

Evolution of Digital Tools Used in Complex Product Design

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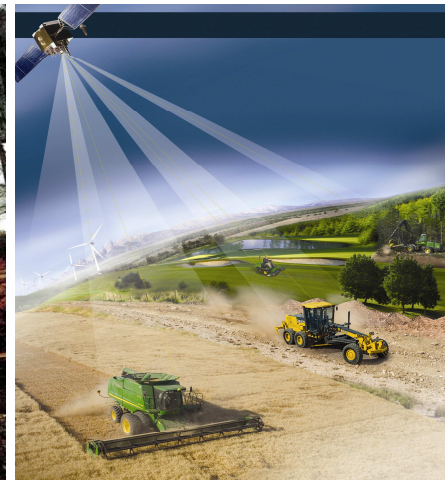
Overview

- **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**



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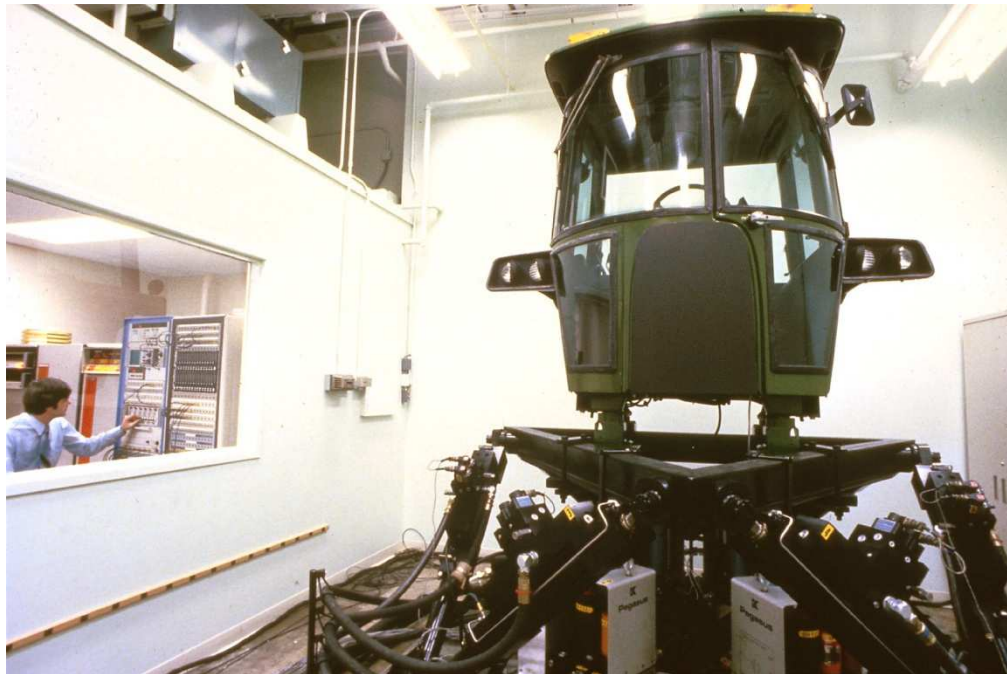
John Deere – global growth in Agricultural and Turf Equipment, Construction & Forestry Equipment, and Intelligent Systems



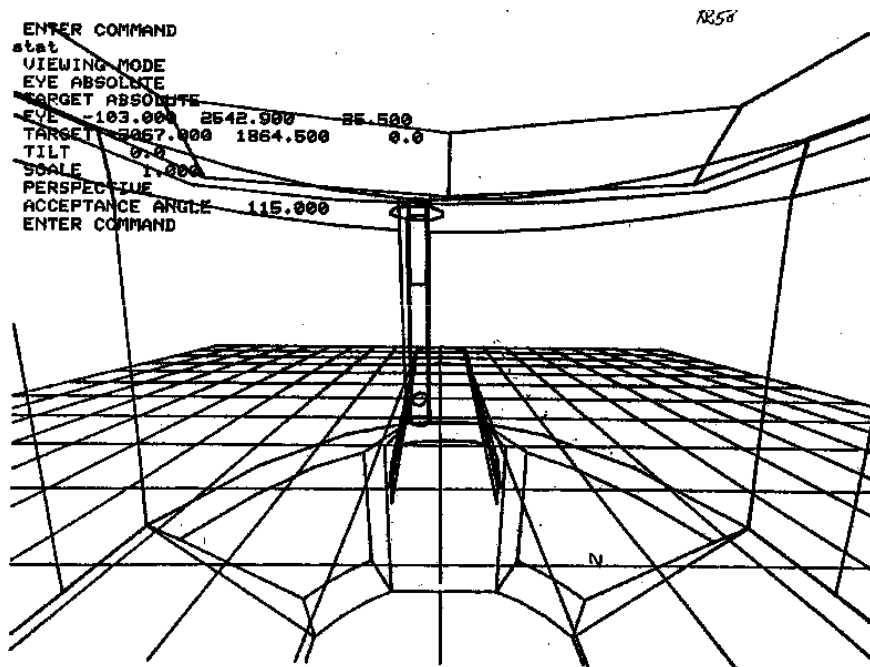
John Deere Manufacturing Locations



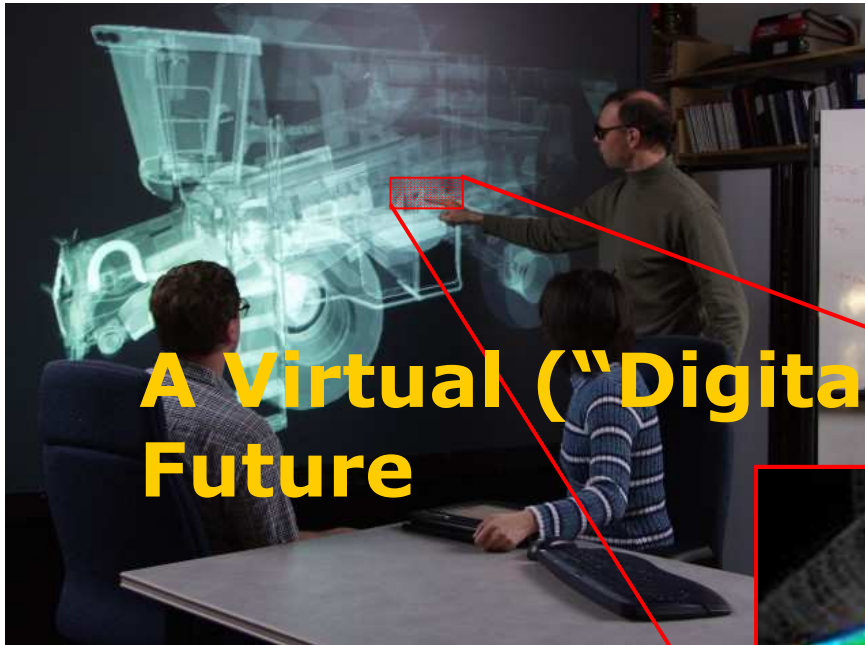
My start at John Deere ... 1978 ... established a Human Factors Research Lab to support off-road vehicle operator workstation design. Featured physical simulation with high-fidelity, 6 degree-of-freedom motion base and low-fidelity visual scene.



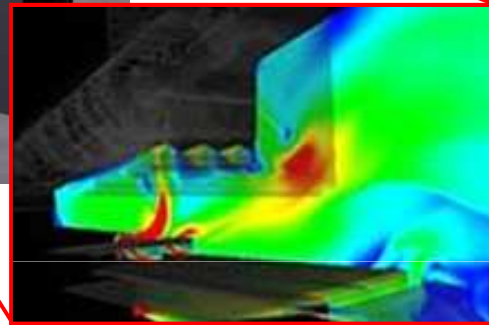
Searching for a better digital human modeling tool leads to Dr. Norman Badler at U Penn. ... 1989 ... "Jack" software (Badler and Phillips, U Penn) ... became early foundation for "VR" (Immersive Collaboration) in John Deere



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.

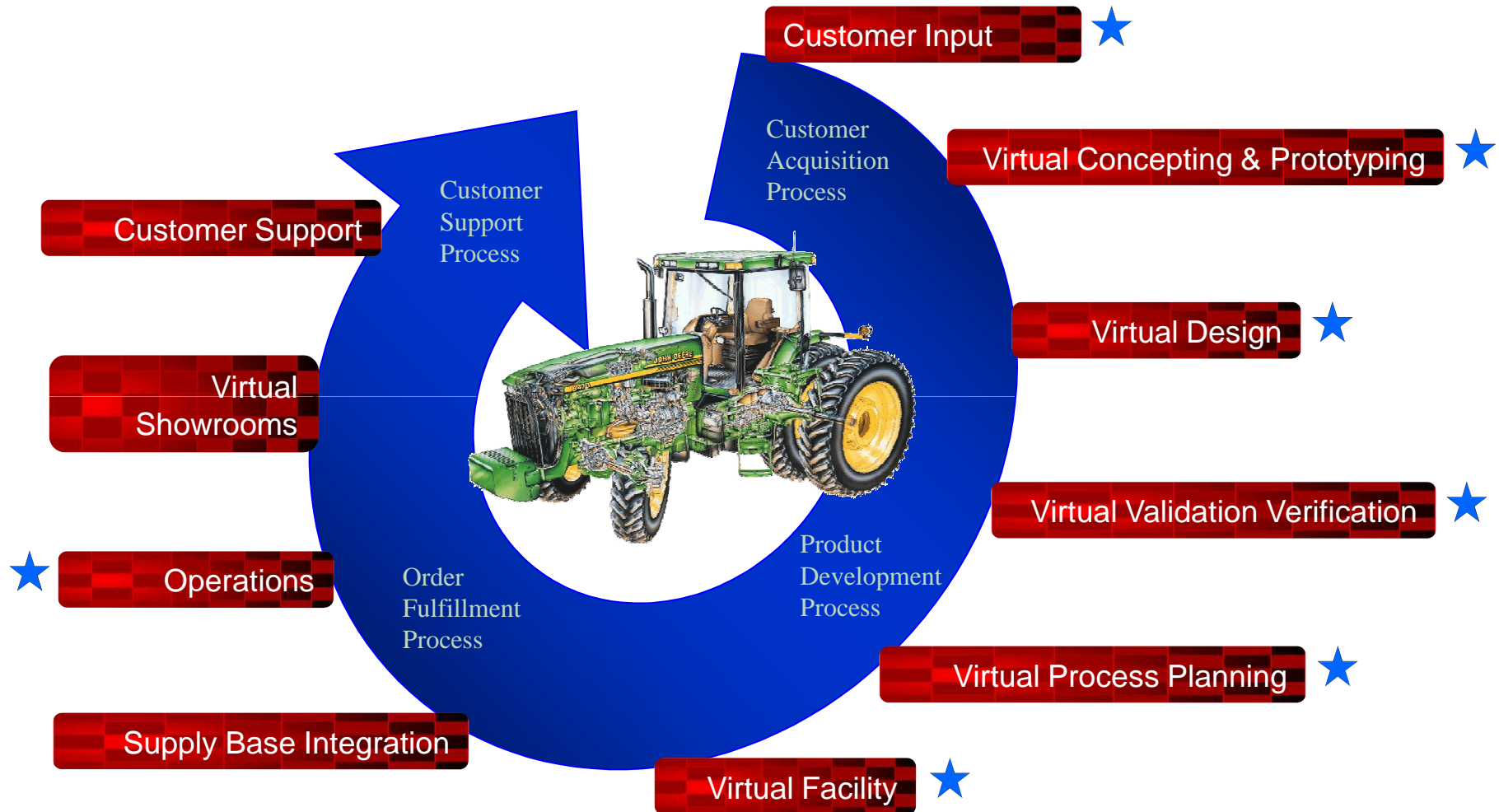
Perform critical product and manufacturing process **evaluations** (serviceability, manufacturability, operator and product performance, customer acceptance) **interactively** from concept to production.

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

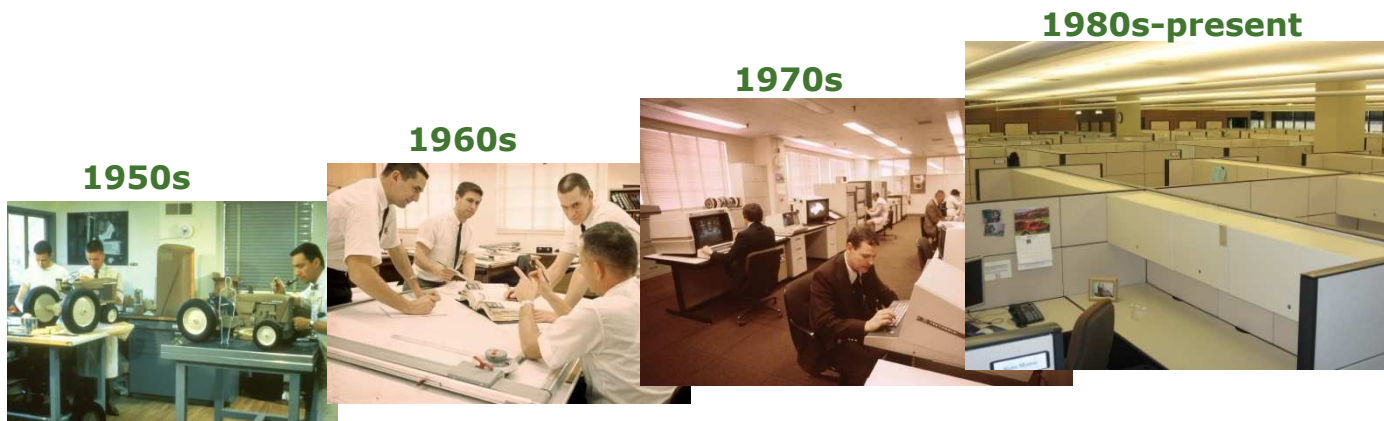


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Businesses are process driven ... processes evolve

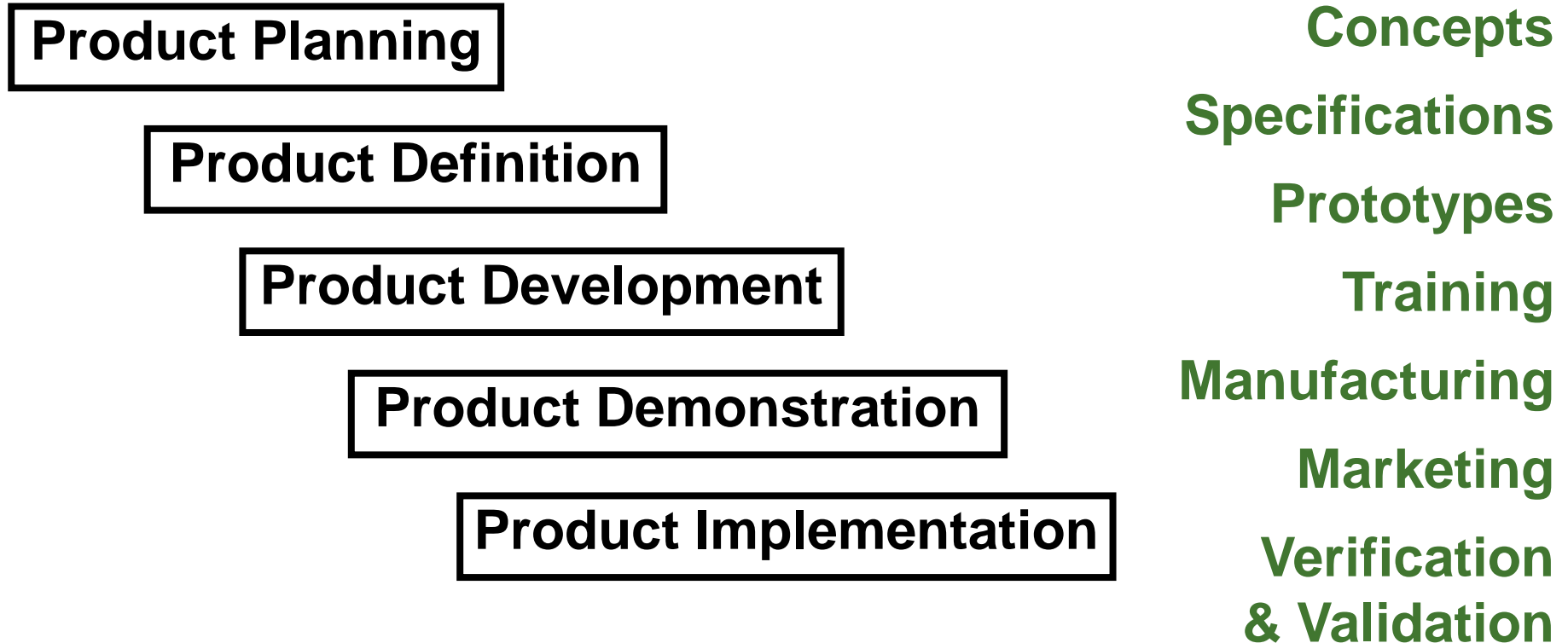


Tools and technology used in product development are evolving ... advancing ...



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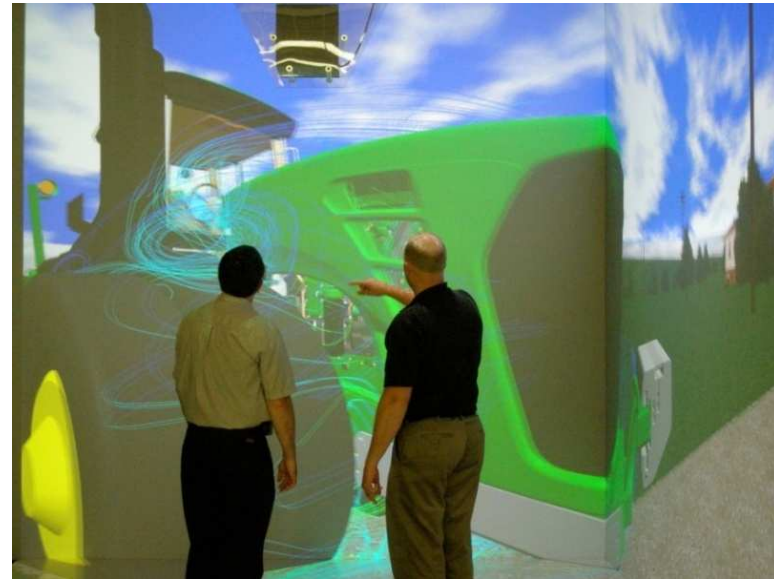
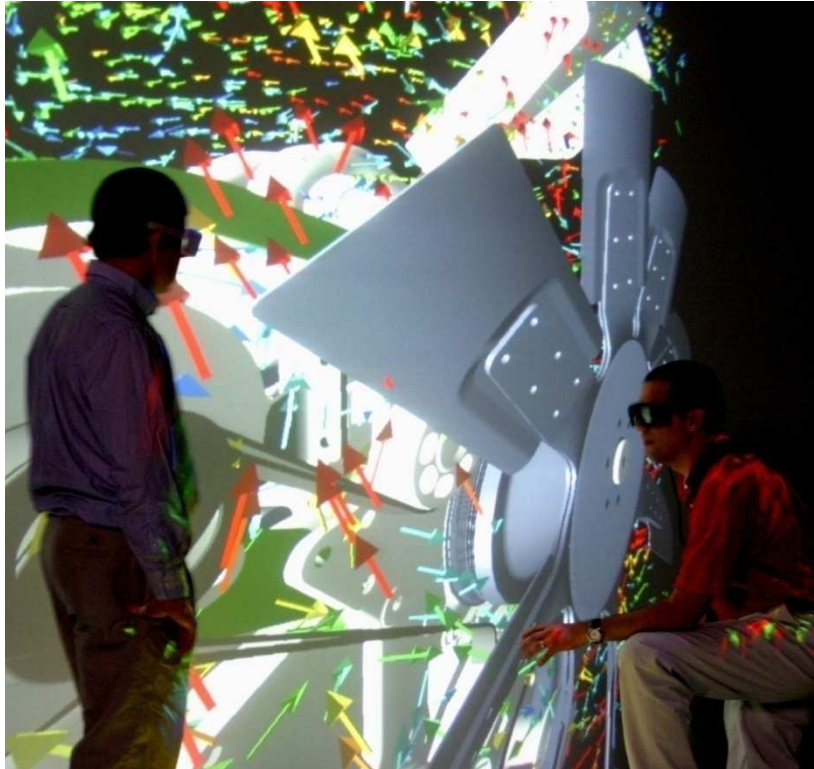
Product development is an information intensive decision-making process



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



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Deere Digital Engineering
Innovation



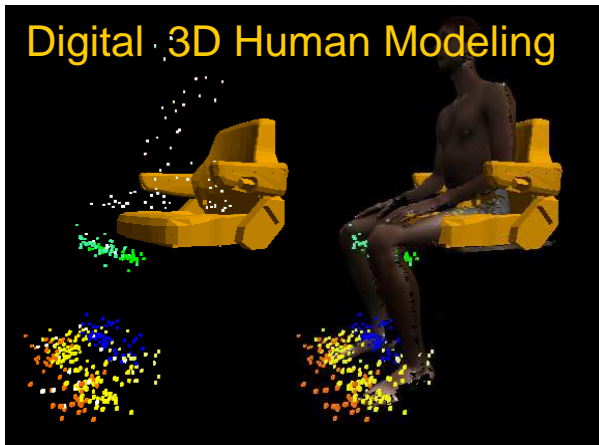
Commercial
Technology vendors

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



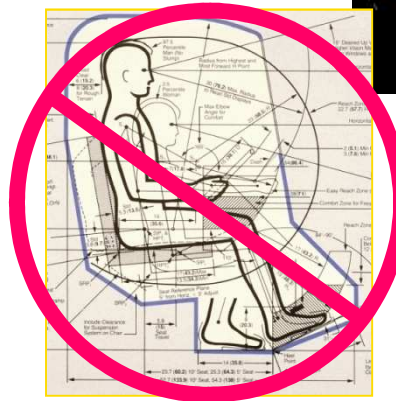
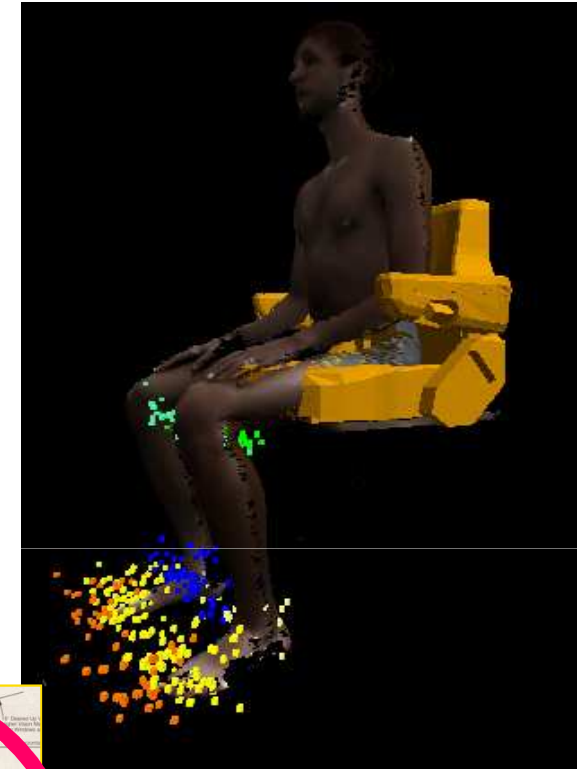
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Example Applications



Immersive Collaboration with Digital Humans

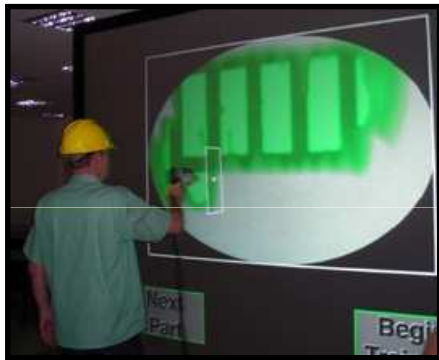
- Moves prototyping from the realm of simulation to experience
- Real size (or scaled) images
- Designer can display complete population
- Uses real working postures
- Allows greater visibility of the individual within a population
- A population of people can be viewed in reference to their workstation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



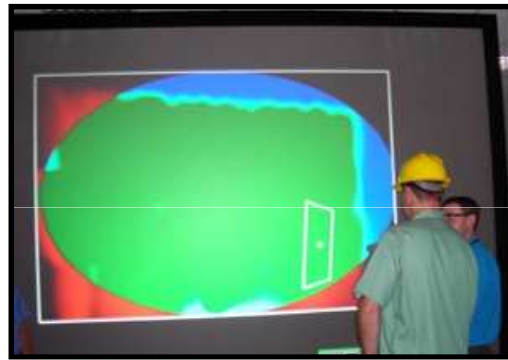
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Using Virtual Reality for Painter Training

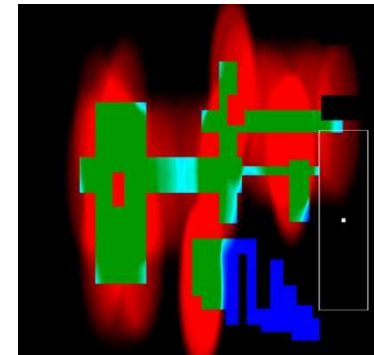
Accelerates training; reduces cost; increases efficiency of instruction



Actual paint gun is integrated into VR



Immediate visual feedback



Feedback: overspray, thickness, and time

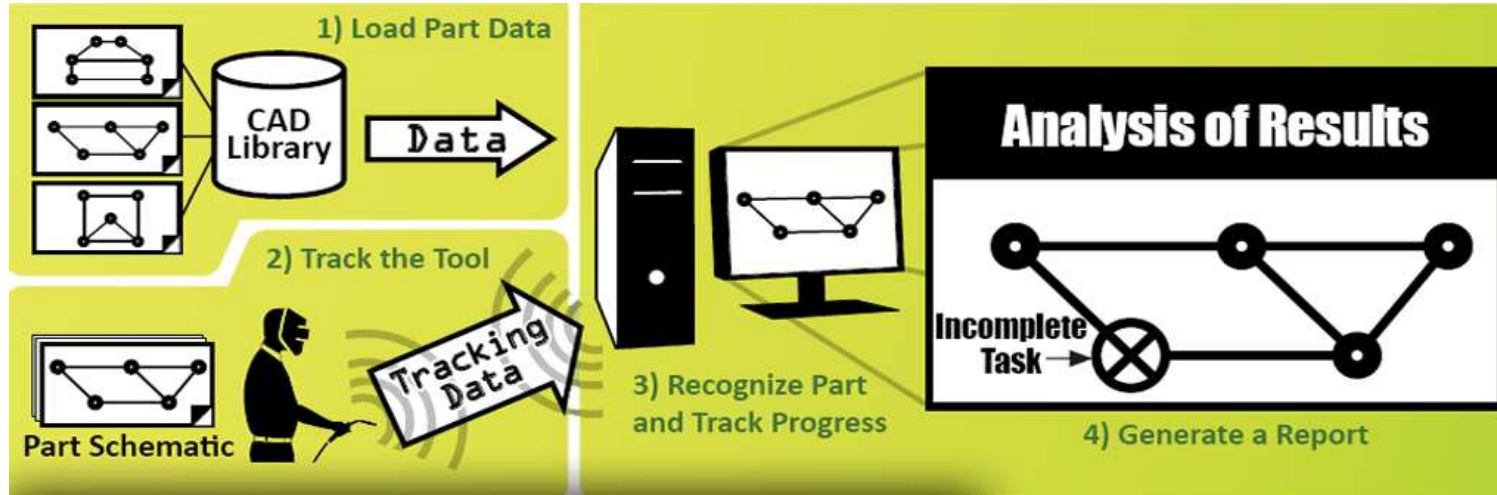


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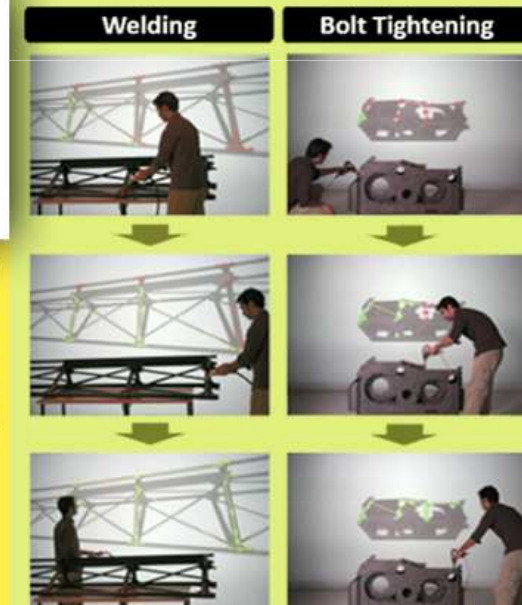


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Tool Tracking for Complex Manufacturing Tasks



Tool Tracking for Complex Manufacturing Tasks



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Tool Tracking Video



Product Analytics: Linking Information

We have lots of product data ...

... that represent missed opportunities

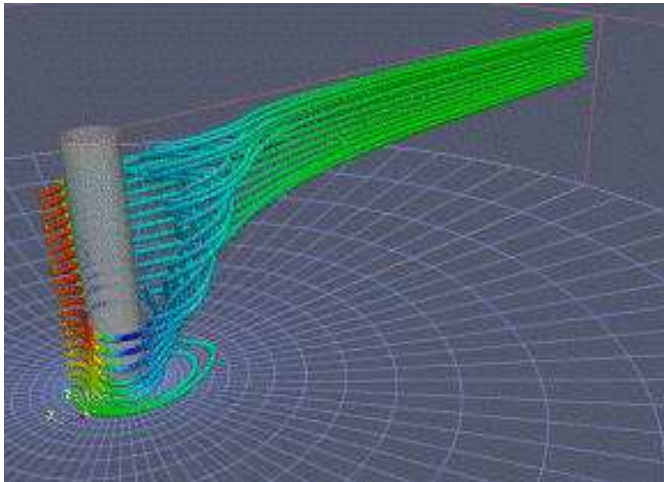


Example product data sources



The problem is that ...

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

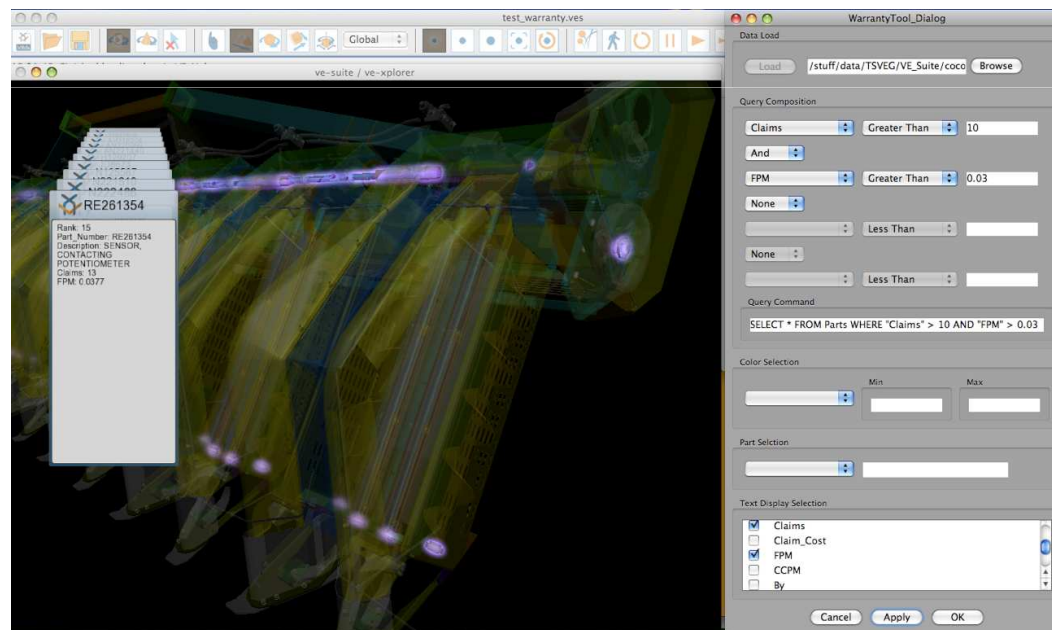


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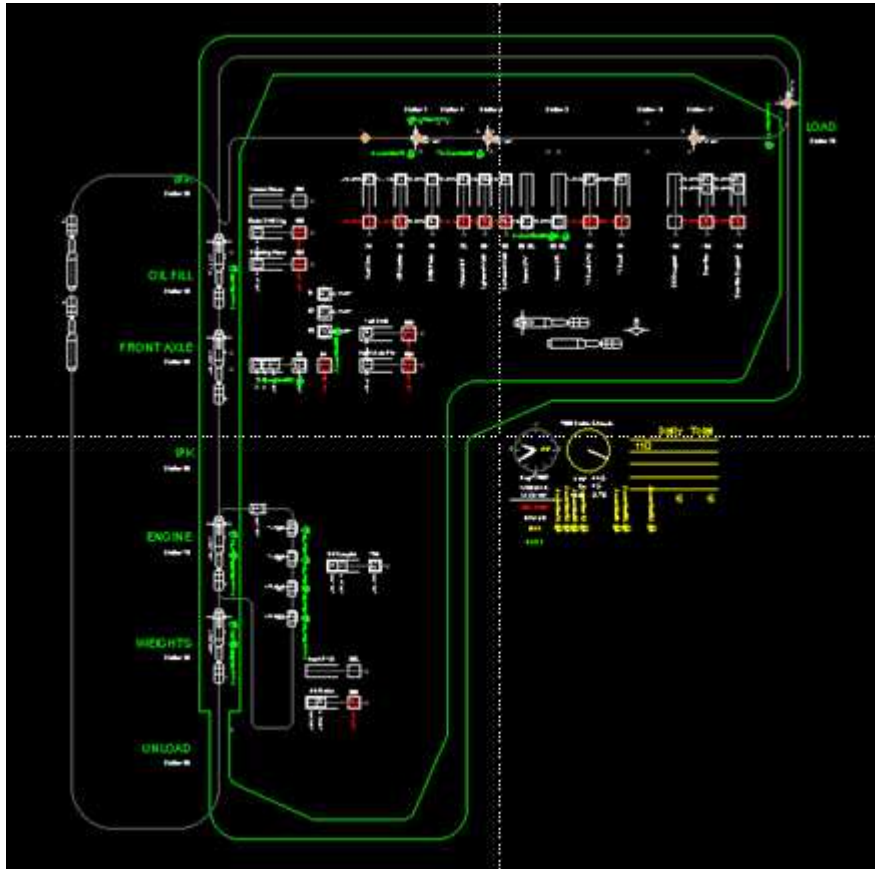


Developing a 3D immersive (and desktop)
application to integrate all product data ...
creating an easily understood interface for:

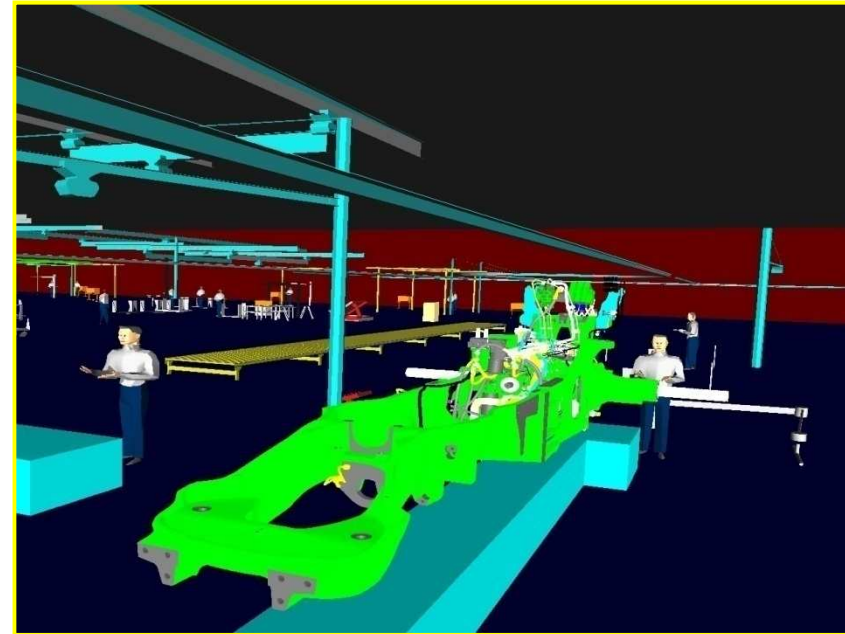
- Quality Control
- Cost Management
- Program Management
- Supply Management
- Manufacturing, and others



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

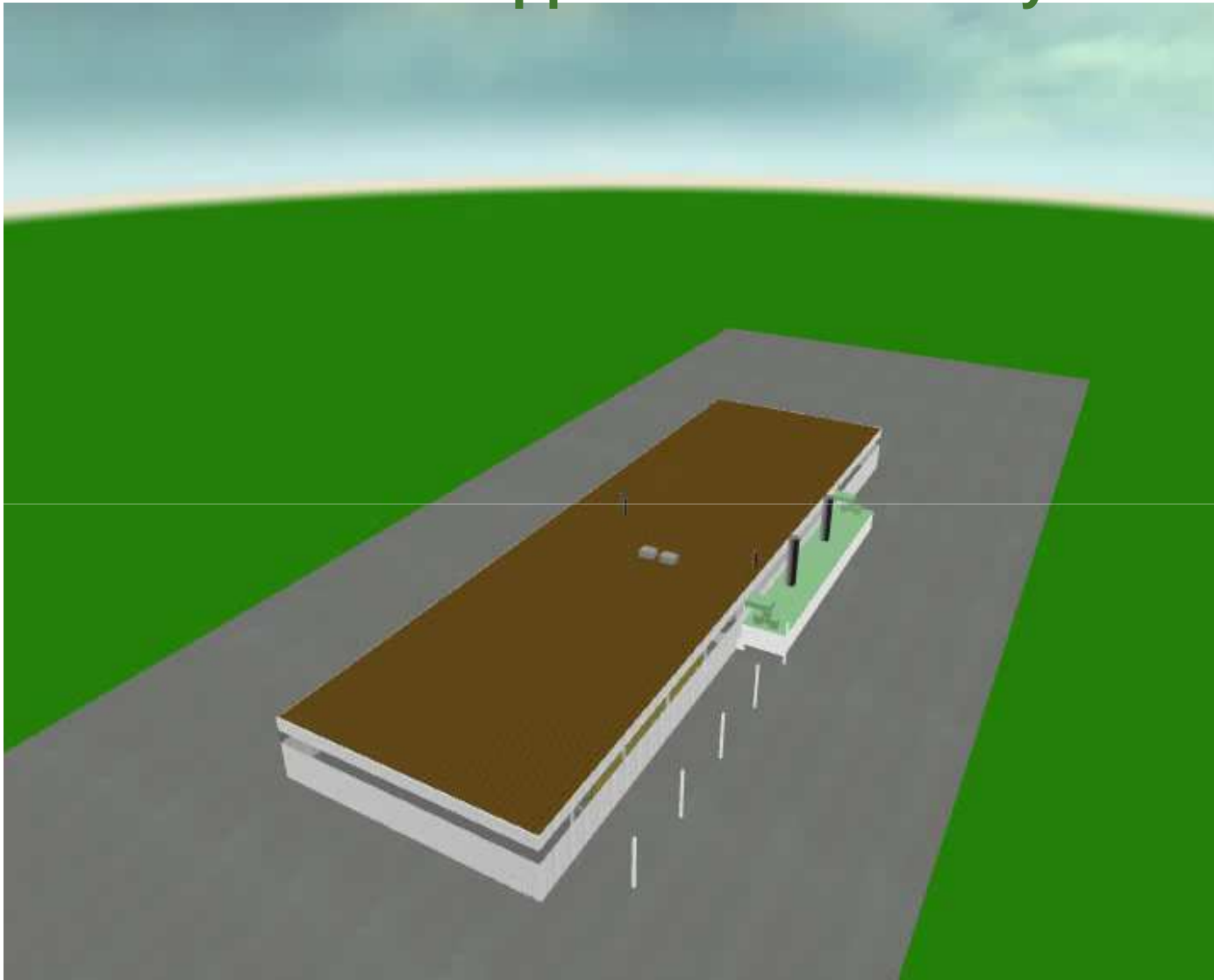


VS



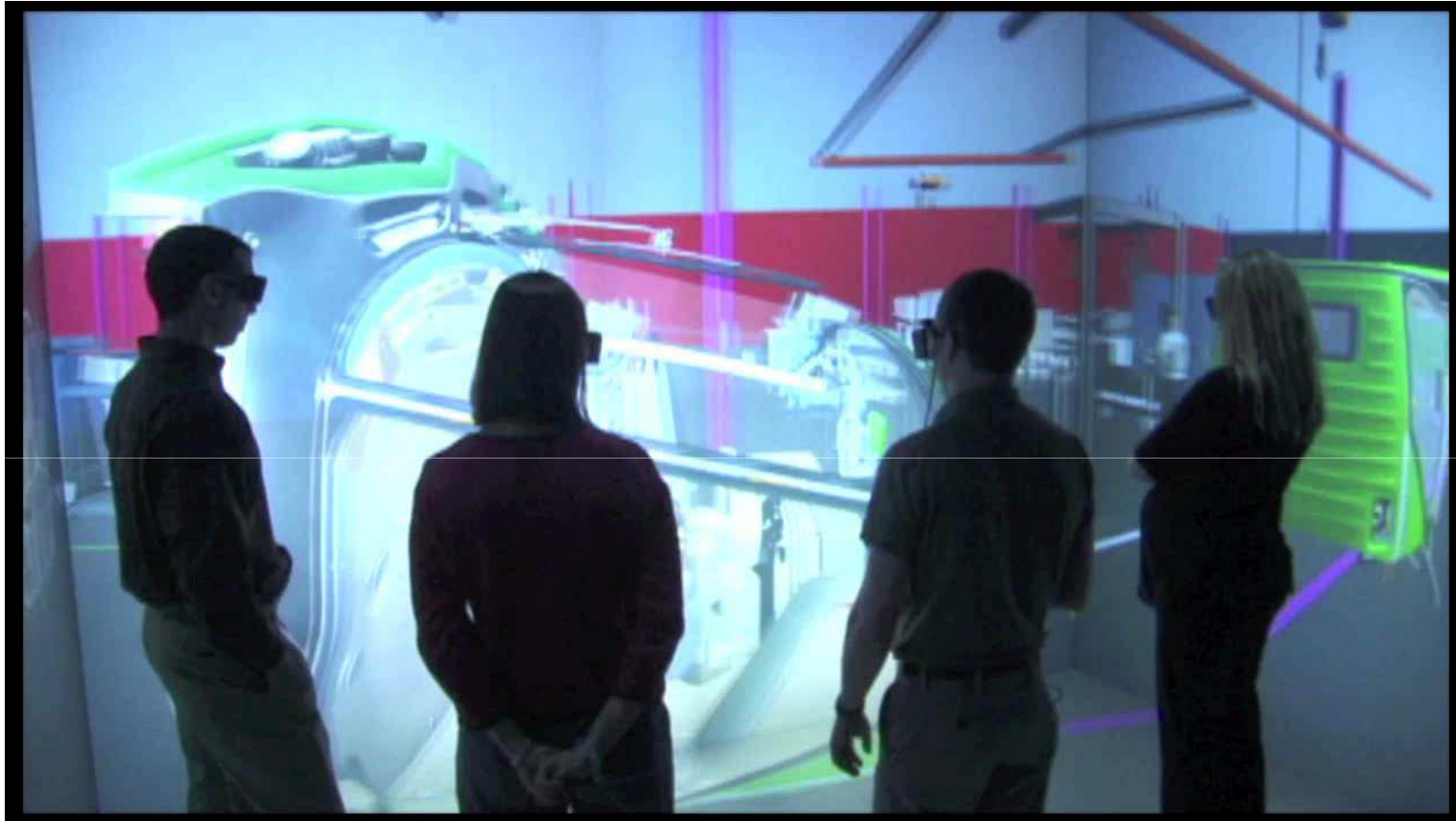
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JD Montenegro, Brazil: Simulated before factory investment was approved and factory built



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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

VR Contributing to Product Innovation



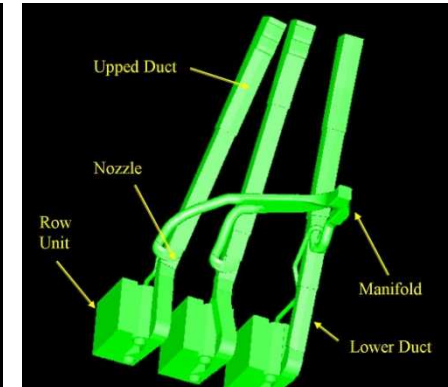
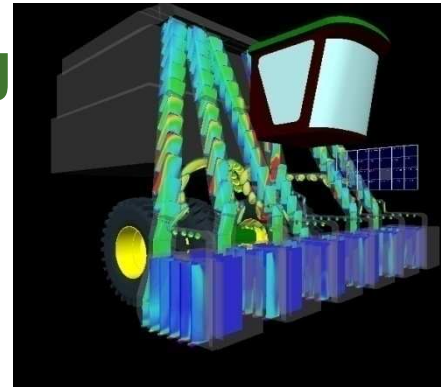
+



New JD 7760 Cotton Harvester



Air Handling Subsystem



Design cycle time

Cost to get verifiable model

Performance

Material cost of production parts

Direct labor

Part count

Integrated design for assembly

Reduced by 12 to 18 months

Reduced by over \$100K; eliminated several developmental prototypes

Increased; exceeded goals

Reduced

Reduced by 50%

Reduced by 60%

First physical parts for validation, not development

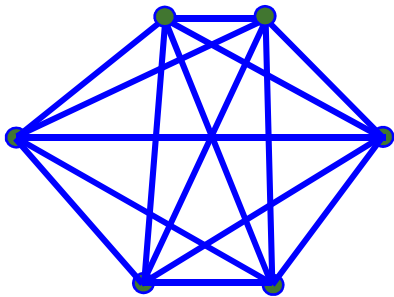
New process took 9 months; old process took 27 months



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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



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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

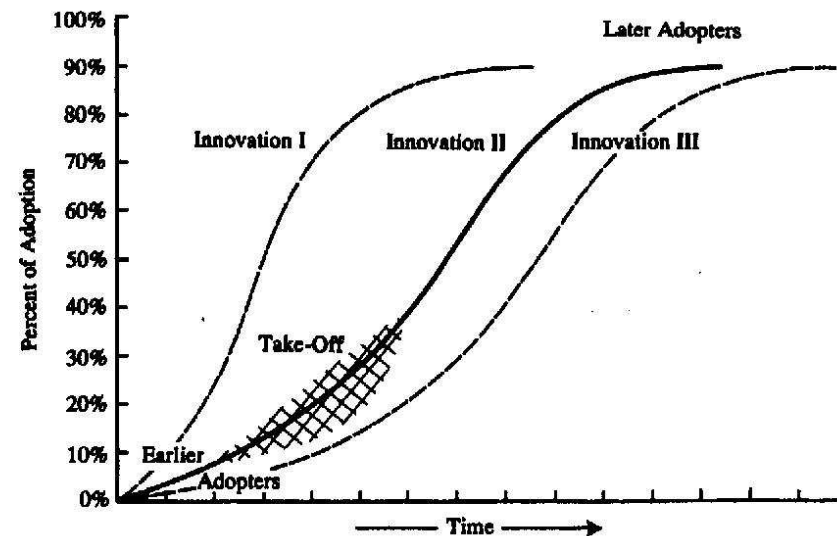
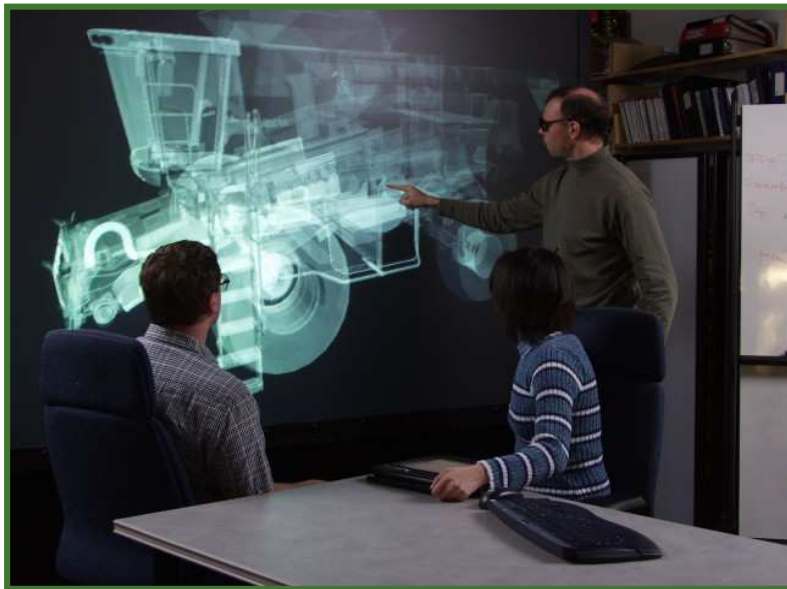
Business decisions today are being made **IN** shared, immersive environments with representation of multiple, key stakeholders



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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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