

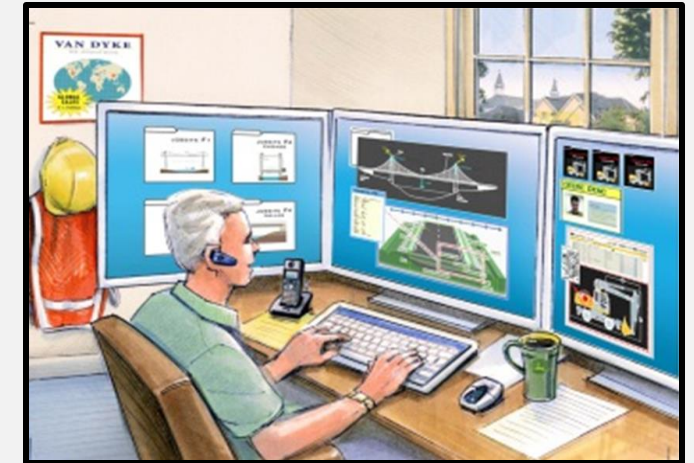
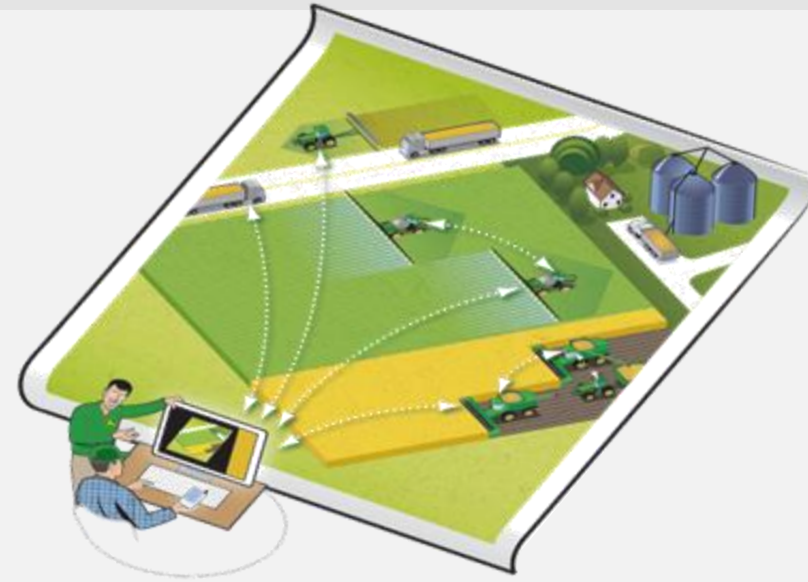
Integrating System Engineering at John Deere

March 2019



Agenda – Enterprise System Engineering (ESE)

- The Future of Farming Video
- Products & Services
- Locations
- Reason for Adoption of System Engineering
- Interface Control
- Competency Development
- System Engineering Guidance



Future of Farming

<https://www.youtube.com/watch?v=jEh5-zZ9jUg>



Platforms/Divisions



Agriculture



Lawn & Garden



Construction



Landscaping & Grounds Care



Golf & Sports Turf



Forestry



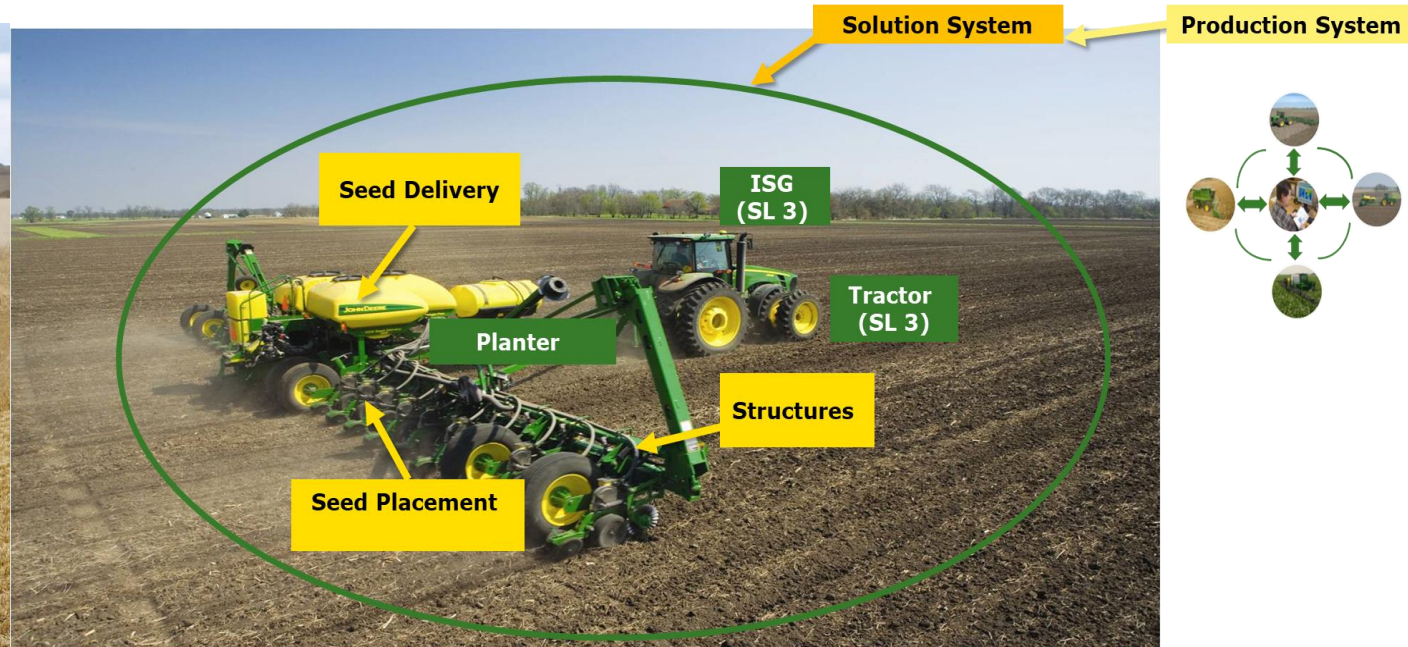
Engines & Drivetrain



Government & Military Sales



Rental Sales

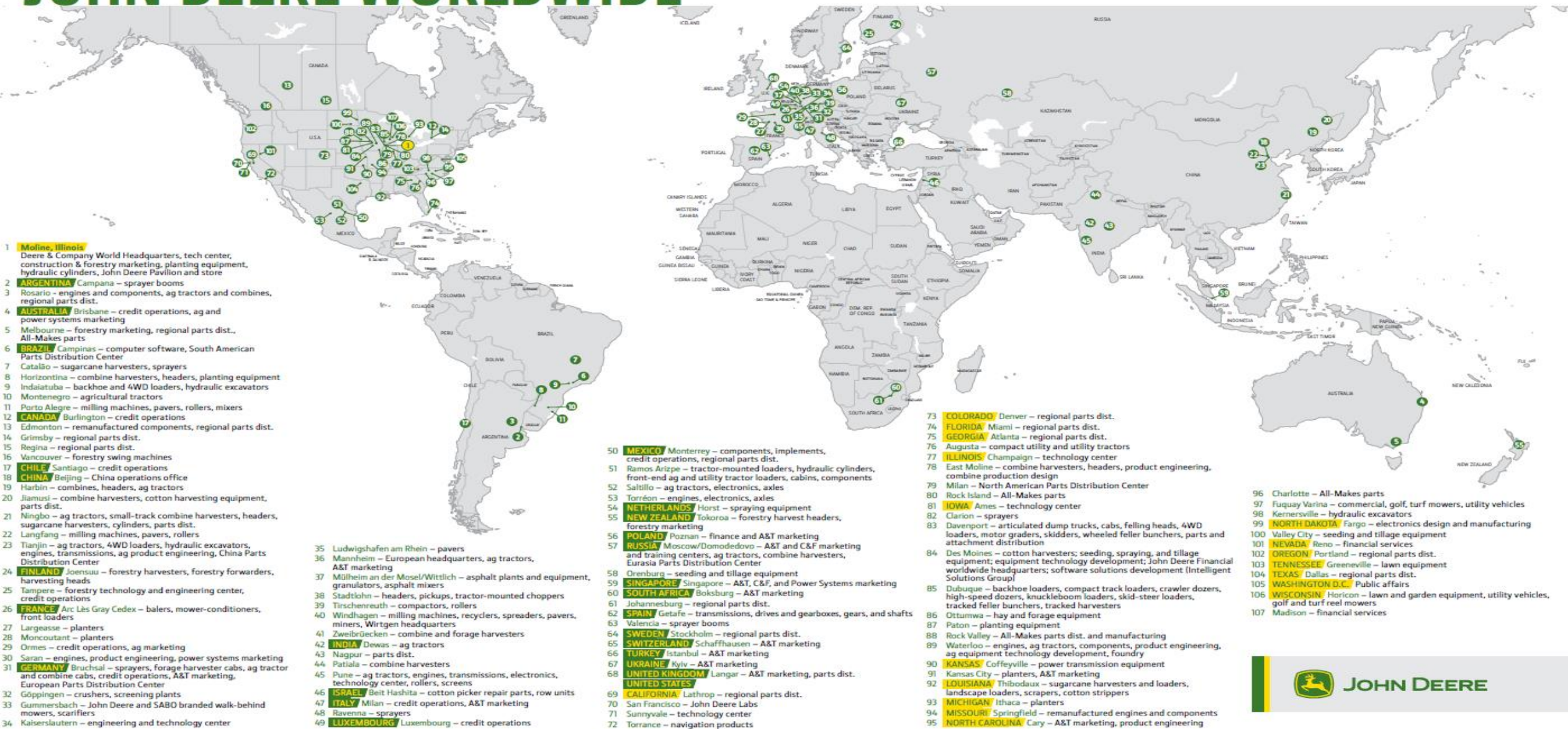


Platforms/Divisions



JOHN DEERE WORLDWIDE

All locations | [Region 1](#) | [Region 2](#) | [Region 3](#) | [Region 4](#) | [U.S. locations](#)



The world map shows major United States locations. World map does not show all locations outside the U.S. | May 2018 Deere & Company Corporate Communications

What is Systems Engineering?

History & Organization

- ✦ Systems engineering dates back to the early 1940s.¹
- ✦ First attempt to teach Systems Engineering in 1950.¹
- ✦ The International Council on Systems Engineering (INCOSE) was founded in 1990.²
- ✦ Systems training begin at top, technical, US schools in mid-1990s.³
- ✦ Modeling Languages Adapted for Widespread Use in the early 2000s.⁴
- ✦ Level 3 (1 week, two sessions) training at Caltech began in 2005.⁵
- ✦ Began certificate program at MIT with 2005 Cohort.
- ✦ Began certificate program at Caltech in 2017 Cohort.

REFERENCES:

- 1) <https://www.incose.org/about-systems-engineering/history-of-systems-engineering>
- 2) https://en.wikipedia.org/wiki/Systems_engineering
- 3) Rick Hefner, Professor, California Institute of Technology, Oct 2018.
- 4) https://en.wikipedia.org/wiki/Systems_Modeling_Language
- 5) Robert Day, Enterprise Systems Engineering Lead, Oct 2018
- 6) MIT | <https://sdm.mit.edu/overseer-of-sdm-certificate-program/>
- 7) CalTech | <https://ctme.caltech.edu/systems-engineering/fundamentals-certificate>



Who *is* a Systems Engineer?

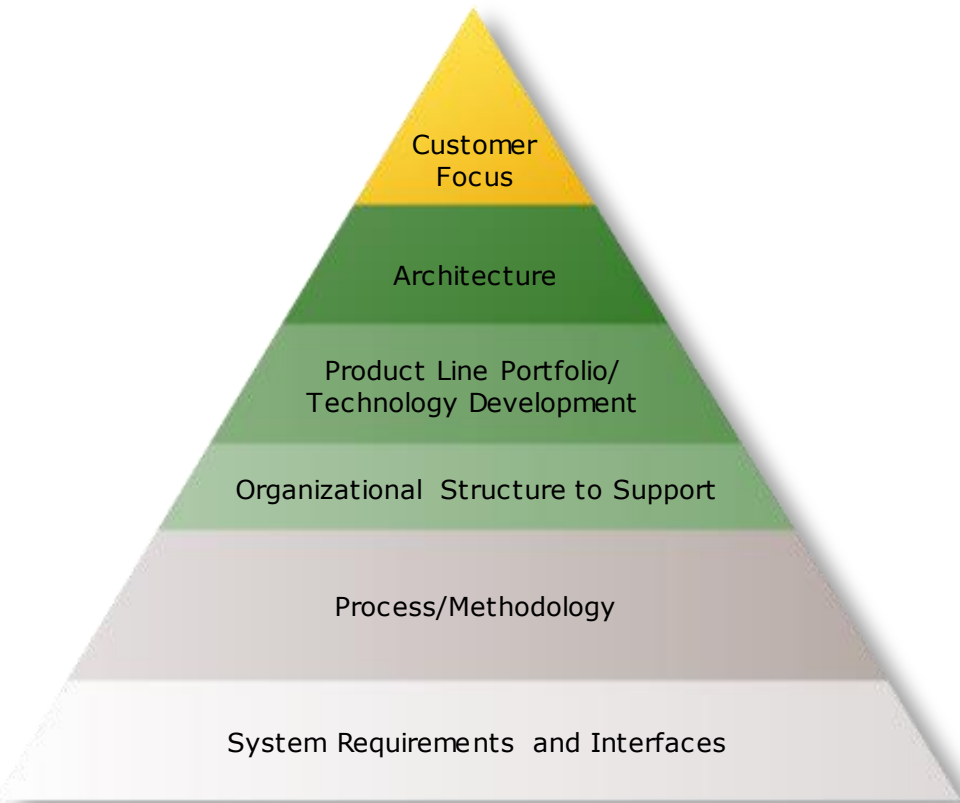
A Holistic Approach



*"The whole is greater than the sum of its
Parts."*
-Aristotle

"None of us are as good as all of us."
-Ray Kroc

Our Key to Flawless PDP Execution



✓ With specified functionality



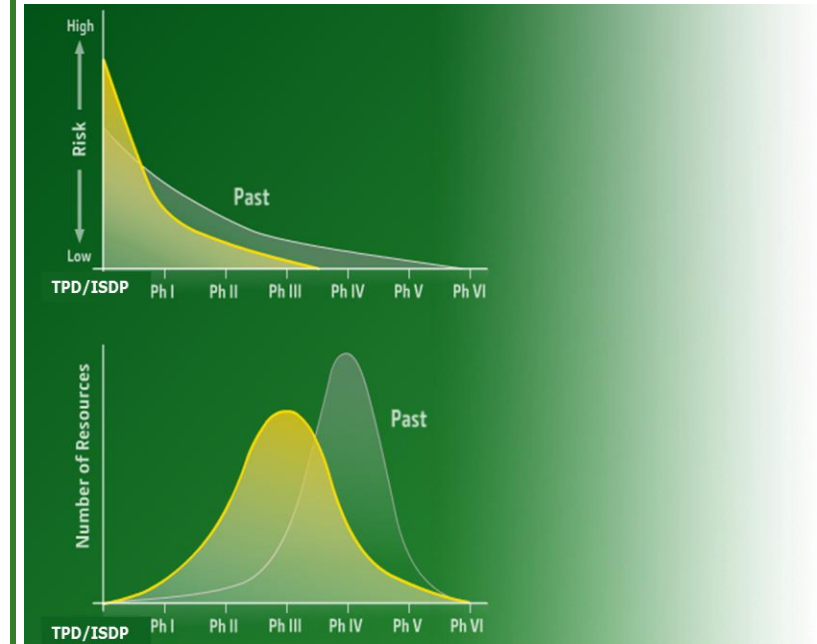
✓ On time



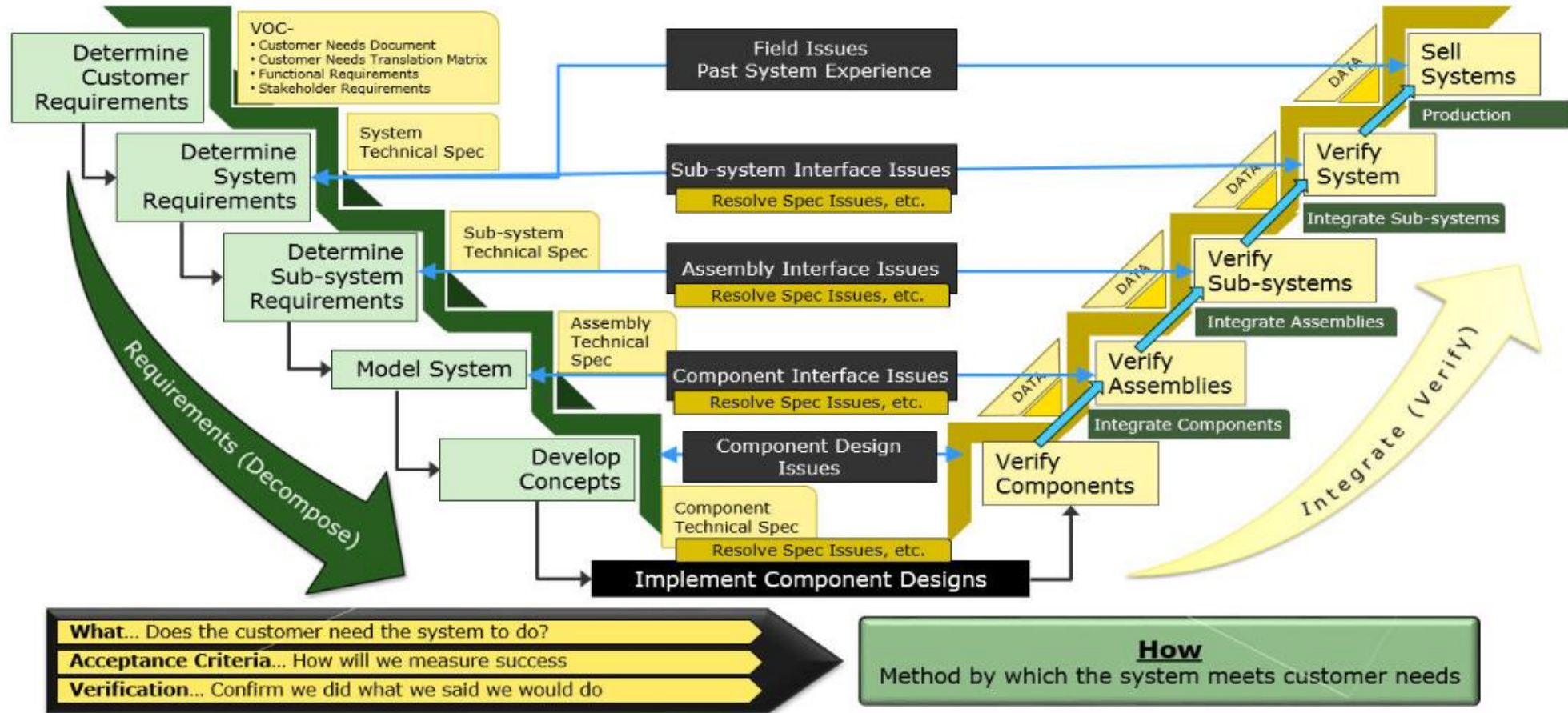
✓ Within cost



✓ With distinctive quality



Enterprise System Engineering - Methodology



TOOLS



INFORMATION



RESOURCES



TRAINING



GOVERNANCE

How ESE Delivers – Structure & Framework

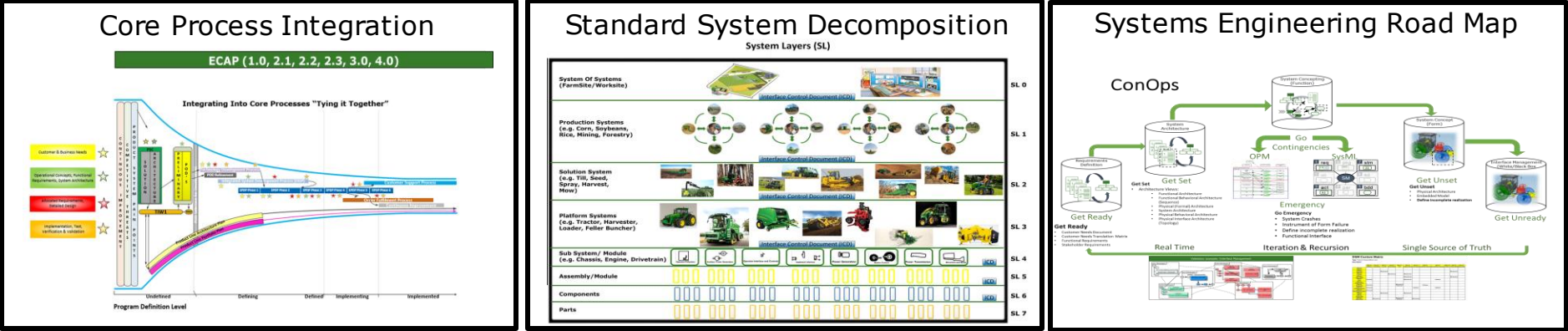
Metrics

System Engineering Metrics									
Item	System Requirements	Product Requirements	Functional Requirements	Performance Requirements	Interface Requirements	Test Requirements	Verification Requirements	Validation Requirements	Comments
1. System Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
2. Product Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
3. Functional Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
4. Performance Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
5. Interface Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
6. Test Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
7. Verification Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
8. Validation Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
9. System Requirements	✓	✓	✓	✓	✓	✓	✓	✓	
10. Product Requirements	✓	✓	✓	✓	✓	✓	✓	✓	

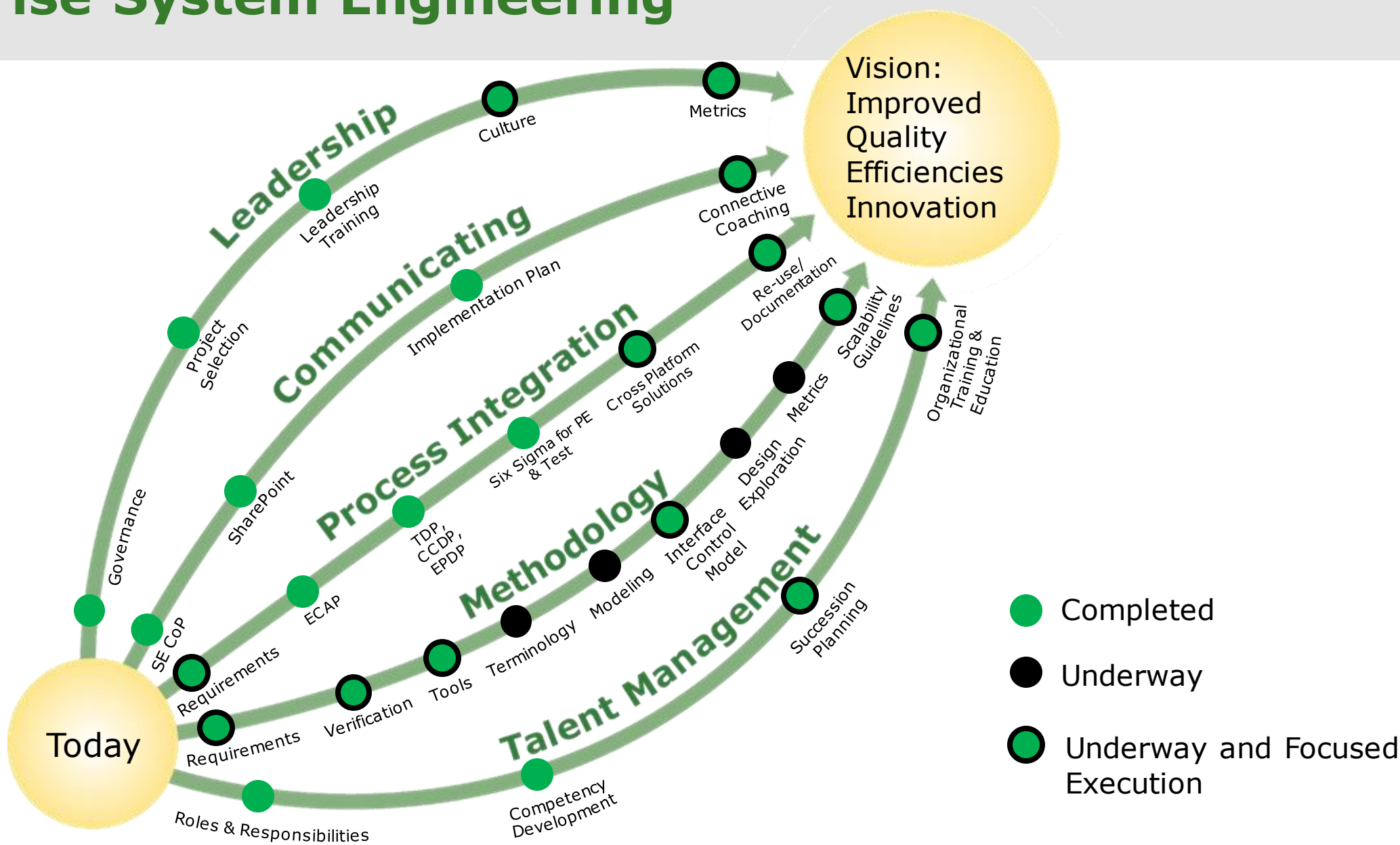
People



Methodology



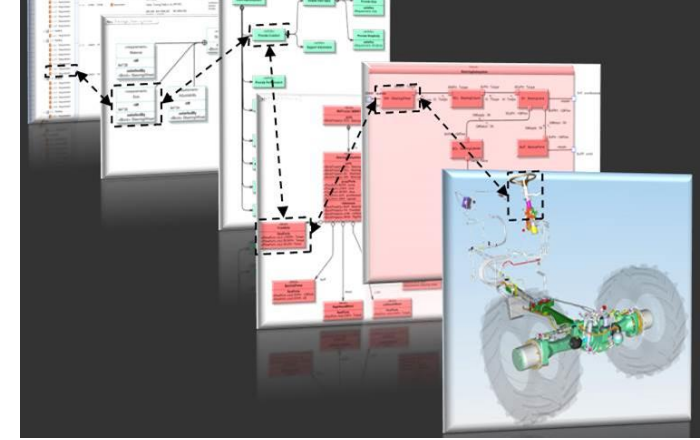
Enterprise System Engineering



Why, What, and How

Interface Control Model

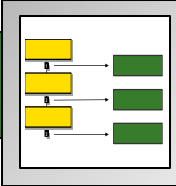
- Why ICM?
 - Sustainability of Systems Engineering methods and practices
 - Foundational to the sustainability of complex systems
- What is ICM?
 - Provides connectivity between systems and system elements
 - Enables reuse through documentation
 - Systems Engineering documents are similar in methodology to our CREO Models
 - Without this documentation/traceability Systems Engineering will have limited success
- How does ICM work?
 - Describes the interface(s) between all systems and system elements throughout the methodology



Interface Control Model (ICM)

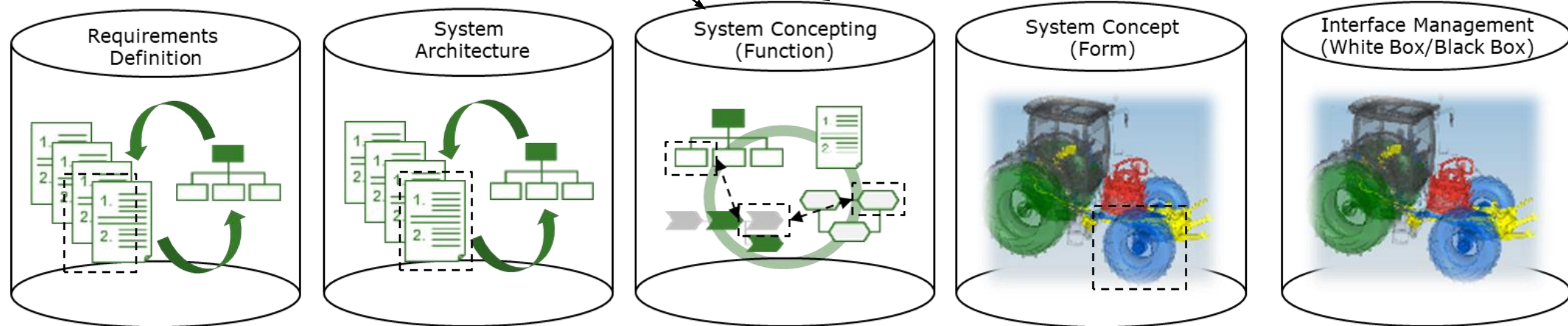
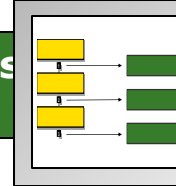
Establish a ICM

- Embed a model-based representation of a system in an existing business context
- Implement a systems model and create a continuously or consistent traceability



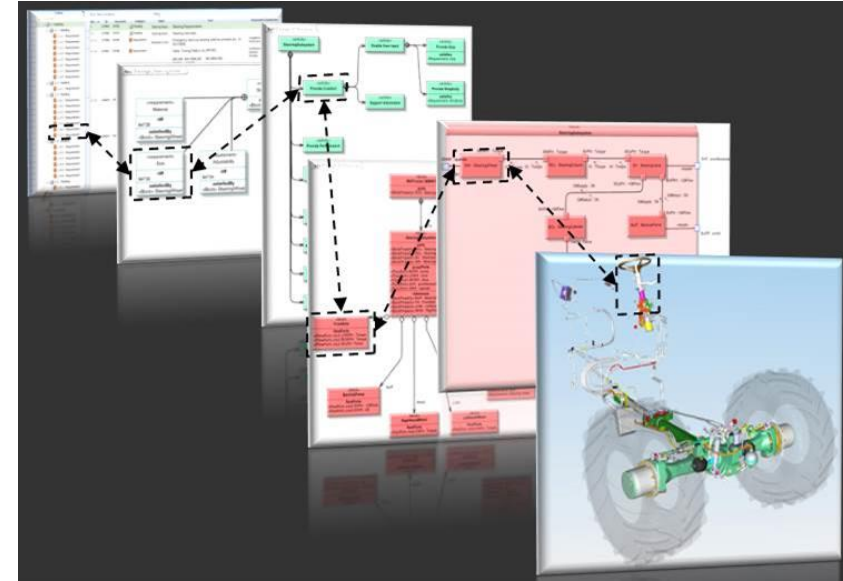
Method for the impact analysis of appearing changes

- Use of the embedded and connected systems model
- Propagating impact of interdisciplinary changes has to be identified, analyzed and documented w/ ability for reuse

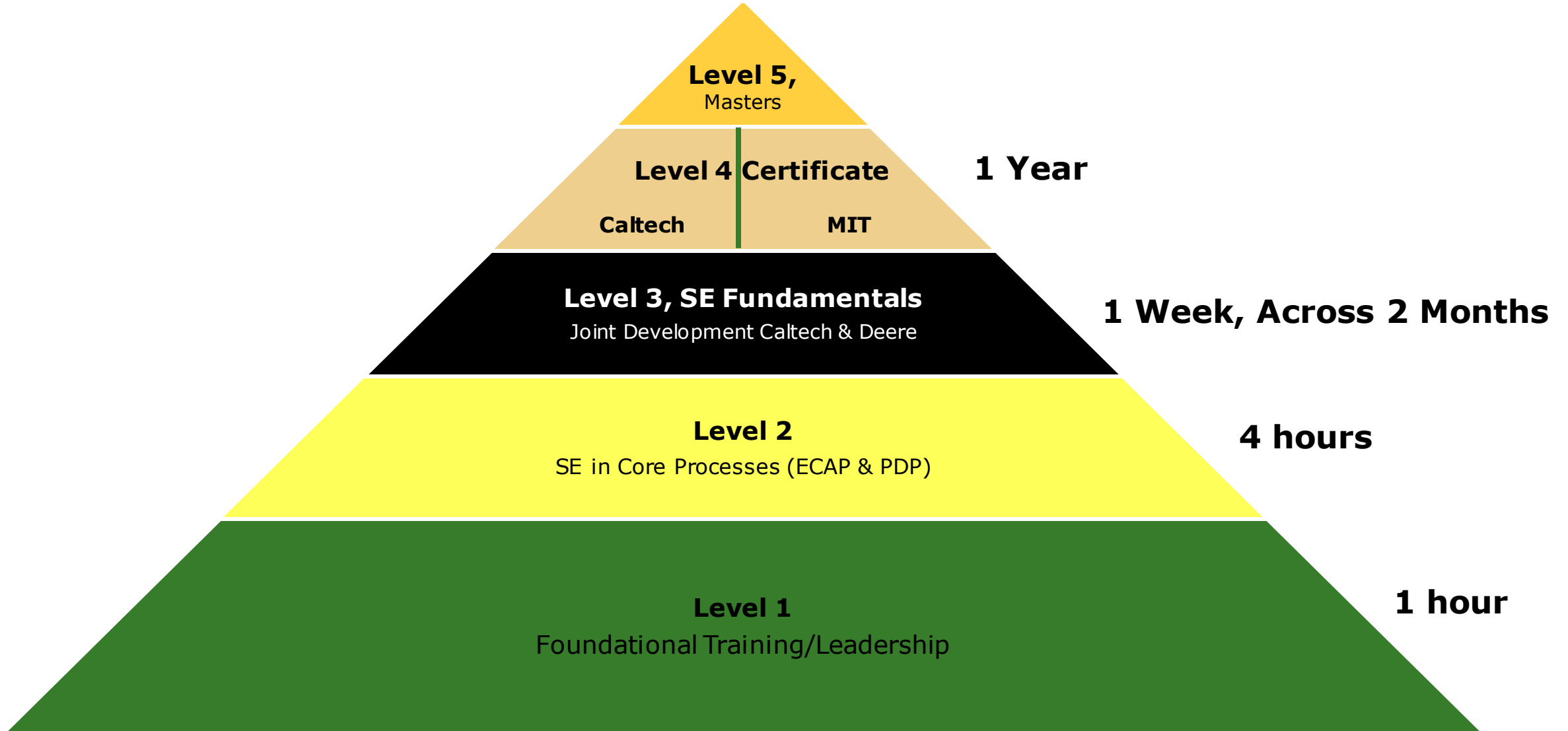


Why, What, and How Competency Development

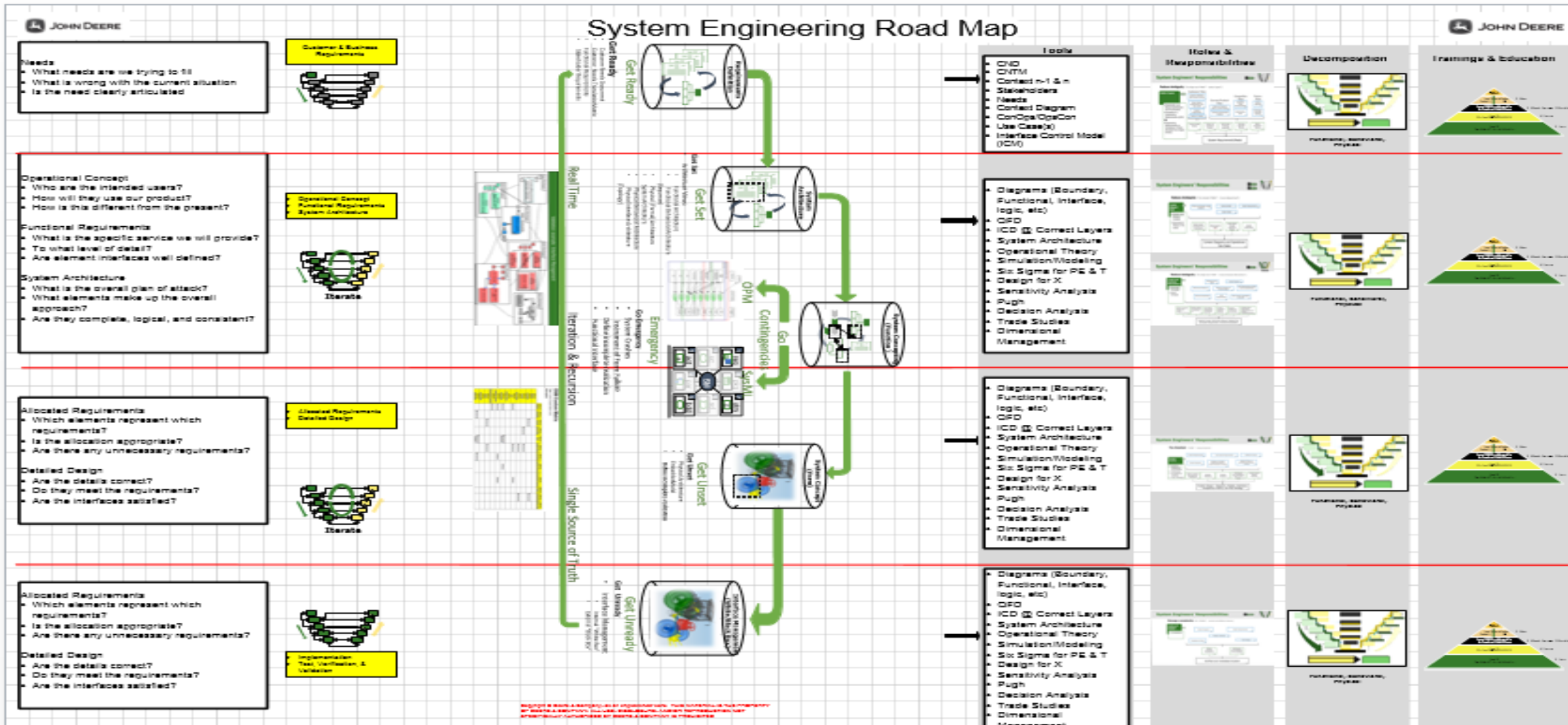
- Why Competency Development?
 - Sustain System Engineering methods and practices
- What is Competency Development?
 - It provides the Enterprise with competent System Engineering personnel
 - It is based on 3 elements
 - Experiential Learning (70%), Coaching/Mentoring (20%) and Education (10%)
 - It is a blend of internal education supplemented with external education from MIT & Caltech
- How does Competency Development work?
 - Projects coupled with connective coaching and education



System Engineering Training and Education

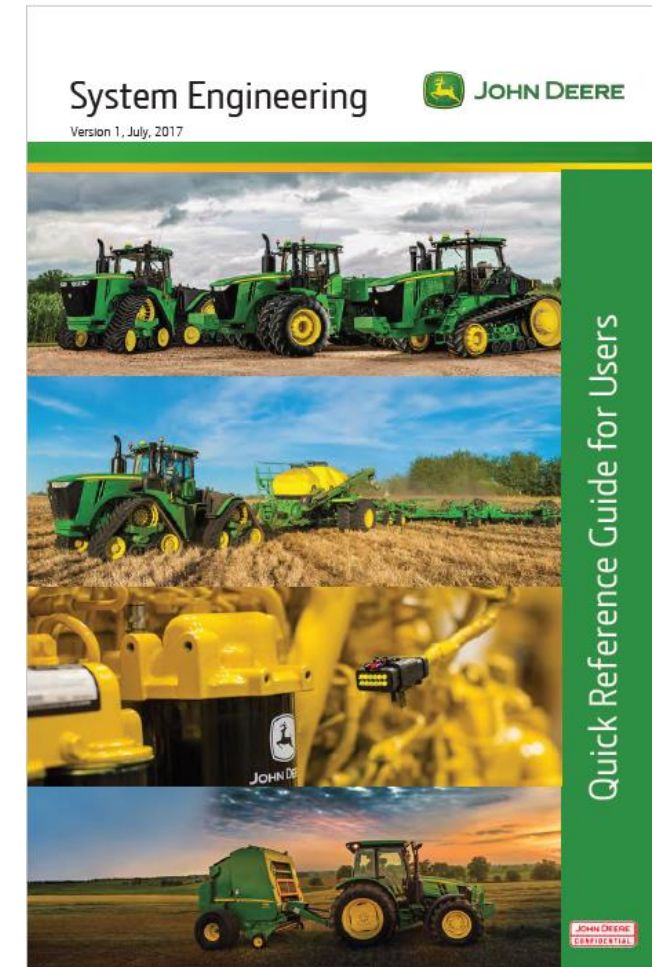
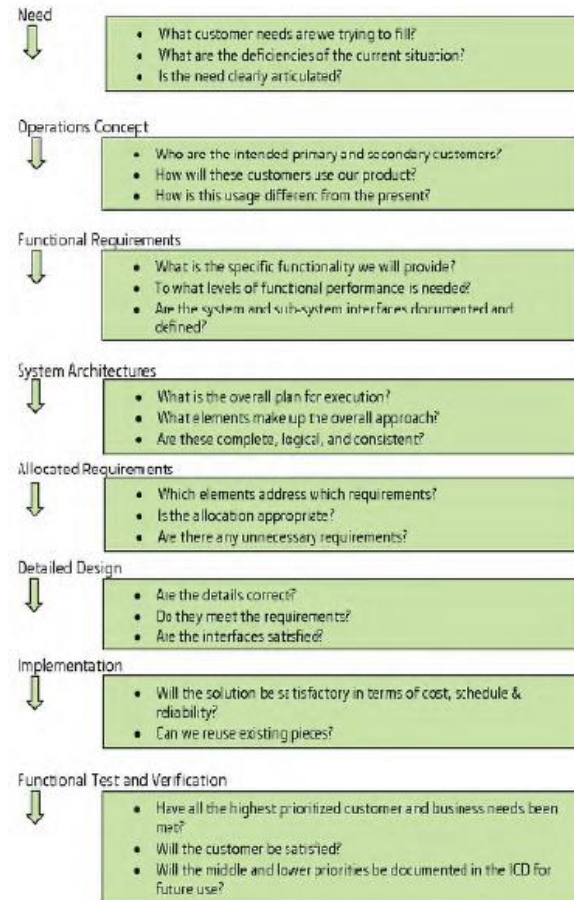


System Engineering Road Map

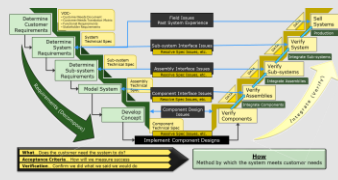


System Engineering Guidance

Quick Reference Guide for System Engineering

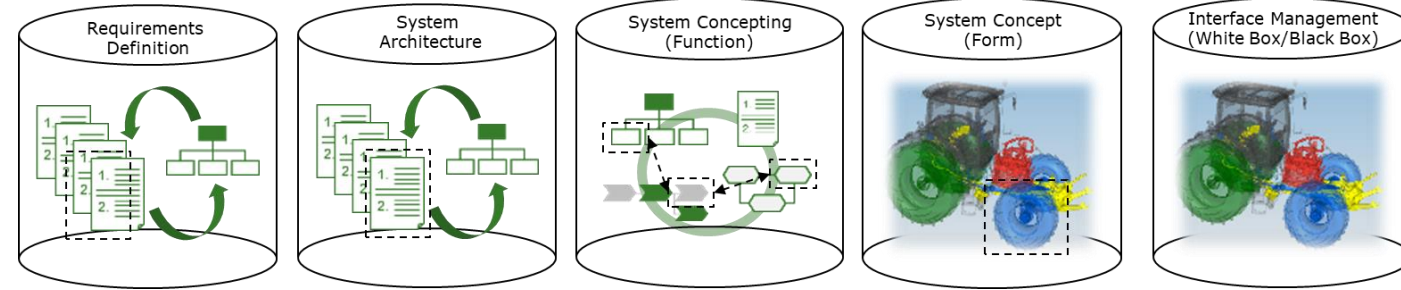


Summary – MBSE/ICM/MIT/Caltech



Agenda

- Insights
- Mission & Problem Statement
- Architecture
- ConOps
- System Demonstration
- Next Steps & Concluding Remarks
- Conclusions:
 - Utilize standard levels of integration based on the dynamics of your business (Mosier)
 - Map integration elements to system functions
 - Follow the John Deere Systems Engineering methodology (with integrated SDM Core)
 - Utilize the entire V-diagram -- start from the beginning, do not jump in at the middle
 - Be willing to accept that the SE process is iterative and recursive



Insights - Why, What, and How of the Integration



Why Integrate?

- Sustainability of Systems Engineering methods and practices
- Foundational to the sustainability of complex systems

What is Integration?

- Provides connectivity between systems and system elements
- Enables reuse through documentation
 - Systems Engineering documents are similar in methodology to our current physical design
 - Without this documentation/traceability Systems Engineering will have limited success

How does Integration work?

- Describes the interface(s) between all systems and system elements throughout the methodology

Additional Insights gained to date:

- OPM and SysML can co-exist “It isn’t one or the other you need them both”
 - OPM allows modeling at a high level of abstraction during architectural development (System of System)
 - SysML allows couplings of the details and there interface parameters needed when decomposing (System, Sub-System, Modules, etc.)
- Employees need a bridge between Academia and Practicality
- OPM has been developed and integrated into the tool suite
- DSM has been developed and integrated into the tool suite



JOHN DEERE