should be concentrated on how this model can be applied to other advanced systems.

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