Experiencing virtual manufacturing:

Collaboration in Product and Process Development

Project overview: Dr Ferdinando Milella, Virtual Engineering Centre
Technical perspective: Andy Reilly, Optis Northern Europe
OEM perspective: Senga Shufflebotham, Bentley Motors

SAE 2015 Augmented and Virtual Reality (AR/VR) Technologies Symposium
Topics

• Project overview and robust assessment framework

• OEM challenge

• SME solution

• Impact
The project

Dr Ferdinando Milella
Virtual Engineering Centre (VEC)
STRIVE: buying time and saving money

Ability to achieve targets, reduce cost and improve time to market
New digital supply chain: Why?

- Manufacturing is changing and many physical processes are being replaced by digital processes.
- Provide a route for SME’s to exploit innovative software tools and accelerate impact.
- Developing a seamless and integrated solution, driven by OEM needs.
Aims of STRIVE:

- Transforming the New Product Development process in order to fully exploits the benefits of high fidelity model analysis and immersive virtual prototypes.

- To create a new “digital” supply chain to support UK manufacturing which is increasingly having to adopt virtual technologies to remain globally competitive.

- Support the development of ‘digitally enabled engineers’ for faster adoption of innovative technologies.
A collaborative R&D project

- **Bentley Motors** | OEM and R&D test bed
- **Northwest Automotive Alliance (NAA)** | Contract lead partner
- **Virtual Engineering Centre** | University of Liverpool, technical lead partner
- **OPTIS** | SME delivery partner, physics based simulation software
- **Icona Solutions (OPTIS Pristine)** | SME delivery partner, perceived quality specialist software
- **DNA Agile (Valuechain.com)** | SME delivery partner, cloud-based data capture and workflow systems
Funding and support

Advanced Manufacturing Supply Chain Initiative (AMSCI)

- STRIVE is a three year R&D project - now in final year

- The STRIVE project was awarded funding from the Advanced Manufacturing Supply Chain Initiative (AMSCI) – a Department for Business Innovation and Skills (BIS) initiative to support the development of UK Manufacturing Supply Chains

- The AMSCI programme is managed by Finance Birmingham.
“VEC sandpit”

Strategic partners & Creating New Supply Chains

Our Research Process:
- Innovation Sand Pit
- Consortium working
- Business Driven
Robust development

Underpinned by academic expertise at the University of Liverpool:

**VEC Digital Design and Manufacturing (School of Engineering)**
Design and realisation of Virtual Immersive Environments, motion and object tracking, development of VR interactive modules, tactile feedback software and hardware development, VR/AR system integration, etc.

**School of Psychology**
(Multi-)sensory perception and cognition, multisensory integration, VR presence and immersion analysis, task performance evaluation, behavioural analysis, etc.
Immersion and presence

*Fundamental concepts to understand subjects’ physical and psychological experiences in virtual environments.*

**Presence** – subjective experience of being in one place or environment, even when one is physically situated in another (Witmer and Singer, 1998)

**Immersion** – refers to objective level of sensory fidelity that a VR system provides (Slater, 2003)

*Two approaches:*
- **Subjective** – conscious introspective judgment regarding their experience (questionnaires)
- **Objective** – physiological or behavioral responses (performance)
Immersion virtual reality allows us to interact and perceive the environment through different modalities (visual, audio and tactile) to improve subject’s presence and quality of experience in real time.

Software plug-ins and modules have been developed and tested by the VEC to implement multi-sensory modality (combining visual, audio and tactile cues) in STRIVE tools to enhance understanding of issues and problem-solving capabilities.
Haptic (Tactile) Devices
Cues in virtual reality

In collaboration with:

- Behavioral study – to evaluate human performance in VR environment
- Perception study, using factorial design, ANOVA - all possible combination of conditions

VIRTUAL REALITY → high realism, high fidelity

Key questions:
- Do we need all cues to be perfect?
- Do we need all the information to be accurately rendered?
- What about giving additional cues?
Underpinning research

Main aim - investigate which sensory feedback contribute most to task performance and the sense of presence in virtual reality environment.

Hypotheses:
1. Faster overall completion times and higher sense of presence when multimodal feedback is presented.
2. Slower overall completion time and increased reports of discomfort during modulation of the VR environment.

Methods
* 16 participants,
* 3D power wall at Virtual Engineering Centre, Daresbury
* Objective measures - task performance
* Subjective measures - Immersive tendencies questionnaire (ITQ) (Witmer and Singer, 1988), Presence questionnaire (PQ) (Witmer and Singer, 1988), Simulation Sickness questionnaire (SSQ) (Kennedy et al, 1993)
Participants performed the best and reported an enhanced sense of presence when multimodal feedback was present (AVT) followed by bimodal feedback (AV, AT, TV) and then by unimodal feedback (A, T, V).
The OEM Challenge

Senga Shufflebotham
Bentley Motors
Introduction to Bentley factory, Crewe

- Over 4,000 employees in Crewe, Cheshire
- All functions integrated on one site
- Manufacture all main components, Wood, Leather, Engine, Seats etc...
Why Bentley joined STRIVE

Technical Challenges & Purpose Of the Project

- Current high use of Physical Properties
- Bentley “Manufacturing “not exploiting opportunities of virtual technologies.
- Low levels of investment available, economies of scale.
- The use of different data sets across various functions causes conflicts (Concept, Eng, Man)
- Government Regional Growth Funding Available
Bentley aim:

- To **reduce project investment** on physical models/properties
- To have **one common data set** used cross business
- To instigate Dynamic Immersive Cross Functional Review
- **Increase effectiveness** of visualising manufacturing feasibility
- **Identify and resolve problems earlier in the project cycle**
Bentley key driving factors

DIGITAL FACTORY

High use of Virtual prototypes

More Efficient use of resource

Mfg Targets

COMPARISON WITH TARGETS

Ability to Achieve targets, reduce cost and improve time to market!
Bentley requirements

1. Visualisation
   Allows us to view vehicles in an immersive environment that looks and feels real, visualising manufacturing issues on the surface of the car.

2. Immersive Manufacture and Assembly
   Allows us to assess the vehicle build before parts are available, validate processes & drive design changes to parts and use virtual reality as a training aid.

3. Real-time Issue Capture and Resolution
   Allows us to capture and resolve issues real-time, reducing inefficiency in capturing issues.
Bentley work stream 1: visualisation

- Cross functional reviews
- Immersive visualisation of gap and rad targets
- Circa 17 surface changes already instigated on new projects
Bentley work stream 2: immersive manufacture

- Demonstrations ran to gain input from Bentley employees in tool development
- Used for identification/resolution of:
  - Part load issues
  - Ergonomic assessments
  - Tool access
- Already stopped 2 no build issues on new projects
Bentley work stream 3: issue capture

Live Issue Capture

Issue Tracking and Reporting
- Advanced Issue Filtering
- Ampleblatt Generation
- Report Generation
- KPI Monitoring
- Concurrent Working
- Issue Closure

Virtual Reviews

Immersive Manufacture

Physical Builds

Bentley iQapture Server
Meeting OEM requirements through SME Innovations

Andy Reilly, Country Manager - Optis Northern Europe
Integration of technologies

- Perceived quality assessment
- Virtual manufacture and assembly
- Real-time issue capture and resolution
Perceived quality assessment
Perceived quality assessment before STRIVE

- High use of physical properties.
- Bentley manufacturing not exploiting opportunities of virtual technologies sufficiently.
Perceived quality assessment with STRIVE

Interior audit
Perceived quality assessment with STRIVE

Exterior audit
Immersive virtual manufacture and assembly
Why a virtual approach?

No need to wait for the first physical parts to:
• Check for assembly by operator
• Visualise product and environment
• Review the whole assembly
• Capture and resolve issues
• Train operators to assemble parts

Manikin in the scene for improved ergonomic assessment
Culture and process change

Seat assembly at Bentley:
Culture and process change

Seat assembly - STRIVE tools:
Digital issue capture and resolution
PROCESS AND TOOLSET INTEGRATION

STRIVE Tools

Virtual Assessment

Virtual Manufacture

Prototype

Production

Lineside issue capture & reporting

STRIVE Tools

Compare virtual vs physical

iQapture

Ampleblatt generation

Issue resolution task console

Issue capture performance monitoring

KNOWLEDGE REPOSITORY
Benefits of real-time issue capture

• Reduces time and costs by streamlining feedback and reporting process

• Proactive issue resolution tracked through integrated task consoles

• Integrated knowledge repository from virtual visualisation through to physical production
Impact and future
Benefits of collaboration

• Fully integrated solution

• 40 Bentley engineers involved in trialling new digital tools

• Co-development of tools based on feedback from manufacturing engineers

• Impact - Bentley already using STRIVE tool set in vehicle development at concept development stage (PR1 and PR2)

• Creating high growth in SMEs

• Safeguarding high value engineering jobs
Impact

- Integrated solution
  - desktop
  - immersive
  - shop floor

- Based on reality
  - physics based
  - real time
Benefits of collaboration

Concept Development | Design | Physical World

PD | PF | KE | DE | DF | BF | LF | VFF | PVS | OS | SOP

Target setting: (PR0) (PR1) (PR2)

Future tools | Tools in Use | Implementation stage

In development
Bentley- implementation and future
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