

**luxexecutivesummit 2018**

Tokyo • October 17

# The final frontier

Unlocking the potential of the commercial spaceflight industry

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**Presenter:** Anthony Schiavo, Analyst , Lux Research



# Why space?

# Agenda

- 1 | The prime directive
- 2 | Opportunities for innovation
- 3 | Back to earth: Key takeaways to start your space journey

# Agenda

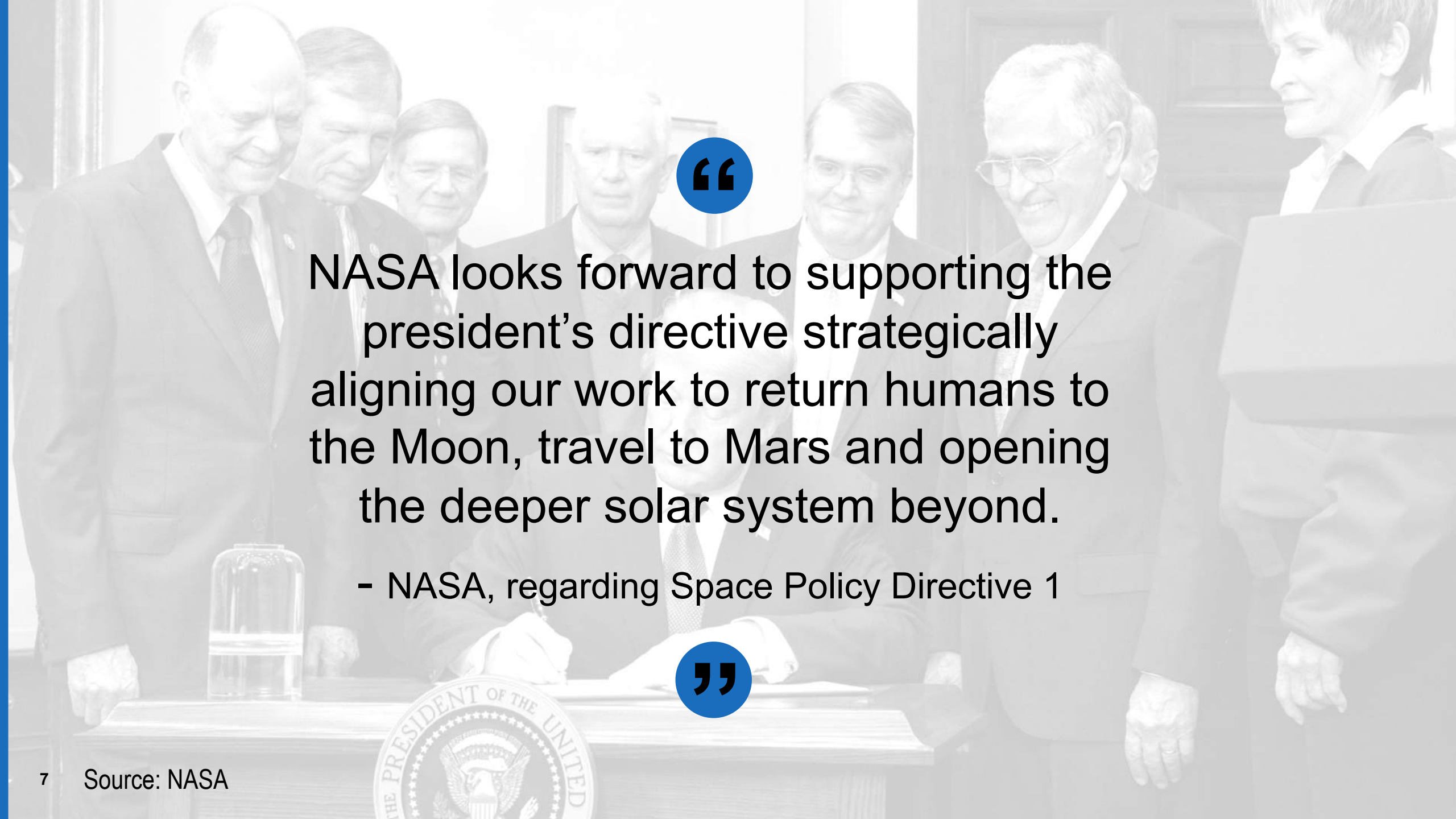
- 1 | **The prime directive**
- 2 | Opportunities for innovation
- 3 | Back to earth: Key takeaways to start your space journey

# We are entering an era of commercial spaceflight



# We are entering an era of commercial spaceflight





NASA looks forward to supporting the president's directive strategically aligning our work to return humans to the Moon, travel to Mars and opening the deeper solar system beyond.

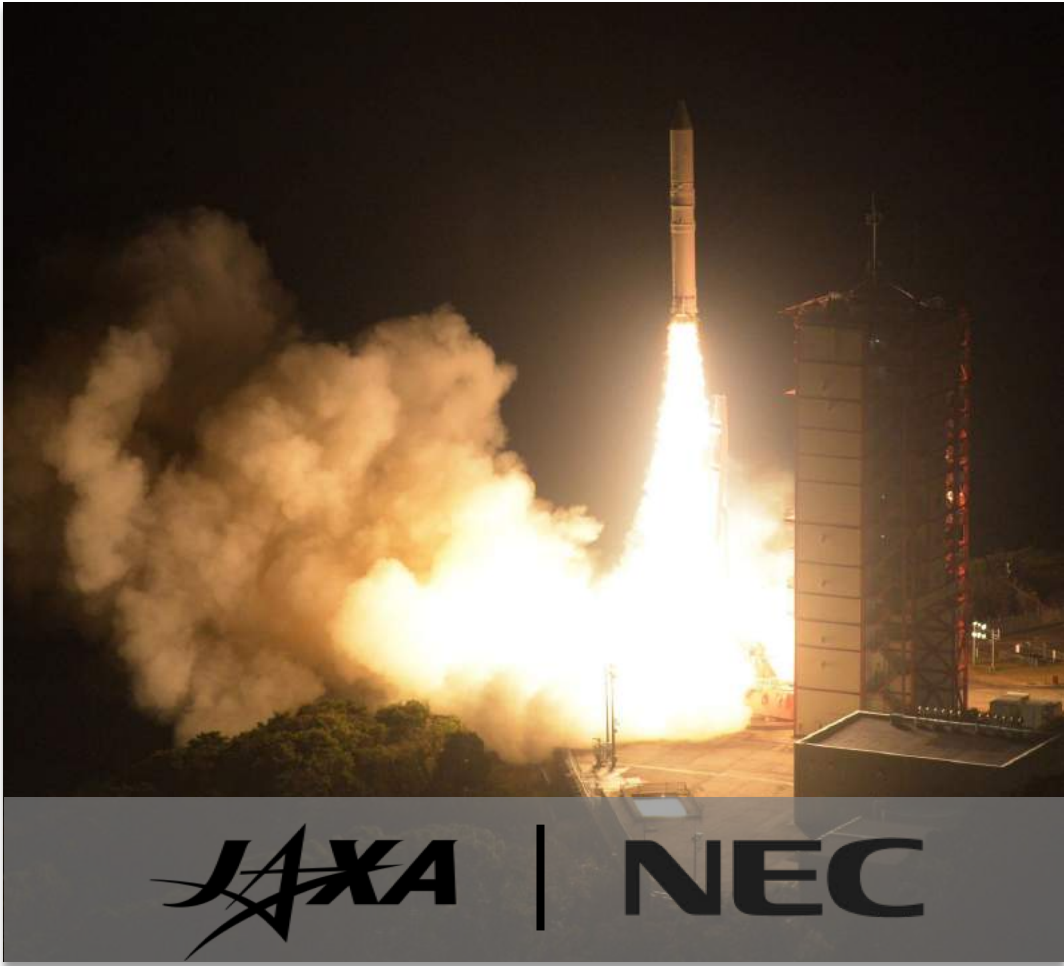
- NASA, regarding Space Policy Directive 1

## Japan is a growing hub for commercial spaceflight activity





# Japan is a growing hub for commercial spaceflight activity



# The potential space market size is sky high

Total space activity today

**\$330 Billion**

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Total space activity today

**\$330 Billion**

**Bank of America**   
**Merrill Lynch**

**\$3 Trillion**

# Spaceflight has long inspired technology innovation...



... but it has also created real materials breakthroughs and products



**MEMORY FOAM**



**RADIANT BARRIER**



**DRY LUBRICANTS**

# This tech development translates into real world business opportunity

## \$6 Billion



MEMORY FOAM



RADIANT BARRIER



DRY LUBRICANTS


### NASA spurs innovation and business growth

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**1,600** new technologies in 2012

**2,200** tech transfer transaction in 2012

**\$1 million** annually per spinoff



Meeting the needs  
of commercial  
spaceflight creates  
terrestrial business  
opportunities




**Commercial  
space flight  
opportunities**

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**Cost reduction**

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**Commercial  
space flight  
opportunities**

---

**Cost reduction**

**Communication**

---



**Commercial  
space flight  
opportunities**

---

**Cost reduction**

**Communication**

**Sustainability**


---

# Agenda

1 | The prime directive

2 | **Opportunities for innovation**

3 | Back to earth: Key takeaways to start your space journey



**Commercial  
space flight  
opportunities**

---

**Cost reduction**

**Communication**

**Sustainability**

---



**Commercial  
space flight  
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**Cost reduction**



**3D Printing**

**Communication**

**Sustainability**

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## 3D PRINTING

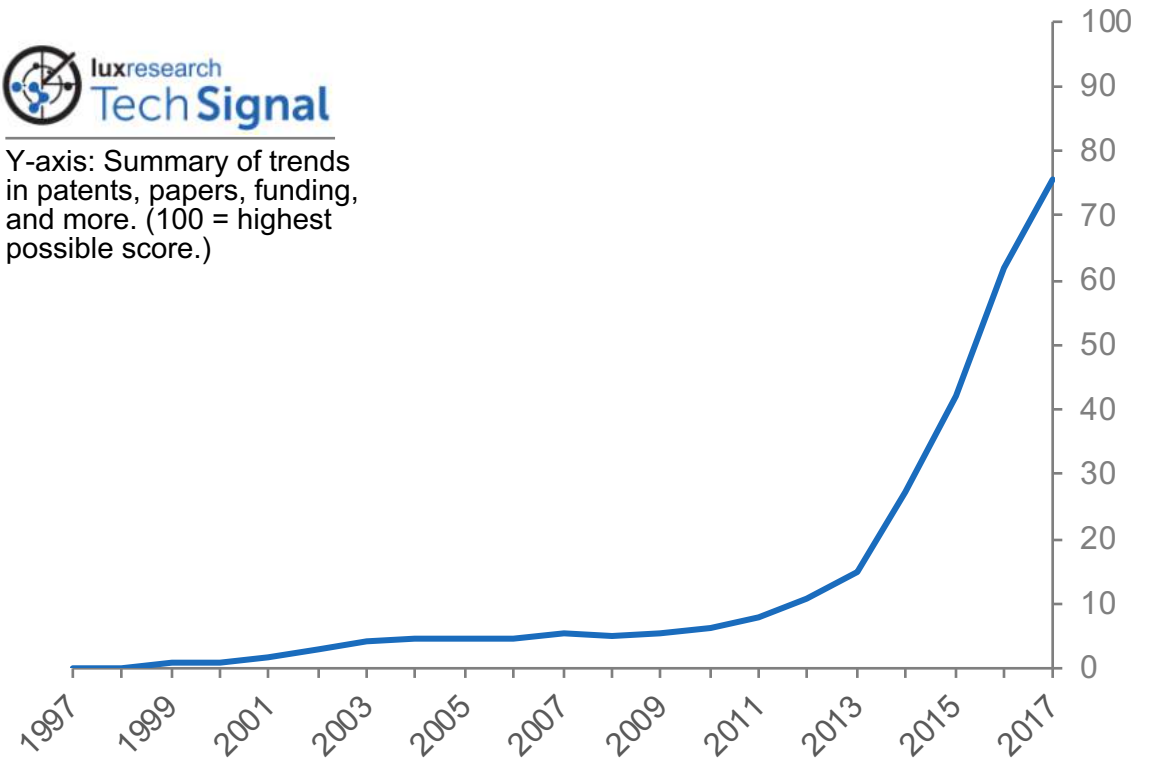
# Overview of technology

### Description:

Additive manufacturing of objects layer by layer, based on digital design data



Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



## 3D PRINTING

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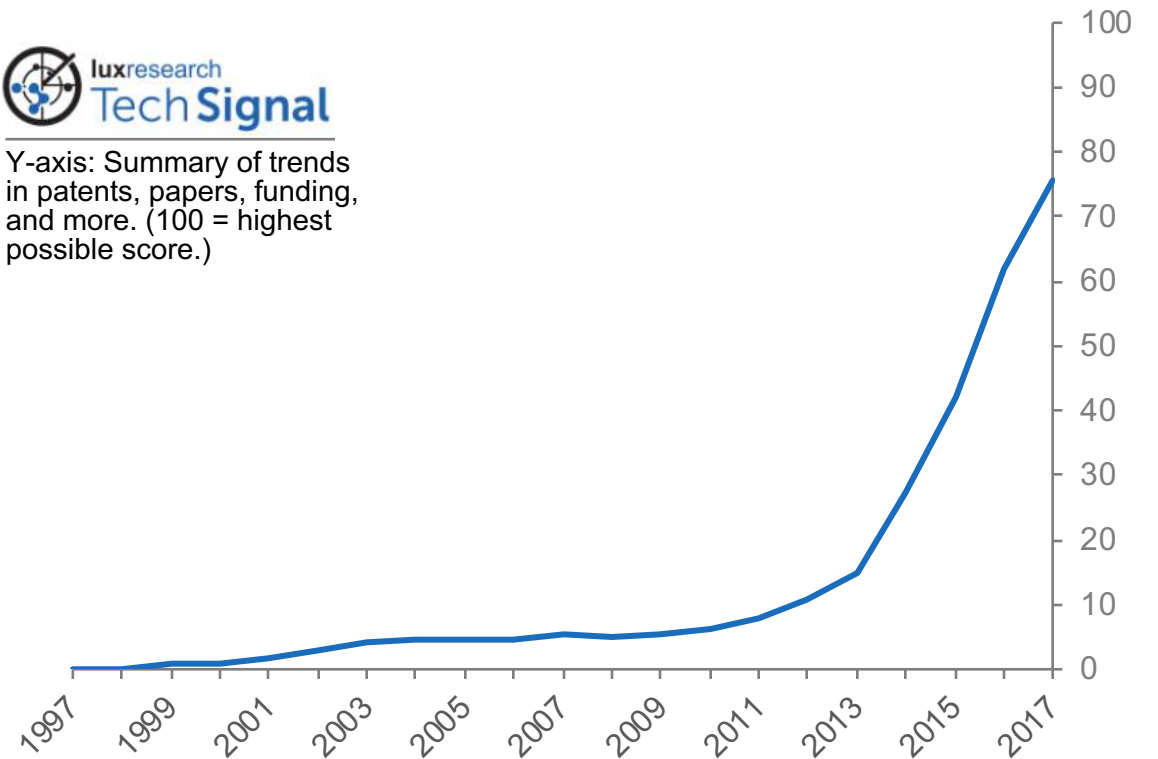
Additive manufacturing of objects layer by layer, based on digital design data

### Key Benefits:

- Novel geometries and compositions enable better performance and operational efficiencies



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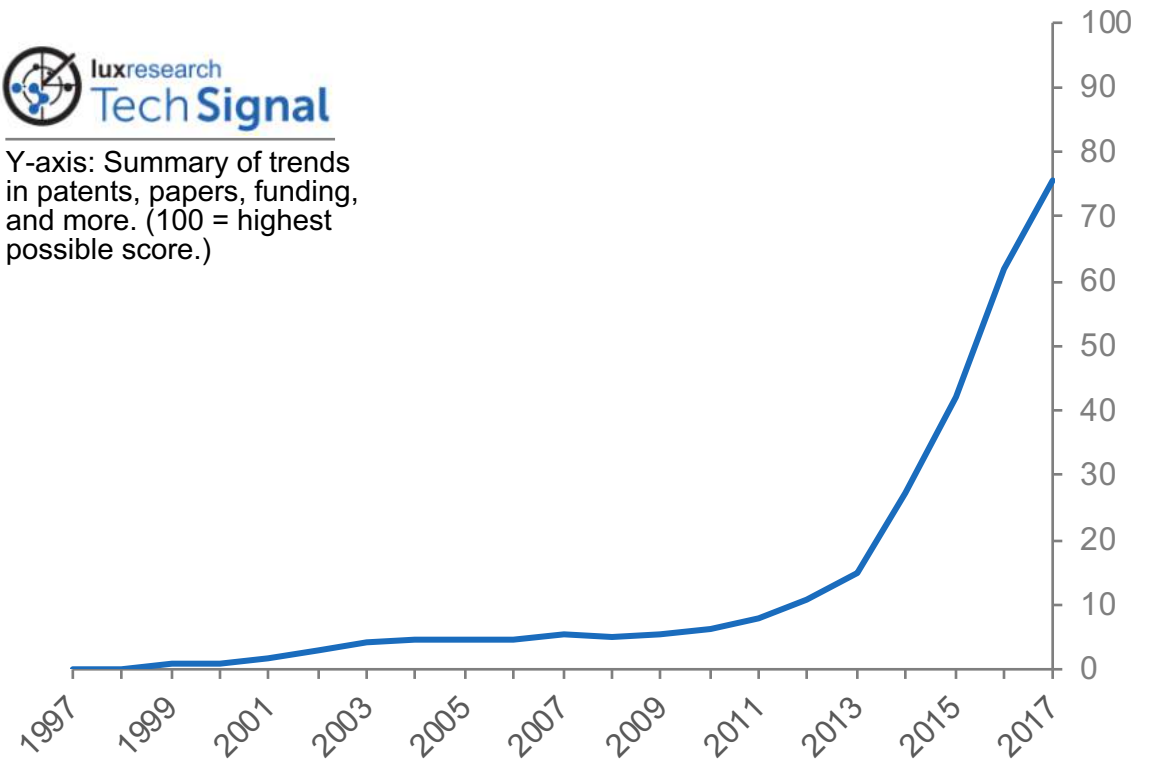
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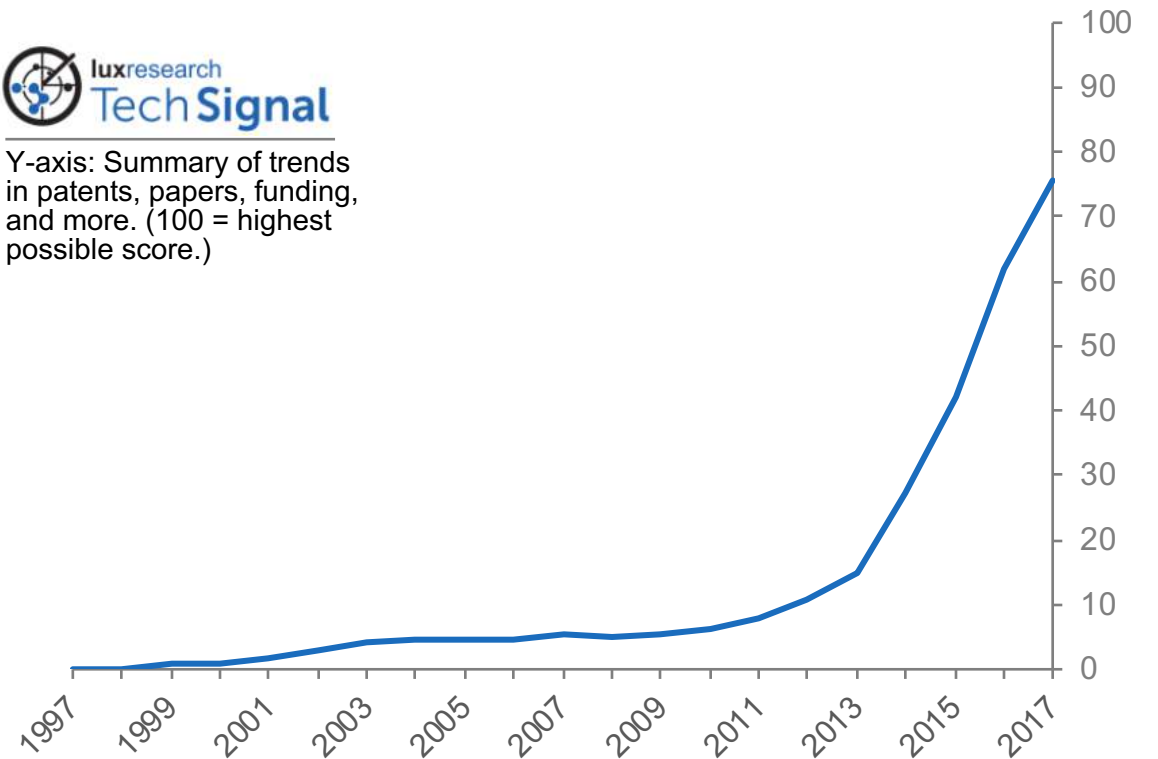
Additive manufacturing of objects layer by layer, based on digital design data

### Key Benefits:

- Novel geometries and compositions enable better performance and operational efficiencies
- Higher materials utilization saves costs
- Distributed manufacturing simplifies supply chains and reduces distribution costs



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3D PRINTING

## The opportunity

Engine printing can  
**improve performance &  
dramatically lower cost**



## 3D PRINTING

Wire based systems are an emerging option for low cost metal printing



LUX TAKE



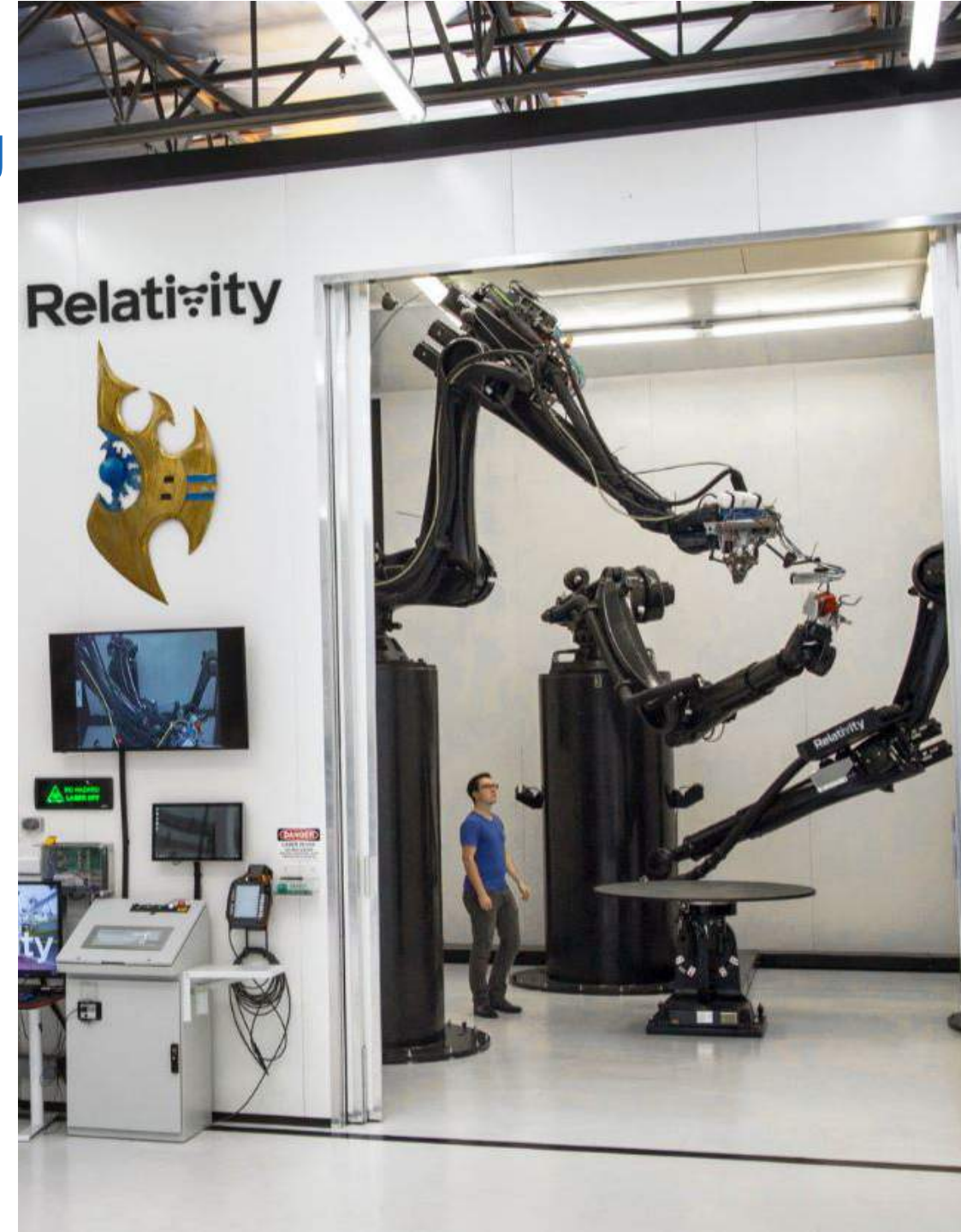
Positive

# Relativity

LUX TAKE

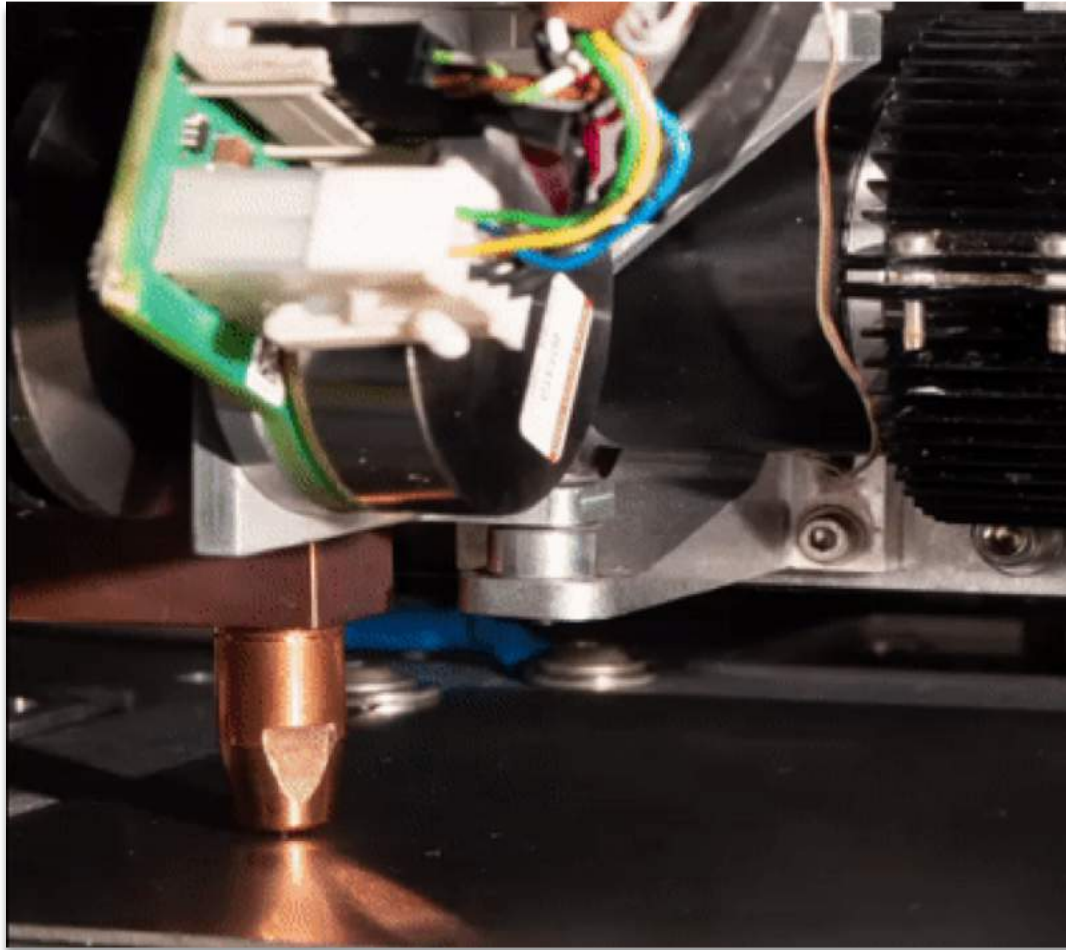


Wait And See



## 3D PRINTING

# High-temperature weldable alloy development will be critical



**QUESTEK**<sup>®</sup>  
INNOVATIONS LLC

LUX TAKE



Positive

 **DigitalAlloys**

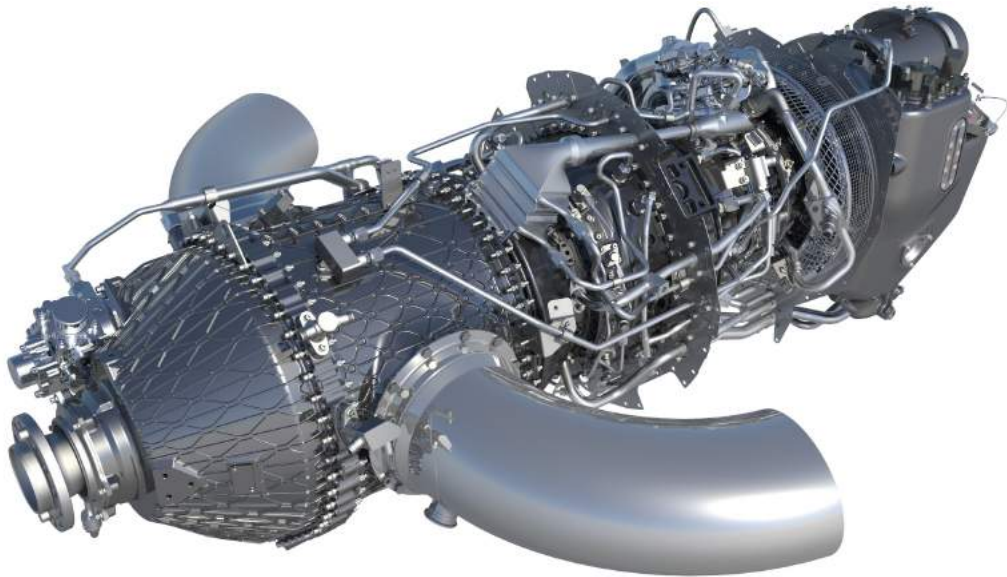
LUX RECOMMENDATION ⓘ



Engage

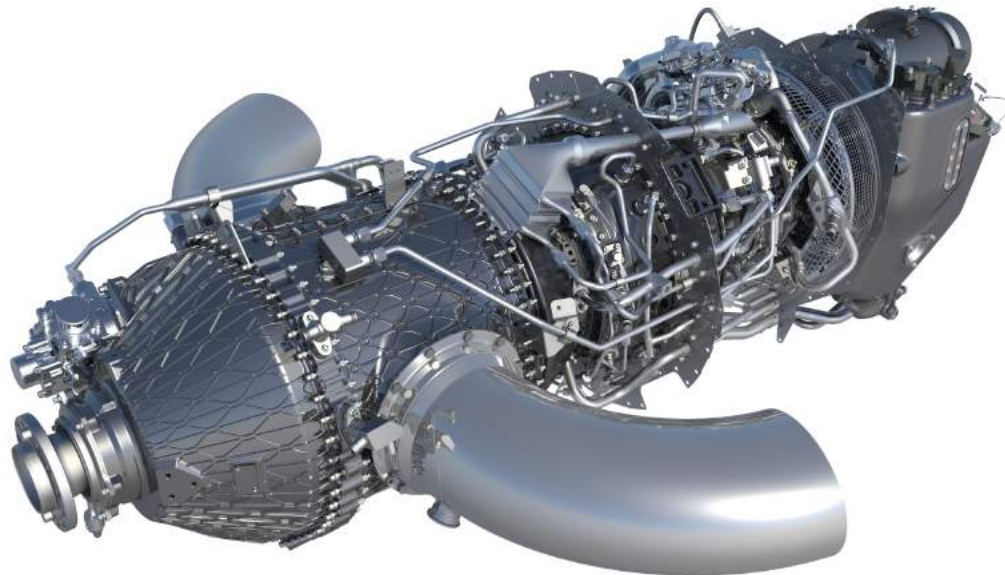
## 3D PRINTING

# Developing printable engines creates opportunities in terrestrial power & mobility




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# SIEMENS





**Commercial  
space flight  
opportunities**

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**Cost reduction**



**3D Printing**

**Communication**



**Metamaterials**

**Sustainability**

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# METAMATERIALS

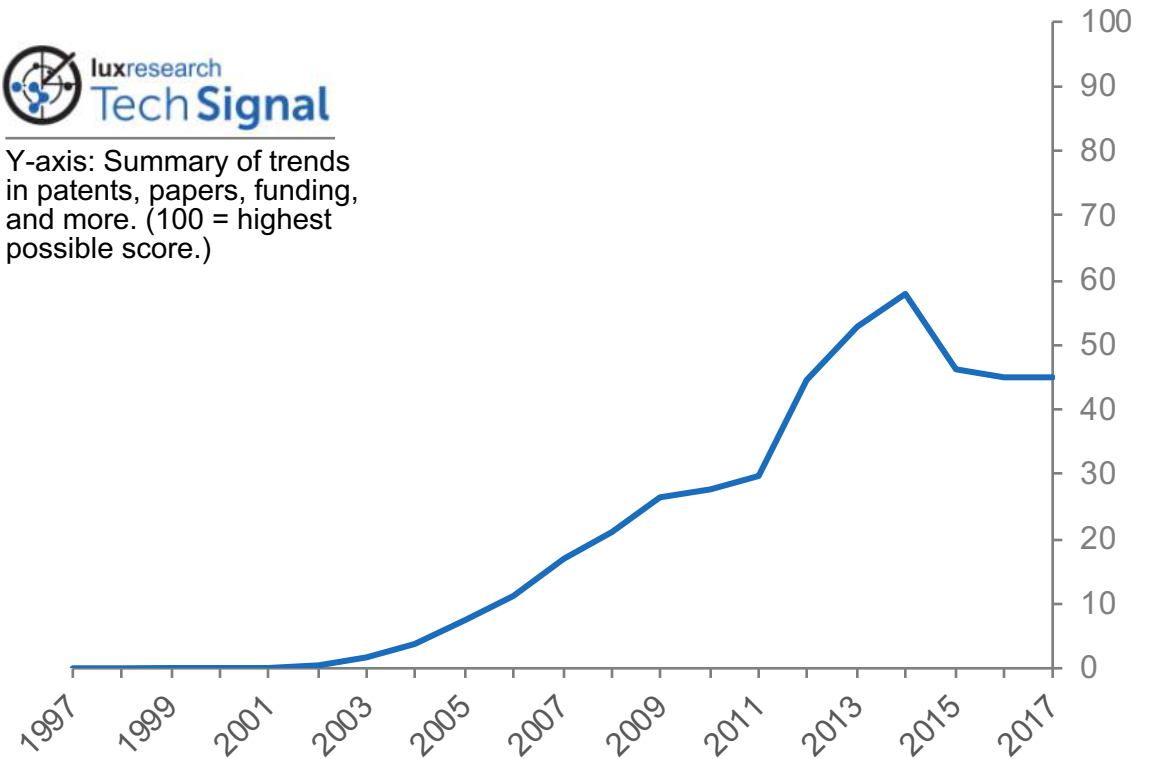
## Overview of technology

### Description:

Materials with patterned structures that enable novel properties



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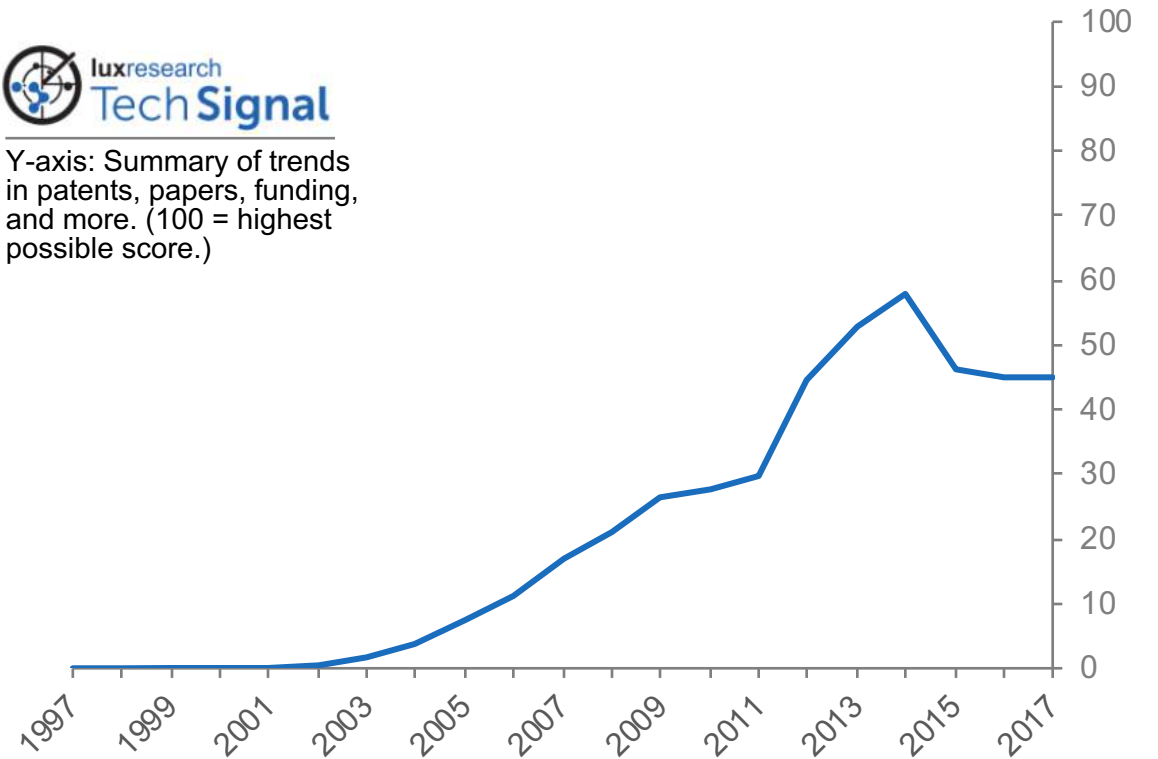
Materials with patterned structures that enable novel properties

### Key Benefits:

- Some properties that are impossible normally – like negative index of refraction – are possible with metamaterials



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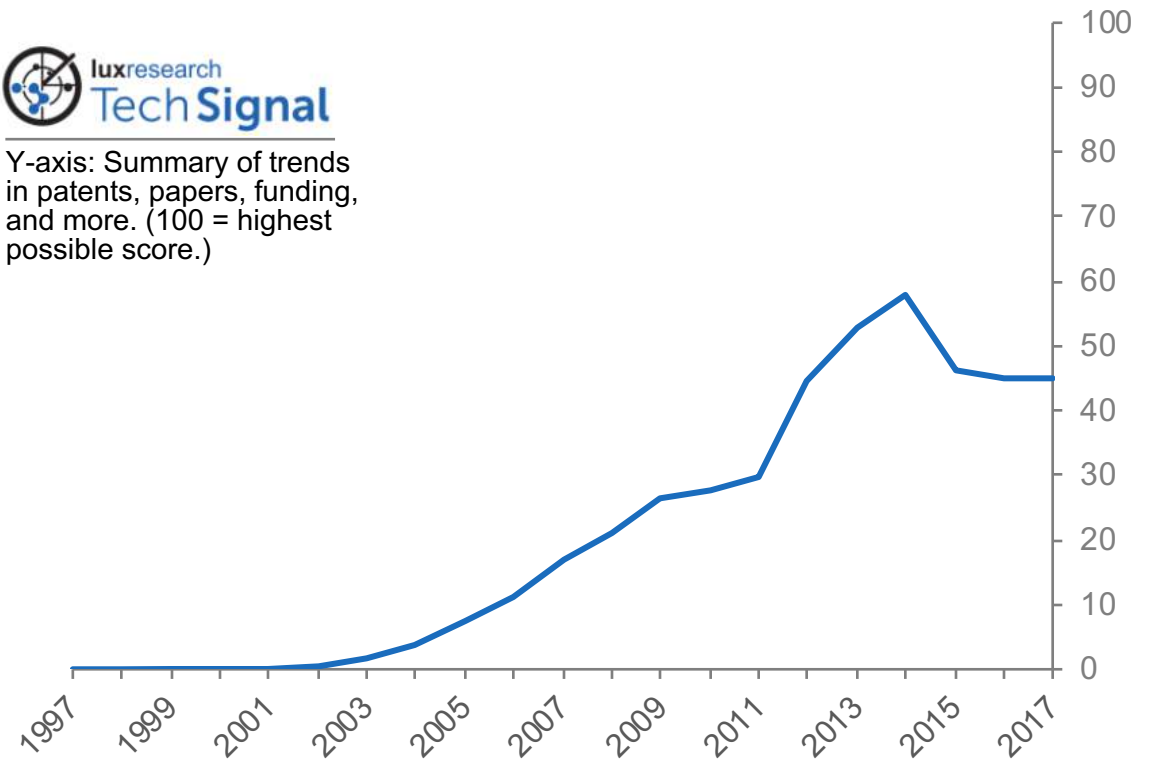
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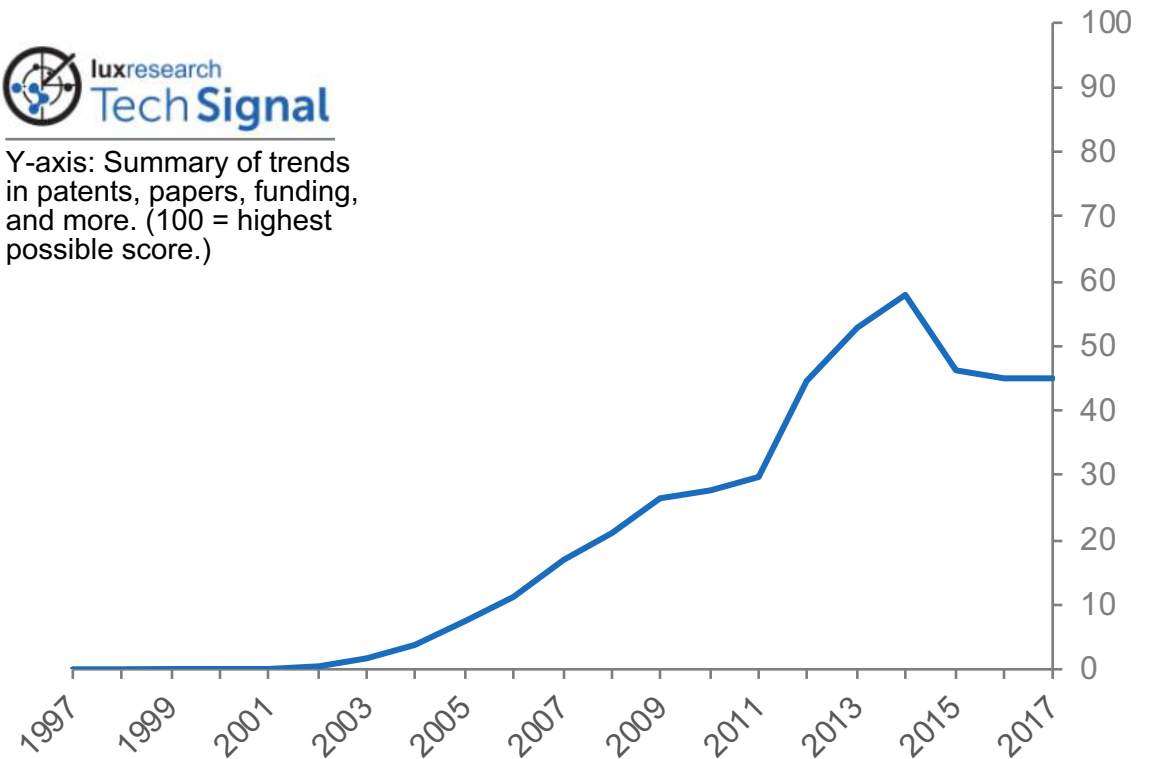
Materials with patterned structures that enable novel properties

### Key Benefits:

- Some properties that are impossible normally – like negative index of refraction – are possible with metamaterials
- Metamaterials can be made from a huge range of materials
- Near term applications include enhanced antennas and novel insulation

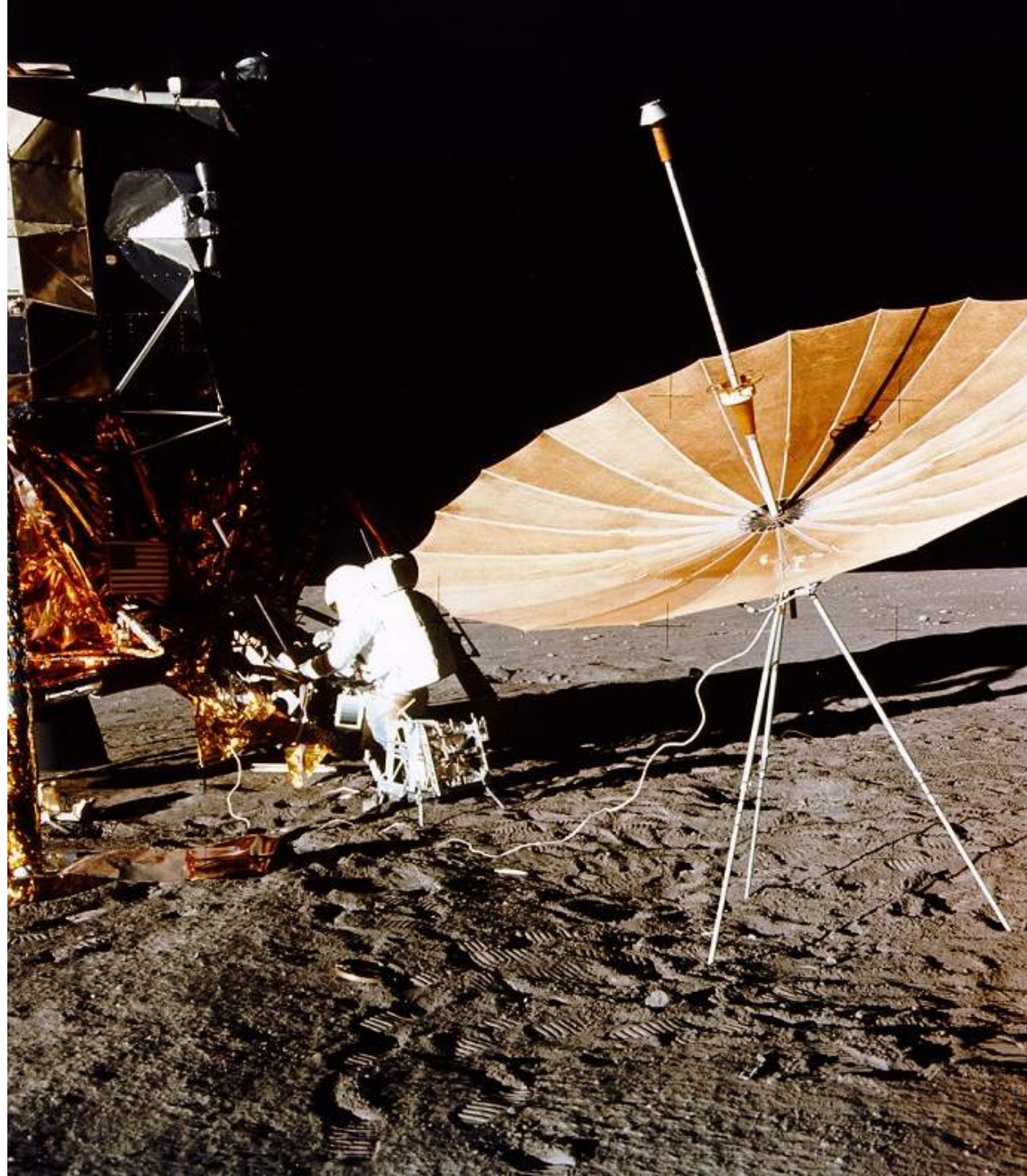


Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



METAMATERIALS  
**The opportunity**

Metamaterials can  
create **flat, compact,  
solid-state** antennas



# METAMATERIALS

## Broadband metamaterials are already in development



**KYMETA™**

LUX TAKE



Strong Positive

**ECHODYNE**

LUX TAKE



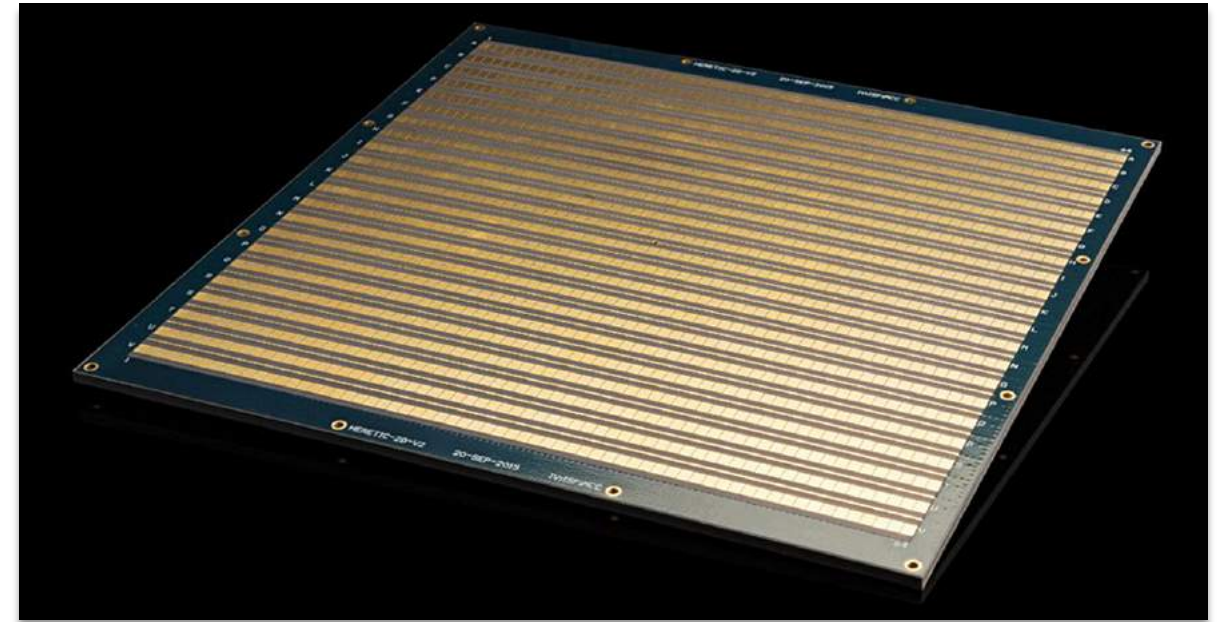
Wait And See

## METAMATERIALS

**High-quality substrate materials are needed to survive the rigors of space**

Standard PCB materials lack **thermal stability** and **dielectric properties**

PIVOTAL  
COMMWARE



## METAMATERIALS

# Miniaturized antennas will help meet the needs of terrestrial 5G/IoT applications

“We see the Pivotal team are a significant component to future networks ... with integrated benefits to our other telecom investments.”

- Jay Monroe, CEO  
The Thermo Companies

## METAMATERIALS

# Miniaturized antennas will help meet the needs of terrestrial 5G/IoT applications

“We see the Pivotal team are a significant component to future networks ... with integrated benefits to our other telecom investments.”

- Jay Monroe, CEO  
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**KYMETA™**

**\$217 M**




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**PIVOTAL**  
COMMWARE

**\$17 M**

**THERMO**  
COMPANIES





**Commercial  
space flight  
opportunities**

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**Cost reduction**



**3D Printing**

**Communication**



**Metamaterials**

**Sustainability**



**CO<sub>2</sub> capture & conversion**

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# CO<sub>2</sub> CAPTURE AND CONVERSION

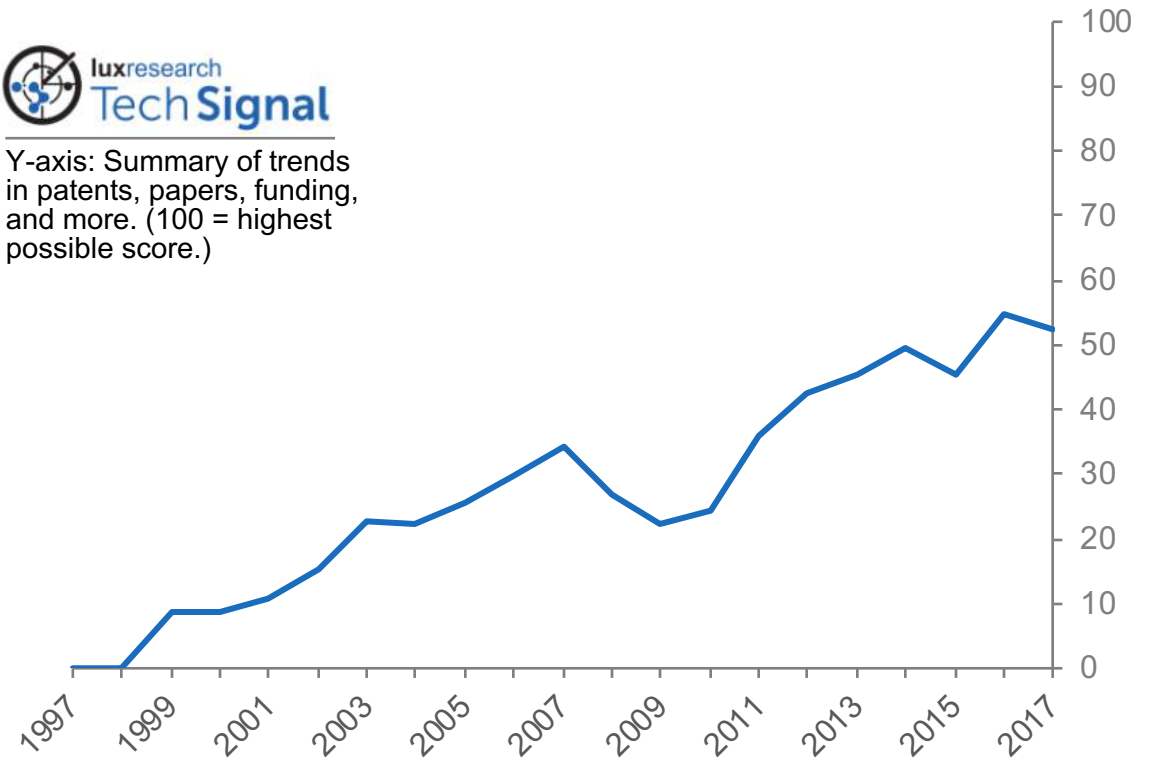
## Overview of terrestrial applications

### Description:

Capture of CO<sub>2</sub> for conversion to fuel and chemical feedstocks



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## CO<sub>2</sub> CAPTURE AND CONVERSION

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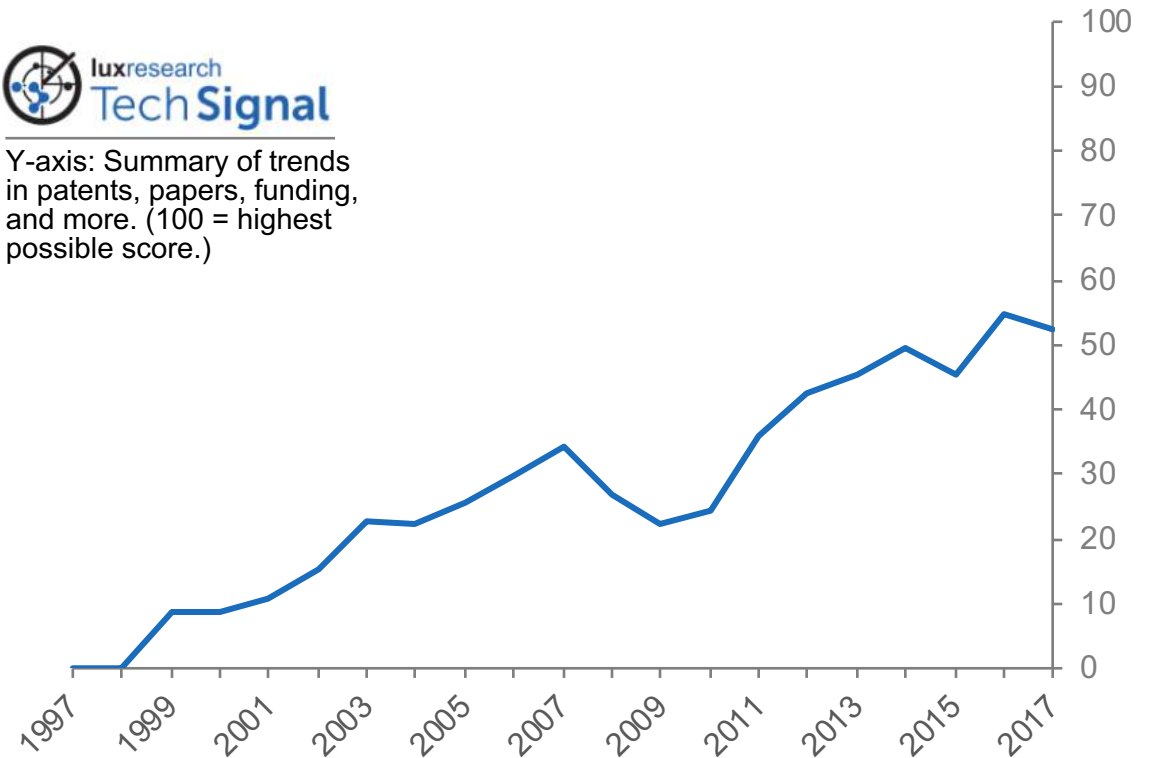
Capture of CO<sub>2</sub> for conversion to fuel and chemical feedstocks

### Key Benefits:

- Allows industries that cannot move away from combustion based processes to slash carbon emissions



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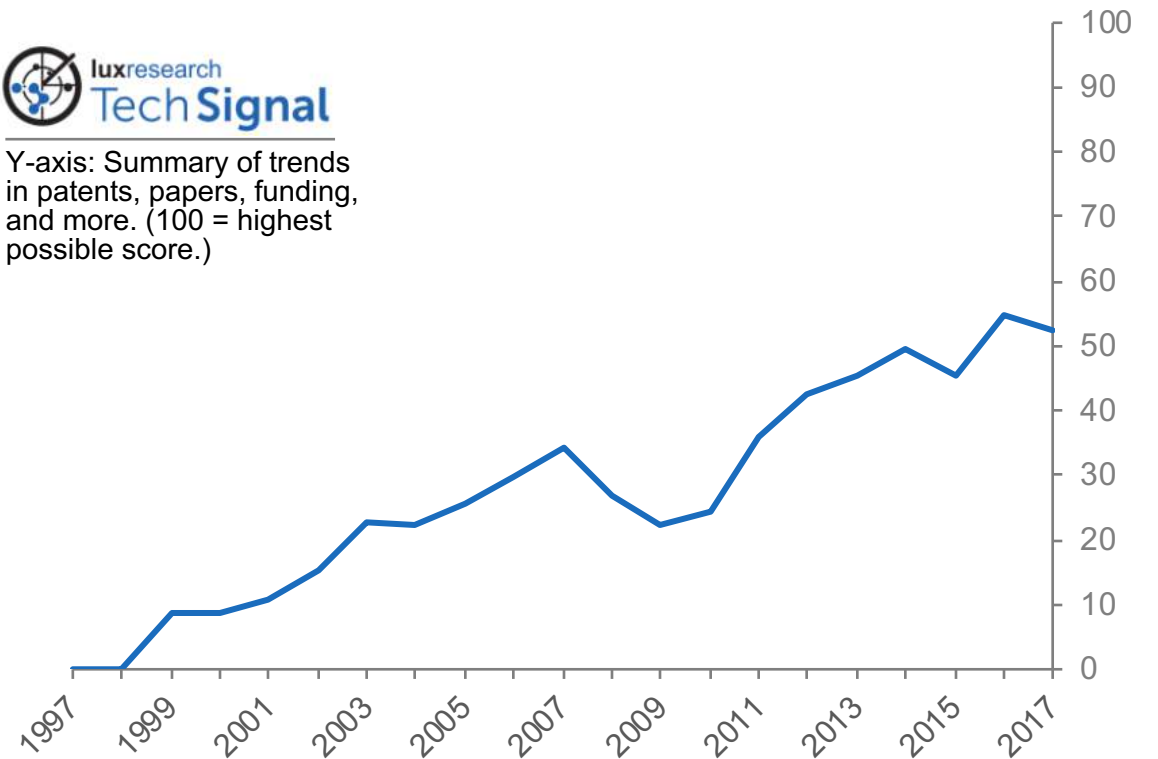
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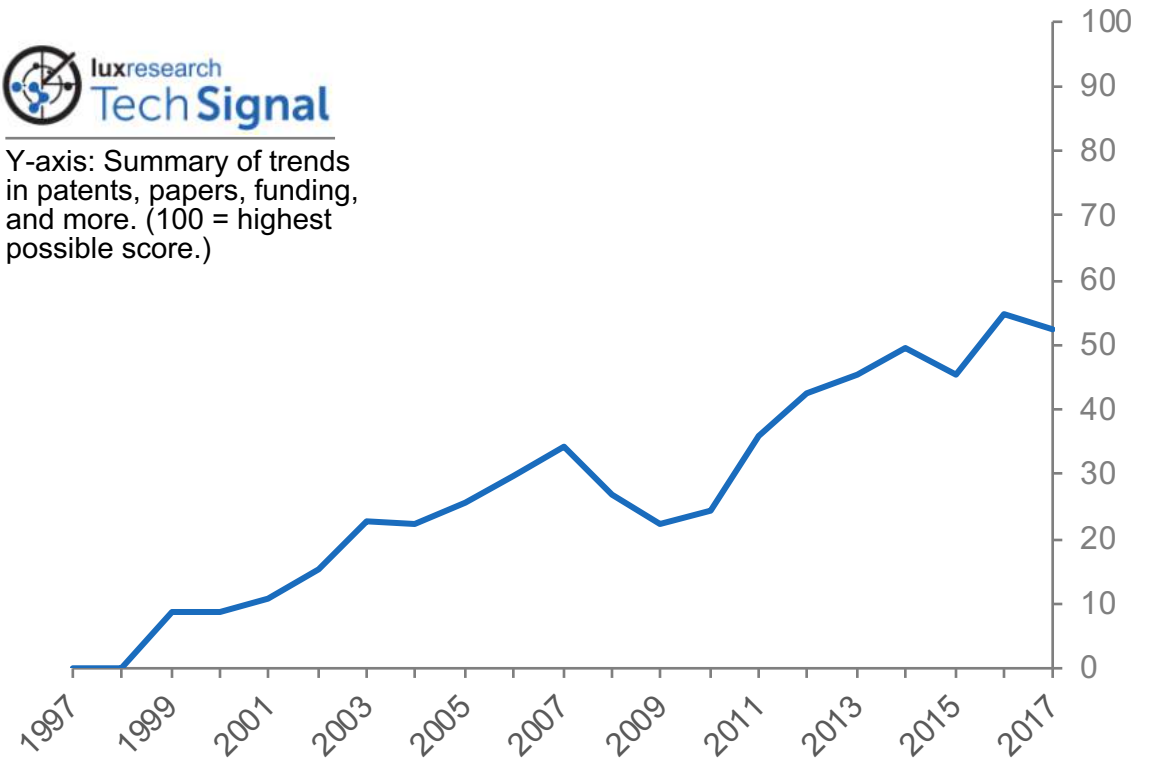
Capture of CO<sub>2</sub> for conversion to fuel and chemical feedstocks

### Key Benefits:

- Allows industries that cannot move away from combustion based processes to slash carbon emissions
- Creates new feedstock streams and potentially new revenue models
- Can actively pull CO<sub>2</sub> from the atmosphere



Y-axis: Summary of trends in patents, papers, funding, and more. (100 = highest possible score.)



# CO<sub>2</sub> CAPTURE AND CONVERSION

## The opportunity

# EARTH

---

**CO<sub>2</sub> = 0.041%**

## CO<sub>2</sub> CAPTURE AND CONVERSION

### The opportunity

#### EARTH

---

**CO<sub>2</sub> = 0.041%**

#### MARS

---

**CO<sub>2</sub> = 95.32%**

## CO<sub>2</sub> CAPTURE AND CONVERSION

### The opportunity

#### EARTH

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CO<sub>2</sub> = 0.041%

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CO<sub>2</sub> = 95.32%



CO<sub>2</sub> → Glucose



# CO<sub>2</sub> CAPTURE AND CONVERSION

## The opportunity

### EARTH

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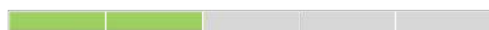
CO<sub>2</sub> → Fuel

# CO<sub>2</sub> CAPTURE AND CONVERSION

## A lack of point sources means capture is a major opportunity



LUX TAKE



Caution



LUX TAKE



Wait And See



## CO<sub>2</sub> CAPTURE AND CONVERSION

# Conversion energy and efficiency need major improvements



LUX TAKE



Wait And See

## CO<sub>2</sub> CAPTURE AND CONVERSION

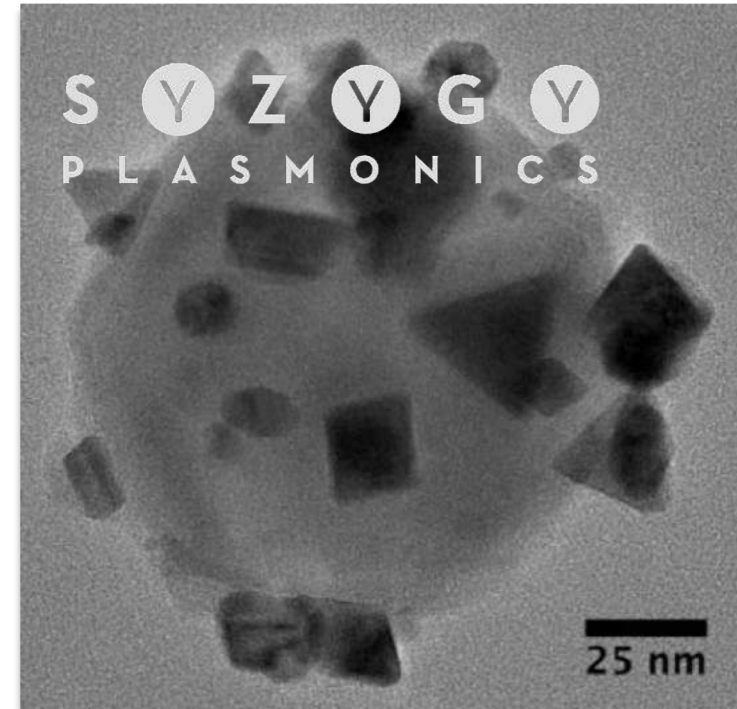
# Conversion energy and efficiency need major improvements



LUX TAKE



Wait And See



LUX TAKE



Wait And See


## CO<sub>2</sub> CAPTURE AND CONVERSION

# Innovations in conversion efficiency can drive terrestrial adoption



# Agenda

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- 2 | Opportunities for innovation
- 3 | **Back to earth: Key takeaways to start your space journey**

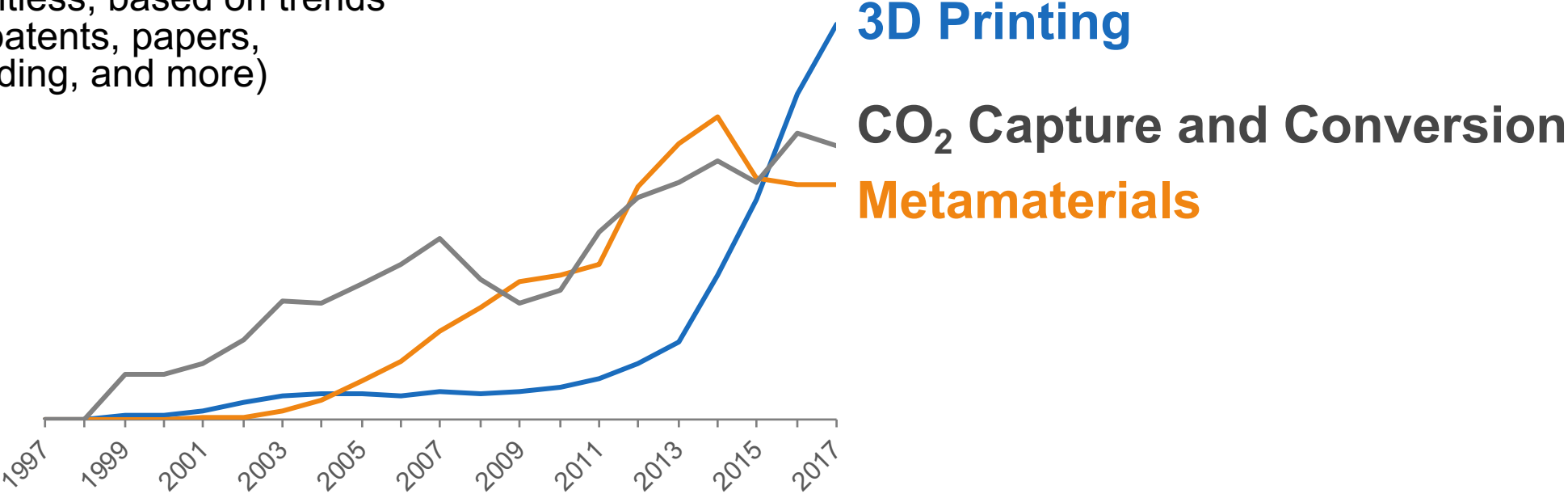


So what can  
you actually do  
about all this?

# A strategic framework that combines data + insight



**Innovation interest**  
(unitless, based on trends in patents, papers, funding, and more)

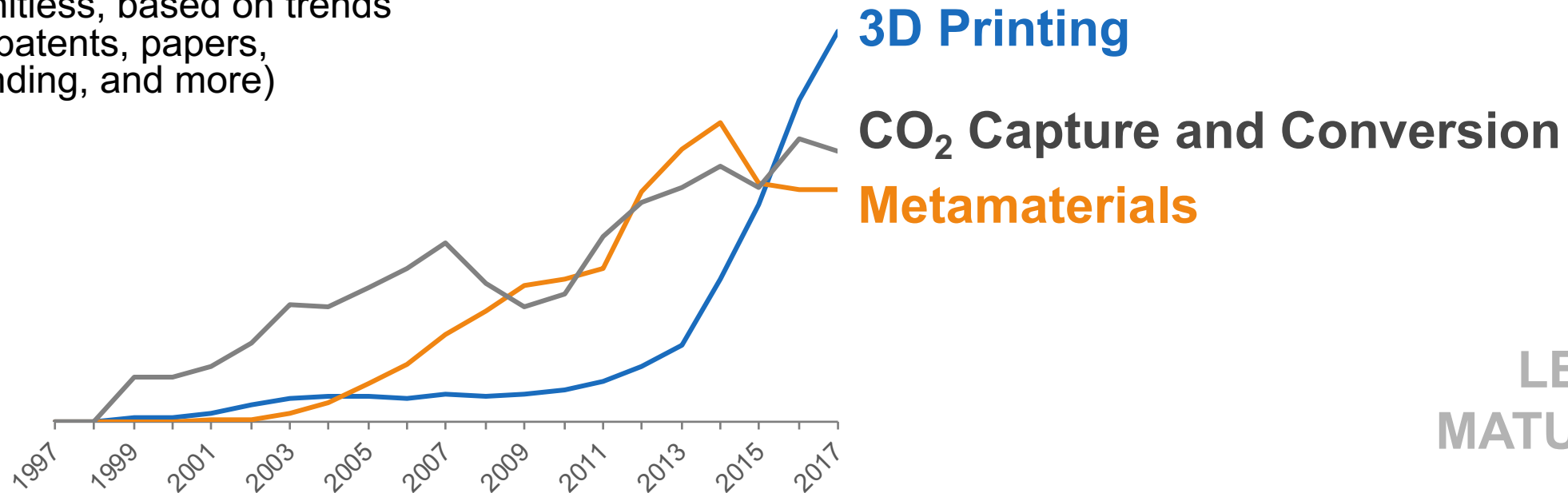




# A strategic framework that combines data + insight



**Innovation interest**  
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**MORE  
MATURE**



**LESS  
MATURE**

## 3D PRINTING

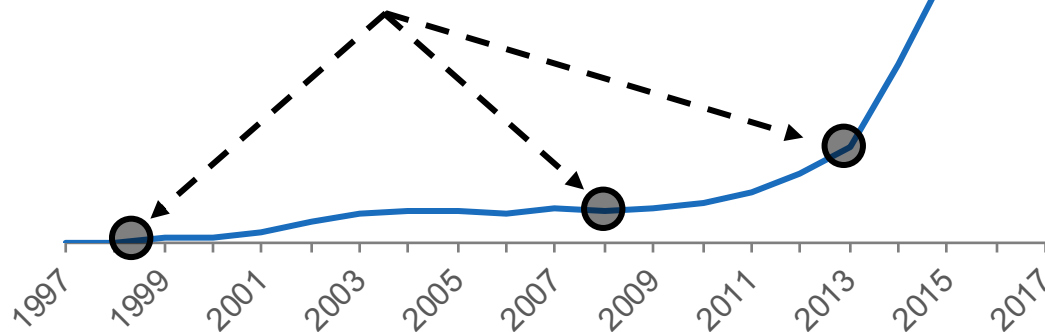
# Build cutting edge partnerships to enhance existing products



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**3D Printing**

## KEY INFLECTION POINTS



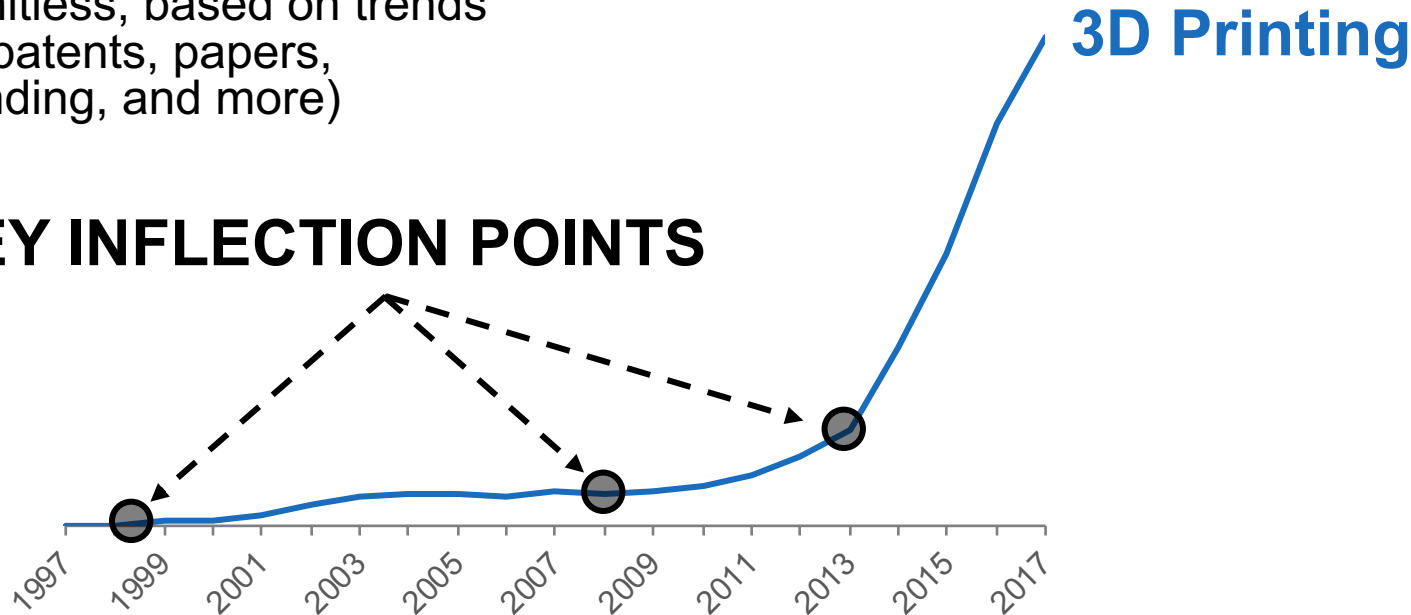
# 3D PRINTING

## Build cutting edge partnerships to enhance existing products



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### KEY INFLECTION POINTS



# DMG MORI



GALACTIC

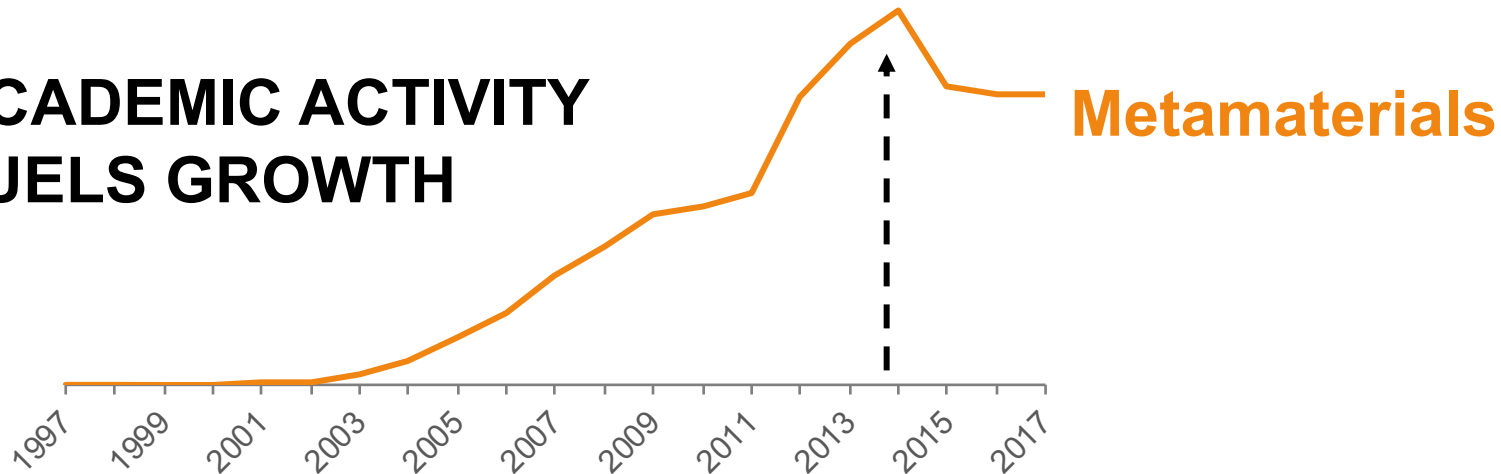
# METAMATERIALS

## Develop IP and core competency to prepare for the future



**Innovation interest**  
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**ACADEMIC ACTIVITY  
FUELS GROWTH**



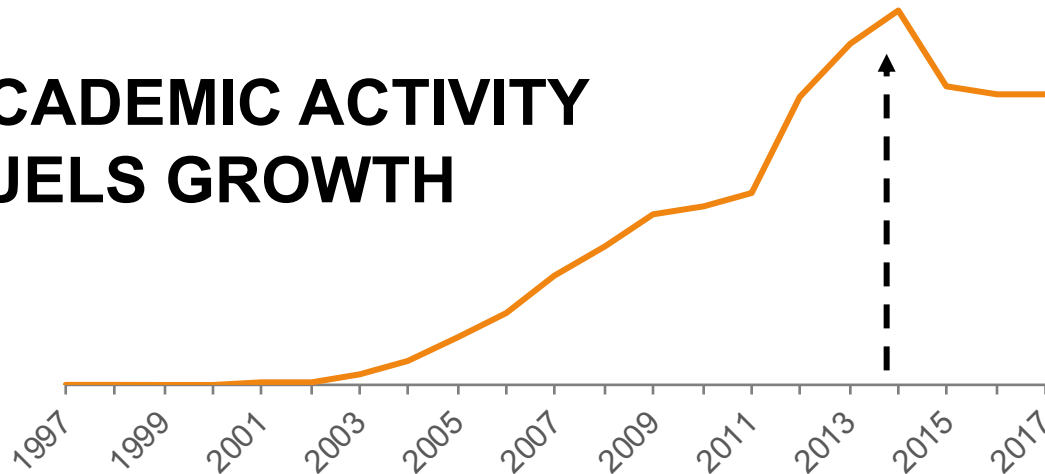
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**Metamaterials**

***NORTHROP GRUMMAN***

**Duke**  
UNIVERSITY

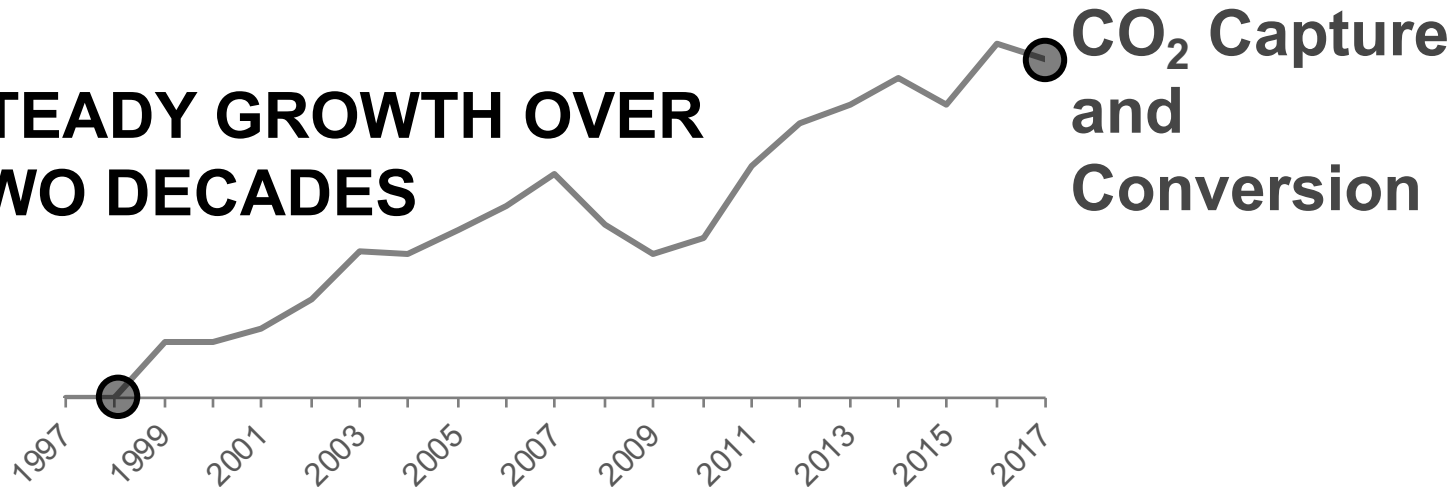
## CO<sub>2</sub> CAPTURE AND CONVERSION

# Align core competencies to specific challenges



**Innovation interest**  
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**STEADY GROWTH OVER  
TWO DECADES**



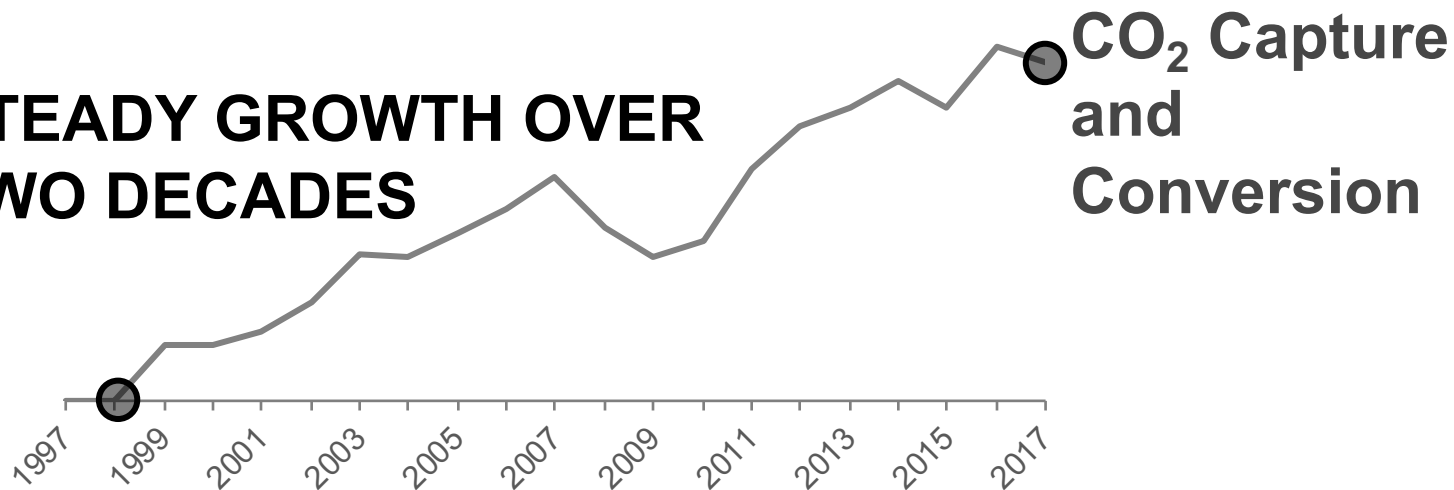
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**STEADY GROWTH OVER TWO DECADES**



**Dioxide Materials™**  
The CO<sub>2</sub> Recycling Company™

## Key takeaways

- 1 Align with the needs of spaceflight to develop key technologies for Earth





## Key takeaways

- 1 Align with the needs of spaceflight to develop key technologies for Earth
- 2 Leverage the resources for space exploration to fund long term bets



## Key takeaways

- 1 Align with the needs of spaceflight to develop key technologies for Earth
- 2 Leverage the resources for space exploration to fund long term bets
- 3 Use data + insight to plan your technology strategy





2018

# luxexecutivesummit

Tokyo • October 17

*Thank you for joining us.*





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