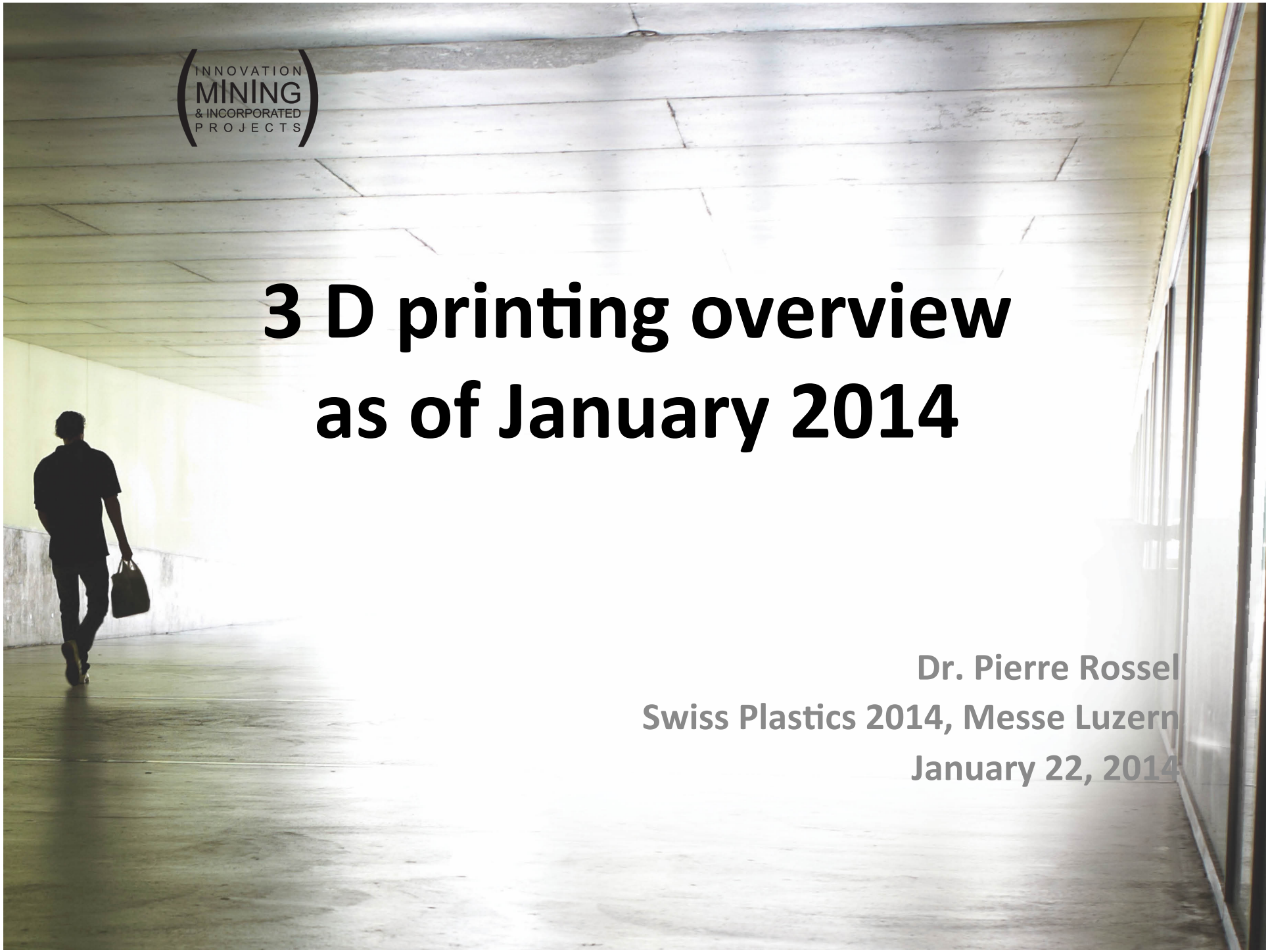


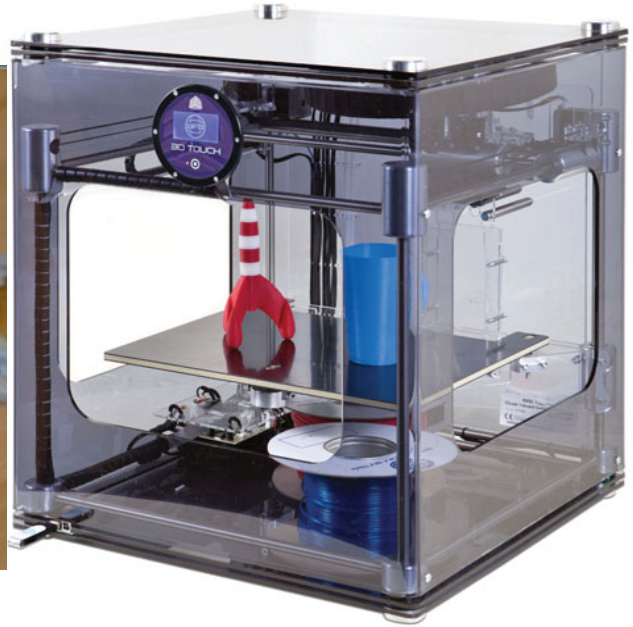
3 D printing overview as of January 2014

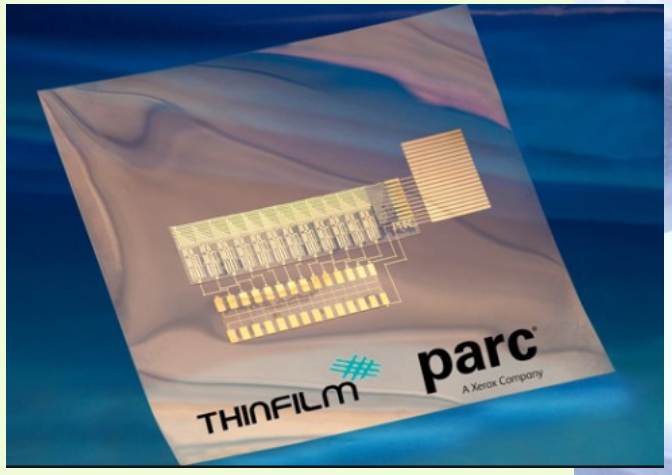
Dr. Pierre Rossel

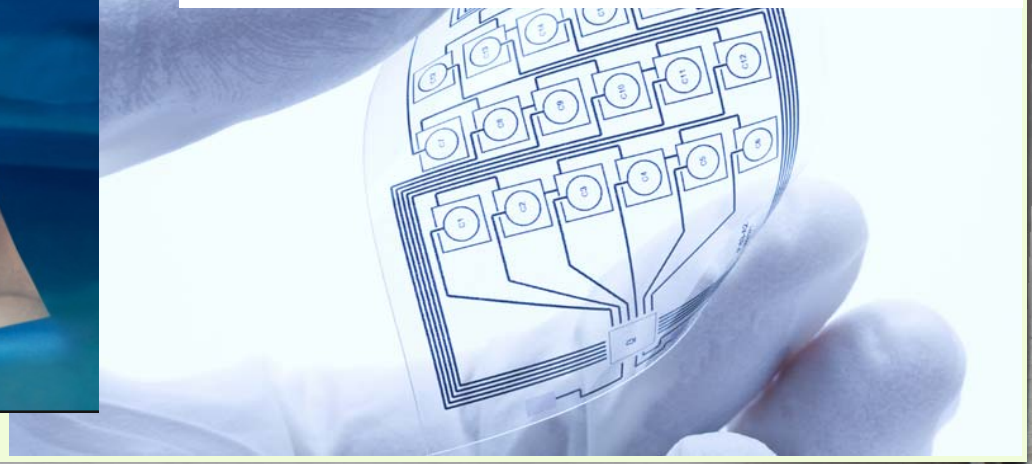
Swiss Plastics 2014, Messe Luzern

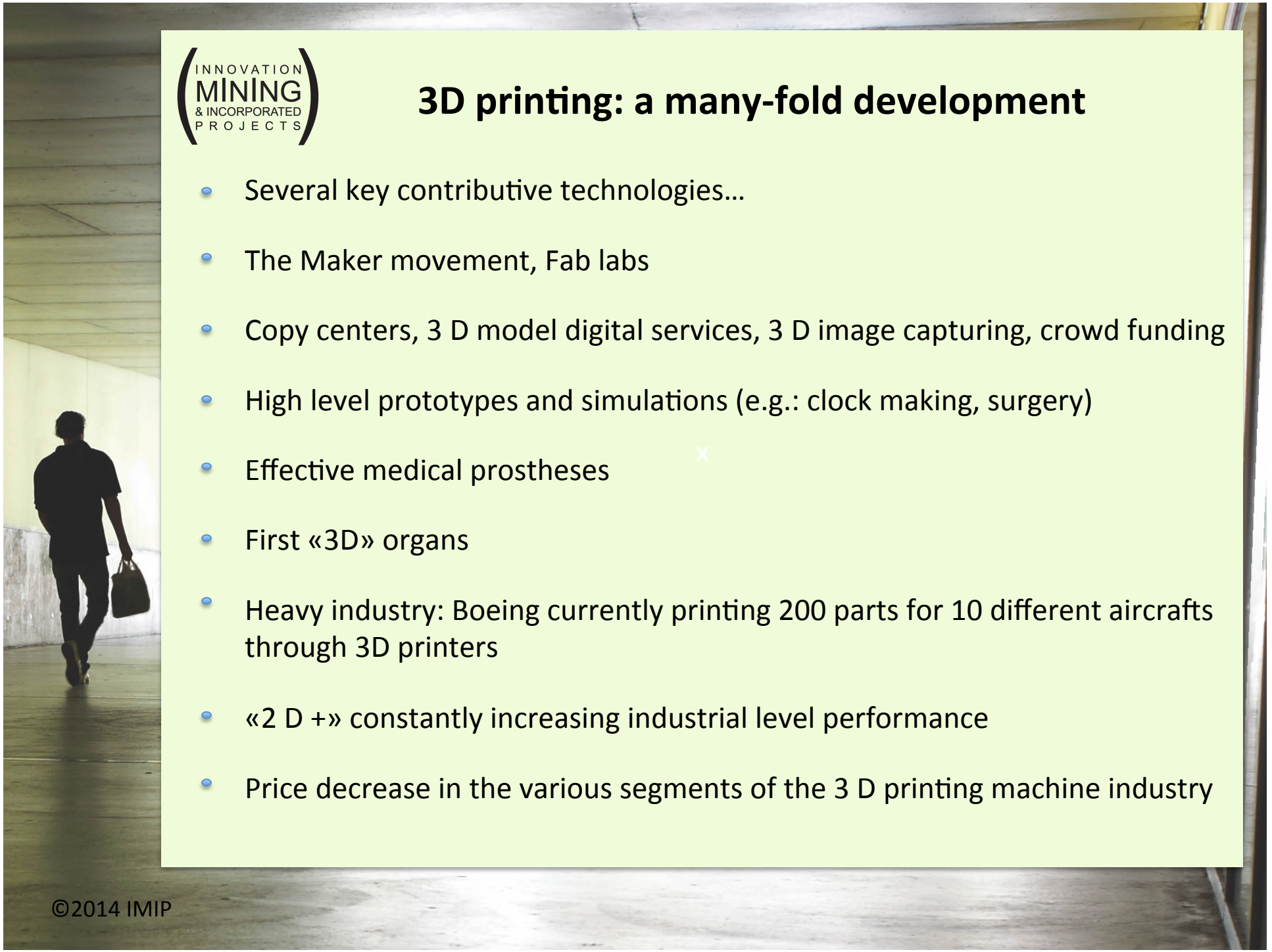
January 22, 2014

3 D / 2D+ printing: the explosion, from rapid prototyping to “unlimited creativity”



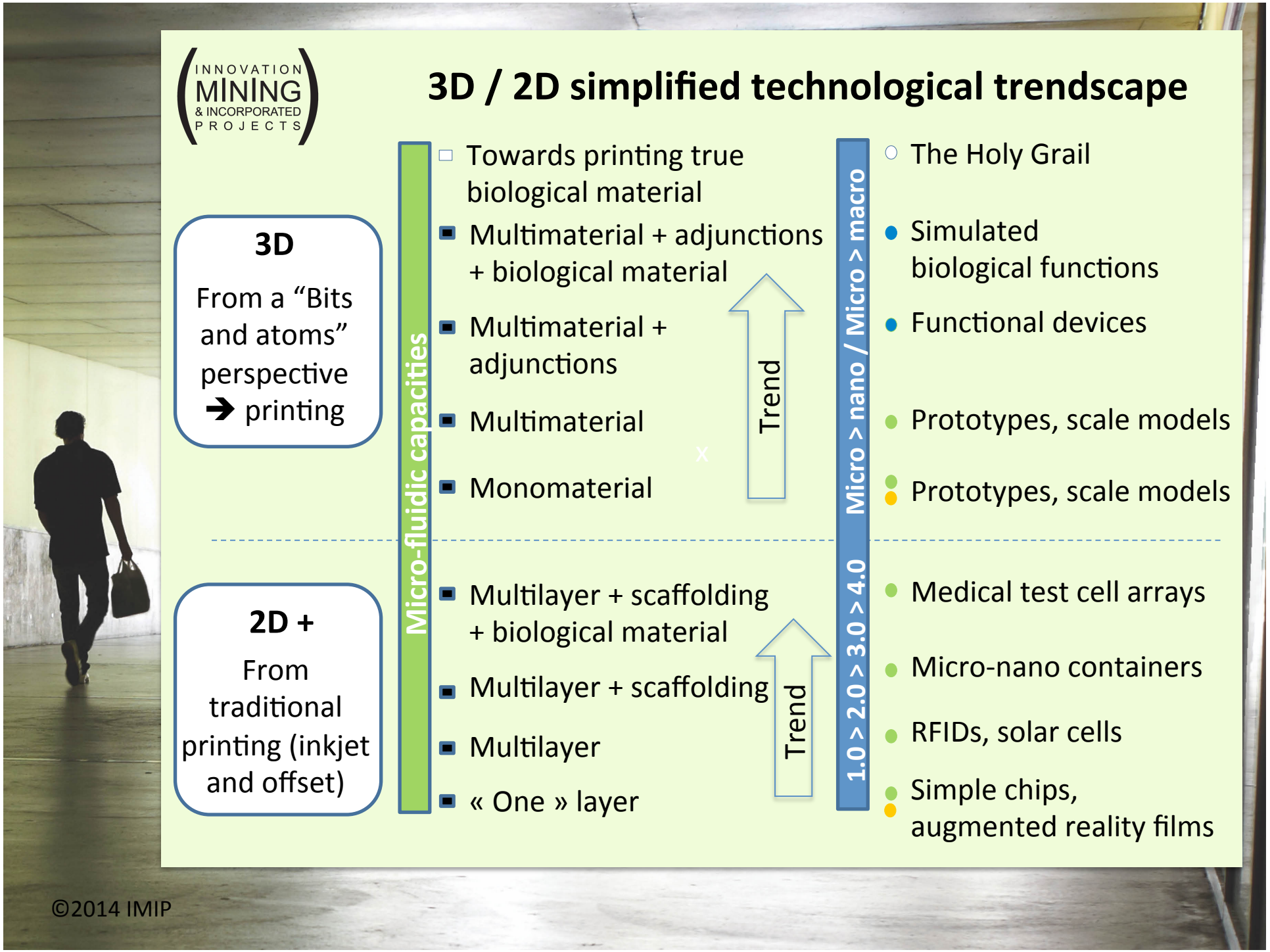






3D printing: a many-fold development

- Several key contributive technologies…
- The Maker movement, Fab labs
- Copy centers, 3 D model digital services, 3 D image capturing, crowd funding
- High level prototypes and simulations (e.g.: clock making, surgery)
- Effective medical prostheses
- First «3D» organs
- Heavy industry: Boeing currently printing 200 parts for 10 different aircrafts through 3D printers
- «2 D +» constantly increasing industrial level performance
- Price decrease in the various segments of the 3 D printing machine industry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3D / 2D simplified technological trendscape
3D
From a "Bits and atoms" perspective
➔ printing
2D +
From traditional printing (inkjet and offset)
Micro-fluidic capacities
Towards printing true biological material
Multimaterial + adjunctions + biological material
Multimaterial + adjunctions
Multimaterial
Monomaterial
Trend
Multilayer + scaffolding + biological material
Multilayer + scaffolding
Multilayer
« One » layer
Trend
1.0 > 2.0 > 3.0 > 4.0
Micro > nano / Micro > macro
The Holy Grail
Simulated biological functions
Functional devices
Prototypes, scale models
Prototypes, scale models
Medical test cell arrays
Micro-nano containers
RFIDs, solar cells
Simple chips, augmented reality films

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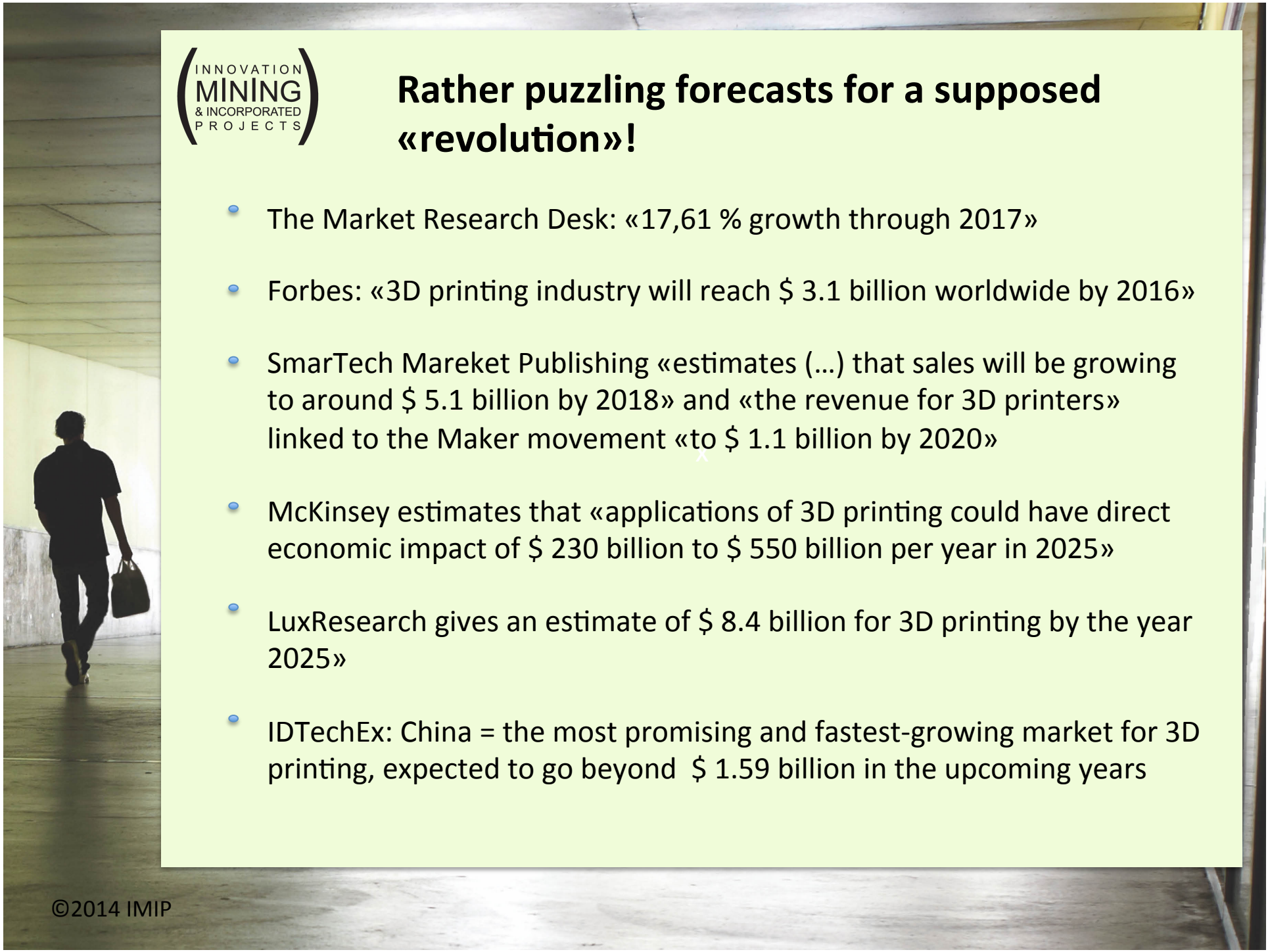
Still, do we know the future? How to get better oriented?

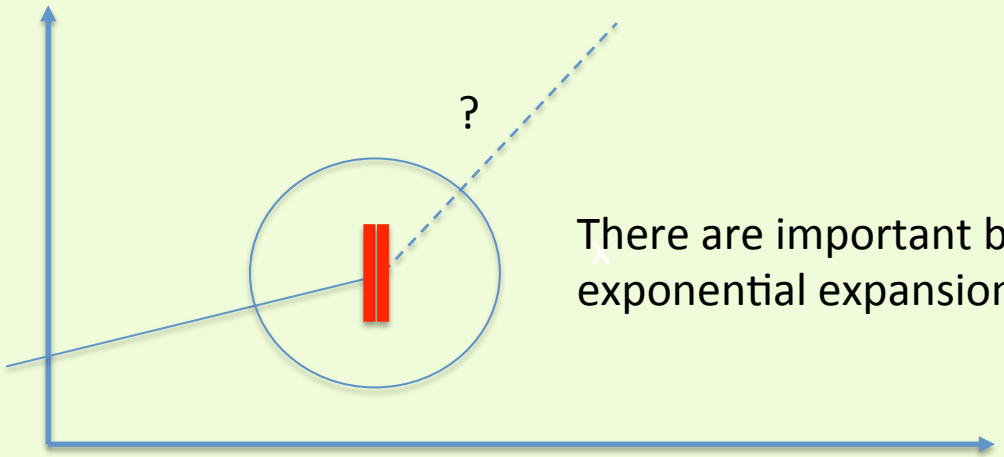
- Is the right moment to enter? Or already too late?
- Will it continue to expand at the same pace?
- What should you do?



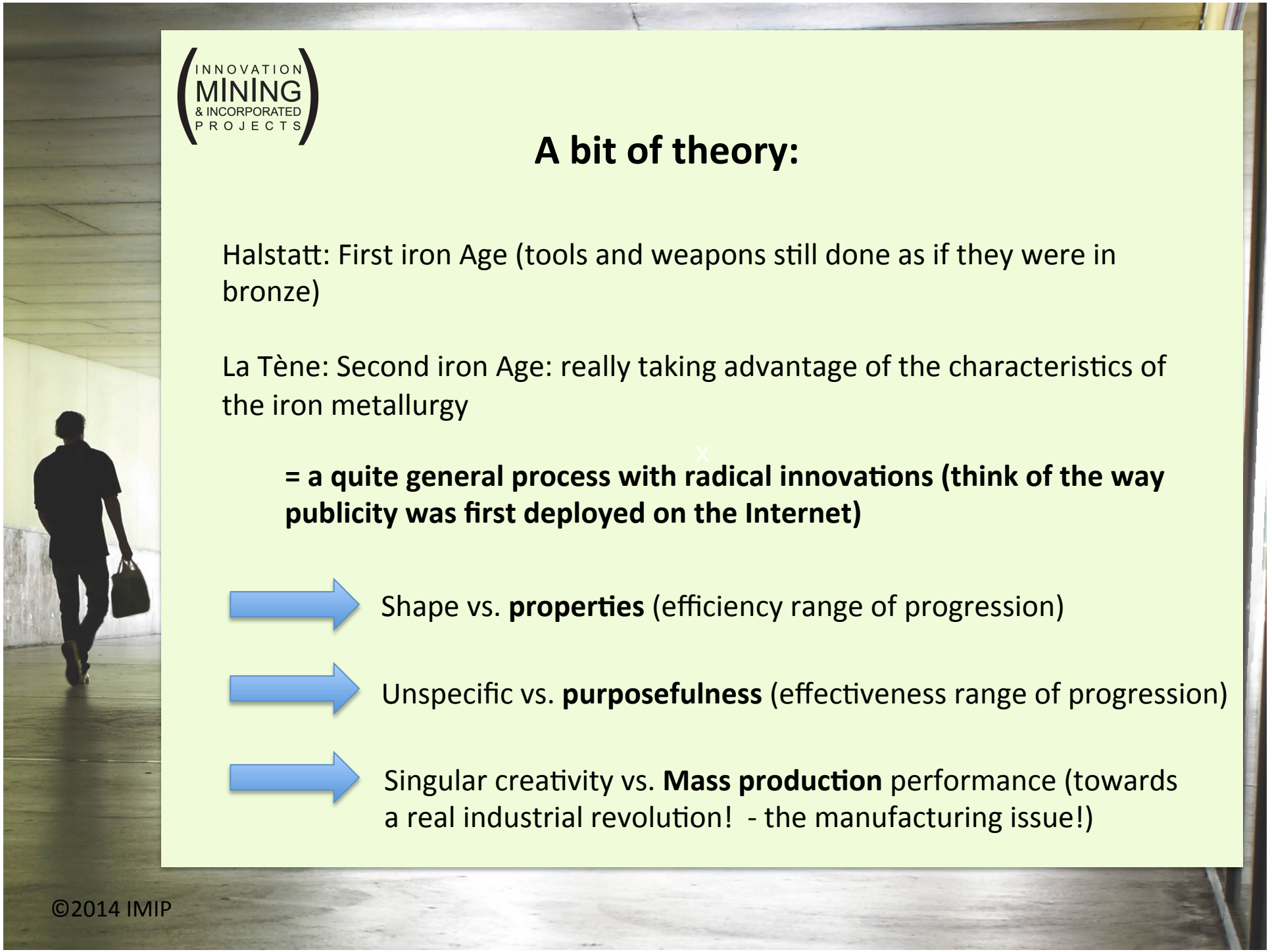
Rather puzzling forecasts for a supposed «revolution»!

- The Market Research Desk: «17,61 % growth through 2017»
- Forbes: «3D printing industry will reach $ 3.1 billion worldwide by 2016»
- SmarTech Mareket Publishing «estimates (…) that sales will be growing to around $ 5.1 billion by 2018» and «the revenue for 3D printers» linked to the Maker movement «to $ 1.1 billion by 2020»
- McKinsey estimates that «applications of 3D printing could have direct economic impact of $ 230 billion to $ 550 billion per year in 2025»
- LuxResearch gives an estimate of $ 8.4 billion for 3D printing by the year 2025»
- IDTechEx: China = the most promising and fastest-growing market for 3D printing, expected to go beyond $ 1.59 billion in the upcoming years

Our claim: 3 D is still in its first age



There are important barriers to the exponential expansion of 3D printing



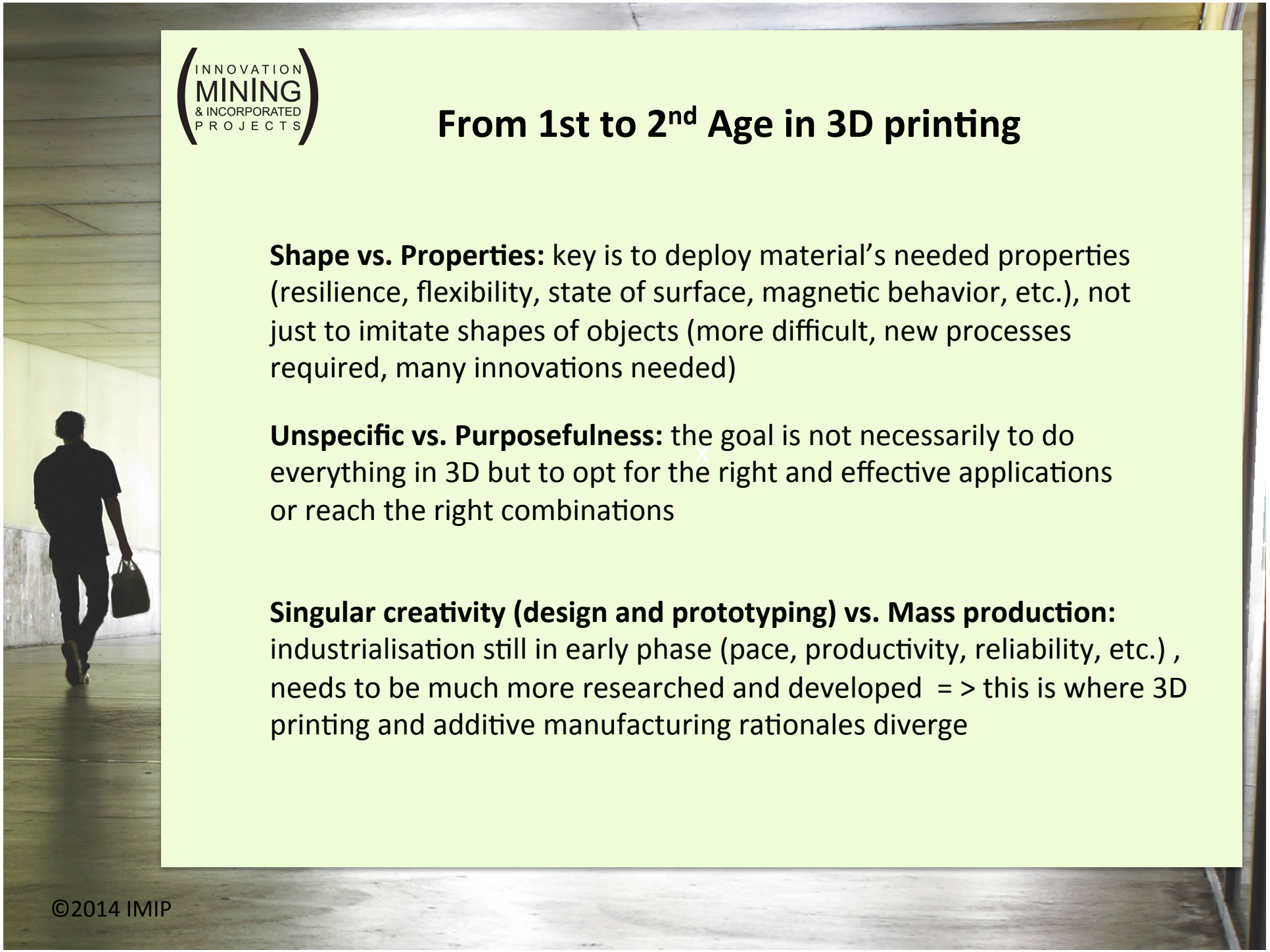
A bit of theory:

Halstatt: First iron Age (tools and weapons still done as if they were in bronze)

La Tène: Second iron Age: really taking advantage of the characteristics of the iron metallurgy

= a quite general process with radical innovations (think of the way publicity was first deployed on the Internet)

- Shape vs. **properties** (efficiency range of progression)
- Unspecific vs. **purposefulness** (effectiveness range of progression)
- Singular creativity vs. **Mass production** performance (towards a real industrial revolution! - the manufacturing issue!)



From 1st to 2nd Age in 3D printing

Shape vs. Properties: key is to deploy material's needed properties (resilience, flexibility, state of surface, magnetic behavior, etc.), not just to imitate shapes of objects (more difficult, new processes required, many innovations needed)

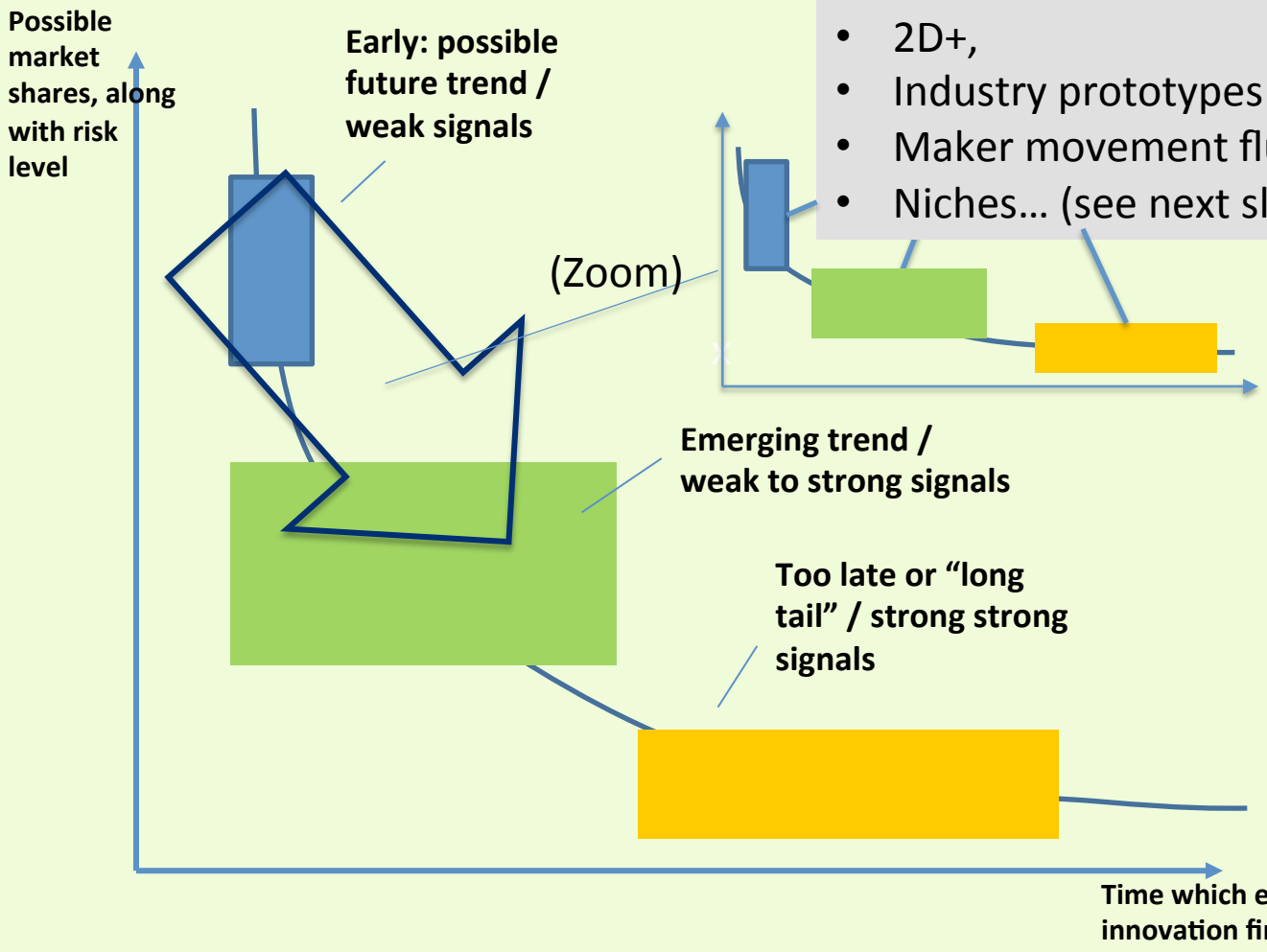
Unspecific vs. Purposefulness: the goal is not necessarily to do everything in 3D but to opt for the right and effective applications or reach the right combinations

Singular creativity (design and prototyping) vs. Mass production: industrialisation still in early phase (pace, productivity, reliability, etc.) , needs to be much more researched and developed = > this is where 3D printing and additive manufacturing rationales diverge

The good new for the plastic industry (focused 3D trend analysis)

There are sub-market segments worth investing in or exploring :

- 2D+,
- Industry prototypes
- Maker movement fluids
- Niches… (see next slides)



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Customised products:

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Items not so easy to produce with conventional means:

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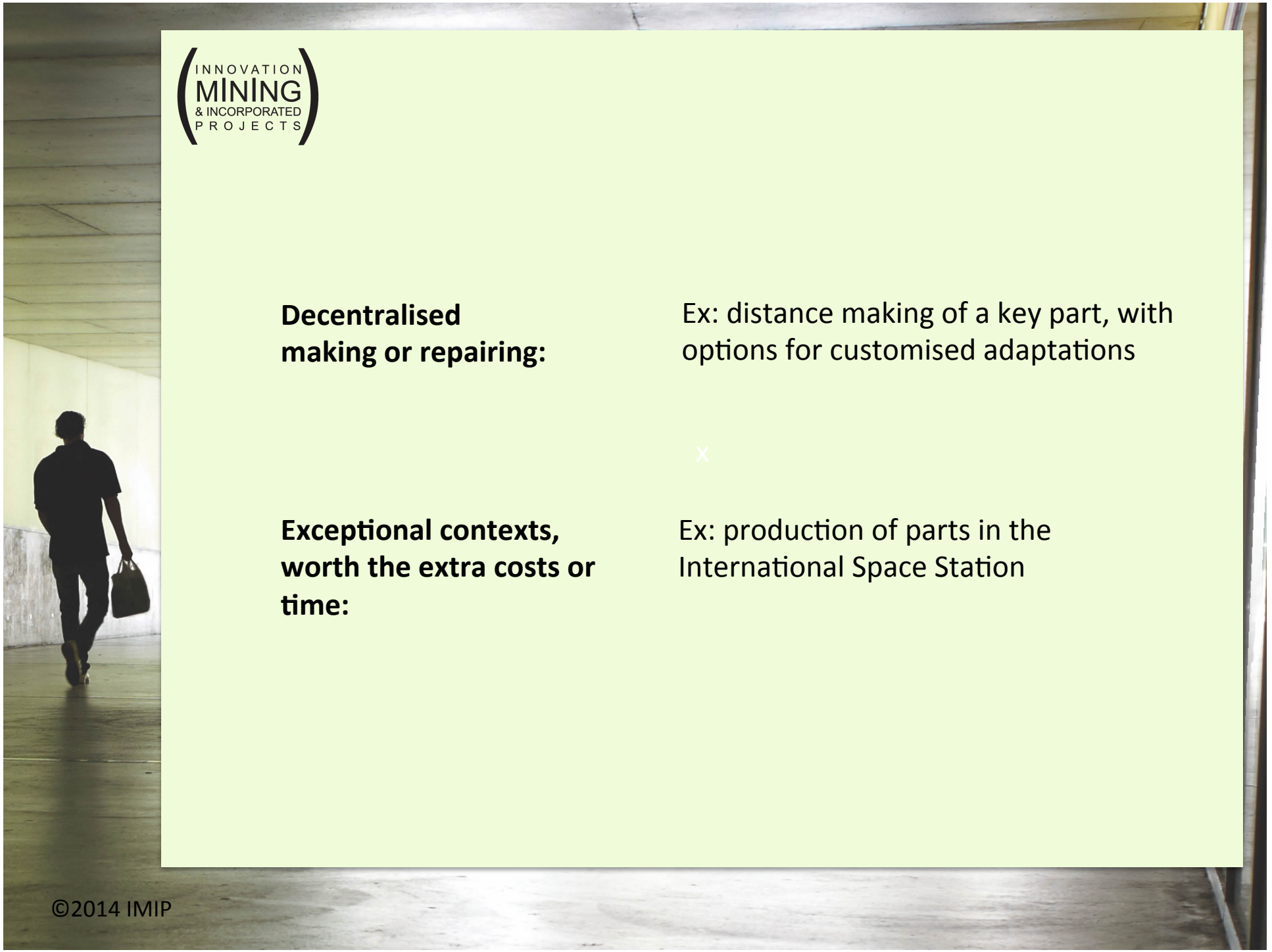
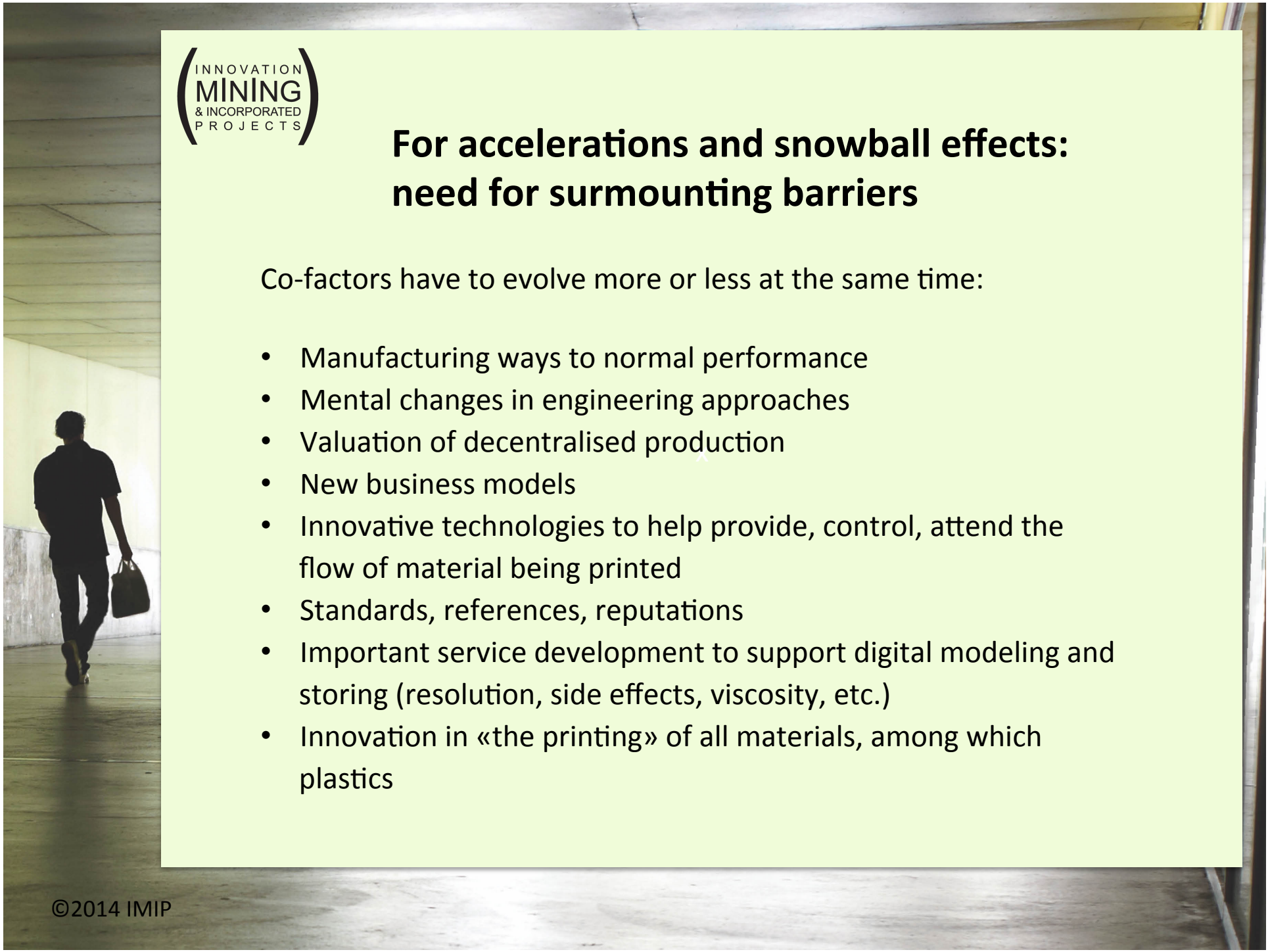
Personalised products:



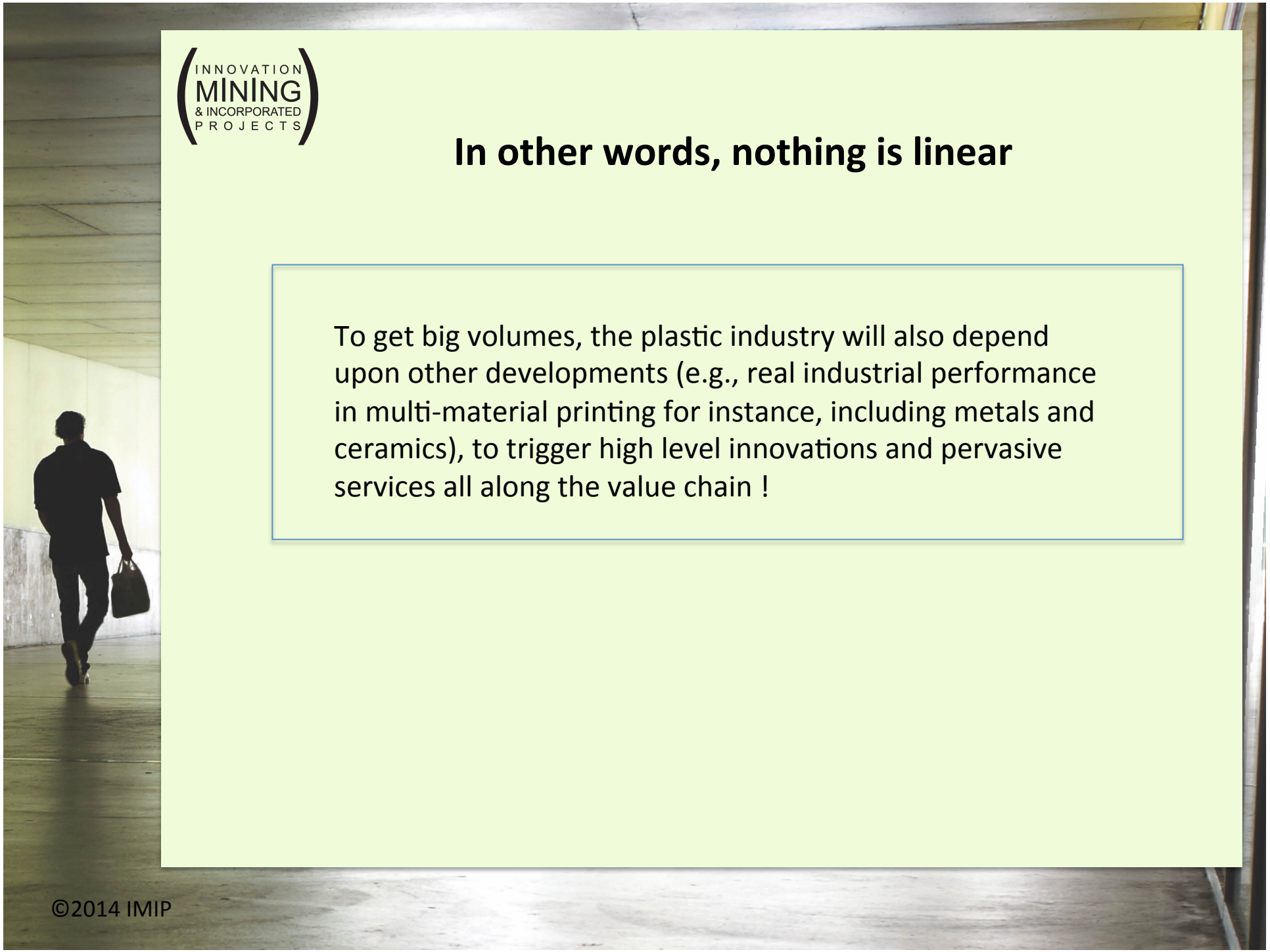
Decentralised making or repairing:	Ex: distance making of a key part, with options for customised adaptations
Exceptional contexts, worth the extra costs or time:	Ex: production of parts in the International Space Station



For accelerations and snowball effects: need for surmounting barriers

Co-factors have to evolve more or less at the same time:

- Manufacturing ways to normal performance
- Mental changes in engineering approaches
- Valuation of decentralised production
- New business models
- Innovative technologies to help provide, control, attend the flow of material being printed
- Standards, references, reputations
- Important service development to support digital modeling and storing (resolution, side effects, viscosity, etc.)
- Innovation in «the printing» of all materials, among which plastics



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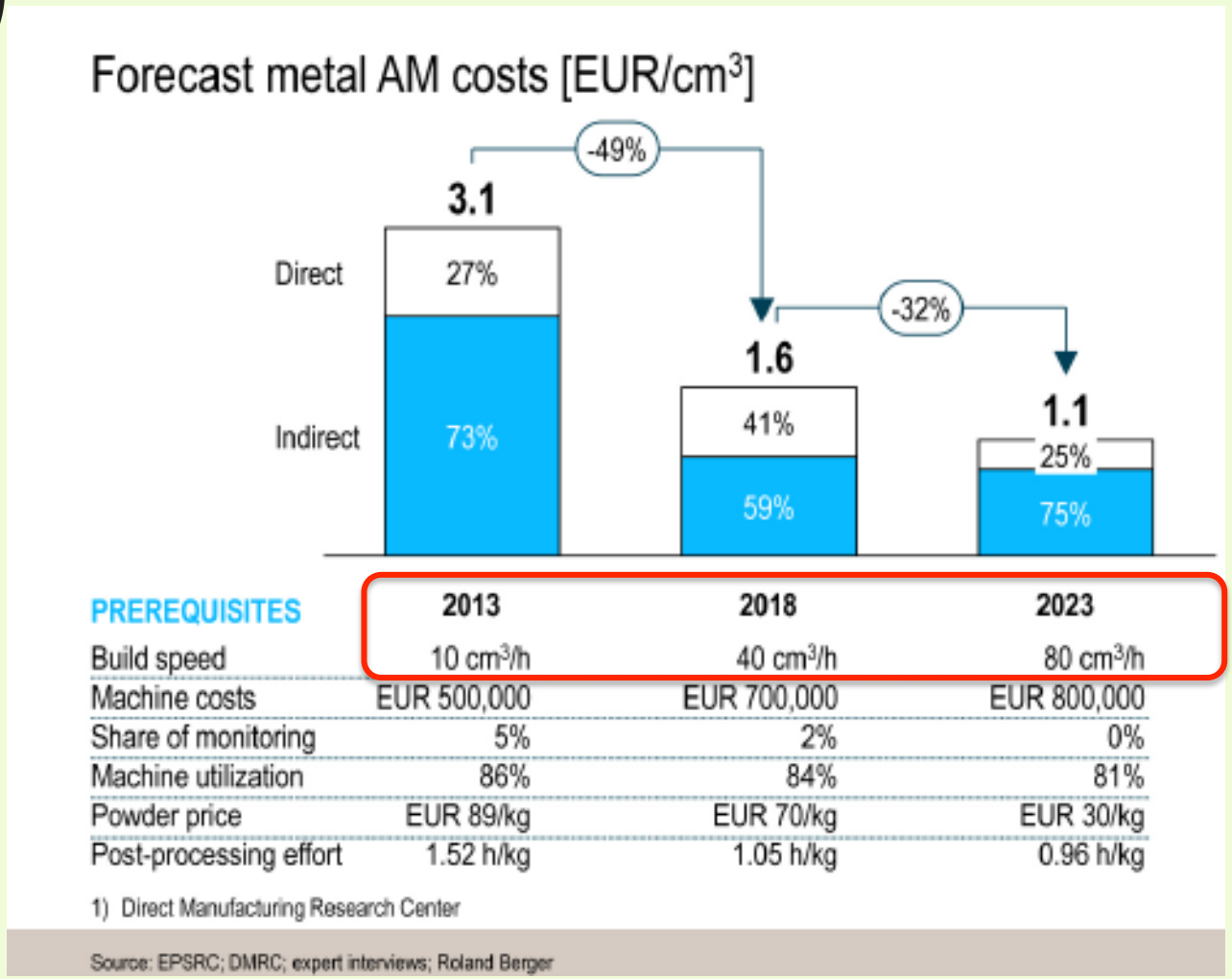
In other words, nothing is linear

To get big volumes, the plastic industry will also depend upon other developments (e.g., real industrial performance in multi-material printing for instance, including metals and ceramics), to trigger high level innovations and pervasive services all along the value chain !

To get an idea of metal 3 D printing's possible evolution



PREREQUISITES	2013	2018	2023
Build speed	10 cm^3/h	40 cm^3/h	80 cm^3/h
Machine costs	EUR 500,000	EUR 700,000	EUR 800,000
Share of monitoring	5%	2%	0%
Machine utilization	86%	84%	81%
Powder price	EUR 89/kg	EUR 70/kg	EUR 30/kg
Post-processing effort	1.52 h/kg	1.05 h/kg	0.96 h/kg

1) Direct Manufacturing Research Center

Source: EPSRC; DMRC; expert interviews; Roland Berger

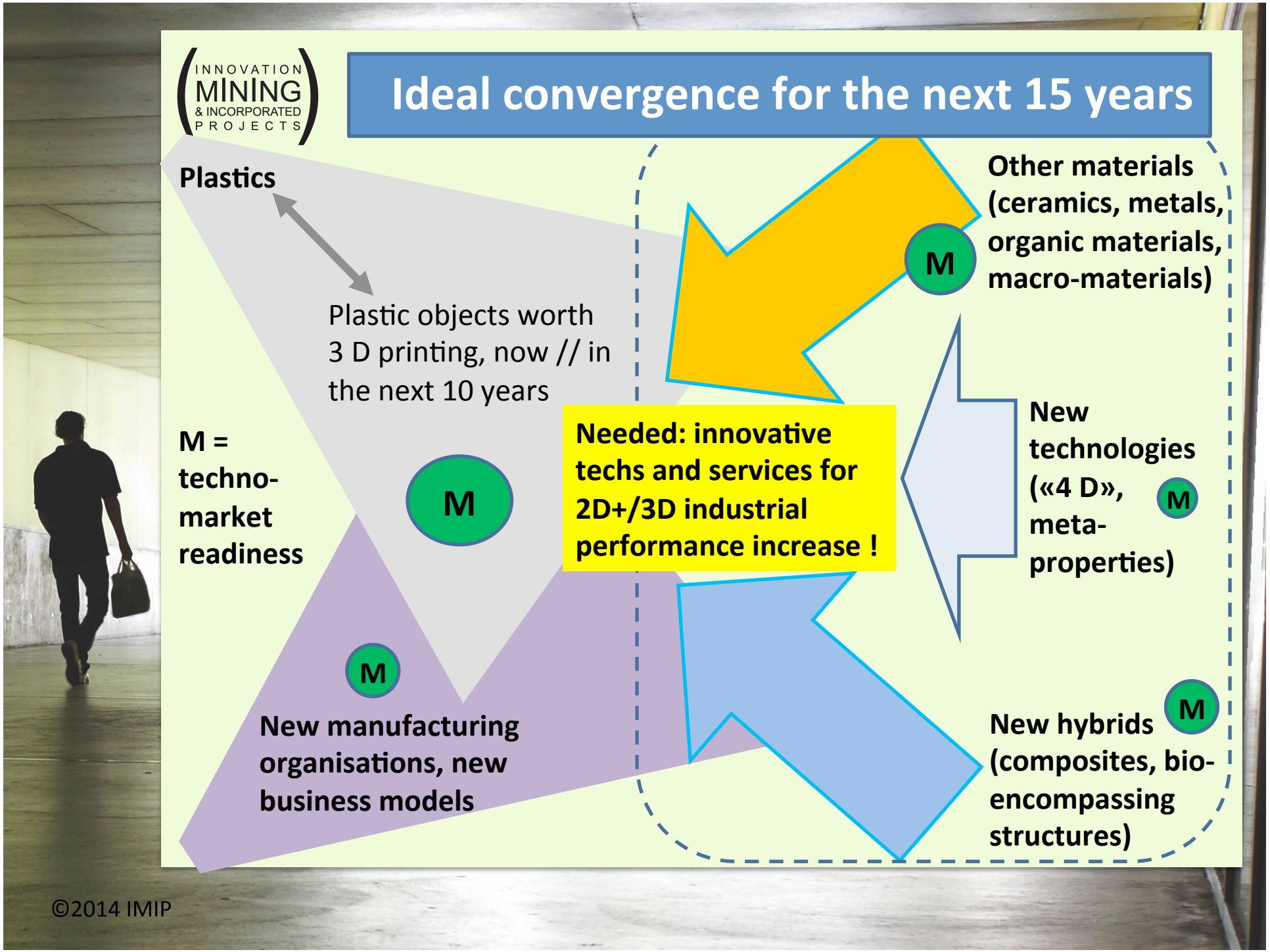
Posted in Printing Equipment and Supplies by Thomas Klein on December 6, 2013, Published on *EMDT - European Medical Device Technology* (http://www.emdt.co.uk)

Another development to play a critical role

Bio-material printing, because of the **high value added benefits and research efforts**, also likely to contribute to the overall development of 3D printing/additive manufacturing in the next 15 years (important for scaffolding, multi-material innovation, material cultivation)

If organs on demand are not on the shelf yet (but tissue engineering is), we have already, e.g.:

- Mini human livers (40 day survival on a 2013 attempt)
- A partially «printed» larynx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Ideal convergence for the next 15 years
Plastics
Plastic objects worth
3 D printing, now // in
the next 10 years
M = techno-market readiness
M
Needed: innovative techs and services for 2D+/3D industrial performance increase !
Other materials (ceramics, metals, organic materials, macro-materials)
M
New technologies («4 D», meta-properties)
M
M
New manufacturing organisations, new business models
New hybrids (composites, bio-encompassing structures)
M
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Thank You for your attention !

Patrick ROTH
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Microtechnologies

Pierre ROSSEL
Futures, Trendcasting,
Smart cities, Technology

Alain SANDOZ
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Information systems