



FORGE

Bootstrapping Hardware Development

Overview

- Innovations by the Open Source and the commercial DIY community have significantly lowered the cost of hardware prototypes
- Likewise, B-to-B Prototyping bureaus are making higher resolution parts at ever lower prices.



- This allows for faster, lower cost, lower risk design cycles

About the Speaker

- Matthew De Remer has worked in multiple industries for the last 20+ years
 - Designed an automotive safety sensor with production volumes of 1,000,000+ year 2
 - Designed medical device capital equipment with production volumes of less than 10 units a year

Agenda

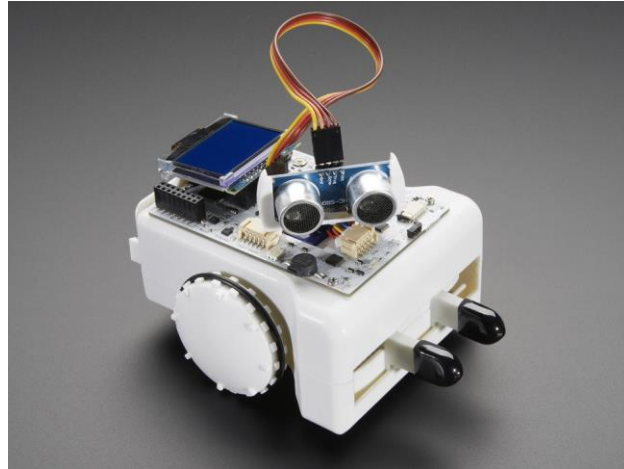
- Who? Where?
- How? Electrical, Mechanical, Firmware
- Costs
- Why Prototype?
- When? Different Development Processes
- Other Thoughts

Who? Where?



How?

- Mechanical Design and Engineering
- Electrical Design and Engineering
- Firmware Authoring

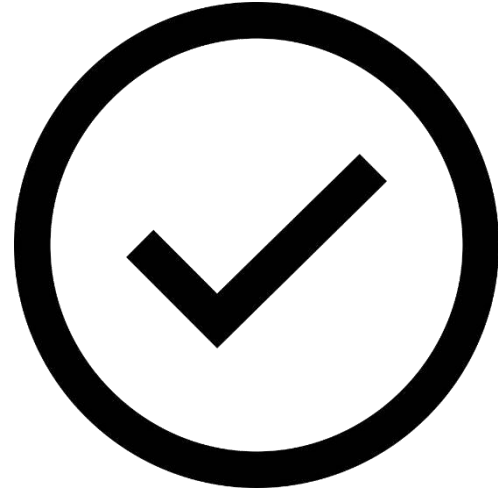
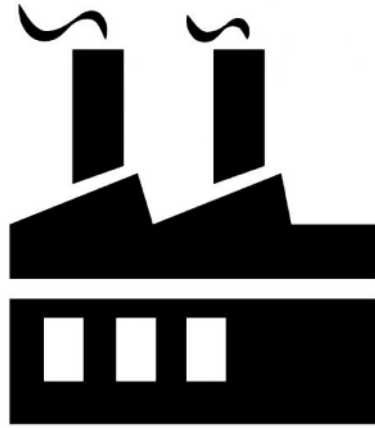


Electrical Fabrication

- Off the shelf Systems-on-a-chip
- Plug and play sensors
- Dev kits



Custom Electrical Design



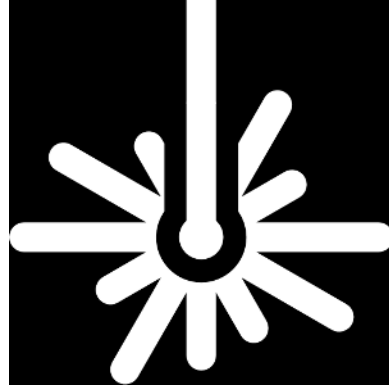
- Altium LaunchPad (free to startups)

- Quick turn PCB Fab and hand solder (1 to 10 days)

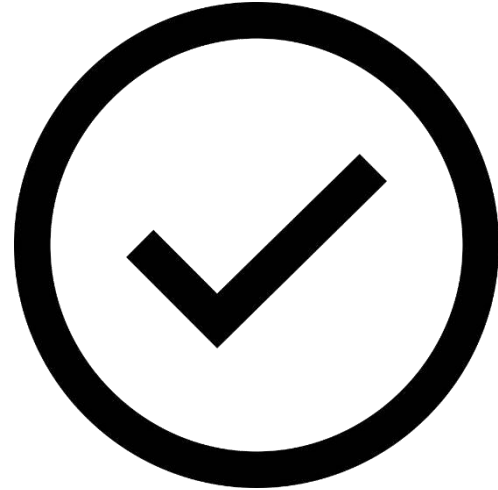
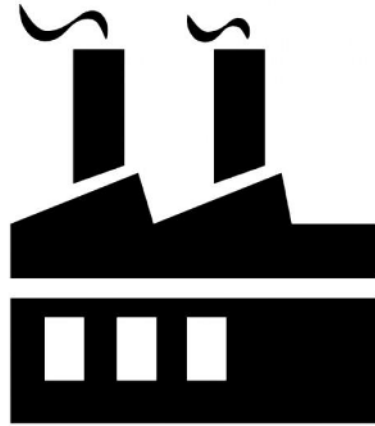
- Production Intent Prototypes

Mechanical Fabrication

- 3D Printing
- Rapid CNC
- Laser Cutting
- Off the shelf subassemblies



Custom Mechanical Design



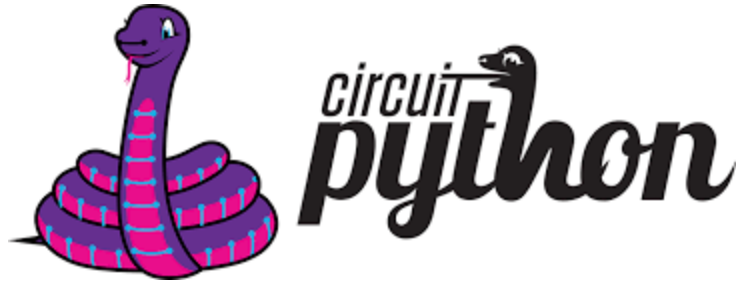
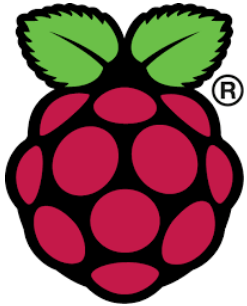
- SolidWorks (free to startups)

- Quick turn high precision or high strength or both (1 to 10 days)

- Look likes or production intent parts

Firmware

- Open-source operating systems with sample code, modules and drivers



Material Costs

- Prototypes can easily be sub-\$500
 - \$45 Arduino Uno with WiFi
 - \$80 LTE Shield
 - \$80 Sensor Shield
 - \$160 FDM case halves
 - \$20 Misc. wires and screws
 - \$100 special sensor or CNC machined part

Why?

- This hypothetical \$500 prototype is not a salable product. Why do it?
- This Proof of Concept (POC) can:
 - Reduce program risk
 - Demonstrate core functionality
 - Demonstrate novel functionality
 - Allow for iteration with use model, software, etc.

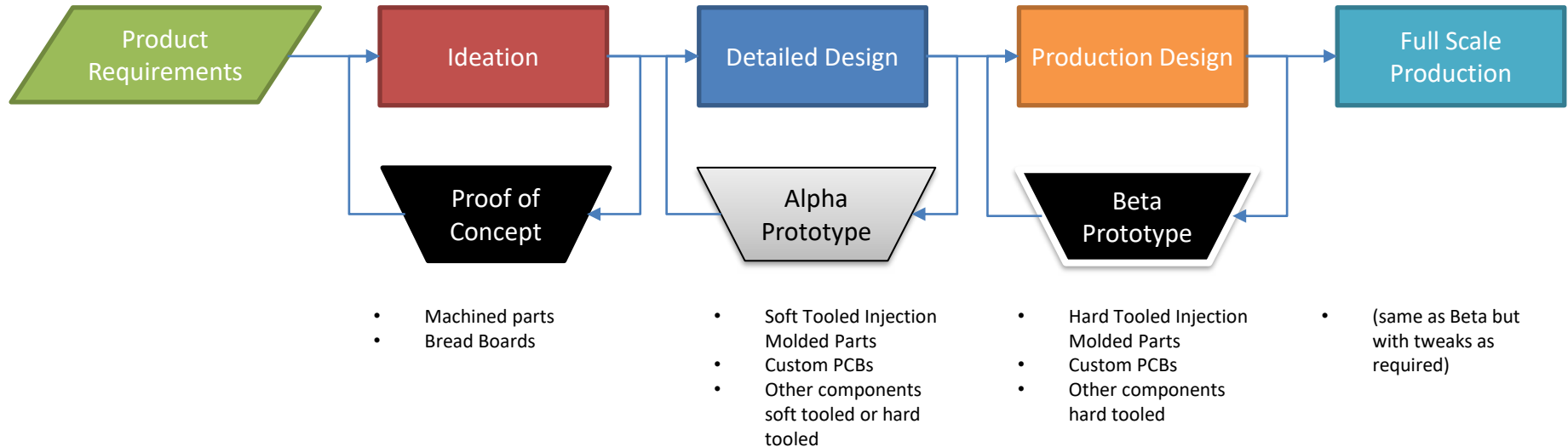
Next steps after POC

- Minimum Viable Product? Alpha? Beta?
 - Alpha: Prototype with only key features
 - Beta: Alpha with more features
 - MVP: Production intent design that has the minimum feature set to be successful in the marketplace
- More feature rich or complex products deserve more prototypes

When? The OLD Paradigm

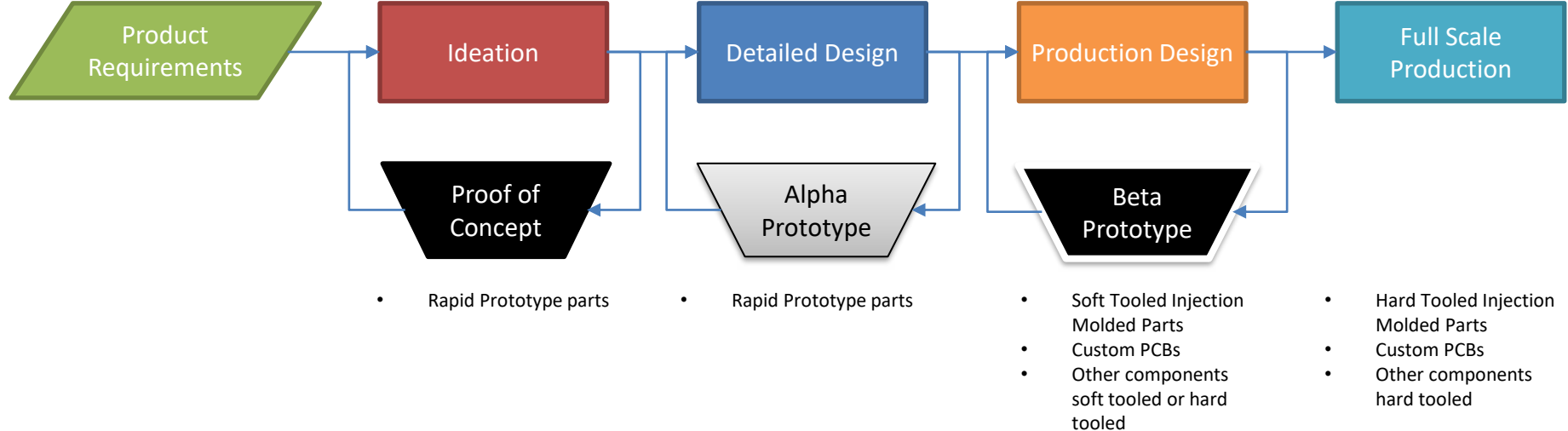
Each phase builds from the previous phase to add more complexity to the design and gradually mitigate risk at the cost of long design cycles and higher development cost.

Overall cycle is 12 to 24 months

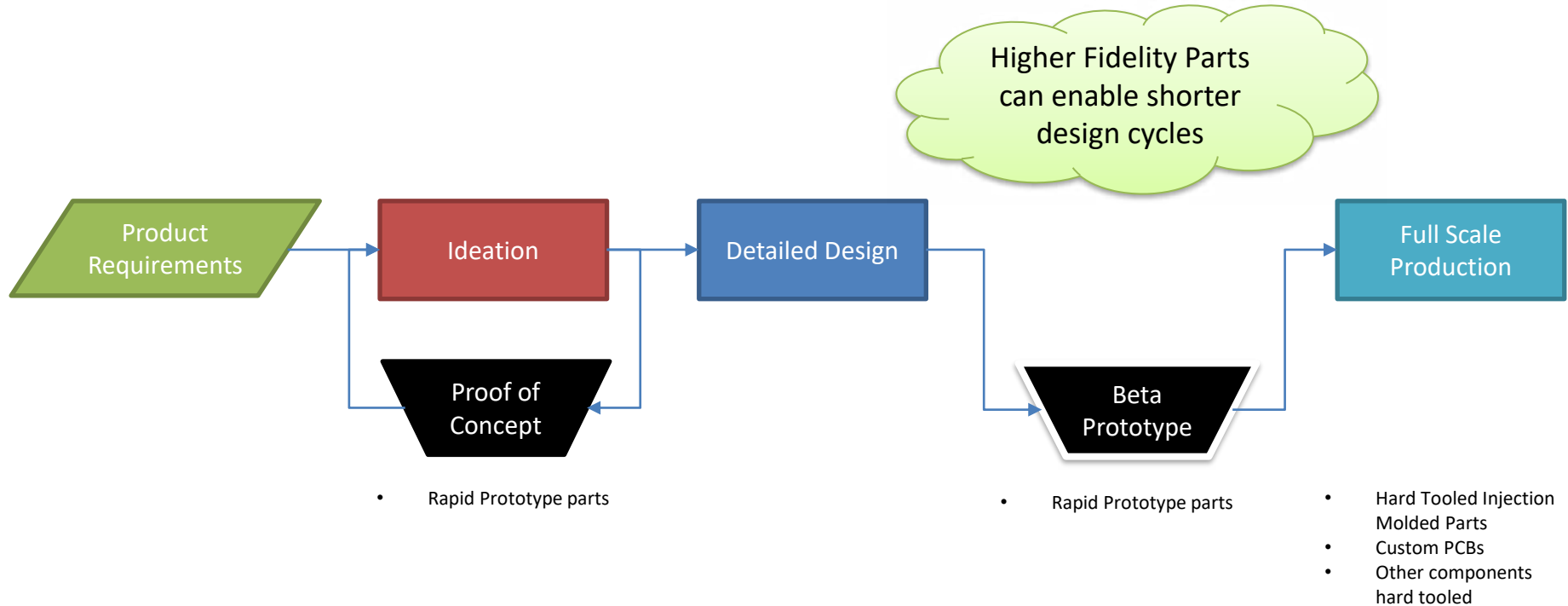


The NEW Paradigm – Delayed Capital

Lower cost and higher fidelity prototype can push capital investment to later in the design cycle and shorten cycles to 6 to 9 months

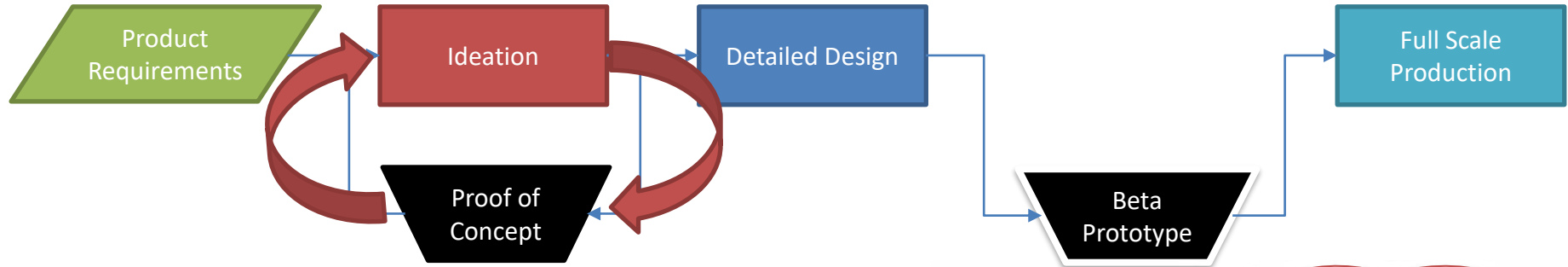


The NEW Paradigm – Faster Design Cycles



The NEW Paradigm - Risks

Don't get trapped in an ideation-prototype loop. Sometimes any decision is better than no decision



Skipping phases and prototypes for expediency can introduce more risk

Other Thoughts

- Prototype and production pricing is very different – make a production intent costed BOM estimate early (and often).
- NRE, tooling, MOQ and other upfront costs can be overwhelming. Try to estimate these as well to budget for production start.

Sourcing in 2022

- The “chip” crisis isn’t over
- Buy earlier in the design cycle at risk
- Hopefully, things will get better later this year, but for some industries it might be 2023



Download slide deck at: <https://www.bayarddesign.com/masterclass-download/>

About Bayard Design

Bayard Design provides engineered solutions to our customers' product design projects. Our team can run your project from concept to detailed design to launch to sustaining to redesign. We bring the latest best practices and techniques to bear on your product.

- Founded in 2007 with offices in Cambridge MA
- 45+ projects with volumes from 10 medical consoles to 1,000,000+ thermostats per year
- A sampling of awards and recognition
 - CNET Editor's Choice Award (2017, ecobee4)
 - New Product Innovation Award in Interventional Cardiology (2014, Corindus CorPath System)
 - Best of What's New, Popular Science (2011, TransMedics OCS Lung)

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3D Printing Landscape

- **2016** was a HUGE year for 3D printing startups



- 2014 3D Systems SLS patent expired
- 2009 Stratasys FDM patent expired
- 2004 3D Systems SLA patent expired