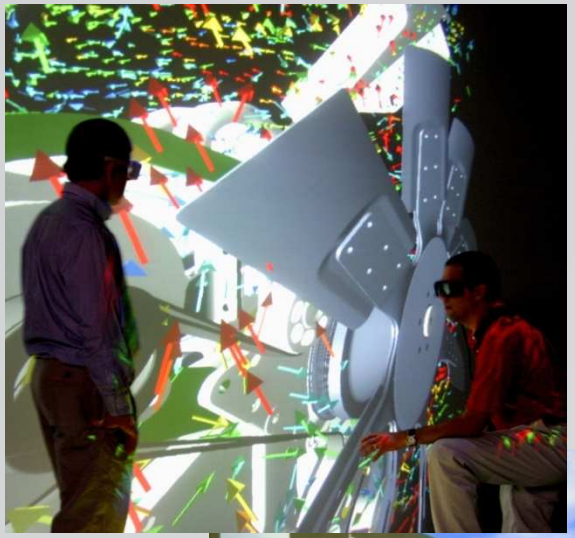
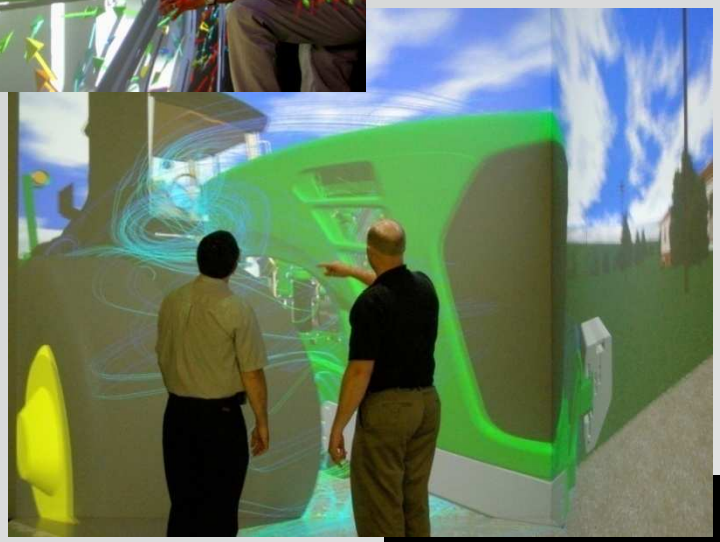




# Evolution of Digital Tools Used in Complex Product Design

Jerry R. Duncan, Ph.D.
Manager, University R&D Relations
and Collaborative Science
Deere & Company

JOHN DEERE

# Overview

- Historical background … what led to our adoption and development of Digital Engineering (Immersive Collaboration) Tools
- Vision and Current State
- Example Applications … Lessons Learned … Benefits
- Challenges and Opportunities
- A Possible Future
- Q&A

# John Deere – global growth in Agricultural and Turf Equipment, Construction & Forestry Equipment, and Intelligent Systems

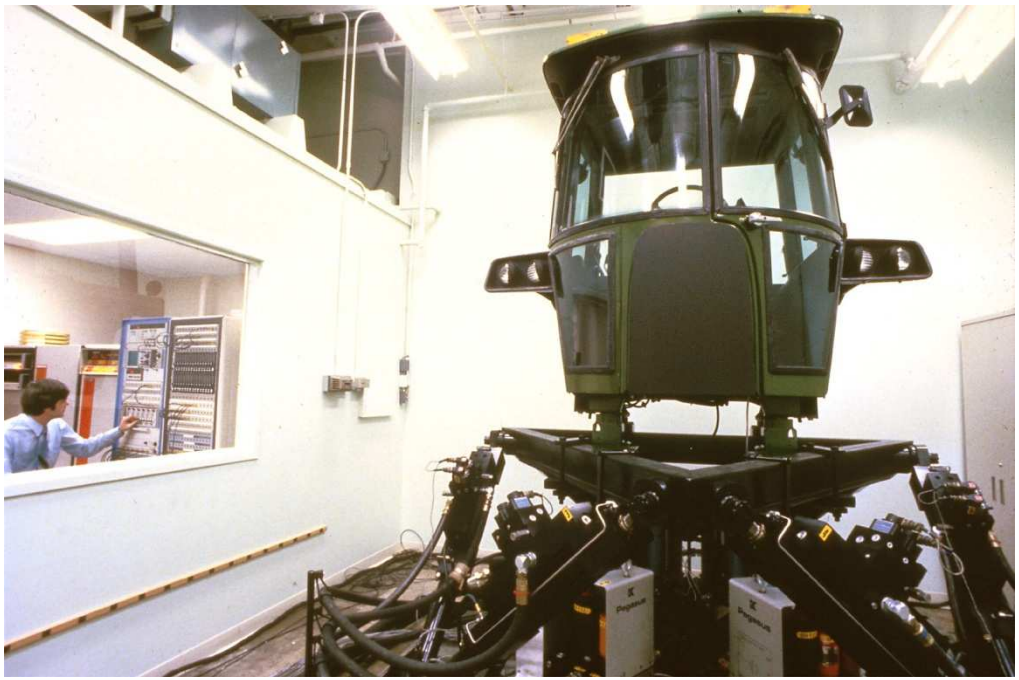


JOHN DEERE

# John Deere Manufacturing Locations

JOHN DEERE

**My start at John Deere … 1978 … established a Human Factors Research Lab to support off-road vehicle operator workstation design. Featured physical simulation with high-fidelity, 6 degree-of-freedom motion base and low-fidelity visual scene.**



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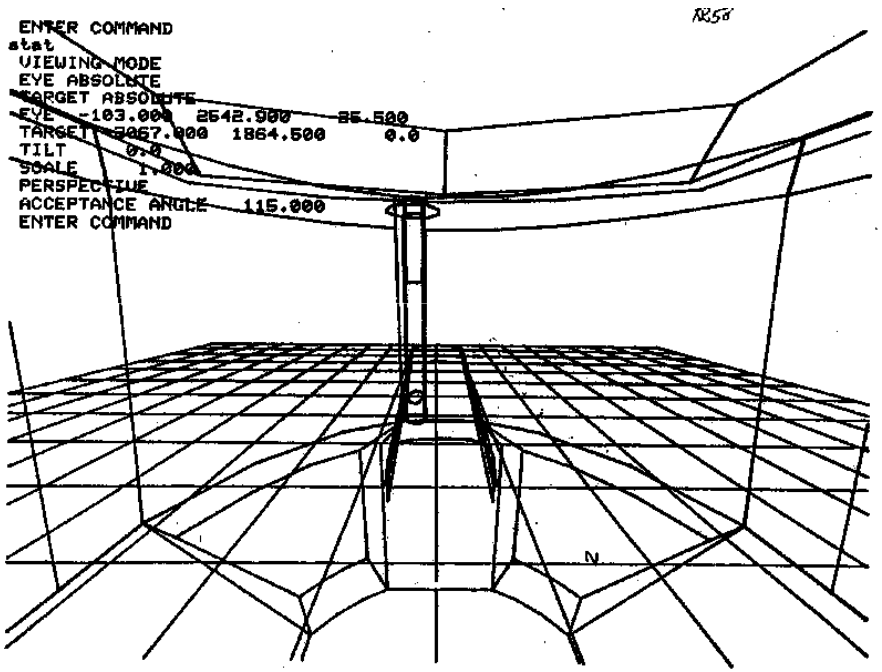
# Searching for a better digital human modeling tool leads to Dr. Norman Badler at U Penn. … 1989 … "Jack" software (Badler and Phillips, U Penn) … became early foundation for "VR" (Immersive Collaboration) in John Deere

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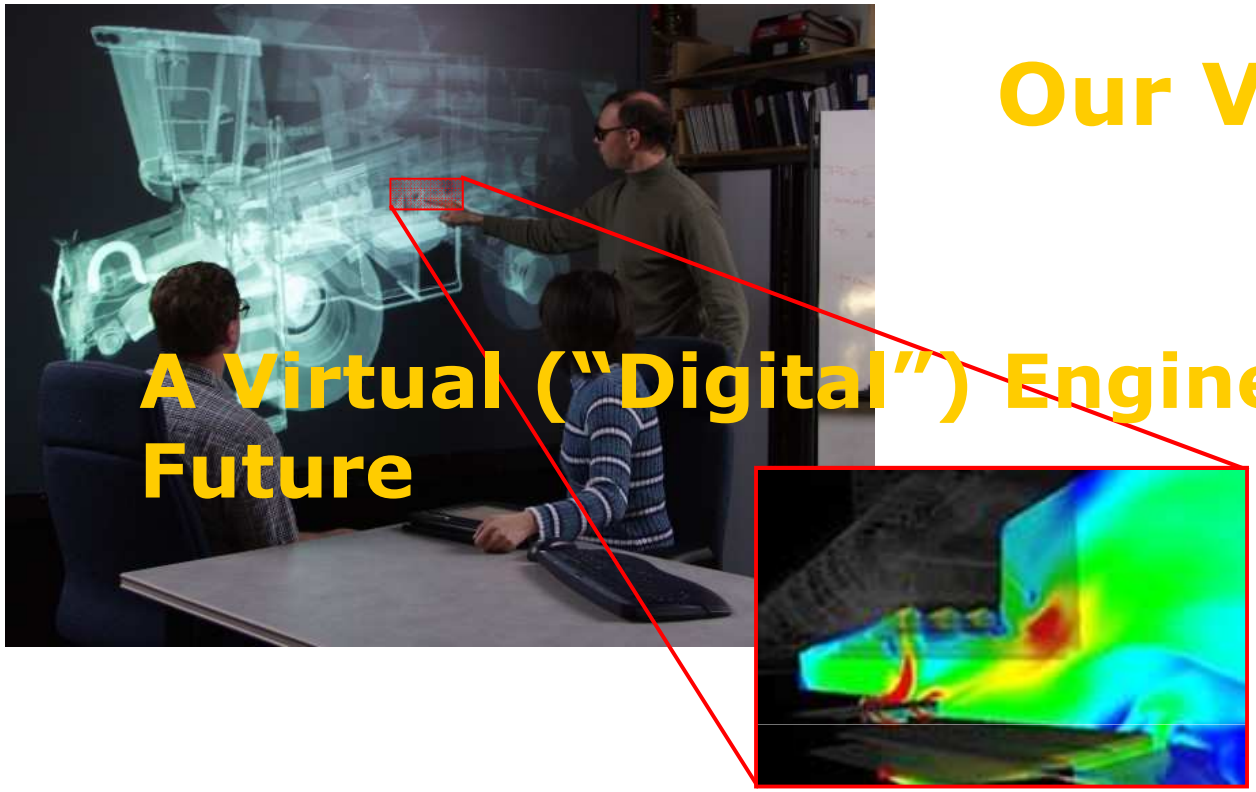

# Our Vision

## A Virtual ("Digital") Engineering Future

**Design, analyze, evaluate products and manufacturing processes within a shared virtual environment … enabling concurrent and collaborative decision making by geographically distributed participants.**

**Perform critical product and manufacturing process evaluations (serviceability, manufacturability, operator and product performance, customer acceptance) interactively from concept to production.**

**Transform from physical test and evaluation processes to simulation-based prediction and verification processes.**

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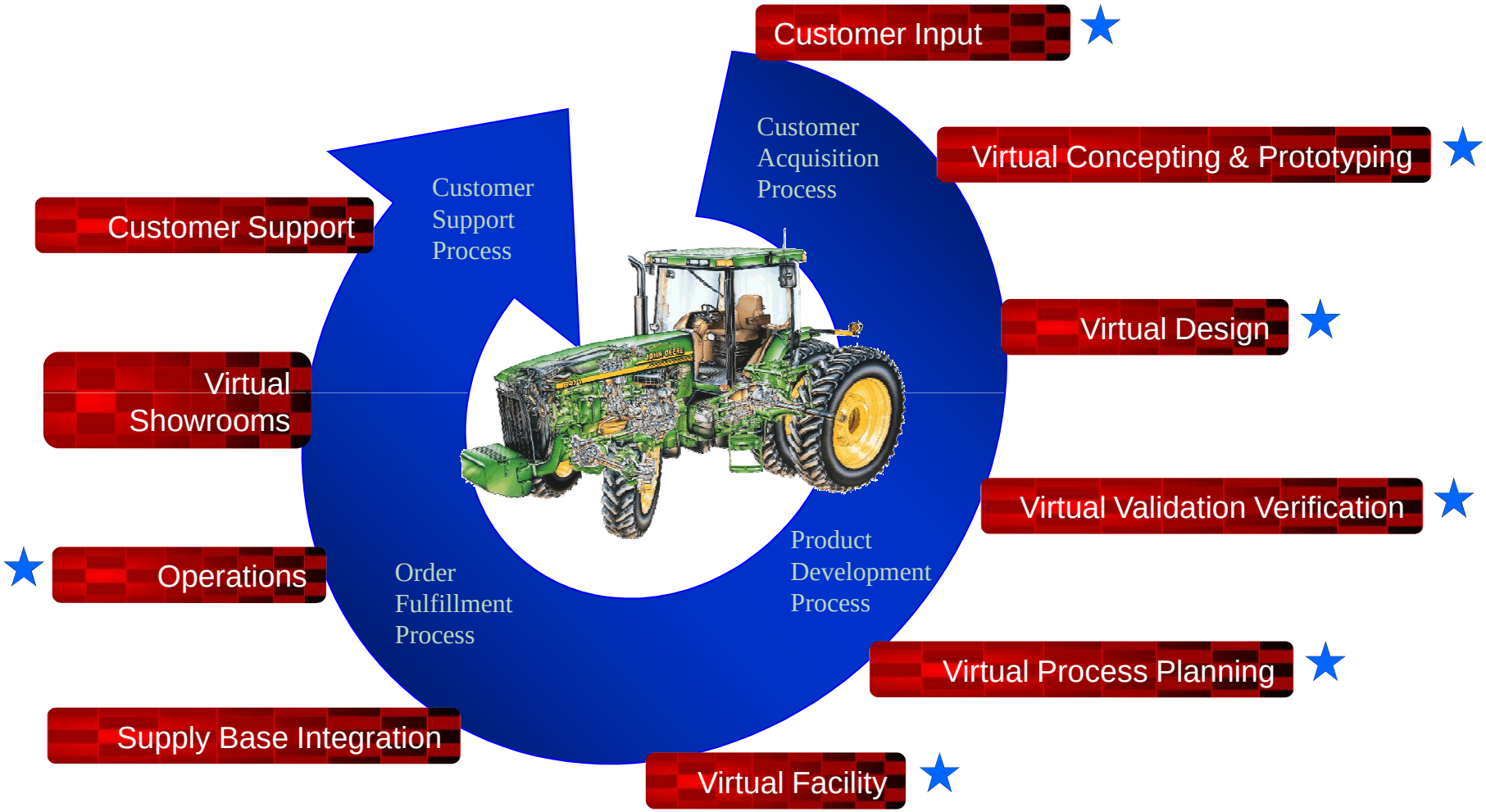
# Businesses are process driven … processes evolve

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# Tools and technology used in product development are evolving … advancing …

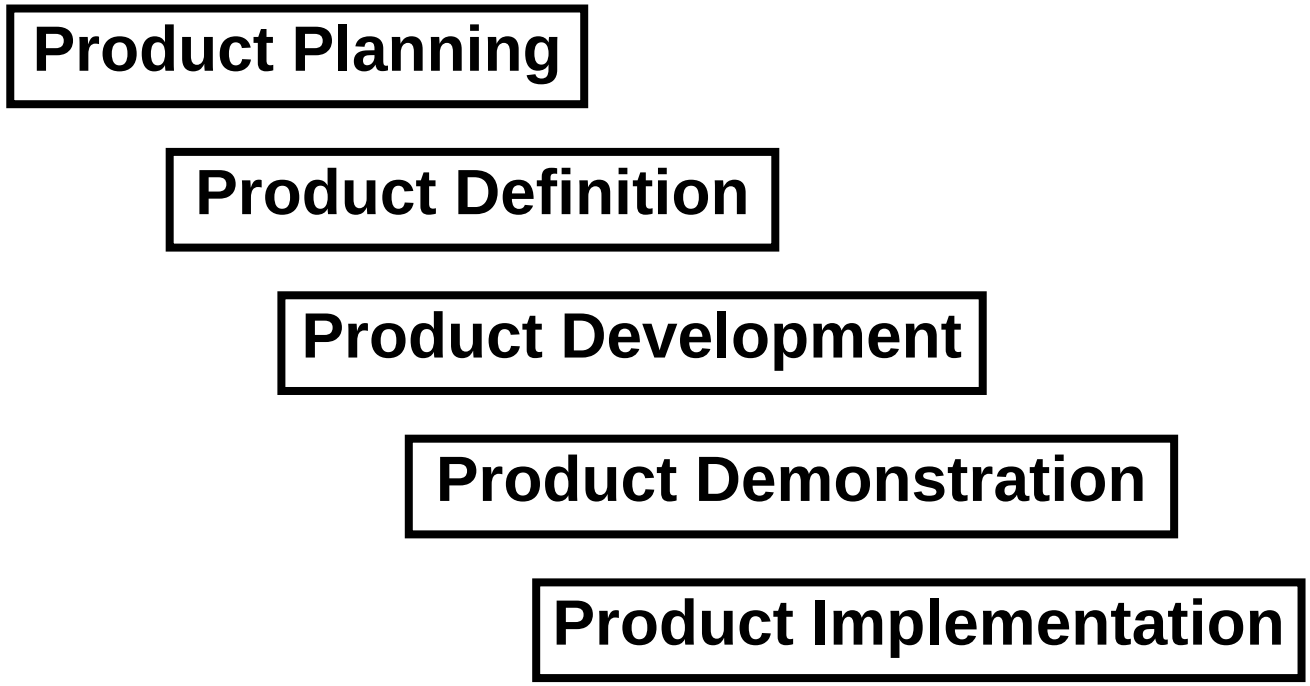
1950s

1960s

1970s

1980s-present

# Product development is an information intensive decision-making process




Concepts

Specifications

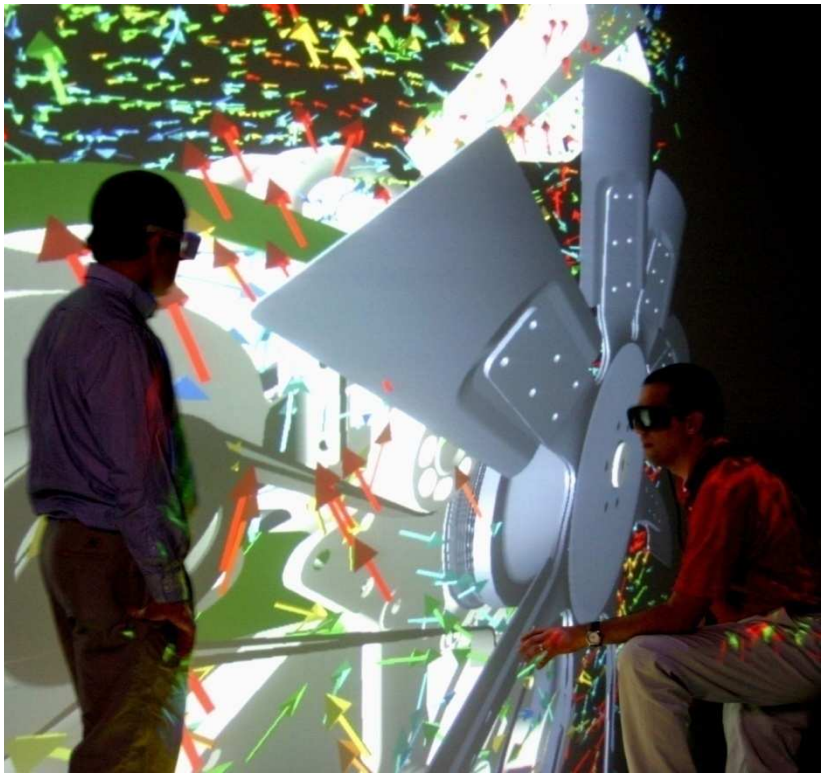
Prototypes

Training

Manufacturing

Marketing

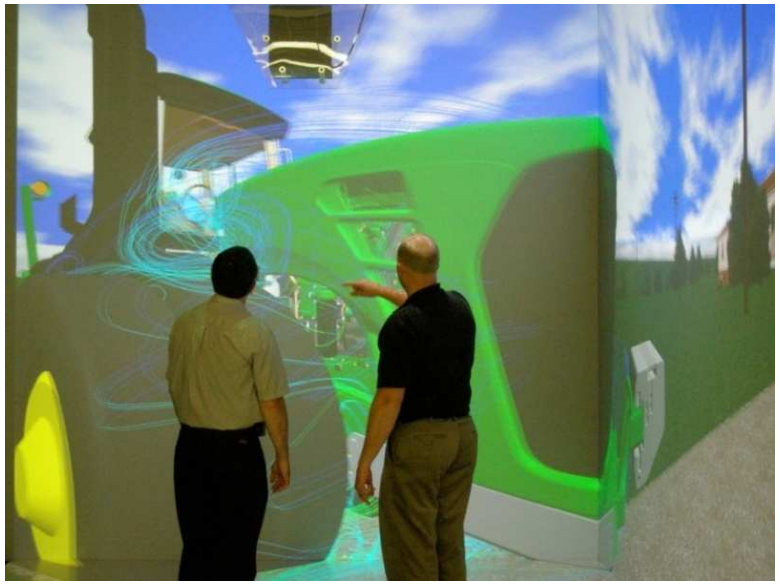
Verification & Validation



# Digital Engineering

## … Immersive Collaboration …

is about making **better decisions** in designing, analyzing, and evaluating complex and uncertain systems



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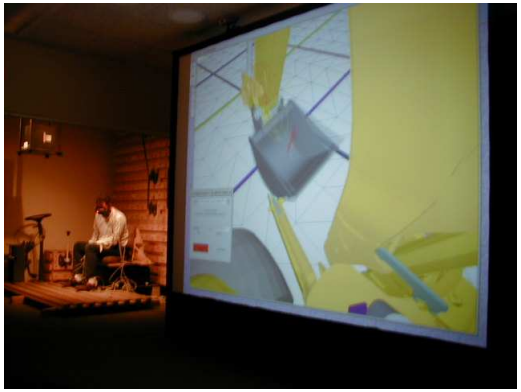
# Current John Deere VR Facilities



- Charlotte, NC
- Des Moines, IA
- Dubuque, IA
- East Moline, IL
- Mannheim, Germany
- Moline, IL Technology Innovation Center
- Montenegro, Brazil
- Univ. of IL, Urbana-Champaign
- Waterloo, IA (3 Factory Sites)
- Waterloo, IA (Product Engr. Center)

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# Business Applications

**Product Development**

Concept Creation and Visualization
* Collaborative Design/Styling Reviews
Operator Visibility Evaluations
Control Layout Evaluations
Display Layout Evaluations
Serviceability Evaluations
Alternative Design Assessments
Evaluating Combinations of Product Options
Operator and System Performance Evaluations (vehicle simulation)

**Facilities and Operations Planning**

* Manufacturing Process Analysis
* Methods Design & Analysis
Resource Planning
* Factory and Production Cell Layout

**Training/Education**

Assembly/Disassembly Procedures
* Painter Training
System Behaviors: visualizing and understanding science (e.g., Bowen Loftin's "Maxwell's World")
Training Customers and Dealers

**Data Analysis (multi-dimensional)**

* Engineering Data (CFD,FEA) Analysis
Strategic Planning and Business Development

**Marketing**

* Customer Participation in Design
Product Promotions
Virtual Showrooms

**Multi-dimensional User-Interface**

Remote vehicle monitoring and control

Deere Digital Engineering Innovation


Commercial Technology vendors

- **16 year relationship (1st VR project in 1994)**
- **Broad range of applications (product design, manufacturing process design, training, data analysis, …)**

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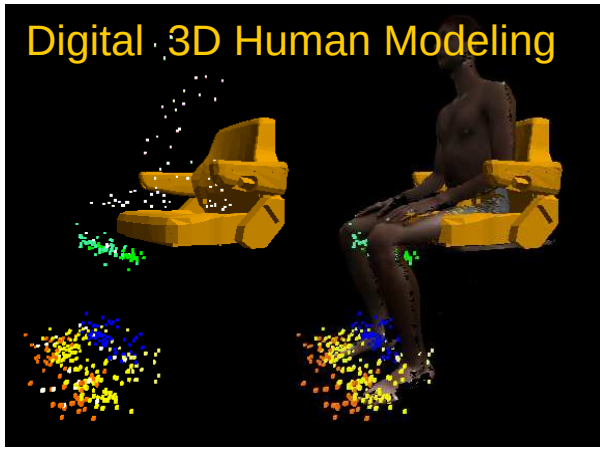
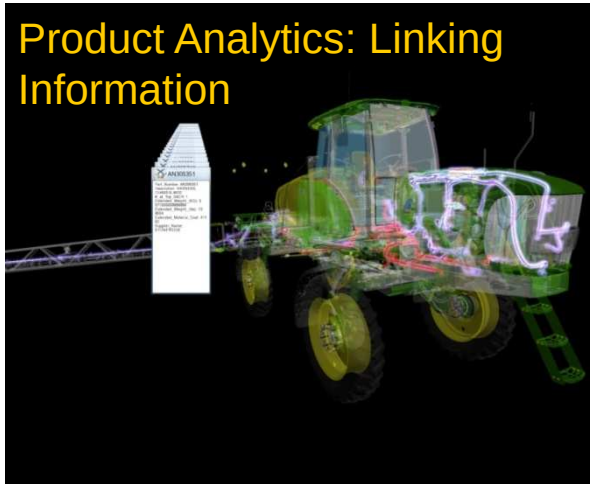
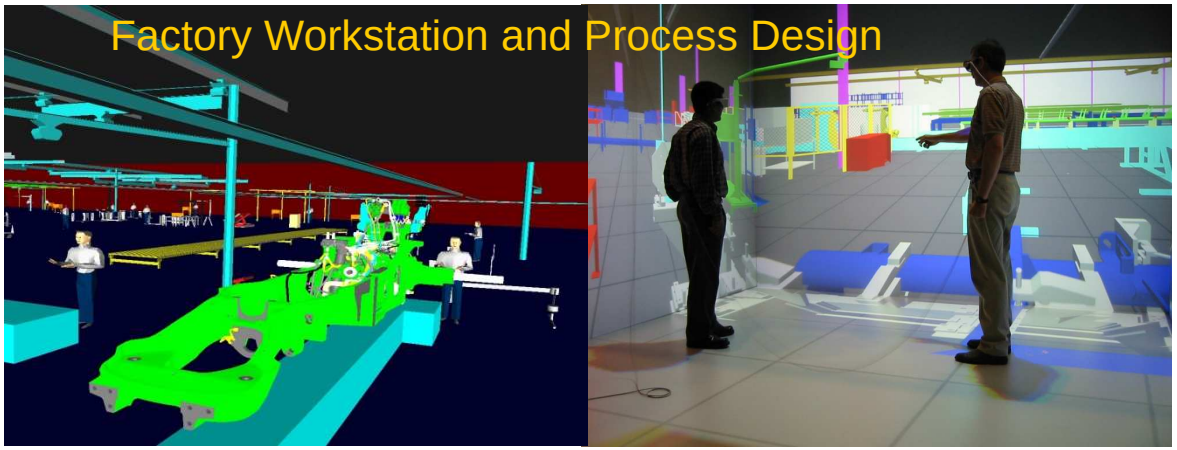
# Example Applications



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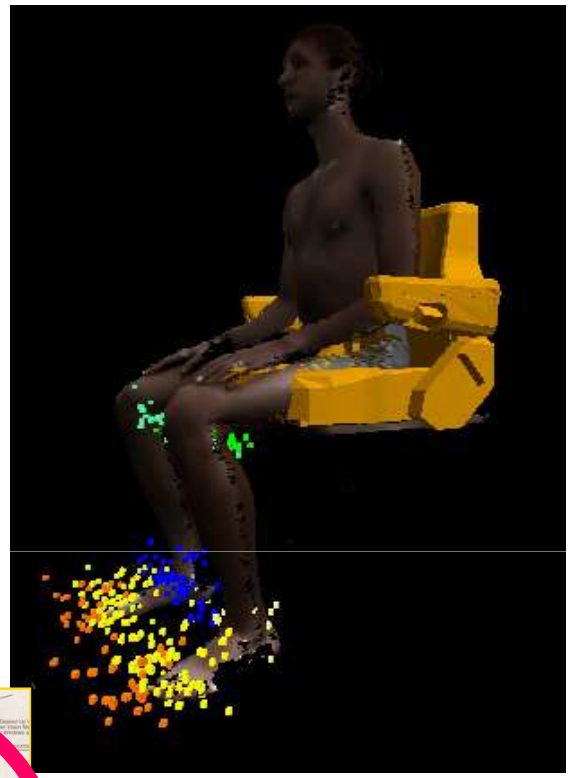
# Immersive Collaboration with Digital Humans

- Moves prototyping from the realm of simulation to experience
- Real size (or scaled)  images
- Designer can display complete population
- Uses real working postures
- Allows greater visibility of the individual within a population
- A population of people can be viewed in reference to their workstation allowing better accommodation of anthropometric diversity



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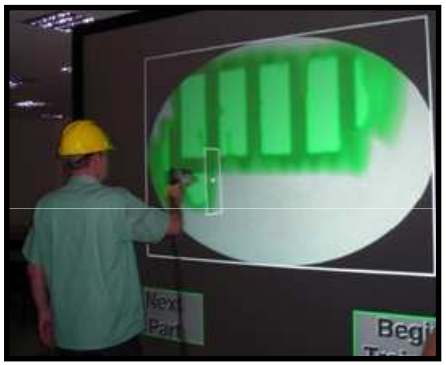
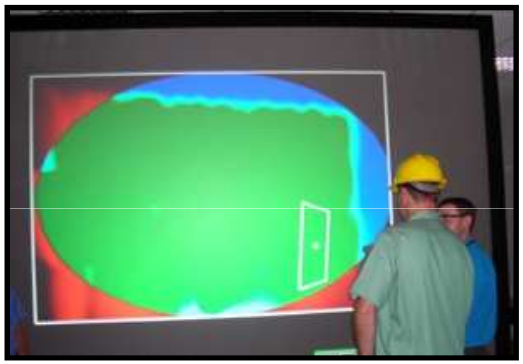
# Using Virtual Reality for Painter Training

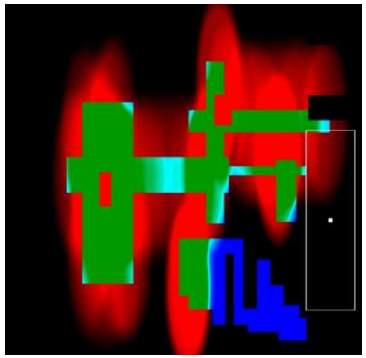
## Accelerates training; reduces cost; increases efficiency of instruction



Actual paint gun is integrated into VR



Immediate visual feedback



Feedback: overspray, thickness, and time

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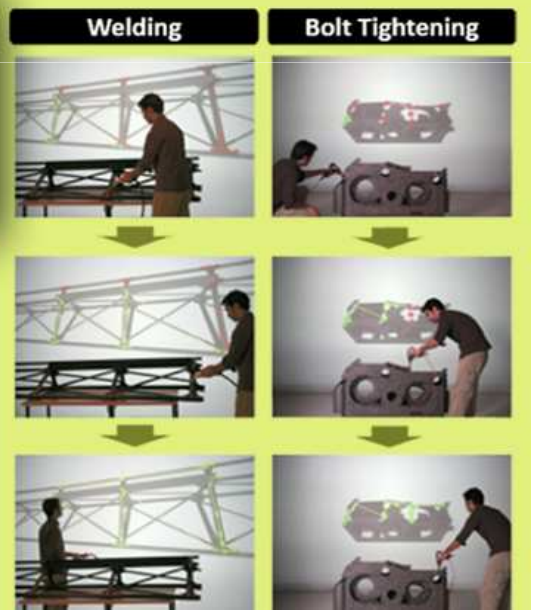
# Tool Tracking for Complex Manufacturing Tasks


Tool Tracking for Complex Manufacturing Tasks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# Tool Tracking Video

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# Product Analytics: Linking Information

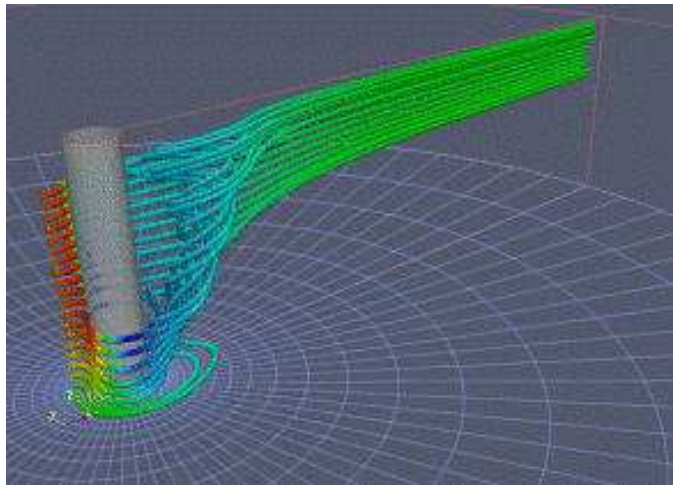
We have lots of product data ...

... that represent missed opportunities


Example product data sources

# The problem is that …

… finding opportunities when complex associations have to be made in your mind is hard.



Developing a 3D immersive (and desktop) application to integrate all product data … creating an easily understood interface for:

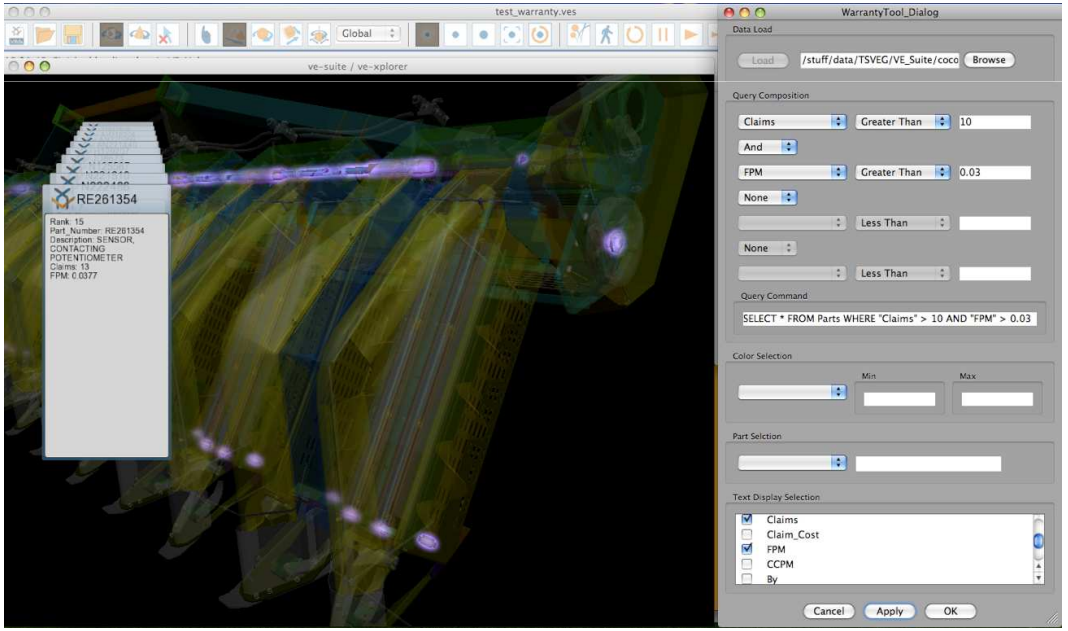
Quality Control

Cost Management

Program Management

Supply Management

Manufacturing, and others

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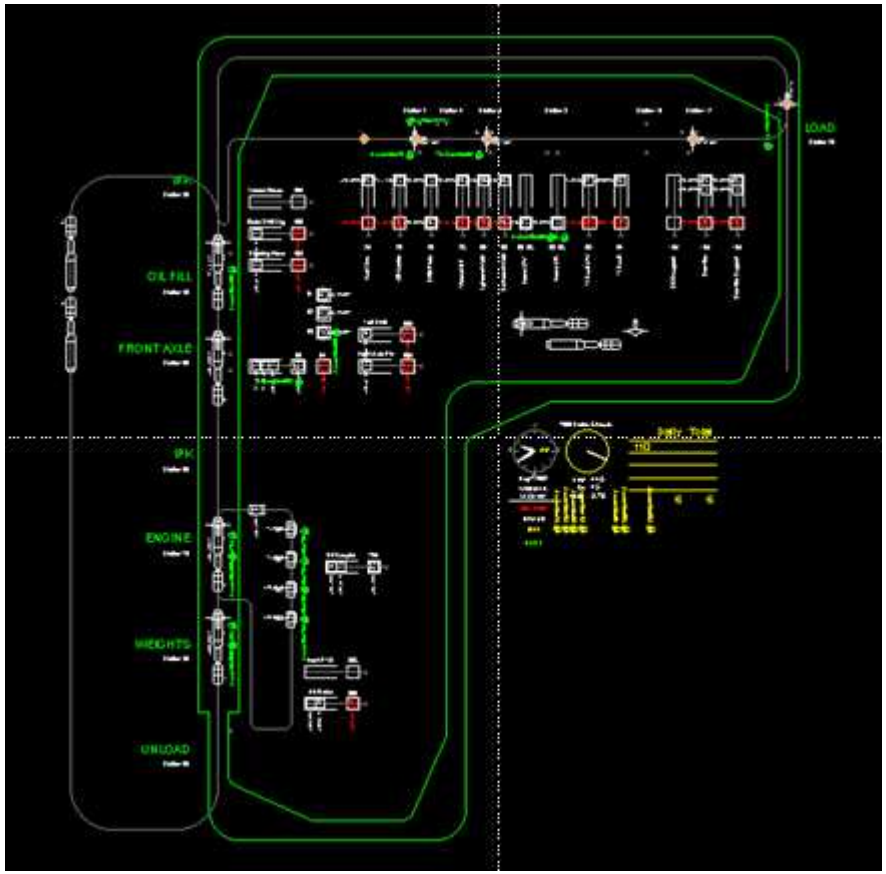
# Discrete Event Simulation + Virtual (“Digital”) Engineering = Better Manufacturing Decisions

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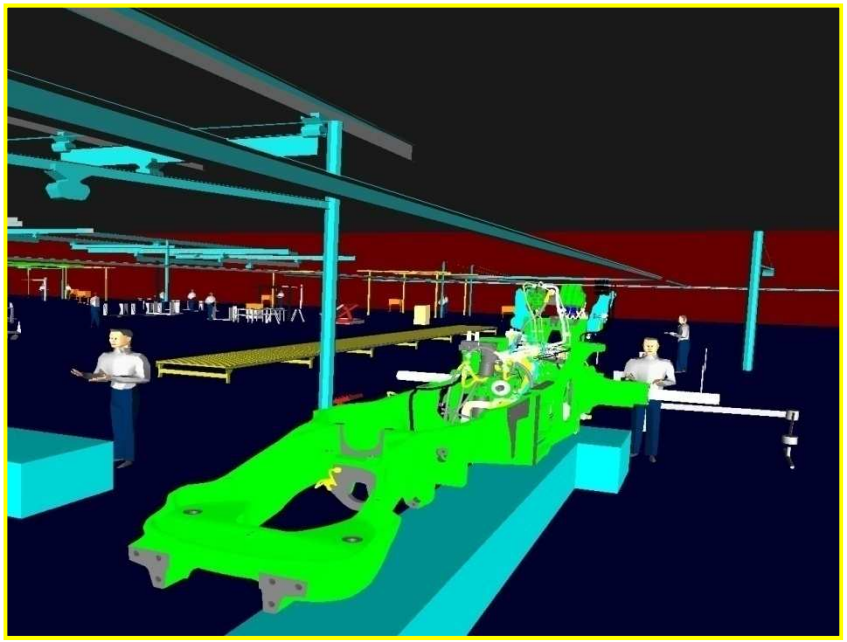
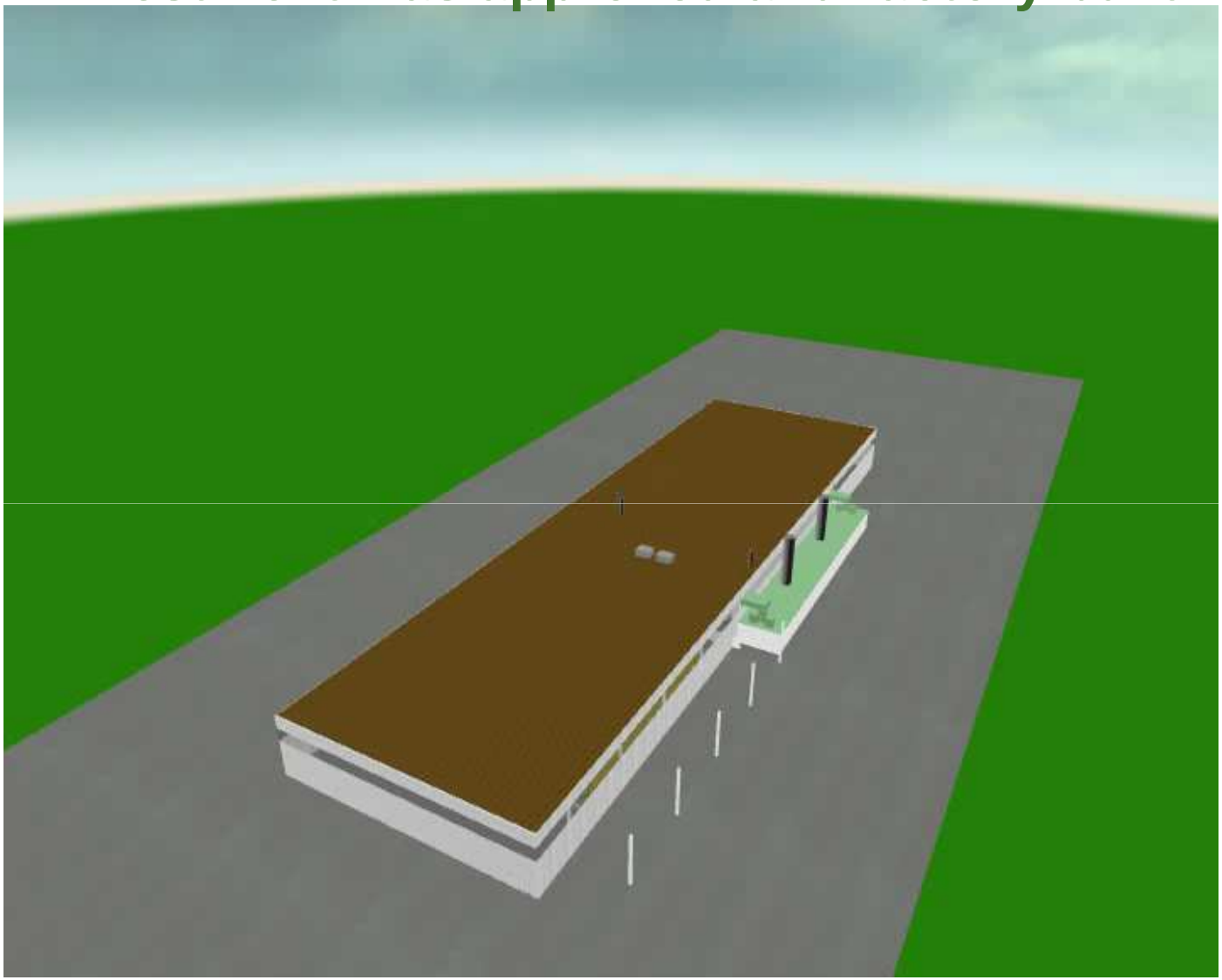


# JD Montenegro, Brazil: Simulated before factory investment was approved and factory built



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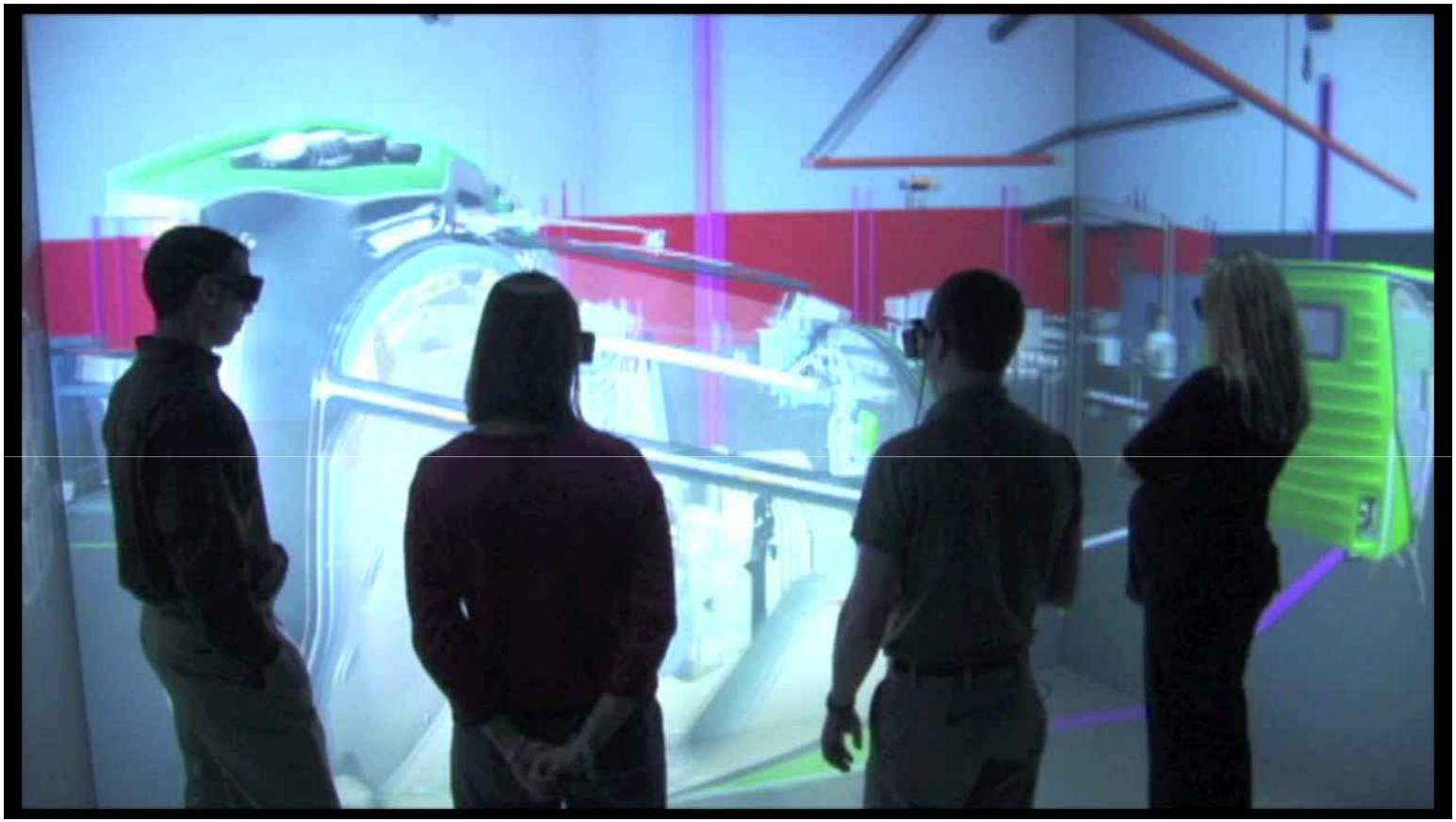
# Immersive Collaboration Enables Manufacturing Engineers to Design Factory Layout for Future Production



**Combine Harvester manufacturing engineers, in reviewing proposed layout, make important discoveries**

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# Immersive Collaboration Enables Customer Input on New Product Design

**Customers evaluating and commenting on early design concepts … expressing their interests and assessments**

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# VR Contributing to Product Innovation

+

New JD 7760 Cotton Harvester

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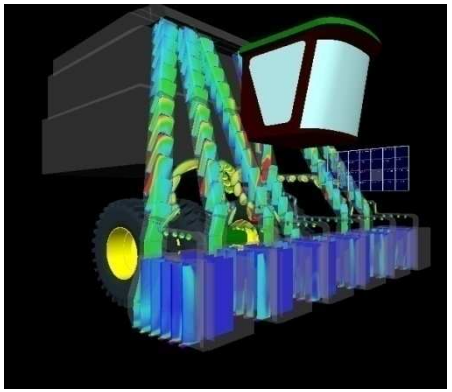
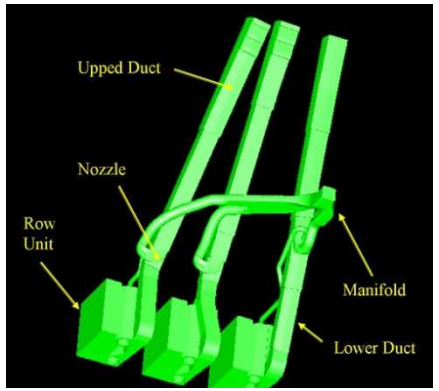
# Air Handling Subsystem






| | |
|---|---|
| **Design cycle time** | **Reduced by 12 to 18 months** |
| **Cost to get verifiable model** | **Reduced by over $100K; eliminated several developmental prototypes** |
| **Performance** | **Increased; exceeded goals** |
| **Material cost of production parts** | **Reduced** |
| **Direct labor** | **Reduced by 50%** |
| **Part count** | **Reduced by 60%** |
| **Integrated design for assembly** | **First physical parts for validation, not development** |

**New process took 9 months; old process took 27 months**

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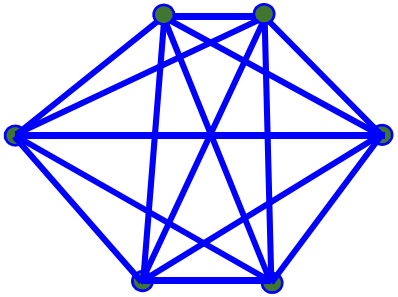
# Lessons Learned

- **Digital Engineering tools enable early and better communication … yielding better decisions**
- **Digital Engineering tools enable participation among multiple key stakeholders … leading to discovery, important new perspectives, and innovation**
- **Digital Engineering tools provide significant financial and system performance benefits**



**A principal benefit is the reduction in time to make decisions; "off-agenda" issues discussed among multiple stakeholders in immersive, collaborative design review sessions lead to accelerated decision making**

# Challenges and Opportunities

- “downstream” users of 3D virtual models expect lower investment (lower cost and less skill/knowledge)
- transitioning from “university” to “internal” to “commercial” software … (overcoming the “IT Code Certification” barrier)
- displacing “incumbent” tools and processes; new digital engineering tools and processes generally mean new work flows … and some “pain” associated with change
- developing better tool integration and human interfaces (more time doing real work within a shared, immersive environment... less time dealing with tool interfaces)
- providing multiple, simultaneous viewpoints (not just one tracked viewer) in immersive environments

# We've come along way since the 1980s …

## Product and manufacturing process design today is:

- more simulation-based
- more globally integrated
- being performed more immersively and more collaboratively

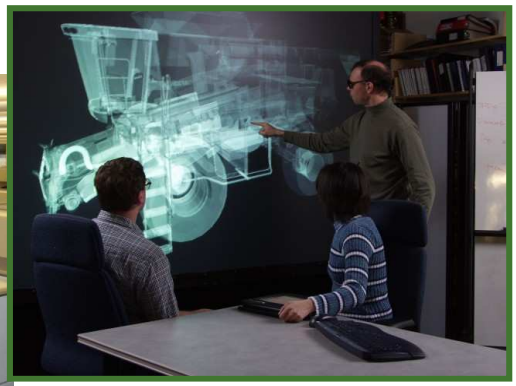
Business decisions today are being made IN shared, immersive environments with representation of multiple, key stakeholders

1950s

1960s

1970s

1980s-present



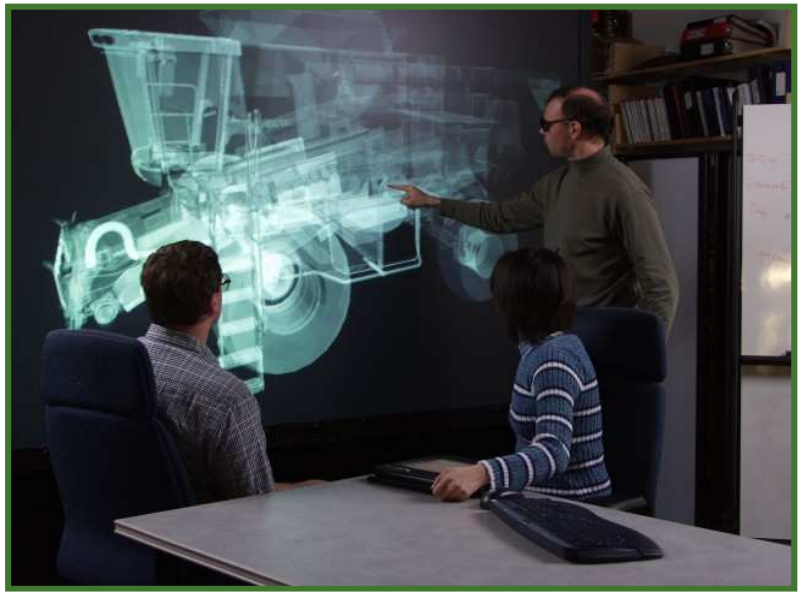
Early 21st Century

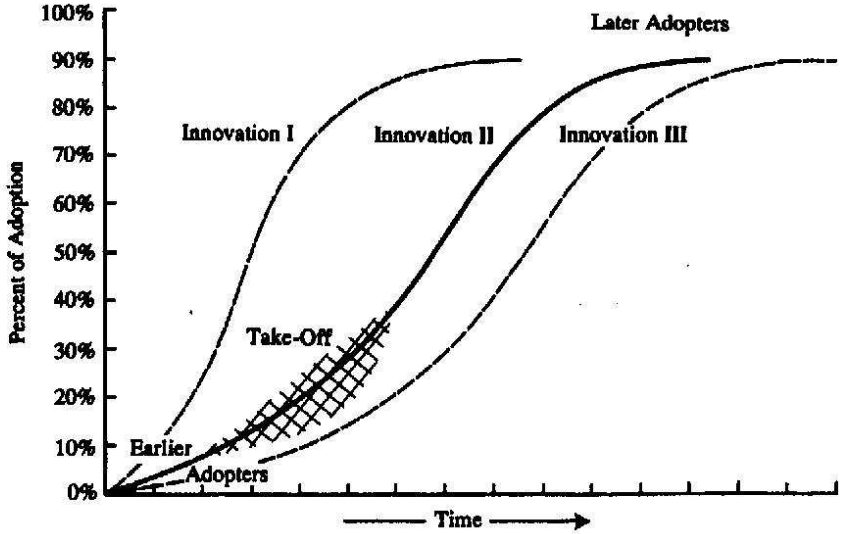
JOHN DEERE

# A Prediction:

- there will be even less physical prototyping, and less independent “desk-top” activity in the future

- the evolution of “Digital Engineering” (and Immersive Collaboration) will continue to advance and broaden in all system engineering domains



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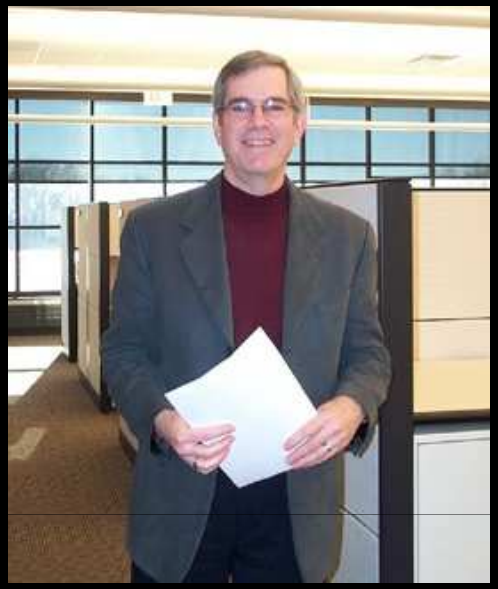
# Thank You !



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