Connect virtual design to actual production for real gains

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by Julie Fraser, Iyno Advisors

This concept may sound like a radical company-wide transformation. It may well be. But, innovation cycles tend not to be linear. Often, a longer term perspective is necessary for better success, including a focus on how the business will look, and what will matter to customers and to company profitability in serving them. An initial focus on connecting virtual products and processes in design into the real production environment can be an effective scope. Then take those measured steps to begin your transformation of this vision into reality, and then measure your benefits based on a new level of performance not previously considered.

Why V2R is Compelling

- Innovative business model now possible
- Rapid response to lot size of one or personalized orders
- Rapid informed product innovation
- Faster, more confident new product ramp to quality & volume
- Improved product quality
- Lower production costs

Can the concept of virtual to real (V2R) actually be accomplished? It is a foundation for the emerging paradigm for production businesses moving forward, variously called Digital Business, Smart Factory, Industrie 4.0, or by an array of other names. Is this vision a reality? And, how close are we to achieving it?

This paper takes a close look into this topic, based on case study review. What are best-in-class manufacturers actually accomplishing? Is it really possible to digitize business processes to achieve improved collaboration, accelerated new product introduction and streamlined innovation? Can results in the plant truly influence the next round of product updates and improvements?

We believe early evidence shows it can happen, but it requires more than just new technology. For one thing, it takes a new business and value-creation strategy. The business case must be strong.

Even with a solid business case, company leaders must overcome a major change management task to overhaul:

- **mindset and culture**: to align with the vision, foster collaboration and be willing to strike out on the new path
- **organizational structure**: to minimize the walls, conflicts and mis-matched incentives that can drive each group to work to local optimum rather than global vision
- **business process**: to extend cross-functional participation and ensure effective ownership and accountability of key processes
- **technology and software applications**: to move into intuitive 3D, measure operations more effectively, and take realistic steps toward standardization and automation

Many are embracing the vision of connecting virtual products and processes to the “real” shop floor. A few are making it a reality today.

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# Table of Contents

The Vision .................................................................................................................. 1
Examples of Possibility ............................................................................................... 2
Key Issues to Address ................................................................................................. 3
    Mindset .................................................................................................................... 3
    Organizational Barriers ............................................................................................ 4
    Business Processes ................................................................................................. 4
Technology ................................................................................................................... 5
    Start at the start ...................................................................................................... 5
    Standardize platforms .............................................................................................. 6
    Approach it realistically .......................................................................................... 6
Bring a vision into reality .............................................................................................. 7
Additional Resources ................................................................................................... 8
Conclusion .................................................................................................................... 8

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**The Sponsor: Dassault Systèmes**

Dassault Systèmes, the 3DEXPERIENCE Company, serves 190,000 customers across 140 countries, providing virtual universes for sustainable innovation. Dassault Systèmes’ DELMIA brand offers products that connect the virtual and real worlds of manufacturing.
The Vision

Conceptually, Virtual-to-Real (V2R) is hardly new. From the introduction of computer-aided design (CAD) and simulation, the aim has been to model the real world as accurately as possible. Feedback between the virtual and real was always an intention, and sparked the concept of design for manufacturability (DfM). Later, the digital manufacturing approach was widely adopted in automotive and aerospace.

Both the product and the production process can be modeled effectively in the virtual design space. This is proven, and has led to improvements in design, production and product success.

Likewise, most production plants do use the product and process design outputs to guide the manufacturing processes. Most production operations plan based on the process and product designed parameters. Manufacturing Operations Management (MOM) software typically provides views of these digital ideals to operators and technicians in the plants as on-line work instructions or videos.

The next logical step in this V2R vision is for the digital systems in design and on the plant floor to communicate and update each other. As more facilities have MOM in place, this seems a logical information flow to fine-tune.

However, in most cases the connection between virtual design and real production operations is not live and two-way. Typically, the interaction is through an intermediary and is a static approach to updates.

So as manufacturing environments improve and change, the design teams may not have a complete view of the new capabilities. As designs change, the production teams may not see that impact for a while.

Stefan Ferber of Bosch says, “Industrie 4.0 is a sophisticated approach changing the entire global value chain: communication, planning, logistics and production.” Given this scope, it’s clear that companies won’t accomplish everything at once.

Virtual-to-Real requires a realistic virtual product and process model as well as comprehensive information flows in the plant. These should match each other as closely as possible. The missing link is effective, immediate two-way integration for feedback. Figure 1 shows that V2R is both like a mirror where the virtual comes first and each side reflects back to the other as a closed-loop control cycle where each side uses input

**CenterLine**

CenterLine (Windsor) Limited is a mid-size company that provides a variety of automated equipment from resistance spot welding guns to full automated assembly lines. Young engineers convinced leaders to invest in digital manufacturing to minimize design issues from reaching the manufacturing floor. Now they are expanding its use in all projects, not only for line design, but also robot programming, interference checking, and path simulation.

**Benefits:** Reduced capital, project time, and floor space. Among other organizational changes, this has helped CenterLine complete significantly larger projects faster, and execute them more effectively.

![Figure 1: Virtual-to-real (V2R) concept: virtual and real mirror each other, with key data feeding between the sides used as a control system.](image-url)
Examples of Possibility

As with any major transformation, even the industry leaders are, for the most part, not taking it all on at once. Finding the right place to start depends on your business needs, style and strategy.

Here are some examples to show that progress is possible. Figure 2 shows examples from different industry segments and starting in different parts of the V2R vision.

Companies that have been using digital manufacturing for a long time such as automotive and aircraft OEMs have made strong advances. Honda, Chrysler and Embraer are great examples. They use 3D data and specific capabilities that help connect their virtual to real worlds in product and process design and validation tools. However most of these companies have not yet fully connected these virtual data streams into their actual plant floor.

Pioneers in personalized medical devices such as Align Technology and ConforMIS have perhaps the strongest V2R implementations. This industry has typically been a laggard in implementing information technology overall, but these specific companies have broken that mold. Their core business concept relies on integrating digital data streams from doctor’s offices through sales, design, manufacturing, and in some cases, back to the doctor’s offices. A clean slate may be the easiest starting point for V2R.

Some of the commercially available technologies manufacturers use to create and connect V2R include:

- 3D design of products and processes for clarity
- Digital Manufacturing to model and simulate processes
- Geometric dimensioning and tolerancing (GD&T) to define specs on a 3D model
- Dimensional quality and systems engineering based on tolerances for parts and assemblies
- 3D printing & translation
- Manufacturing operations management (MOM)

The V2R activities of Honda and CenterLine, who provided interviews for this paper, are also described briefly in call-out boxes. Further information came from an interview with DCS, which provides consulting and dimensional quality software.

At the end of this paper are links to longer documents on all of the companies mentioned, where they are available, along with the companies’ websites.

### Company & Industry

<table>
<thead>
<tr>
<th>Company &amp; Industry</th>
<th>V2R Focus and Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>CenterLine – Industrial robotics fixtures: assembly automation and robotic cell re-tooling</td>
<td>Digital manufacturing used to program and prove out robotic lines prior to physical prove-out</td>
</tr>
<tr>
<td>Embraer – Aircraft manufacturing</td>
<td>GD&amp;T and simulation used to ensure quality and assembly tolerances</td>
</tr>
<tr>
<td>Chrysler – Automotive manufacturer</td>
<td>Centralized metrology; Dimensional systems engineering: Parts Qualification Process (PQP)</td>
</tr>
<tr>
<td>Honda – Automotive manufacturer</td>
<td>Globalized New Model product &amp; process design and verification: same data in real-time 3D</td>
</tr>
<tr>
<td>ConforMIS – Personalized medical devices: knee replacements</td>
<td>Complete digital from doctor’s office to product molding and 3D tooling production</td>
</tr>
<tr>
<td>Align Technology – Personalized medical devices: invisible orthodontics, scanners &amp; software</td>
<td>Complete digital from dentist’s office X-rays to virtual modeling software, rapid manufacturing processes and mass customization</td>
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Figure 2: Examples of companies making headway with V2R.
Key Issues to Address

The transition from current loosely connected virtual and real worlds to tighter V2R will be challenging for most companies. While more effective, real-time and two-way information flows between design and manufacturing have been part of the discussion for many years, there are some clear reasons why for most companies that vision is not yet a reality. In roughly rank order of importance, these are:

- Mindset and culture
- Organizational barriers, objectives and incentives
- Business processes that work effectively and cross-discipline
- Technology – identifying and utilizing the right set of applications and applying an effective integration framework to accomplish feedback loops

Leaders seeking to make progress must focus on all of these in their change management program.

Mindset

There are a variety of cultural or mindset barriers that can prevent companies from making progress on integrating Virtual-to-Real. Each reader may recognize one or more of these issues in their situation.

**Fishbowl syndrome:** Just as a fish does not realize that his entire life is in one tiny fishbowl, people often truly believe they are doing all that is possible. Enabling a big transformation generally requires re-framing or painting a broader scope. Education that is credible on what is possible in addition to real-world examples can begin to address this mindset challenge.

**Expertise blinders:** There is no question that the people who work in the fields of design or production have deep expertise and experience, which in turn leads them to believe strongly in what they do now. This often sounds like: “We know what we do better than anyone else, so we don’t need their help, nor do we want them interfering with our business.” To combat this, outside solution providers must not only present themselves as having significant, relative expertise, but also the expertise, knowledge and respect as a trusted advisor from within their client’s company.

**Internal competition:** Many companies set up internal competition to drive improvement, but it can backfire. This often sounds like “Our group is competing with others in the company, so we don’t want to share too much of what we do.”

**Change is not always welcome**

“There is so much detail in the process you can visualize it easier in the 3D tool. However, some of our very seasoned associates are slow to adopt the new system.”

Gregg Dennis
Senior Staff Engineer
Honda North America

Even if the company does not choose to modify the incentive to compete internally, creating clear and compelling common goals that people own and align behind can combat this protectiveness.

**Lack of leadership drive:** When an idea comes from the bottom-up, the champions often struggle to gain full commitment from executives. A comment like “We can’t get resources we need” is an indicator. That is probably true until an executive “gets it.” The way to change that is to expose how the project aligns with one or more executives’ stated top priorities or visions. This appeal must be not
only intellectual but also emotional. In short, line up the purpose or “why” to gain support.

**Fear of biting off too much:** Many people have had experiences with big vision programs that never quite got off the ground. The view “Building to a big vision means we won’t get benefits from these IT investments for a long time, if ever.” is how this sounds. Overcoming this block requires a short-term focus on solving a “low-hanging fruit” issue early in the project. This is a project management and structure issue, and the benefits from first stages must be compelling and address a recognized challenge.

**Organizational Barriers**

Cross-functional collaboration can be quite challenging, and V2R is inherently crossing many disciplines, as Figure 3 shows. As you craft a project that touches every group from sales and marketing to design and development to manufacturing and ultimately to customer service and value delivered, you can expect to encounter some organizational challenges.

**Skilled people still required**

“From our experience, a well-rounded individual with design, robot programming, and manufacturing knowledge will not only excel at learning the software, but also use it effectively.”

John-Paul Girard
Robotics Simulation Leader
CenterLine (Windsor) Ltd.

Overcoming these organizational barriers is likely to require some changes in metrics and incentives. It may also truly demand reorganization and new groups to own and work to resolve the alignment issues that arise. A high level company champion will be critical to the success of V2R initiatives as a result.

**Business Processes**

One of the key things that V2R aims to address is improving
business processes. Streamlining into a digital process from one that is typically fraught with disconnects may seem inherently attractive. That does not mean it’s easy.

Existing business processes often touch more people and other processes than we realize. Making a change can require a number of other changes to other processes. Processes that help the company often add more work for one group or another. The continuous feedback from manufacturing to engineering will create new check points and data sets for designers to consider in their work.

Similarly, manufacturing people will not easily carve out time to ensure the virtual world matches their reality. In many cases, they have been accommodating mis-matches in the designs and work instructions with their own work-arounds for years. Relinquishing control of that modification process may seem threatening.

A critical process change involves people knowledgeable in manufacturing at the early stages of design. This will shift some of those people’s time as well as responsibilities. CenterLine and Embraer have both found this as an essential change.

Quite often in crafting new V2R processes, companies find that there is not a clear process owner. Where do all the responsibilities of the design, quality and production teams start and end? It is likely that existing processes have multiple owners that are not aligned well today. It is possible to create shared ownership of a process, but that must be explicit and defined. While everyone must be involved, in most organizational structures the accountability for a process and its outcomes is more easily managed with a clear owner.

Process change is often well served with a formal value mapping exercise. An important support for process change will be performance metrics that reflect the key priorities and objectives the company has for re-vamping these processes. It will also include management and organizational decisions about who owns what, whose jobs might change, and how to migrate from current processes to new ones effectively.

**Technology**

While the virtual world is all technology, the real world also needs strong IT support to be effective. Figure 4 shows some of the foundational software applications that enable V2R. For most companies, there are holes in the information systems used and the information flows within and among them.

**Start at the start**

V2R, as the name suggests, is an integration challenge. Considering what is involved in V2R, the cornerstones for success will be in digital or virtual and physical or real manufacturing. Without sound and consistent IT, there are a few problems that could limit the potential of a V2R initiative.

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**Organizational disparity**

“The biggest issue is all of the players in this. How the design, manufacturing and sales groups all interact and share data is complex. I can’t make those sales or R&D decisions from manufacturing. I try to find like-minded individuals in those organizations to provide input.”

Gregg Dennis
Senior Staff Engineer
Honda North America

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**Figure 4: Key technologies on which V2R must rest.**
Lost in translation: Today most manufacturing groups receive 3D models, translate them to 2D drawings and then a human being must interpret them in 3D reality. This translation creates numerous opportunities for mis-interpretation and even loss of original design intent. (Think of the game Telephone in the US or Chinese Whispers in the UK, where each person in a circle repeats what the previous said, and the speaker is invariably amazed how different the final message is from the original.)

The technical building blocks are now available and proven for clear 3D communication in production without translation into 2D format. These include new approaches to geometric dimensioning and tolerancing (GD&T), model-based product definitions, and 3D PDF files that current MES can leverage in work instructions.

You don’t know what you don’t know: While plants always have performance metrics, they are not always complete enough to provide good feedback on process and product design. Be sure you are:

- measuring as-operated and as-built data in production – a function of MES automation
- aggregating that data into meaningful intelligence – a function of manufacturing intelligence
- creating full context for insight and decisions – a function of search, collaboration and enterprise intelligence

Quality issue solved

“Johnson Controls discussed a challenge with the supply base not prepared to work with semantic GD&T. Going from 3D to 2D and back looks like a comedy, but it’s a serious issue. All of this so called translation is an opportunity to introduce error in that process. We use the 3D representation to define and control the manufacturing process.”

Don Jasurda
VP Sales
DCS

Standardize platforms

As with any integration challenge, the fewer elements there are to integrate, the easier. So, to the degree it is possible to standardize on software platforms for both virtual process and product design, and real production support, the path to V2R can be significantly smoother.

Many companies have built up their manufacturing systems division-by-division or plant-by-plant. Honda is a great example of this, and the culture of local control builds beneficial buy-in. However, as the vision expands, company-wide standardization can come through positive example. One of the easiest ways to achieve this is to upgrade to the most modern software and leverage new capabilities that older systems can’t match. Honda and CenterLine have both done this with their Dassault Systèmes digital manufacturing platform.

Standardizing across the enterprise is equally valuable for the real production plants as well. New Gartner research indicates that companies approaching an MES/MOM project from an enterprise perspective are more likely to achieve project objectives and continue their investment in MES/MOM.

This research, which was conducted in conjunction with MESA International and presented in December 2014 as the Webcast Has MES Come of Age?, shows that those with an enterprise approach were more likely to gain benefits rapidly in these areas:

- Reporting latency
- Visibility across the manufacturing network
- Reducing cycle or lead times

Those taking an enterprise approach were the only ones able to report MES benefits in these key business areas:

- Expanding markets and segments
- Improving market share

Approach it realistically

Standardization and end-to-end automated data flows do not occur overnight. Most manufacturers have many systems to change and integrate. So the key is to look for areas that need improvement and make those gains first.
Appropriate automation: Issues such as measuring what’s happening in production and simulating how a process will work often begin with automating a process. Finding where the most critical information leaks and risks occur can point to where an automation project can deliver short term gains and build toward that long-term V2R vision. It’s also important to recognize that some things shouldn’t be fully automated: they need systems that help people to interpret what is happening in virtual, real, or both worlds.

Lose legacy little by little: While standardization would point toward replacing many older systems, it’s important to prioritize. Select the elements of the V2R flow that are most deficient for possible benefits from a modern system. Another approach is to consider which systems could be replaced with minimum disruption for high benefit. Recognize that some things are probably going to be in non-standard systems for a while. Leverage the best of those legacy systems whenever you can.

Creativity for Cracks: You may need to create something custom in the short term to fill in specific gaps in your information flows. Realize that this is either

- a temporary situation where you collaborate with a preferred software provider to build new capabilities for their system
- an area of competitive advantage where you will build intellectual property that you must continue to maintain and modernize for business continuity

Some of those furthest along, such as Align and ConforMIS, have developed some custom software. They know they are ahead of the market, and will provide limited information about their implementations.

We do know that those two medical device companies have commercial software in place for both 3D design (CAD) and production management (MES) along with the proprietary software they developed. What we do know is that the custom software is specifically designed to translate models built from medical imaging into usable 3D models for production. So this is integration of V2R for their very specialized needs.

Other companies and industries may similarly find that there are technology needs that commercial packaged software cannot fully address today. However, the depth and breadth of application software commercially available and open for integration has grown rapidly in the past few years. Any decisions about whether to build or buy requires vigorous research about both current and near-future roadmap capabilities of commercial applications.

For example, Honda is working with the Dassault Systèmes team to ensure that certain required digital manufacturing capabilities are incorporated in the core offering.

Bring a vision into reality

Creating a breakthrough way of doing business is always challenging. A vision such as V2R that crosses so many boundaries is particularly fraught. V2R crosses conceptual, knowledge set, organizational, process and application boundaries. In fact, some simpler version of V2R has been a dream in the manufacturing IT world for at least 30 years. (Anyone else remember computer integrated manufacturing or CIM?)

Incomplete or inadequate application and integration technology was a major factor decades ago.

Fortunately, the technology has come a long way. Depending on the company, the mindset, organization, processes and technology will each need different levels and focus areas to build toward the V2R vision.

The goal is for each step to create an effective and collaborative building block toward V2R. Early examples of companies that have done that tend to be clean slates. However, many larger companies with more legacy systems and equipment in place are stepping up to this vision.
Promote progress: To achieve success, companies must show and celebrate their successes. The typical approach is to measure benefits, publicize them and celebrate both small and large wins. In many cases, visible gains in efficiency and effectiveness make a large impression on those not yet a part of the process. This starts momentum, pulling the project through the organization rather than pushing it out.

Conclusion
To successfully deliver innovation with V2R, a company needs both a broad vision of how this concept will impact their operations and its benefits as well as a pragmatic plan to move toward the vision. The plan and its execution must be multi-dimensional, well beyond the 3D virtual needs.

Try to avoid “big bang” types of transformations – the risks and complexity are too high. Rather, start small, gain experience and continue along a multi-year strategy.

Make the vision and the path to achieving it clear. It can be a reality if you can align to it.

Additional Resources

Align Technology – [www.aligntech.com](http://www.aligntech.com)


DELMIA Case Study [http://www.3ds.com/customer-stories/single/centerline-windsor-limited/?xtmc=CenterLine&xtcr=1](http://www.3ds.com/customer-stories/single/centerline-windsor-limited/?xtmc=CenterLine&xtcr=1)

Chrysler – [www.chrysler.com](http://www.chrysler.com)


ConforMIS – [www.conformis.com](http://www.conformis.com)

http://www.conformis.com/mass-production-mass-customization-todays-medical-developments/


DCS - [http://www.3dcs.com/](http://www.3dcs.com/)

Case studies here: [http://www.3dcs.com/more-info.html](http://www.3dcs.com/more-info.html)

Embraer – [www.embraer.com](http://www.embraer.com)


Honda – [www.honda.com](http://www.honda.com)

Presentation at COE 2014 Annual PLM Conference & TechniFair April 2014: DELMIA V6: Honda First Step Into PLM


Has MES Come of Age webcast [https://services.mesa.org/ResourceLibrary/ShowResource/47eff093-b4f9-417e-9aa1-1ddb3e82757](https://services.mesa.org/ResourceLibrary/ShowResource/47eff093-b4f9-417e-9aa1-1ddb3e82757)

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