### **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 Guideance





### **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

#### Deere & Company World Headquarters, tech center, construction & forestry marketing, planting equipment, hydraulic cylinders, John Deere Pavilion and store ARGENTINA, Campana - sprayer booms Rosario - engines and components, ag tractors and combines, regional parts dist. AUSTRALIA Brisbane - credit operations, ag and power systems marketing Melbourne - forestry marketing, regional parts dist., All-Makes parts BRAZIL Campinas - computer software, South American Parts Distribution Center Catalão - sugarcane harvesters, sprayers Horizontina - combine harvesters, headers, planting equipment Indaiatuba - backhoe and 4WD loaders, hydraulic excavators Montenegro - agricultural tractors Porto Alegre - milling machines, pavers, rollers, mixers CANADA Burlington - credit operations Edmonton - remanufactured components, regional parts dist. Grimsby - regional parts dist. Regina - regional parts dist. Vancouver - forestry swing machines CHILE Santiago – credit operations CHINA Beijing – China operations office Harbin - combines, headers, ag tractors 20 Jiamusi - combine harvesters, cotton harvesting equipment, parts dist. Ningbo - ag tractors, small-track combine harvesters, headers, sugarcane harvesters, cylinders, parts dist. Langfang - milling machines, pavers, rollers 23 Tianjin - ag tractors, 4WD loaders, hydraulic excavators, 35 Ludwigshafen am Rhein – pavers engines, transmissions, ag product engineering, China Parts Distribution Center A&T marketing FINLAND Joensuu – forestry harvesters, forestry forwarders, harvesting heads granulators, asphalt mixers 25 Tampere – forestry technology and engineering center, credit operations FRANCE Arc Les Gray Cedex – balers, mower-conditioners, front loaders 27 Largeasse - planters 28 Moncoutant – planters 42 INDIA Dewas - ag tractors 29 Ormes - credit operations, ag marketing 43 Nagpur - parts dist. Saran - engines, product engineering, power systems marketing 44 Patiala - combine harvesters CERMANY Bruchsal – sprayers, forage harvester cabs, ag tractor and combine cabs, credit operations, A&T marketing,

- European Parts Distribution Center Göppingen – crushers, screening plants 33 Gummersbach - John Deere and SABO branded walk-behind mowers, scarifiers
- 34 Kaiserslautern engineering and technology center

- 50 MEXICO Monterrey components, implements, redit operations, regional parts dist. 51 Ramos Arizpe - tractor-mounted loaders, hydraulic cylinders, front-end ag and utility tractor loaders, cabins, components
- 52 Saltillo ag tractors, electronics, axles
- 53 Torréon engines, electronics, axles
  - Horst spraying equipment W ZEALAND Tokoroa - forestry harvest headers, forestry marketing
  - Moscow/Domodedovo A&T and C&F marketing ind training centers, ag tractors, combine harvesters, **Eurasia Parts Distribution Center**
- Orenburg seeding and tillage equipment
- GAPORE Singapore A&T, C&F, and Power Systems marketing 60 SOUTH AFRICA Boksburg - A&T marketing
- 61 Johannesburg - regional parts dist.
- SPAIN Getafe transmissions, drives and gearboxes, gears, and shafts 63 Valencia - sprayer booms
  - Stockholm regional parts dist.
- 64 LAND Schaffhausen - A&T marketing 65
- 66 istanbul - A&T marketing
- 67 Kviv - A&T marketing
  - Langar A&T marketing, parts dist.
- 69 IA. Lathrop – regional parts dist.
- 70 San Francisco John Deere Labs
- 71 Sunnyvale technology center

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72 Torrance - navigation products

- 73 COLORADO Denver regional parts dist.
- 74 FLORIDA Miami regional parts dist. 75 GEORGIA Atlanta - regional parts dist.
- 76 Augusta compact utility and utility tractors
- 77 ILLINOIS Champaign technology center
- 78 East Moline combine harvesters, headers, product engineering, combine production design

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- Milan North American Parts Distribution Center 79
- 80 Rock Island All-Makes parts
- 81 IOWA Ames technology center
- 82 Clarion sprayers

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- 83 Davenport articulated dump trucks, cabs, felling heads, 4WD loaders, motor graders, skidders, wheeled feller bunchers, parts and attachment distribution
- 84 Des Moines cotton harvesters; seeding, spraying, and tillage equipment; equipment technology development; John Deere Financial worldwide headquarters; software solutions development (Intelligent Solutions Group
- 85 Dubuque backhoe loaders, compact track loaders, crawler dozers, high-speed dozers, knuckleboom loaders, skid-steer loaders, tracked feller bunchers, tracked harvesters
- 86 Ottumwa - hay and forage equipment
- 87 Paton planting equipment
- 88 Rock Valley All-Makes parts dist. and manufacturing 89 Waterloo - engines, ag tractors, components, product engineering, ag equipment technology development, foundry
- on KANSAS Coffeyville - power transmission equipment
- 91 Kansas City planters, A&T marketing
- LOUISIANA Thibodaux sugarcane harvesters and loaders, landscape loaders, scrapers, cotton strippers
- 93 MICHIGAN Ithaca planters
- 94 MISSOURE Springfield remanufactured engines and components 95 NORTH CAROLINA, Cary - A&T marketing, product engineering



97 Fuquay Varina - commercial, golf, turf mowers, utility vehicles

99 NORTH DAKOTA Fargo – electronics design and manufacturing

106 WISCONSIN Horicon - lawn and garden equipment, utility vehicles,

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ALCORAGE IN

Kernersville - hydraulic excavators

101 NEVADA Reno - financial services

104 TEXAS Dallas - regional parts dist.

105 WASHINGTON D.C. Public affairs

golf and turf reel mowers

107 Madison - financial services

100 Valley City - seeding and tillage equipment

103 TENNESSEE Greeneville - lawn equipment

102 OREGON Portland - regional parts dist.

96 Charlotte - All-Makes parts

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6 Enterprise System Engineering – March 2019

- 36 Mannheim European headquarters, ag tractors,
- 38 Stadtlohn headers, pickups, tractor-mounted choppers
- 40 Windhagen milling machines, recyclers, spreaders, pavers,
- miners, Wirtgen headquarters

- technology center, rollers, screens
- EL Beit Hashita cotton picker repair parts, row units
- 49 LUXEMBOURG Luxembourg credit operations

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

- 37 Mülheim an der Mosel/Wittlich asphalt plants and equipment,
- 39 Tirschenreuth compactors, rollers
- 41 Zweibrüecken combine and forage harvesters
- 45 Pune ag tractors, engines, transmissions, electronics,
- 47 ITALY Milan credit operations, A&T marketing
- 48 Ravenna sprayers

Poznan – finance and A&T marketing 57

### What is Systems Engineering? History & Organization

- ★ Systems engineering dates back to the early 1940s.<sup>1</sup>
- ★ First attempt to teach Systems Engineering in 1950.<sup>1</sup>
- ★ The International Council on Systems Engineering (INCOSE) was founded in 1990.<sup>2</sup>
- ★ Systems training begin at top, technical, US schools in mid-1990s.<sup>3</sup>
- ★ Modeling Languages Adapted for Widespread Use in the early 2000s.<sup>4</sup>
- ★ Level 3 (1 week, two sessions) training at Caltech began in 2005.<sup>5</sup>
- ★ 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 | <u>https://ctme.caltech.edu/systems-engineering/fundamentals-certificate</u>





### 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**





## **Enterprise System Engineering - Methodology**







Resources



TRAINING



### **How ESE Delivers – Structure & Framework**





## **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)**





### 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



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- 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**









### 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
    - $\succ$   $\;$  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





