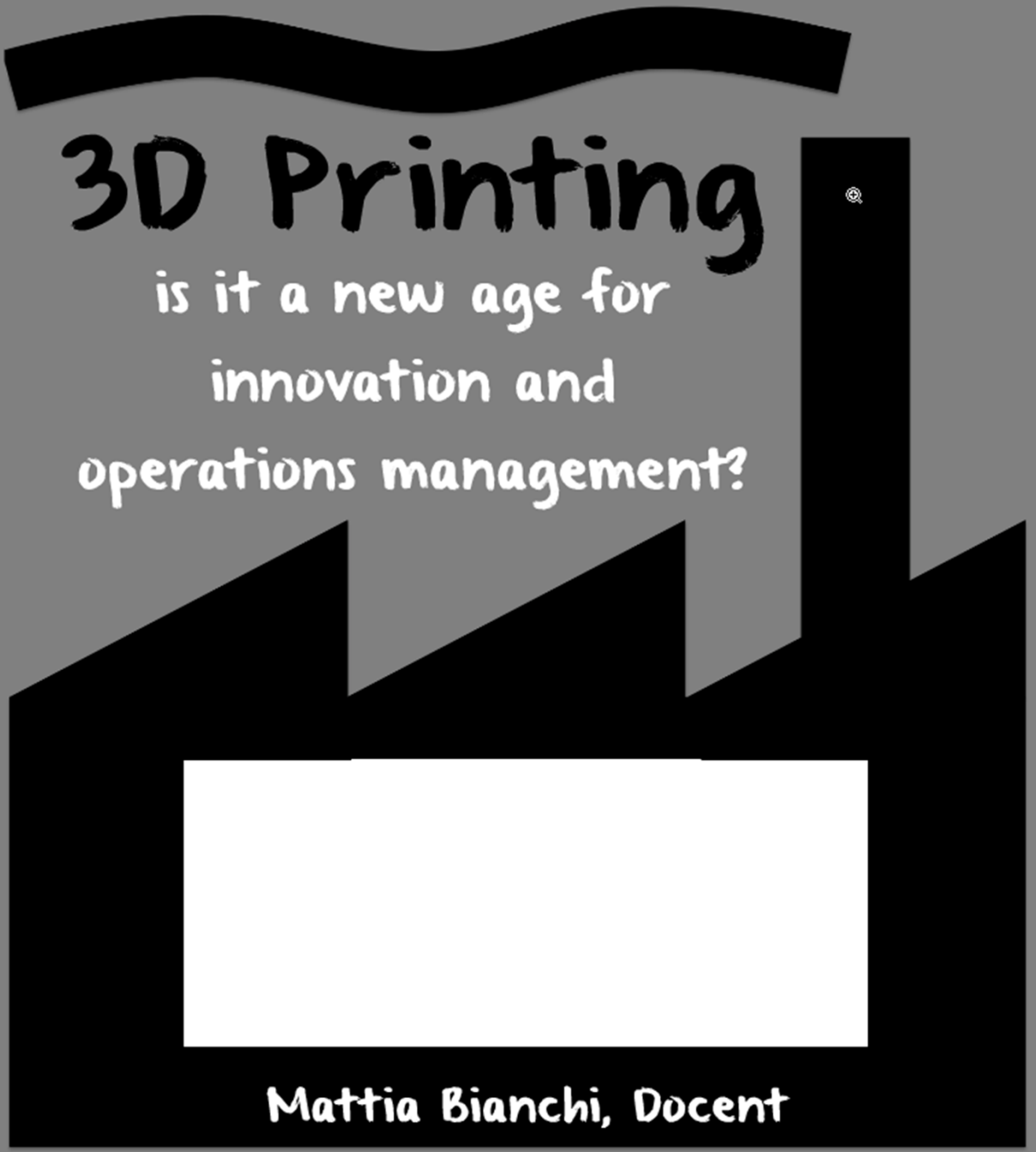
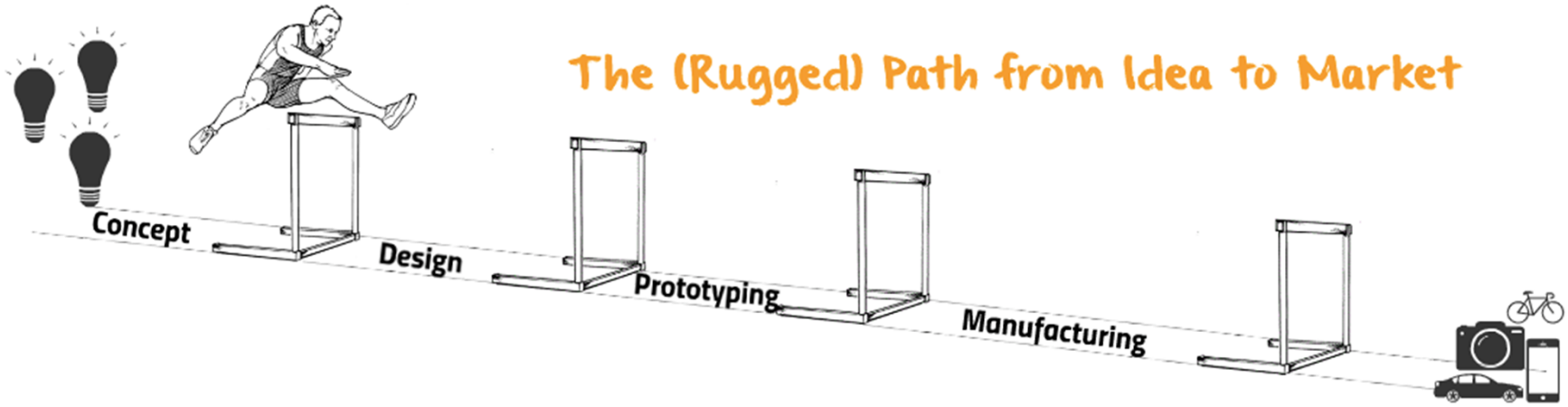
3D Printing

is it a new age for innovation and operations management?

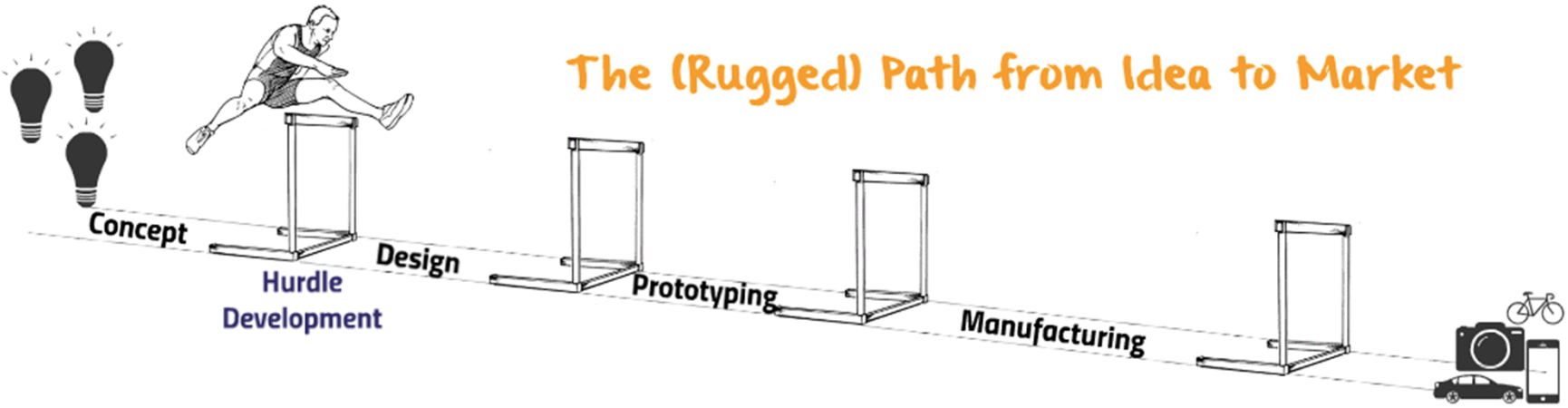


Mattia Bianchi, Docent

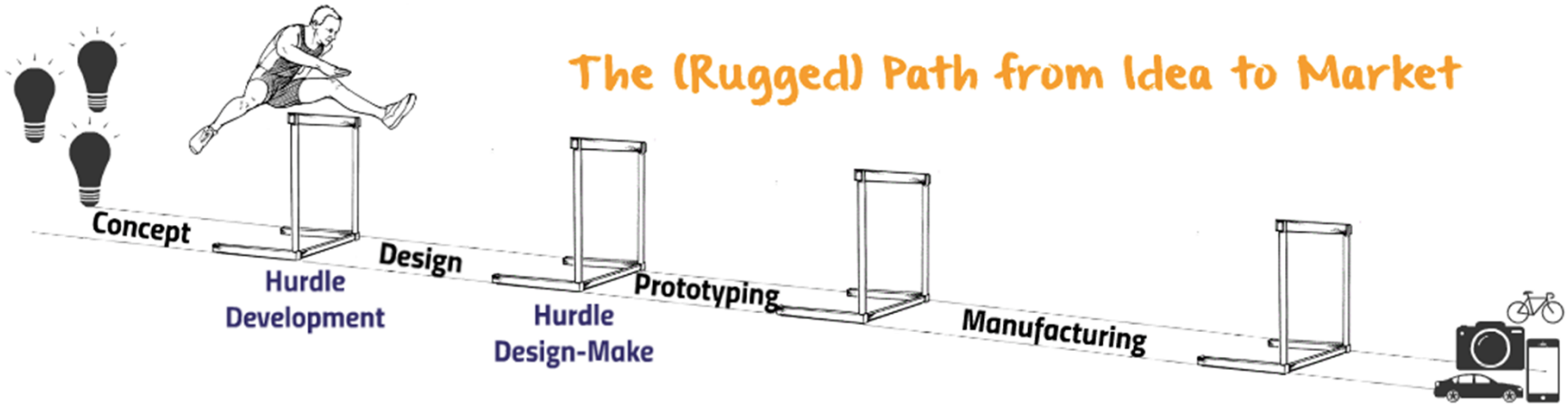
The (Rugged) Path from Idea to Market



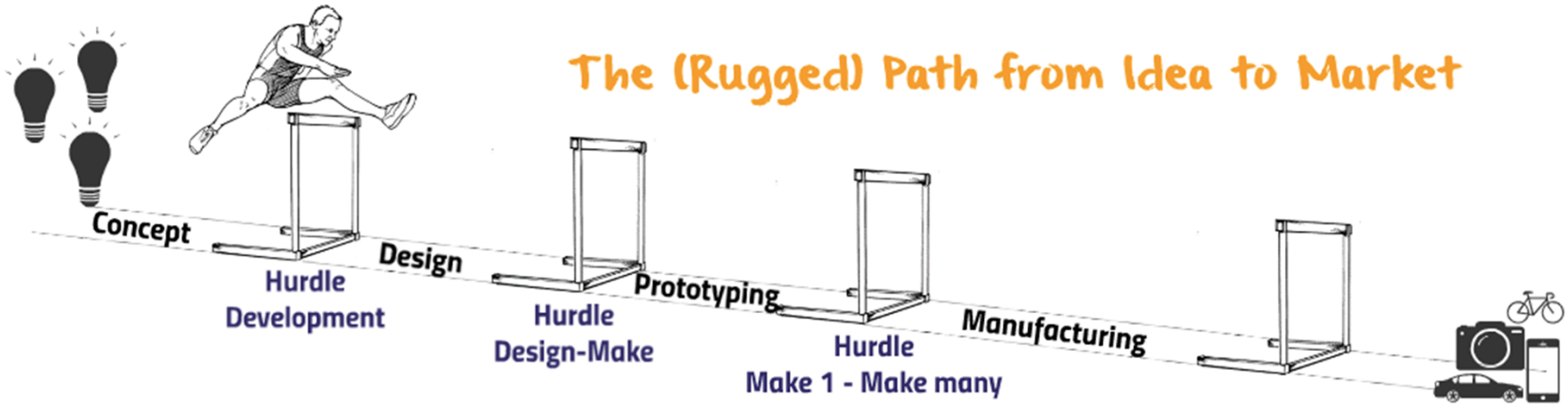
The (Rugged) Path from Idea to Market



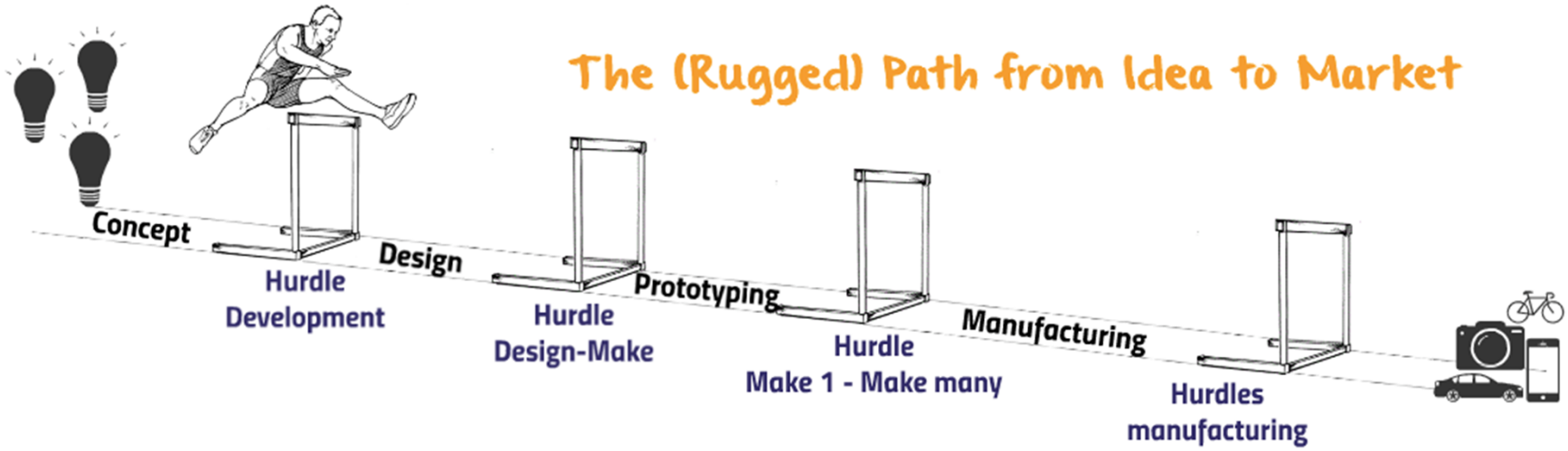
The (Rugged) Path from Idea to Market

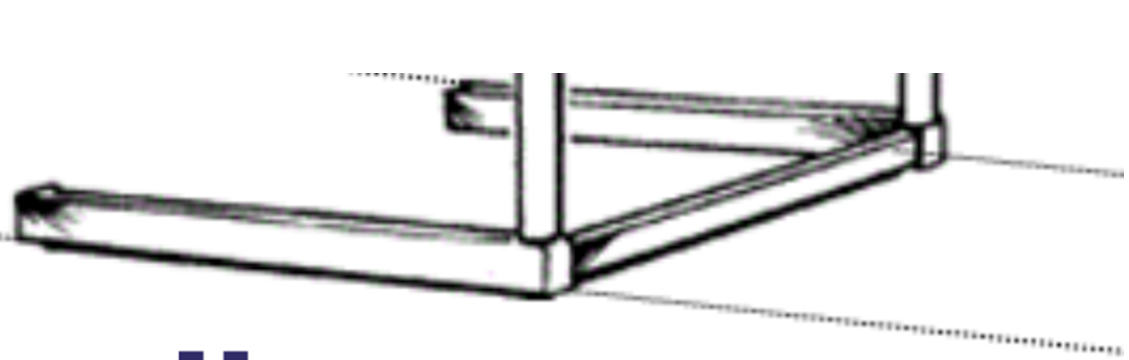


The (Rugged) Path from Idea to Market



The (Rugged) Path from Idea to Market





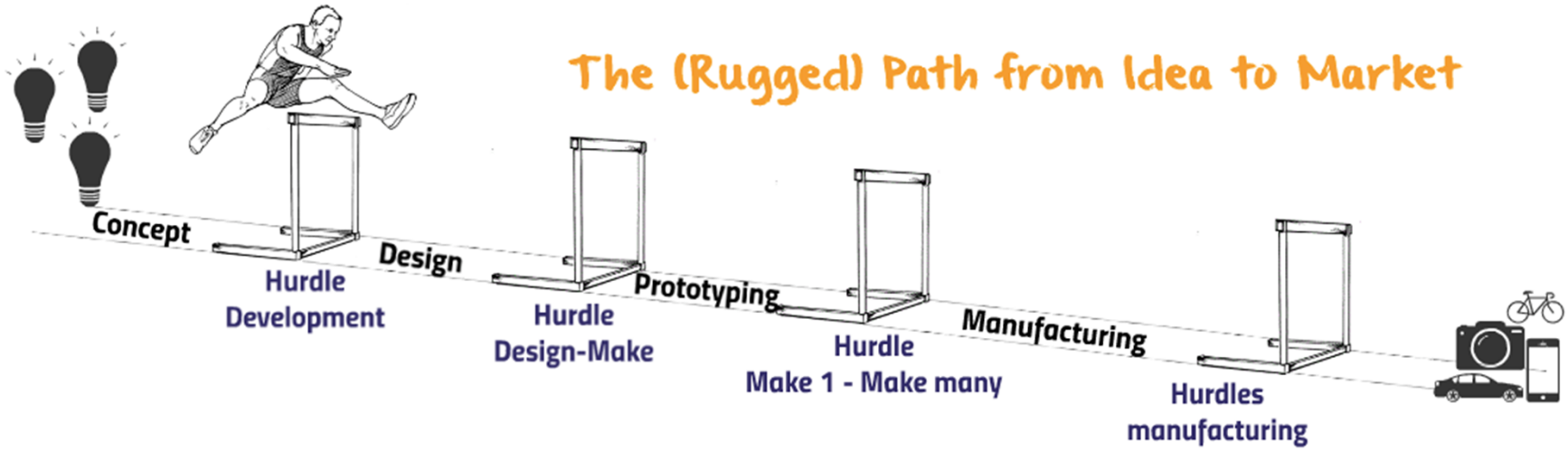
Same old
trade-offs

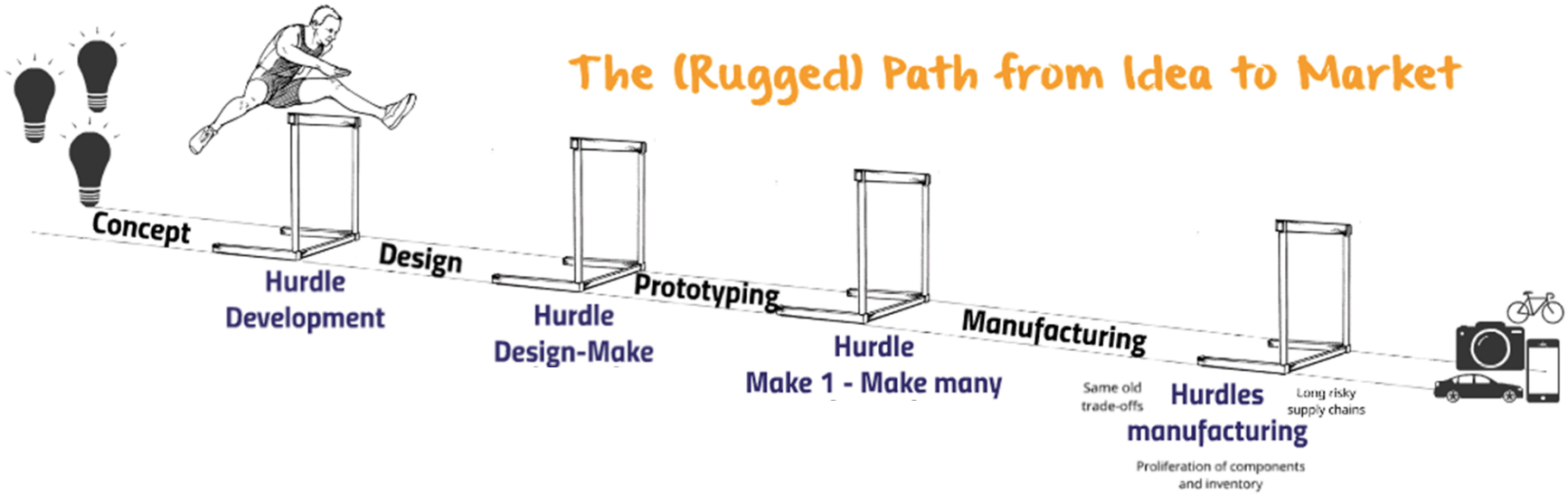
Hurdles manufacturing

Long risky
supply chains

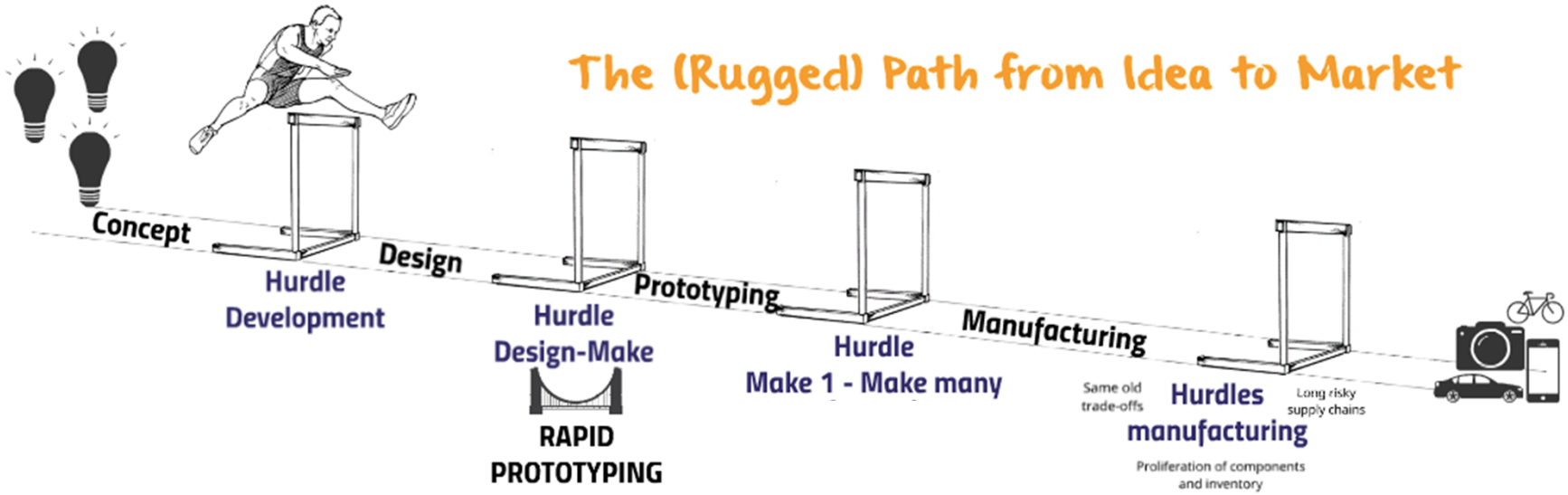
Proliferation of components
and inventory

The (Rugged) Path from Idea to Market



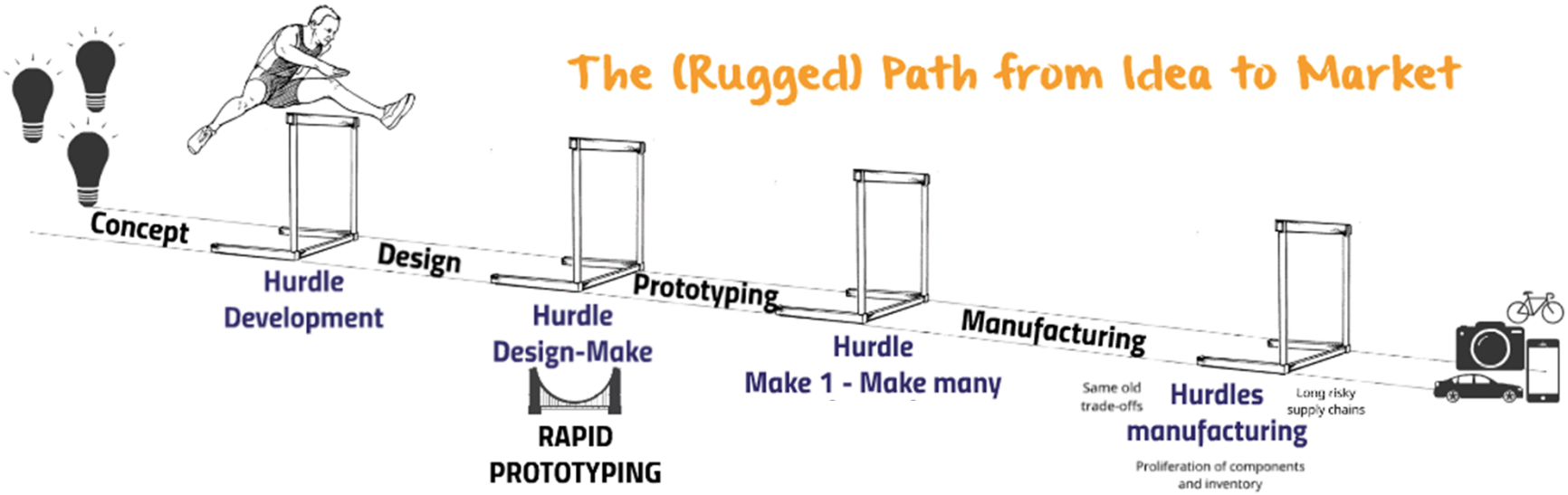

The (Rugged) Path from Idea to Market
Concept
Hurdle
Development
Design
Hurdle
Design-Make
Prototyping
Hurdle
Make 1 - Make many
Manufacturing
Same old
trade-offs
Hurdles
manufacturing
Proliferation of components
and inventory
Long risky
supply chains

3D PRINTING


The (Rugged) Path from Idea to Market
Concept
Design
Prototyping
Manufacturing
Hurdle
Development
Hurdle
Design-Make
RAPID
PROTOTYPING
Hurdle
Make 1 - Make many
Same old
trade-offs
Hurdles
manufacturing
Proliferation of components
and inventory
Long risky
supply chains

3D PRINTING

The (Rugged) Path from Idea to Market



Automated

3D PRINTING

What is it?

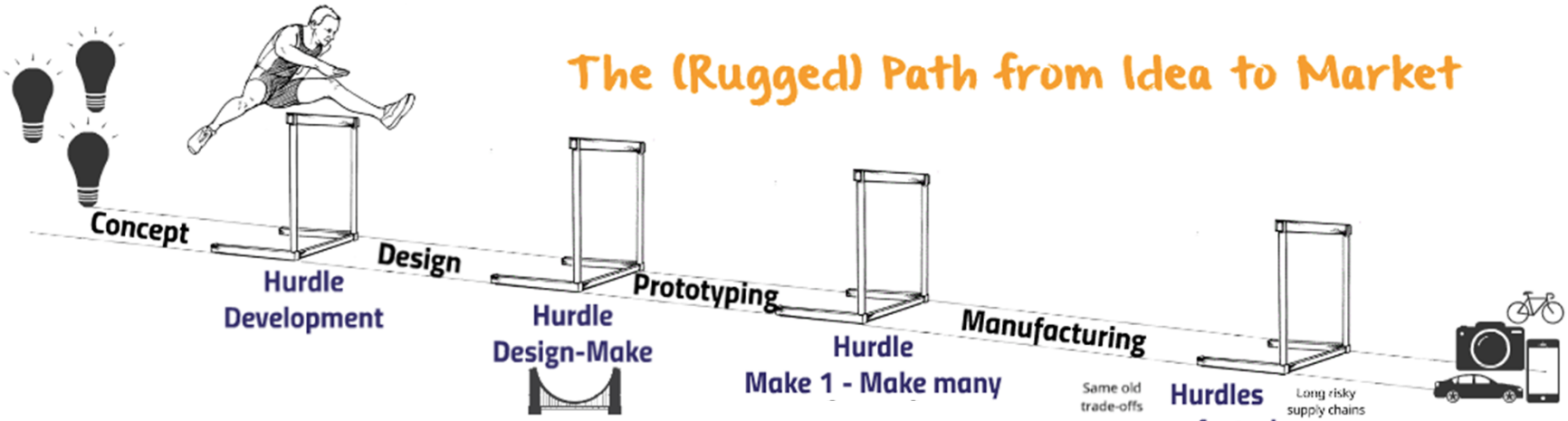
Additive manufacturing (the official name for 3D printing) is the process of joining materials in successive layers to make objects from 3D model digital data

How does it work?

Material extrusion technique

3D PRINTING

The (Rugged) Path from Idea to Market



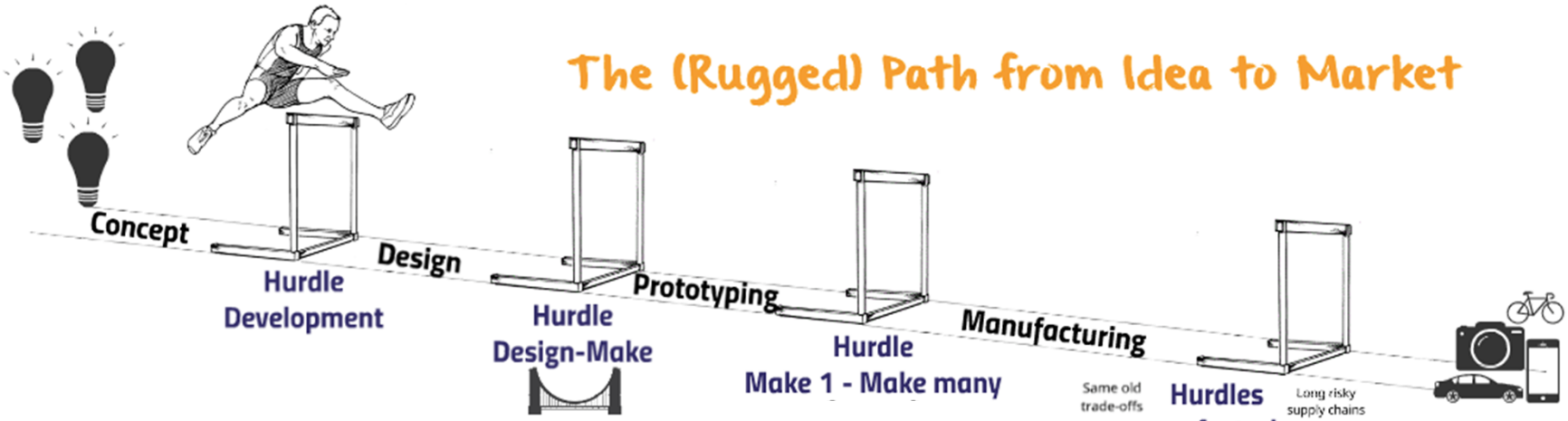
RAPID PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

Automated

3D PRINTING

The (Rugged) Path from Idea to Market



RAPID PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

Proliferation of components
and inventory

Digital

Automated

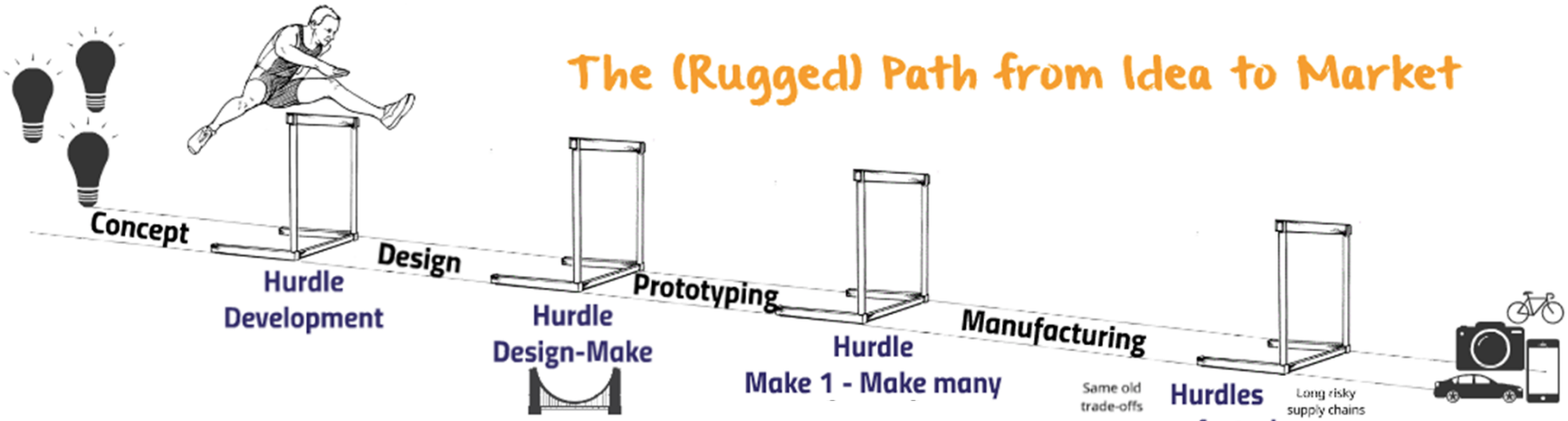
3D PRINTING

Digital

"If you have an apple and I have an apple
and we exchange apples
then you and I will still each have one apple.
But if you have an idea and I have an idea
and we exchange these ideas,
then each of us will have two ideas."

George Bernard Shaw
(1856-1950)

The (Rugged) Path from Idea to Market



RAPID PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

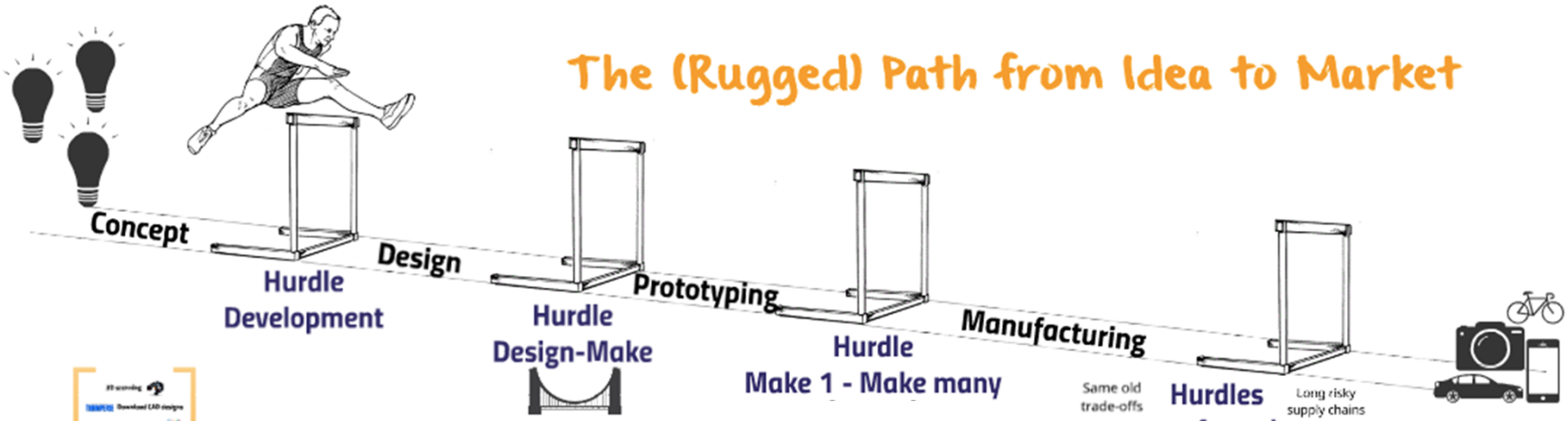
Proliferation of components
and inventory

Digital

Automated

3D PRINTING

The (Rugged) Path from Idea to Market



RAPID PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

Proliferation of components
and inventory

Digital

Automated

3D PRINTING

3D scanning

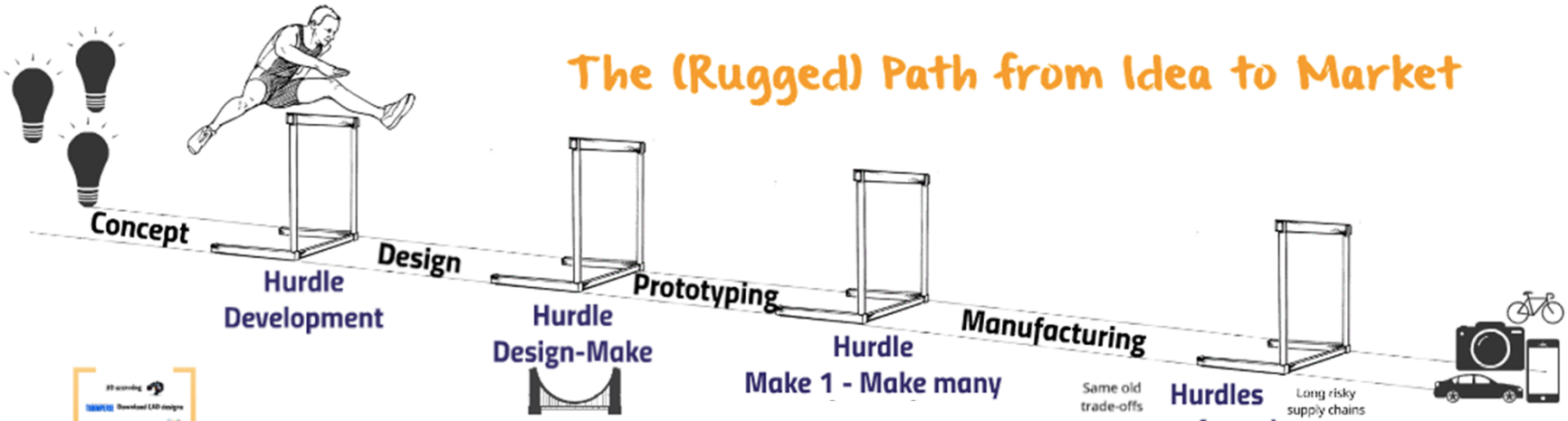
THINGIVERSE Download CAD designs

Open Source CAD software

connect + develop Crowdsourcing

Crowdfunding KICK STARTER

The (Rugged) Path from Idea to Market



RAPID PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

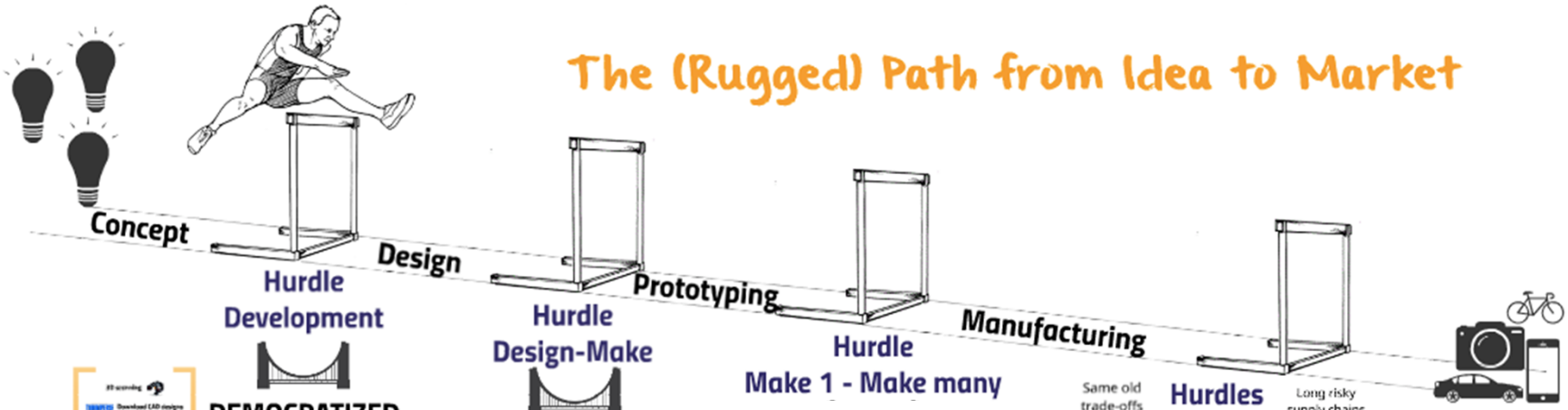
Proliferation of components
and inventory

Digital

Automated

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle
Development

DEMOCRATIZED
INNOVATION

Hurdle
Design-Make

RAPID
PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

Hurdle
Make 1 - Make many

Same old
trade-offs

Hurdles
manufacturing

Long risky
supply chains

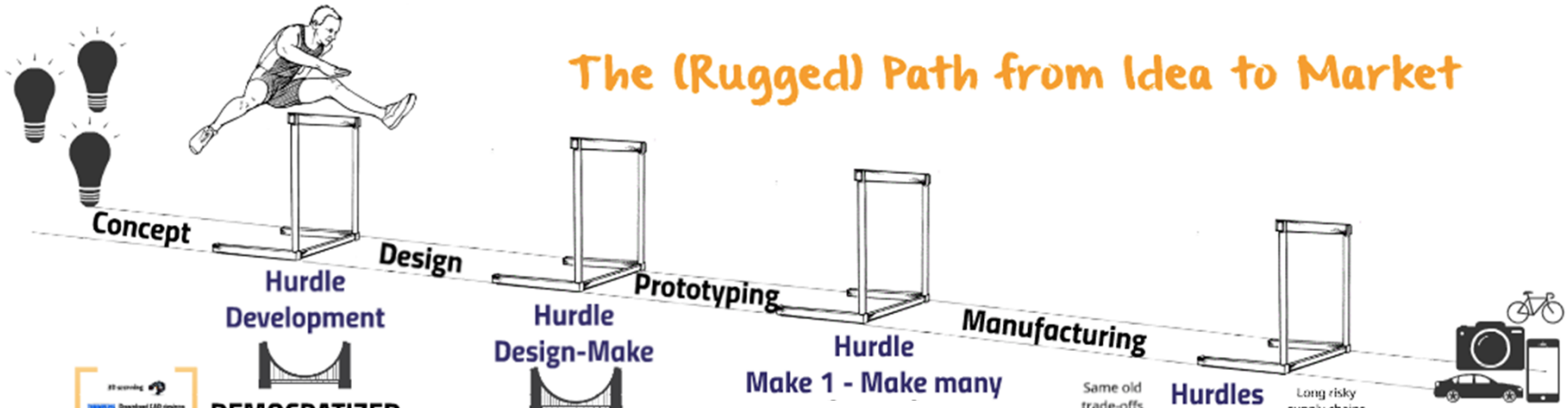
Proliferation of components
and inventory

Digital

Automated

3D PRINTING

The (Rugged) Path from Idea to Market



DEMOCRATIZED INNOVATION

RAPID PROTOTYPING

More prototypes,
cheaper,
more accurate
and realistic,
more easily
updated

Proliferation of components
and inventory

Digital

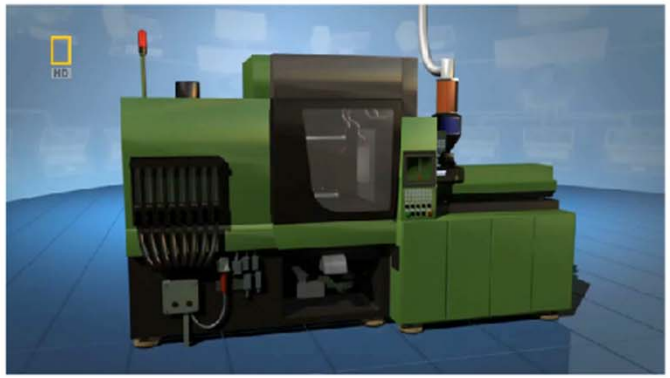
Automated

No tooling

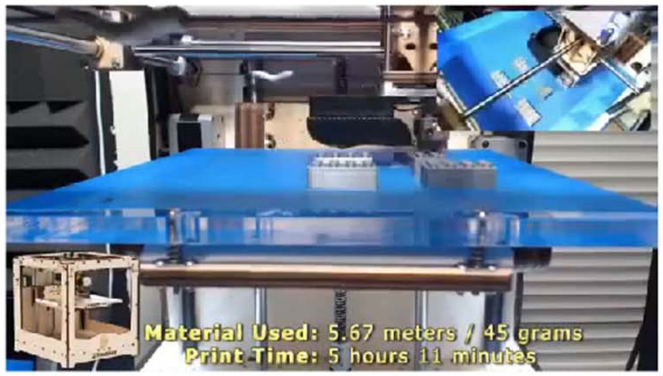
3D PRINTING

No tooling

Making Lego bricks...

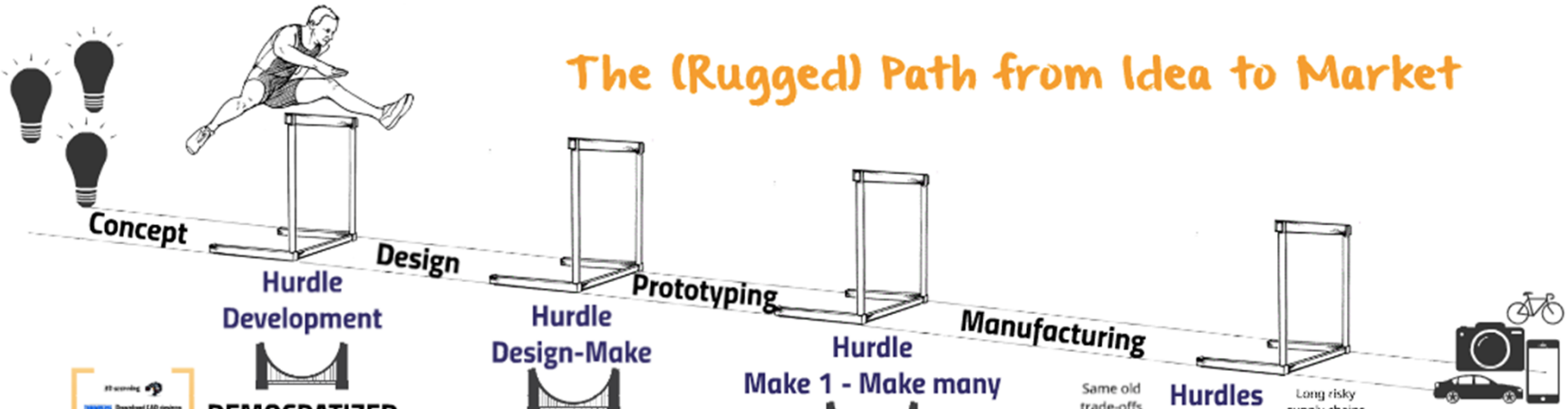


Traditional formative technique
Injection moulding



3D printing
No tooling required

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Proliferation of components and inventory

Long risky supply chains

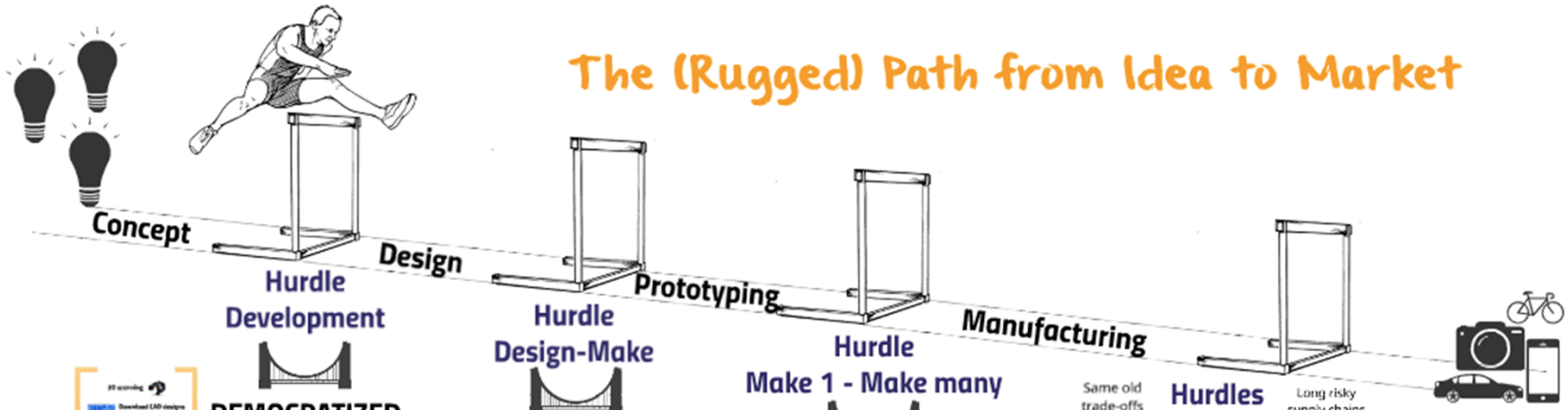
Digital

Automated

No tooling

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle
Development

DEMOCRATIZED INNOVATION

Hurdle
Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle
Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

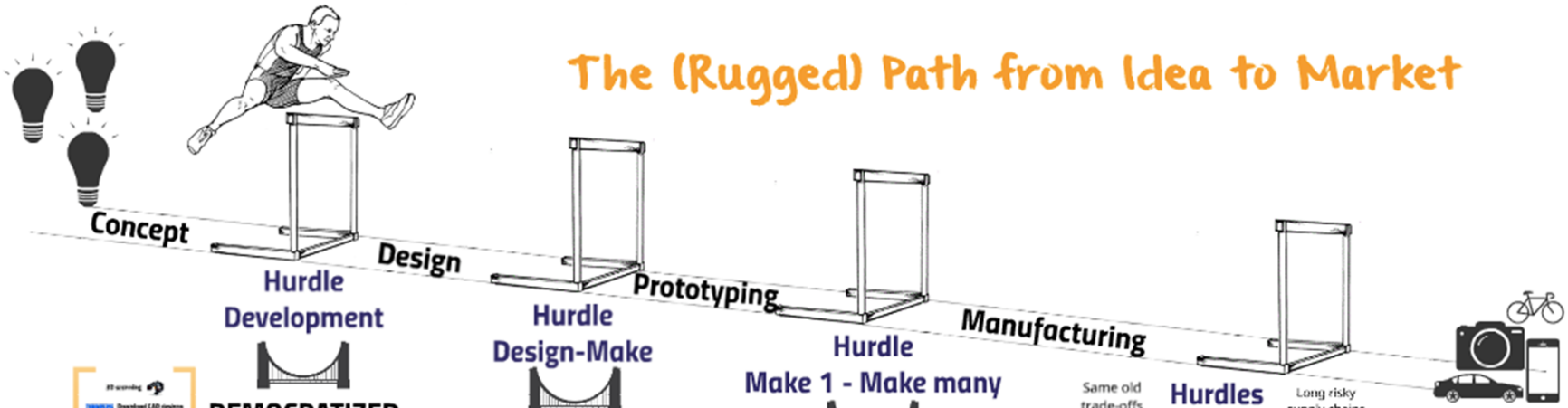
Digital

Automated

No tooling

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Proliferation of components and inventory

TRUE CUSTOMIZATION

Long risky supply chains

IMPROVED DESIGN

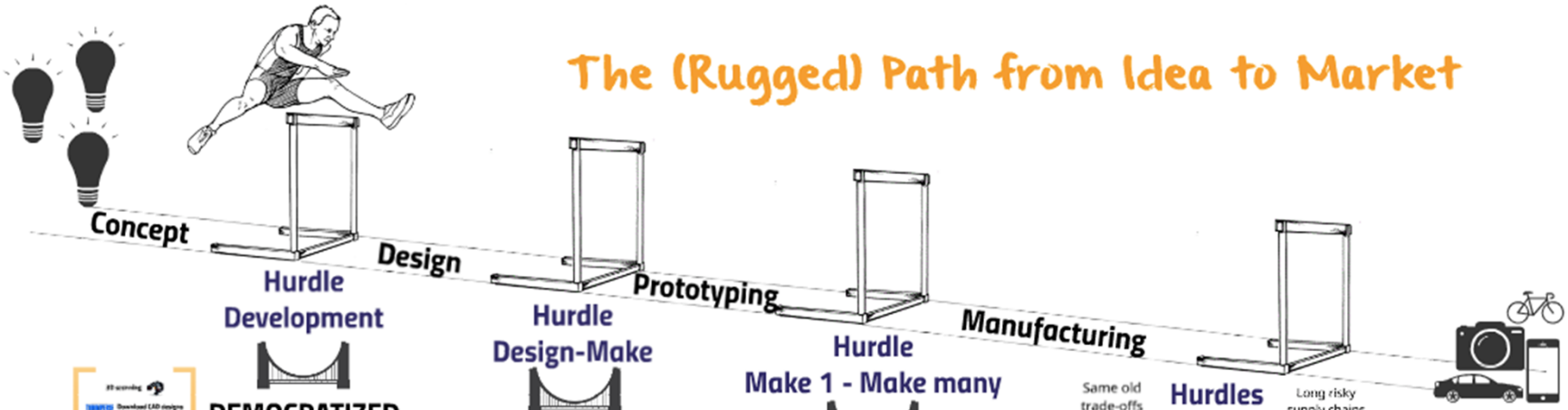
Digital

Automated

No tooling

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

...AT LITTLE ADDITIONAL COST

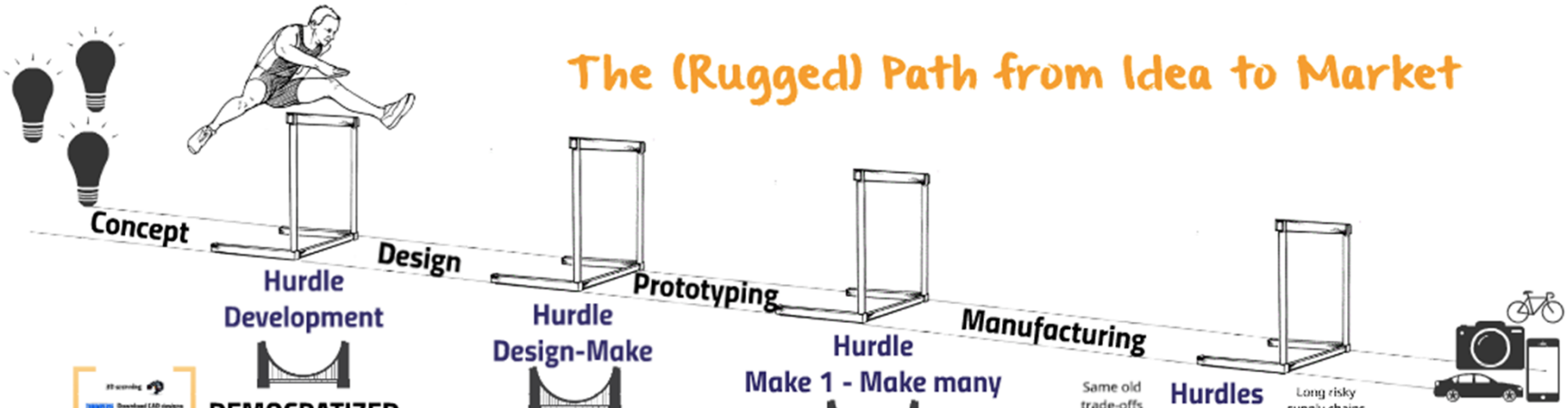
Digital

Automated

No tooling

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle
Development

DEMOCRATIZED INNOVATION

Hurdle
Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle
Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

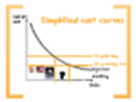
...AT LITTLE ADDITIONAL COST

Digital

Automated

No tooling

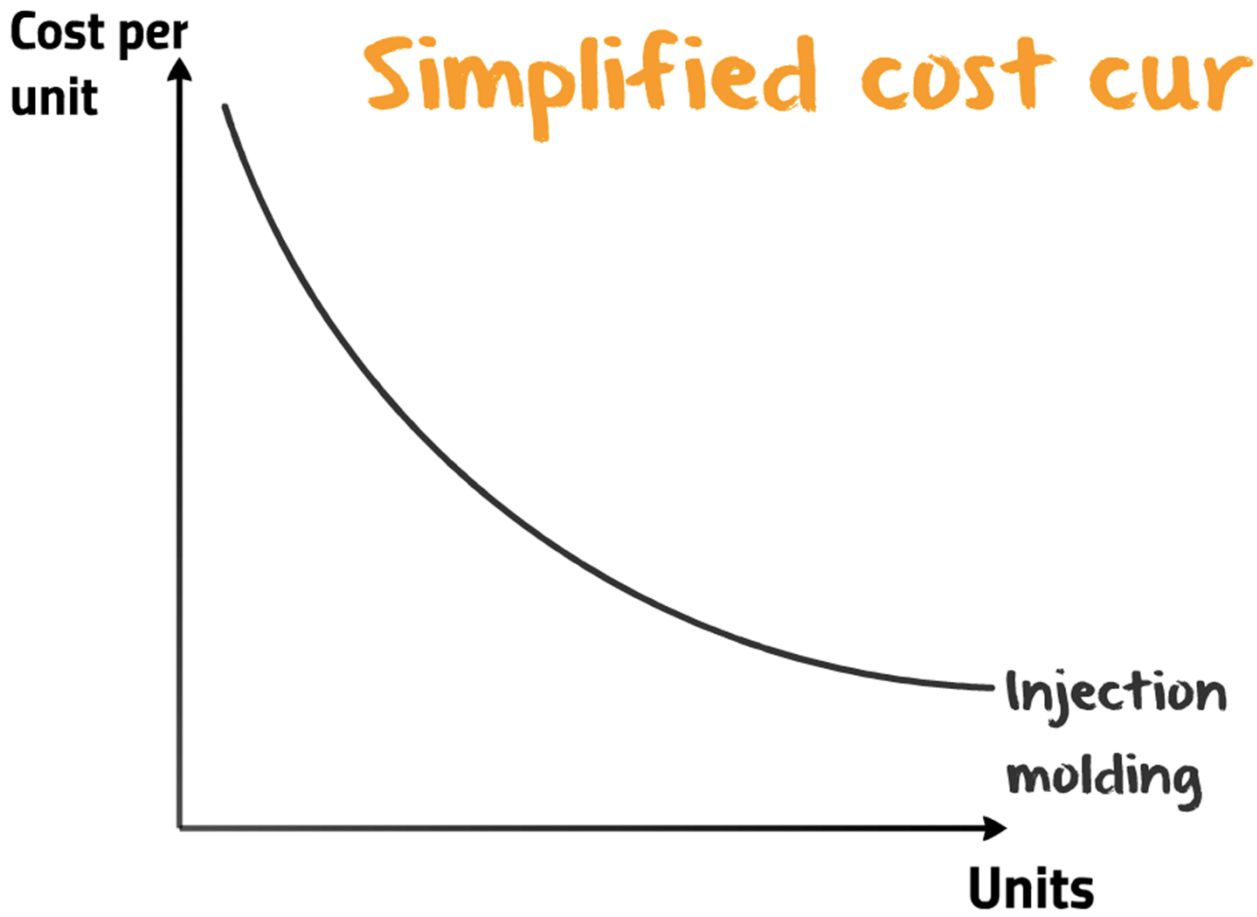
No/little scale economies



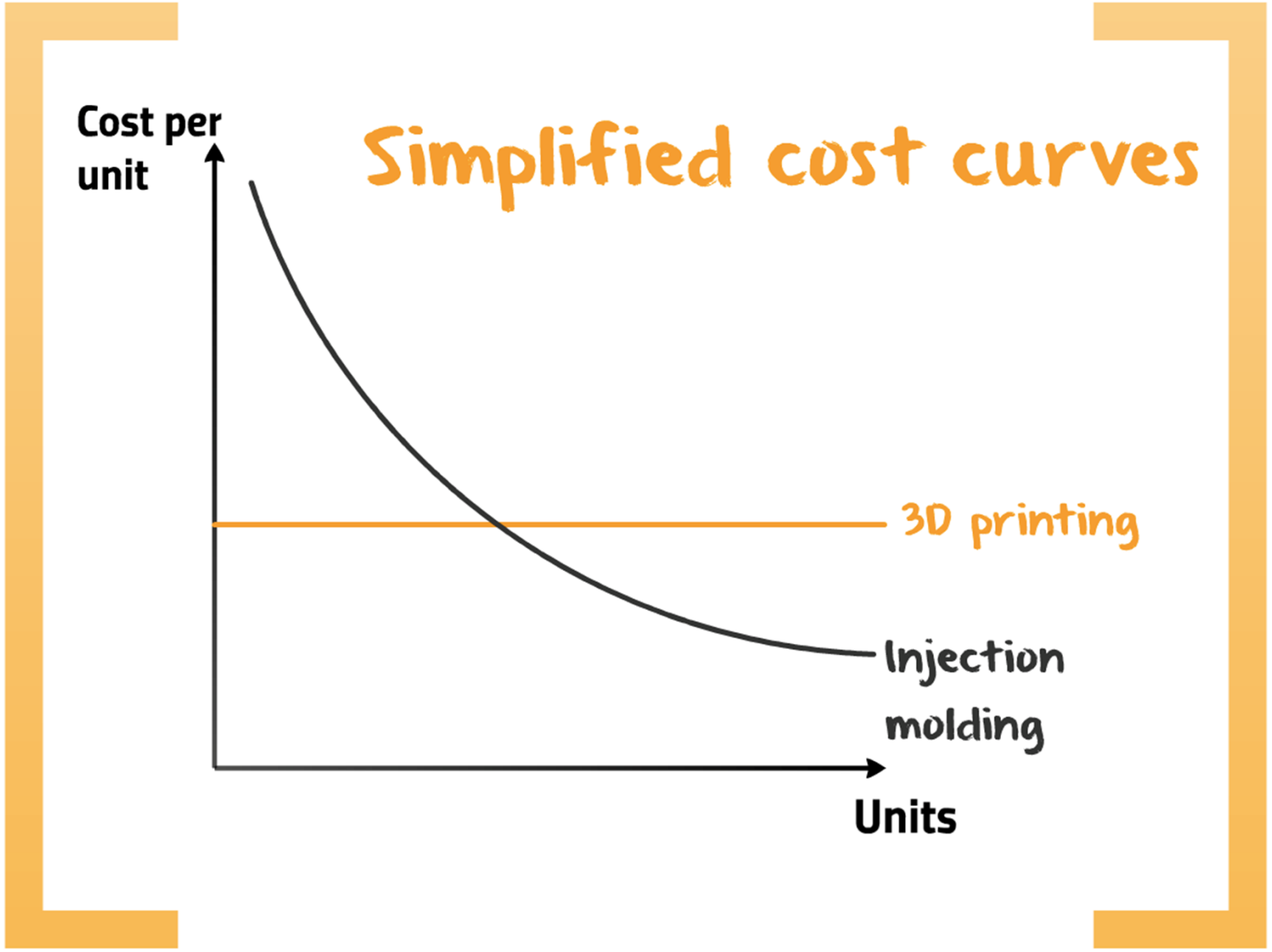
3D PRINTING

No/little scale economies

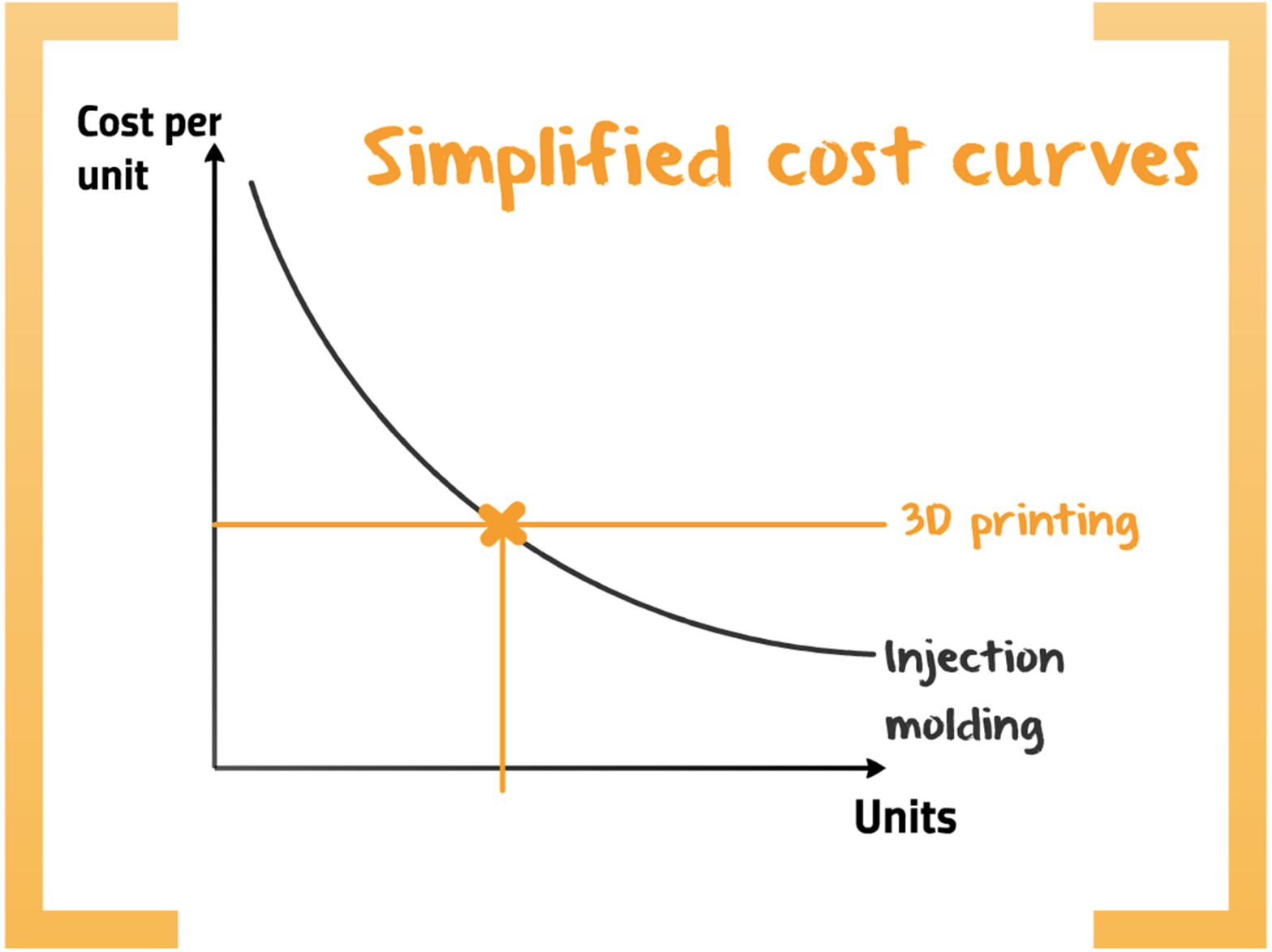
Simplified cost curves



No/little scale economies

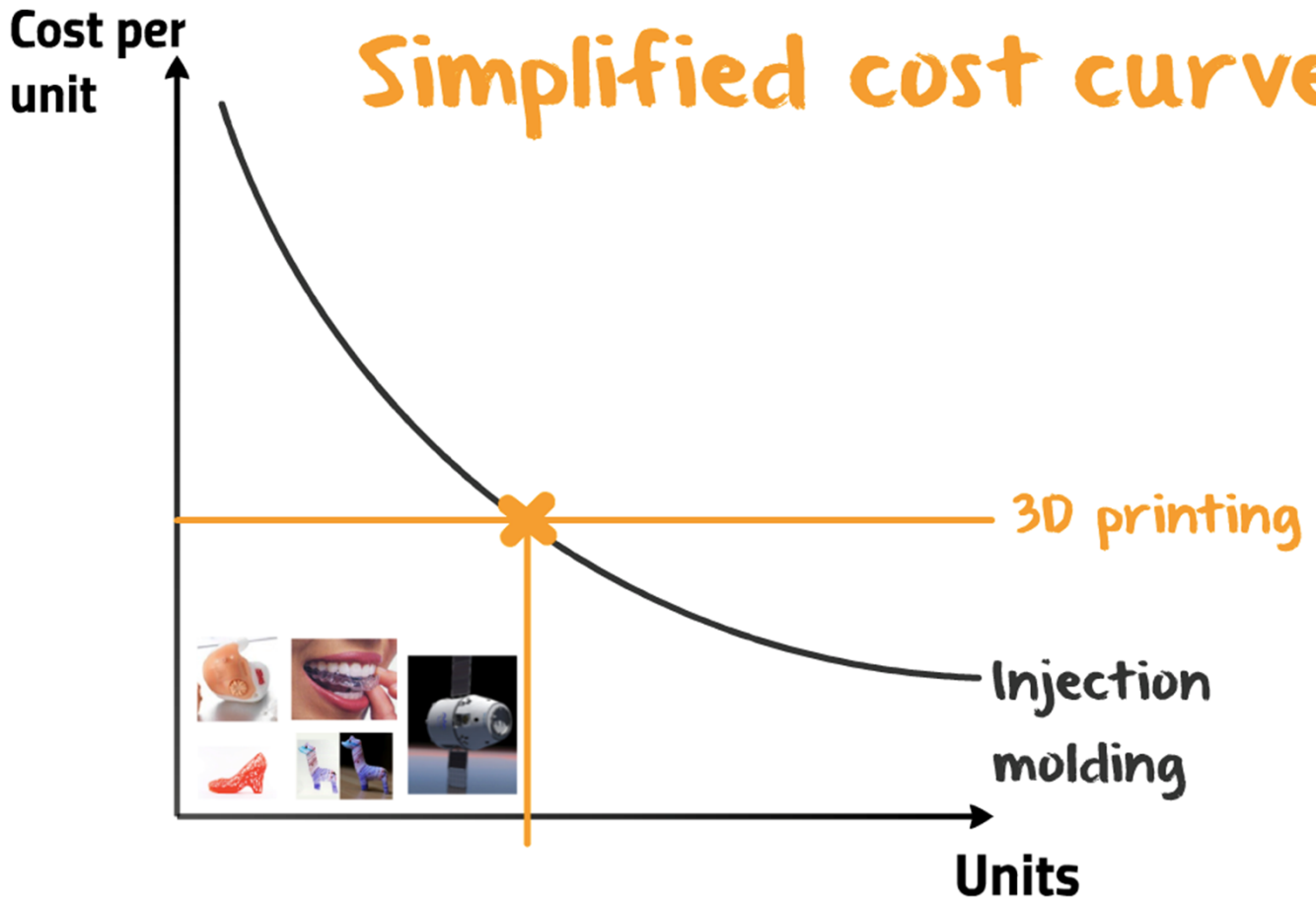


No/little scale economies

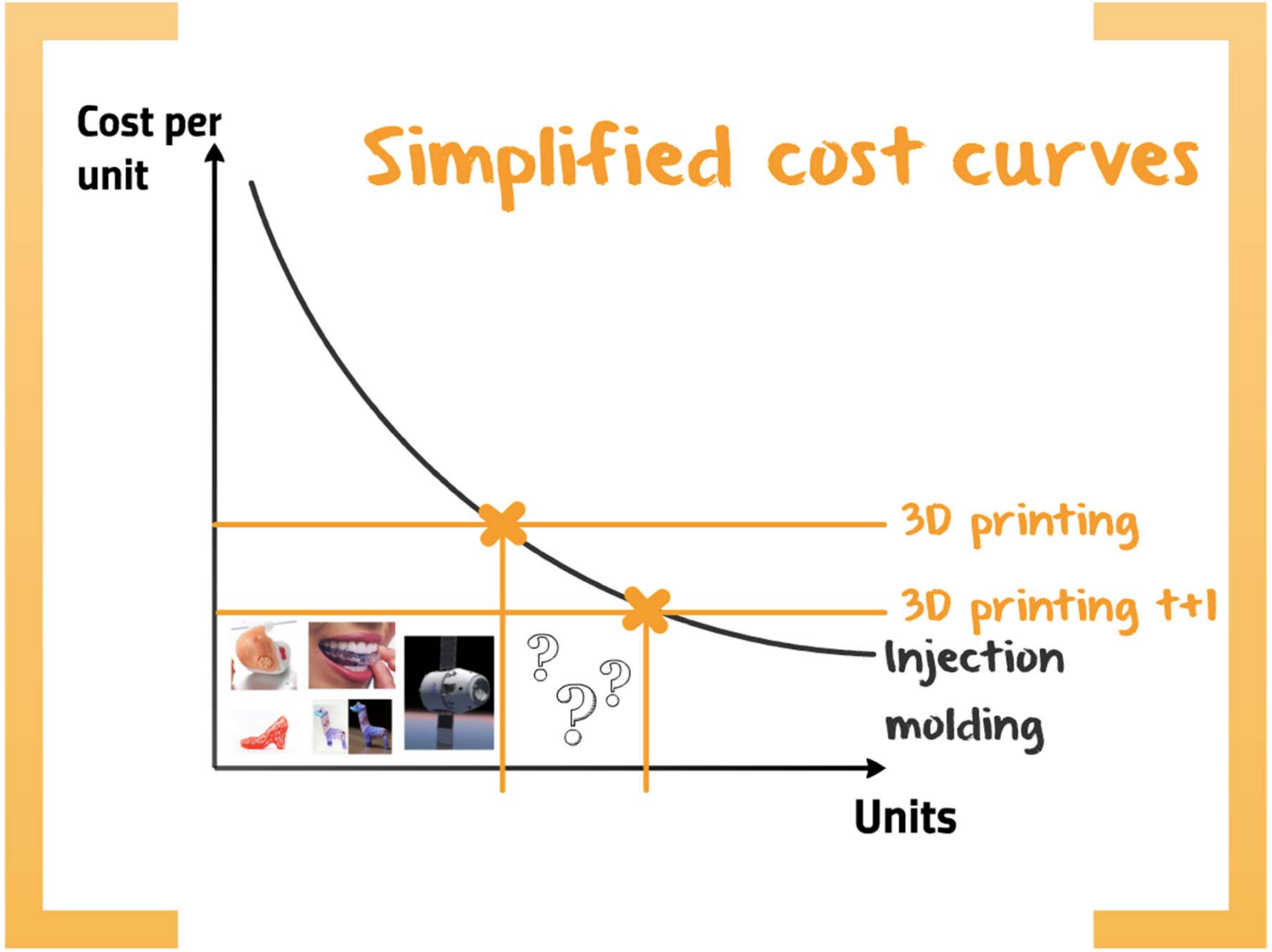


No/little scale economies

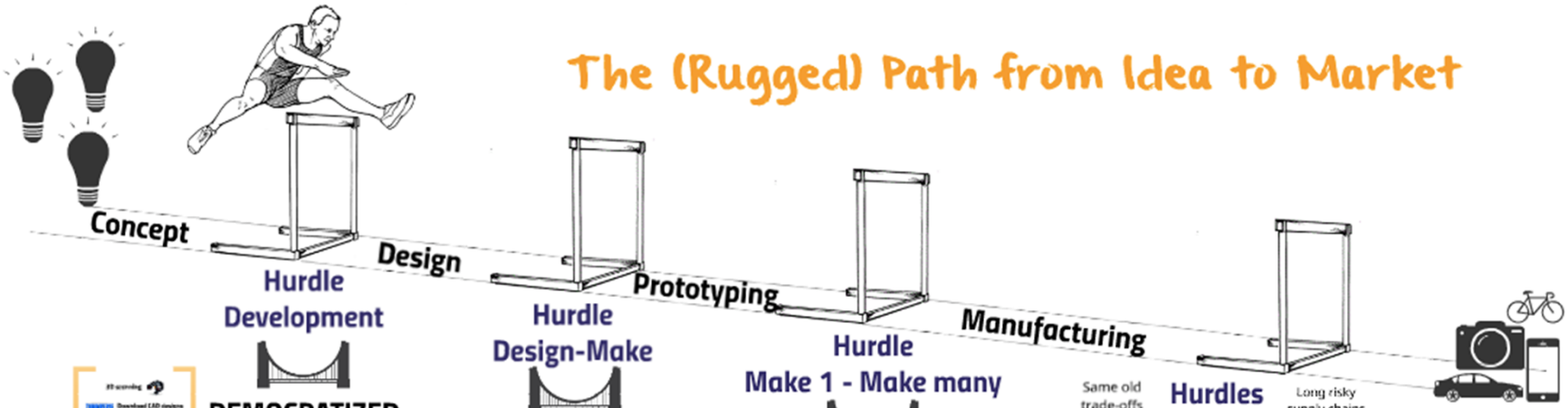
Simplified cost curves



No/little scale economies



The (Rugged) Path from Idea to Market



Hurdle
Development

DEMOCRATIZED INNOVATION

Hurdle
Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle
Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

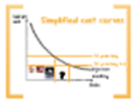
...AT LITTLE ADDITIONAL COST

Digital

Automated

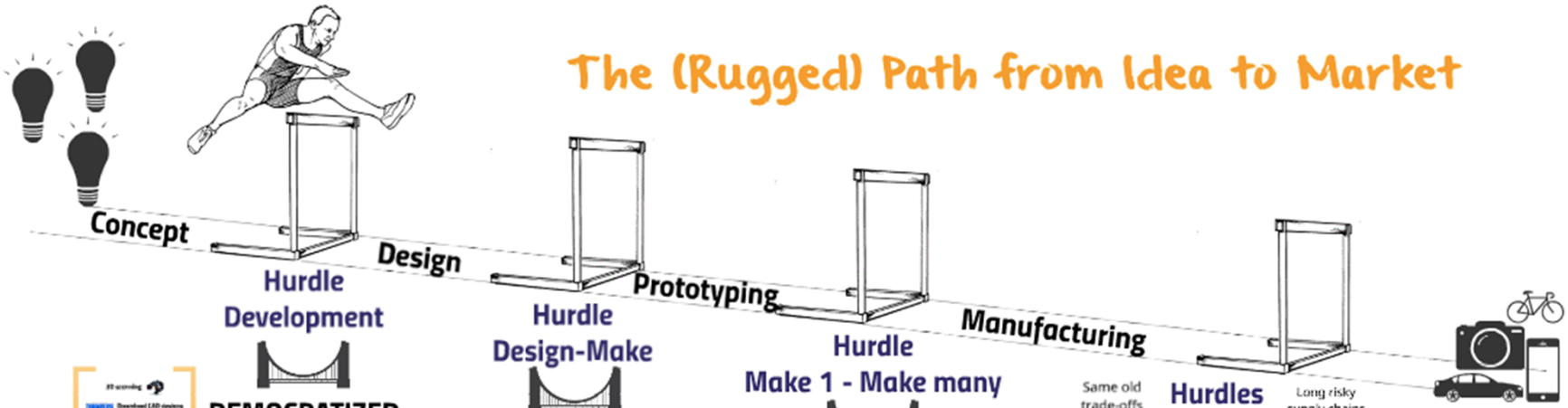
No tooling

No/little scale economies



3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

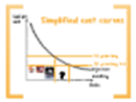
...AT LITTLE ADDITIONAL COST

Digital

Automated

No tooling

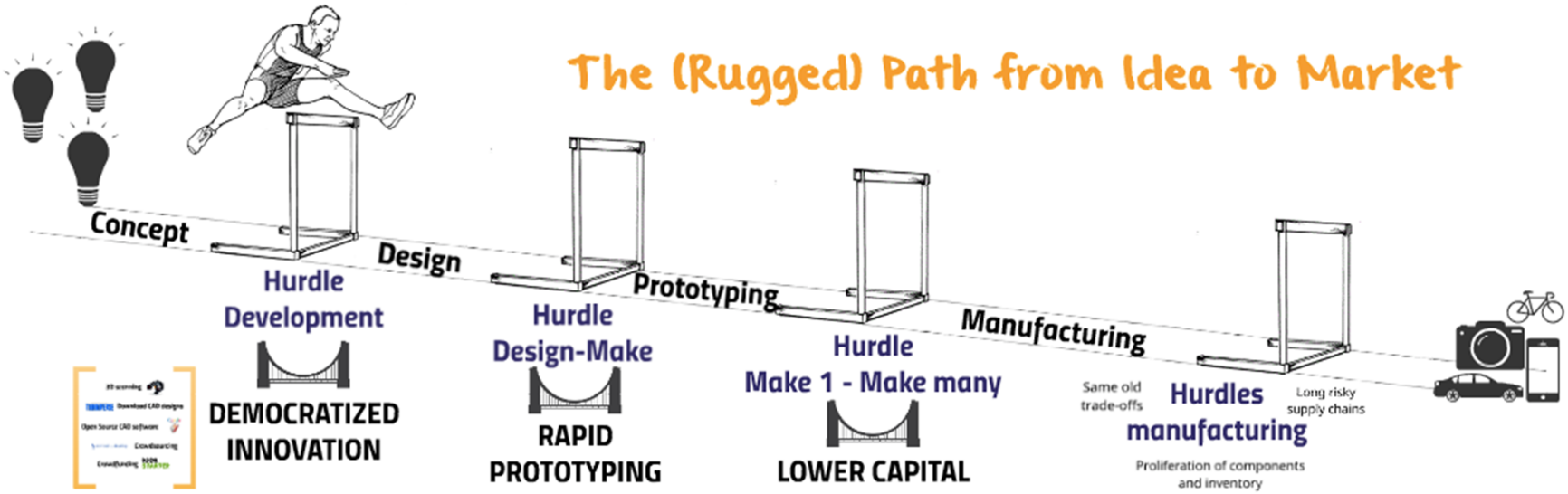
No/little scale economies



Part consolidation

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

...AT LITTLE ADDITIONAL COST

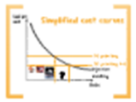
REDUCED ASSEMBLY

Digital

Automated

No tooling

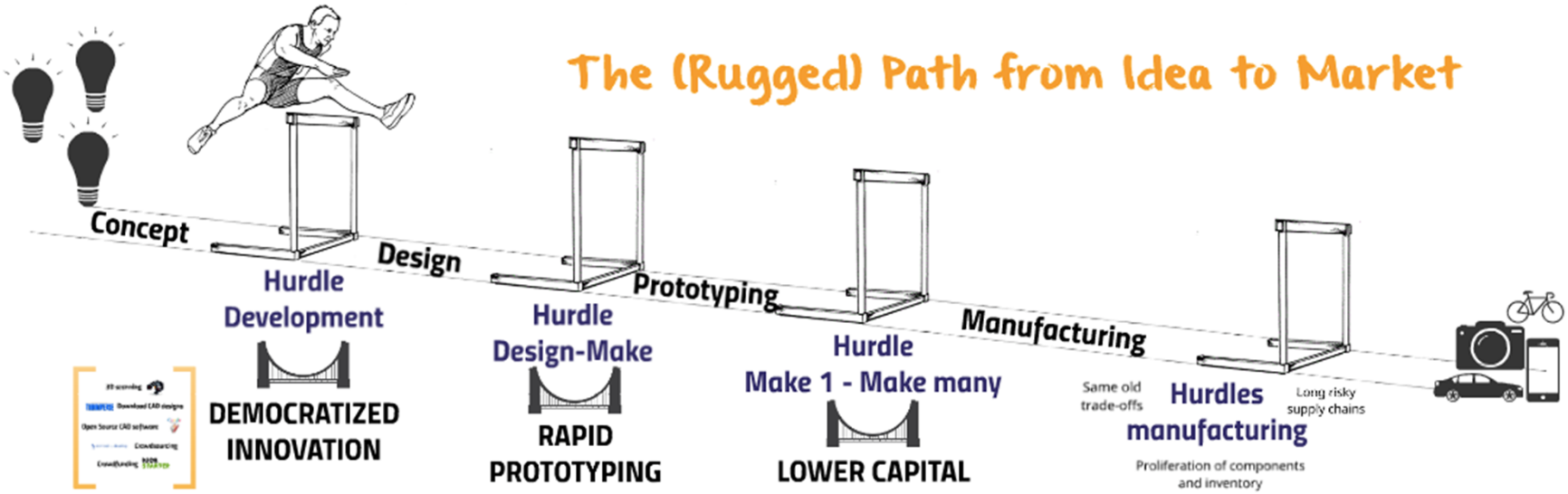
No/little scale economies



Part consolidation

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

...AT LITTLE ADDITIONAL COST

REDUCED ASSEMBLY

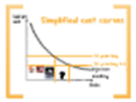
THINNER AND SHORTER SUPPLY CHAINS

Digital

Automated

No tooling

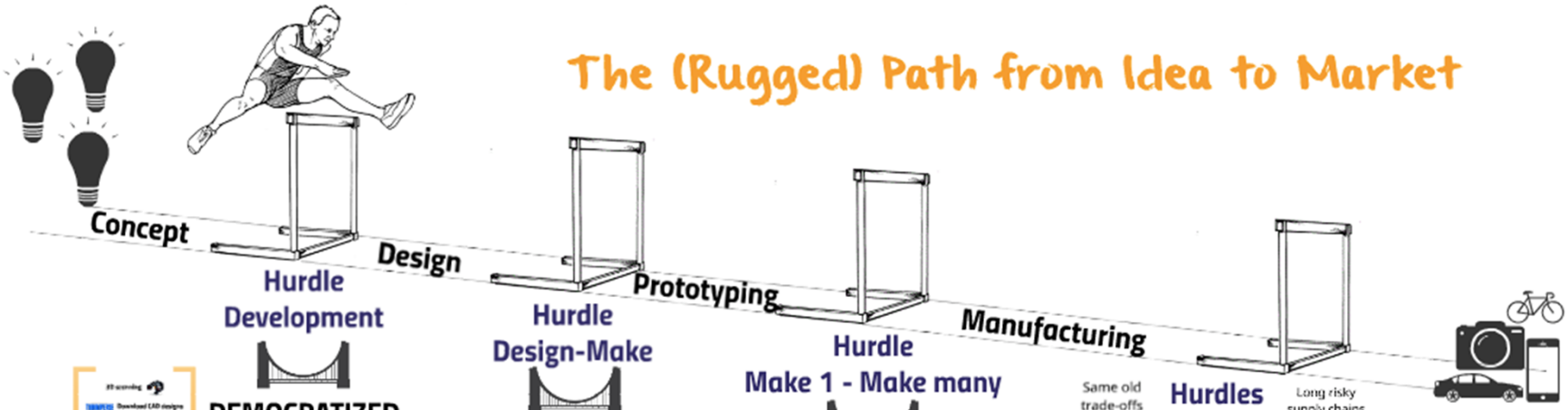
No/little scale economies



Part consolidation

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Same old trade-offs

Hurdles manufacturing

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

...AT LITTLE ADDITIONAL COST

REDUCED ASSEMBLY

THINNER AND SHORTER SUPPLY CHAINS

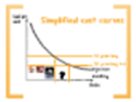
LESS WASTE OF MATERIAL

Digital

Automated

No tooling

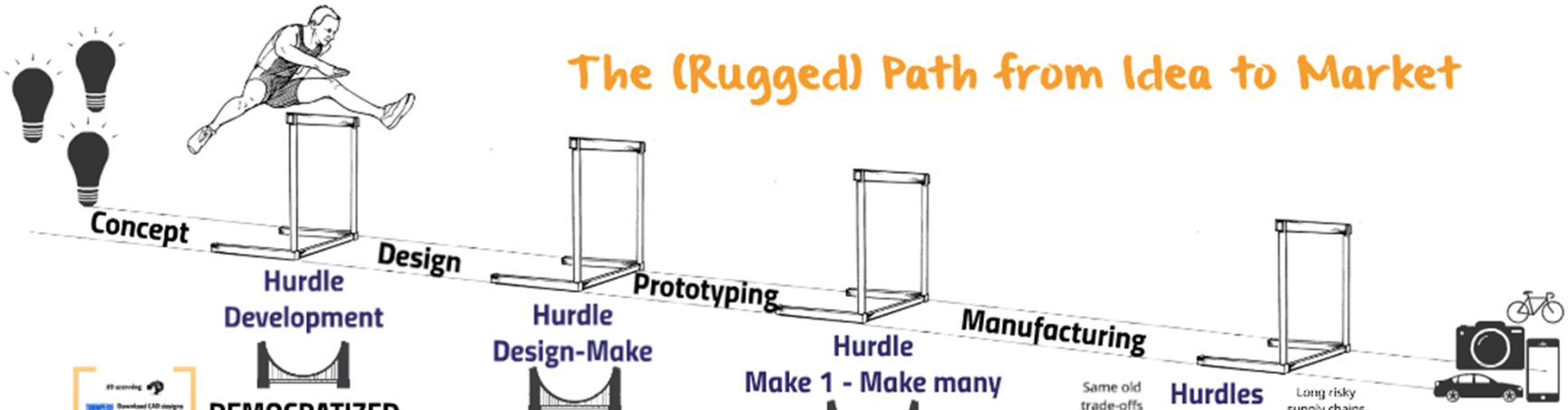
No/little scale economies



Part consolidation

3D PRINTING

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Hurdles manufacturing

Same old trade-offs

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

...AT LITTLE ADDITIONAL COST

REDUCED ASSEMBLY

THINNER AND SHORTER SUPPLY CHAINS

LESS WASTE OF MATERIAL

3D PRINTING CONSISTENT MANAGEMENT

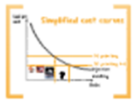
- (From closed to) Open Innovation
- (From DFMA to) **Design for Printing**
- (From waterfall models to) **lean start-up** and **agile development** and **co-creation**
- (From centralized to) **decentralized production**
- (From big to) **small batches: one piece flow**
- (From long thin to) **short fat process**
- (From push to) **pull production**

Digital

Automated

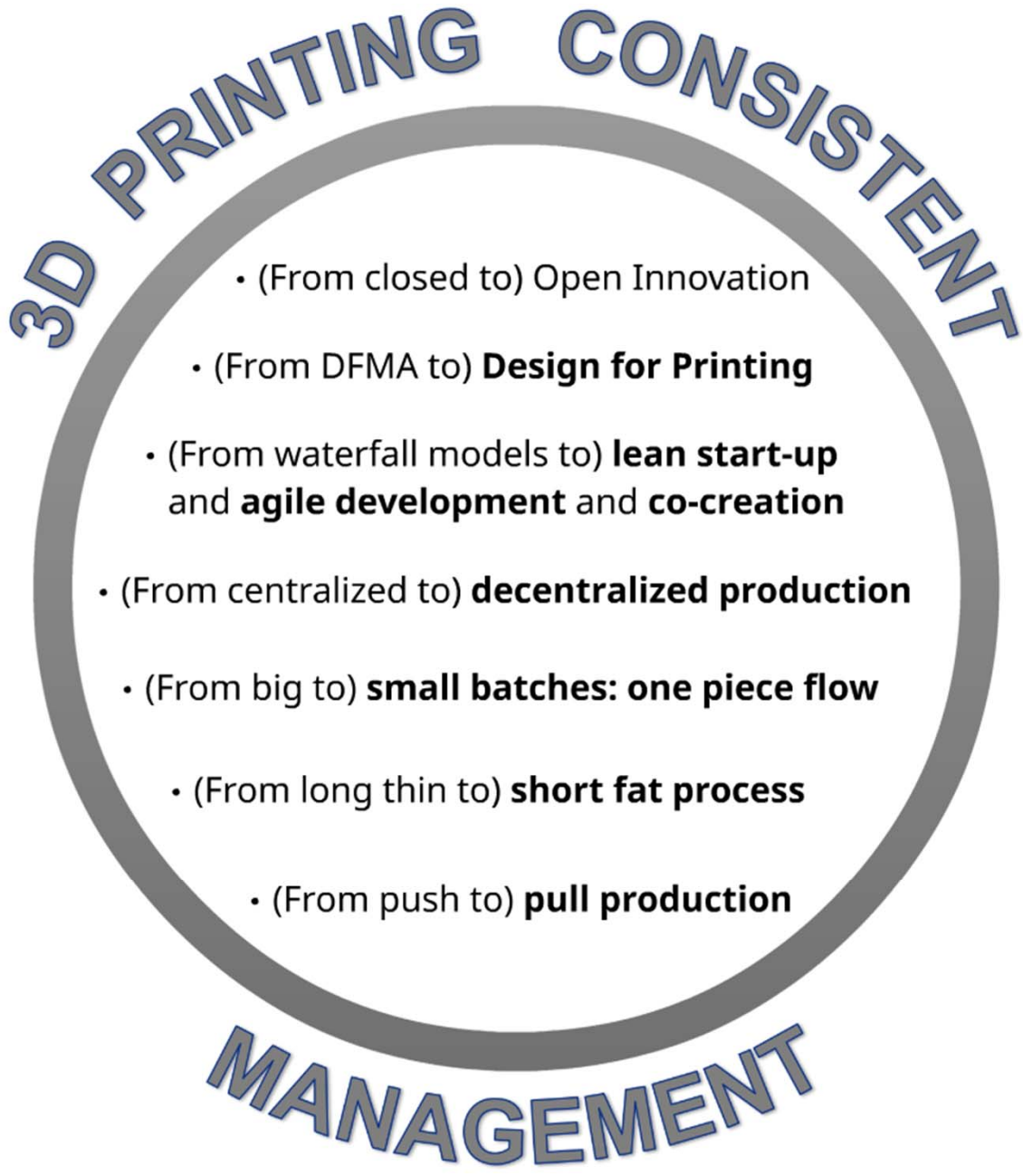
No tooling

No/little scale economies



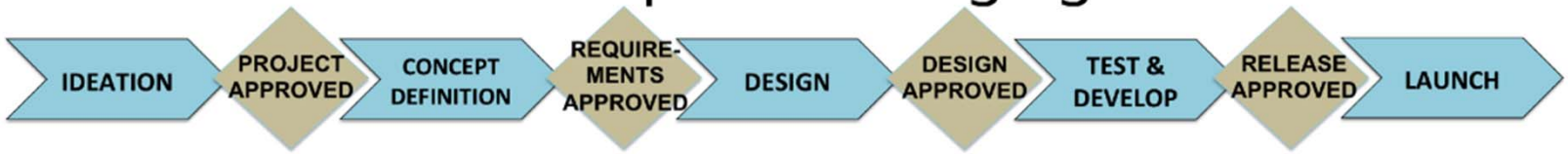
Part consolidation

3D PRINTING


3D PRINTING CONSISTENT
• (From closed to) Open Innovation
• (From DFMA to) Design for Printing
• (From waterfall models to) lean start-up and agile development and co-creation
• (From centralized to) decentralized production
• (From big to) small batches: one piece flow
• (From long thin to) short fat process
• (From push to) pull production
MANAGEMENT

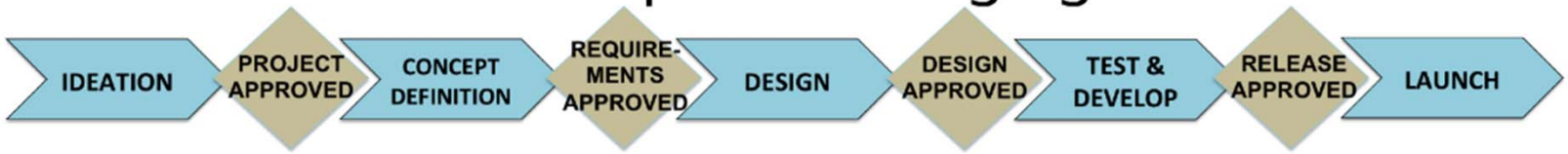
The digitalization of hardware allows to substitute

traditional sequential stage gate models

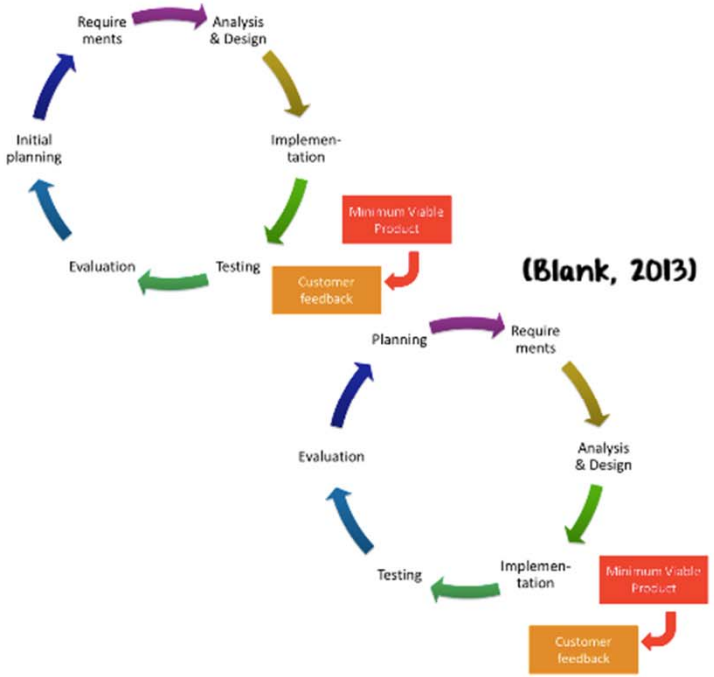


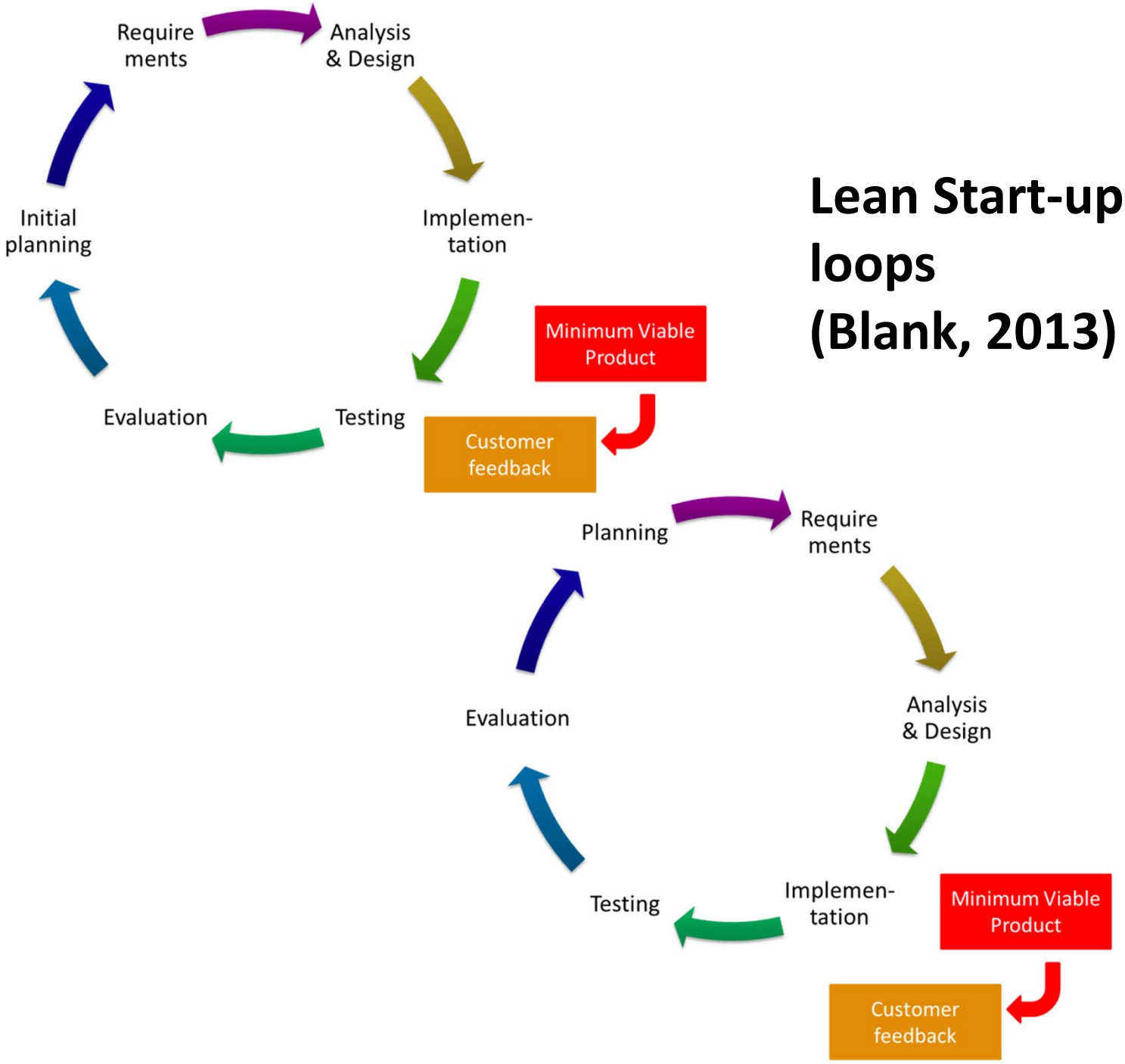
The digitalization of hardware allows to substitute

traditional sequential stage gate models

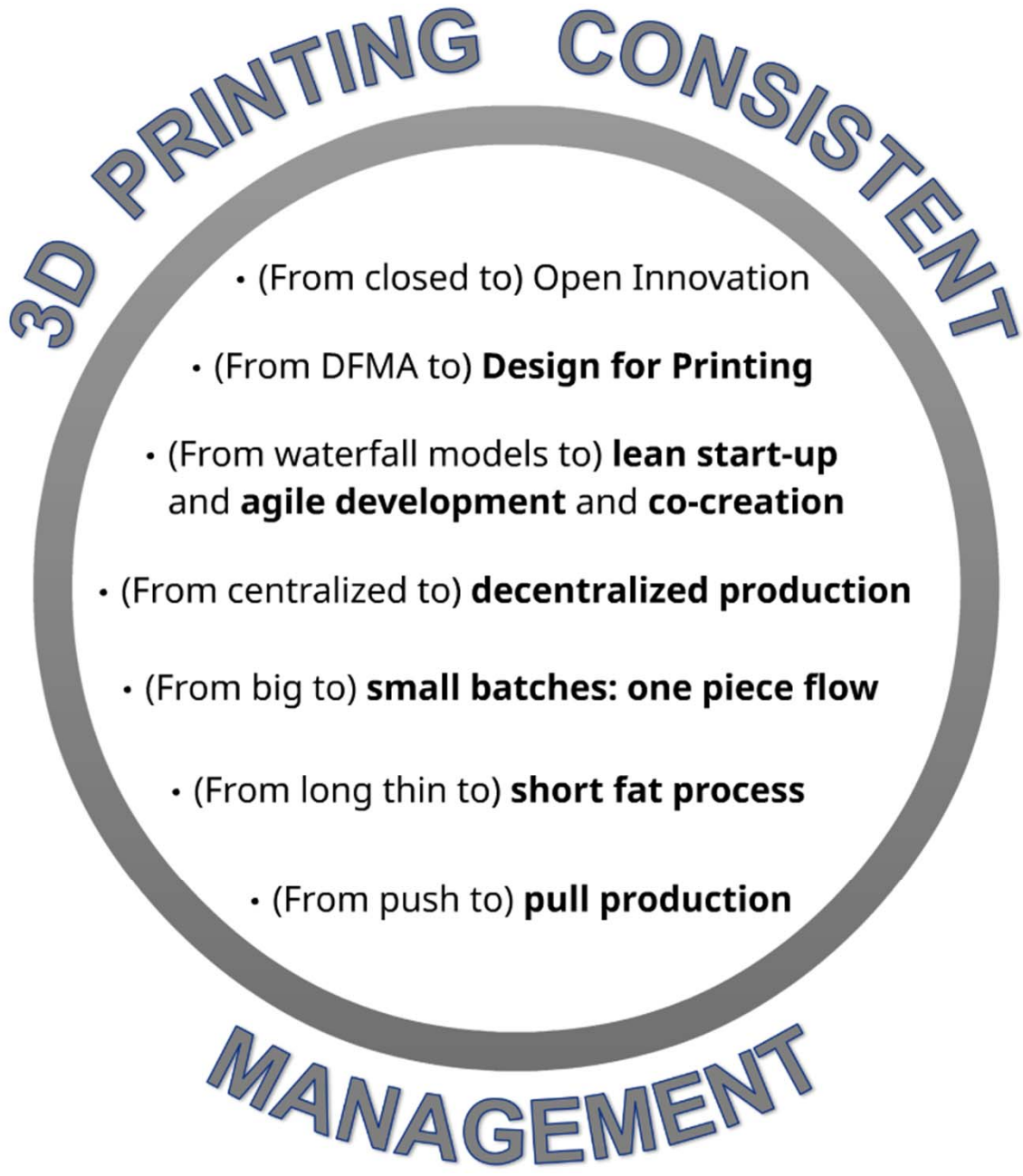


with best innovation practices coming from software development, e.g., the **Lean Startup** (Ries, 2011) and the **Scrum methodology** (Sims and Johnson, 2011).

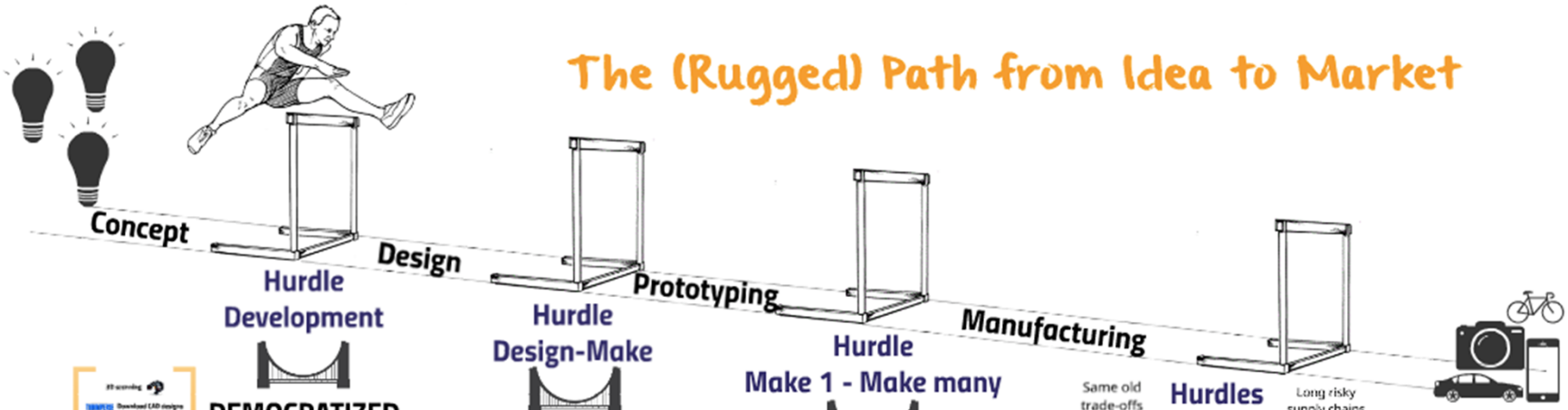




Lean Start-up loops (Blank, 2013)


3D PRINTING CONSISTENT
• (From closed to) Open Innovation
• (From DFMA to) Design for Printing
• (From waterfall models to) lean start-up and agile development and co-creation
• (From centralized to) decentralized production
• (From big to) small batches: one piece flow
• (From long thin to) short fat process
• (From push to) pull production
MANAGEMENT

The (Rugged) Path from Idea to Market



Hurdle Development

DEMOCRATIZED INNOVATION

Hurdle Design-Make

RAPID PROTOTYPING

More prototypes, cheaper, more accurate and realistic, more easily updated

Hurdle Make 1 - Make many

LOWER CAPITAL OUTLAY

Hurdles manufacturing

Same old trade-offs

Long risky supply chains

Proliferation of components and inventory

TRUE CUSTOMIZATION

IMPROVED DESIGN

...AT LITTLE ADDITIONAL COST

REDUCED ASSEMBLY

THINNER AND SHORTER SUPPLY CHAINS

LESS WASTE OF MATERIAL

3D PRINTING CONSISTENT MANAGEMENT

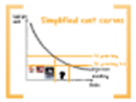
- (From closed to) Open Innovation
- (From DFMA to) **Design for Printing**
- (From waterfall models to) **lean start-up** and **agile development** and **co-creation**
- (From centralized to) **decentralized production**
- (From big to) **small batches: one piece flow**
- (From long thin to) **short fat process**
- (From push to) **pull production**

Digital

Automated

No tooling

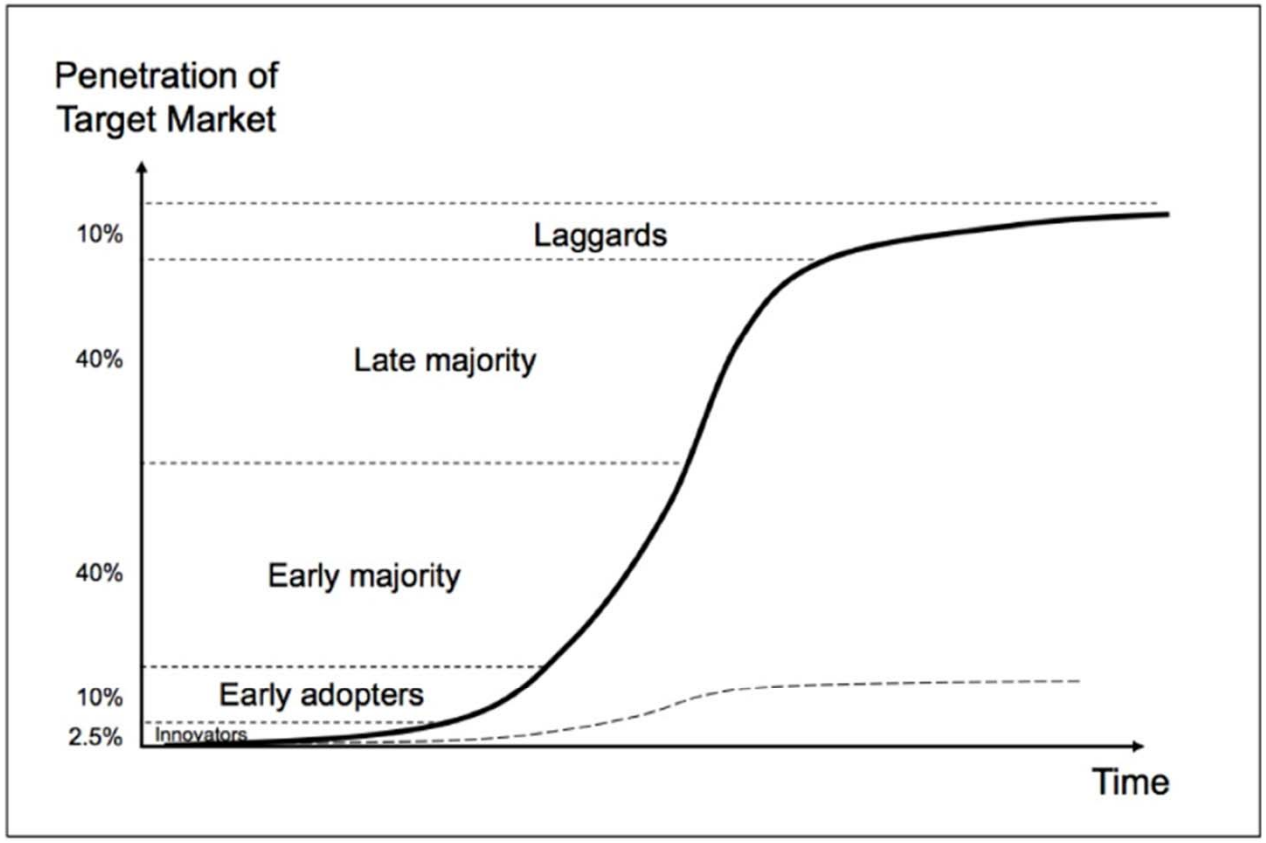
No/little scale economies



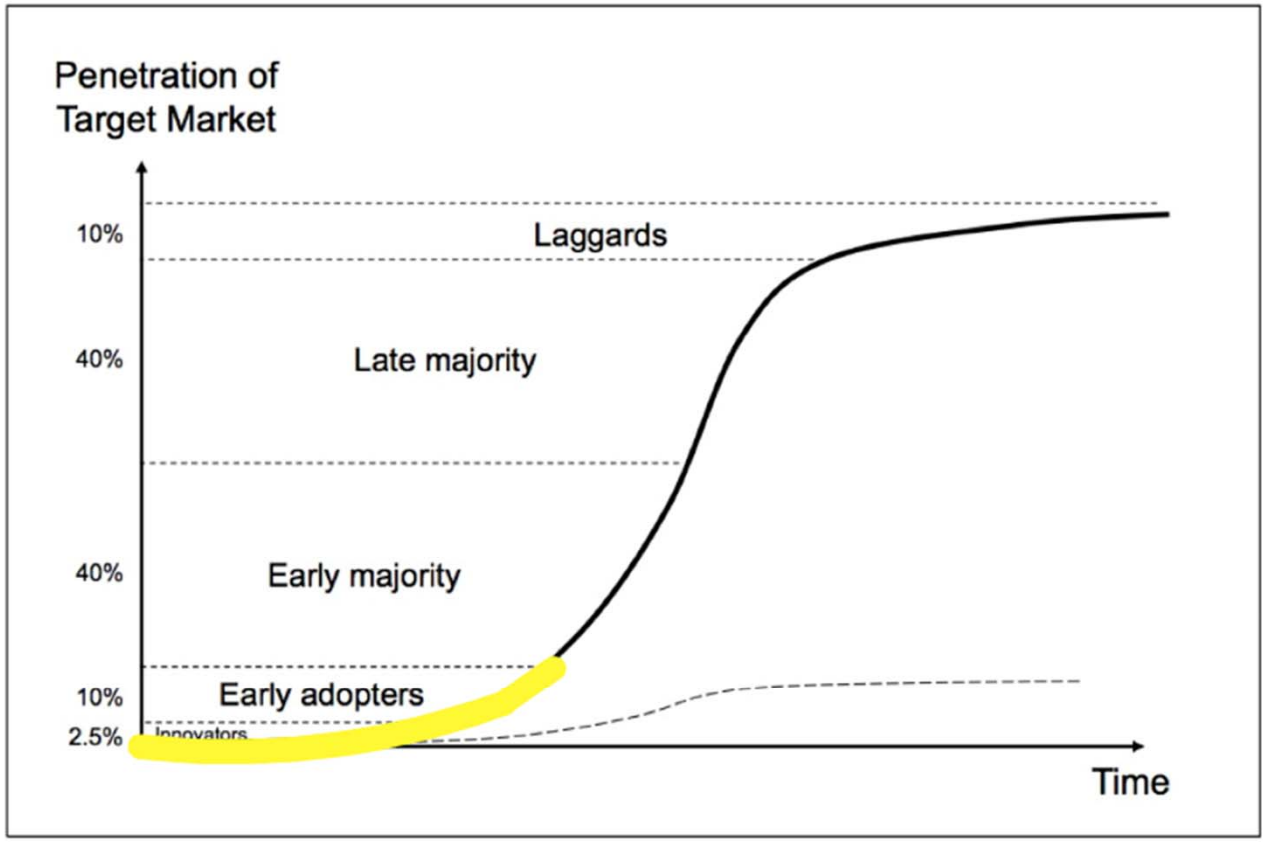
Part consolidation

3D PRINTING

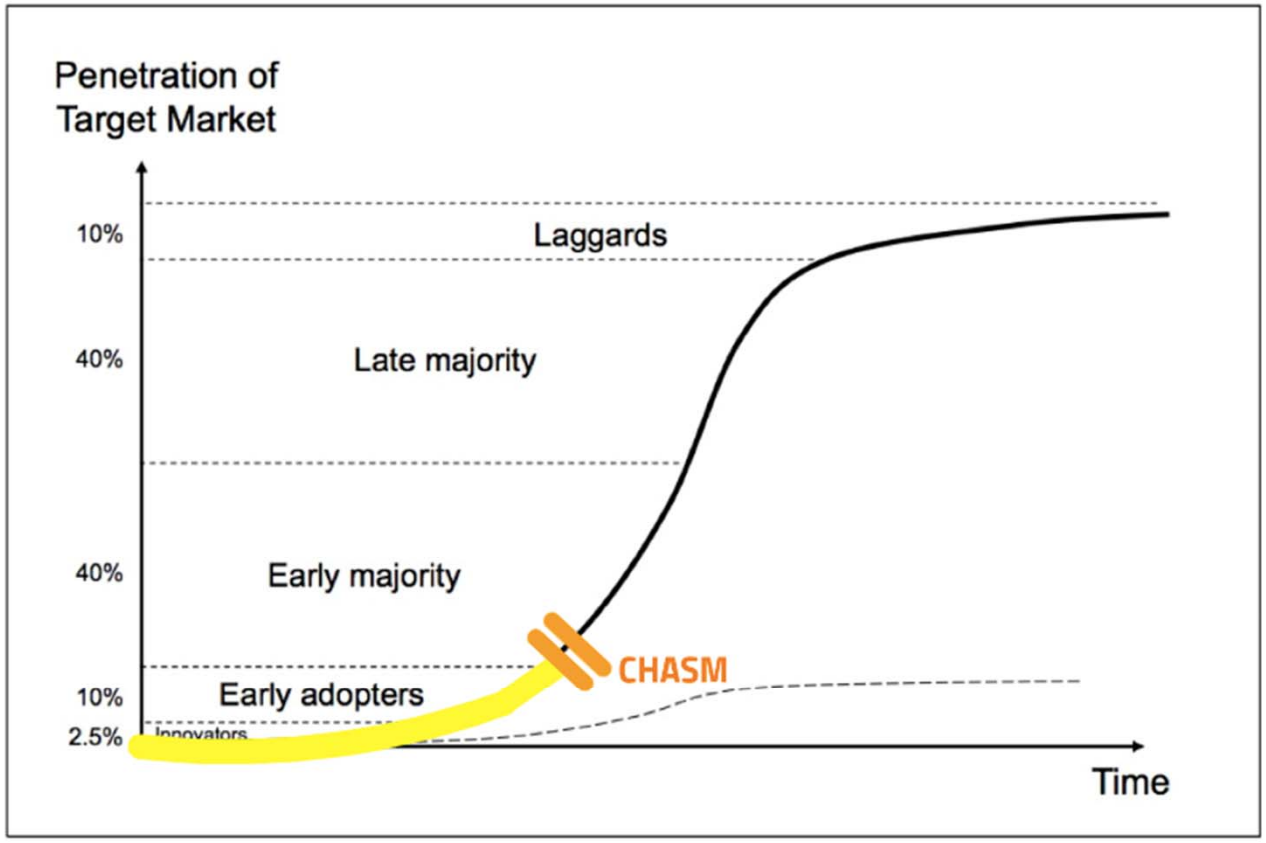
The diffusion of 3D printing technology



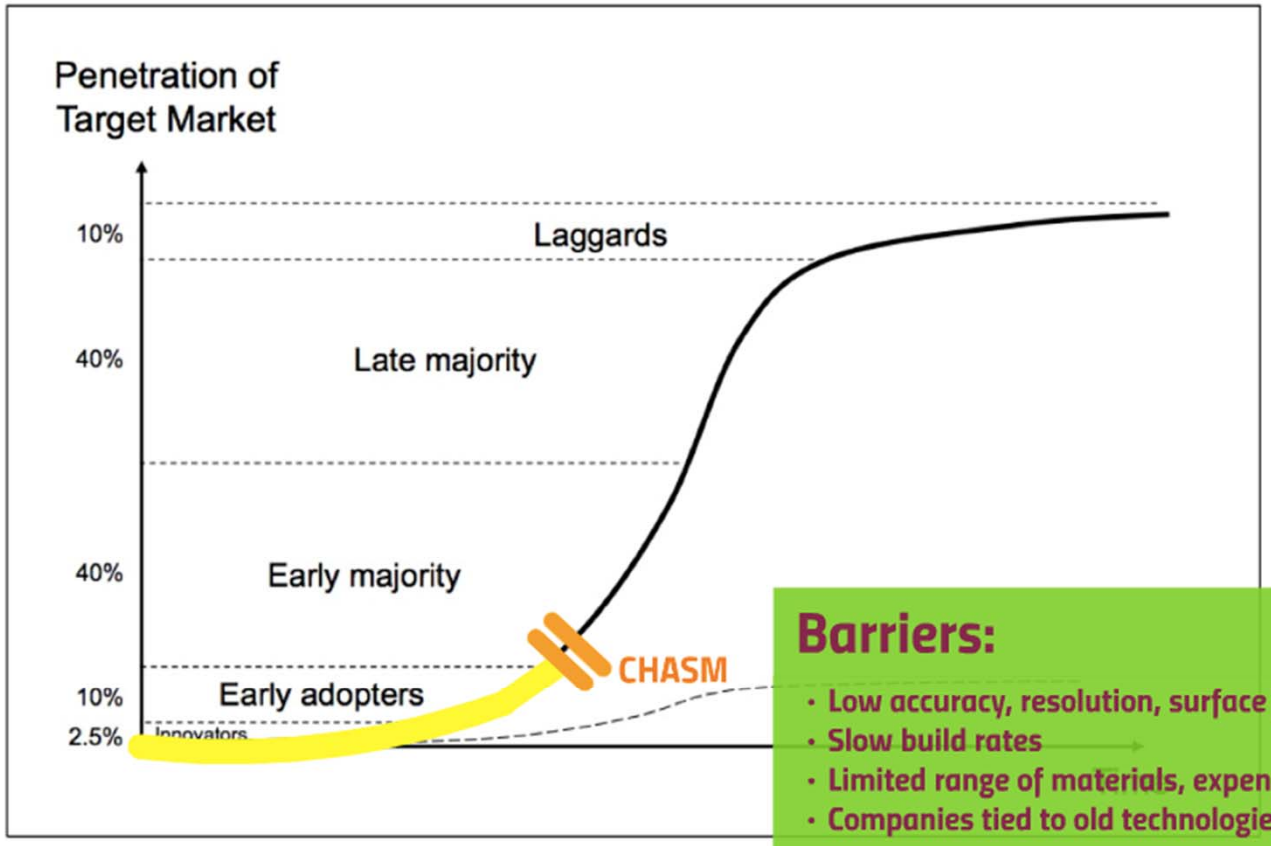
The diffusion of 3D printing technology



The diffusion of 3D printing technology



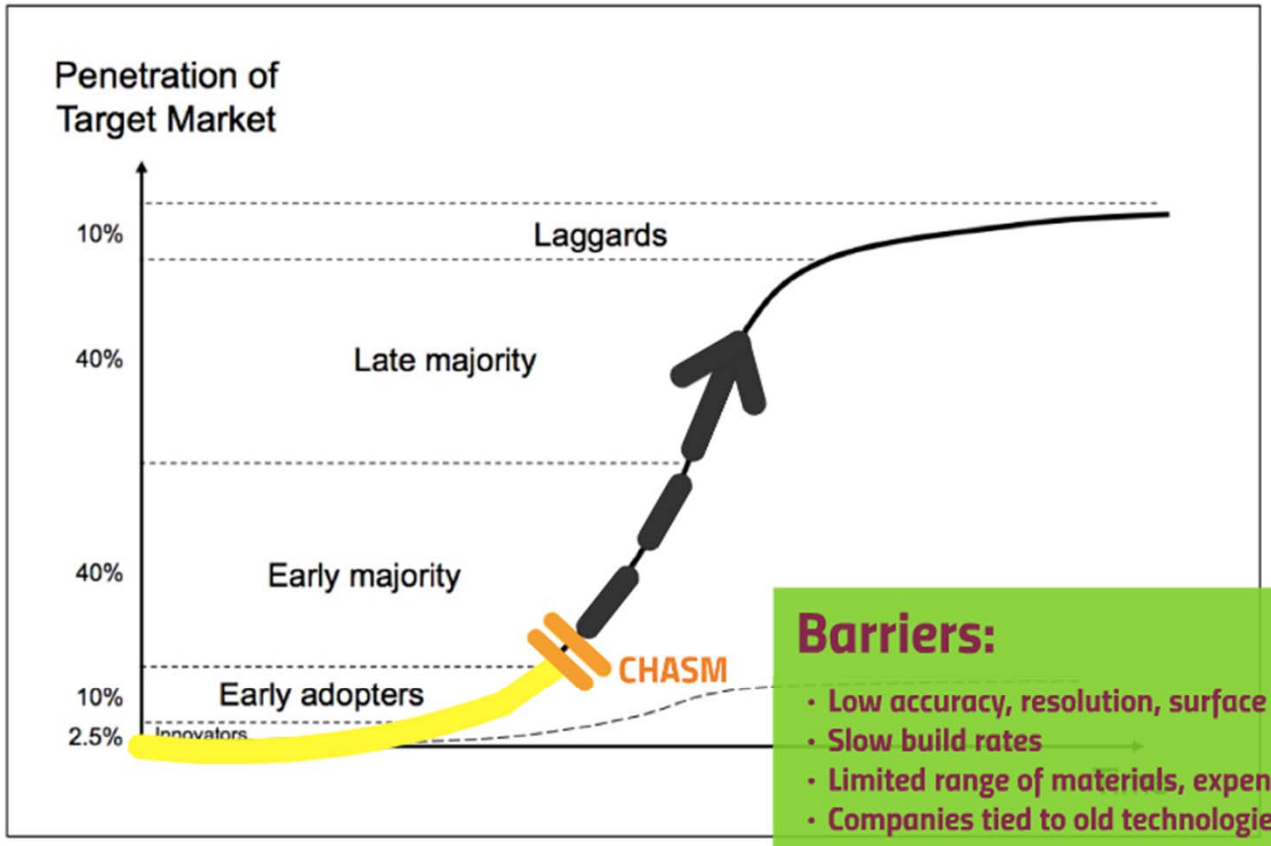
The diffusion of 3D printing technology



Barriers:

- Low accuracy, resolution, surface finish, ...
- Slow build rates
- Limited range of materials, expensive
- Companies tied to old technologies
- ...

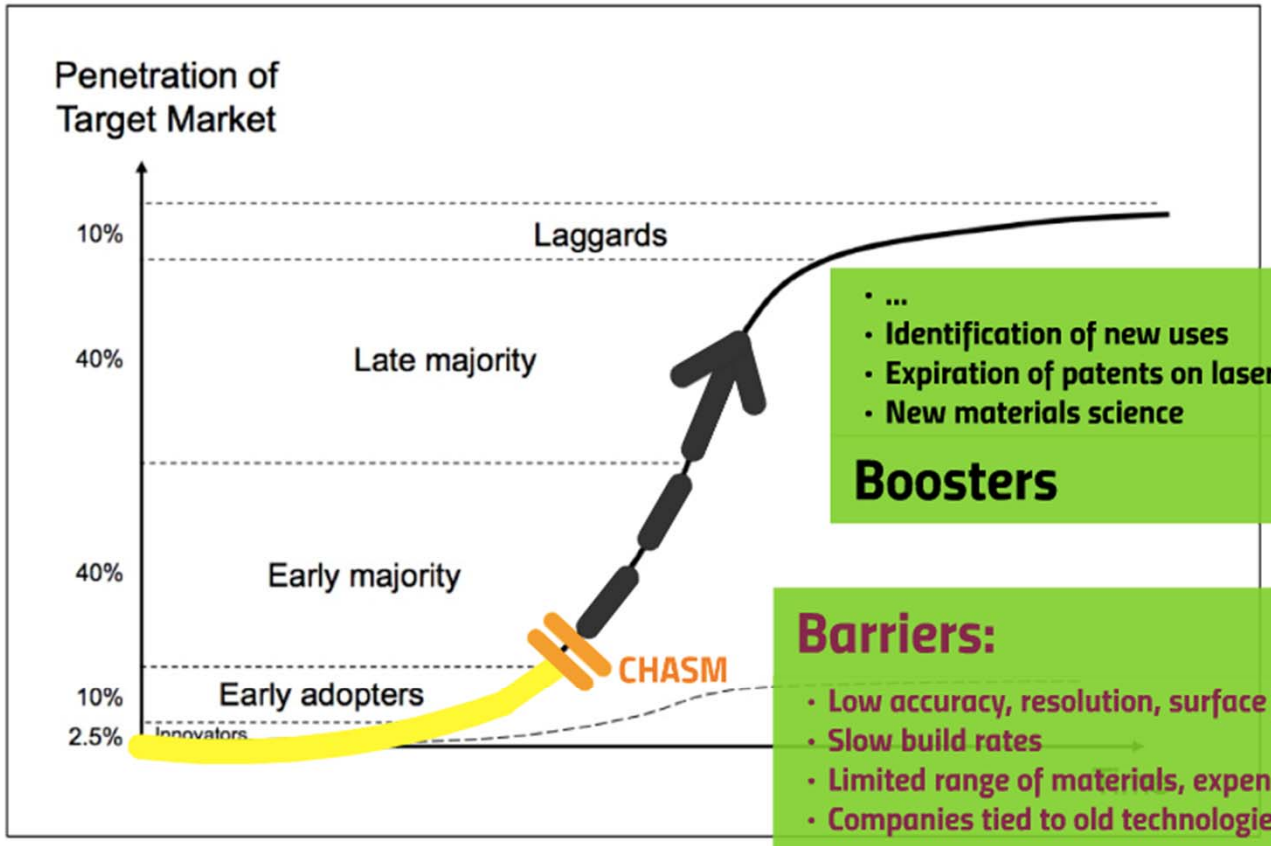
The diffusion of 3D printing technology



Barriers:

- Low accuracy, resolution, surface finish, ...
- Slow build rates
- Limited range of materials, expensive
- Companies tied to old technologies
- ...

The diffusion of 3D printing technology



- ...
- Identification of new uses
- Expiration of patents on laser sintering in 2015
- New materials science

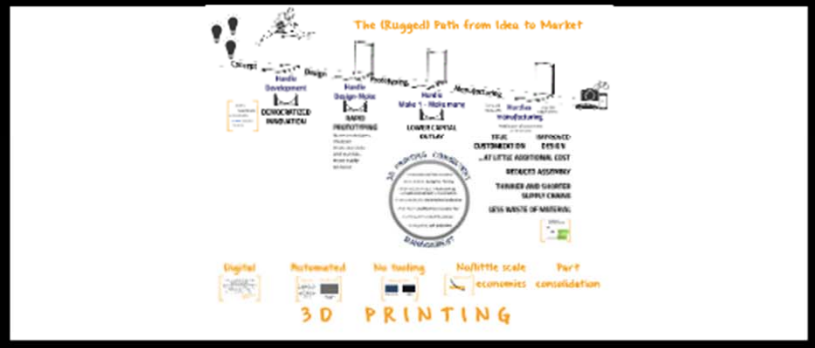
Boosters

Barriers:

- Low accuracy, resolution, surface finish, ...
- Slow build rates
- Limited range of materials, expensive
- Companies tied to old technologies
- ...

3D Printing

is it a new age for innovation and operations management?



Mattia Bianchi, Docent

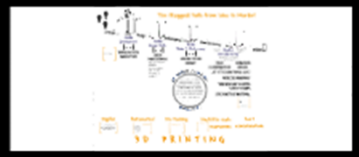
3D Printing

is it a new age for innovation and operations management?

Mattia Bianchi, Docent

3D Printing

is it a new age for innovation and operations management?



Mattia Bianchi, Docent

Will 3D printing destroy jobs?

Will 3D printing move manufacturing back to the west?

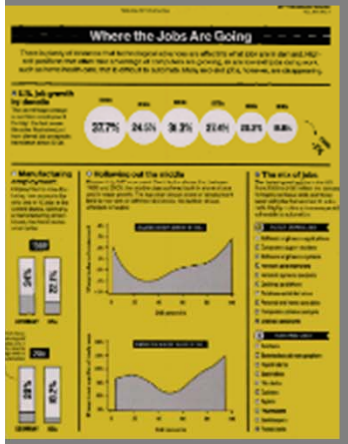
3D Printing

is it a new age for innovation and operations management?

Mattia Bianchi, Docent

Power belongs to whom owns the means of production (Karl Mark)

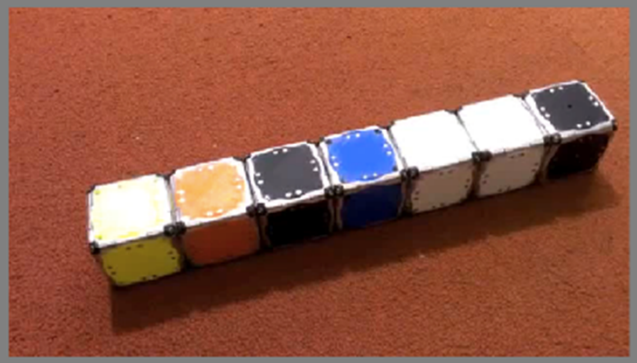
3D printing is distributing this power to millions of people



Will 3D printing bring the freedom of proletariat?

In the far future...

4D printing **self assembling things**



time

Takeaways

3D printing is an automated digital general purpose process technology that consolidates parts, has little economies of scale and does not require tooling.

3D printing has the potential to bring benefits to the development and manufacturing of new products, reducing innovation costs and times, improving design quality, shortening supply chains and allowing true customization.

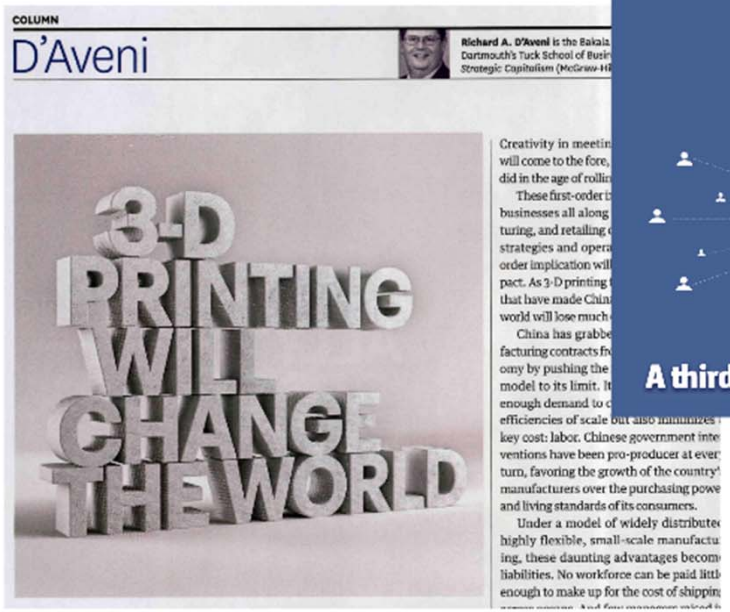
A new managerial paradigm, including e.g. practices such as co-creation, decentralized pull production and one piece flow, is needed to get the most out of the 3D printing and realize its potential.

Thank you!

mattia.bianchi@hhs.se

www.mattiabianchi.com

The third industrial revolution or hot air?



COLUMN

D'Aveni

3-D PRINTING WILL CHANGE THE WORLD

3D printing panorama

TECHNIQUE	MATERIALS	BRANDS	$
Material extrusion	Mainly thermoplastic (PLA, ABS)	RepRap	500
		MakerBot	2.000
		Stratasys FOR A 3D WORLD	10.000 – 500.000
Material jetting	Photopolymers, steel, ceramics	OBJET	20.000 – 250.000
		3DSYSTEMS	
Stereolithography	Photopolymers	envisionTEC	16.000 – 800.000
		formlabs	
Laser sintering	Polymers, metals	EOS	350.000 – 850.000
		CAD TO METAL arcam Arcam AB	

Personal printers avg. price =1,100$

Industrial printers avg. price =79,000$