Scrum for Full-Scale Manufacturing
How the Shop Floor Can Keep Up with Scrum R&D

Joe Justice
President Scrum Hardware Practice, Scrum Inc.
Joe Justice

“WE HAVE FOUND TEAM MORALE TO BE A MULTIPLIER FOR VELOCITY.”

• Founder and Team Lead of Team WIKISPEED - global manufacturer of 100 mpg prototype cars and MicroHouses to help end involuntary homelessness.

• Creator of eXtreme Manufacturing – Technical practices accelerating Scrum in hardware manufacturing and engineering organizations.

• Worked with Scrum in space systems, rockets, missiles, automotive, housing, metrology, medical devices, radio, radar, dev-ops, organizational transformation, entertainment, legal, software architecture, composites, etc.

• Speaker and Consultant at Unesco World Headquarters, Cambridge University UK, UC Berkley USA, Google, Microsoft, Johnson Controls, Boeing, Lockheed Martin, Raytheon, HP, Wikimedia Foundation, Open Source Ecology, TEDx Rainier, Aspen Institute, Pictet Bank, and other organizations world-wide.

Justice@ScrumInc.com
Agenda

• Discuss Lean as a jumping off point
  • Lean is great but it can sub-optimize and increase cost to make changes

• Present four XM principles to speed up the manufacturing line
  • Scrum teams as lean cells
  • Contract-first design
  • Shorten supply chains
  • Keep the line flexible

• Address why you CAN do this (debunk objections)
  • Show tooling and suppliers that make it possible

• Share examples from companies that have succeeded
  • Tait Radio
  • Rocket Bunny (WIKISPEED and Tesla)

Joe Justice @WikiSpeed
Scrum in Manufacturing: A Motivational Example

F-35 “Joint Strike Fighter” – Traditional Design

- $143 billion over budget
- Delayed until 2022 (final systems integration)
- Cost of Navy F-35C grew from $273 million in 2014 to $337 million by 2015

SAAB JAS 39E “Gripen” – Agile Design

- Cumulative program cost of $15 billion
- New iteration of all systems released every 6 months
- $43M cost (20% of F-35)

1. According to Jane’s Aviation Weekly, the Gripen is the world’s most cost-effective military aircraft

Joe Justice @WikiSpeed
Extreme Manufacturing (XM)

I. Scrum Organization
   a. Roles and Responsibilities
   b. Sprints/Iterative Design
   c. Make Work Visible
   d. Measure Velocity
   e. Continuous Improvement (Lean)

II. XP Engineering Principles
   a. User Stories
   b. Pairing and Swarming
   c. Test Driven Development

III. Object-Oriented Architecture
   a. Modular Components
   b. Contract-First Design
   c. Design Patterns
   d. Re-use and Inheritance

IV. Line Setup
   a. Machine Rationalization
   b. Material Selection
   c. Line Skills Selection

Morale is a multiplier for Velocity!

Joe Justice @WikiSpeed
Scale as Competitive Advantage is Declining

If You Aren’t Making Millions of the Exact Same Product, Speed of Changeover is More Important

Major Auto Company’s CNC Machine: $100,000,000
Capacity: One dye per day

Startup Auto Company’s CNC Machine: $2,000
Capacity: One dye per day

That’s 1/50,000th the cost

Source: www.wikispeed.org
Joe Justice @WikiSpeed
Lean Thinking is the Essential Foundation

Lean: Take a systematic view to maximize value delivery across the entire “value stream” rather than focusing on just one step.

Lean: Any activity that does not add value to the end product is waste and should be eliminated from the process.

Lean: Identify root causes of waste and eliminate them rather than treating symptoms.

Lean: Build quality into each step of the manufacturing process to avoid the waste of rework.

However, Lean can make it more expensive to change the line. As speed to change becomes more important than scale, this risks sub-optimizing lifecycle value delivery.

Joe Justice @WikiSpeed
XM Principles and Practices to Build into the Manufacturing Line

A. **Use Scrum teams as lean cells** – Scrum for organization allows teams to improve faster and implement more lean improvements in the same timeframe.

B. **Object-Oriented Architecture** – be willing to over-build at key points to allow greater flexibility for the overall product and leverage design patterns.

C. **Shorten supply chains** – longer supply chains are more prone to disruption and slower to respond. Short ones can turn around iterations faster.

D. **Keep the line flexible** – make it as easy as practical to reformat the line in response to process improvement experiments.

Joe Justice @WikiSpeed
Scrum Teams as Lean Cells

Sprint provides team improvement cadence in addition to Takt time cadence

Retrospective results in at least one Kaizen event per sprint

Pre-shift Daily Scrum helps align cell members and coordinate across cells to achieve day’s production goals

Joe Justice @WikiSpeed
• Volvo’s SPA, or Scalable Product Architecture, announced August 13th, 2014
• This Contract-First Design reduces cost to produce many descendent designs
• The next step? Reduce the cost to change the manufacturing process
• For that, we need to add Known Stable Interfaces

Joe Justice @WikiSpeed
Object-Oriented Architecture: Known Stable Interfaces

Pre-negotiated physical and data connections permit greater design versatility, and loose production coupling.

Interfaces deliberately over-designed to reduce need for disruptive re-negotiation.

Joe Justice @WikiSpeed
Object-Oriented Architecture
Design Patterns and Inheritance

- Don’t re-invent the wheel
  - If a proven solution has worked well in the past, start with that and modify as needed

- Reduce complexity – Find solutions that work for multiple aspects of the problem
  - Eg. If a particular bolt works as a fastener in one location, use the same bolt in all similar situations
Shorten Supply Chains for Added Responsiveness

Long and complicated Supply Chains increase...

- WIP Inventory and Working Capital
- Supply Chain Risk
- Feedback Cycles

Joe Justice @WikiSpeed
Keep the Line Flexible

Long changeover time to switch the physical line limits the ability to experiment with new process improvements.

Designing the line equipment to be flexible accelerates continuous improvement and supports multi-product manufacturing.

Some companies go as far as to mount all equipment on casters to drive flexibility.

Joe Justice @WikiSpeed
Top Reasons Companies Say They Can’t Do This

1. “Our product is too complicated to not plan everything meticulously in advance”
   - “Our quality expectations are too high to not follow a documented and unvarying plan”
2. “We have already made large investments in fixed machinery and tooling”
   - “Our product design is too tightly coupled to iterate modules without changing the entire design”
3. “Our vendors are not Agile enough to support this approach”
4. “Key steps of the manufacturing process require too long a lead time to fit in sprints”

Joe Justice @WikiSpeed
Even Cheaper for Plastics:

Protomold

- Prototype parts or molds same-day
- Volume parts or molds same-week
- $1-$10k per mold

Joe Justice @WikiSpeed
Suppliers that Make this Possible:
Electronics

RushPCB

- 2-layer circuit boards in 5 days for $10
- Up to 8 layer circuit boards

RuggedCircuits

- Military and aviation grade hardening
- In stock same day $40
- USB programmable, Arduino compatible

Joe Justice @WikiSpeed
Partners that Make this Possible: Full Ecosystem

Local Motors

How It Works

Submit Ideas
Vote to Decide
Prototype Solutions
Micro-Manufacture
Market and Sell

Joe Justice @WikiSpeed
A Lean Production Cell:

Capable of one part every six seconds.
The cost to change?
New metal molds, called dies, up to 40 tons each.
Suppliers for your Production Molds:
Molds Shipped to you Within a Sprint

3d Green Sand Casting

- Volume metal castings same-week
- Fastest, cheapest, quality metal tooling

Joe Justice @WikiSpeed
Even Better, Make your own Molds:
Make your own molds inside each sprint

Subtractive Rapid Prototyping (SRP)

- Roland MDX-40A
  - $8k USD, 12”x12”x4”
  - Quiet for desk office use
  - 28x gives similar work area

- Okuma M560-V
  - $120k USD, 41”x22”x18”
  - Requires trained operator
  - Durable, but costly repairs

Joe Justice @WikiSpeed
Reducing the Time to Change Molds: Change your Production Each Sprint with your Own Molds

Globe Industries

- Line-Speed composites: 17 minutes part-to-part.
- 1 minute tool exchange time.
- $1M USD tool.

Joe Justice @WikiSpeed
Even Better, Entirely Skip Molds and Press

Cincinnati BAAM

- Production structural parts same day
- Carbon Filament reinforced 3d printing

Joe Justice @WikiSpeed
Mission Bell Winery
Madera, CA
60 acres of Scrum Wine
UTAS Aerospace Systems
Des Moines, IA
Jet engine fuel injection

Joe Justice @WikiSpeed
KVH Satellite Systems
Middletown, RI
Scrum Maritime Data and streaming

Joe Justice @WikiSpeed
Profile of a Disruptive Supplier:
Rocket Bunny and Liberty Walk

Joe Justice @WikiSpeed
From Idea to Customer in 1 Sprint

1) Scan
2) CAD, post to Facebook
3) Machine Foam Mold

4) Build and Race
5) Polish and Show
6) Sell Sell Sell

Suppliers are doing this now. If your suppliers can’t do this...find different suppliers

Joe Justice @WikiSpeed
Conclusions

• As market responsiveness becomes more important than scale, adding agility to manufacturing is essential

• XM enhances Lean with Scrum and other Agile practices to the physical R&D and manufacturing world

• Four practices should be of interest to manufacturers:
  • Scrum teams as Lean cells
  • Contract-First Design
  • Shorten supply chains
  • Keep the line flexible

• All of the reasons you think you can’t do this have already been solved

• Companies are starting to leverage Agile manufacturing to succeed in the market. Is your competitor one of them?

Joe Justice @WikiSpeed
Questions?

Joe Justice @WikiSpeed
Stay Connected

Scruminc.com
• For up coming events, new content releases, and more!

ScrumLab
• articles, online courses, tools, and papers on all things scrum
• www.scruminc.com/scrumlab

Blog
• http://www.scruminc.com/category/blog/

Online Courses
• advance your scrum with our online courses. Visit the Scrumlab store to view upcoming topics.

Twitter, Facebook, and G+
• @ScrumInc, @jeffsutherland, scrum and scrum inc.